Reduced community antibiotic dispensing in New Zealand during 2015–2018: marked variation in relation to primary health organisation

Mark Thomas, Andrew Tomlin, Eamon Duffy, Murray Tilyard

ABSTRACT

AIMS: The overall rate of community antibiotic dispensing in New Zealand in recent decades has been high when compared with many other nations, but since 2015 has consistently declined each year. We aimed to determine whether the magnitude of reductions in community antibiotic dispensing in New Zealand between 2015 and 2018 differed in relation either to the patient’s demographic features or in relation to the primary health organisation of the patient’s registered general practitioner.

METHODS: Demographic data on all patients registered with a general practice in New Zealand, and on all community pharmacy antibiotic dispensing for these patients during 2013–2018 were obtained from national healthcare databases. The rates of dispensing for patients registered with a general practitioner were measured as antibiotic courses dispensed per 1,000 population per day, and as defined daily doses per 1,000 population per day.

RESULTS: Total community antibiotic dispensing in New Zealand, measured as defined daily doses per 1,000 inhabitants per day, decreased by 13.8% during 2015–2018, an average annual reduction of 4.6% per year, with especially large reductions in dispensing of amoxicillin/clavulanate, fluoroquinolones and macrolides. The reductions in dispensing were greatest in children aged 0–4 years old, but lesser reductions were seen in all age groups. Antibiotic dispensing declined regardless of patient ethnicity or level of socioeconomic deprivation. There were marked differences between primary health organisations in the size of the reductions in antibiotic dispensing during 2015–2018, which ranged between 4.8% for the Te Tai Tokerau PHO to 21.5% for the Ngati Porou Hauora Charitable Trust PHO.

CONCLUSIONS: Total community antibiotic dispensing has reduced significantly in New Zealand between 2015 and 2018, with large disparities between primary health organisations in the size of the reductions. The overall rates of antibiotic dispensing remain high for non-Māori and non-Pacific people, and prescribers should aim to further reduce inappropriate antibiotic prescribing for these populations. However, the overall rate of antibiotic dispensing for Māori and Pacific people may now approximate an optimal level. Prescribers should aim to further reduce inappropriate antibiotic prescribing, but also to increase appropriate antibiotic prescribing for these populations.
Concern about the rising prevalence of resistance to antibiotics in a wide range of bacteria has stimulated efforts in many countries to reduce inappropriate antibiotic use. In New Zealand, during each winter between 1998 and 2016, PHARMAC conducted a national “Wise use of antibiotics” campaign to “focus on the responsible use of antibiotics, particularly with regard to the treatment of colds and flu”, and since 2017 has conducted a broadly similar “Keep antibiotics working” campaign “aimed at informing Kiwis that taking antibiotics won’t fix a cold or flu”. Other educational programmes, such as the Antibiotic Guideline first published in 2013 by the Best Practice Advocacy Centre (bpac) and revised in 2015 and 2017, and numerous articles and online resources produced by bpac, the Goodfellow Unit and the Ministry of Health have encouraged wise use of antibiotics in New Zealand.

These campaigns and resources, together with other publicly available information, are likely to have increased public and professional concern about the immediate and long-term adverse impacts of inappropriate antibiotic use, and led to reductions in community antibiotic dispensing. The total amount of antibiotics dispensed in the community in New Zealand had increased each year until 2012, but since 2015 has declined each year. However, when compared with other similar nations, the level of community antibiotic dispensing in New Zealand has been high. For example, during 2015 in New Zealand there were 3.01 antibiotic courses dispensed per 1,000 inhabitants per day. This rate of dispensing was 3.3 times greater than in Sweden, 2.1 times greater than in Denmark, 1.7 times greater than in Canada, and 1.3 times greater than in the US.

Primary health organisations (PHOs) play an important role in encouraging the provision of high-quality healthcare by general practitioners (GPs) at their contracted practices. We postulated that, during recent years, there may have been significant variation between PHOs in their efforts to discourage inappropriate antimicrobial prescribing. We therefore examined community antimicrobial dispensing in New Zealand between 2013 and 2018 to better understand the changes in dispensing that had occurred during this period, and to determine whether there were significant disparities between PHOs in the magnitude of these changes.

