Longitudinal trends in community antibiotic dispensing: a surveillance study of Aotearoa New Zealand from 2010 to 2019

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ABSTRACT

AIM: We aimed to investigate community systemic antibiotic dispensing in New Zealand across 2010–2019.

METHODS: This longitudinal study utilised dispensing data from the National Pharmaceutical Collection and population data from the Health New Zealand – Te Whatu Ora populations web tool. Dispensing rates were measured as the number of defined daily doses/1,000 inhabitants per day (DIDs) and courses dispensed/1,000 inhabitants/year. Dispensing data were stratified by antibiotic group, AWaRe (Access, Watch, Reserve) categories, district health board (DHB) region and patient characteristics.

RESULTS: Between January 1 2010 and December 31 2019, community systemic antibiotic dispensing in New Zealand declined, with courses dispensed dropping from 930 to 782 (average annual change [AAC] −1.9%) and DID from 20.9 to 19.6 (AAC −0.75%). Watch antibiotics decreased by 8% in courses dispensed/1,000 inhabitants/year, with quinolones showing the largest proportional reduction (−37 courses dispensed/1,000 inhabitants/year; AAC −13.4%). Conversely, first-generation cephalosporins increased significantly (+45 courses dispensed/1,000 inhabitants/year; AAC +56%), primarily due to cefalexin. Ethnic differences persisted, with Pacific people consistently exhibiting the highest dispensing rates. Most DHB regions experienced an overall decline in dispensing during this period.

CONCLUSIONS: The study identified encouraging trends in antibiotic dispensing, reflecting New Zealand's antimicrobial stewardship initiatives, but also highlighted the rise in cefalexin and ongoing variations that require further investigation.

Antibiotics play a critical role in healthcare by providing essential treatment and prevention of bacterial infections, ranging from common ailments to life-threatening illnesses. However, the effectiveness of antibiotics is increasingly threatened by the emergence of antimicrobial resistance (AMR).[1,2] AMR now ranks among the top 10 global health threats, with an estimated 1.27 million deaths worldwide in 2019.[2] Future projections suggest a marked rise in AMR-related deaths, potentially reaching 10 million annually by 2050, accompanied by substantial increases in healthcare costs exceeding US$1 trillion.[2]

Excessive use of antibiotics can lead to the emergence of resistant bacteria. Human consumption in the community is a significant driver of high antibiotic use.[3] This is particularly evident in high-income countries (HICs), where community consumption accounts for 85–95% of all antibiotic use.[3] There is limited development of new antibiotics by the pharmaceutical industry; hence, re-evaluating and reducing antibiotic use is critical to mitigating the progression of AMR and its associated consequences.[1]

Encouragingly, over the last decade, there have been signs of decreased community antibiotic dispensing in countries such as New Zealand, Australia, Canada, the United Kingdom (UK), Denmark and Sweden.[4–11] Despite this reduction, New Zealand still exhibits comparatively high dispensing rates. In 2018, the number of defined daily doses per 1,000 inhabitants per day (DIDs) in New Zealand (22.5 DIDs) exceeded those in UK (18.7 DIDs), Denmark (15.5 DIDs), Sweden (12.4 DIDs), Netherlands (9.7 DIDs) and Australia (22.4 DIDs). However, it remained lower than those in Spain (26.2 DIDs) and Greece (34.1 DIDs).[9,10]

One factor contributing to New Zealand's comparatively high antibiotic dispensing rates could be the higher burden of infectious diseases among certain groups. Māori and Pacific people experience disproportionately high hospitalisation rates for certain infectious diseases, particularly acute rheumatic fever, which is almost exclusively seen in Māori and Pacific children.[12]

Prescribing practices may also be contributing to the high dispensing rates in New Zealand. For instance, during 2014–2015, a 26% increase in

antibiotic dispensing for upper respiratory tract infections during winter may suggest a tendency to prescribe antibiotics for viral cases, which are not effectively treated with these medications.[6]

Given these potential contributing factors, it is essential to analyse recent trends in community-based antibiotic dispensing within New Zealand to gain a comprehensive understanding of current practices. Such understanding is crucial for promoting more judicious use of antibiotics in healthcare and ensuring that existing frameworks are responsive to the unique health needs of New Zealand's diverse population.

This study aims to describe the trends in community antibiotic dispensing in New Zealand from 2010 to 2019, with a focus on examining the demographic and geographic patterns associated with this usage.

Methods

Study design and data collection

This was a longitudinal study using national, community-based, systemic antibiotic dispensing data from 2010 to 2019. Dispensing and demographic data were obtained from the National Pharmaceutical Collection (NPC). The NPC contains records of all subsidised drugs dispensed by community pharmacies across New Zealand since 1992.[13] Antibiotics dispensed to hospital inpatients, patients without subsidises and by practitioner supply orders (PSO) were excluded.

Collected data included the type of antibacterial agent, the quantity and the dosage dispensed. Antibiotics were classified under the Anatomical Therapeutic Chemical (ATC) system, specifically under the J01 category for antibacterial agents intended for systemic use (see Appendix 1).[14] The dataset also included details of the district health board (DHB) region where the antibiotics were dispensed, as well as patient demographic characteristics. These comprised age groups (<5 years, 5–9 years, 10–19 years, 20–59 years and 60+ years), sex (male or female), prioritised ethnicity (Māori, Pacific people, Asian, and "Other") and socio-economic deprivation measured by the New Zealand Index of Deprivation (NZDep) quintiles. NZDep13 was used for the years 2010–2016, while NZDep18 was used for the years 2017–2019. Population estimates were obtained from the Health New Zealand – Te Whatu Ora population web tool, which provides detailed demographic information for New Zealand, including breakdowns by DHB, age, prioritised ethnicity and deprivation quintiles.[15]

Derived variables

Antibiotic dispensing was assessed using two measures: i) the number of dispensed courses per 1,000 inhabitants per year, and ii) the number of DIDs per 1,000 inhabitants per day. The DID represents the average daily dosage for a 70kg adult as defined by the World Health Organization (WHO).[16] However, because the DID calculation is based on adult weight, it does not accurately estimate paediatric dosage.[14] Therefore, for the age group analysis, only the number of dispensed courses per 1,000 inhabitants per year was considered.

In addition to these measures, antibiotic categories were further classified according to the AWaRe (Access, Watch, and Reserve) tool introduced by the WHO in 2018.[17] This tool monitors antimicrobial stewardship (AMS) efforts by grouping commonly used antibiotics based on their spectrum and resistance potential. The *Access* group includes narrow-spectrum antibiotics recommended as first-choice agents, while the *Watch* group comprises broader-spectrum antibiotics associated with higher-resistance risks.[17] The *Reserve* group is reserved for infections involving suspected multi-drug–resistant organisms and is recommended as a last resort.[17] WHO guidelines suggest that at least 60% of national antibiotic usage should come from the Access category.[17] Building on this, the UK set a more ambitious target in its 2024 AMR action plan, aiming to increase Access category usage to 70% by 2029.[18]

Data analysis

Data was grouped by year, age group, sex, prioritised ethnicity and deprivation quintiles before calculating the number of dispensed courses per 1,000 inhabitants per year and DIDs. For sex, prioritised ethnicity and deprivation quintiles, the dispensed courses per 1,000 inhabitants per year were age-standardised using the direct method and the World Standard (WHO 2000–2025) as the reference population.[16]

Changes over time in overall dispensing patterns were examined by presenting the data in figures and tables and calculating the average annual change (AAC) between the first and last study years (2010 and 2019). Additionally, stratified analyses were conducted according to ATC groupings and WHO AWaRe classification (see Appendix 1), DHB regions and patient characteristics including age group, sex, prioritised ethnicity and deprivation. All analyses were conducted using R (Version

2023.06.02).

