ACTA ODONTOLOGICA SCANDINAVICA, 2018
VOL. 76, NO. 3, 204–211
https://doi.org/10.1080/00016357.2017.1402209

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ORIGINAL ARTICLE

Reduced antibiotic prescription rates following physician-targeted interventions in a dental practice

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ABSTRACT

Background: The prescription rate for antibiotics in dental clinics is not declining despite the increase in the antibiotic resistance problem. In this study, we observed the change in antibiotic prescription rates by dentists in a Korean dental hospital for various treatments after conducting interventions targeting dentists.

Methods: The first intervention was to distribute guidelines. The second intervention was to remove the bundled prescription button containing antibiotics from the Electronic Medical Record system. A total of 22,098 treatment records were divided into 12 main treatment categories, and Chi-square tests and logistic regression analyses were performed.

Results: After the interventions were applied, the overall prescription rate for antibiotics dropped. The antibiotic prescription rate decreased by an odds ratio of 0.774 (95% CI: 0.686–0.873) after intervention 1 and by an odds ratio of 0.574 (95% CI: 0.501–0.658) after intervention 2. The treatments with significantly reduced antibiotic prescription rates were extraction for orthodontic treatment, dental implant surgery, extraction of an impacted tooth and general extraction. These treatments are typically performed in patients without an active infection. The prescription rate did not change for periodontal treatments or endodontic treatments, which are usually performed in patients with an infection. The prescription rate also remained constant for minor operations and other basic treatments.

Conclusion: The interventions induced behavioural changes in the dentists and were effective in lowering the antibiotic prescription rates in a dental hospital. In particular, there was a significant reduction in the prescription rates for implant surgery and tooth extraction in the absence of infection.

ARTICLE HISTORY
Received 12 July 2017
Revised 11 October 2017
Accepted 2 November 2017

KEYWORDS
Dentists; behavioural sciences; antibiotics; prescriptions; drug

Introduction

Dentists prescribe antibiotics to treat orofacial infections and prevent the systemic spread of infections [1]. Dental clinics account for 7–11% of the total antibiotic prescriptions annually [2]. Next to pain relievers, antibiotics are the most commonly prescribed medications in dental clinics [3]. Antibiotics are routinely used to treat infectious diseases. Used improperly, the effects of these drugs can be lessened, and antibiotic resistance can increase [4,5]. Many researchers argue that the prescription rate of antibiotics should be reduced in dental practices, but this has not been easy to achieve [6].

The principles for prescribing antibiotics are taught in dental schools but have been largely ignored in dental clinics for various reasons. There are four general indications in principles of antibiotic prescriptions [7,8]. First, the severity of infection at the time of admission should be determined, and antibiotics should be prescribed when there is severe swelling or unidentified cellulitis. Second, if it is not possible to extract an infected tooth immediately, antibiotics should be prescribed to control the infection. Third, antibiotics should be prescribed when the patient's immune response is weakened. Fourth, antibiotic prophylaxis can be used in an attempt to prevent complications even in immune competent individuals. Antibiotics used for these cases should have narrow spectrums, have low side effects, and be administered in appropriate doses.

According to these principles, it is not desirable to prescribe prophylactic antibiotics in the absence of infection. However, local dental clinics have recently increased the number of invasive surgical operations they perform, such as dental implant placement and bone grafting, and antibiotic prescriptions for preventing infection are increasing [6]. In addition, dentists often see patients who are delaying treatment for economic reasons. For these patients, dentists may prescribe antibiotics to alleviate symptoms and maintain the relationship with the patient [9].

In developed countries, various studies have identified essential factors for prescribing antibiotics, and efforts have been made to prescribe antibiotics appropriately. In Europe, the 2007 European Surveillance of Antimicrobial Consumption (ESAC) Project has been comparing the quantity of outpatient antibiotic use by country [10]. In Sweden, efforts have been made to reduce antibiotic use through ongoing education of the general public, patients and health care providers, and antibiotic prescriptions have been steadily decreasing since 1993 [11]. In Turkey, regulations on the

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use of antibiotics since 1999 have reduced the frequency of antibiotic use [12]. Specifically, there is an attempt to induce the appropriate use of antibiotics by controlling demand in a way that institutionally reduces the insurance rate for remuneration [13].

