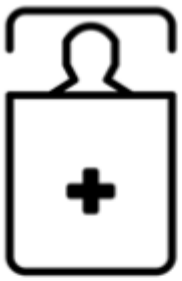
Surveillance of Antimicrobial Use and Resistance in Northern Ireland, Annual Report

2018

HSC Public Health Agency

Contents

Executive summary



E.coli
Bloodstream infection has increased from **980** in 2009 to **1703** in 2017

K. pneumoniae
Bloodstream infection increased from **143** in 2009 to **256** in 2017

E.coli resistance to Piperacillin-tazobactam
8.8% in 2009
17.7% in 2017

K. pneumoniae resistance to Piperacillin-tazobactam
8.6% in 2009
24.2% in 2017

Antibiotic Prescribing:
Primary care: **85.4%** (84% in-hours, 1.4% out-of-hours)
Secondary care: **14.6%**

Slight decrease in total antibiotic use from **31.37** DDD/1000 inhabitants per day in 2014 to **29.87** in 2017

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Acknowledgements

The information produced in this report is based on information derived from data submitted by Health and Social Care Trust microbiology and pharmacy staff, and we thank them for the time and effort involved in producing these data.

We also thank David Farren, Derek Fairley and Sara Hedderwick for their input into the original design of this report.

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Background

Antibiotics have been one of the most important life-saving medical developments of the last century. However, they are not effective against all types of bacteria (so-called intrinsic resistance). In addition, some bacteria can develop tolerance to certain antibiotics or develop ways to break them down (so-called extrinsic resistance). In either case, if these go on to cause an infection it can be much more difficult to treat resistant bacteria. If the use of antibiotics remains unchecked, common infections will become more dangerous, and surgical procedures where antibiotics are used will become more difficult to perform safely. Antimicrobial-resistant infections already cause illness and death in patients, and also disrupt care in hospitals. Reducing the use of antibiotics where they are not necessary will help keep antibiotics working in the future. In recognition of this, the NI Department of Health (then the Department of Health, Social Services and Public Safety) published a five year Strategy for Tackling Antimicrobial Resistance (STAR 2012-2017) in 2012[1]. One of the key objectives of STAR was "to establish and maintain systems to monitor antimicrobial usage and surveillance of resistance". This report is a product of the systems that have been established in response to this goal.

The tasks of preventing and reducing antimicrobial resistant infections, and reducing antimicrobial consumption in Northern Ireland are led by the Strategic Antimicrobial Resistance and Healthcare-associated Infection (SAMRHAI) group, which includes representatives responsible for animal and environmental as well as human health. For translating policy and strategy into action for human health, the Public Health Agency leads a multi-agency group, the Healthcare-associated Infection and Antimicrobial Stewardship Improvement Board, which has a number of themed subgroups that are responsible for regional efforts to reduce harm from antimicrobial use and resistance in different settings. This report is issued under the auspices of the Improvement Board and is divided into two major sections. The first describes trends in antibiotic resistance in Northern Ireland. Selected combinations of bacteria and antibiotics in line with those identified as key indicators as part of the UK Antimicrobial Resistance strategy[2] were chosen. In addition, bacteria-antibiotic combinations included in the English surveillance programme for antimicrobial utilisation and resistance (ESPAUR) report[3] were also chosen.

The second section describes the trends in antibiotic consumption in Northern Ireland. Antibiotic consumption is the key driver for the emergence of resistance in healthcare. Antibiotics are prescribed across a range of settings including primary care (GP), secondary care (hospitals) and by dentists. In this report, information from primary and secondary

care is provided. More detailed information about different healthcare settings and clinical specialities will be provided in future reports.

The aim of the report is to describe trends in antimicrobial resistance and antibiotic consumption in Northern Ireland. As surveillance data is 'information for action', this report will inform and drive best practice in antimicrobial prescribing.

Method

Antibiotic resistance

Data sources

Testing for bacteria in human specimens and their susceptibility to antibiotics is conducted in the laboratories of the five Health and Social Care Trusts in Northern Ireland. Infections that meet certain criteria, usually the most severe that occur in the blood (bacteraemias), are reported voluntarily to the Public Health Agency's CoSurv Information System directly from each Trust's laboratory. The resistance data included in this report includes selected bacteraemias that were reported to the PHA between 2009 - 2017 (presented by calendar year).

The data for carbapenemase producing organisms (CPO) has been collected as part of a voluntary reporting service. In cases where a microbiology laboratory suspects a CPO, the specimen is submitted to Public Health England's (PHE) Antimicrobial Resistance and Healthcare Associated Infections (AMRHAI) reference unit for investigation. Most recently, some health and social care trusts have developed the capacity to perform this function locally. Confirmed isolates include both colonisation and infections.

Definitions

Hospital microbiology laboratories report antimicrobial susceptibility test results "susceptible", "intermediate" or "resistant". For the purpose of this report, antibiotic susceptibility test results reported as "intermediate" or "resistant" were combined and presented as "non-susceptible". For analysis of resistance to more than one antibiotic, multidrug resistance (MDR) was defined as acquired non-susceptibility to at least one agent in three or more antimicrobial classes.

Antibiotic consumption

Data sources

Consumption data for primary and secondary care was obtained using the data submitted to the European Antimicrobial Consumption Surveillance Network (ESAC-Net). The primary care antimicrobial consumption data were extracted from the Electronic Prescribing Database by the Health and Social Care Board. The data includes all Health and Social Care, general practitioner prescribing in practices and out-of-hours centres; all nurse, pharmacy and allied health professional HSC prescribing; and dental prescribing. The secondary care antimicrobial consumption data were extracted by each Trust's JAC Medicines Management System and aggregated for all five Trusts to give Northern Ireland totals. It was not possible to analyse at the level of inpatient or outpatient. The data for both settings are available from 2014 - 2017 and are presented by calendar year.