Ethical considerations

Māori consultation was conducted, and ethical approval for this study was granted by the University of Otago Human Ethics Committee (Reference: HD23/061).

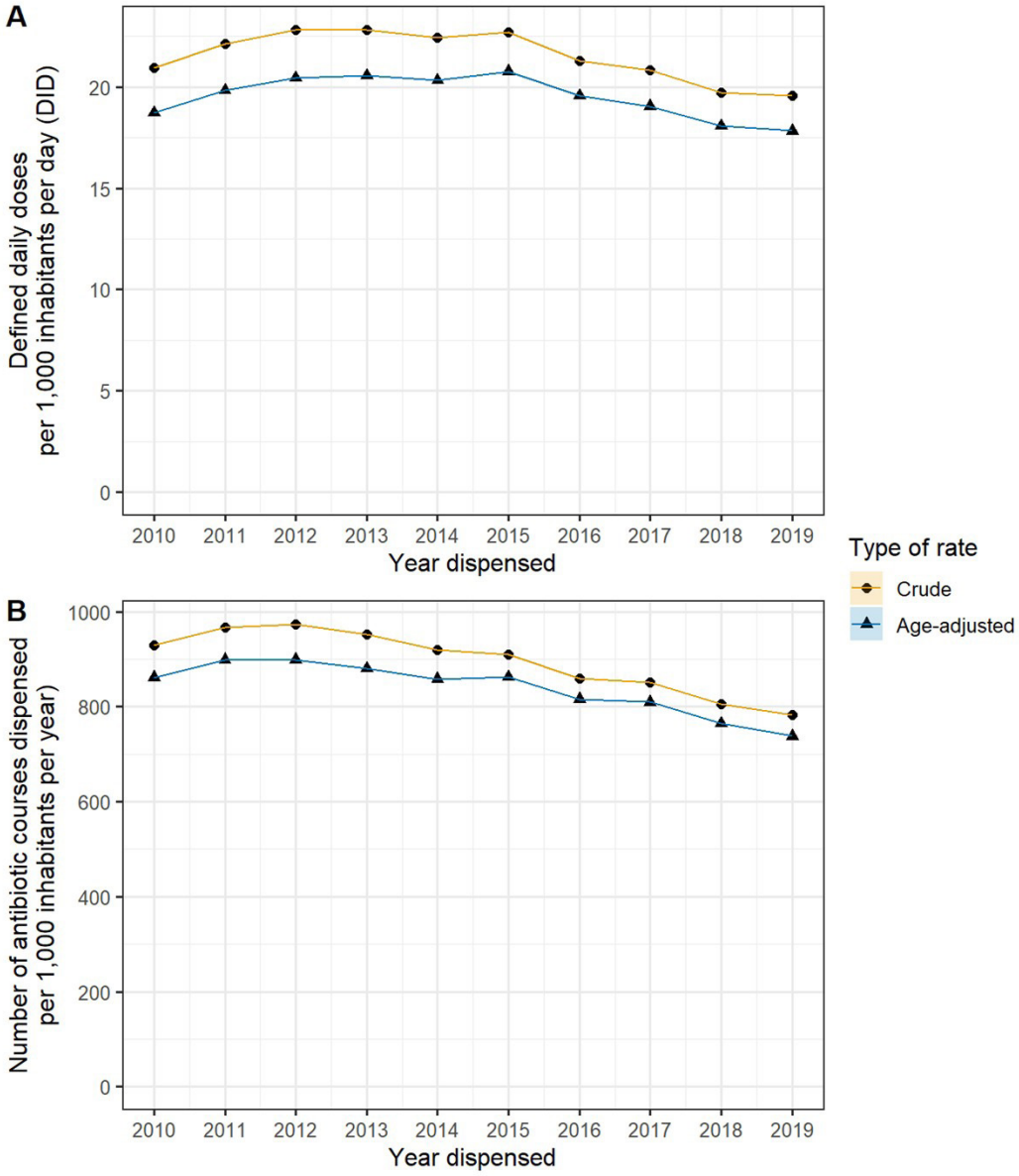
Results

In 2010, 4,045,177 systemic antibiotic courses were dispensed to at least 1,796,538 individuals. By 2019, this had decreased to 3,894,786 courses dispensed to 1,926,149 people. A small number (3.3%) of courses could not be linked to specific people and were missing demographic data. The proportion of courses not linked to specific people decreased steadily between 2010 (5.5%) and 2019 (1.2%).

Overall antibiotic dispensing

Between 2010 and 2019, there was an overall decline in community-based antibiotic dispensing per person. The courses dispensed/1,000 inhabitants/year fell from 930 in 2010 to 782 in 2019, indicating an AAC of −1.9%. The DID decreased modestly from 20.9 to 19.6, with an AAC of −0.75% (see Figure 1 and Appendix 2).

Figure 1: Community systemic antibiotic dispensing between 2010 and 2019 by defined daily doses per 1,000 inhabitants per day (DIDs) (a), and antibiotic courses dispensed per 1,000 population per year (b).



Over the study period, both measures initially increased before showing a subsequent decline. The number of courses dispensed/1,000 inhabitants/year rose by 44 from 2010 to 2012, then decreased by 191 from 2013 to 2019. Similarly, the DID increased by 1.9 from 2010 to 2012, and remained elevated until 2015 before dropping by 3.1 between 2015 and 2019 (see Appendix 2).

Antibiotic dispensing per antibiotic group

The largest reductions in the number of courses dispensed/1,000 inhabitants/year were observed in relation to penicillin with beta-lactamase inhibitors (−63 courses dispensed/1,000 inhabitants/year; AAC −4.6%), quinolones (−37 courses dispensed/1,000 inhabitants/year; AAC −13%) and macrolides/lincosamides (−30 courses dispensed/1,000 inhabitants/year; AAC −3.4%) (see Appendix 3). Quinolones were associated with the largest proportional decrease, with an approximately 3.5-fold reduction in courses dispensed/1,000 inhabitants between 2010 and 2019.

Some antibiotic groups exhibited an increase in dispensing over the study period. First-generation cephalosporins increased the most (+45 courses dispensed/1,000 inhabitants/year; AAC +56%), largely driven by cefalexin. There were also small increases in nitrofuran derivatives (+8.3 courses dispensed/1,000 inhabitants/year; +5.5 DIDs) and Other antibiotics (+0.8 courses dispensed/1,000 inhabitants/year; AAC +12%) (see Appendix 3).

Antibiotic dispensing per WHO AWaRe group

The proportion of antibiotics in the Access category rose from 81% to 86% when measured by DIDs and from 78% to 86% when assessed by the number of courses dispensed/1,000 inhabitants/year (see Figure 2 and Appendix 4). Conversely, in the Watch category, there was a decrease in DIDs from 19% to 13%, with a parallel decline from 22% to 14% in the number of courses dispensed/1,000 inhabitants/year (see Figure 2 and Appendix 4).

Antibiotic dispensing per DHB

Between 2010 and 2019, notable discrepancies were observed among DHBs in relation to the absolute changes in both DIDs and courses dispensed/1,000 inhabitants/year for systemic antibiotics in the community.