South Korea has higher antibiotic production and consumption rates than the average Organization for Economic Cooperation and Development (OECD) country. In 2009, the OECD average of consumption (DDD/1000person/day) of antibacterials for systemic use was 21.1, while Korea was 26.9 [14]. Since separation of the prescribing and the dispensing of drugs began in 2000, many efforts have been made to lower the prescription rate for antibiotics at the national level. Since 2002, the appropriateness evaluation of medicines has been carried out in Korea, focusing on antibiotics and injections. Since 2006, the prescription rate of antibiotics for each hospital has been publicly disclosed [15]. However, the antibiotic prescription rate in South Korea is still higher than in other developed countries, and problems with antibiotic resistance remain [15–17]. Among Asian countries with a relatively high rate of bacterial resistance to penicillin G and erythromycin A, resistance to *Pneumococcus* was the highest in Korea [18]. In addition, cephalosporin antibiotics are used in Korea hundreds of times more than in Denmark, Norway and Sweden, and other antibiotics were also used frequently [19]. According to Korean National Health Insurance statistics from 2004, 23.6 per 1000 people per day received an antibiotic prescription [14].

The goal of antibiotic prescription management is to offer an effective treatment for bacterial infections and to reduce the use of unnecessary antibiotics. Methods of prescription management can be divided into restrictive intervention and persuasive intervention categories. The restrictive intervention category includes prior authorization of prescriptions by infectious diseases physicians regarding antibiotic selections and prescription methods. The persuasive intervention category includes distribution of education materials, audits and methods that induce behavioural changes in doctors or patients. Many studies investigating how to manage antibiotic prescriptions efficiently have been undertaken in the past, and various methods have been proposed and shown to be effective. In fact, the antibiotic prescription rate of one experimental group that had received training, monitoring and feedback was reduced by approximately 12% after 9 months compared with a control group. In that same study, there were no significant clinical side effects or patient satisfaction changes [20].

In this study, we conducted physician-targeted interventions aimed to reduce the antibiotic prescription rate in dental clinics. It has been reported that such interventions may lower the antibiotic prescription rate more effectively than other intervention methods [21]. To achieve this, we first selected a large dental hospital that had provided service for more than 10 years in a metropolitan centre. We then conducted two interventions intended for dentists and observed the reduction in antibiotic prescriptions for different dental treatments. In the first intervention, we distributed antibiotic prescription guidelines and educated dentists on the principles of prescription. In the second intervention, we transformed the bundled prescription button (which included antibiotics) to a separate prescription button in the Electronic Medical Record (EMR) system. The latter change forced dentists to deliberately add antibiotics to prescriptions if desired. Collectively, these interventions triggered behavioural changes in the dentists.

Materials and methods

Materials

This study was conducted in compliance with the principles of the Declaration of Helsinki, and it was approved by the Institutional Review Board (IRB) of Appletree Dental Hospital (IRB number 0841-201605-006-01). We used the medical records and prescription records of patients who visited S Dental Hospital in the city of Goyang, South Korea. The data from 1 January 2015 to 31 March 2015 and from 1 January 2016 to 31 March 2016 was extracted for this study.

At the dental clinic, two interventions were performed to reduce the number of antibiotic prescriptions. The first intervention, the dissemination of guidelines for antibiotic prescription to the dentists, was started on 1 January 2016 and continued until 20 February 2016. The guidelines were based on the textbooks that the dentists used during college and the latest practical recommendations on antibiotic prescribing [22–25]. The second intervention, a change in the prescription button of the EMR system used at the dental hospital, started on 22 February 2016 and continued until 31 March 2016. Previously, the bundled prescription button which included antibiotics was prominent and allowed for easy antibiotic prescription. In the new system, this bundled button was either removed or placed in a hard-to-find location, making it more difficult for the dentists to prescribe antibiotics. In the new system, the dentist had to search for and specifically add the antibiotics to prescribe them.

Data from the dental clinic that were not directly related to antibiotic prescriptions were excluded from the analysis. The criteria for exclusion or inclusion of patient visit information are as follows: Simple administrations such as customer relationship management (CRM) were excluded. Orthodontic treatments were excluded from the analysis because these usually involved no antibiotic prescriptions. However, antibiotics could be prescribed when premolars or wisdom teeth were extracted before orthodontic treatment, so extractions as part of orthodontic treatments were included in the analysis. Simple examinations for the National Health Survey and fitting tests for prosthodontic restorations were excluded. Since the medical records from 2015 were used as the control group for the interventions and the medical records from 2016 were used as the experimental group, only dentists who worked full-time during both periods were selected. Of the 63,651 total patient visits, 22,098 were used for our analysis.

