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Dispensing Patterns of Medicines Prescribed by Australian Dentists From 2006 to 2018 – a Pharmacoepidemiological Study



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Objectives: Dentists are independent prescribers that can prescribe subsidised medicines under the Australian Pharmaceutical Benefits Scheme (PBS). It is hypothesised that increased dental prescribing can partly be accounted for by the growth in both the Australian population and the number of practising dentists. This pharmacoepidemiological study aims to determine the dispensing patterns of medications amongst dentists and to identify trends over time.

Materials and methods: Data on dental medications under PBS from 2006 to 2018 were accessed. All the dentist-prescribed concessional medicines dispensed at pharmacies in 2018 were included for time trend analysis. Cumulative dispensing counts and defined daily dose (DDD) per 1,000 concessional population days (DPD) were analysed for time trend analysis.

Results: Out of the 56 medications within the dental PBS schedule, the top 20 medicines had a total cumulative dispensing count of 5,058,556, which accounts for 97.4% of the total dispensing count. Eleven out of 20 medicines were antibiotics. Overall, increases were observed for seven out of 20 medicines (amoxicillin + clavulanic acid, clindamycin, ibuprofen, diazepam, oxycodone, tramadol, naproxen) in both dispensing count and trend, as expressed per DPD.

Conclusion: This study highlights the increasing dispensing pattern and trends of dentist-prescribed antibiotics, opioids and benzodiazepines. Further investigation may be required to determine whether the medicine use is appropriate. In the future, this could provide new educational opportunities on the appropriate use of medicines for dentists.

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Introduction

Dentists prescribe medicines to treat localised oral diseases, and adjuvant therapies to provide a symptom management approach before undertaking dental procedures¹. Over one million dental prescriptions per annum were dispensed in Australia between 2013 and 2017². The appropriateness and quality of that prescribing have been questioned, with research indicating that dentists may over-prescribe some

medications³. Other research has shown substantial increases (approximately 50%–400%) in the prescribing of antibiotics (most commonly amoxicillin and metronidazole), opiates and benzodiazepines among Australian dentists in the 15 years leading to 2017^{3–6}.

Concerns have been raised around the quality of dental prescribing. For example, a recent USA study found that dentists accounted for 10% of all antibiotic prescription, but 81% of the antibiotics prescribed by dentists were deemed unnecessary⁷. The overuse of medications such as benzodiazepines and opioids can also lead to serious side-effects and risks, including overdose and addiction⁸. According to a recent cross-sectional analysis, 55% of the dentists in Australia reported overprescribing of antibiotics, 46% prescribing

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inappropriate anxiolytics, and 16%–27% prescribing analgesics over anti-inflammatories⁹. Further, although benzodiazepines are the most commonly utilised medicine for anxiolysis in dentistry, their efficacy and safety are questionable for this use¹⁰.

It is hypothesised that increased dental prescribing can partly be accounted for by the growth in both the Australian population and the number of practising dentists. The number of general dentists in Australia increased by 70% (10,400–17,720), and dental specialist numbers increased by 39% (1,300–1,805) between 2006 and 2018^{11,12}. Over the same time period, the Australian population increased by 22% (20,450,966–24,992,400).

The pharmaceutical benefits scheme (PBS) provides timely, reliable and affordable access to necessary medicines for Australians¹³. Although previous pharmacoepidemiological studies on the dental PBS in Australia have been carried out^{3–6}, no comprehensively documented studies in Australia have analysed the trends over time in the dispensing rates of PBS medicines prescribed by dentists.

Aim of the study

This pharmacoepidemiological study aims to determine the dispensing patterns of medications amongst dentists, and to identify trends over time.

Ethics approval

This Australian-based epidemiological analysis was conducted following approval from the Human Research Ethics Committee at the University of Western Australia (Approval Number – RA/4/20/5262), and followed the guidelines of the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement¹⁴.

