*Acta Odontologica Scandinavica*, 2005; 63: 321–329

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**ORIGINAL ARTICLE**

# Antibiotic prophylaxis in oral health care: administration strategies of general dental practitioners

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**Abstract**

***Objective.*** To examine the strategies that general dental practitioners (GDPs) use to administer antibiotic prophylaxis and to study the agreement between the administration strategies of GDPs and local recommendations. ***Methods.*** Postal questionnaires in combination with telephone interviews were used. Two hundred GDPs in two Swedish counties, Skåne and Örebro, were asked to participate. The response rate was 51% ($n = 101$). The GDPs were presented with eight simulated cases of patients with different medical conditions for which antibiotic prophylaxis might be considered necessary when performing dental procedures (scaling, tooth removal, root canal treatment). The administration strategies of the GDPs were compared with local recommendations. ***Results.*** In general, the variation in the administration strategies of the GDPs was large. For two medical conditions, type 1 diabetes that was not well controlled and hip prosthesis, significantly more GDPs in Skåne than in Örebro administered antibiotic prophylaxis for tooth removal. Agreement between the administration strategies of the GDPs and local recommendations was low. Differences between the two counties were non-significant. Furthermore, within Örebro, GDPs who did not have formal access to local recommendations did not differ in their administration strategies from those who did. The choice of substance was seldom in agreement with the substance recommended, while the majority followed the recommended duration of treatment. ***Conclusion.*** Although recommendations existed, their impact appeared to be limited. This is significant, since the implementation of recommendations is crucial in making clinical practice more effective and in promoting the health of patients.

**Key Words:** *Drug prescriptions, health planning guidelines, physiological effects of drugs, premedication*

## Introduction

Average life spans in developed countries have continuously increased, and the proportion of adults over 65 years of age has tended to grow [1]. In a population in which a substantial proportion are elderly, the number of medically compromised patients, for example patients with valvular heart disease [2] and patients with prosthetic joint replacement [3], increases, as does the need for medical care [1]. In these patients, dental procedures can cause complications such as bacterial endocarditis [4] or late joint infections [5].

Common dental procedures frequently induce transient bacteremia. To prevent complications from transient bacteremia, antibiotic prophylaxis may be necessary. Decisions on whether or not to use antibiotic prophylaxis should weigh the risk of a bacteremia inducing complications against the risk of adverse reactions to antibiotics and the risk of developing resistant bacterial strains [6]. Antibiotics are the most common medication prescribed by dental practitioners [7]. Even though many guidelines for the rational use of antibiotic prophylaxis have been published, recommendations often conflict [8]. From this perspective, it is not surprising that evidence of overuse has been found in previous studies on antibiotic prophylaxis administered by general dental practitioners (GDPs) [8,9]. This could imply that even though guidelines exist the administration strategies of dental practitioners could be expected to vary considerably and thus not always be in agreement with the published guidelines. This is inappropriate, however, considering

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*(Received 25 February 2005; accepted 8 June 2005)*

ISSN 0001-6357 print/ISSN 1502-3850 online 
DOI: 10.1080/00016350500206660

the risk of adverse reactions and antibiotic resistance [10].

The aim of this study was to examine the administration strategies of GDPs, that is, whether antibiotic prophylaxis is administered for selected medical conditions and dental procedures and which antibiotic regimen is proposed. The second aim was to study the agreement between the administration strategies of the GDPs and the current published local recommendations.

## Material and methods

### *Selection of respondents*

In a computer-generated randomization procedure, 100 GDPs were selected from each of two counties in Sweden, Skåne and Örebro, a total of 200 GDPs. The two counties were selected because recommendations for the administration of antibiotic prophylaxis differed. These counties were also selected because their demographic characteristics regarding population, area, and number of dentists in relation to the population were similar. The selection of GDPs was made through the membership register of the Swedish Dental Association (which includes ~88% of all licenced dentists in Sweden).