Data from Out-of-Hours settings was extracted from two sources; the JAC Medicines Management System and a private pharmaceutical company responsible for over-labelling of antibiotic packs. Data was only available for the years 2016-2017.

Definitions

The classification of antibiotic used is based on the anatomical therapeutic chemical (ATC) classification system, using the WHO defined daily doses (DDD) for each drug and where grouped, this has been done according to Kucer's "The Use of Antibiotics" (6th edition)[4]. It is important to note that in England, hospitals usually dispense outpatient medications, whereas in Northern Ireland these are usually prescribed by general practitioners at the request of secondary care specialists. A significant proportion of outpatient prescribing is therefore counted under primary care in Northern Ireland as opposed to secondary care in England. There is currently no way of separating these prescriptions from the rest of primary care prescribing in Northern Ireland. In England, outpatient prescribing accounts for 7% of secondary care antimicrobial prescribing [3]. The data for both settings in this report include ATC classification groups J01, A07 and P01, please refer to Appendix 2 for specific inclusions.

Denominator

Mid-year population estimates for 2014-2017 were obtained from the Northern Ireland Statistics and Research Agency (NISRA) and used to express DDD's per 1,000 inhabitants per day. Hospital activity and occupancy statistics were obtained from data published by the Department of Health.

Results

Antibiotic resistance

E. coli bacteraemia

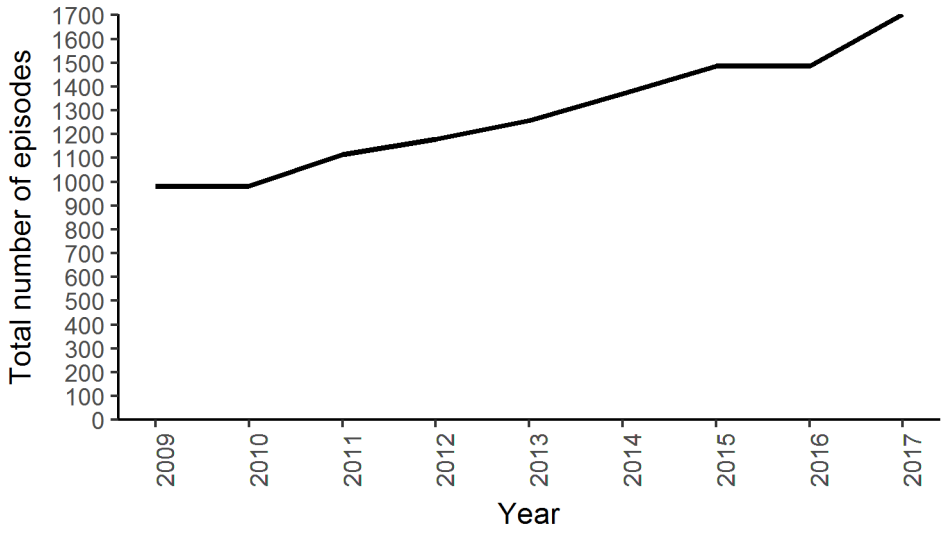


Figure 1: The number of *E. coli* bacteraemias reported to the Public Health Agency, 2009 - 2017

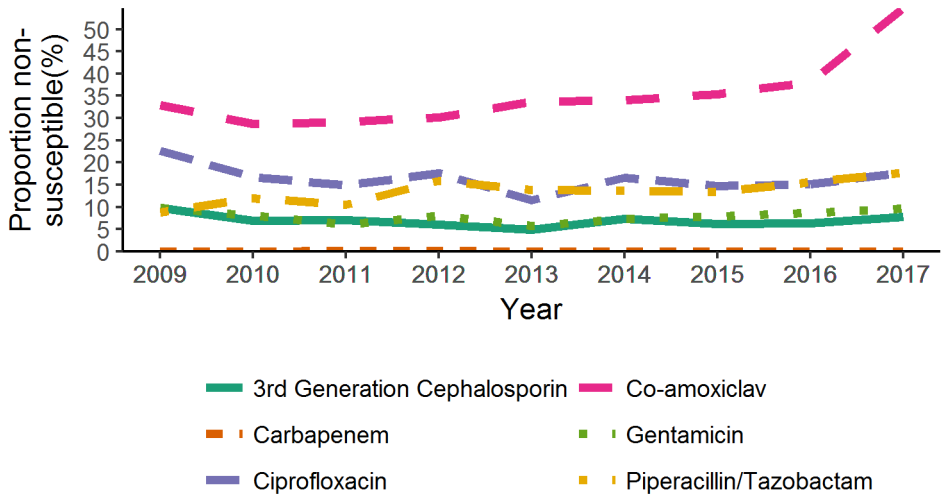


Figure 2: The proportion of *E. coli* bacteraemias resistant to selected antibiotics in NI, 2009 - 2017

The number of *E. coli* bacteraemias has increased from 980 in 2009 to 1703 cases in 2017 (Figure 1). The proportion of isolates tested against key antibiotics during 2017 is shown in Appendix 3.

Resistance to piperacillin/tazobactam and co-amoxiclav has increased over the time period (8.8% to 17.7% and 32.9% to 54.7% respectively). The proportion of isolates resistant to gentamicin has remained relatively stable during 2009 - 2017 (9.8% and 9.6%). There were no *E. coli* isolates resistant to carbapenems detected in 2017. Resistance to third generation cephalosporins and ciprofloxacin has decreased (9.8% to 7.7% and 22.6% to 17.7% respectively (Figure 2)).