Materials and methods

Data source

The PBS provides timely, reliable and affordable access to necessary medicines for Australians¹³. Dentists are not able to prescribe general PBS items, but have a separate dental schedule from which they can prescribe medicines for their patients. All the medicines that can be prescribed by dentists under the PBS have a specific code that allows epidemiological analysis¹⁵. Prescription medicines have two schemes under which it is subsidised, namely the PBS, and the Repatriation Pharmaceutical Benefits Scheme (RPBS)¹⁶. This study included all the PBS-approved concessional medicines for dentists to prescribe¹⁵.

Many PBS medicines cost more than what is paid as co-payment, but the Australian Government pays the remaining cost¹⁷. Australians contribute a co-payment towards the cost of PBS medicine, which varies depending on whether the person is a general or concessional beneficiary. All medicines dispensed to concessional beneficiaries will be

over the co-payment threshold, whereas only some medicines are over the co-payment threshold for general beneficiaries. Since July 2012, all PBS-listed medicines have been captured in the PBS dataset, regardless of price¹⁸. We used the PBS online dataset, which only included the concessional data in the analysis.

Defined daily dose

The defined daily dose (DDD) by the World Health Organisation (WHO)¹⁹ is the assumed average maintenance dose per day for medicines used for its main indication in adults²⁰. By applying DDD, it is possible to examine changes in drug utilisation over time.

Cumulative prescription count

Any medicines that accounted for at least 0.5% of all nationally dispensed medicines by dentists in 2017 and 2018 were included for time trend analysis. The cumulative prescription count, from 2006 to 2018, was calculated. Furthermore, average annual prescription count and average DDD per 1,000 concessional population per days (DPD) for each medicine were calculated as per the equation outlined below²¹:

$$DPD = \frac{1000 \times \text{Annual quantity of medicine (respective units) dispensed}}{DDD (\text{respective units}) \times 365 \text{ days} \times \text{Concessional population}}$$

The concessional population was the denominator for the DDD. Residential population data ranging from 2006 to 2018 were obtained from the Australian Bureau of Statistics²², as based on census data that then underwent a further adjustment to determine the concessional population from the proportion data available from the Department of Social Services annual reports²³.

Time trend: prescription count and DDD per 1,000 concessional population per days (DPD)

The top 20 nationally dispensed medicines by dentists in 2017 and 2018 were included, and time trend was generated using the annual prescription count as well as DPD.

Statistical analysis

After generating a time trend, a linear regression analysis was undertaken to generate a slope for both prescriptions count as well as DPD. Furthermore, Pearson's *r* (range = –1 to 1), as well as a two-tailed *P*-value, was generated to assess the correlation²⁴.

The collected data were imported, and the descriptive statistics, as well as the regression analysis, undertaken using SPSS version 25.0 (IBM, Chicago, IL, USA). The time trend and the regression were formulated using GraphPad Prism version 8.00 for Windows (GraphPad Software, San Diego, CA, USA).

Results

Top 20 medicines prescribed by dentists

In the 13 years, there were a total of 56 medicines available for dentists to prescribe under the PBS, with a total cumulative dispensing count of 5,189,456. The top 20 medicines had a total cumulative prescription count of 5,058,556, which accounts for 97.4% of the total prescription count (Table 1).

Eleven out of the 20 medicines were antibiotics, one was an antifungal, three were opioids and opiate analgesics, three

were anti-inflammatories, and two were benzodiazepine anxiolytics. From 2006 to 2018, cumulative prescription count ranged from 4,299 to 2,786,670, average annual prescription count ranged from 331 to 214,359, and average annual DPD ranged from 0.0004 to 0.48. Amoxicillin had the highest cumulative prescription count, average annual prescription count, and average annual DPD.

