Longitudinal trends in community antibiotic consumption in the Waitaha Canterbury Region of Aotearoa New Zealand over 10 years (2012–2021): an observational study

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ABSTRACT

AIMS: To investigate community antibiotic consumption in the Waitaha Canterbury Region of Aotearoa New Zealand across 2012–2021.

METHODS: This observational study was based on antibiotic dispensing data from Waitaha Canterbury. Outcome measures included number of dispensings/1,000 inhabitants per year and defined daily doses/1,000 inhabitants per day (DIDs), expressed as average annual change (AAC). We stratified antibiotic dispensing per antibiotic group, and per the World Health Organization (WHO) AWaRE (Access, Watch, Reserve) classification.

RESULTS: Across 2012–2021, antibiotic dispensing decreased from 867 to 601 dispensings/1,000 inhabitants (AAC -4.2% [95%CI -4.3 to -4.2]). In the pre-COVID period of 2012 to 2019, antibiotic dispensings decreased with AAC of -3.5% (95%CI -3.6 to -3.5). Considering number of dispensings, the largest reductions were observed in quinolones (-14.6%), macrolides/lincosamides (-8.5%) and penicillins with extended spectrum (-4.8%). The number of dispensings increased for nitrofurans (6.0%) and first generation cephalosporins (28.1%), of which 98% comprised cefalexin dispensing. The proportion of Watch antibiotics decreased from 22.0% to 11.9%.

CONCLUSIONS: Community antibiotic consumption decreased in Waitaha Canterbury Aotearoa New Zealand from 2012 to 2021, as did use of Watch antibiotics. These changes concord with increasing antimicrobial stewardship guidance for more judicious use of antibiotics. Further research should investigate the factors driving the observed 10-fold rise in cefalexin dispensing.

Antimicrobial resistance is listed by the Health Emergency Preparedness and Response Authority among the top three health threats facing the European Union.[1] Worldwide, antibiotic resistant bacteria were associated with approximately 5 million deaths in 2019, and were the direct cause of death in 1.27 million cases.[2] One of the main drivers for antimicrobial resistance is overall antibiotic consumption in the community.[3] Insight into local antibiotic dispensing patterns in the community, where most antibiotics are used, is crucial to define areas of improvement. These include ensuring antimicrobial medicines are used optimally to treat infections while avoiding the harms associated with their use including antimicrobial resistance and adverse effects.[4]

In Aotearoa New Zealand, community care accounts for up to 95% of antibiotic dispensing.[5] Compared to other high-income countries, dispensing rates in Aotearoa New Zealand were the fourth highest, exceeded only by Greece, Italy and Korea in 2019.[6–8] Although community antibiotic dispensing decreased by 3.5% per year between 2015 and 2018 in Aotearoa New Zealand, it was still notably higher than in other high-income countries (i.e., ~4 defined daily doses per 1,000 inhabitants per day [DIDs]). Moreover, within Aotearoa New Zealand large variation exists in community antibiotic dispensing rates across regions ranging from 20 to 30 DIDs.[9] Compared to other regions in Aotearoa New Zealand, the Waitaha Canterbury Region had one of the lowest rates of people who are dispensed at least one systemic antibiotic per year in 2018.[10]

The World Health Organization (WHO) developed the AWaRe classification (Access, Watch, Reserve), which is designed for antimicrobial stewardship and surveillance purposes, and also enables international comparison.[11] The WHO defines Access antibiotics as antibiotics of choice for the most common infections whilst Watch antibiotics are only recommended for specific indications (e.g., macrolides, quinolones, and second/third generation cephalosporins). The WHO AWaRe guideline recommends that >60% of antibiotic dispensings are Access antibiotics in the hospital and in the community.[12] Aotearoa New Zealand reached that target between 2000 and 2015, with 80% of all antibiotic dispensings in 2015 being from the Access classification, although AWaRE data for only the community setting has not yet been reported.

Studies in other high-income countries have shown recent decreases in total community use of antibiotics, and a change in antibiotic type.[13–15] Insight into local prescribing patterns and the relation to antibiotic guidance is essential to inform areas of improvement for antimicrobial stewardship programs. In this study, we aimed to investigate longitudinal trends in community antibiotic consumption in the Waitaha Canterbury Region of Aotearoa New Zealand between 2012–2021.

Methods

Ethics

This research was approved by the Human Ethics Committee of the University of Otago (HD22/032).

Study design and data collection

This was an observational study based on routinely collected data on systemic antibiotic prescriptions dispensed in the community from the National Pharmaceutical Collection in Aotearoa New Zealand.[16] We extracted data on all subsidised dispensed systemic antibacterial agents in the Waitaha Canterbury Region from 1 January 2012 to 31 December 2021. The dataset did not include antibiotics supplied to patients unsubsidised nor those supplied to prescribers for use in emergencies, for demonstration purposes, or for when an individual prescription is not practical (termed practitioner supply order). In 2021, Waitaha Canterbury covered 586,400 inhabitants, which comprised 12% of the total Aotearoa New Zealand population. In Waitaha Canterbury, 10% of inhabitants is of Māori ethnicity, 3% of Pacific ethnicity, 11% of Asian ethnicity, and 76% of Other ethnicity, which includes NZ European, Middle Eastern, Latin American and African, and others. Collected data included type of antibacterial agent, dosage and quantity dispensed. Antibiotic agents were grouped by Anatomic Therapeutic Chemical classification (see Appendix 1).[17] This grouping includes beta-lactamase sensitive penicillins, beta-lactamase resistant penicillins, penicillins with extended spectrum, combinations of penicillins including beta-lactamase inhibitors, macrolides/lincosamides, first generation cephalosporins, second generation cephalosporins, third generation cephalosporin, trimethoprim and sulphonamides, nitrofurans, quinolones, imidazoles, and other antibiotics. We stratified data per age group (<5 years, 5–9 years, 10–19 years, 20–59 years, ≥60 years)[9] and per prioritised ethnicity (Māori, Pacific people, Asian, and "Other", which included NZ European, Middle Eastern, Latin American and African, and others).[18] Statistics New Zealand prepared a custom dataset for the Aotearoa New Zealand Ministry of Health | Manatū Hauora, consisting of population projections stratified by district health board, age, sex and prioritised ethnicity. Projections were based on the 2013 census and updated in 2018.