The age distribution of the respondents in Skåne County and Örebro County was equal (mean 48 years, range 26–64 years), as was the professional experience of the GDPs (mean 20 years, range 1–44 years). In both counties, more respondents worked in the public dental health service (~60%) than in the private dental health service (~40%).

The sex distribution of the GDPs varied. In Skåne County, the number of male respondents (52%) was almost equal to the number of female respondents (48%). In Örebro, male respondents (63%) considerably outnumbered female respondents (37%). These distributions reflected the total number of female and male dentists in each of the counties according to the membership register of the Swedish Dental Association. Fifty-five percent (110/200) of the GDPs took part in the study. Nine questionnaires were not returned, leaving 101/200 (51%) respondents for analysis. There were no significant differences between respondents and non-respondents regarding age, place of work (public/private dental health service), or sex ($p > 0.05$) analyzed with the chi-square analysis.

### *Questionnaire and telephone interview*

A postal questionnaire in combination with a structured telephone interview was used. Initially, an inquiry was sent to the GDPs asking whether they were willing to participate in the study. The inquiry included an introductory letter, a document of consent to participate, and a reply-paid envelope. Two reminders were sent to non-responding GDPs.

The confidentially coded questionnaire was sent about a week prior to the telephone interview to the GDPs who had agreed to participate. The GDPs were interviewed at a date and time of their convenience. The telephone interviews (performed by EE) averaged 10–20 min in length. The interviewer began each interview by asking whether the respondent had reviewed the questionnaire and if there were any questions about it. The respondent was asked if he or she had understood how the questionnaire was to be filled in. Then, each case and adherent questions were attended. The completed questionnaire was then returned. Data were collected between January and June 2003.

### *Cases presented in the questionnaire*

The questionnaire comprised eight simulated cases of patients with different medical conditions for which antibiotic prophylaxis might be considered necessary when performing dental procedures [14–17]. The questionnaire was tested by two GDPs and modified (clarifying questions and extended with one case) before the final version was developed.

The patient cases comprised the following medical conditions:

1. Type 1 diabetes mellitus, insulin-dependent, well controlled.
2. Type 2 diabetes mellitus, medicating with oral anti-diabetic agents, well controlled.
3. Type 1 diabetes mellitus, insulin-dependent, not well controlled.
4. Moderate hypertension, medicating with beta-receptor antagonist.
5. Myocardial infarction 3 months ago, medicating with ACE inhibitor, beta-receptor antagonist, low-dose aspirin, and simvastatin.
6. Kidney transplant 3 years ago, medicating with immunosuppressive and beta-receptor antagonist for moderate hypertension, well controlled without complications.
7. Heart valve prosthesis, medicating with warfarin.
8. Hip prosthesis, replacement performed 3 years ago.

Following these patient cases, the GDPs were instructed not to take conditions other than the medical condition into consideration.

For each medical condition, three types of dental procedures were presented: A. Scaling lingually in the lower jaw (the probing pocket depth is between 2 and 3 mm); B. Surgery, for example removal of an asymptomatic tooth; C. Root canal treatment of tooth 13 due to pulp exposure as a result of caries (the pulp is vital).

For each dental procedure, the GDPs were asked to consider the following questions, see example in Fig. 1.

**Case 1. Patient with type 1 diabetes mellitus, insulin-dependent, well controlled**
(The GDPs were instructed not to take conditions other than the medical condition into consideration)

- If you would scale lingually in the lower jaw (the probing pocket depth is between 2 and 3 mm), would you administer antibiotics? ☐yes ☐no
- If you chose to administer antibiotics:
  - Which drug would you administer?……
  - What would be the duration of the treatment?……
  - When would you begin treatment?……

Figure 1. One of the cases presented to the GDPs.

*Published local recommendations in the two counties in 2003*

Published recommendations in Skåne County and Örebro County differed in which medical conditions were considered for administration of antibiotic prophylaxis and in the antibiotic regimen recommended. In both counties, however, the recommendations stated that antibiotic prophylaxis is indicated primarily in dental procedures that could produce gingival bleeding such as scaling, extraction, or surgery [11,12]. The format of the recommendations and how they were communicated also differed between the counties.