Nine out of 20 medicines (paracetamol + codeine, amoxicillin + clavulanic acid, clindamycin, ibuprofen, diazepam, oxycodone, tramadol, naproxen, temazepam) had an annual increase in the prescription count (Table 2; Figure 1). Eleven out of 20 medicines (amoxicillin, metronidazole, cefalexin,

Table 1 – Cumulative dispensing count, average annual dispensing count and average annual DDD per 1000 concessional population days (DPD) of top 20 medicines prescribed by dentists nationally from 2006 to 2018.

	Cumulative prescription count	Average annual prescription count	Average DPD
Amoxicillin	2,786,670	214,359	0.48
Paracetamol + codeine	686,370	52,798	0.12
Metronidazole	562,618	43,278	0.05
Amoxicillin + clavulanic acid	301,508	23,193	0.04
Clindamycin	254,156	19,550	0.02
Cefalexin	134,218	10,324	0.02
Erythromycin	93,575	7,198	0.02
Phenoxyethylpenicillin	58,149	4,473	0.02
Ibuprofen	58,729	4,518	0.02
Amphotericin B	29,945	2,303	0.004
Diazepam	23,554	1,812	0.015
Doxycycline	15,322	1,179	0.003
Oxycodone	11,229	864	0.0004
Diclofenac	10,458	804	0.007
Tramadol	6,681	514	0.001
Trimethoprim + sulfamethoxazole	5,714	440	0.0006
Roxithromycin	5,423	603	0.0004
Naproxen	5,370	413	0.008
Temazepam	4,568	351	0.002
Cefaclor	4,299	331	0.0004

Table 2 – Adjusted dispensing count and DDD per 1,000 concessional population days (DPD) of the top 20 (most frequently prescribed) medicines prescribed by dentists nationally from 2006 to 2018

	Adjusted – dispensing count			Adjusted – DPD		
	Annual trend	r	P-value	Annual trend	r	P-value
Amoxicillin	-975	-0.20	0.5180	-0.007	-0.55	0.0506
Paracetamol + codeine	724	0.57	0.0400*	-0.0003	-0.12	0.6933
Metronidazole	-543	-0.46	0.1137	-0.0008	-0.53	0.0617
Amoxicillin + clavulanic acid	1373	0.94	< 0.0001*	0.002	0.91	< 0.0001*
Clindamycin	565	0.70	0.0073*	0.0003	0.42	0.1509
Cefalexin	-198	-0.68	0.0104*	-0.0005	-0.84	0.0003*
Erythromycin	-642	-0.99	< 0.0001*	-0.002	-0.99	< 0.0001*
Phenoxyethylpenicillin	-28	-0.20	0.5133	-0.0001	-0.22	0.4947
Ibuprofen	268	0.90	< 0.0001*	0.0006	0.65	0.0027*
Amphotericin B	-71	-0.80	0.0011*	-0.0002	-0.88	< 0.0001*
Diazepam	95	0.90	< 0.0001*	0.0006	0.84	0.0004*
Doxycycline	-119	-0.97	< 0.0001*	-0.0003	-0.97	< 0.0001*
Oxycodone	124	0.98	< 0.0001*	0.00006	0.99	< 0.0001*
Diclofenac	-16	-0.46	0.1132	-0.0003	-0.67	0.0117*
Tramadol	16	0.72	0.0057*	0.0001	0.45	0.1271
Trimethoprim + sulfamethoxazole	-34	-0.97	< 0.0001*	0.000007	-0.98	< 0.0001*
Roxithromycin	-7	-0.12	0.7604	-0.00003	-0.25	0.5236
Naproxen	22	0.91	< 0.0001*	0.0003	0.81	0.0007*
Temazepam	2	0.18	0.5600	-0.00002	-0.43	0.1465
Cefaclor	-30	-0.96	< 0.0001*	-0.00005	-0.97	< 0.0001*

* Statistically significant ($P < 0.05$).