The majority of DHBs experienced a decline in DIDs during this period. This ranged from a substantial decrease in Tairāwhiti (−4.2 DIDs) to a small reduction in the West Coast (−0.6 DIDs). Conversely, two DHBs had an increase in DIDs: Taranaki (+0.6 DID) and Southern (+0.1 DID) (see Appendix 5a and Appendix 5b).

All DHBs showed a decline in the annual number of systemic antibiotic courses dispensed per 1,000 inhabitants per year. Bay of Plenty experienced the most significant reduction (−255 courses dispensed/1,000 inhabitants/year), while Taranaki exhibited the smallest decrease (−68 courses dispensed/1,000 inhabitants/year) (see Appendix 5a and Appendix 5b).

Antibiotic dispensing by patient characteristics

The number of courses dispensed/1,000 inhabitants/year declined across all age groups. Notably, children under 5 years old had a substantial reduction, with the dispensing rate decreasing by approximately a third from 2010 to 2019 (see Figure 3 and Appendix 6).

Over the study period, females consistently exhibited a higher dispensing rate compared with males, regardless of whether it was measured by the number of courses dispensed/1,000 inhabitants/year or DIDs (see Appendix 6a and Appendix 6b).

Ethnic differences persisted throughout the study years, with Pacific people consistently having the highest dispensing rates and people of Asian ethnicity having the lowest, both in terms of DIDs and the courses dispensed/1,000 inhabitants/year (see Figure 4 and Appendix 6).

The most deprived quintile (quintile 5) consistently had the highest dispensing rates between 2010 and 2019, regardless of whether it was measured by the number of courses dispensed/1,000 inhabitants/year or DIDs (see Figure 5 and Appendix 6).

Discussion

Community systemic antibiotic dispensing per inhabitant in New Zealand decreased between 2010 and 2019. The number of courses dispensed/1,000 inhabitants/year decreased by 148 courses (16% decrease), while the number of DIDs declined by a smaller amount (1.3 DIDs, 6.2% decrease). There was also a notable decrease in the proportion of antibiotics dispensed from the WHO Watch category, particularly a significant drop in quinolones. Conversely, cefalexin showed a marked increase in proportional usage. Significant variation in dispensing rates was observed among ethnic groups, with Pacific people exhibiting the

Figure 2: Percentage of community systemic antibiotic dispensing by the World Health Organization AWaRe groups in Aotearoa New Zealand during 2010-2019.

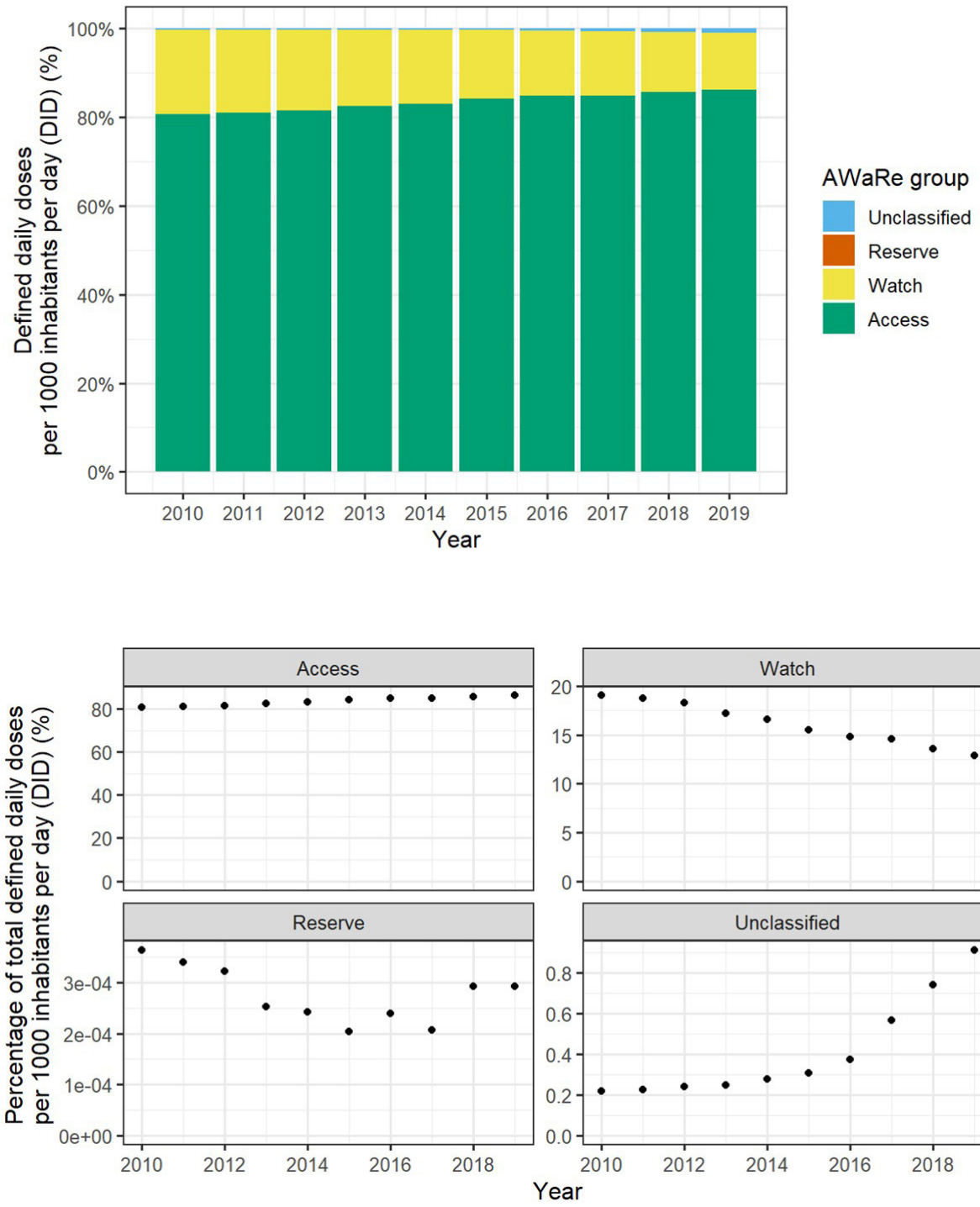
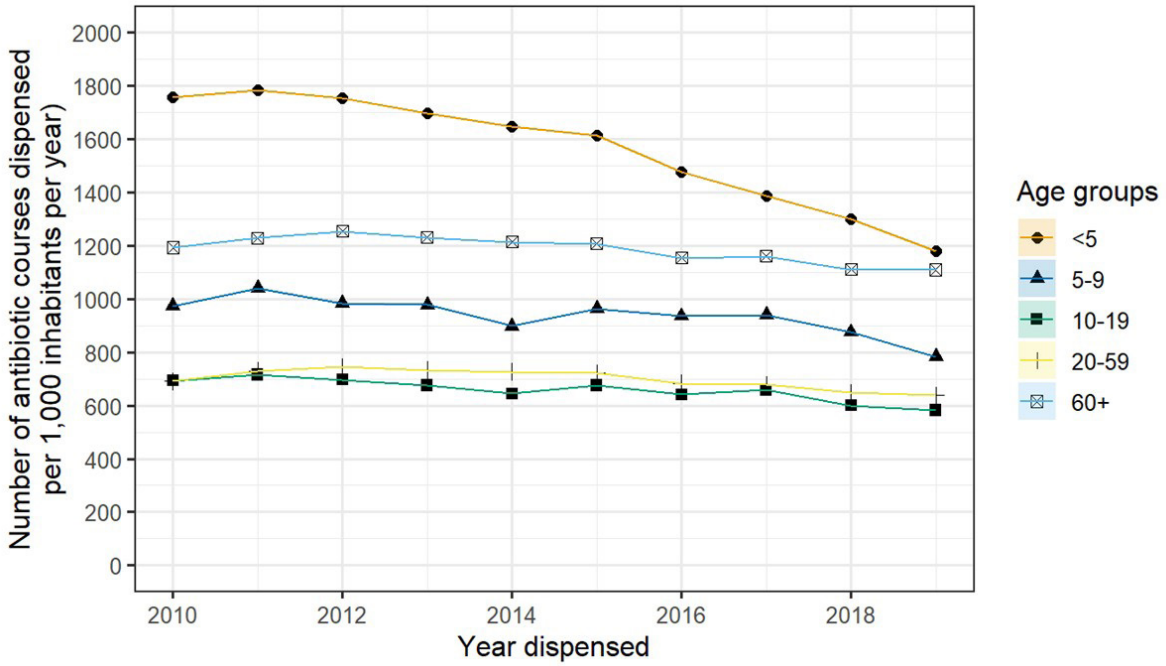


