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Antibiotic Prescription among Norwegian Dentists (2010-2016)

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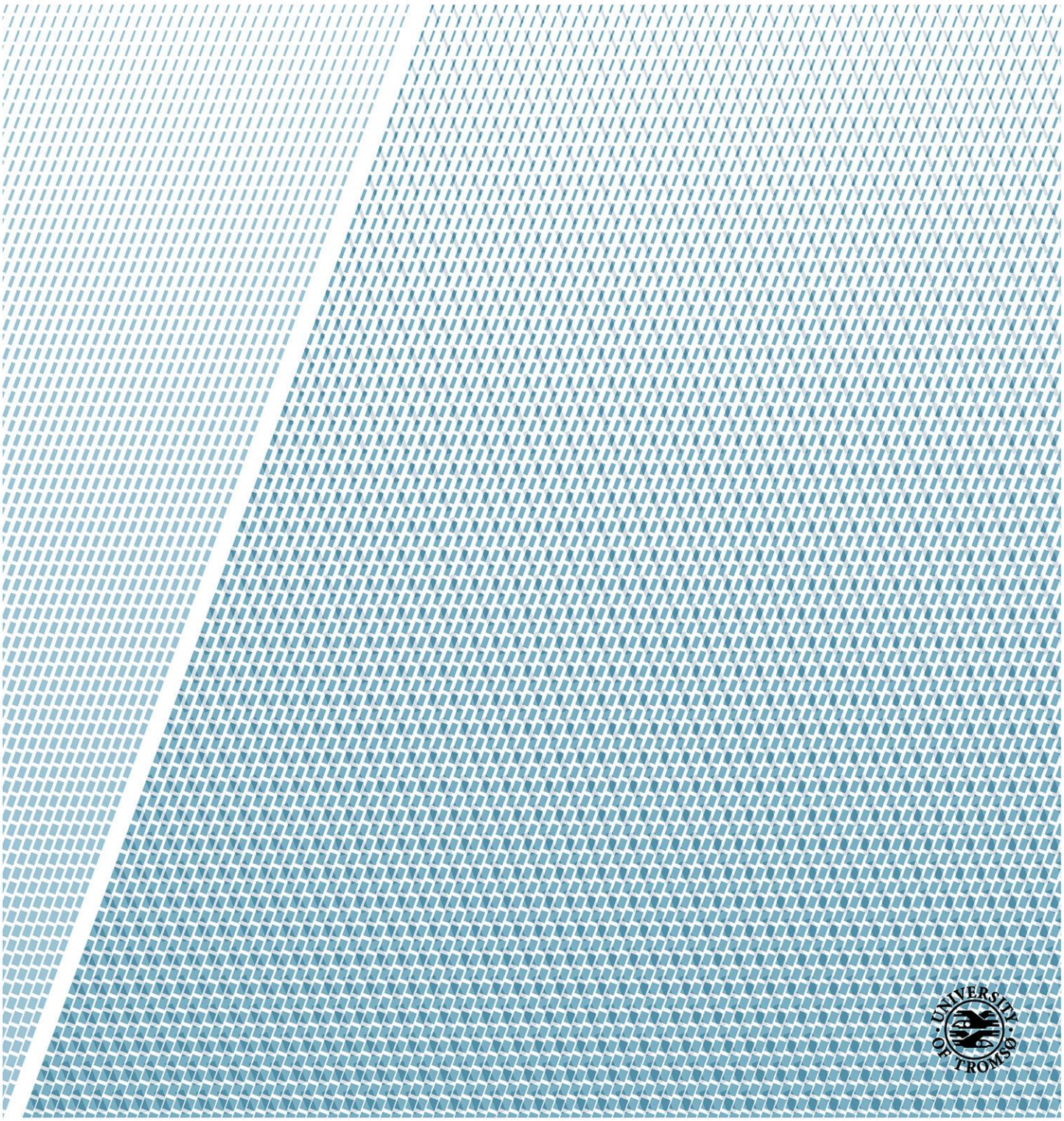

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Acknowledgement

The overall objective of this master project is to investigate and map the antibiotic prescription pattern among Norwegian dentists over a period of seven years. There is currently a lot of focus on the use of antibiotics in terms of the growing problem of resistance and we are grateful that we had the opportunity to do a master project with such a relevant topic.

We will like to thank our supervisor Mohammed Al-Haroni from UiT The Arctic University of Norway for guidance through this master project. He has answered all our questions and gave us a lot of advice through this process.

We also want to thank Norwegian Prescription Database (NorPD) for the data they provided about the antibiotic prescription pattern among Norwegian dentists from 2010-2016.

Abstract

Objective

Norwegian health authorities have a goal to reduce the total antibiotic use by 30% by 2020 (1). Studies have shown that dentists contribute to about 8% of the total antibiotic consumption in Norway (2, 3), which emphasizes the role of dentists to achieve a reduction in the use of antibiotics in the society. The antibiotic prescription pattern among Norwegian dentists from 2010 until 2016 have been mapped and investigated through this master thesis.

Materials and method

Data from Norwegian Prescription Database (NorPD) were analyzed to evaluate the antibiotic prescription pattern by Norwegian dentists between 2010-2016. The statistical analysis was done by Excel and SPSS version 25. The consumption of antibiotics was expressed using The WHO measurement unit, i.e., defined daily doses (DDDs). The amount of each antibiotic dispensed in the society by dentists was measured as DDDs per 100 000 inhabitants per day (DID). Number of inhabitants in the each different county per year was obtained by The Central Bureau of Statistics (SSB). The number of authorized dentists in the different counties per year was obtained by SSB as well. The total number of authorized working dentists in Norway for each year (without division into counties) was obtained from the Institute of Public Health in Norway.

Results

A total of 1 048 575 prescriptions were analyzed. Vest-Agder, Aust-Agder and Hedmark were the counties with the highest average total DID for the whole period (2010-2016), while Finnmark, Sør-Trøndelag and Oslo were the counties with the lowest average DID. The counties with the highest average number of antibiotic prescriptions per dentist in the total period (2010-2016) were Østfold, Vest-Agder and Aust-Agder. On the other hand, Finnmark, Troms, Oslo and Sogn og Fjordane, were the counties with the lowest average number of antibiotic prescriptions per dentist in the total period. Overall, 62,96% of the prescriptions were made by male dentists. Male prescribers prescribed 316 antibiotic prescriptions on average, while the representative number for female prescribers is 165. Males prescribed significant more antibiotics than females. Females received antibiotic more often than males.

The month with the highest amount of prescriptions was March, while the month with the lowest amount of prescriptions was July.

Conclusion

It seems dentists now tend to prescribe less antibiotics than previously. It is important to continue the positive trend of prescribing less antibiotics which would help in reducing the serious problem of antibiotic resistance. Reduction of antibiotic prescription by dentists over the years in Norway might help to achieve the national goal of reducing the antibiotic prescription by 30% by the end of 2020.

1. Background

In 1928 Aleksander Fleming discovered Penicillin, and after 1940 antibiotics were used as a medicine for serious infections (4). This medical discovery would turn out to revolutionize the whole world by contributing to better public health, increase the life expectancy and be life-saving in terms of infections(4).

With the increased use of penicillin over time, resistance to the drug gradually developed (4). Antibiotic resistance means that the bacteria have obtain mechanisms to survive antibiotic challenge. Bacteria can develop resistance through genes inherited or obtained through transmission of resistance genes, for example, resistance genes found on mobile genetic elements like plasmids. It can also be achieved spontaneously through mutations in their existing genes (4).