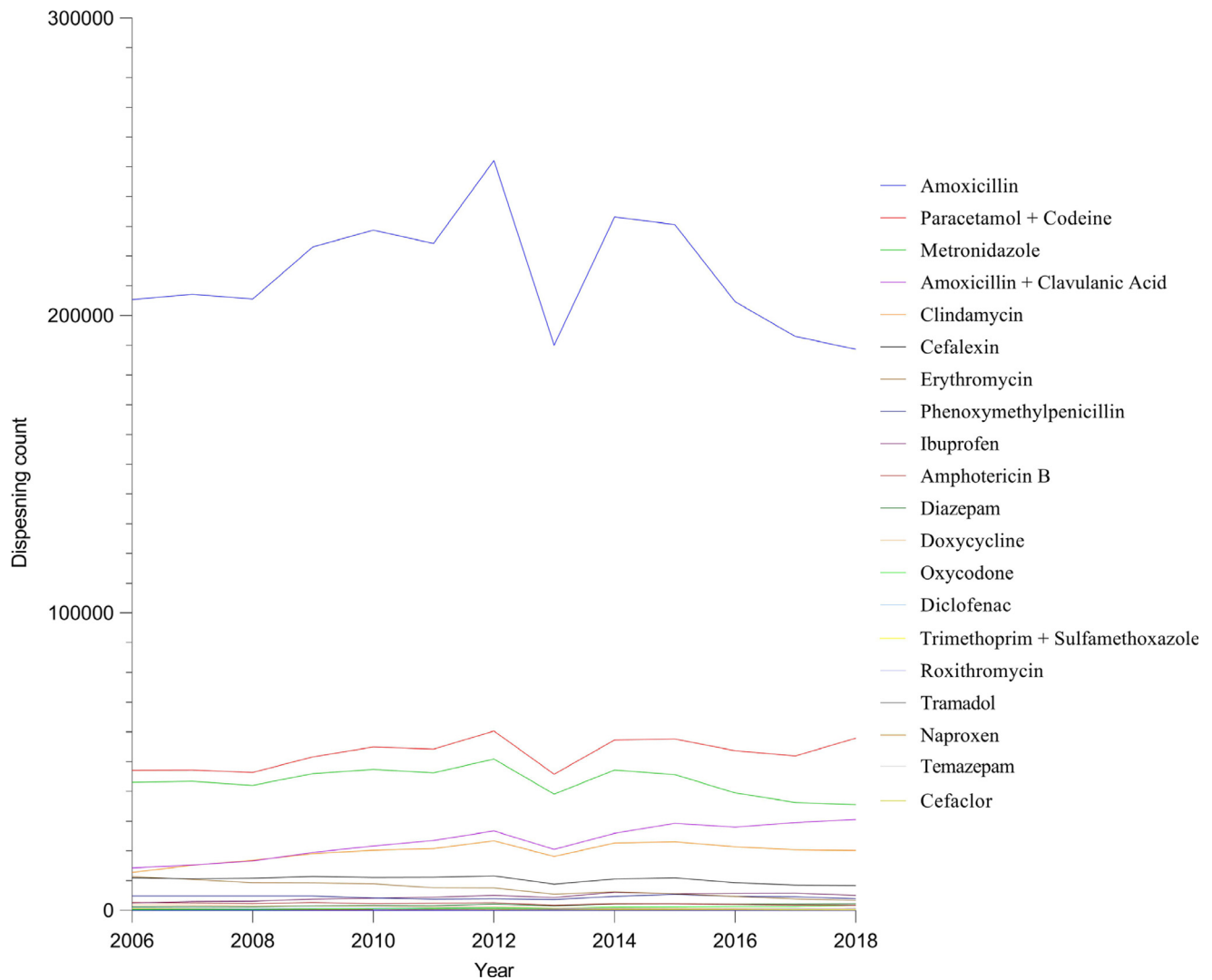


Fig. 1 – Adjusted annual dispensing count of top 20 medicines by dentists nationally from 2006 to 2018.

erythromycin, phenoxymethylpenicillin, amphotericin b, doxycycline, diclofenac, roxithromycin, trimethoprim + sulfamethoxazole, cefaclor) had an annual decline. Out of the 14 medicines that have had a statistically significant correlation, between prescription count and time, nine medicines had a very strong correlation (r -value greater than 0.9).