Methods

Selection of representative treatments

In Korea, patients typically received multiple treatments during a single visit. Among these treatments, that with the

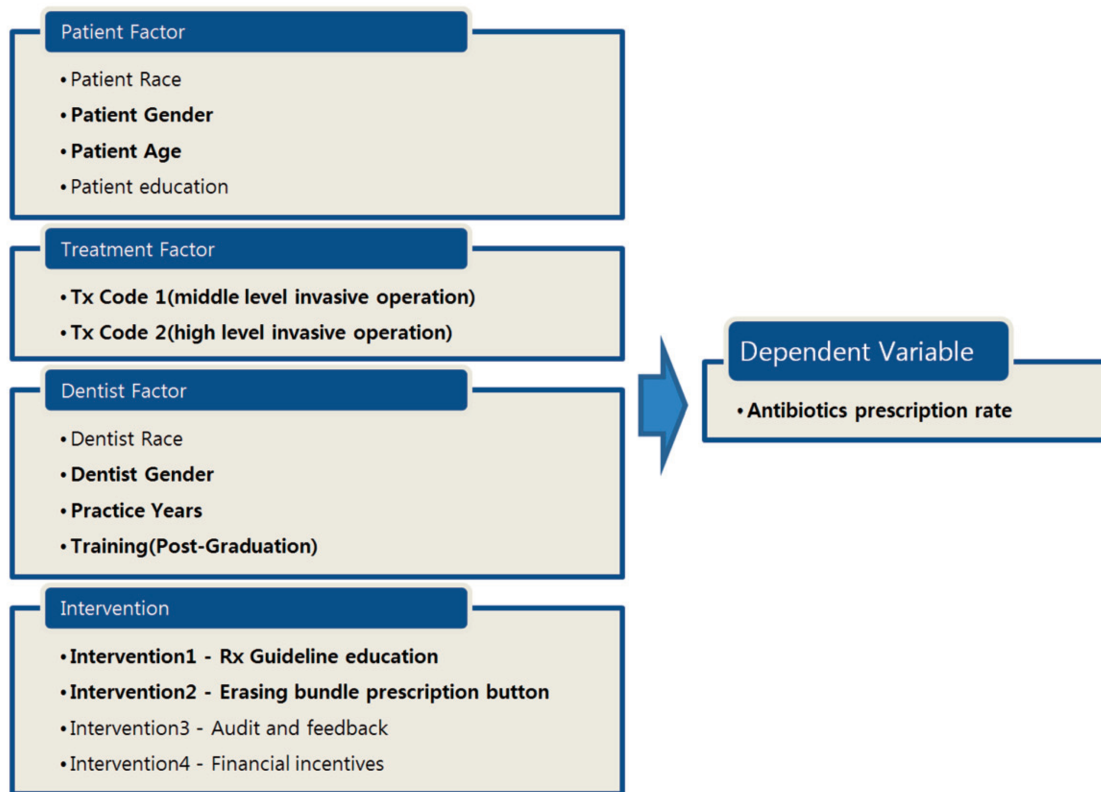

Figure 1. Conceptual framework for the factors evaluated in regard to antibiotic prescription rates. The **bold text** indicates the variables selected for the regression analysis.

highest probability of antibiotic prescription was designated as the representative treatment for the visit. Implant first surgeries including sinus bone grafts, and minor operations including incision and drainage, had the highest rankings. Tooth extractions, followed by periodontal treatments and endodontic treatments had the next highest rankings. Implant first surgery is the first stage of surgery for dental implant placement on the alveolar bone of a patient. Implant second surgery is a less invasive stage because dentists simply change the cover screw into a healing abutment on the top of the osseo-integrated dental implant. A dressing is treated with topical disinfection medication is typically applied to the treatment area 1–3 days after the treatment.

Univariate association of antibiotic prescription rate with the type of interventions

We performed a Chi-square test to determine if the antibiotic prescription rate changed for some treatments when the intervention was applied to the dentists. For both interventions, the time period in 2016 when the intervention was performed was used as the experimental group, and the same time period in 2015 was used as the control group.

Multivariate association of antibiotic prescription rates with the type of interventions

A logistic regression analysis was performed to obtain odds ratios of factors associated with antibiotic prescriptions. When the probability of an antibiotic prescription was p, the dependent variable was logit p. The independent variables were classified into four groups: patient factors, treatment factors, dentist factors and interventions (Figure 1). A suitable model was found by using the backward elimination method using the likelihood ratio. Selected independent variables are described below.