The "Pharmaceutical Committee" of Skåne County had developed and distributed recommendations by mail to all GDPs working in the county. The recommendations that were applicable to the medical conditions in this study included for which conditions antibiotic prophylaxis should be administered, which substance to administer, and duration of treatment [11]:

- *patient with diabetes, not well controlled*: penicillin V, minimum 3–5 days
- *patient with kidney transplant*: penicillin V, minimum 3–5 days
- *patient with a heart valve prosthesis*: amoxicillin, single dose

In Örebro County, GDPs had access to recommendations through two different media. GDPs working in the public dental health service had access to recommendations on their intranet. These recommendations were also given to GDPs who had attended a seminar on antibiotic prophylaxis as part of a 4-day course in oral surgery. The recommendations that were applicable to the medical conditions in this study included for which conditions antibiotic prophylaxis should be administered, which substance to administer, and duration of treatment [12]:

- *patient with diabetes, not well controlled*: penicillin V, 7–10 days
- *patient with kidney transplant*: penicillin V, 7–10 days
- *patient with a heart valve prosthesis*: amoxicillin, single dose
- *patient with a joint prosthesis (for example, hip or knee)*: no prophylaxis when more than 2 months has passed since the replacement surgery.

In Örebro County, 11 respondents (of the GDPs working in private dental health service) had no formal access to recommendations through intranet or in a seminar.

To ensure accurate interpretation of the recommendations in both Skåne County and Örebro County, the content was reviewed by the authors (EE, KK, EV) along with the chairman of the Odontology Working Group of the "Pharmaceutical Committee" of Skåne County.

*Analysis of agreement with local recommendations*

Three levels were used to determine whether the administration of antibiotics by the GDPs was in agreement with local recommendations: (1) the decision to administer antibiotics (yes/no), (2) which drug to administer, and (3) the duration of treatment. All GDPs would begin antibiotic treatment 1–2 h before the dental procedure, which is in agreement with local recommendations and therefore this is not presented in the results. The questionnaire did not ask about dosage, since this can easily be looked up in "FASS" (Swedish National Drug Formulary).

The type of drug to administer was divided into substances in accordance with FASS. For duration of treatment, the answers were of four different groups: single dose, 1–3 days, 3–5 days, and 7–10 days. In the analysis, these answers were classified into two categories: "prophylactic regimen", to prevent bacteremia (for durations <3 days), and "treatment regimen", to achieve primary healing, and/or to prevent a local infection or spread of infection (for durations between 3 and 10 days).

*Statistics*

Differences between Skåne County and Örebro County in the decisions made by the GDPs about whether or not to administer antibiotic prophylaxis for each medical condition and each dental procedure

were analyzed with Fisher's exact test. Within each county, differences in the decisions made by the GDPs about whether or not to administer antibiotics for different dental procedures within each medical condition were analyzed with McNemar's test. Differences between recommendations on whether or not to administer antibiotics and the decisions made by the GDPs were analyzed with Fisher's exact test. The level of significance was 0.05 in all statistical tests.

## Results

During the telephone interviews, a few GDPs stated that if they had not previously encountered the medical condition in their practice, they would need to contact the patient's physician for advice about antibiotic administration. Since this was not an alternative given in the questionnaire, the interviewer agreed that the GDPs could write "would contact patient's physician" as a response in the questionnaire. This alternative was selected by three GDPs for the patient with a heart valve prosthesis and by seven GDPs for the patient with a kidney transplant.