Adjusted DDD per 1,000 concessional population days (DPD)

Table 2 and Figure 2 outlined the adjusted DPD of the top 20 (most frequently dispensed) medicines by dentists nationally from 2006 to 2018. The annual trend ranged from -0.007 to 0.002 .

Seven out of 20 medicines (amoxicillin + clavulanic acid, clindamycin, ibuprofen, diazepam, oxycodone, tramadol, naproxen) had an annual increase in the prescription count in the adjusted DPD. Twelve out of 20 medicines (amoxicillin, paracetamol + codeine, metronidazole, cefalexin, erythromycin, phenoxymethylpenicillin, amphotericin b, doxycycline, diclofenac, roxithromycin, temazepam, cefaclor) had an annual decline. Out of the 12 medicines that have had a

statistically significant correlation between rate and time, six medicines had a very strong correlation (r -value greater than 0.9).

Discussion

This analysis indicated an increase in dental dispensing rates of antibiotics, opioids and benzodiazepines between 2006 and 2018. Dispensing data presented in DPD provide an estimate of the proportion of the study population treated daily with a specific medicine. Overall, seven out of 20 medicines (amoxicillin + clavulanic acid, clindamycin, ibuprofen, diazepam, oxycodone, tramadol, naproxen) had an increase in both dispensing count and rate, as expressed per DPD. Previous findings show that there was a decline in the prescription rate of clindamycin, whereas the other six medicines had a significant increase from 2013 to 2016^{3,6}.

Out of the 11 antibiotics, amoxicillin had the highest prescription count. Systemic oral antibiotics are commonplace for community dentistry in both general and specialist