Figure 3: The number of systemic antibiotic courses dispensed per 1,000 inhabitants per year in the Aotearoa New Zealand community between 2010 and 2019 by age group.



highest age-adjusted dispensing rates. Additionally, individuals in the most deprived quintile had the highest rates of antibiotic dispensing, based on the age-adjusted courses dispensed rate. Furthermore, both the young and elderly consistently showed higher rates of antibiotic dispensing.

The observed decline in antibiotic consumption in New Zealand during the second half of the past decade parallels similar trends in other HICs, including the UK, Canada, Australia and the European Union.[9–11] This trend may reflect concerted international efforts to enhance AMS. A significant milestone in this global initiative was the launch of the WHO's global action plan on AMR in 2015, which was adopted by 79% of member countries—including New Zealand—who implemented their own national action plans (NAPs) by 2017.[19]

New Zealand's NAP embodies a "one-health" approach, incorporating initiatives across human, animal and agricultural sectors.[20] In 2015, the New Zealand Veterinary Association set an ambitious goal to eliminate the necessity of using antibiotics for maintaining animal health by 2030.[21] Since then, significant progress has been made, with a reported 42% decrease in antibiotic sales in the animal and agricultural sectors from 2017 to 2022.[21]

In human health, multiple efforts are underway. The Institute of Environmental Science and Research (ESR) is responsible for national AMR surveillance of human pathogens, monitoring ongoing trends and the potential emergence of new AMR threats.[20] Numerous initiatives aimed at promoting responsible antibiotic use include national programmes (such as the AMR group and DHB-based AMR teams), comprehensive guidelines (both national, like the Best Practice Advocacy Centre *Antibiotic Guide* and the New Zealand Formulary, and regional, such as HealthPathways), targeted interventions and campaigns, such as the 2019 Antibiotic Amnesty.[21–26]

During this same period (2011–2017), New Zealand implemented the Rheumatic Fever Prevention Programme—a national initiative that aimed to improve access to antibiotics, particularly penicillin, for high-risk populations through school-based sore throat services and public health campaigns.[27] Eleven DHBs in the North Island participated, reflecting a substantial investment in improving accessibility in regions with the highest incidence of rheumatic fever.[27] While this programme likely increased antibiotic use in targeted communities, the fact that a national decline in dispensing was still observed is encouraging, suggesting that reductions occurred despite efforts to expand access in specific areas.

These human health initiatives have likely

Figure 4: Age-standardised rates of community systemic antibiotic dispensing between 2010 and 2019 by ethnicity measured by defined daily doses per 1,000 inhabitants per day (DIDs) (a), and antibiotic courses dispensed per 1,000 population per year (b).