As a response to the growing problem of bacterial resistance, there has been ongoing research and development of new types of antibiotics (4). Antibiotics have different mechanisms of action, but they all have in common that they inhibit or kill bacteria (5). Despite the development of several types of antibiotics, the bacteria have managed to develop resistance to most of them (4). An example of a resistant bacterial strain is methicillin resistant *Staphylococcus aureus* (MRSA). Infections with MRSA account for 30-60% of all *S. aureus* infections in the US, Japan and in most countries in Europe, while in the Nordic countries, the prevalence of MRSA is still low (about 1%) (6).

Antibiotic resistance was a known problem already in 1945 when Alexander Fleming warned against the possibility of resistance to improper use of antibiotics (4, 7). Today, antibiotic resistance is a growing problem worldwide (8-10), and can lead to a growing number of infections, longer hospital stays, higher medical costs and increased mortality (11). In Norway, the degree of resistance has been stable, but the use of antibiotics is increasing, especially the use of broad-spectrum antibiotics (1, 2, 10).

Broad-spectrum antibiotics work on several bacteria and affects the bacteria in our normal flora too. There is a greater chance that the bacteria manage to develop antibiotic resistance when the normal flora is disturbed because of the use of antibiotics. The effect is even worse with the use of broad-spectrum antibiotics. During the course of antibiotic use, resistant bacteria do not need to compete with other bacteria and, therefore propagate in bacterial population. It is always recommended to use narrow-spectrum antibiotic (2).

World Health Organisation (WHO) has found that antibiotic resistance is among the three biggest health threats during the 2000's (12). In 2013, The European Center for Disease Prevention and Control (ECDC) found that about 25,000 deaths in Europe each year can be attributed to antibiotic resistance (2). Furthermore, it has been estimated that after 2050, about 10 million people will die each year worldwide because of antibiotic resistance (13, 14). The development and spread of bacterial resistance are linked to, for example, excessive and improper use of antibiotics (15-17). As a measure to reduce the development of resistance, Norwegian health authorities work to reduce the total antibiotic use by 30% by 2020 (1).

Development of antibiotic resistance among oral bacteria is on the rise. Several studies have shown that certain oral bacterial strains have developed resistance to various antibiotics (18-20). Dentists have a shared responsibility with other health professionals to avoid overuse and improper use of antibiotics. Antibiotic consumption by Norwegian dentists in 2004/2005 amounted to approximately 8% of total antibiotic consumption in Norway (2, 3).
In a previous study in 2014 dentists most commonly prescribed phenoxymethylpenicillin (72% of DID) followed by amoxicillin (11% DID) and clindamycin (6% DID). In addition, there was more prescribing of broad-spectrum antibiotics in 2014, compared to 2004. This is due to a greater proportion of prescribing of amoxicillin and clindamycin (21).

Based on guidelines for antibiotic use, antibiotics are only recommended as additional therapy for acute odontogenic infections and chronic marginal periodontitis. Examples of acute odontogenic infections are apical periodontitis, pericoronitis, abscess or ulcerative periodontal disease. It is important to emphasize that the main treatment for such infections are local treatment, like drainage or subgingival scaling. Antibiotics may be appropriate as additional treatment in aggressive cases, in patients with underlying diseases or if there is a systematic involvement of the infection, for example, risk of spreading to other parts of the body, especially the brain, as this can be life threatening (2).

In addition, the European Society of Cardiology (ESC) recommends only antibiotic prophylaxis in patients at high risk of infectious endocarditis. These are patients who have a prosthetic valve, have previously had endocarditis or patients with certain types of congenital heart defects. In the dental treatment of such patients, antibiotic prophylaxis should only be given if the treatment is considered high-risk, for example before surgical treatment or subgingival scaling **(**22**).**

When it comes to how often and in which cases Norwegian dentists actually prescribe antibiotics, a study has been made in 2006. It shows that 35% of dentists did not prescribe antibiotics in a typical week while 3% prescribed 5 or more antibiotic prescriptions in one typical week. In the case of antibiotic prescribing during periodontal therapy, 50% of dentists responded that they did so. 71% prescribed antibiotics to prevent general dental complications. For prophylactic use, in a patient with prior endocarditis, 80% of dentists reported that they prescribed antibiotics (23).

It is important to increase awareness and to combat the problem of antibiotic resistance, because antimicrobial resistance have no boundaries or geographical limits (13). So, although the resistance problem is still relatively limited in Norway today, the situation can quickly turn around in this global world. Therefore, it is important to focus on preventing further development and dissemination of resistance (24).

Our master project:

The aim:

The aim of this master project is to map and investigate the antibiotic prescription pattern among Norwegian dentists from 2010 to 2016 and look if there are any obvious trends when it comes to the demographic factors of the prescriber. This present project aimed to contribute to more awareness about the proper antibiotic prescription in dental care.

Research questions:

- Which county has the highest and lowest number of DDD per 100 000 inhabitants per day (DID)?
- Which county has the highest and lowest average number of prescriptions per. dentist?
- How many prescriptions are made by male prescribers and by female prescribers?
- How many prescriptions are made according to the prescriber's year of birth?
- Which antibiotic are most often prescribed?
- The proportion of total antibiotic prescription made by dentists to the national prescriptions?

Our data is organized using the Anatomical Therapeutic Chemical (ATC) classification. The ATC classification is a system recommended by the World Health Organisation (WHO) as an international standard for submitting drug statistics (25). Furthermore, the WHO has

recommended its own unit of measurement for presentation of drug statistics, named DDD (25). The definition of DDD is: "assumed average maintenance dose per day for a drug used for its main indication in adults" (25), and has proven to be beneficial in comparing antibiotic use in primary care (25). DID is also a measurement used in this master thesis. In our master thesis, the abbreviation, DID, will account for the number of DDD per 100 000 inhabitants per day.

2. Material and Methods

The data

In this master project, the prescription data were obtained from The Norwegian Prescription Database (NorPD). The data showed antibiotic prescription among Norwegian dentists in a period of 7 years from 2010-2016 with 1 048 575 antibiotic prescriptions. In total, there is 6446 unique number of prescribers in the total period. The data is anonymous.

The data was collected and sorted in Excel. The data contains information such as unique prescriber number assigned by NorPD, the gender of the prescriber, the prescriber's year of birth, and county of the patient. Furthermore, the data included the delivery month (1-12), delivery year (2010-2016), the number of DDD, the ATC code, the type of antibiotic and the dose that was prescribed.
For statistical purposes, the prescriber's year of birth was divided into four groups: Group 1: 1921-1941, group 2: 1942-1962, group 3: 1963-1983 and group 4: 1984-).

Number of inhabitants in the different counties per year was obtained from SSB (table number 04860) (26). The number of authorized dentists in the different counties per year was obtained by SSB as well (table number 04778)(26). The total number of dentists each year (without division into counties), was obtained by NorPD and the Public Health Institute. The statistical program SPSS (SPSS 25.0 for Windows / Mac) was used to calculate frequencies and to test for significant differences.

The number of DDD per 100 000 inhabitants per day (DID)

The number of consumed DDD for each year in each county was calculated in SPSS. To find DDD per 100,000 inhabitants per. day (hereby referred to as DID), the population size in the county was used along with the number of days in each respective year, 365 or 366 days (for leap years), to calculate the DID. The average DID for the total period (2010-2016) of the study for each county, was also calculated by dividing the total DID by 7. The average DID was then sorted from the highest to the lowest value, based on the average DID in the total period. The values of DID from 2010-2016 for each county was also presented in a graph.