Despite the reduction in the proportion of resisant isolates reported for the chosen antibioitics, it should be noted that in absolute terms the number of resistant isolates have increased. For example, while the proportion of isolates resistant to ciprofloxacin decreased during 2009 - 2017 (22.6% to 17.7%), the number of infections increased (182 to 271 episodes). The number of isolates resistant to three or more antibiotic classes also increased (34 to 70 episodes).

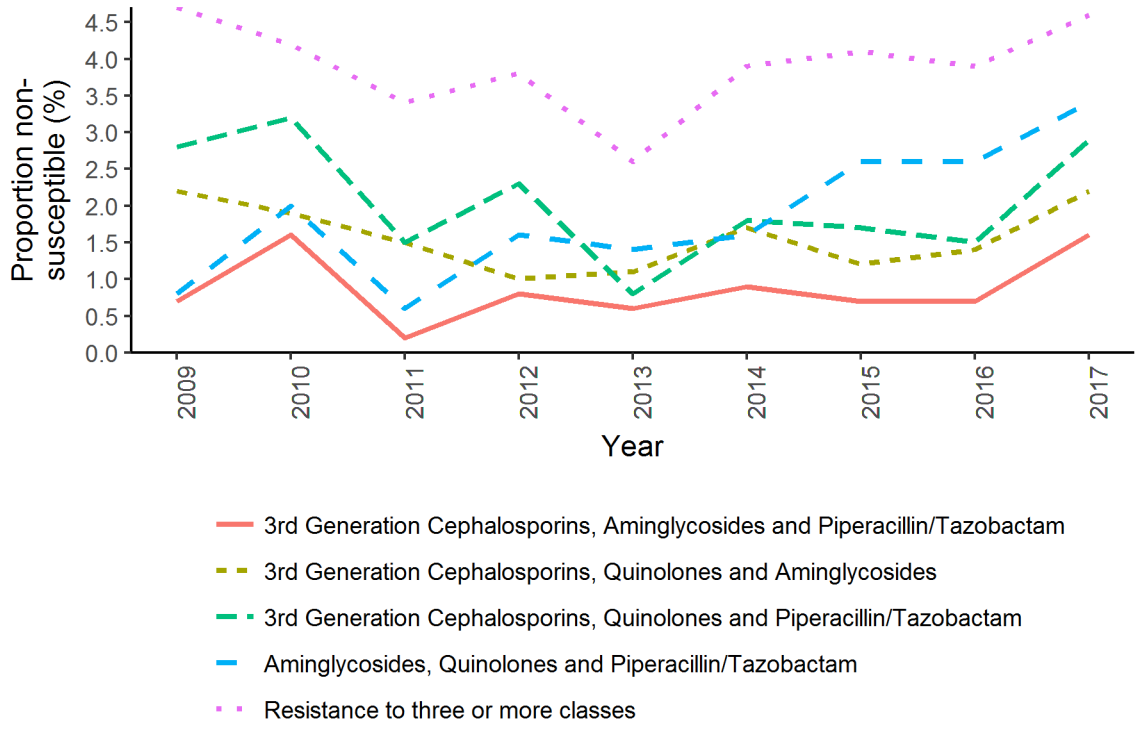


Figure 3: The proportion of *E. coli* bacteraemias reported to the Public Health Agency with multi-drug resistance, 2009 - 2017

The proportion of *E. coli* bacteraemias showing multi-resistance remained stable between 2009 and 2017 and varied in the range of 1-4%. Resistance to at least three or more antibiotic classes has fluctuated around 4%. Within the combination of antibiotic classes, the highest proportion of resistance was seen for combinations of aminoglycosides, quinolones and piperacillin/tazobactam and the lowest for third-generation cephalosporins, aminoglycosides and piperacillin/tazobactam (Figure 3).

K. pneumoniae bacteraemia

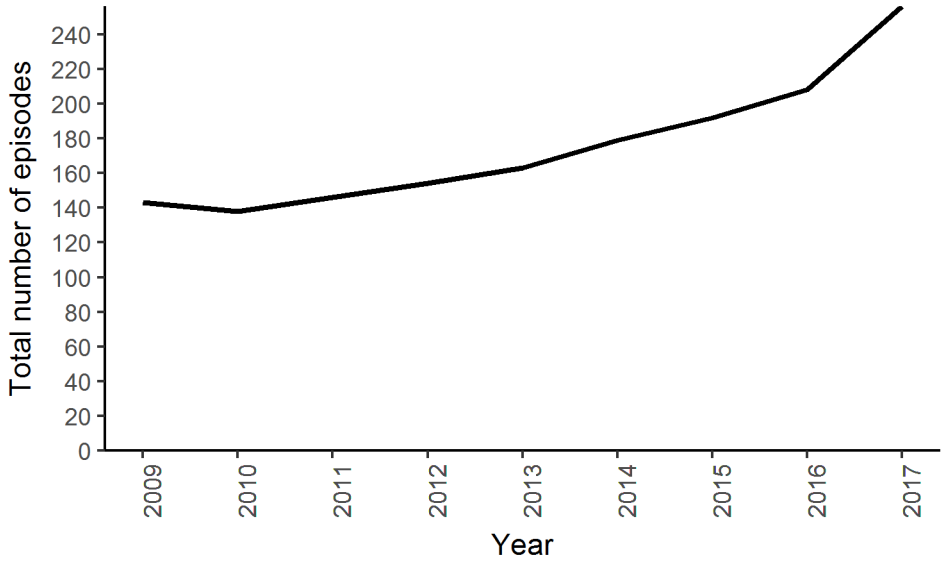


Figure 4: The number of *K. pneumoniae* bacteraemias reported to the Public Health Agency, 2009 - 2017