The variables included in the patient factor were gender and age. The treatment factors were categorized into three dummy-coded values, for inclusion in the regression equation. Implant first surgery and minor operations, which together had the highest antibiotic prescription rates in 2015, were coded as TxCode2 = 1. General extractions and extraction of an impacted tooth, which also had high prescription rates, were coded as TxCode1 = 1. Dentist factors included gender, years of practice and training. Dentist age was excluded because of multicollinearity with practice years.

Finally, the interventions included intervention 1 which consisted of the prescription guideline education for dentists, and intervention 2, which consisted of removal of the bundled prescription button. Intervention 3 (audit and feedback) and intervention 4 (financial incentives) were not included in this study. The regression equation was:

Model 1: logistic regression for antibiotic prescriptions

$$\ln\left(\frac{p}{1-p}\right) = \beta_0 + \beta_1 \text{Pt_Sex} + \beta_2 \text{Pt_Age} + \beta_3 \text{TxCode1} + \beta_4 \text{TxCode2} + \beta_5 \text{Dent_Sex} + \beta_6 \text{Dent_YrPrac} + \beta_7 \text{Dent_Training} + \beta_8 \text{Intervention1} + \beta_9 \text{Intervention2}$$

Adjusted odds ratios of intervention 1 and intervention 2 in different treatment groups

Logistic regression analysis was used to determine the degree of reduction in antibiotic prescriptions caused by each intervention. Twelve new sets of data were made by dividing the treatment records according to 12 different treatment codes, and each set was subjected to logistic regression. The regression equation used in this step was:

Model 2: logistic regression for antibiotic prescriptions in different treatment groups

$$\ln\left(\frac{p}{1-p}\right) = \beta_0 + \beta_1 \text{Pt_Sex} + \beta_2 \text{Pt_Age} + \beta_3 \text{Dent_Sex} + \beta_4 \text{Dent_YrPrac} + \beta_5 \text{Dent_Training} + \beta_6 \text{Intervention1} + \beta_7 \text{Intervention2}$$

Statistical analyses

Statistical software R 3.1.1 (2014, The R Foundation for Statistical Computing, Vienna, Austria) and SPSS 21.0 (SPSS Inc., Chicago, IL) were used. The 'stringr' package was used to extract representative treatments and classify antibiotics with various product names. The 'plyr' package in R was used for comparing the number of prescription days. Chi-square tests were performed using SPSS.

Results

Changes in antibiotic prescription rates

Antibiotic prescription rates were significantly ($p < .05$) decreased for several treatments (Table 1). The antibiotic prescription rate for all treatments was 12.1% in the absence of intervention, decreased to 10.4% after intervention 1, and further decreased to 8.7% after intervention 2. A reduction in the antibiotic prescription rate was observed for implant first surgery, extractions for orthodontic treatment, implant second surgery, general extractions, extractions of an impacted tooth, basic treatments and scaling. There were no significant reductions in the antibiotic prescription rate for minor operations, periodontal treatments, endodontic treatments, implant prosthodontics or dressings.

Significant reductions in antibiotic prescription rates were observed for some treatments. Antibiotic prescriptions for extractions for orthodontic treatments decreased from 60.0% to less than 5%. In the case of implant first surgery, the pre-existing antibiotic prescription rate was 91.4%, which was reduced to 84.3% by intervention 1 and to 69.2% by intervention 2. For implant second surgery, the pre-existing antibiotic prescription rate was 30.7%, which decreased to 14.6% after intervention 1 and to 12.9% after intervention 2. For extractions of an impacted tooth, the pre-existing antibiotic prescription rate was 16.7%, which decreased after intervention 1 to 8.5%, and decreased after intervention 2 to 6.5%. For general extractions, the pre-existing antibiotic prescription rate was 33.7%, which decreased after intervention 1 to 25.6%, and decreased after intervention 2 to 24.9%.

The adjusted odds ratios of the type of interventions for antibiotic prescriptions

Descriptive statistics of variables in logistic regression are shown in Table 2. Logistic regression results showed that the odds ratios for intervention 1 and intervention 2 were all less than 1.000 (Table 3). Intervention 1 decreased the antibiotic prescription rate 0.774-fold (95% CI: 0.686–0.873), and

Table 1. Antibiotic prescription rate of each treatment.