### *Administration strategies*

Table I describes the administration strategies of the GDPs. Overall, there was no significant difference between GDPs in Skåne County and in Örebro County in their decision on whether or not to administer antibiotic prophylaxis when analyzed for each medical condition and each dental procedure. However, there were two exceptions. These were when tooth removal was performed in the patient with type 1 diabetes that was not well controlled and in the patient with a hip prosthesis, where more GDPs in Skåne than in Örebro would administer antibiotic prophylaxis ($p < 0.05$). In the case with the hip prosthesis, the differences between the counties could be explained by the existing recommendation in Örebro County stating that antibiotics should not be administered to patients with hip prosthesis when more than 2 months had passed since replacement surgery. Generally, in both counties, the GDPs were most inclined to administer antibiotic prophylaxis in the patient with heart valve prosthesis, followed by the patient with a kidney transplant, compared to patients with other medical conditions. The GDPs were least inclined to administer antibiotic prophylaxis to the patient with moderate hypertension.

The GDPs' choice of substance was most often either amoxicillin or penicillin V. Clindamycin was seldom chosen, and then almost solely by GDPs in Skåne County. The most frequently proposed duration of treatment was a single dose or 7–10 days. Durations of 1–3 days or 5–7 days were seldom selected.

Table II presents the GDPs' decisions on whether to administer antibiotic prophylaxis for the different dental procedures within each medical condition. With the exception of the patient with type 2 diabetes that was well controlled and the patient with moderate hypertension, there was a difference depending on which dental procedure was to be performed ($p < 0.05$). The GDPs were more inclined to administer antibiotic prophylaxis for tooth removal compared to other procedures ($p < 0.05$). When scaling and root canal treatment were compared, the GDPs were more inclined to administer antibiotics for scaling in the patient with type 1 diabetes that was not well controlled and in the patient with a heart valve prosthesis ($p < 0.05$).

### *Agreement between GDPs' administration strategies and recommendations*

Table III presents the administration strategies of the GDPs and their agreement with local recommendations. Generally, the agreement on whether or not to administer antibiotics was low. There were no differences between the GDPs in Skåne County and in Örebro County in the agreement of their administration strategies with what was recommended ($p > 0.05$). Agreement was higher for the patient with heart valve prosthesis than for the patient with type 1 diabetes that was not well controlled or for the patient with a kidney transplant. However, despite the unambiguous recommendation for patients with heart valve prosthesis in both counties, four GDPs neglected to administer antibiotic prophylaxis for tooth removal and about one-fourth (26 GDPs) neglected this recommendation for scaling. Inverse, a substantial proportion of the GDPs administered antibiotics for medical conditions that are not considered in need of prophylaxis according to recommendations, for example, myocardial infarction and hip prosthesis that had not been performed in the recent past. Among the GDPs who followed the recommendations for a certain medical condition, the choice of substance was often not in agreement with what was recommended, especially for the medical conditions where penicillin V was recommended. Of the GDPs who followed the recommendations to administer and selected the recommended substance, a majority also followed the recommended duration of treatment.

When comparing the group of GDPs who had access to local recommendations with the group who had no formal access in Örebro County, the only difference was in the number of GDPs who administered antibiotics to the patient with myocardial infarction ($p < 0.05$). The recommendations did not cover this medical condition. Yet, more GDPs with access to the County's recommendations chose to administer antibiotics than GDPs without access.

## Discussion

### *The methodological approach*

Our study comprises responses from 101 GDPs, which is about 10% of all GDPs practicing in Skåne County

Table I. Administration strategies of GDPs for patients with different medical conditions when performing dental procedures analyzed on three levels: number of GDPs who would administer antibiotics, their choice of substance, and duration of treatment. For an exact description of the medical conditions, see Material and Methods section