Average number of antibiotic prescriptions per dentists per year

The number of prescriptions per county obtained from NorPD was used to calculate the number of prescriptions per county per dentists. The number of dentists in different counties for each year was obtained from SSB (table number 04778)(26).
Finally, the average number of prescriptions made by dentists for the total period (2010-2016) for each county was calculated, by adding the numbers for each county and divide on 7 years. The table was sorted from the highest to the lowest value, based on the average values of the total period, and was also presented in a graph.

Evaluation of number of prescriptions and gender of the prescriber

The number of antibiotic prescriptions dispensed in the community was grouped into 4 groups based on the prescriber's year of birth. In addition, the average number of prescriptions for male and female prescribers was found, by using the information about the total number of male and female dentists in Norway in 2016(table 04778)(26).

The type of antibiotic which is most often prescribed by dentists - The number of DDD made by dentists for the different types of antibiotics:

A table from The Norwegian Institute of Public health was used to make a crosstab in Excel that shows the DDD dispensed by dentists for the different types of antibiotic. The average DDD dispensed by dentists for the total period (2010-2016) was calculated, by adding the values for each year and divide on 7 years. This was done for each county. The table was sorted from highest to lowest value, based on the average values of the total period

The proportion of DDD made by dentists in relation to total human use in the period 2010-2016:

Based on the table from NorPD and Norwegian Institute of Public Health, the proportion of DDD dispensed in the society by dentists compared to total human use in the period 2010-2016 for each type of antibiotics was calculated.

Changes in number of prescriptions in the period:

We wanted to investigate the development of the number of prescriptions through the period 2010-2016. We made a cross tab in SPSS with number of prescriptions for each year. Then

we calculated the changes from 2010-2016 by subtract the total number of prescriptions in 2016 from the total number of prescriptions in 2010. This sum was divided on the total number of prescriptions in 2016 and multiplied with 100 to get the percent. We used the same procedure, but other numbers, to calculate the changes from 2014-2016.

Difference in number of prescriptions between gender:

The significant difference in number of prescriptions between male and female was calculated. The number of prescriptions was cut down to 1000 prescriptions due to practical considerations (SPSS). SPSS randomly picked out 1000 prescriptions of the first 3000 prescriptions in the dataset. A new table with the 1000 prescriptions was made and the significance was calculated by using a non-parametric test, which was based on the median-value.

3. Results

The data:

In total, there was 1 048 575 antibiotic prescriptions in the period 2010-2016.
The number of prescriptions each year was:
2010: 146 673 prescriptions, 2011: 149 165 prescriptions, 2012: 152,027 prescriptions, 2013: 153 994 prescriptions, 2014: 155 644 prescriptions, 2015: 150 828 prescriptions and 2016: 140 244 prescriptions.

Antibiotic prescription and age groups:

11 900 prescriptions were made by prescribers in group 1 (born in 1921-1941) and 385 632 prescriptions were made by prescribers in group 2 (born in 1942-1962). Furthermore, 574 545 prescriptions were prescribed by prescribers in group 3 (born in 1963-1983) and it was 76 463 prescriptions in group 4 (born in 1984). Figure 1 below shows the distribution in the different year of birth of the prescriber. The result is not adjusted accordingly to number of dentists in the different groups, and only shows the distribution.

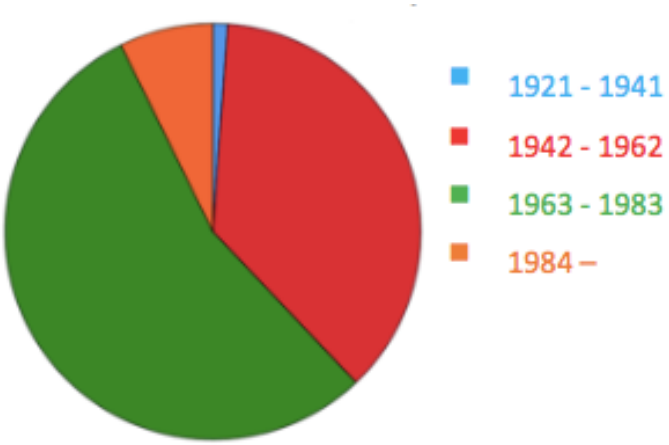

Figure 1: Pie-chart of the number of prescriptions based on the prescriber's year of birth: Group 1: 1921-1941, 2. 1942-1962, 3: 1963-1983, 4: 1984-

The gender of the prescriber:

63,0% of the prescriptions in the total period were made by males, while 37,0% of the prescriptions were made by female prescribers. The sex ratio is shown in figure 2 below.

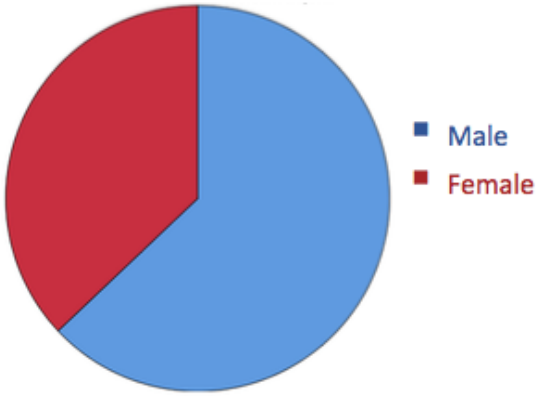

Figure 2: Pie chart of the number of prescriptions based on the gender of the prescriber: 1: Male, 2: Female

The county of the patient:

The highest number of prescriptions was found in Oslo (11.6%), Hordaland (10.8%) and Akershus (10.6%). The part of Norway with the lowest number of prescriptions was Finnmark (1.0%), Sogn og Fjordane (1.7%) and Nord-Trøndelag (2.3%). Figure 3 shows the distribution between the counties. This is only descriptive data and shows only the distribution. This means that these results are not adjusted for the number of inhabitants in the different counties.

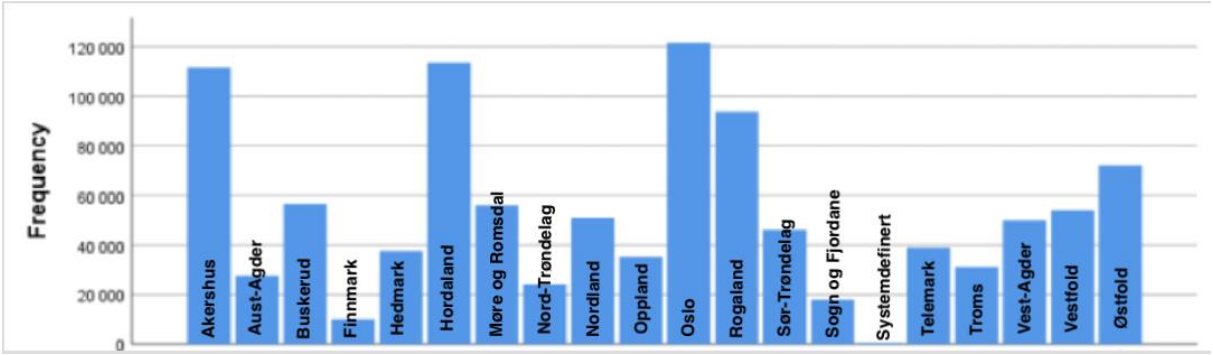

Figure 3: Bar-chart: The number of prescriptions based on the county of the patient

The gender of the patient:

Male received 477 994 prescriptions of antibiotics, while female received 570 581 prescriptions. Figure 4 below shows the sex ratio.