	Antibiotics	Control	Intervention 1	Intervention 2	*p* Value
Implant first surgery	Yes	320 (91.4%)	188 (84.3%)	128 (69.2%)	.000***
	–	30 (8.6%)	35 (15.7%)	57 (30.8%)	–
Extraction for orthodontic Tx	Yes	45 (60.0%)	0 (0.0%)	1 (3.7%)	.000***
	–	30 (40.0%)	34 (100.0%)	26 (96.3%)	–
Minor operation	Yes	31 (55.4%)	10 (40.0%)	15 (53.6%)	.423
	–	25 (44.6%)	15 (60.0%)	13 (46.4%)	–
Implant second surgery	Yes	35 (30.7%)	14 (14.6%)	9 (12.9%)	.004**
	–	79 (69.3%)	82 (85.4%)	61 (87.1%)	–
Extraction (general)	Yes	289 (33.7%)	117 (25.6%)	90 (24.9%)	.001***
	–	569 (66.3%)	340 (74.4%)	272 (75.1%)	–
Extraction of impacted tooth	Yes	33 (16.7%)	8 (8.5%)	6 (6.5%)	.024*
	–	165 (83.3%)	86 (91.5%)	86 (93.5%)	–
Periodontal Tx	Yes	138 (18.6%)	57 (18.0%)	38 (16.3%)	.754
	–	605 (81.4%)	259 (82.0%)	195 (83.7%)	–
Endodontic Tx	Yes	92 (6.6%)	43 (5.8%)	26 (4.5%)	.221
	–	1305 (93.4%)	698 (94.2%)	547 (95.5%)	–
Basic Tx	Yes	239 (6.6%)	111 (5.7%)	77 (4.4%)	.004**
	–	3392 (93.4%)	1848 (94.3%)	1682 (95.6%)	–
Scaling	Yes	80 (4.2%)	23 (2.4%)	23 (2.7%)	.026*
	–	1820 (95.8%)	916 (97.6%)	815 (97.3%)	–
Implant prosthodontics	Yes	28 (3.1%)	27 (4.8%)	17 (3.6%)	.237
	–	876 (96.9%)	533 (95.2%)	460 (96.4%)	–
Dressing	Yes	27 (2.8%)	9 (2.4%)	12 (2.7%)	.942
	–	933 (97.2%)	371 (97.6%)	432 (97.3%)	–
Total	Yes	1357 (12.1%)	607 (10.4%)	442 (8.7%)	.000***
	–	9,829 (87.9%)	5,217 (89.6%)	4,646 (91.3%)	–

Significance codes: '***' $p < .001$, '**' $p < .01$, '*' $p < .05$.

Table 2. Descriptive statistics of variables in logistic regression.

Variable	Detail	Value
Total number of cases		$N = 22{,}098$
Dependent variables		
antipr	Antibiotics prescription 1 if YES, case include prescribing antibiotics	1: 2406
Independent variables		
1. Patient factor		
Patient gender[a]	Gender of patient = 1 if male	1: 48.12%
Patient age	Age of patient	Mean = 39.10, Stdev = 21.103 Min = 1, Max = 96
2. Treatment factor		
TxCode(1)[a]	Treatment category 1 = 1 if extraction (general), impacted tooth extraction	1: 9.3%
TxCode(2)[a]	Treatment category 2 = 1 if implant first surgery, minor operation	1: 3.9%
3. Dentist factor		
Dentist gender[a]	Gender of dentist = 1 if male	1: 65.5%
Dentist practice year	Number of years the dentist has practiced	Mean = 14.81, Stdev = 6.935 Min = 1, Max = 24
Dentist training[a]	Special training after graduation = 1 if dentist received special training after graduation	1: 68.5%
4. Intervention		
Intervention	No intervention = 0 if control group (year 2015) Prescription guideline = 1 if dentist received the guideline Erase bundle prescription button = 2 if dentist used the new EMR system	0: 50.6% 1: 26.4% 2: 23.0%

[a]Binary variable, where 1 is designated and other non-missing cases = 0.

Table 3. Results of multivariate logistic regression to find factors associated with antibiotic prescription.