Methods

Data was obtained from two national healthcare databases managed by the Ministry of Health. Our study included all patients registered with a New Zealand general practice in the first quarter of each year 2013–2018 and listed in the PHO Enrolment Collection. This database contains information on each patient’s date of birth, gender, prioritised ethnicity, estimated level of socioeconomic deprivation, the practice with which they are registered, and the PHO of the practice. Patients were assigned to one of six ethnic groups: Asian, European, Māori, MELAA (Middle Eastern, Latin American and African), Pacific and Other. Each patient’s level of socioeconomic deprivation was estimated using the New Zealand Deprivation Index based on data in the 2013 Census of Population and Dwellings, with patients allocated to deprivation quintiles (quintile 1 = the least deprived and quintile 5 = the most deprived).

Data on all antibiotic medicines dispensed in the community, from 1 January 2013 to 31 December 2018, were obtained from the National Pharmaceutical Collection. Pharmaceuticals in this dataset are classified under the Anatomical Therapeutic Chemical (ATC) system. Data for each antibiotic dispensing included the antibacterial agent, its formulation, quantity dispensed and daily dose information. Records for each patient from the two national datasets were linked using an encrypted form of their National Health Index (NHI) code.

Antibiotic dispensing was measured both as number of antibiotic courses dispensed per 1,000 population per day, and as defined daily doses (DDD) per 1,000 inhabitants per day (DID). Repeat prescriptions were not included when measuring the number of antibiotic courses per 1,000 population per day but were included when measuring DIDs.

Our analysis of changes in antibiotic dispensing within New Zealand PHOs included 31 PHOs, two of which were
divided regionally for funding purposes into sub-PHOs: Compass Health-Capital and Coast, and Compass Health-Wairarapa; and Midland Health Network-Lakes, Midlands Health Network-Tairawhiti, Midlands Health Network-Taranaki, and Midlands Health Network-Waikato.

We used published data quantifying national rates of community antibiotic dispensing in other countries during 2013–2018, to provide comparisons with New Zealand rates.\textsuperscript{15–21} Data published by the Ministry of Health\textsuperscript{22} and the Health Quality and Safety Commission\textsuperscript{23} were used to investigate potential associations between the magnitude of change in antibiotic dispensing for each PHO, and the PHO’s performance with regard to other measures of the quality of care they provided. These measures of quality of care included: rates of childhood immunisation coverage at two years of age, provision of smoking cessation advice, dispensing of urate lowering therapy to people with a recent hospitalisation for gout, or provision of influenza vaccination to people with a recent hospitalisation for asthma.

We used Poisson regression to test for trends in the rates of antibiotic dispensing during 2015–2018. We calculated the Pearson product moment correlation using Fisher’s transformation to examine the correlation between PHO levels of antibiotic dispensing in 2015 and changes in antibiotic dispensing between 2015 and 2018.

Results

A total of 4,269,050 people were registered with a general practice in 2013 and 4,509,851 people in 2018. These study populations represented approximately 96% of the estimated total New Zealand population of 4,442,100 in 2013, and 92% of the estimated total New Zealand population of 4,885,350 in 2018.\textsuperscript{24} In 2015, 3,697,012 antibiotic courses were dispensed by community pharmacies to 1,763,044 registered patients and in 2018, 3,501,247 courses were dispensed to 1,751,851 registered patients. Antibiotic courses dispensed to registered patients constituted 90.2% of all antibiotic courses dispensed in the community in New Zealand in 2013, and 91.9% of all antibiotic courses dispensed in the community in 2018.

Changes in dispensing for patients registered with a GP

Total annual community antibiotic dispensing in New Zealand, for patients registered with a GP, whether measured in antibiotic courses dispensed per 1,000 population per day (Figure 1a), or in DIDs (Figure 1b), remained relatively stable from 2013 to 2015, but then declined from 2015 to 2018. Total antibiotic dispensing measured in DIDs decreased, by 5.6% between 2015 and 2016, by 3.1% between 2016 and 2017, and by 5.8% between 2017 and 2018, an average annual reduction of 4.6% between 2015 and 2018. This average annual reduction was comparable in magnitude to reductions

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**Figure 1:** Rates of total community antibiotic dispensing measured in courses dispensed per 1,000 population per day (a), and in DDDs per 1,000 inhabitants per day (DIDs) (b), in New Zealand and other countries, during 2013–2018.
occurring over the same period in Australia (6.5%), Denmark (3.6%), the UK (3.2%), Sweden (2.4%) and the Netherlands (1.9%).