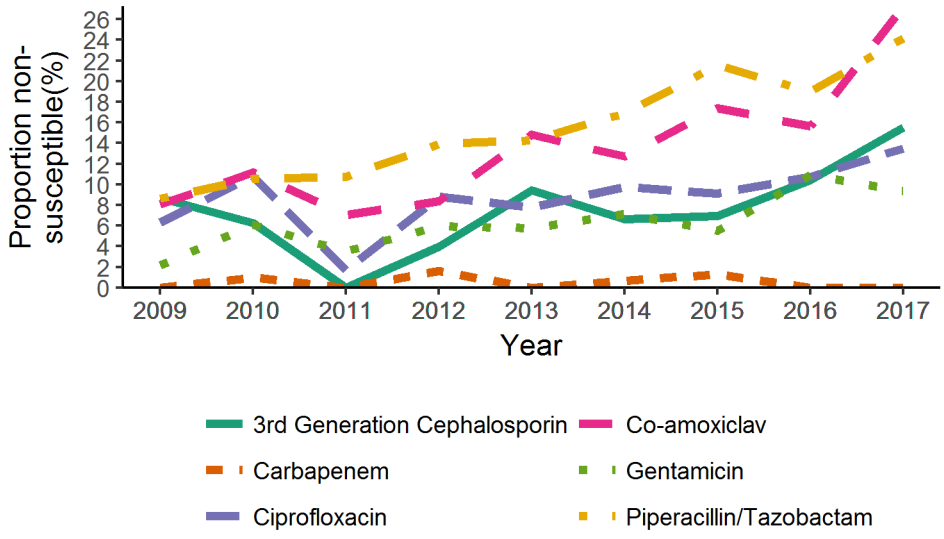


Figure 5: The proportion of *K. pneumoniae* bacteraemias resistant to selected antibiotics in NI, 2009 - 2017

The number of *K. pneumoniae* bacteraemias has increased from 143 cases in 2009 to 256 cases in 2017 (Figure 4). The proportion of isolates tested against key antibiotics during

2017 is shown in Appendix 3.

There has been an increase in the proportion of *K. pneumoniae* bacteraemias resistant to selected antibiotics over the 5 year period: ciprofloxacin (6.3% to 13.5%); gentamicin (2.2% to 9.4%); co-amoxiclav (8.1% to 27.2%); piperacillin/tazobactam (8.6% to 24.2%) and cephalosporins (8.7% to 15.5%). There were no isolates resistant to carbapenems detected over the period; Figure 5).

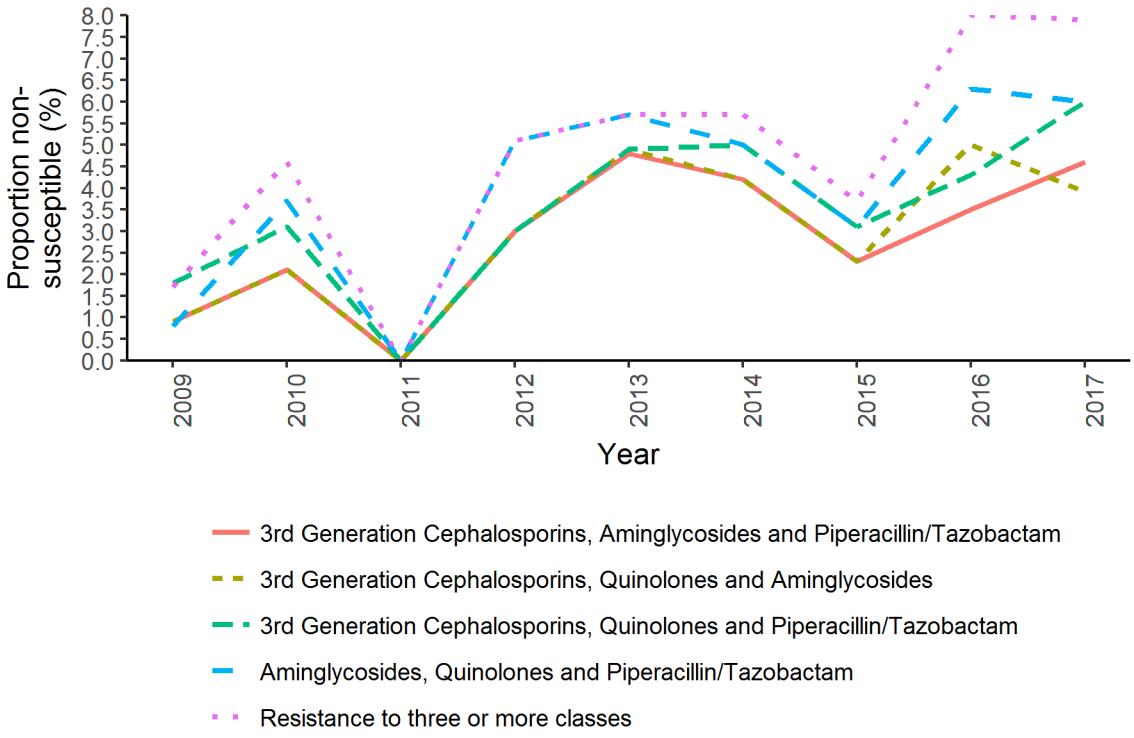


Figure 6: The proportion of *K.pneumoniae* bacteraemias reported to the Public Health Agency with multi-drug resistance, 2009 - 2017

The proportion of *K. pneumoniae* bacteraemias showing multi-resistance has increased slightly between 2009 and 2017 across all antibiotic combinations. Multi-resistance varied between 0 - 8%.The proportion of *K. pneumoniae* bacteraemias exhibiting resistance to three or more classes has increased over time. Within the named combinations of antibiotic classes, the highest proportions were seen for combinations of aminoglycosides, quinolones and piperacillin/tazobactam and the lowest for third generation cephalosporins, aminoglycosides and piperacillin/tazobactam (Figure 6).