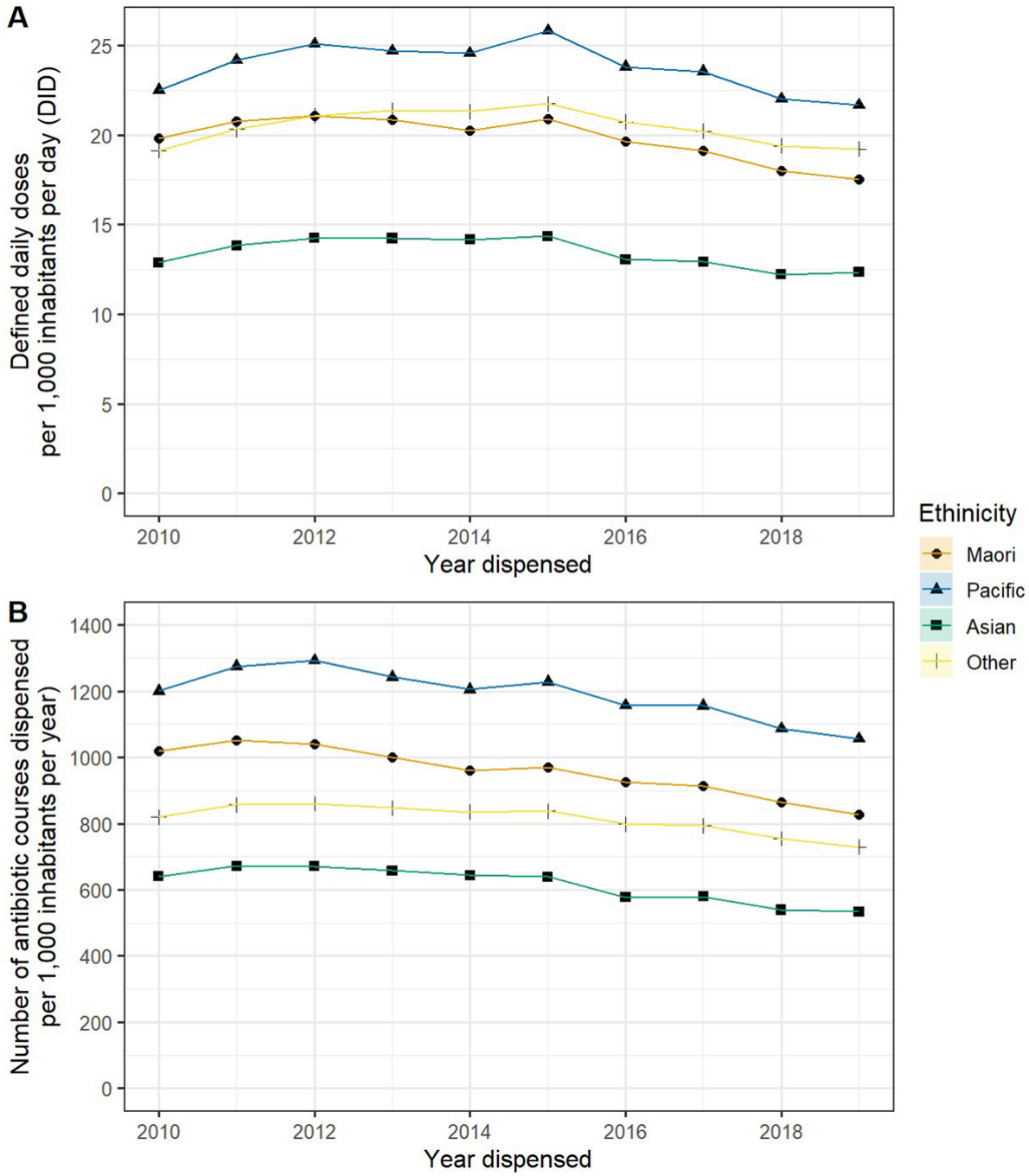
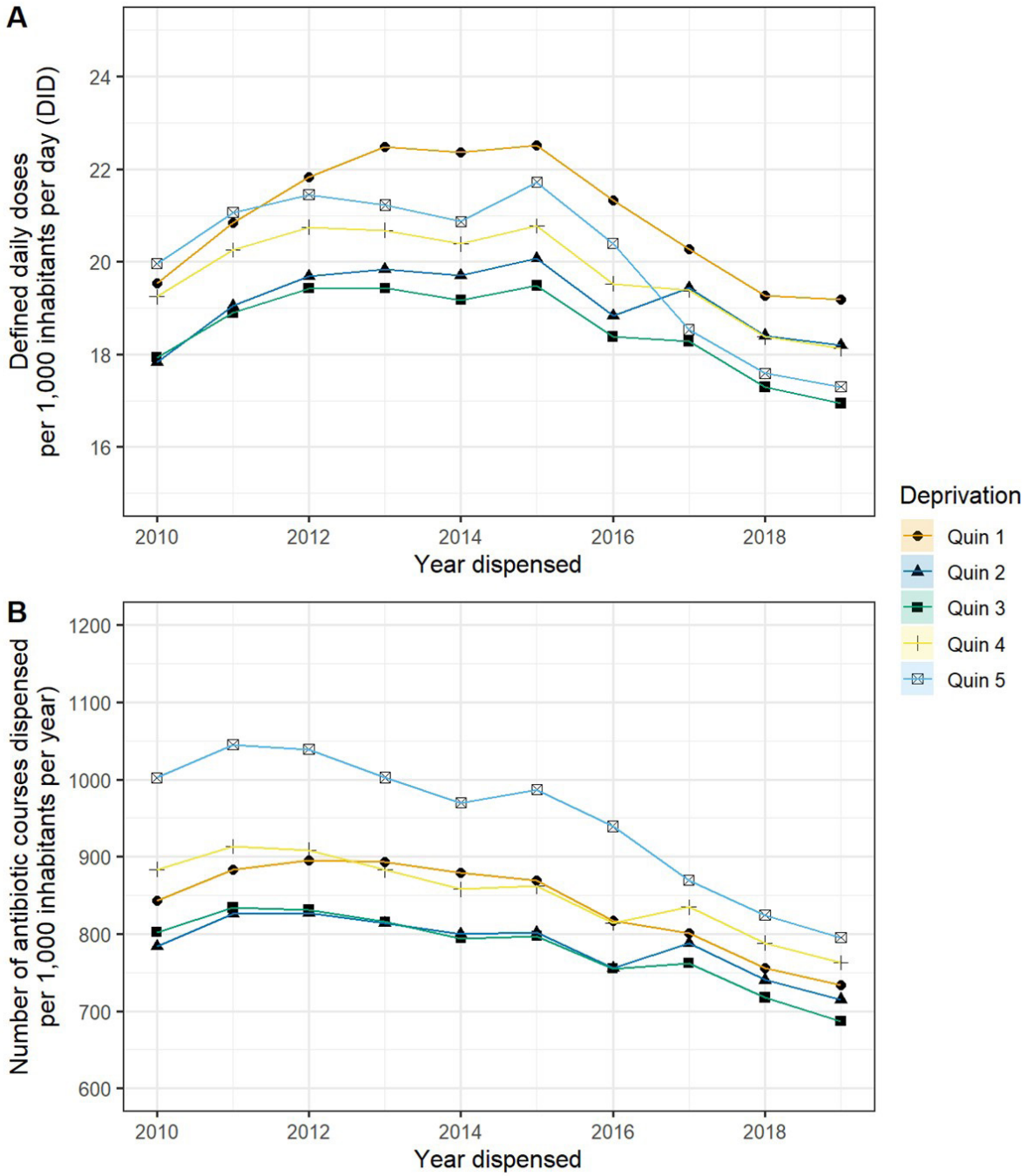


Figure 5: Age-standardised rates of community systemic antibiotic dispensing between 2010 and 2019 by New Zealand Deprivation (NZDep) quintiles (quintile 1 = least deprived, quintile 5 = most deprived). Measured by the number of defined daily doses per 1000 population per day (DIDs) (a), and the number of antibiotic courses dispensed per 1,000 inhabitants per year (b).



(a) y axis range is 16–24 DIDs and (b) y axis range is 600–1200 courses dispensed per 1,000 inhabitants per year.

contributed to the observed decrease in community antibiotic dispensing, especially for antibiotics with a greater risk of resistance, such as those in the Watch category. Recent guideline revisions for quinolones strongly discourage prescribing these antibiotics and impose several prescribing restrictions.[28] Ciprofloxacin now requires endorsement from a specialist before use, and midstream urine test results do not include sensitivity to ciprofloxacin unless the microbe is resistant to first- and second-line antibiotics.[28] Quinolone prescribing has reduced by one-third, suggesting that ongoing initiatives such as these may be changing prescribing practices.

By contrast, first-generation cephalosporins have seen a significant proportional increase in both the number of courses dispensed/1,000 inhabitants/year and DIDs, driven primarily by the rising use of cefalexin. Similar patterns have been observed in Australia over the past decade.[10] Cefalexin is commonly prescribed for various indications, including skin and soft tissue infections and urinary tract infections.[23] Until national guidelines were revised in 2019, cefalexin was also recommended for the treatment of recurrent group A streptococcal sore throats, which may partly account for its increased use during the study period.[29] Given that cefalexin is a broad-spectrum antibiotic, a more detailed understanding of the factors contributing to its increased use in New Zealand is warranted. Further research is currently underway to investigate this trend.

There was marked variation in dispensing rates related to ethnicity, with the highest rates observed among Pacific people, while the "Other" ethnic group had the second highest dispensing rates per 1,000 inhabitants per year. Although ethnicity is associated with differing infectious burdens, drawing definitive conclusions about disparities in healthcare access from the data remains challenging.[13]

During the COVID-19 pandemic, Duffy et al. observed that reducing antibiotic dispensing across all ethnic groups did not lead to an increase in specific sentinel infections, suggesting that healthcare needs could still be fulfilled with lower antibiotic use.[30] However, this study coincided with a period of reduced infectious burden due to COVID-19 interventions.[6] To gain deeper insights into the relationship between antibiotic dispensing and healthcare outcomes outside of COVID-19 contexts, looking at the relationship between antibiotic dispensing and hospitalisation rates using the National Minimum Dataset (NMD) would be highly useful.[31] This approach would contribute to a balanced assessment, monitoring both lowering dispensing targets while simultaneously assessing whether healthcare needs were being met.

Implications for research, policy and practice

This study shows a reduction in community antibiotic dispensing per inhabitants across a period (2010–2019), but the large proportional rise in cefalexin use warrants further investigation to understand its causes and implications for New Zealand's AMS.