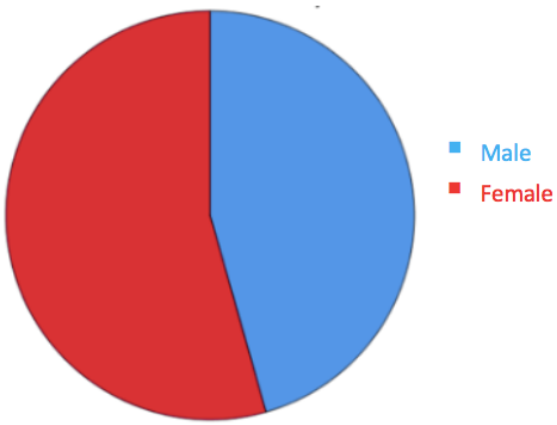

Figure 4: Pie chart: The number of prescriptions based on the gender of the patient: 1: Male, 2: Female.

Delivery Months from 2010-2016:

The highest number of prescriptions during the study period was in March. The distribution is shown in Figure 5 below. On average, it was prescribed 87 386 each month. There were 7 823 more prescriptions in March compared to the average. July was the month with less prescription with about 14 742 fewer prescriptions of antibiotics compared to the average.

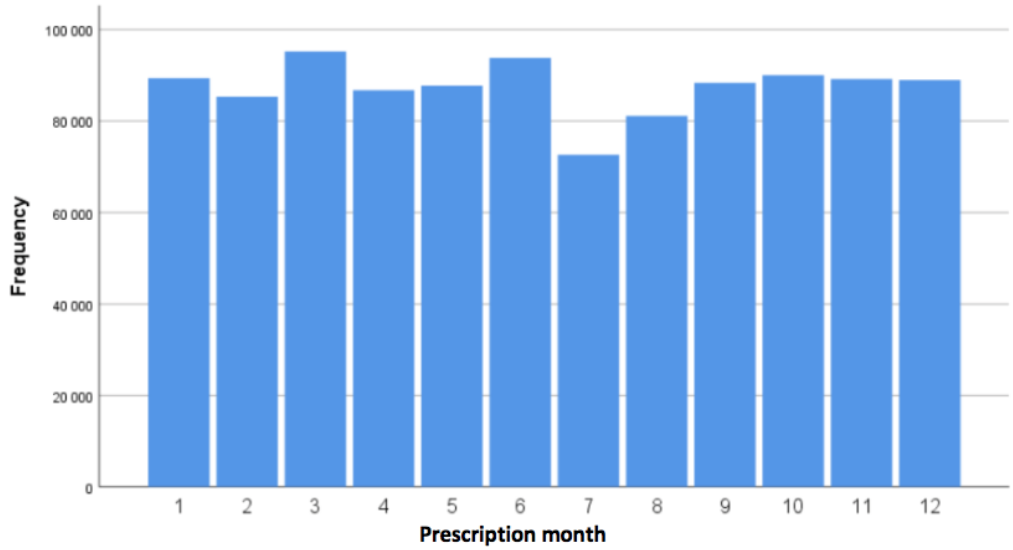

Figure 5: Bar chart – the number of prescriptions based on the delivery month: Number 1-12 (January-December)

Delivery year:

Figure 6 shows an increase in the number of prescriptions from 2010 with a peak in 2014 with 155 644 prescriptions. From 2014 to 2016, a reduction in the number of prescriptions is seen.

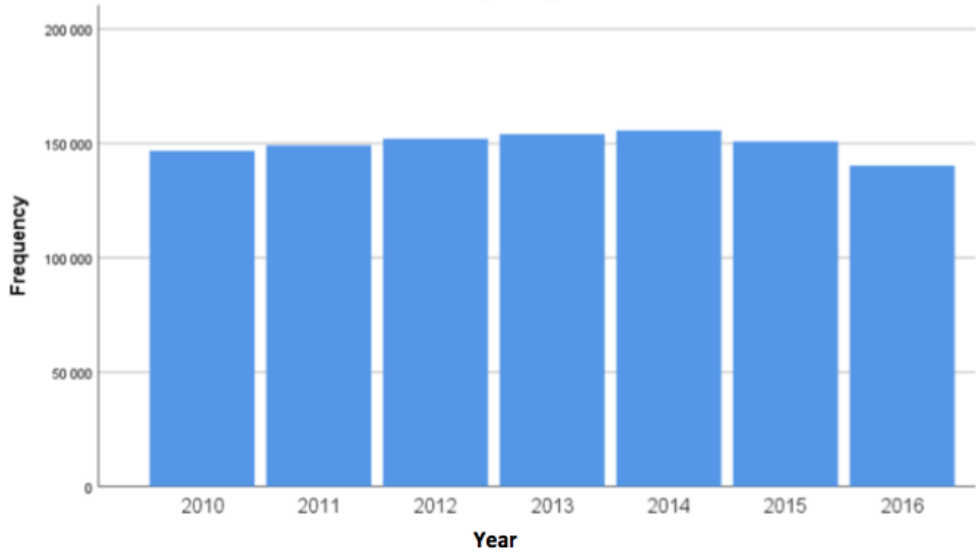

Figure 6: Bar chart – The number of prescriptions based on the delivery year: 2010-2016

The number of DDD per 100 000 inhabitants per day (DID)

As shown in Table 1 in the appendix, the three counties with the highest average number of DID for the total period (2010-2016) were Vest-Agder (13,29 DID), Aust-Agder (12,92 DID) and Hedmark (12,69 DID). On the other hand, the three counties with the lowest average number of DID for the total period were Finnmark (6,69 DID), Sør-Trøndelag (7,35 DID) and Oslo (7,70 DID)

The data shown in Figure 1 in the appendix, show the trend of DID values for each county throughout the study period. Generally, there was an increase in number of DID from 2010 to 2013/2014, and then a reduction until 2016. The high increase in DID was from 2010 to 2011 for most of the counties. As shown in Table 1 and figure 1 in appendix, the highest number of DID through the total period was in Aust-Agder in 2013 (14,70 DID). The lowest number of DID was in Finnmark in 2010 (5,28 DID). In addition, Finnmark had the lowest number of DID almost every year in the period, except for one year (in 2015), when Sør-Trøndelag had the lowest number.

Figure 2 in appendix shows the data of only the three counties with the highest and the three counties with the lowest average number of DID for the total period (2010-2016). This graph shows that the number of DID was quite stable in Oslo in the seven-year period. Hedmark, on the other hand, shows more variability in the DID, which started with quite low DID, but had a large increase from 2010-2011.

Average number of antibiotic prescriptions per dentists per year

As shown in Table 2 in appendix, the three counties with the highest average number of prescriptions per dentists for the total period (2010-2016), were Østfold (46,44), Vest-Agder (44,77) and Aust-Agder (41,11). The lowest average number of prescriptions per dentists for the total period, were in Finnmark (25,03), Troms (25,86) and Oslo/Sogn and Fjordane (27,89). Based on the average for the entire period, Østfold prescribed almost twice as much as Finnmark. Figure 3 in appendix shows the average number of prescriptions per dentists per year for each county.

Number of prescriptions based on the demographic factors by the prescriber

Table 3 in appendix shows that 659 864 of the prescriptions were made by male prescribers, which amounts to 62,96%, while 388 165 of the prescriptions were made by female prescribers, which amounts to 37,04%.