| | | Administer antibiotics | | | Choice of substance | | Duration of treatment | |
|---|---|---|---|---|---|---|---|---|
| Medical condition | Dental procedure | Skåne ($n=50$) | Örebro ($n=51$) | | Skåne | Örebro | <3 days | 3–10 days |
| 1. Type 1 diabetes, well controlled | Scaling | | | | | | | |
| | Tooth removal | 7 | 3 | amoxicillin | 3 | 1 | 4 | |
| | | | | penicillin V | 3 | 2 | | 5 |
| | | | | clindamycin | 1 | | | 1 |
| | Root canal treatment | | 1 | penicillin V | | 1 | | 1 |
| 2. Type 2 diabetes, well controlled | Scaling | | | | | | | |
| | Tooth removal | 5 | 1 | amoxicillin | 2 | | 2 | |
| | | | | penicillin V | 2 | 1 | | 3 |
| | | | | clindamycin | 1 | | | 1 |
| | Root canal treatment | | | | | | | |
| 3. Type 1 diabetes, not well controlled | Scaling | 19 | 11 | amoxicillin | 9 | 8 | 17 | |
| | | | | penicillin V | 8 | 3 | 2 | 9 |
| | | | | clindamycin | 2 | | 2 | |
| | Tooth removal* | 43 | 34 | amoxicillin | 15 | 20 | 34 | 1 |
| | | | | penicillin V | 26 | 14 | 4 | 36 |
| | | | | clindamycin | 2 | | 1 | 1 |
| | Root canal treatment | 12 | 10 | amoxicillin | 7 | 4 | 11 | |
| | | | | penicillin V | 5 | 6 | 2 | 9 |
| 4. Moderate hypertension | Scaling | | | | | | | |
| | Tooth removal | 1 | | clindamycin | 1 | | | 1 |
| | Root canal treatment | | | | | | | |
| 5. Myocardial infarction | Scaling | 16 | 12 | amoxicillin | 12 | 11 | 22 | 1 |
| | | | | penicillin V | 4 | 1 | 2 | 3 |
| | Tooth removal | 31 | 23 | amoxicillin | 26 | | 42 | 3 |
| | | | | penicillin V | 4 | 19 | 2 | 5 |
| | | | | clindamycin | 1 | 3 | | 2 |
| | Root canal treatment | 11 | 13 | amoxicillin | 8 | 1 | 20 | 1 |
| | | | | penicillin V | 3 | 13 | 1 | 2 |
| 6. Kidney transplant | Scaling | 29 | 21 | amoxicillin | 22 | 18 | 39 | 1 |
| | | | | penicillin V | 7 | 3 | 5 | 5 |
| | Tooth removal | 42 | 41 | amoxicillin | 26 | 22 | 45 | 3 |
| | | | | penicillin V | 15 | 19 | 5 | 29 |
| | | | | clindamycin | 1 | | | 1 |
| | Root canal treatment | 22 | 17 | amoxicillin | 15 | 15 | 30 | |
| | | | | penicillin V | 7 | 2 | 4 | 5 |
| 7. Heart valve prosthesis | Scaling | 41 | 34 | amoxicillin | 37 | 34 | 70 | 1 |
| | | | | penicillin V | 3 | | 2 | 1 |
| | | | | clindamycin | 1 | | 1 | |
| | Tooth removal | 48 | 49 | amoxicillin | 42 | 46 | 86 | 2 |
| | | | | penicillin V | 4 | 3 | 1 | 6 |
| | | | | clindamycin | 2 | | 1 | 1 |
| | Root canal treatment | 29 | 34 | amoxicillin | 26 | 34 | 60 | |
| | | | | penicillin V | 3 | | 2 | 1 |
| 8. Hip prosthesis, 3 years ago | Scaling | 7 | 3 | amoxicillin | 7 | 3 | 10 | |
| | Tooth removal* | 27 | 14 | amoxicillin | 20 | 12 | 30 | 2 |
| | | | | penicillin V | 6 | 2 | 4 | 4 |
| | | | | clindamycin | 1 | | | 1 |
| | Root canal treatment | 5 | 7 | amoxicillin | 5 | 7 | 12 | |

* Difference between GDPs in the two counties on whether to administer antibiotic prophylaxis ( $p<0.05$).