Unlike *E. coli* both the proportion and absolute numbers of *K. pneumoniae* bacteraemias have increased. For example, the proportion of *K. pneumoniae* resistant to ciprofloxacin

increased by 7% during 2009 - 2017 (6.3% to 13.5%), the number of infections trebled (8 to 30 episodes). The number of isolates resistant to three or more classes also increased (2 to 17 episodes).

K. oxytoca bacteraemia

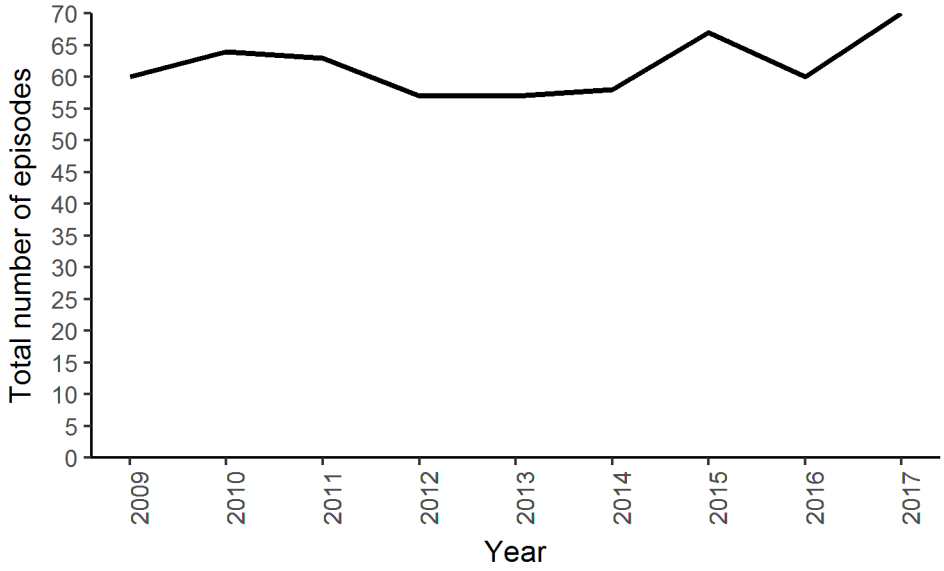


Figure 7: The number of *K. oxytoca* bacteraemias reported to the Public Health Agency, 2009 - 2017

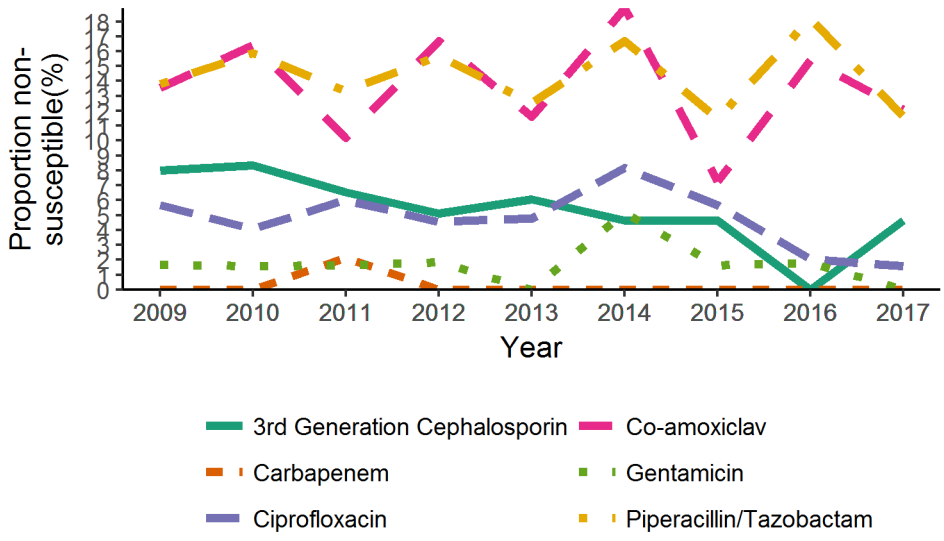


Figure 8: The proportion of *K. oxytoca* bacteraemias resistant to selected antibiotics in NI, 2009 - 2017

The number of *K. oxytoca* bacteraemias has increased from 60 cases in 2009 to 70 cases in 2017 (Figure 7). The proportion of isolates tested against key antibiotics during 2017 is

shown in Appendix 3.

There has been a decrease in the proportion of *K. oxytoca* bacteraemias resistant to selected antibiotics over the 5 year period: ciprofloxacin (5.7% to 1.6%); gentamicin (1.7% to 0%); co-amoxiclav (13.6% to 12.1%) and piperacillin/tazobactam (13.8% to 11.6%) and cephalosporins (8% to 4.7%). There was no resistance to carbapenems detected over the period 2009 - 2017; Figure 8).