The total number of male dentists in 2016 was 2087, while the total number of female dentists in the same year was 2357. This means that the average number of prescriptions for male dentists was 316, 18 and the average number of prescriptions for female dentists was 164,69. Based on these numbers, male prescribers prescribed about 193% more than female prescribers on average, which is almost twice as many prescriptions.

As shown in Table 3, the highest number of prescriptions based on the age groups of the prescribers, was found in age group 3 (born in 1963-1983) with 574 209 prescriptions, followed by age group 2 (born in 1942-1962) with 385 494 prescriptions. The lowest number of prescriptions was found in age group 1 (born in 1921-1941) with 11 898 prescriptions, followed by age group 4 (born in 1984-) with 76 428 prescriptions. It is worth mentioning that these numbers are not adjusted for the number of dentists in each age groups.

The type of antibiotic which is mostly consumed - The number of DDD dispensed by dentists in the society:

Based on the average DDD made by dentists of the total period, it was found three types of antibiotics that were most often prescribed by dentists. Phenoxymethylpenicillin (1 140 554,27 DDD), follow by Amoxicillin (155 042,73 DDD) and Clindamycin (82 668,14 DDD). The types of antibiotics with the lowest average number of DDD prescribed by dentists of the total period, were Augmentin (7,14 DDD), followed by Oxytetracycline (441,43 DDD) and Clarithromycin (1054,29 DDD).

The proportion of DDD made by dentists in relation to total human use in the period 2010-2016:

As shown in table 4 in appendix, the percentage of the dentist's contribution to the total human use for the different types of antibiotic, is highest for Spiramycin (24,96% in average of seven years), Phenoxymethylpenicillin, (18,79% in average of seven years), Metronidazole (18,78% in average of seven years) and Clindamycin (18,74% in average of seven years). The proportion of DDD dispensed by dentists in relation to the total DDD dispensed in the community was about 8%.

Changes in the number of prescriptions in the period:

From 2010 to 2016, the number of prescriptions has been reduced by 4,4% from a total number of 146 673 prescriptions to 140 244 prescriptions (see table 1 below). The number of prescriptions was on its highest in 2014 with a total number of 155 644. From 2014 to 2016, the reduction was 9,9%.

Table 1: Number of prescriptions for each year

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	2010	146673	14,0	14,0	14,0
	2011	149165	14,2	14,2	28,2
	2012	152027	14,5	14,5	42,7
	2013	153994	14,7	14,7	57,4
	2014	155644	14,8	14,8	72,2
	2015	150828	14,4	14,4	86,6
	2016	140244	13,4	13,4	100,0
	Total	1048575	100,0	100,0	

Differences in prescription behavior between genders

A significant difference in number of prescriptions between male and female prescribers was found (*p-value* ≤0,013) where male dentists significantly prescribed more antibiotics than female dentists.

4. Discussion

The current study found that Vest-Agder, Aust-Agder and Hedmark are among the counties receiving the highest DID, while those who receive at least are Finnmark, Sør-Trøndelag and Oslo. The fact that Aust-Agder is one of the counties receiving the most antibiotics in Norway is confirmed in other reports (27). It is hard to give an accurate explanation to these results without further studies. There are many factors that might explain these results. It might be reasonable to think socioeconomic factors like education level and unemployment to be the explanation. Statistics provided by NAV indicates that both Aust-Agder and Vest-Agder is among the three counties with highest unemployment in 2016 (respectively 3,9% and 3,7% of the workforce). On the other hand, the statistics shows that Hedmark is among the counties with lowest unemployment, with only 2,2% of the workforce. Average unemployment in 2016 in Norway was 3% of the workforce (28). By looking at statistics provided by The Central Bureau of Statistics regarding level of education, there is no clear trends to support our results (26). This study cannot conclude that either of the above factors alone is the reason for the results. Further studies might look into population age in each county, and also if there are aspects regarding the dentists in the counties that might be the reason for the differences.

The average number of antibiotic prescriptions per dentist per year is highest in the counties Østfold, Vest-Agder and Aust-Agder. The number is, however, lowest in Finnmark and Troms. Østfold had almost twice as many prescriptions per dentist on average of the total period as Finnmark. Data from the Norwegian Pharmacy Association's industry statistics showed that Østfold was the county that used most antibiotics in 2015 (29). Another study about antibiotics in children, revealed that Finnmark and Troms prescribed the lowest amount of antibiotics in 2016 (30).

Our data suggest that most antibiotics are prescribed in March and it is hard to explain why. On the other hand, the month with the lowest number of prescriptions in total, is July. This could be explained by the fact that dental offices have limited opening hours during this period because of the summer holiday in the country. A study conducted in the United States showed a similar trend, where the amount of antibiotic prescriptions was higher in the winter months compared to the months of the summer (31).

Male prescribers prescribed a significantly more amount of antibiotics than female prescribers. The average number of prescriptions made by male during the period was almost twice as high as the average number of female prescribers in the same period (2010-2016), despite the fewer males in the profession. A study shows that males take more risk than females in everyday situations and the scientist believe it is psychological factors in the male that make the difference. Males took more chances, while females were more careful (32). Another possible explanation is that a consultation with a female doctor has been associated with a communication style where the patient is more centered (33). An another study conducted in United Kingdom showed opposite results, where males prescribed less than females (34). The difference between male and female dentists in prescription behavior worth further investigation. It would be interesting to know if the awareness of antibiotic resistance and the danger of overprescribing are conceived differently by male and females.

There are higher number of female patients receiving antibiotic prescriptions compared to male patients. This is also confirmed in a previous report made by the Institute of Public Health regarding data on the overall antibiotic prescription in Norway (27). This result is also seen in studies conducted in other countries. An example is a study done in Croatia in 2015. Their study found a ratio of prescription of 54% to 46% favoring females (35). Another study published in *Journal of Antimicrobial chemotherapy* focusing on Gender differences in antibiotic prescribing, makes the same discovery. Females receive 36% higher amounts of antibiotics than male in the 16 -34-year age group, as well as 40% greater in the 35-54 year age group (36). An initial though is that this result may be because of the ratio of male to female in the population. Although this might have answered some of the question, it is a fact that the Norwegian population has a larger portion of male than female (26). Therefore, we cannot conclude this to be the reason. A study regarding the gender gap in antibiotic prescription in English primary care, concluded that the differences in prescriptions of antibiotics was largely explained by the patient's behavior during consultation (37). A further explanation to the results found in this master thesis regarding the gender gap will not be present in this study but might be a possible topic for future studies.

The antibiotics that were most prescribed (based on DDD) during this 7-year period were phenoxymethylpenicillin (penicillin V). This is a narrow-spectrum antibiotic, recommended by the national guidelines, to limit the resistance problem (2). The highest amount of phenoxymethylpenicillin may be explained by the fact that this type of antibiotic is

recommended through national professional guidelines as adjunctive therapy in acute odontogenic infections (2). Amoxicillin and clindamycin are the types of antibiotics that is prescribed the second and third most (based on number of DDD). The high proportion of amoxicillin and clindamycin may be due to these antibiotic types being recommended as antibiotic prophylaxis in Norway (22). Amoxicillin is a broad-spectrum antibiotic, which means that it works against multiple types of bacteria, compared to narrow-spectrum ones (38). When comparing the result with a study done in the period 2004 to 2005, phenoxymethylpenicillin is still the most prescribed antibiotic in the country (3). In another study, it was stated that Norwegian dentists prescribe more broad-spectrum antibiotics than they used to do previously and one of the explanation for the change in prescription behavior is the increase of dental treatment abroad (39). Several studies conducted in other countries confirm the use of broad-spectrum antibiotics abroad, where amoxicillin is the first choice (40-42). Although these results are not directly comparable due to different methods of measuring, we can see a trend.