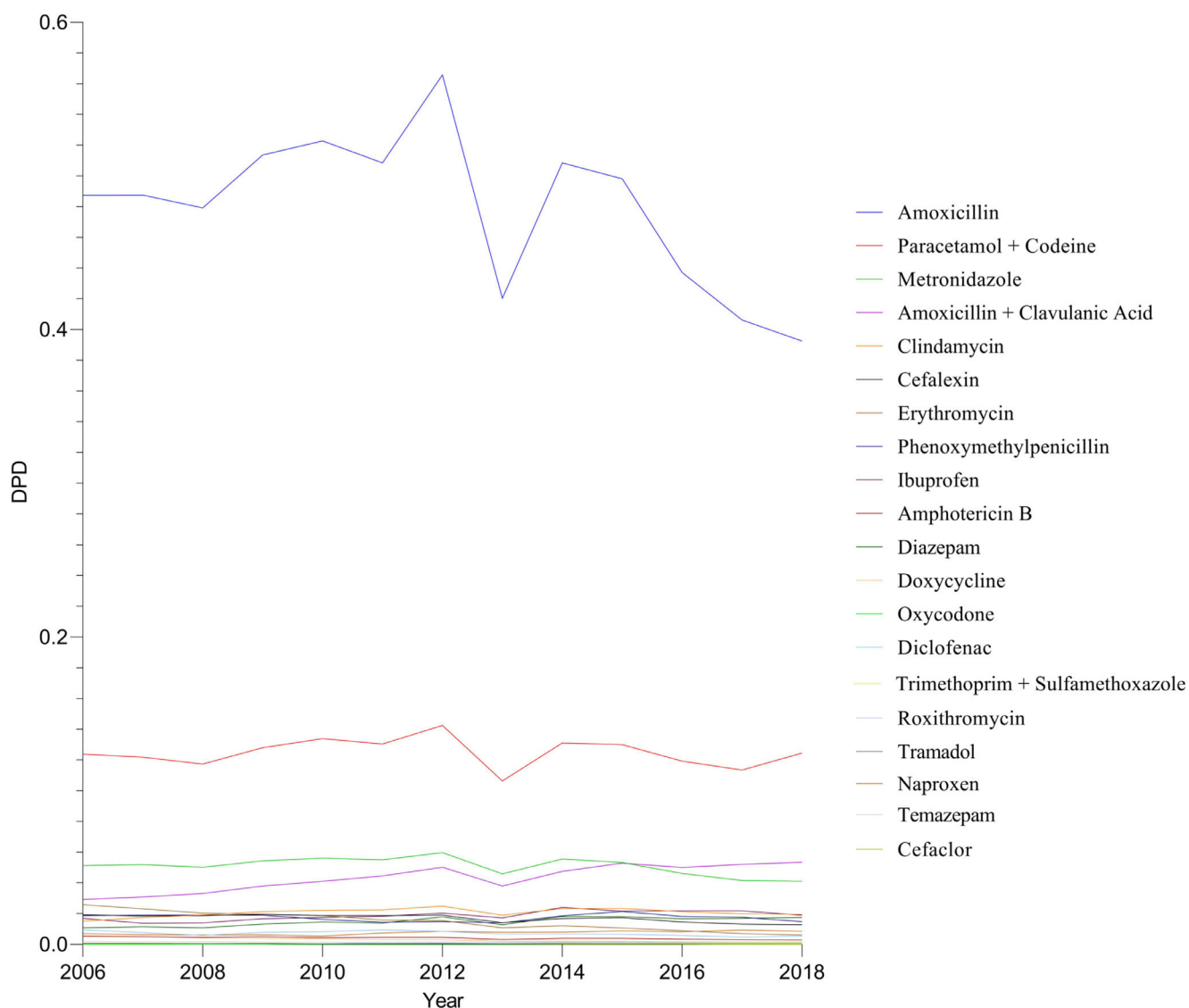


Fig. 2 – Adjusted annual defined daily dose (DDD) per 1,000 concessional population days (DPD) of top 20 medicines by dentists nationally from 2006 to 2018.

practice^{4,25}. Except for amoxicillin + clavulanic acid and clindamycin, there has been an overall decrease in the use of other antibiotics. The most commonly prescribed antibiotics other than beta-lactams would have been prescribed to overcome penicillin allergies or cephalosporin allergies. Globally, amoxicillin was the antibiotic of choice for endodontic infections. However, clindamycin and erythromycin were indicated for penicillin-allergic patients²⁶. Furthermore, in the USA, broad-spectrum antibiotics are prescribed for longer periods²⁷.

Dentists prescribe antibiotics for various reasons, both for empirical and therapeutic reasons²⁸. In most cases, clinicians do not know the causative organism for the infection as most of pus or exudate is not cultured in a laboratory setting²⁹. In dentistry, antibiotics are commonly provided for various reasons, including pulpitis, endodontic treatment, abscess, acute periodontal infections and systemic infections. An increase in indications may be why there is an increase in

broad-spectrum antibiotics^{26,30}. Further studies are required to assess whether the increased number of antibiotic prescriptions may be appropriate.

Dentists that are registered in Australia can prescribe two antifungals on the PBS¹⁵. Dentists most commonly prescribe them for oral candidiasis. Similar to previously published studies, Amphotericin B, which is available as a dissolvable lozenge, had a higher cumulative prescription count than Nystatin^{4,6}. However, in this study, Amphotericin B had an overall decrease in both dispensing count and DPD.