Outcome measures

We assessed antibiotic consumption using different measures:[15] (i) number of dispensed prescriptions per 1,000 inhabitants per year, and (ii) defined daily doses per 1,000 inhabitants per day (DIDs). The defined daily dose is the assumed average maintenance dose per day for an individual drug in adults.[17]

Data analysis

First, we assessed total systemic antibiotic dispensing and performed regression analyses to assess trends over time (Poisson regression for number of dispensings, linear regression for DIDs). Because the infectious disease burden and antibiotic prescriptions decreased during the COVID-19 pandemic,[19] we analysed the period before the COVID-19 pandemic (2012 to 2019) separately. Second, we evaluated antibiotic dispensing per antibiotic group, and per the WHO AWaRE classification (see Appendix 1).[11] The WHO defines Access antibiotics as antibiotics of choice for the most common infections, whilst Watch antibiotics are only recommended for specific indications (e.g., macrolides, quinolones, and second/third generation cephalosporins). Third, we performed stratified analyses for age and ethnicity. Dispensed prescriptions with missing data for age (~6%) or ethnicity (~9%) were excluded for this analysis. All analyses were performed in R version v4.2.

Results

Overall antibiotic dispensing

Across the 10 years of the study, community antibiotic dispensing decreased by 30.7% (867 dispensings per 1,000 inhabitants per year in 2012 to 601 dispensings per 1,000 inhabitants per year in 2021) representing an average annual change (AAC) of -4.2% (95% CI -4.3 to -4.2)) (see Table 1). Furthermore, DIDs decreased by 20.8% (22.8 in 2012 to 18.0 in 2021), representing an AAC of -0.64 DIDs (95%CI -0.76 to -0.53)).

The largest reduction of antibiotic dispensing was observed in 2020 compared to 2019 (-108 dispensings per 1,000 inhabitants; -2.0 DIDs). Dispensings increased again in 2021, yet levels in 2021 were lower than in 2019.

In the stratified analysis focussing on the years 2012 to 2019, similar trends were observed in overall antibiotic dispensing (number of dispensings per 1,000 inhabitants: AAC -3.5% (95%CI -3.6 to -3.5), DIDs: AAC -0.64 DIDs (95%CI -0.75 to -0.53)), although differences were smaller.

Antibiotic dispensing per antibiotic group

Over the decade, the number of dispensings decreased in 10 of the 14 antibiotic groups (Figure 1; Appendix 2). The largest reductions in total number of dispensings were observed in macrolides/lincosamides (124 to 54 dispensings per 1,000 inhabitants; AAC -8.4% [95%CI -8.5 to -8.3]), penicillins with extended spectrum (201 to 139 dispensings per 1,000 inhabitants; AAC -4.8% [95%CI -4.9 to -4.8]), and combinations of penicillins with beta-lactamase inhibitors (134 to 91 dispensings per 1000 inhabitants; AAC -4.5% [95%CI -4.6 to -4.4]). The largest reduction in percentage was observed in quinolones (AAC -14.6% [95% CI -14.8 to -14.5]; 49 to 11 dispensings per 1,000 inhabitants). Increases in dispensings were observed for first-generation cephalosporins (3.4 to 38 dispensings per 1,000 inhabitants; AAC: 28.1% [95%CI 27.7 to 28.4]) and nitrofurans (19 to 34 dispensings per 1,000 inhabitants; AAC: 6.0% [95%CI 5.8 to 6.2]). The large increase in first generation cephalosporins was mainly attributable to increased dispensing of cefalexin (98%). In addition, increases for third generation cephalosporin and other antibiotics were observed, although absolute number of dispensings were low in these groups. The stratified analysis for 2012 to 2019 showed similar results (presented in Appendix 2).

When measured by DIDs, similar trends were observed for community antibiotic consumption with decreases in macrolides/lincosamides, combinations of penicillins with beta-lactamase inhibitors and penicillins with extended spectrum (Appendix 2). The largest reduction was, however, observed in tetracyclines (7.6 to 6.3 DIDs, AAC -0.20 DIDs [95%CI -0.25 to -0.16]). Similarly, increases were observed in first generation cephalosporins, nitrofurans, third generation cephalosporin and other antibiotics.

Table 1: Community antibiotic dispensings in Waitaha Canterbury in 2012–2021.

Year	Number of dispensings per 1,000 inhabitants per year	Defined daily doses per 1,000 inhabitants per day (DIDs)
2012	867	22.8
2013	833	22.5
2014	820	22.3
2015	781	21.2
2016	736	20.1
2017	733	19.8
2018	692	18.8
2019	681	18.9
2020	573	16.9
2021	601	18.0

Figure 1: Antibiotic dispensing per antibiotic group in Waitaha Canterbury in 2012–2021.