Implementing an ongoing surveillance programme for community antibiotic dispensing in New Zealand, similar to those in Australia, Canada, the UK and the European Union/European Economic Area, could be a promising strategy for enhancing AMS in the future.[9–11] These countries collect and report dispensing data every 1–2 years, offering valuable insights into dispensing patterns.[9–11] A similar programme, managed by Health New Zealand – Te Whatu Ora, could be a publicly accessible resource that complements existing strategies such as prescribing guidelines and Antimicrobial Awareness Week.[21–26]

A unified surveillance system would strengthen existing AMR efforts led by ESR and provide clinicians with regular feedback to refine their prescribing practices.[21] By capturing detailed data on antibiotic use—including recipients, types and geographic trends—this programme could drive evidence-based AMS initiatives and enable local stakeholders to measure their progress more effectively. Furthermore, integrating dispensing data with hospitalisation trends from the NMD could offer a more comprehensive view of antibiotic use and healthcare needs.[31] Ultimately, this system would serve as a supportive tool, bolstering both existing and future AMS interventions and guiding more appropriate prescribing practices across New Zealand.

Strengths and limitations

This study is the first nationwide analysis in New Zealand to use the AWaRe classification system for investigating community antibiotic dispensing, highlighting AMS efforts over time. Study strengths include dual outcome measures and a thorough analysis of community antibiotic trends. By examining data across antibiotic groups, geographical regions and patient characteristics, the study identifies demographic variations and provides insights for future AMS strategies.

Additionally, the updated DDD Index (Defined Daily Dose Index) enhances the accuracy of DID calculations and, in turn, improves interpretation of New Zealand's dispensing patterns and international comparability.[14]

However, the study is not without limitations. Primarily, it is limited to observations of the quantity and distribution of antibiotics dispensed, without providing underlying information about the clinical conditions that lead to the dispensing. Thus, the study cannot comment on whether the observed changes are due to appropriate or inappropriate prescribing. Additionally, the study fails to account for all community antibiotic dispensing, particularly from PSOs. In addition to PSOs, unsubsidised antibiotics with a prescription from a practitioner and pharmacist-supplied antibiotics (e.g., trimethoprim) were not included in this dataset.[5] Finally, the use of DDD may not accurately reflect paediatric antibiotic usage patterns.

Conclusions

There has been a small decline in community antibiotic dispensing per inhabitant in New Zealand from 2010 to 2019, aligning with global trends. These findings are encouraging, particularly due to the overall reduction in the Watch group of antibiotics, indicating progress in AMS efforts.

Study results underscore persistent variation in dispensing across demographic groups. It remains uncertain whether the dispensing trends reflect healthcare needs and represent appropriate prescribing.

Further research is needed to investigate the factors contributing to the observed prescribing variations and the increase in cefalexin usage. Establishing a national surveillance framework that also utilises NMD data for bacterial infections would provide valuable insights.

COMPETING INTERESTS
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Appendices

Appendix 1: Anatomic therapeutic chemical and AWaRe classification for funded systemic antibiotics.

ATC group	Antibiotic agent	AWaRe classification
J01A: tetracyclines	Doxycycline, minocycline, tetracycline	Access
J01C: penicillins		
J01CA: penicillins with extended spectrum	Amoxicillin	Access
J01CE: β-lactamase-sensitive penicillins	Phenoxymethylpenicillin, benzyl-penicillin, benzathine penicillin, procaine penicillin	Access
J01CF: β-lactamase-resistant penicillins	Flucloxacillin	Access
J01CR: combinations of penicillins with β-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

Appendix 1 (continued): Anatomic therapeutic chemical and AWaRe classification for funded systemic antibiotics.

J01XE: nitrofuran derivatives	Metronidazole, ornidazole,	Access
J01XE: nitrofuran derivatives	Nitrofurantoin	Access
J01XX: other	Colistin, gentamicin, methenamine, tobramycin, vancomycin	Reserve, Access, Unclassified, Access Watch, Watch

Appendix 2: The defined daily doses per 1,000 inhabitants per day (DIDs) and number of antibiotic courses per 1,000 inhabitants per year in the Aotearoa New Zealand community from 2010 to 2019. Presented alongside the average annual change (AAC) between 2010 and 2019.

	2010	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**AAC (%)**
DIDs	20.4	21.6	22.3	22.4	22.3	22.8	21.4	21.0	20.0	19.9	−0.27
Number of antibiotic courses per 1,000 inhabitants per year	867	906	914	897	879	879	834	830	787	767	−1.7

Appendix 3: Systemic antibiotic dispensing rates in the Aotearoa New Zealand community for 2010 and 2019 by antibiotic group. Rates are presented as defined daily doses per 1,000 inhabitants per day (DIDs) and number of antibiotic courses per 1,000 inhabitants per year in the Aotearoa New Zealand community for 2010 and 2019. Presented alongside the average annual change (AAC) between 2010 and 2019.

Antibiotic group	DID				Number of antibiotic courses per 1,000 inhabitants per year			
	2010	2019	Delta: 2010–2019	AAC (%)	2010	2019	Delta: 2010–2019	AAC (%)
J01A: tetracyclines								
Tetracyclines	5.6	6.0	+0.4	−3.2	57	56	−1	−1.7
J01C: penicillins								
Penicillin with extended spectrum	3.2	4.1	+0.9	−3.0	210	222	+12	−3.8
Beta-lactamase sensitive penicillins	0.5	0.3	−0.2	−4.3	28	15	−13	−6.5
Beta-lactamase resistant penicillins	1.8	1.7	−0.1	−0.7	106	89	−17	−2.5
Penicillin with beta-lactamase inhibitors	3.2	2.3	−0.9	−8.5	165	115	−50	−5.0
J01D: cephalosporins								
First-generation cephalosporins	0.0	0.6	+0.6	+19.2	1	45	+45	+30.0
Second-generation cephalosporins	0.8	0.4	−0.4	−16.9	42	19	−23	−10.3

Appendix 3 (continued): Systemic antibiotic dispensing rates in the Aotearoa New Zealand community for 2010 and 2019 by antibiotic group. Rates are presented as defined daily doses per 1,000 inhabitants per day (DIDs) and number of antibiotic courses per 1,000 inhabitants per year in the Aotearoa New Zealand community for 2010 and 2019. Presented alongside the average annual change (AAC) between 2010 and 2019.

Antibiotic group	DID				Number of antibiotic courses per 1,000 inhabitants per year			
	2010	2019	Delta: 2010–2019	AAC (%)	2010	2019	Delta: 2010–2019	AAC (%)
Third-generation cephalosporins	0.00	0.00	0	0	0	0	0	0.0
J01E: sulfonamides and trimethoprim								
Sulfonamides and trimethoprim	1.6	1.5	−0.1	−2.6	67	61	−6	−2.5
J01F: macrolides and lincosamides								
Macrolides/ lincosamide	2.3	1.8	−0.5	−6.2	105	80	−25	−4.2
J01M: quinolones								
Quinolones	0.1	0.3	+0.2	−10.3	49	14	−35	−14.4
J01X: other antibacterials								
Imidazole derivatives	0.2	0.3	+0.1	−1.8	24	29	+5	−2.0
Nitrofuran derivatives	0.4	0.5	+0.1	−0.6	13	22	+9	+2.7
Other	0.1	0.2	+0.1	+26.6	1	2	+1	+13.0

All standard errors (SE) were minuscule (SE <0.0001); therefore, level of precision for results is how it is presented.