Variables	β	S.E.	Wald	df	Sig.	AOR	95% C.I. Lower	95% C.I. Upper
Patient gender	0.265	0.051	27.3	1	0.000	1.304	1.180	1.440
Patient age	0.027	0.001	372.8	1	0.000	1.027	1.024	1.030
TxCode	–	–	2323.5	2	0.000	–	–	–
TxCode(1)	1.981	0.065	940.1	1	0.000	7.251	6.389	8.230
TxCode(2)	3.970	0.094	1771.6	1	0.000	52.982	44.040	63.741
Dentist gender	0.557	0.074	56.8	1	0.000	1.745	1.510	2.017
Dentist practice year	−0.016	0.005	11.5	1	0.001	0.984	0.975	0.993
Dentist training	0.240	0.058	17.3	1	0.000	1.271	1.135	1.423
Intervention	–	–	67.9	2	0.000	–	–	–
Intervention 1	−0.257	0.062	17.4	1	0.000	0.774	0.686	0.873
Intervention 2	−0.555	0.069	64.2	1	0.000	0.574	0.501	0.658
Constant	−4.208	0.108	1509.1	1	0.000	0.015	–	–

TxCode(1) = extraction (general), extraction of impacted tooth; TxCode(2) = implant first surgery, minor operation; logistic regression method = backward stepwise (likelihood ratio); Nagelkerke R square = 0.321.

intervention 2 decreased the antibiotic prescription rate 0.574-fold (95% CI: 0.501–0.658). The largest odds ratios were associated with treatment factors. General extractions and extractions of an impacted tooth (i.e. TxCode1 = 1) had odds ratios that were 7.251 (95% CI: 6.389–8.230) times higher than those for reference treatments. Implant first surgery and minor operations (i.e. TxCode2 = 1) had odds ratios that were 52.982 (95% CI: 44.040–63.741) times higher.

Other factors influencing the prescription of antibiotics were male patients, older patients, male dentists and dentists received specialty training after graduation. Antibiotic prescriptions were 1.304 (95% CI: 1.180–1.440) times higher for male patients than female patients and 1.027 (95% CI: 1.024–1.030) times higher in patients aged 1 year older. The antibiotic prescription rate was 1.745 (95% CI: 1.510–2.017) times higher for male dentists than for female dentists, and 1.271 (95% CI: 1.135–1.423) times higher for those receiving training. On the other hand, an increase in dentist years of practice was a factor in reducing antibiotic prescriptions. Prescriptions decreased 0.984 (95% CI: 0.975–0.993) times for each additional year a dentist had practiced.

Adjusted odds ratios of intervention 1 and intervention 2 for antibiotic prescriptions in different treatment groups

Twelve separate sets of data were prepared for each of the 12 treatments, and logistic regression was performed for each (Table 4, Figure 2). Antibiotic prescription rates were significantly decreased by intervention 1 for implant first surgery, implant second surgery, general extractions and scaling with odds ratios of 0.454, 0.312, 0.601 and 0.594, respectively. Antibiotic prescription rates were significantly decreased by intervention 2 for implant first surgery, extractions for orthodontic treatments, implant second surgery, general extractions, extractions of an impacted tooth, endodontic treatments and basic treatments with the odds ratios of 0.211, 0.033, 0.288, 0.409, 0.403, 0.616 and 0.650, respectively.

Overall, the odds ratios of intervention 2 were lower than those of intervention 1. Particularly, in implant first surgery, extractions, endodontic treatments and basic treatments, odds ratios of intervention 2 were much lower than those of intervention 1. For minor operations, periodontal treatments, implant prosthodontics and dressings, there were no significant reductions in antibiotic prescription rates due to intervention 1 or 2.

Discussion

In this study, we observed that antibiotic prescription rates were lowered for some dental treatments as a result of interventions targeting physicians. Interventions induced a behavioural change in that dentists more carefully considered the benefits of prescribing antibiotics. In particular, antibiotic prescription rates were reduced for several treatments, including implant surgery and tooth extraction. When dental operations are performed in the absence of infection, antibiotics do not help prevent inflammation and are not always necessary [26–28]. In many cases, implant surgery and tooth extraction for orthodontic treatment are often non-inflammatory.

Table 4. Adjusted odds ratio and 95% confidence intervals of antibiotic prescription rates in various treatment groups after intervention 1 and intervention 2.