Table 1 shows the annual rates of community dispensing (measured in DIDs) of the most commonly prescribed antibiotics, for patients registered with a GP, during 2013–2018. Total annual dispensing of antibiotics peaked in 2015 and then consistently declined during each subsequent year (p<0.001 for each antibiotic class or agent). The largest average annual reductions in community antibiotic dispensing during 2015–2018 were for amoxicillin/clavulanate (9.4%), fluoroquinolones (7.7%) and macrolides (6.7%).

### Changes in dispensing by patient demographics
Total annual community antibiotic dispensing declined significantly (p<0.001) in all age groups during 2015–2018, with the largest reductions in children aged 0–4 years, whether measured in antibiotic courses dispensed per 1,000 population per day (Figure 2) or in DIDs (data not shown).

Total community antibiotic dispensing, measured in DIDs, during 2013–2018, declined significantly in all ethnic groups (p<0.001), and at all levels of socioeconomic deprivation (p<0.001). (Figures 3a and 3b).

### Changes in dispensing by DHB and PHO
There were marked differences between the 20 DHBs, and between the 29 PHOs and six sub-PHOs, in the rates of change in total community antibiotic dispensing, measured in DIDs, during 2015–2018. The magnitude of the reductions in dispensing during this three-year period ranged from 7.5% for the Tairawhiti DHB to 18.8% for the Waitemata DHB (Figure 4a) with a median reduction of 11.5% for the Canterbury DHB. During the same period, the median reduction was 12% for the Central PHO, with reductions ranging from 4.8% for the Te Tai Tokerau PHO to 21.5% for the Ngati Porou Hauora Charitable Trust PHO (Figure 4b).

We compared the 35 PHOs to determine whether those with the largest percentage reductions in antibiotic dispensing...

### Table 1: Annual community dispensing of antibiotics by class and agent (for penicillins), measured in DDDs per 1,000 population per day (DIDs), during 2013–2018.

<table>
<thead>
<tr>
<th></th>
<th>2013</th>
<th>2014</th>
<th>2015</th>
<th>2016</th>
<th>2017</th>
<th>2018</th>
<th>average annual reduction 2015 to 2018</th>
</tr>
</thead>
<tbody>
<tr>
<td>Penicillins total</td>
<td>13.05</td>
<td>13.15</td>
<td>14.26</td>
<td>13.14</td>
<td>12.85</td>
<td>11.99</td>
<td>-5.3%</td>
</tr>
<tr>
<td>Penicillin V</td>
<td>0.42</td>
<td>0.37</td>
<td>0.38</td>
<td>0.36</td>
<td>0.38</td>
<td>0.34</td>
<td>-3.6%</td>
</tr>
<tr>
<td>Flucloxacillin</td>
<td>1.83</td>
<td>1.74</td>
<td>1.73</td>
<td>1.79</td>
<td>1.69</td>
<td>1.71</td>
<td>-0.4%</td>
</tr>
<tr>
<td>Amoxicillin</td>
<td>6.08</td>
<td>6.38</td>
<td>6.92</td>
<td>6.62</td>
<td>6.68</td>
<td>6.18</td>
<td>-3.6%</td>
</tr>
<tr>
<td>Amox/clav</td>
<td>4.73</td>
<td>4.65</td>
<td>5.23</td>
<td>4.37</td>
<td>4.09</td>
<td>3.76</td>
<td>-9.4%</td>
</tr>
<tr>
<td>Cephalosporins</td>
<td>0.94</td>
<td>1.00</td>
<td>1.04</td>
<td>1.04</td>
<td>1.02</td>
<td>1.00</td>
<td>-1.4%</td>
</tr>
<tr>
<td>Macrolides</td>
<td>2.34</td>
<td>2.27</td>
<td>2.25</td>
<td>2.05</td>
<td>2.02</td>
<td>1.79</td>
<td>-6.7%</td>
</tr>
<tr>
<td>Tetracyclines</td>
<td>6.55</td>
<td>6.60</td>
<td>6.66</td>
<td>6.57</td>
<td>6.25</td>
<td>6.04</td>
<td>-3.1%</td>
</tr>
<tr>
<td>Trimethoprim and cotrimoxazole</td>
<td>1.32</td>
<td>1.33</td>
<td>1.32</td>
<td>1.30</td>
<td>1.26</td>
<td>1.28</td>
<td>-1.2%</td>
</tr>
<tr>
<td>Fluoroquinolones</td>
<td>0.51</td>
<td>0.51</td>
<td>0.49</td>
<td>0.48</td>
<td>0.43</td>
<td>0.38</td>
<td>-7.7%</td>
</tr>
<tr>
<td>Total*</td>
<td>24.78</td>
<td>24.93</td>
<td>26.09</td>
<td>24.64</td>
<td>23.87</td>
<td>22.48</td>
<td>-4.6%</td>
</tr>
</tbody>
</table>