Pseudomonas species bacteraemia

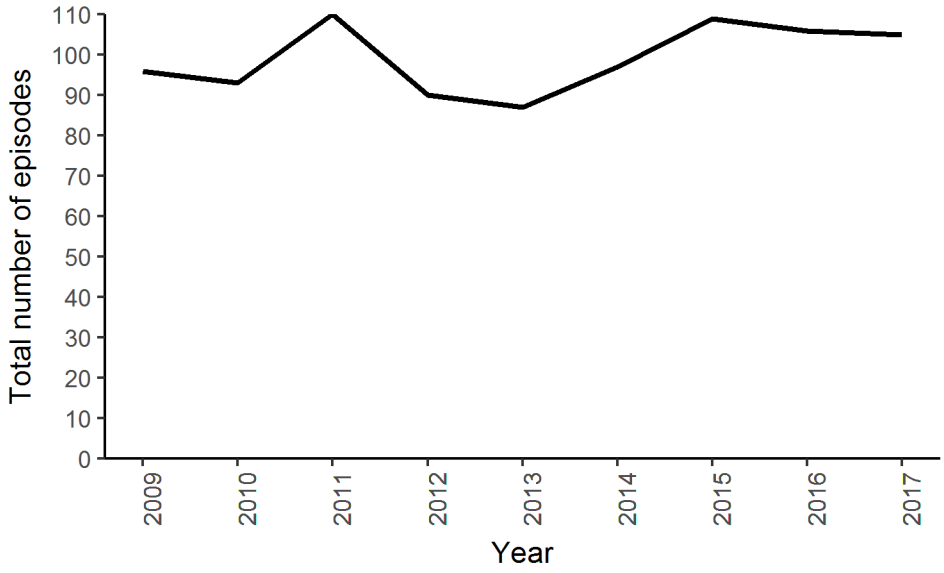


Figure 9: The number of Pseudomonas species bacteraemias reported to the Public Health Agency, 2009 - 2017

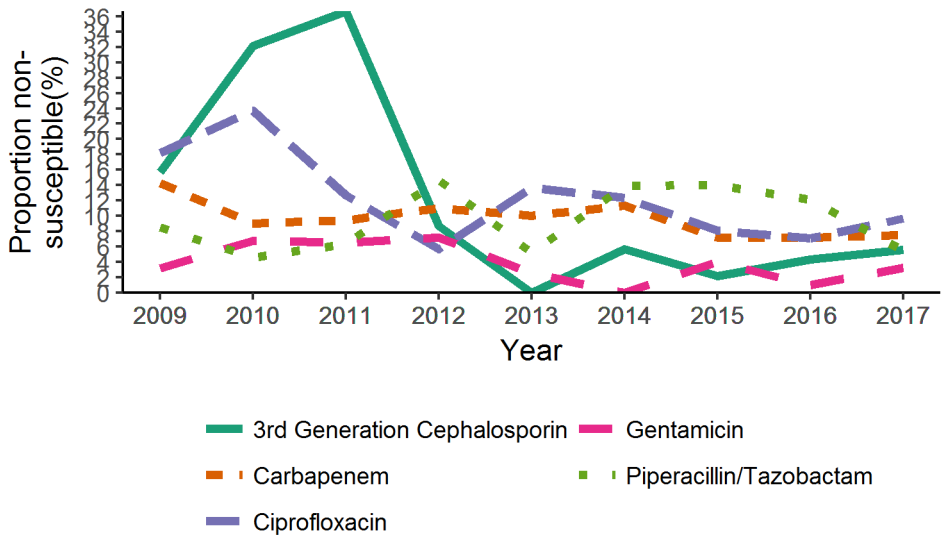


Figure 10: The proportion of Pseudomonas species bacteraemias resistant to selected antibiotics in NI, 2009 - 2017

The number of *Pseudomonas species* bloodstream infections has remained relatively stable with 109 cases in 2009 and 105 cases in 2017 (Figure 9). The proportion of isolates

tested against key antibiotics during 2017 is shown in Appendix 3.

There was a slight increase in the proportion of *Pseudomonas species* bacteraemias resistant to piperacillin/tazobactam between 2009 to 2016 (8.5% to 12.1%) with a decrease noted in 2017 (5.5%). Resistance among selected antibiotics has decreased: ciprofloxacin (18.2% to 9.7%); third generation cephalosporins (15.7% to 5.6%) and; carbapenems (14.3% to 7.5%). Resistance to gentamicin has fluctuated across the period but is similar in 2017 and 2009 (3.2%); (Figure 10).

S. aureus bacteraemia

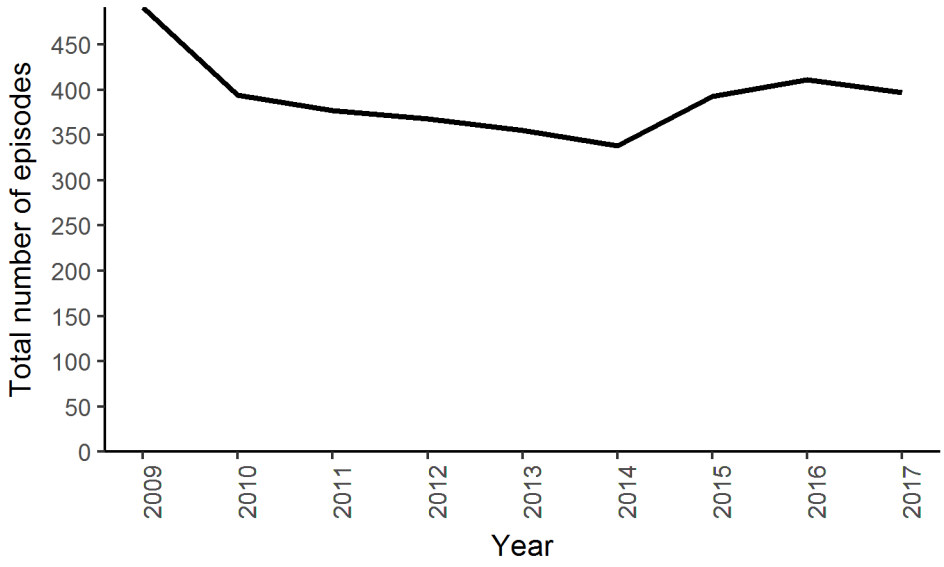


Figure 11: The number of *S. aureus* bacteraemias reported to the Public Health Agency, 2009 - 2017