and Örebro County. Fifty-one percent of the GDPs selected agreed to participate in this study, which can be compared to similar studies with response rates between 20% and 60% [8,9,13]. One reason for the rather low response rate could be the time-consuming method of collecting answers that comprised a questionnaire in combination with a telephone interview. This combination of methods was aimed to increase the validity of the results. The approach required more effort and time on the part of the

Table II. Difference between numbers of GDPs administering antibiotic prophylaxis for three different dental procedures in patients with different medical conditions in Skåne ($n=50$) and Örebro ($n=51$)

| Medical condition | Dental procedure | Skåne | Örebro |
|---|---|---|---|
| 1. Type 1 diabetes, well controlled | Scaling – Tooth removal* | 0.016 | n.s. |
| | Tooth removal* – Root canal treatment | 0.016 | n.s. |
| | Scaling – Root canal treatment | † | n.s. |
| 2. Type 2 diabetes, well controlled | Scaling – Tooth removal | n.s. | n.s. |
| | Tooth removal – Root canal treatment | n.s. | n.s. |
| | Scaling – Root canal treatment | † | † |
| 3. Type 1 diabetes, not well controlled | Scaling – Tooth removal* | 0.000 | 0.000 |
| | Tooth removal* – Root canal treatment | 0.000 | 0.000 |
| | Scaling* – Root canal treatment | 0.039 | n.s. |
| 4. Moderate hypertension | Scaling – Tooth removal | n.s. | † |
| | Tooth removal – Root canal treatment | n.s. | † |
| | Scaling – Root canal treatment | † | † |
| 5. Myocardial infarction | Scaling – Tooth removal* | 0.002 | 0.035 |
| | Tooth removal* – Root canal treatment | 0.000 | 0.012 |
| | Scaling – Root canal treatment | n.s. | n.s. |
| 6. Kidney transplant | Scaling – Tooth removal* | 0.001 | 0.000 |
| | Tooth removal* – Root canal treatment | 0.000 | 0.000 |
| | Scaling – Root canal treatment | n.s. | n.s. |
| 7. Heart valve prosthesis | Scaling – Tooth removal* | n.s. | 0.000 |
| | Tooth removal* – Root canal treatment | 0.000 | 0.000 |
| | Scaling* – Root canal treatment | 0.002 | n.s. |
| 8. Hip prosthesis, 3 years ago | Scaling – Tooth removal* | 0.000 | 0.001 |
| | Tooth removal* – Root canal treatment | 0.000 | 0.016 |
| | Scaling – Root canal treatment | n.s. | n.s. |

* The dental procedure for which significantly more GDPs administered antibiotics ($p<0.05$).
† No statistical comparison was possible since no GDPs chose to administer antibiotics for these procedures.

Table III. Administration strategies of GDPs in agreement with local recommendations for patients with different medical conditions when performing dental procedures in Skåne ($n=50$) and Örebro I ($n=40$). One group of GDPs in Örebro County had no formal access to recommendations, Örebro II ($n=11$). The administration strategies of the GDPs in Örebro County I and II are compared. Three levels in administration strategies were analyzed: number of GDPs who would administer antibiotics, their choice of substance, and duration of treatment

| Medical condition | Dental procedure/ strategy | Skåne ($n=50$) | Örebro I ($n=40$) | Örebro II ($n=11$) |
|---|---|---|---|---|
| Type 1 diabetes, not well controlled | Scaling/ | | | |
| | yes | 19 | 9 | 2 |
| | penicillin V | 8 | 3 | |
| | treatment duration[ab] | 6 | 2 | |
| | Tooth removal/ | | | |
| | yes | 43 | 29 | 5 |
| | penicillin V | 26 | 14 | |
| | treatment duration[ab] | 24 | 10 | |
| Kidney transplant | Scaling/ | | | |
| | yes | 29 | 16 | 5 |
| | penicillin V | 7 | 3 | |
| | treatment duration[ab] | 2 | 2 | |
| | Tooth removal/ | | | |
| | yes | 42 | 33 | 8 |
| | penicillin V | 15 | 18 | 1 |
| | treatment duration[ab] | 12 | 14 | 1 |
| Heart valve prosthesis | Scaling/ | | | |
| | yes | 41 | 28 | 6 |
| | amoxicillin | 37 | 28 | 6 |
| | single dose | 37 | 27 | 6 |
| | Tooth removal/ | | | |
| | yes | 48 | 38 | 11 |
| | amoxicillin | 42 | 35 | 11 |
| | single dose | 39 | 34 | 11 |