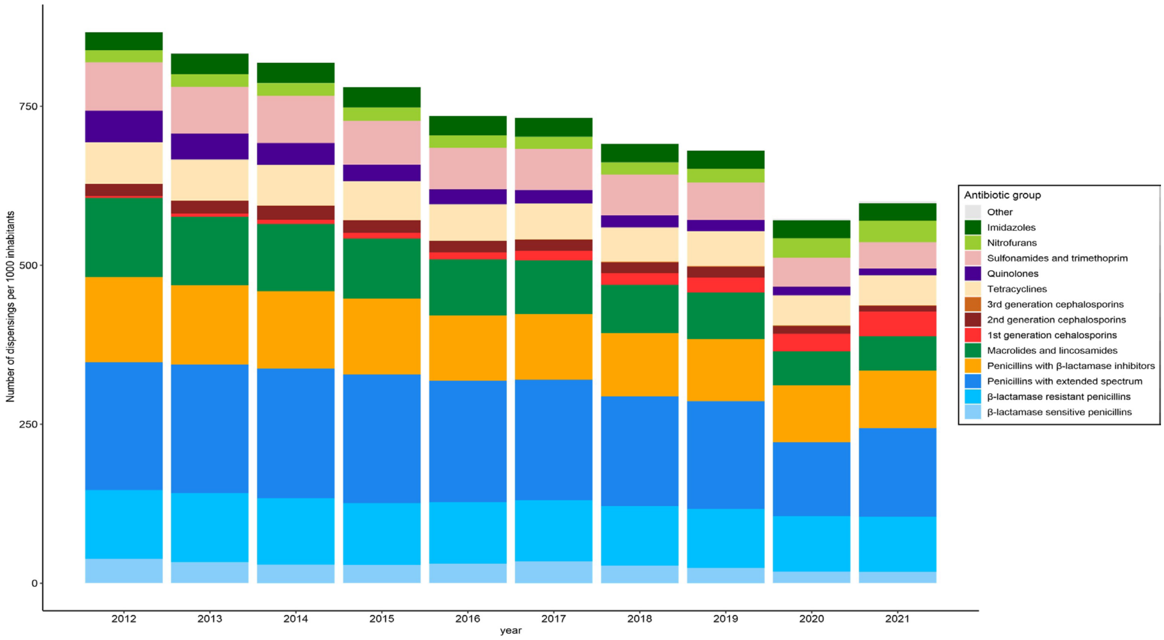
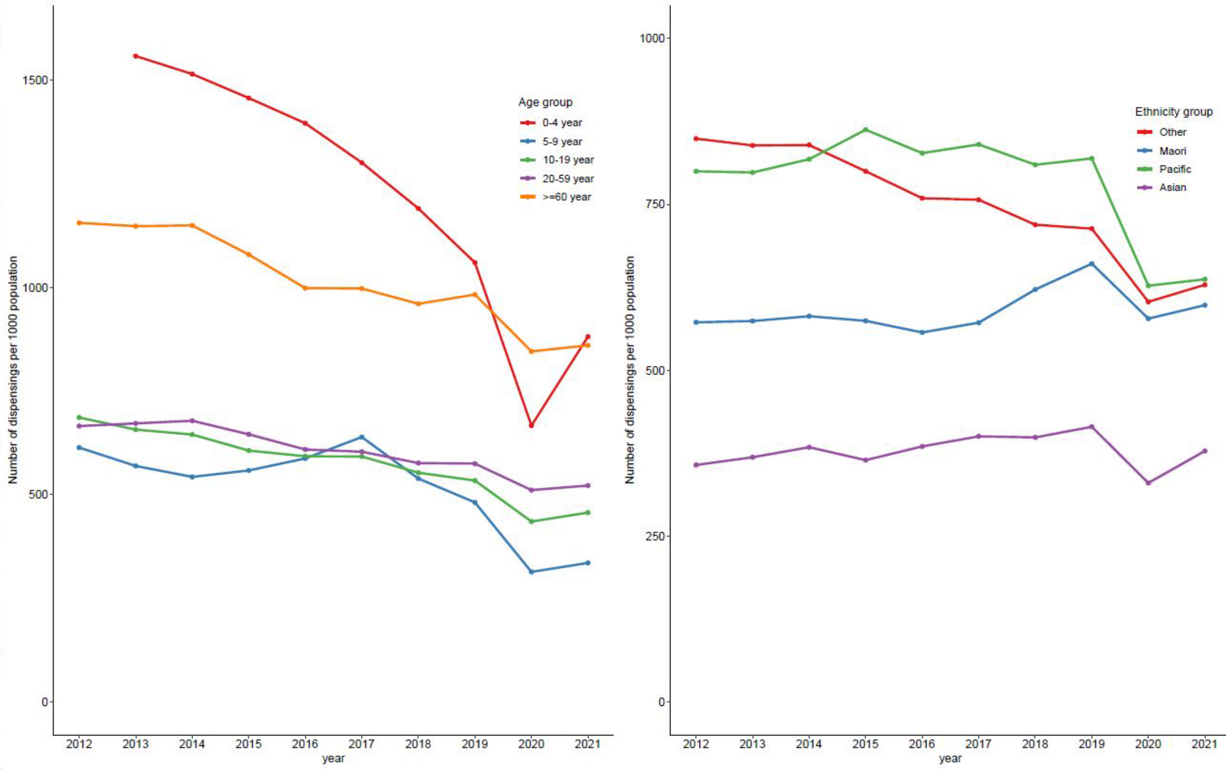


Figure 2: Antibiotic dispensing stratified per age groups (2a) and per ethnicity groups (2b).



Antibiotic dispensing per AWaRe groups

Between 2012 and 2021, the antibiotic dispensing of WHO Access and Watch antibiotics decreased (see Appendix 3). The proportion of antibiotics which were Watch antibiotics decreased as well (dispensings 22.0% to 11.9%; DIDs 17.8% to 10.4%).

Stratification per age group and ethnicity and per age group

Between 2012–2021, reductions in number of dispensings were observed in all age groups. The largest decrease was observed in those <5 years of age (AAC -7.6% [95%CI -7.7 to -7.5]) followed by those 5–9 years (AAC -5.4% [95%CI -5.5 to -5.2]), and 10–19 years (AAC -4.5% [-4.6 to -4.4]) (Figure 2a; Appendix 4). For the period 2012 to 2019, similar results were observed for number of dispensings with the largest decrease in those <5 years of age (AAC -5.6% [95%CI -5.7 to -5.5]).

In addition, number of dispensings remained similar in people with Asian ethnicity. Number of dispensings were reduced in Pacific peoples and other ethnicities, but increased in Māori (554 to 562 dispensings per 1,000 inhabitants, AAC 0.7% [95%CI 0.6 to 0.9]). (Figure 2b; Appendix 4).