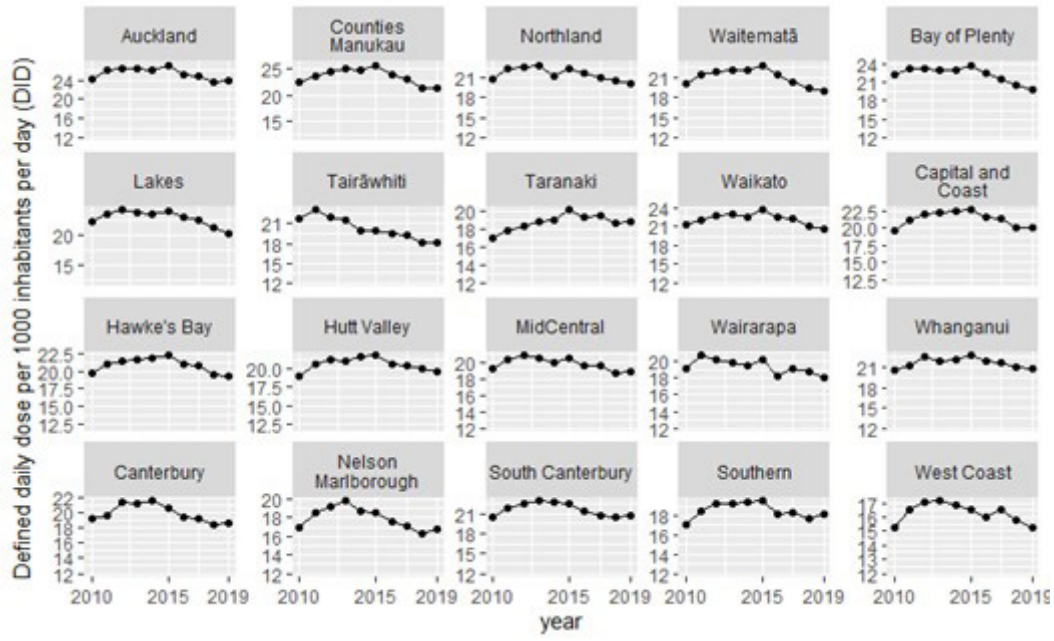
Appendix 4: Proportion of total community systemic antibiotic dispensing attributed to each World Health Organization AWaRe group in Aotearoa New Zealand for 2010 and 2019, with absolute change (delta: 2019–2010) and average annual change (AAC).

	DID				Number of antibiotic courses per 1,000 inhabitants per year			
AWaRe group	**2010**	**2019**	**Delta: 2019–2010**	**AAC (%)**	**2010**	**2019**	**Delta: 2019–2010**	**AAC (%)**
Access	81	87	+7	1.0	78	86	+8	1.0
Watch	19	13	−6	−1.3	22	14	−8	−18
Reserve	0.0	0.0	0	0.0	0.0	0.0	0	0.0
Unclassified	0.2	0.9	+0.7	18	0.0	0.2	+0.2	18

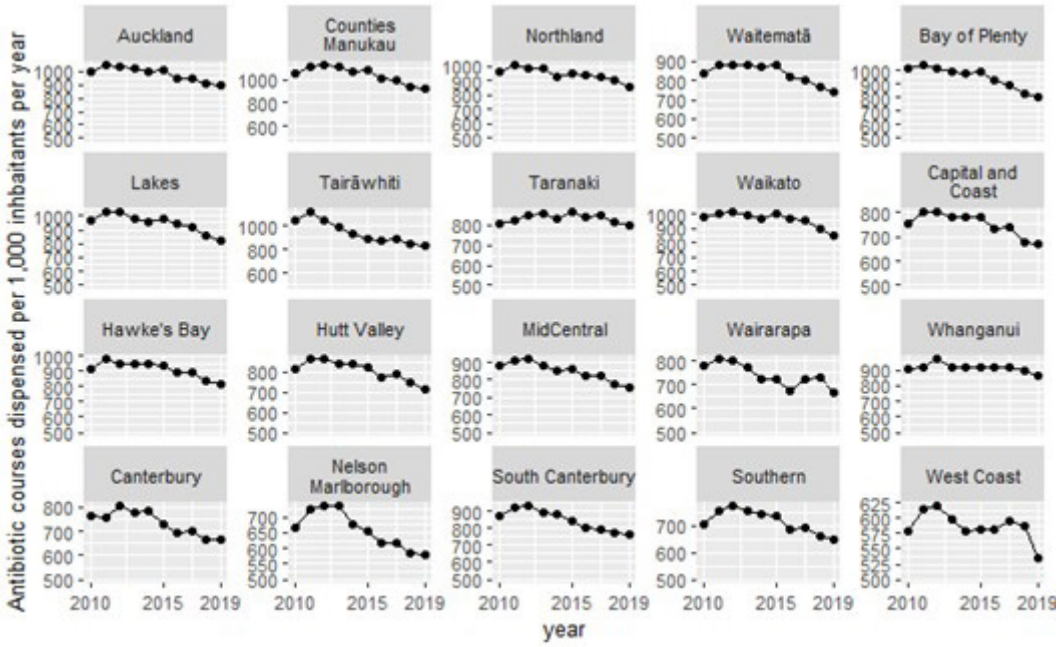
Values represent the proportion (%) of total community systemic antibiotic dispensing attributed to each AWaRe group, calculated separately for defined daily doses per 1,000 inhabitants per day (DIDs) and antibiotic courses per 1,000 inhabitants per year.

Appendix 5a: Rates of in-community systemic antibiotic dispensing between 2010 and 2019 for each district health board (DHB) region by defined daily doses per 1,000 inhabitants per day (DIDs) (a), and antibiotic courses dispensed per 1,000 population per year (b).

(a)



(b)



Graph (a) y axis limit is 10 DIDs and Graph (b) y axis limit is 500 courses dispensed per 1,000 inhabitants per year.

Appendix 5b: Systemic antibiotic dispensing rates in the Aotearoa New Zealand community by district health board (DHB) region between 2010 and 2019. Rates presented as defined daily doses per 1,000 inhabitants per day (DIDs) and number of antibiotics courses dispensed per 1,000 inhabitants per year alongside the average annual change (AAC).

	DID				Number of courses dispensed per 1,000 inhabitants per year			
DHBs	**2010**	**2019**	**Delta: 2019–2010**	**AAC (%)**	**2010**	**2019**	**Delta: 2019–2010**	**AAC (%)**
Northern Region								
Auckland	24.1	23.9	−0.2	−0.7	972	665	−307	−1.6
Counties Manukau	22.4	21.2	−0.8	−1.0	1,031	899	−132	−2.1
Northland	20.9	20.1	−0.8	−0.9	959	853	−106	−1.3
Waitematā	20.0	19.1	−0.9	−1.0	816	724	−92	−1.7
Midland Region								
Bay of Plenty	22.2	19.9	−2.3	−1.4	999	798	−201	−2.6
Lakes	22.1	20.3	−1.8	−1.2	966	817	−149	+2.0
Tairāwhiti	21.7	18.1	−3.6	−2.5	1,037	831	−206	−3.1
Taranaki	17.0	18.8	−1.8	+1.0	802	797	−5	−0.2
Waikato	21.4	20.5	−0.9	−0.5	963	844	−119	−1.4
Central Region								
Capital and Coast	19.7	20.0	+0.3	−0.4	746	664	−82	−1.7
Hawke's Bay	19.7	19.4	−0.3	−0.6	910	812	−98	−1.6
Hutt Valley	18.9	19.6	+0.7	−0.2	804	712	−92	−1.7

Appendix 5b (continued): Systemic antibiotic dispensing rates in the Aotearoa New Zealand community by district health board (DHB) region between 2010 and 2019. Rates presented as defined daily doses per 1,000 inhabitants per day (DIDs) and number of antibiotics courses dispensed per 1,000 inhabitants per year alongside the average annual change (AAC).