[a] Minimum 3–5 days (Skåne County).
[b] 7–10 days (Örebro County I).

respondents compared to written answers in a questionnaire.

The analysis of the non-respondents revealed no differences in age, place of work (public/private dental health service), or sex compared to the respondents. It is reasonable to assume that the variation in administration strategies within this population of GDPs could be, not smaller, but perhaps even more extensive in a larger population.

The medical conditions were not randomly selected from a population of patients, but were selected to demonstrate expected differences in administration strategies by the GDPs. Type 1 diabetes that was not well controlled, kidney transplant, heart valve prosthesis, and hip prosthesis are medical conditions for which there are indications and recommendations to administer antibiotic prophylaxis [14–17]. In patients with moderate hypertension or patients with type 1 or type 2 diabetes that is well controlled, dental colleagues had expressed uncertainty concerning whether or not to administer antibiotic prophylaxis. For these medical conditions, no clear-cut indications exist. As the medical conditions were not randomly selected, a statistical comparison between the administration strategies of the GDPs related to medical conditions would have been irrelevant.

The dental procedures, that is, scaling, tooth removal, and root canal treatment, were selected to represent interventions that could produce gingival bleeding in various degrees and for which indications for the administration of antibiotics exist [18]. However, for root canal treatment, the indications are different. If the diagnosis is apical periodontitis, evidence supporting antibiotic prophylaxis exists since bacteremia occurs in about 20% of these patients during root canal treatment [19]. In the case described in this study, the pulp was vital and the diagnosis was pulpitis. In such cases, no evidence for prophylactic antibiotics exists.

*Results*

The variation in the administration strategies of GDPs was large. These findings are similar to those in a previous Scandinavian study including GDPs prescription on patients with a previous history of endocarditis [20]. Large variations in health care have been reported for many decades [21]. As for the use of antibiotics, previous studies have found that generous general medical practitioners administered three times as much or more antibiotics than more restrictive practitioners [22,23]. Although simple educational programs were implemented, general practitioners retained their positions as generous or restrictive medical practitioners [23]. Generally, more GDPs administered antibiotic prophylaxis for the procedure of tooth removal compared to scaling. These results indicate that GDPs seem to judge the risk of complication differently for these procedures. Bacteremia occurs when gingival bleeding is present, independent of the procedure. Thus, many common interventions in the oral cavity produce bacteremia, including toothbrushing, scaling, and removal of a tooth [18].

The GDPs' agreement with the published recommendations varied. They were in agreement with recommendations for the patient with heart valve prosthesis but not for the patient with type 1 diabetes that was not well controlled or the patient with a kidney transplant. Even when the GDPs proposed antibiotic prophylaxis for these two patients, the duration was often not in agreement with the recommendations. The GDPs administered antibiotics for $<3$ days to prevent bacteremia, which is different from the recommendation stating that the intention is to prevent a local infection with antibiotics until primary wound healing occurs, at least 3–5 days [11]. In patients with a heart valve prosthesis, however, the majority of GDPs chose to administer antibiotics for $<3$ days to prevent bacteremia, which is in agreement with recommendations [11,12]. These results suggest that GDPs may have better knowledge about the administration of antibiotics in patients with "locus minoris resistentiae".

The GDPs seldom chose the antibiotic substance that was recommended. Our results suggest low cost-effectiveness of the regimen in some patients, as the antibiotics cannot be expected to have the intended effect.