For inflammatory pain conditions, ibuprofen, one of the frequently dispensed medicines, is well tolerated and safe in combination with paracetamol³¹. Nevertheless, other pain medications (diclofenac, oxycodone and tramadol) showed different results. In essence, diclofenac had an overall decrease in both dispensing count and DPD, but there has been a rise in both oxycodone and tramadol prescribing. Our findings were consistent with international trends, where the

use of opioids increased in the USA³². Naloxone injection is recommended for suspected opiate overdose. However, our published pharmacoepidemiological study concluded that only one naloxone injection was dispensed from 1992 to 2018³³.

A cross-sectional study assessing dentists' hypothetical clinical scenarios conducted as a form of a questionnaire concluded that analgesics and antibiotics had been known for medication error among dentists³⁴. In addition, improper use of benzodiazepines has received significant interest in the media³⁵. Diazepam had an overall increase in both dispensing count and DPD. However, there has been a rise in the alternative benzodiazepine, temazepam, on a cumulative dispensing level. It is important to consider that emergencies can arise as a result of medication error in dental clinics. Dentists can prescribe lifesaving emergency medications (e.g. adrenaline, glucagon and glycerol trinitrate), but the dispensing pattern is usually low³³.

Strengths and limitations

This is the first study that has investigated medicine-prescribing trends over time by Australian dentists. Prescription rates, adjusted for population growth, indicated increases in some and decreases in other medicines. Regression analysis was utilised to quantify the magnitude, as well as the direction of the prescription rates, amongst dentists in Australia^{27,36}. Currently, it is the most up to date, as annual prescription rates are only available up to 2018.

One of the limitations of this study was that the cumulative dispensing count is only for PBS medicines. Because it was only prescribed then dispensed, it was not possible to determine the appropriateness of the prescribing amongst dentists. Furthermore, the medicines prescribed by dentists were only dispensed in a community pharmacy. This may impact the potential external validity. Out of the 56 medicines available, it only underwent pharmacoepidemiological analysis of the top 20 medicines, which accounted for 97.4% of the total prescription count. In addition, it does not include private or co-payment prescriptions, which account for approximately 29% of the total dispensing count³⁷. This could impact the external validity. In addition, in 2012 and 2013, there was an outlier, noted in all the medicines dispensed by dentists. Furthermore, it was not possible to distinguish between general dental practitioners and dental specialists (including oral maxillofacial surgeons). In addition, because of the indiscriminative nature of the open-access dispensing count, it is not possible to age standardise. Another limitation to note is that DDD may differ to the actual amount supplied due to the assumption that the pack size is the quantity dispensed.

Implications for practice

Therefore, undertaking further prospective research should be conducted to include both PBS-funded, as well as medicines purchased privately and co-payment wise. However, based on previously published studies, it may not make a significant difference³⁻⁶. Nevertheless, analysing this could create a complete picture for the future analysis. Further research can be undertaken using PBS analysis. Because there

are reports of patient contributions cost for PBS medicines, a potential cost-analysis could be conducted. Furthermore, potential studies investigating the appropriateness and the quality use of dental medicines could be an avenue for future research as PBS data provides a limited and broad overview of prescribing and dispensing patterns. In addition, studies highlighting the appropriateness of medication prescribing amongst dentists can help create a consensus guideline to ensure quality use of medicines when treating patients under their care. One way to do this is to either see whether there was poisoning associated with medicines prescribed by dentists while utilising the International Classification of Diseases (ICD) data, or undertaking a questionnaire to assess the dental students' knowledge in pharmacotherapeutics to determine whether there is a fundamental gap in the knowledge of medication prescribing.

Conclusion

This study highlights the increasing dispensing pattern and trends of dentist-prescribed antibiotics, opioids and benzodiazepines. Further investigation may be required to ascertain whether appropriate antimicrobial stewardship and training are needed amongst dentists to reduce inappropriate prescribing of medicines.

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Conflicts of interest

The authors declare no conflict of interests.

Ethics approval

This study was approved by the Human Research Ethics Committee at the University of Western Australia (Approval Number – RA/4/20/5262). This study has been conducted in full accordance with the World Medical Association Declaration of Helsinki.

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