Discussion

In this longitudinal study in the Waitaha Canterbury Region of Aotearoa New Zealand, community antibiotic consumption decreased significantly from 2012 through 2021. Over this decade, the number of dispensings decreased by 31%, and the DIDs by 21%. In the pre-COVID period from 2012 to 2019, the number of dispensings decreased with 21% and DIDs by 17%. The largest decline in antibiotic dispensings occurred in young children. Importantly, the proportion of WHO Watch antibiotics also decreased. However, whilst reductions were observed for the majority of antibiotic groups including quinolones, penicillins with extended spectrum, and combinations of penicillins with beta-lactamase inhibitors, dispensing of first generation cephalosporins showed a large increase.

Our study confirms that Waitaha Canterbury displays the ongoing decreasing trend for community antibiotic dispensing reported for Aotearoa New Zealand across 2015 to 2018.[9] From 2013 to 2018, antibiotic dispensing in Waitaha Canterbury was on average 3.7 DIDs lower than for the whole of Aotearoa New Zealand. Therefore, the decrease observed in Canterbury from 2012 to 2021 may not be generalisable to other regions in Aotearoa New Zealand. Compared to other high-income countries, the magnitude of the difference in average community antibiotic consumption between Waitaha Canterbury and the European union has decreased (3.5 DIDs in 2012 to 1.9 DIDs in 2020; Appendix 5). Nevertheless, community antibiotic dispensing in Waitaha Canterbury was higher than in Canada, the United Kingdom and 21 of 28 European countries in 2020.[14,20,21] The higher rate of antibiotic consumption in Aotearoa New Zealand might be partly explained by a higher burden of infectious disease in Māori and Pacific peoples, and the higher incidence of acute rheumatic fever in these groups.[22] The latter risk means that Aotearoa New Zealand prescribers are advised to consider the need for antibiotics in young people presenting with possible streptococcal infections, in particular those presenting with sore throats.

In our study, differences in antibiotic consumption across ethnicity groups reduced over time. Antibiotic consumption decreased mainly in people with other ethnicities and Pacific people whereas Māori had a minimal increase in antibiotic consumption. Considering the increased burden of infectious diseases in Māori and Pacific people,[22] Thomas et al. suggested antibiotic targets for Aotearoa New Zealand to be 2.5 dispensings per 1,000 inhabitants per day for Māori and Pacific peoples, and 1.5 for Other ethnicities.[9,23] Our study shows that antibiotic dispensings for Asian and Other ethnicities are close to these suggested targets (antibiotic dispensings per 1,000 inhabitants per day: Other 1.7; Asian 1.0), but the reduced dispensings for Māori and Pacific peoples are potentially of concern (antibiotic dispensings per 1000 inhabitants per day: Māori: 1.6; Pacific peoples 1.7).

The COVID-19 pandemic has largely influenced antibiotic dispensings. Our finding of a 16% reduction in antibiotic dispensing in the year 2020 was also reported by Duffy et al. who reported a 36% decrease for the whole of Aotearoa New Zealand comparing antibiotic consumption before and after implementation of public health interventions in response to the COVID-19 pandemic.[19] The decrease in 2020 can be partly explained by a lower incidence of infections due to social distancing. In our study, the increase in antibiotic dispensing from 2020 to 2021, which was mainly due to increased dispensings of penicillins with extended spectrum, may be explained by an increase in infections due to increased social interactions after lockdown restrictions were eased, but it may also represent potentially avoidable antibiotic use. It should be noted that the level of restrictions in Waitaha Canterbury have been less impactful compared to other districts in Aotearoa New Zealand in 2020 and 2021.

The WHO AWaRe guideline recommends that >60% of antibiotic dispensings are Access antibiotics in the hospital and in the community.[12] In our study including only community antibiotic dispensing, the proportion of Access antibiotics increased from 82% to 87% across 2012 to 2021. Other international studies that report on the WHO AWaRe classification have focussed on total antibiotic consumption or hospital consumption, and have not reported community dispensing separately.[12,24–26] Insight into both community and hospital antibiotic consumption using a uniform definition such as the AWaRe classification is important to inform antimicrobial stewardship programs, and to compare antibiotic consumption internationally.

Aotearoa New Zealand has an antimicrobial resistance action plan (2017) but does not currently have sector-wide national antimicrobial stewardship leadership, or activities. However, positive work has commenced, for instance via national organisations and local antimicrobial stewardship groups.[27,28] In our study, a decrease in antibiotic dispensing was observed in antibiotic agents that are known to have increasing rates of antimicrobial resistance, for example quinolones and macrolides. In Aotearoa New Zealand, the use of quinolones has been discouraged by guideline changes, antimicrobial stewardship awareness campaigns, and education on rational use resulting in a reduction of almost 80%.

Dispensing of first-generation cephalosporins increased more than 10-fold, which was attributable to an increase in cefalexin. Cefalexin dispensings increased in all age groups, and was highest in children <5 years and those ≥60 years (data not shown). In Australia, cefalexin is now the most frequently prescribed antibiotic accounting for almost one-quarter of antibiotic prescriptions in general practice.[13] In Aotearoa New Zealand, changes in national guidelines, local guidelines, and prescriptions of hospital specialists could have contributed to cefalexin dispensings. First, cefalexin is increasingly recommended as an alternative option in case of mild penicillin allergy or intolerance for flucloxacillin.[29] Second, cefalexin is now included in the list of antibiotics suitable for use in urinary tract infections in place of quinolones, and since 2016 cefalexin has been recommended as a second-line option for cystitis treatment in children. Third, guidance for the treatment for minor skin infections has changed from topical antibiotics to skin hygiene advice, and oral flucloxacillin for more wide spread infections is advised.[30] The liquid formulation of cefalexin, however, is considered more palatable compared to flucloxacillin, an important consideration in children. It is not possible to deduce from our study whether the observed increase of cefalexin is of concern since data on infection focus, allergies or previous antibiotic prescriptions were not available in our data. Further research focussing on the indications and reasons for the increasing use of cefalexin in the community is warranted.

Strengths of our study include the longitudinal nature of dispensing data for the Waitaha Canterbury Region of Aotearoa New Zealand. Second, we reported different measures of antibiotic consumption, including DIDs and number of dispensings.[15] In addition, this is the first study reporting WHO AWaRe categories in the community in Aotearoa New Zealand.