*Note: the total includes relatively small numbers of dispensings for antibiotics not listed in the table.
Figure 2: Rates of total community antibiotic dispensing measured in courses dispensed per 1,000 population per day, in relation to patients' age, during 2013–2018.

Figure 3: Rates of total community antibiotic dispensing, measured in DIDs, in relation to patients' ethnicity (a), and socioeconomic deprivation quintile (b), during 2013–2018.
(measured in DIDs) during 2015–2018 had begun with the highest rates of antibiotic dispensing during 2015, or were PHOs that had performed particularly well with regard to other measures of the quality of healthcare. There was no correlation between the PHO rate of dispensing during 2015 and the size of the reduction in dispensing during 2015–2018 (correlation coefficient: 0.32, 95% CI: -0.02–0.59). Nor were there any significant correlations between the rate of change in community antibiotic dispensing for each PHO during 2015–2018, and the PHO rates of childhood immunisation coverage at two years of age, provision of smoking cessation advice, dispensing of urate lowering therapy to people with a recent hospitalisation for gout, or provision of influenza vaccination to people with a recent hospitalisation for asthma, during the same period (data not shown).

Discussion

There has been a significant decline in the rate of community antibiotic dispensing in New Zealand in recent years. This decrease in antibiotic dispensing, as measured in DIDs, is clearly apparent from 2015, but had been preceded by a decrease in antibiotic courses dispensed to children under five years of age since 2012. Similar sustained declines in total community antibiotic dispensing have also occurred in the Netherlands since 2012, in Denmark since 2014, in the UK since 2015 and in Australia since 2016. The average annual reduction in total community antibiotic dispensing in New Zealand during 2015–2018, measured in DIDs, was 4.6%, which was comparable to, or larger than, those observed during the same period, in many other nations (Australia: 6.5%; Denmark: 3.6%; Sweden: 2.4%; UK: 2.1%; Netherlands: 1.9%; France: 0.3%; Canada: 0%). The greatest reduction
in antibiotic dispensing in New Zealand was for children aged 0–4 years, and this was also the case in the US, Denmark and Sweden. The marked similarities between these countries in the year of onset of the decline, the magnitude of the reductions and the age group with the largest reductions in antibiotic dispensing strongly suggests that comparable changes in community and medical attitudes to antibiotic use have occurred in many developed countries.

Despite the reductions in dispensing during 2015–2018, New Zealand had a higher rate of total community antibiotic dispensing during 2018 (22.5 DIDs) than many other developed countries, such as the UK (18.2 DIDs), Denmark (13.98 DIDs), Sweden (10.15 DIDs) and the Netherlands (10.05 DIDs). These marked differences might lead one to conclude that total community antibiotic dispensing in New Zealand is approximately two times higher than is required to maintain a healthy population, and by implication that approximately 50% of antibiotic dispensing in New Zealand is inappropriate. However, New Zealand differs from these European countries in that it is a nation with a markedly higher incidence of infectious diseases in Māori and Pacific people, who frequently also suffer from socioeconomic deprivation. Concern has been expressed that initiatives aimed at reducing antibiotic prescribing might exacerbate the worse health outcomes experienced by Māori and Pacific people. Many doctors and patients are likely to be concerned that reducing community antibiotic dispensing may lead to adverse health impacts. However, studies conducted in England and Sweden found that large, sustained reductions in antibiotic dispensing were not associated with an overall increase in the rate of serious infections. These, and similar findings from other studies, have contributed to a growing awareness that antibiotics have been widely overprescribed in many countries, and that inappropriate antibiotic “treatment” of self-limiting respiratory tract infections is at least as common in Māori and Pacific people as it is in people of other ethnicities.