Our data suggests that in the period 2010 to 2016 there has been a reduction in antibiotics clearance of 4.3%. This means that dentists have become more restrictive throughout this 7-year period. One reason may be the general increase in the awareness of antibiotic resistance in the country and possibly because of the national action plan against antibiotic resistance in the health service sector in Norway that came into effect at the end of 2015 (21).

Dentist's prescription of antibiotics (measured in DDD) accounted for approximately 8% of total DDD antibiotics for human use during the period 2010-2016. Other sources have also reported the same proportion where dentists contributed with 8% to the total national prescription (2, 3).

All health authorities have to reduce antibiotic prescriptions the next few years to avoid resistance, that is one of the biggest threats to global health. It is important to reflect upon which conditions that requires antibiotics, as well as which type of antibiotic that is prescribed by using national guidelines (43). A study looked at the use and abuse of antibiotics in the dental industry and concluded that dentists have acquired their prescribing knowledge from variety of sources (44). Even if the dentists are the best in the health care system when it comes to antibiotic use, we can get better and prescribe less to avoid resistance (45).

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6. Appendix I

Tables in appendix:

Figures in appendix:

Table 1, appendix: Cross tab that shows number of DDD per 100 000 inhabitants per day (DID). The county is shown in the green column to the left, while the prescription year is shown in the orange line at the top. The table is sorted by the highest to the lowest average DID, shown in the column at the right side of the table.

	2010	2011	2012	2013	2014	2015	2016	Average DID in the 7 year-period (highest to lowest value)
Vest-Agder	11,15	13,44	13,68	14,10	14,30	13,90	12,45	**13,29**
Aust-Agder	9,32	13,52	14,57	14,70	14,16	12,83	11,34	**12,92**
Hedmark	7,18	13,63	13,62	14,18	14,08	13,40	12,74	**12,69**
Oppland	7,53	13,36	13,39	12,99	12,43	12,41	12,06	**12,02**
Møre og Romsdal	8,25	12,44	12,62	12,25	12,34	12,17	11,11	**11,60**
Østfold	10,36	12,08	12,64	12,01	11,87	11,48	10,48	**11,56**
Nordland	9,07	12,51	12,01	11,99	12,36	11,47	10,53	**11,42**
Nord-Trøndelag	6,69	12,42	12,33	12,42	11,58	11,79	11,87	**11,30**
Telemark	8,19	10,77	11,39	12,21	12,53	12,25	11,52	**11,26**
Hordaland	9,23	11,98	11,71	11,15	11,02	10,54	9,31	**10,71**
Troms	8,10	11,81	11,52	10,66	10,67	10,77	10,03	**10,51**
Sogn og Fjordane	6,80	11,92	11,09	10,40	10,71	10,94	10,49	**10,34**
Vestfold	9,56	11,38	10,88	10,42	10,67	9,88	8,93	**10,25**
Buskerud	7,96	10,01	10,35	10,46	10,90	10,37	9,63	**9,95**
Rogaland	8,42	9,68	9,81	9,54	9,70	9,17	8,15	**9,21**
Akershus	7,88	8,99	8,89	8,90	8,70	8,29	7,65	**8,47**
Oslo	7,76	7,81	7,99	8,07	7,94	7,46	6,86	**7,70**
Sør-Trøndelag	6,15	7,97	8,09	8,01	7,72	6,92	6,60	**7,35**
Finnmark	5,28	6,75	6,59	7,50	6,82	7,42	6,45	**6,69**

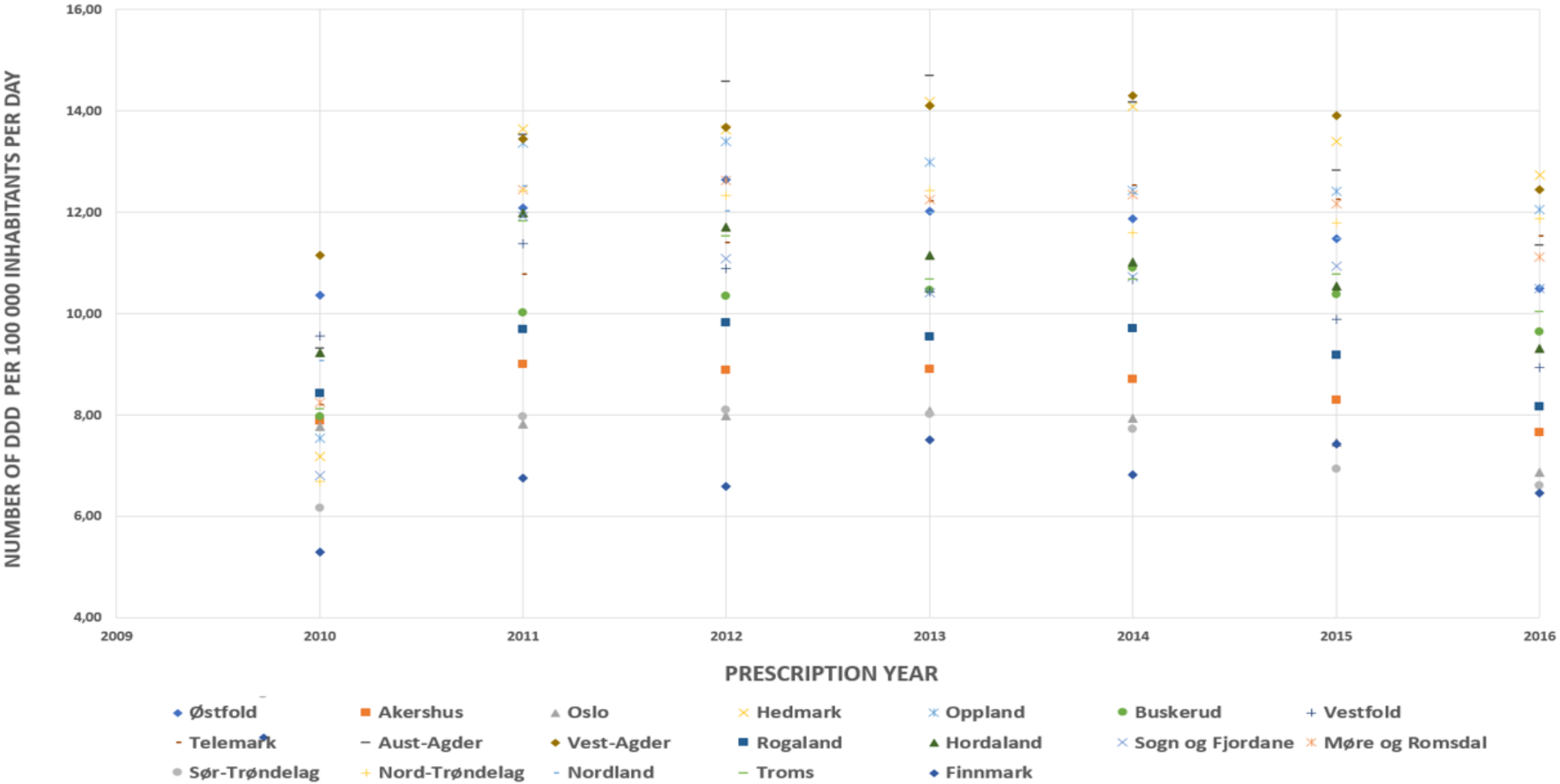

Figure in appendix 1: Chart corresponding to table 1. The chart is showing the number of DDD per 100 000 inhabitants per day (DID) at the y-axis. The x-axis shows the prescription year. The counties have their own symbol, which is shown below the chart.