Our study has some limitations. First, we focussed on all community antibiotic dispensings, which is expected to capture the vast majority of community systemic antibiotic usage in the Region. Some antibiotics are supplied via other routes such as direct supply by a general practitioner in emergencies. Another route not included is pharmacist supply of trimethoprim, which has been available to women with uncomplicated cystitis without prescription since 2012. In our study, we observed a decrease in trimethoprim and sulphonamides; 70% of this decrease was due to reduced dispensing of trimethoprim. This decrease could be partly explained by the guideline change of first-line agent from trimethoprim to nitrofurantoin for cystitis due to increasing *E. coli* resistance. Data for pharmacist-supplied trimethoprim are not available, so it is unclear to what extent this decrease in trimethoprim dispensing has been substituted by pharmacist supplied provision of this agent. These are data that should be recorded and made publicly available. Second, we applied the defined daily dose in children although this method does not consider child-specific dosages. It is unlikely that this has influenced our results as the proportion of children <15 years has been stable (~20%) during the study period. Lastly, we did not have access to individual data on medical history or presenting symptoms, so we were unable to determine the indication or appropriateness of antibiotic dispensings.

Conclusion

Community antibiotic dispensing decreased in Waitaha Canterbury Aotearoa New Zealand during the past decade (2012–2021). This brings the Region's community antibiotic consumption more closely in line with consumption in other high-income countries. In addition, reductions were observed in WHO Watch antibiotics such as quinolones and macrolides which may help reduce development of antimicrobial resistance. Despite these encouraging changes, current use still exceeds that in other similar countries and other published Aotearoa New Zealand data indicate that we can still further reduce antibiotic consumption without compromising health outcomes. Dispensing of cefalexin, however, increased over 10-fold. Further research should investigate which factors may be driving use of this broad-spectrum agent.

COMPETING INTERESTS

Nil.

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Appendices

Appendix 1: Anatomic therapeutic chemical classification of funded systemic antibiotics

ATC group[1]	Antibiotic agent	AWaRe classification[2]
J01A: Tetracyclines	Doxycycline, Minocycline, Tetracycline	Access
J01C: Penicillins		
J01CA: Penicillins with extended spectrum	Amoxicillin	Access
J01CE: β-lactamase-sensitive penicillins	Phenoxymethylpenicillin, Benzylpenicillin, Benzathine penicillin, Procaine penicillin	Access
J01CF: β-lactamase-resistant penicillins	Flucloxacillin	Access
J01CR: Combinations of penicillins with beta-lactamase inhibitors	Amoxicillin and clavulanic acid	Access
J01D: Cephalosporins		
J01DB: First generation cephalosporins	Cefalexin, Cefazolin	Access
J01DC: Second generation cephalosporins	Cefaclor, Cefuroxime	Watch
J01DD: Third generation cephalosporins	Ceftriaxone	Watch
J01E: Sulfonamides and trimethoprim	Trimethoprim, Trimethoprim and sulfamethoxazole	Access
J01F: Macrolides and lincosamides		
J01FA: Macrolides	Azithromycin, Clarithromycin, Erythromycin, Roxithromycin	Watch
J01FF: Lincosamides	Clindamycin	Access
J01M: Quinolones	Ciprofloxacin, Moxifloxacin, Norfloxacin	Watch
J01X: Other antibacterials		
J01XA: Glycopeptides	Vancomycin	Watch
J01XE: Nitrofuran derivatives	Metronidazole, Ornidazole	Access
J01XE: Nitrofuran derivatives	Nitrofurantoin	Access
J01XX: Other	Colistin, Gentamicin, Methenamine, Sodium fusidate, Tobramycin, Vancomycin	Reserve, Access, Unclassified, Access, Watch, Watch

[1] WHO Collaborating Centre for Drug Statistics Methodology. International language for drug utilization research. Edition., [updated 14/11/2021; cited 10/03/2022.Available from: https://www.whocc.no/atc_ddd_index/

[2] Geneva: World Health Organization. WHO Access, Watch, Reserve (AWaRe) classification of antibiotics for evaluation and monitoring of use. 2021.

Appendix 2a: Antibiotic dispensings per antibiotic groups, stratified for 2012 to 2021, and 2012 to 2019.

Antibiotic groups—number of dispensings per 1000 inhabitants per year						
Antibiotic group	**Number of dispensings per 1,000 inhabitants, year 2012**	**Number of dispensings per 1,000 inhabitants, year 2021**	**Delta: 2021 minus 2012 for number dispensings per 1,000 inhabitants**	**Average annual change between 2012–2021, RR (95% CI)**	**Delta: 2019 minus 2012 for number dispensings per 1,000 inhabitants**	**Average annual change in number of dispensings per 1,000 inhabitants between 2012–2019 RR (95% CI)**
β-lactamase-sensitive penicillins	38	18	-20	-6.7 (-6.9 to -6.6)	-15	-4.3 (-4.5 to -4)
β-lactamase-resistant penicillins	108	87	-21	-2.5 (-2.6 to -2.4)	-15	-2.4 (-2.5 to -2.3)
Penicillins with extended spectrum	201	139	-62	-4.8 (-4.9 to -4.8)	-31	-2.6 (-2.7 to -2.5)
Combinations of penicillins with betalactamase inhibitors	134	91	-43	-4.5 (-4.6 to -4.4)	-37	-4.7 (-4.8 to -4.6)
Macrolides and lincosamides	124	54	-70	-8.4 (-8.5 to -8.3)	-51	-7.1 (-7.3 to -7)
First generation cephalosporins*	3	38	35	28.1 (27.7 to 28.4)	20	29.4 (28.9 to 30)
Second generation cephalosporins	19	9	-9	-6.2 (-6.4 to -5.9)	-2	-2.7 (-3 to -2.4)
Third generation cephalosporin	0	1	1	14.1 (12.8 to 15.4)	1	21.7 (19.7 to 23.8)
Tetracyclines	65	47	-18	-3.7 (-3.8 to -3.6)	-10	-3 (-3.1 to -2.8)
Quinolones	49	11	-39	-14.6 (-14.8 to -14.5)	-32	-14.5 (-14.8 to -14.3)
Sulfonamides and trimethoprim	76	42	-35	-5.7 (-5.8 to -5.6)	-18	-3.5 (-3.7 to -3.4)
Nitrofuran derivatives	19	34	14	6 (5.8 to 6.2)	3	0.9 (0.6 to 1.2)
Imidazole derivatives	28	28	0	-1.2 (-1.4 to -1.1)	0	-0.9 (-1.2 to -0.7)
Other+	0.6	3.1	2.5	21.6 (20.5 to 22.8)	0.3	3.5 (2 to 5.1)