We have previously suggested that appropriate targets for annual total antibiotic dispensing in New Zealand may be approximately 1.5 antibiotic courses per 1,000 population per day for people who are not of Māori or Pacific ethnicity, and 2.5 antibiotic courses per 1,000 population per day for Māori and Pacific people—1.66 times higher in Māori and Pacific people, to account for their increased burden of bacterial infectious diseases. Achieving these targets would require a 26% decrease in total antibiotic dispensing for people who are not of Māori or Pacific ethnicity, from their 2018 dispensing rate of 2.03 antibiotic courses per 1,000 population per day, and a 2% increase in total antibiotic dispensing for Māori and Pacific people from their 2018 dispensing rates of 2.45 antibiotic courses per 1,000 population per day.

Achieving these targets by increasing appropriate antibiotic prescribing and reducing inappropriate antibiotic prescribing may be expected to improve health outcomes for all people, but will require increased awareness of the impact of ethnicity on the burden of infectious diseases in New Zealand. It does not make sense that the rate of dispensing of penicillins for people aged 5–20 years of age was only 1.45 times higher in Pacific people, and 1.24 times higher in Māori people than in people of other ethnicities, when the incidence of rheumatic fever was 63 times higher in Pacific people and 27 times higher in Māori people, than in people of other ethnicities.

Many doctors and patients are likely to be concerned that reducing community antibiotic dispensing may lead to adverse health impacts. However, studies conducted in England and Sweden found that large, sustained reductions in antibiotic dispensing were not associated with an overall increase in the rate of serious infections. These, and similar findings from other studies, have contributed to a growing awareness that antibiotics have been widely overprescribed in many countries, and that inappropriate antibiotic “treatment” of self-limiting respiratory tract infections (such as colds and influenza) and other minor illnesses, rarely confers any significant benefit, frequently causes relatively minor adverse effects (such as diarrhoea and rash), occasionally causes severe adverse effects (such as anaphylaxis) and selects for the spread of antibiotic resistant bacteria. Improved public education about the benefits of reducing inappropriate antibiotic
consumption, and medical education about the benefits of adhering to treatment guidelines, will be required to ensure that people in New Zealand achieve the benefits that will result not only from reduced inappropriate antibiotic use, but also from increased antibiotic use for those conditions for which it is beneficial.

The strengths of this study include the inclusion of demographic and antibiotic dispensing data for more than four million people (over 90% of the total New Zealand population) during a six-year period. The large amount of information recorded in New Zealand’s high-quality, comprehensive, national databases enabled us to analyse antibiotic dispensing by age, ethnicity, socioeconomic deprivation, geographic region and general practice administrative organisation (PHO). Weaknesses of the study include the inability to measure the amount of antibiotic issued by school or community-based programmes for the management of sore throats and skin infections in children and young people. In some regions of New Zealand in recent years, antibiotic courses issued by these programmes have comprised a large proportion of antibiotic courses given to school-aged children. Furthermore, we were unable to measure the quantity of antibiotic medicines dispensed by general practices using medicines obtained through practitioner supply orders. It is possible that in some practices this may have been a relatively common method of circumventing both the potential costs to patients and the perceived inconvenience of having medicines dispensed by a pharmacy.

We have noted with particular interest the striking variation between PHOs in the magnitude of their annual reductions in antibiotic dispensing during 2015–2018. We suggest that, taking into account the ethnicity of the population they serve, all PHOs might aim to achieve a 5% annual reduction in total antibiotic dispensing, a target that was achieved by approximately one-third of New Zealand PHOs during the 2015–2018 period. Achieving sustained reductions in inappropriate antibiotic dispensing during the coming decades will be beneficial for the health of the people of New Zealand, both in the short term and in the long term.

Competing interests:
Nil.

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