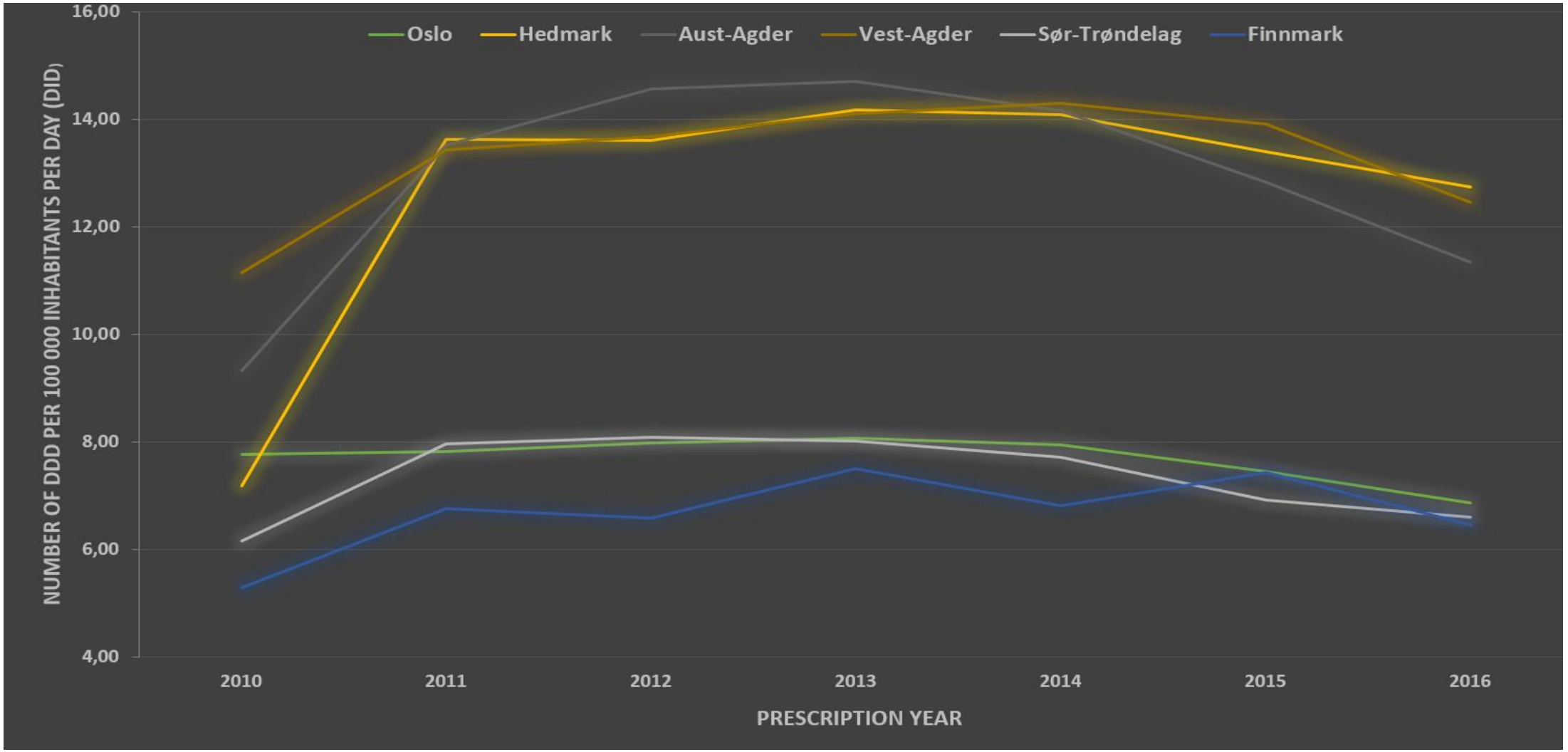

Figure in appendix 2: Chart corresponding to table 1. The chart is showing the three counties with the highest average value of DID and the three counties with the lowest average value of DID. The number of DDD per 100 000 inhabitants per day (DID) is shown at the y-axis. The x-axis shows the prescription year. The counties have their own color, shown on the top of the chart.

Table 2, appendix: Cross tab that shows average number of antibiotic prescriptions per dentists per year. The county is shown in the green column to the left, while the prescription year is shown in the orange line at the top. The table is sorted by the highest to the lowest average of the total period (2010-2016), shown in the column at the right side of the table.

	2010	2011	2012	2013	2014	2015	2016	Average of the total period
Østfold	48,46	46,91	50,58	49,04	47,95	43,85	38,26	46,44
Vest-Agder	43,35	42,56	42,65	45,66	46,53	49,36	43,3	44,77
Aust-Agder	39,67	38,9	41,5	41,54	43,86	44,4	37,93	41,11
Akershus	37,64	38,91	40,64	40,18	38,96	38,76	34,3	38,48
Møre og Romsdal	35,68	37,41	39,12	37,62	36,58	36	34,01	36,63
Hedmark	34,23	36,29	37,35	37,5	36,26	37,46	36,65	36,53
Telemark	32,86	34,71	36	38,61	38,9	37,59	36,5	36,45
Vestfold	38,07	36,94	35,53	33,84	36,09	36,2	31,9	35,51
Hordaland	34,81	35,98	37,1	36,67	36,11	36,08	31,59	35,48
Buskerud	32,82	32,82	34,76	34,3	36,42	36,79	33,85	34,54
Rogaland	35,06	34,25	35,13	35,35	36,74	34,43	30,46	34,49
Nord-Trøndelag	33,47	37,77	34,95	34,33	32,68	32,87	31,88	33,99
Nordland	40,09	35,55	32,72	31,56	34,31	31,61	28,32	33,45
Oppland	33,95	35,3	32,2	32,22	30,83	32,08	30,97	32,51
Sør-Trøndelag	32	30,87	32,74	32,21	32,22	27,55	26,24	30,55
Sogn og Fjordane	28,27	27,6	28,28	27,33	28,27	28,18	27,31	27,89
Oslo	26,39	26,03	28,86	29,05	28,52	29,16	27,2	27,89
Troms	28,4	27,47	27,55	24,98	26,29	24,16	22,14	25,86
Finnmark	23,81	20,78	19,23	22,93	46,42	22,2	19,86	25,03