			Intervention 1				Intervention 2			
Treatment	*n*	r2CU	OR	Lower CI	Upper CI	*p* Value	OR	Lower CI	Upper CI	*p* Value
Implant first surgery	758	0.318	0.454	0.252	0.815	.008**	0.211	0.120	0.365	.000***
Extraction for orthodontic Tx	136	0.559	0.000	0.000	5E + 22	.991	0.033	0.002	0.177	.001**
Minor operation	109	0.145	0.471	0.158	1.336	.163	0.917	0.326	2.579	.869
Implant second surgery	280	0.157	0.312	0.145	0.645	.002**	0.288	0.118	0.645	.004**
Extraction (general)	1677	0.498	0.601	0.427	0.843	.003**	0.409	0.283	0.586	.000***
Extraction of impacted tooth	384	0.246	0.485	0.170	1.191	.138	0.403	0.132	1.032	.079.
Periodontal Tx	1292	0.036	0.949	0.668	1.334	.765	0.829	0.551	1.224	.357
Endodontic Tx	2711	0.059	0.842	0.571	1.224	.376	0.616	0.385	0.954	.036*
Basic Tx	7349	0.081	0.881	0.691	1.117	.300	0.650	0.493	0.850	.002**
Scaling	3677	0.080	0.594	0.360	0.945	.034*	0.720	0.434	1.156	.188
Implant prosthodontics	1941	0.028	1.533	0.882	2.662	.128	1.067	0.560	1.974	.840
Dressing	1784	0.050	0.774	0.337	1.621	.517	0.883	0.423	1.739	.727

AOR: adjusted odds ratio; CI: confidence interval.
Significance codes: '***' $p < 0.001$, '**' $p < 0.01$, '*' $p < 0.05$, '.' $p < 0.1$.
In the 12 treatments, ORs of intervention 1 and 2 were adjusted for patient gender, patient age, dentist gender, dentist practice year and dentist training.

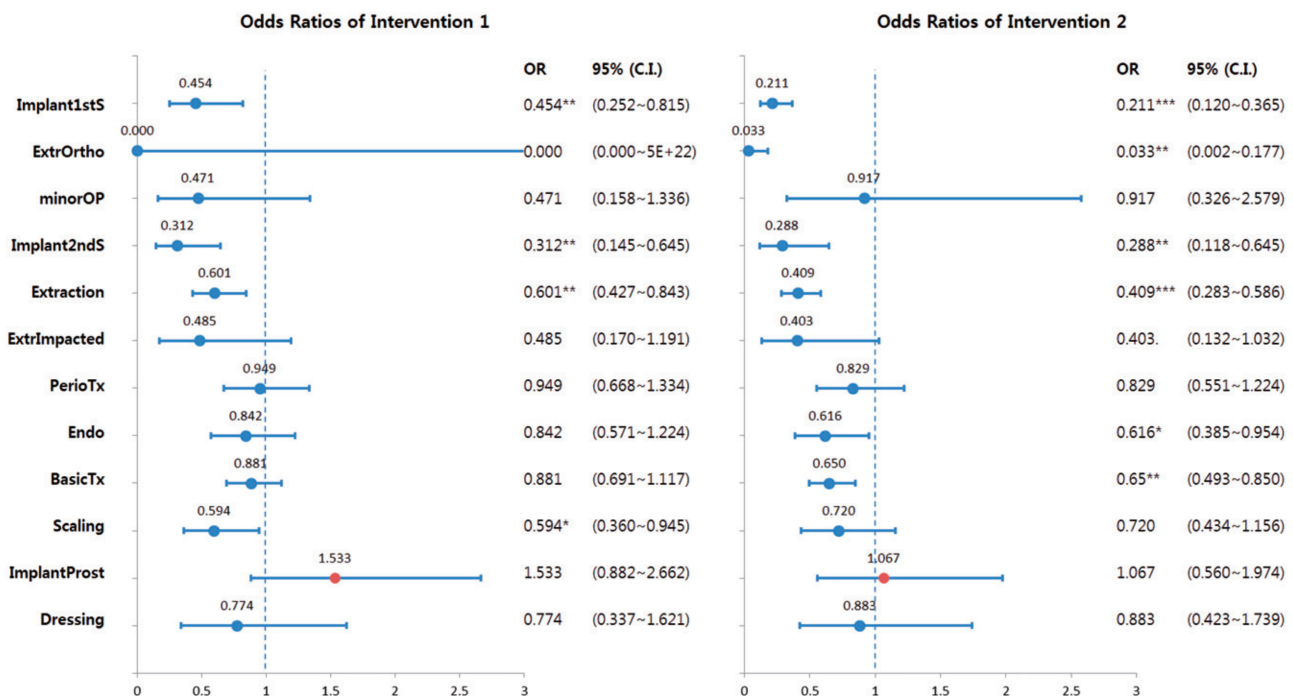

Figure 2. Adjusted odds ratios of intervention 1 and intervention 2 in 12 different treatment groups. Significance codes: '***' $p < .001$, '**' $p < .01$, '*' $p < .05$, '.' $p < .1$.