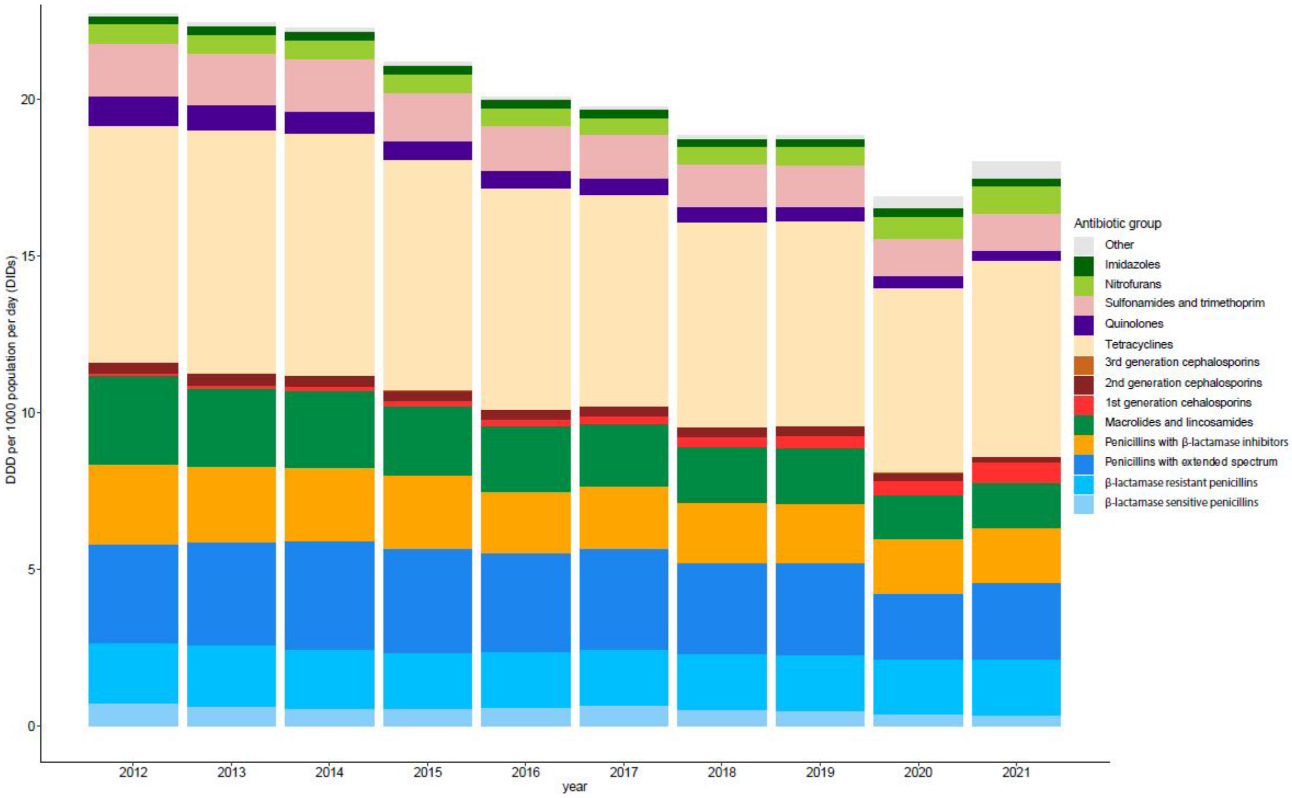
*Increase in first-generation cephalosporins mainly attributable to increases in cefalexin
+ Increase in other antibiotics mainly attributable to increases in methenamine hippurate

Appendix 2a (continued): Antibiotic dispensings per antibiotic groups, stratified for 2012 to 2021, and 2012 to 2019.

Antibiotic groups—defined daily doses per 1000 inhabitants per day (DIDs)						
Antibiotic group	**DIDs, year 2012**	**DIDs, year 2021**	**Delta 2021 minus 2012 for DIDs**	**Average annual change in DIDs between 2012–2021, Beta (95% CI)**	**Delta: 2019 minus 2012 for DIDs**	**Average annual change in DIDs between 2012–2019, Beta (95% CI)**
β-lactamase-sensitive penicillins	0.73	0.36	-0.37	-0.03 (-0.05 to -0.02)	-0.24	-0.02 (-0.04 to 0)
β-lactamase-resistant penicillins	1.92	1.76	-0.15	-0.02 (-0.03 to -0.01)	-0.14	-0.03 (-0.04 to -0.02)
Penicillins with extended spectrum	3.15	2.47	-0.69	-0.11 (-0.17 to -0.05)	-0.19	-0.05 (-0.09 to -0.01)
Combinations of penicillins with betalactamase inhibitors	2.58	1.74	-0.84	-0.1 (-0.11 to -0.08)	-0.68	-0.1 (-0.13 to -0.08)
Macrolides and lincosamides	2.83	1.43	-1.40	-0.15 (-0.17 to -0.13)	-1.07	-0.15 (-0.17 to -0.13)
First generation cephalosporins*	0.07	0.67	0.60	0.06 (0.05 - 0.07)	0.33	0.04 (0.04 to 0.05)
Second generation cephalosporins	0.33	0.17	-0.16	-0.02 (-0.02 to -0.01)	-0.02	-0.01 (-0.01 to 0)
Third generation cephalosporin	0.00	0.01	0.00	0 (0 to 0)	0.00	0 (0 to 0)
Tetracyclines	7.58	6.27	-1.31	-0.2 (-0.25 to -0.16)	-1.05	-0.2 (-0.25 to -0.14)
Quinolones	0.93	0.32	-0.61	-0.06 (-0.07 to -0.05)	-0.49	-0.07 (-0.08 to -0.05)
Sulfonamides and trimethoprim	1.69	1.19	-0.50	-0.06 (-0.07 to -0.05)	-0.34	-0.05 (-0.07 to -0.04)
Nitrofuran derivatives	0.61	0.85	0.24	0.01 (0 to 0.03)	-0.04	-0.01 (-0.02 to 0)
Imidazole derivatives	0.24	0.26	0.02	0 (0 to 0)	0.01	0 (-0.01 to 0)
Other+	0.09	0.53	0.44	0.04 (0.01 to 0.06)	0.04	0 (0 to 0.01)