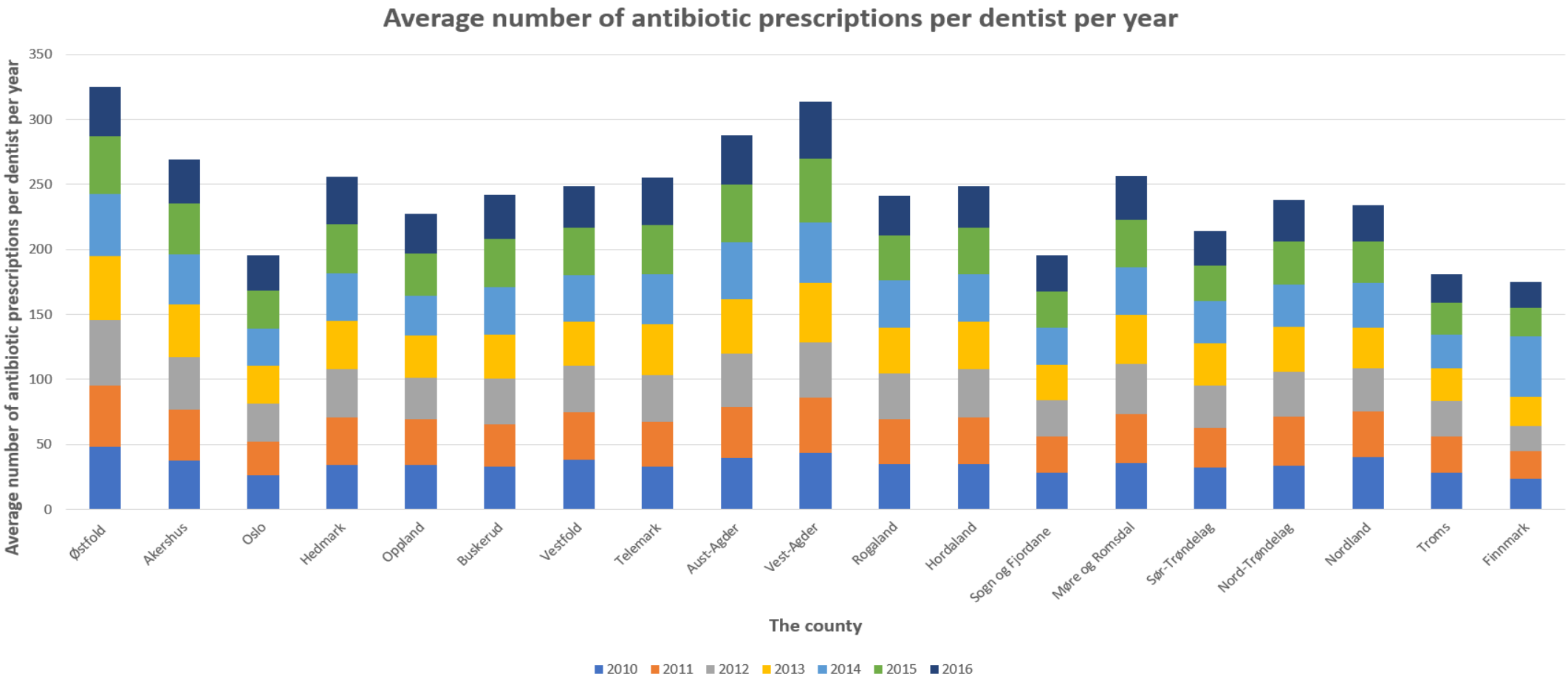

Figure in appendix 3: Chart corresponding to table 2. The chart is showing average number of antibiotic prescriptions per dentist per year for each county. The county is shown at the x-axis. The y-axis shows average number of antibiotic prescriptions per dentist per year. The prescription years have their own color, which is shown below the x-axis.

Table 3, appendix: Shows the number of prescriptions based on demographic factors by the prescriber: Gender of the prescriber and the prescriber's year of birth. The county is shown in the green column to the left. The total number of prescriptions in the county in the period (2010-2016) is shown at the right side of the table. The sum for each column is shown at the bottom line.

Table 3: Number of prescriptions based on the demographic factors by the prescriber: Gender and year of birth

	Total number of prescriptions by prescriber's gender:				Total number of prescriptions by prescriber's year of birth:				
	Male prescribers	%	Female prescribers	%	Gr.1: 1921-1941	Gr.2: 1942-1962	Gr. 3: 1963-1983	Gr.4: 1984-	Total number of prescriptions in the county from 2010-2016
Østfold	45787	63,53	26283	36,47	1272	26286	40051	4461	**72070**
Akershus	65550	58,80	45928	41,20	988	37635	66609	6246	**111478**
Oslo	72364	59,56	49127	40,44	963	40813	69912	9803	**121491**
Hedmark	25551	68,11	11965	31,89	642	17299	16915	2660	**37516**
Oppland	22009	62,48	13219	37,52	659	13918	18457	2194	**35228**
Buskerud	30112	53,28	26401	46,72	1087	21493	30930	3003	**56513**
Vestfold	36852	68,25	17147	31,75	693	23322	27736	2248	**53999**
Telemark	26315	67,75	12526	32,25	728	16352	19250	2511	**38841**
Aust-Agder	19152	69,33	8473	30,67	139	11990	13038	2458	**27625**
Vest-Agder	34927	69,95	15006	30,05	593	17414	27925	4001	**49933**
Rogaland	57508	61,40	36151	38,60	532	31566	54542	7019	**93659**
Hordaland	71646	63,17	41771	36,83	986	46313	57904	8214	**113417**
Sogn og Fjordane	13103	72,73	4913	27,27	156	8364	7661	1835	**18016**
Møre og Romsdal	38318	68,47	17644	31,53	1208	20109	31657	2988	**55962**
Sør-Trønderlag	30237	65,47	15949	34,53	109	13189	30274	2614	**46186**
Nord-Trønderlag	15589	64,66	8519	35,34	252	7920	12964	2972	**24108**
Nordland	32827	64,39	18155	35,61	513	17789	26216	6464	**50982**
Troms	17332	55,95	13646	44,05	332	10445	16631	3570	**30978**
Finnmark	4685	46,72	5342	53,28	46	3277	5537	1167	**10027**
Totalt:	**659864**	62,96	**388165**	**37,04**	**11898**	**385494**	**574209**	**76428**	**1 048 029**

Table 4, appendix: Cross tab that shows the number of DDDs by dentists for each year for the different types of antibiotics. The different types of antibiotics are shown in the green column to the left, while the prescription year is shown in the orange line at the top. The table is sorted by the highest to the lowest average value of DDDs by dentist for the total period (2010-2016), which is shown in the column at the right side of the table.

	2010	2011	2012	2013	2014	2015	2016	Average of the total period
Phenoxymethylpenicillin	1122707,9	1135852,7	1143984,4	1156454,6	1176428,4	1164898,8	1083553,0	1140554,27
Amoxicillin	126410,7	133863,5	144443,7	158630,7	171721,3	172955,6	177273,6	155042,73
Clindamycin	66113,8	70798,0	79133,2	85379,9	94689,3	97215,7	85347,0	82668,14
Metronidazole	58176,1	60046,8	63570,8	67229,2	69050,1	64452,6	62875,0	63628,66
Erythromycin	49360,5	48567,0	46360,2	45598,6	42492,0	36647,3	34033,5	43294,15
Doxycycline	30906,0	31388,0	35386,5	32359,0	34066,9	33997,1	25987,0	32012,93
Azithromycin	17926,0	20821,3	21151,7	21242,7	19818,3	17470,1	15407,7	19119,68
Tetracycline	9166,8	7119,8	6303,0	5709,8	5822,0	5124,0	4884,8	6304,29
Spiramycin	2793,1	2649,8	2679,8	2389,8	2473,1	2349,8	1996,5	2475,99
Clarithromycin	951,0	964,0	771,0	897,0	1539,0	1266,0	992,0	1054,29
Oxytetracycline	2076,0	1014,0	0,0	0,0	0,0	0,0	0,0	441,43
Augmentin	0,0	0,0	0,0	0,0	0,0	50,0	0,0	7,14