	DID				Number of courses dispensed per 1,000 inhabitants per year			
DHBs	**2010**	**2019**	**Delta: 2019–2010**	**AAC (%)**	**2010**	**2019**	**Delta: 2019–2010**	**AAC (%)**
MidCentral	19.2	18.8	−0.4	−0.7	874	754	−120	−1.9
Wairarapa	19.1	18.0	−1.1	−1.1	781	661	−120	−1.9
Whanganui	20.5	20.9	+0.4	0	905	859	−46	−0.6
South Island Region								
Canterbury	19.2	18.6	−0.6	−1.0	750	656	−94	−2.0
Nelson Marlborough	17.0	16.7	−0.3	−1.2	662	577	−105	−2.5
South Canterbury	20.6	20.6	0.0	−0.7	866	762	−104	−2.1
Southern	17.0	18.1	+1.1	−0.1	697	647	−50	−1.5
West Coast	15.2	15.2	0.0	−0.4	577	534	−43	−0.8

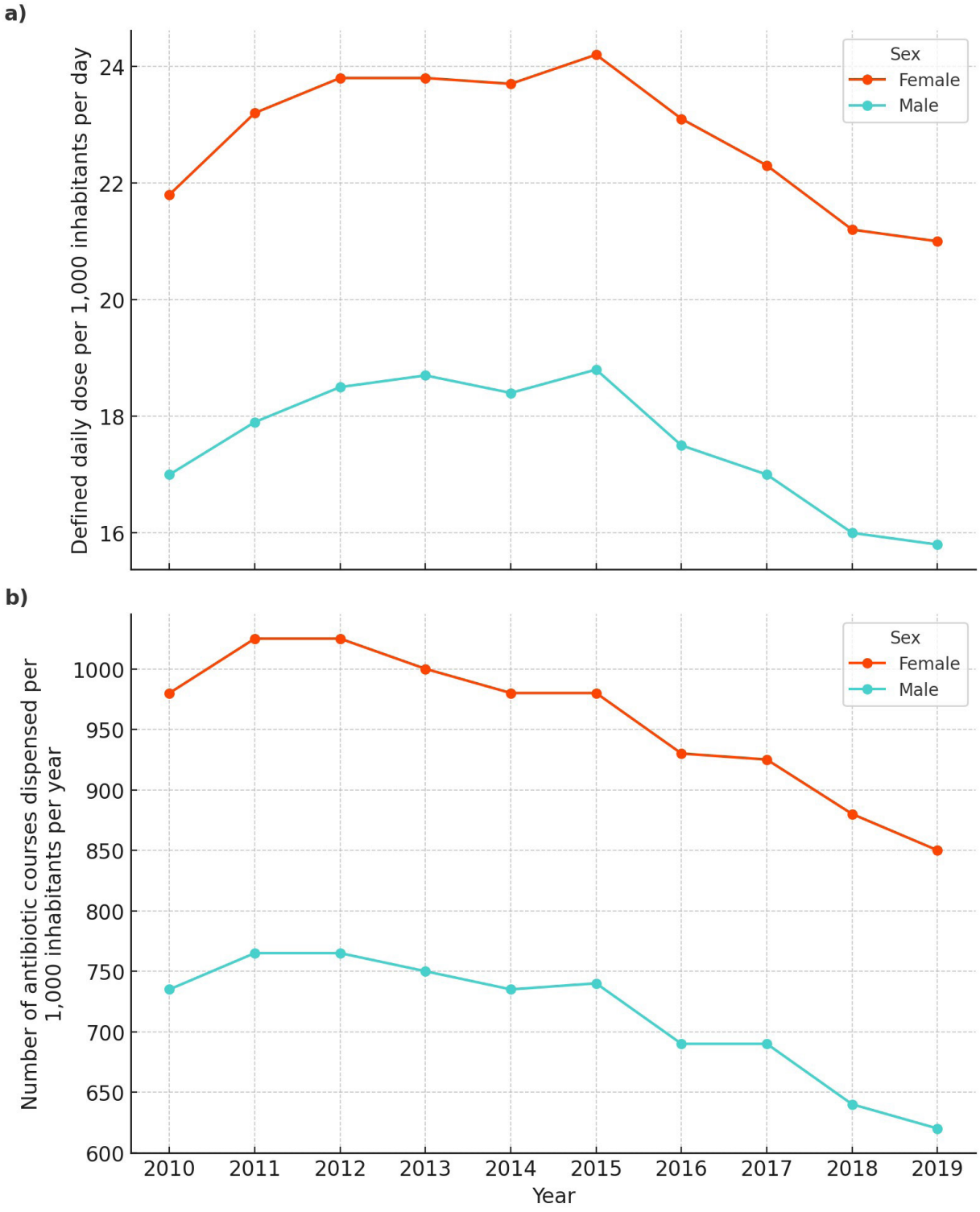
All standard errors (SE) were minuscule (SE <0.0001); therefore, level of precision for results is how it is presented.

Appendix 6a: Systemic antibiotic dispensing rates in the Aotearoa New Zealand community by patient characteristics. Rates presented as defined daily doses per 1,000 inhabitants per day (DIDs) and number of antibiotics courses dispensed per 1,000 inhabitants per year and the average annual change (AAC).

	DID				Number of antibiotic courses per 1,000 inhabitants per year			
Patient characteristics	**2010**	**2019**	**Delta: 2019–2010**	**AAC (%)**	**2010**	**2019**	**Delta: 2019–2010**	**AAC (%)**
Age								
>5					1,758	1,179	−579	−1.8
5–9					975	785	−190	−1.8
10–19					695	584	−111	−1.8
20–59					692	641	−51	−1.8
60+					1,200	1,117	−83	−1.8
Sex								
Females	21.8	21.1	−0.7	−1.0	981	851	−130	−1.6
Males	17.0	15.9	−1.1	−1.0	732	625	−107	−1.6
Ethnicity								
Māori	28.1	28.5	+0.4	−0.5	1,322	1,228	−94	−1.4
Pacific people	34.7	34.6	−0.1	−0.3	1,674	1,555	−119	−1.0
Asian	20.4	20.3	−0.1	−0.6	918	838	−80	−1.3
Other	30.9	32.7	+1.8	0	1,278	1,208	−70	−0.7
Deprivation quintile								
1	30.2	30.1	−0.1	−0.6	1,371	1,235	−136	−1.3
2	29.0	31.4	+2.4	0	1,184	1,169	−15	−0.3

Appendix 6a (continued): Systemic antibiotic dispensing rates in the Aotearoa New Zealand community by patient characteristics. Rates presented as defined daily doses per 1,000 inhabitants per day (DIDs) and number of antibiotics courses dispensed per 1,000 inhabitants per year and the average annual change (AAC).

	DID				Number of antibiotic courses per 1,000 inhabitants per year			
Patient characteristics	**2010**	**2019**	**Delta: 2019–2010**	**AAC (%)**	**2010**	**2019**	**Delta: 2019–2010**	**AAC (%)**
3	30.8	30.5	−0.3	−0.5	1,273	1,165	−108	−1.1
4	31.7	28.9	−2.8	−1.8	1,343	1,123	−220	−2.4
5	39.0	33.2	−5.8	−2.2	1,672	1,322	−350	−2.9

All standard errors (SE) were minuscule (SE <0.0001); therefore, level of precision for results is how it is presented.

Appendix 6b: Age-standardised rates of community systemic antibiotic dispensing between 2010 and 2019 by sex and measured in defined daily doses per 1,000 inhabitants per day (DIDs) (a), and antibiotic courses dispensed per 1,000 population per year (b).