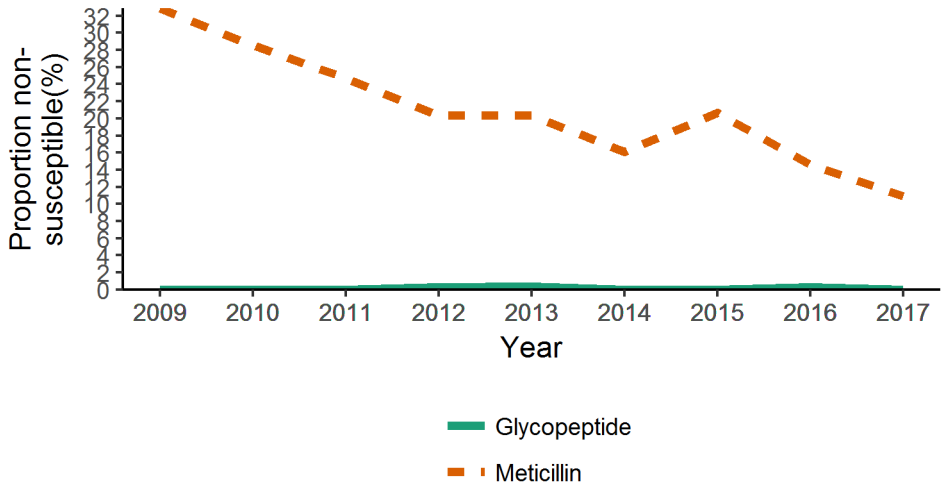


Figure 12: The proportion of *S. aureus* bacteraemias resistant to selected antibiotics in NI, 2009 - 2017

The number of *S. aureus* bacteraemias had been decreasing between 2009 and 2014 but began to increase from 338 in 2014 to 411 cases in 2016 before again decreasing in 2017

(397 cases); (Figure 11). The proportion of isolates tested against key antibiotics during 2017 is shown in Appendix 3. The proportion of *S. aureus* that are resistant to meticillin (MRSA) has been decreasing over the last 5 years, with a low of 10.9% in 2017. The proportion of *S. aureus* that are resistant to glycopeptides (eg. Vancomycin or Teicoplanin) has remained low (Figure 12).

Enterococcus species bacteraemia

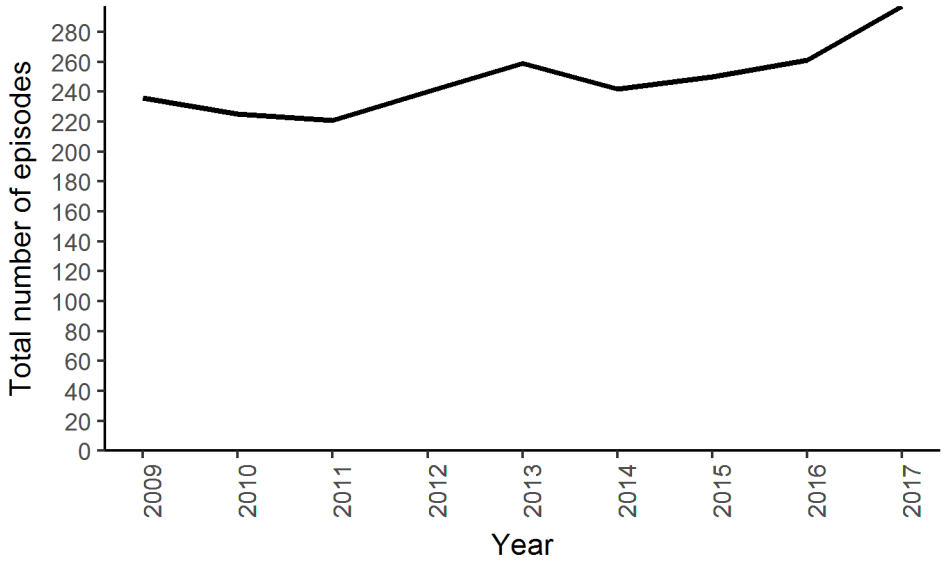


Figure 13: The number of Enterococcus species bacteraemias reported to the Public Health Agency, 2009 - 2017