According to the four general indications in principles of antibiotic prescriptions, we do not require prescribing antibiotics before and after these treatments.

The prescription rate of antibiotics remained unchanged and still high for minor operations such as incision and drainage or periodontal surgery to remove infected tissue. In the case of invasive surgery, dentists and physicians had routinely prescribed antibiotics because of concerns about infection after the treatment [29,30]. The spread of unwanted infection may occur after the soft tissue surgery, because it is difficult for a dentist to completely remove the infected tissue. Dentists might tend to underestimate the health status of patients with severe infections and think that antibiotics could help prevent complications after treatment [9].

The antibiotic prescription rate was reduced by the intervention 1, providing prescription guidelines and educational materials. In one study, every intervention to lower the antibiotic prescription rate was somewhat effective [31]. Among these interventions, it was more effective to perform multiple interventions, including the providing educational guidelines designed to target physicians [21]. Patient-targeted intervention is important because patients often request antibiotics [32–35]. However, antibiotics are prescribed at the discretion of doctors, and it is more important to encourage doctors to change their behaviour because doctors can persuade patients in the cases of information asymmetry [36].

The antibiotic prescription rate reduction was further enhanced by the intervention 2, removing bundle prescription buttons in EMR system in our study. Intervention 2 imposed a direct constraint on the behaviour of dentists. When an EMR was introduced into dental clinics in South Korea, the method using the bundled prescription buttons was very sensational. Without the EMR system, dentists had

to handwrite the name of various medicines on the prescription papers. With the EMR system, dentists can prescribe antibiotics, analgesics and digestive medicine by simply clicking on the bundle prescription button. These days, almost all dentists use the predefined bundle prescription buttons with different combinations of medicines in South Korea. By eliminating the bundled prescription button containing antibiotics, dentists were required to consider situations more carefully, which reduced the use of antibiotics.

The average duration of an antibiotic prescription decreased from 3.39 days to 3.03 days as a result of our interventions (data not shown). The duration had a significant decrease only for implant surgery and tooth extraction procedures. In South Korea, the National Assessment and Evaluation Centre monitors and supervises the duration of antibiotic prescriptions, and most doctors and dentists prescribe antibiotics for three days on average [37]. Since this is a short duration, it was not significantly reduced by intervention in many cases. Although it is generally regarded that antibiotics should not be given for more than 10 days to reduce the likelihood of antibiotic resistance, many studies have pointed out that there is no significant difference in efficacy between a long duration of antibiotics and a short duration [38–42]. If antibiotics are prescribed for a long duration, they can become problematic by destroying the intestinal environment [43,44]. When an infection is confirmed, it is preferable to evaluate the patient after prescribing antibiotics for 2–3 days, and then make additional prescriptions as needed.

The limitations of this study are as follows: The dental hospital in this study (S Dental Hospital) is one of the largest hospitals nationwide, and employs many dentists. Since it covers a specific service catchment area, it may be difficult to generalize these results to the whole population. Also, the time period over which cases were collected was short (three months each for the control and experimental groups). However, most dental clinics in Korea are small private clinics, and the owners are reluctant to provide patient data. Given this challenging situation, it is meaningful that the treatment, prescription and doctors' profiles were obtained, and that an intervention-based study could be carried out. Additionally, since intervention 2 was carried out after intervention 1, the effects of intervention 1 were included in the effects of intervention 2. However, in order to eliminate the bundled prescription button (which included antibiotics), an explanation was needed as to why the button disappeared, and prescription guidelines had to be delivered to the dentists. Going forward, when studying these interventions in other active dental hospitals, removing the bundled prescription button should be one component of a multiple-part intervention. Dental clinics that undertake similar studies are likely to obtain fruitful results.

Conclusion

Physician-targeted interventions in a dental hospital reduced the prescription rate of prophylactic antibiotics after surgery performed in patients without active infections, especially for implant surgeries and some extractions. In addition, we found that the antibiotic prescription rate for treatment of infections was not easily lowered, even the interventions were applied. Based on these results, it should be possible to lower the antibiotic prescription rate in dental hospitals by prioritizing education and stewardship surrounding the antibiotic prescription rates for specific treatments.

Disclosure statement

Authors declare they have no competing interest.

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