* Increase in first-generation cephalosporins mainly attributable to increases in cefalexin.
+ Increase in other antibiotics mainly attributable to increases in methenamine hippurate.

Appendix 2b: Defined daily doses per 1,000 inhabitants per day (DIDs) per antibiotic group



Appendix 3a: Analysis per WHO AWaRe groups

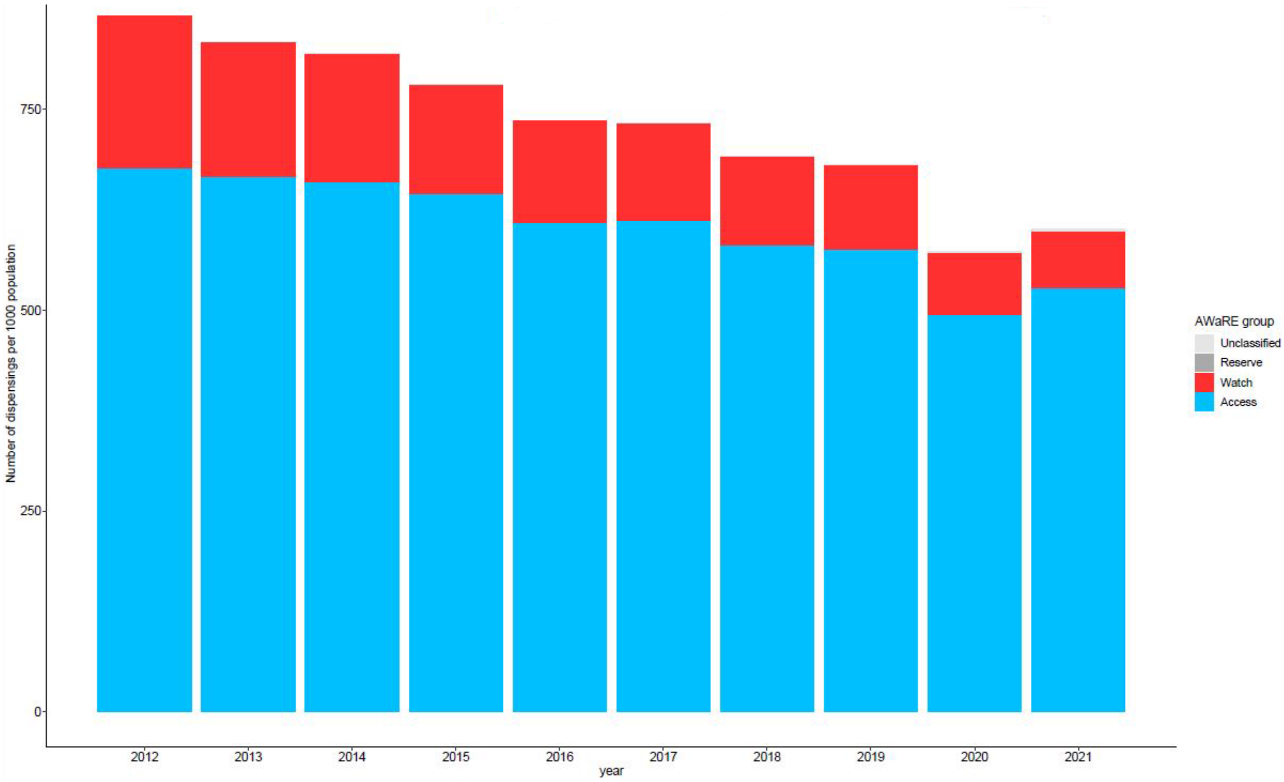
WHO AWaRe groups —number of dispensings per 1,000 inhabitants per year						
AWaRe	**Number of dispensings per 1,000 inhabitants, year 2012**	**Number of dispensings per 1,000 inhabitants, year 2021**	**Delta 2021 to 2012 for number dispensings per 1,000 inhabitants**	**Average annual change between 2012-2021, RR (95% CI)**	**Delta: 2019 minus 2012 for number dispensings per 1,000 inhabitants**	**Average annual change in number of dispensings 2012–2019 RR (95% CI)**
Access	675	527	-149	-3.2 (-3.2 to -3.1)	-101	-3.2 (-3.3 to -3.2)
Watch	191	71	-120	9.5 (-9.6 to -9.5)	-85	-9.9 (-10 to -9.8)
Reserve	0	0	0	12.1 (1.8 to 23.9)	0	14.5 (2.2 to 29.1)
Unclassified	0	3	2	26.7 (25.3 to 28.1)	0	17.6 (16.1 to 19.2)