The risk of adverse reactions to antibiotics should always be considered, however, figures on the rate of drug-induced anaphylaxis vary widely. It has been suggested that 1 in every 2700 hospitalized patients suffers drug-induced anaphylaxis, and that the rate of fatal anaphylaxis of penicillin is 0.002% in the general population [24]. In a large international case-control study of anaphylaxis in a hospital population, the incidence of severe anaphylaxis to most analgesics and antibiotics was in the range 5–15 cases per 100 000 exposed. For parenteral penicillin it was 32 per 100 000 exposed patients (95% confidence interval 11–92), but for oral penicillin no cases were identified. For oral amoxicillin the incidence was 6.0 (95% confidence interval 2.4–15) [25].

To help and support GDPs in a rational use of antibiotic prophylaxis, many recommendations have been published, both nationally [11,12] and internationally [16,17]. In Sweden, national therapeutic guidelines are usually based on consensus among specialists in the field. The Swedish recommendations on antibiotic prevention in dental practice dated from 1988 [26], and have been widely adopted. In some counties, leading experts have involved local Pharmaceutical Committees to make guidelines based on the recommendations. The original source was not always cited, and the message might have been altered over time. Over the years, the view on preventive use of antibiotics has changed. The increasing focus on benefit-risk assessments in medicine, and the growing

problem with multi-resistant bacterial strains, calls for more strict use of antibiotics. In 2003, revised guidelines for endocarditis prophylaxis were issued by the Swedish Societies of Specialists in Infectious Diseases, Dentists and Cardiologists [27]. However, these guidelines do not include non-cardiac indications for antibiotic prophylaxis. The recommendations of the two Swedish counties in this study were similar regarding three medical conditions and which substance to administer, but different as to the duration of treatment. This suggests that developing recommendations for the administration of antibiotic prophylaxis is difficult, perhaps due to the absence of solid evidence [28]. Unfortunately, recommendations may give conflicting advice or advice that is hard to interpret to gain rational treatment strategies of when to administer antibiotic prophylaxis and which regimen should be used. Aside from the weak evidence to support the recommendations, difficulties in interpretation may arise between the description of the medical condition and the actual patient, which might indicate that actual conditions of the patients in clinical practice are more complex than the medical conditions described in the recommendations. Many GDPs administered antibiotic prophylaxis for medical conditions that are not considered in need of prophylaxis according to local recommendations. Inverse they fail to administer antibiotics for medical conditions that are considered in need of prophylaxis according to recommendations, for example heart valve prosthesis. The results from this study suggest that there could also be other factors influencing the decisions of GDPs, for example, the clinicians' knowledge, attitudes, or habits [29], which could explain their inverse behaviour in comparison to the recommendations.

The recommendations were not found to have any impact in this study, that is, the population that did not have access to recommendations did not differ from the populations that did have access. As the population not having formal access to recommendations in the study was small, our results must be interpreted with care. This lack of success in implementing recommendations in health care is common [30]. Simple dissemination of recommendations has been found to be ineffective, although more active implementation strategies, for example, the use of educational approaches, have had some effect [31,32]. In this study, however, the strategy of both distribution and an educational approach used in Örebro County was not more effective than simple distribution of recommendations used in Skåne County.

In conclusion, our study adds to the present scientific literature that recommendations for administration of antibiotic prophylaxis are not implemented by GDPs in their practice in these counties. This is significant, since the implementation of such recommendations is crucial in making clinical practice more effective and promoting the health of patients.

## Acknowledgements

The study was approved by the Ethics Committee at Lund University, Lund, Sweden (LU 305–02). Grants from the Swedish Research Council (grant 521-2001-6341), the Swedish Federation of County Councils, and the Swedish Dental Society supported this study. We thank Per-Erik Isberg, B.Sc., for statistical advice, and Bengt Götrick, Associate Professor and Chairman of the Odontology Working Group of the "Pharmaceutical Committee" of Skåne County, for reviewing the content of published recommendations in both Skåne County and Örebro County.

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