Appendix 3a (continued): Analysis per WHO AWaRe groups

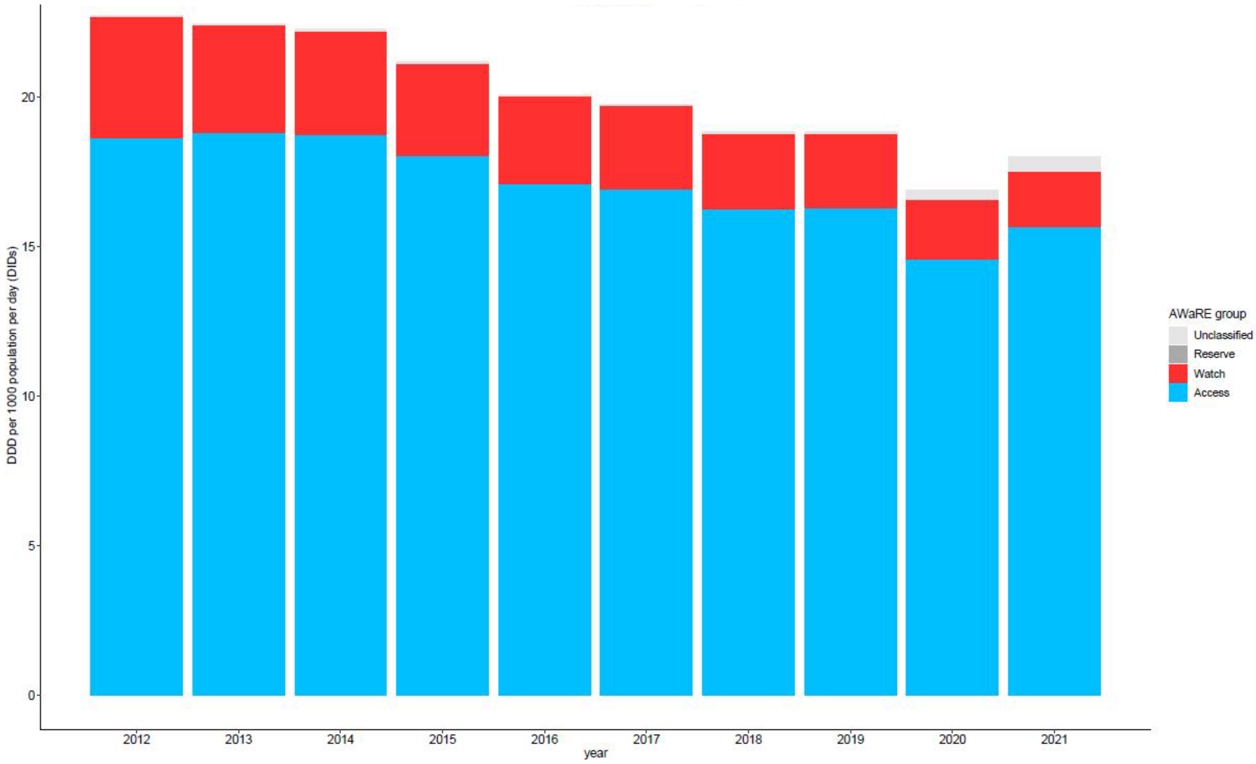
WHO AWaRe groups—defined daily doses per 1,000 inhabitants per day (DIDs) per antibiotic group						
AWaRe	**DIDs, year 2012**	**DIDs, year 2021**	**Delta 2021 to 2012 for DIDs**	**Average annual change in DIDs between 2012–2021, Beta (95% CI)**	**Delta: 2019 minus 2012 for DIDs**	**Average annual change in DIDs Beta (95% CI)**
Access	18.6	15.6	-3.0	-0.45 (-0.56 to -0.34)	-2.35	-0.42 (-0.53 to -0.32)
Watch	4.1	1.9	-2.2	-0.23 (-0.25 to -0.21)	-1.57	-0.22 (-0.26 to -0.19)
Reserve	0.0	0.0	0.0	0 (0 to 0)	0.00	0 (0 to 0)
Unclassified	0.1	0.5	0.4	0.04 (0.01 to 0.06)	0.04	0 (0 to 0.01)

DIDs: Defined daily doses per 1,000 inhabitants per day.

Appendix 3b: Dispensings per 1,000 inhabitants per WHO AWaRE group (figure).



Appendix 3c: Defined daily doses per 1,000 inhabitants per day (DIDs) per WHO AWaRe group (figure).



Appendix 4a: Stratified analysis for age and ethnicity.

Age groups—number of dispensings per 1,000 inhabitants per year						
Age groups	**Number of dispensings per 1,000 inhabitants year 2012**	**Number of dispensings per 1,000 inhabitants year 2021**	**Delta 2021 to 2012 for number dispensings per 1,000 inhabitants**	**Average annual change between 2012–2021, RR (95% CI)**	**Delta 2019 to 2012 for number dispensings per 1,000 inhabitants**	**Average annual change between 2012-2019, RR (95% CI)**
0–4 years	1,652	881	-772	-7.6 (-7.7 to -7.5)	-593	-5.6 (-5.7 to -5.5)
5–9 years	613	335	-278	-5.4 (-5.5 to -5.2)	-132	-1.6 (-1.8 to -1.4)
10–19 years	686	456	-229	-4.5 (-4.6 to -4.4)	-152	-3.4 (-3.5 to -3.2)
20–19 years	665	521	-144	-3.1 (-3.2 to -3.1)	-91	-2.6 (-2.7 to -2.5)
60 years and above	1,155	860	-296	-3.5 (-3.6 to -3.5)	-173	-3 (-3 to -2.9)

Appendix 4a (continued): Stratified analysis for age and ethnicity.

Ethnicity groups—number of dispensings per 1,000 inhabitants per year						
Ethnicity groups	**Number of dispensings per 1,000 year 2012**	**Number of dispensings per 1,000 year 2021**	**Delta 2021 to 2012 for number dispensings per 1,000**	**Average annual change between 2012–2021, RR (95% CI)**	**Delta 2019 to 2012 for number dispensings per 1,000 inhabitants**	**Average annual change between 2012–2019, RR (95% CI)**
Other	849	629	-220	-3.6 (-3.6 to -3.6)	-136	-2.8 (-2.8 to -2.7)
Māori	572	598	26	0.8 (0.7 to 1)	88	1.7 (1.5 to 1.9)
Pacific peoples	800	637	-163	-2.3 (-2.5 to -2.1)	19	0.3 (0 to 0.6)
Asian	357	378	-21	0.1 (0 to 0.3)	58	2 (1.8 to 2.2)

Appendix 5: International comparison for defined daily doses per 1,000 inhabitants per day.