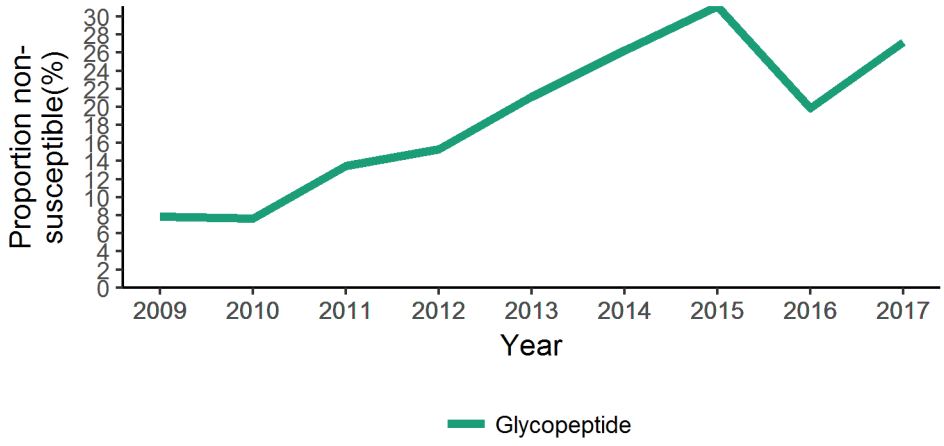


Figure 14: The proportion of Enterococcus species bacteraemias resistant to selected antibiotics in NI, 2009 - 2017

The number of *Enterococcus species* bacteraemias has generally increased between 2009 and 2017 with a steady year on year increase during the period 2015 to 2017 (250; 261

and 297 cases respectively; Figure 13). Resistance to glycopeptides has been increasing over the period, with a decreased noted only in 2016. In 2017, 92.9% were tested against glycopeptides- 27.2% were resistant (Figure 14).

S. pneumoniae bacteraemia

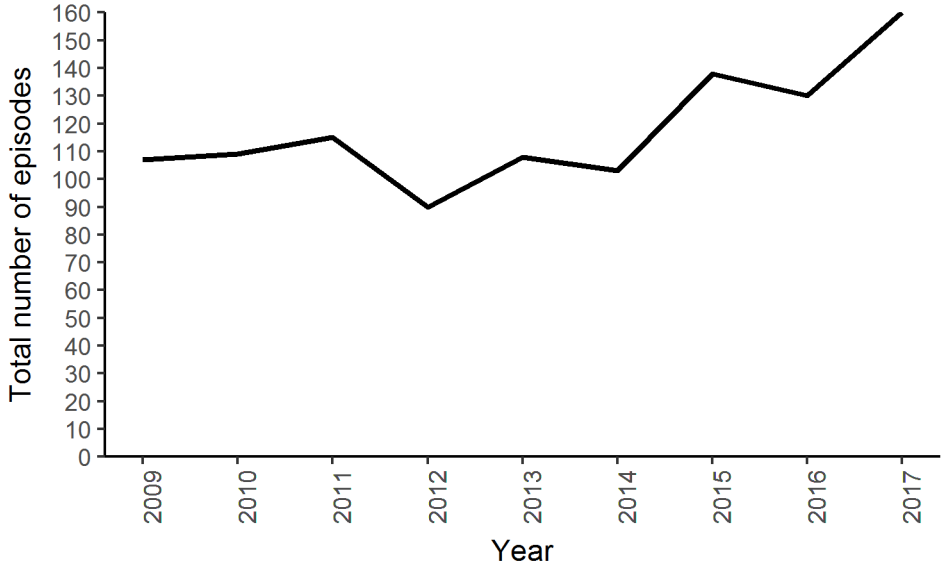


Figure 15: The number of *S. pneumoniae* bacteraemias reported to the Public Health Agency, 2009 - 2017

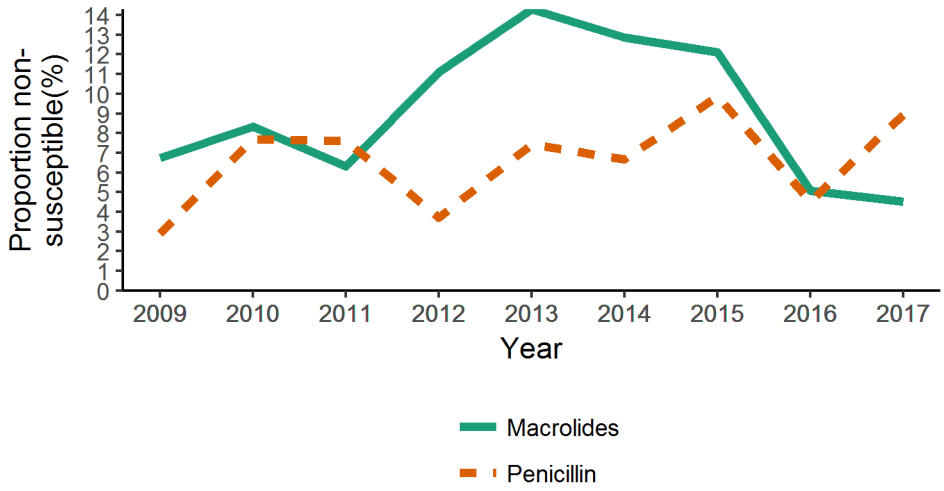


Figure 16: The proportion of *S. pneumoniae* bacteraemias resistant to selected antibiotics in NI, 2009 - 2017

There has been a general increase in the number of *S. pneumoniae* bacteraemias during the time period, with slight decreases reported from 2011-2012 (115 cases to 90 cases),

2013-2014 (108 cases to 103cases) and 2015 to 2016 (138 cases to 130 cases). Between 2016 and 2017 the number of cases increased to 160; the highest recorded during the period (Figure 15). The proportion of isolates tested against key antibiotics during 2017 is shown in Appendix 3. While the proportion of *S. pneumoniae* resistant to macrolides increased between 2009-2013, resistance has been decreasing from 2009 (6.7% to 4.5% 2017. Resistance to penicillin has increased (2.9% to 8.9% during the same period; Figure 16).

Acinetobacter species bacteraemia

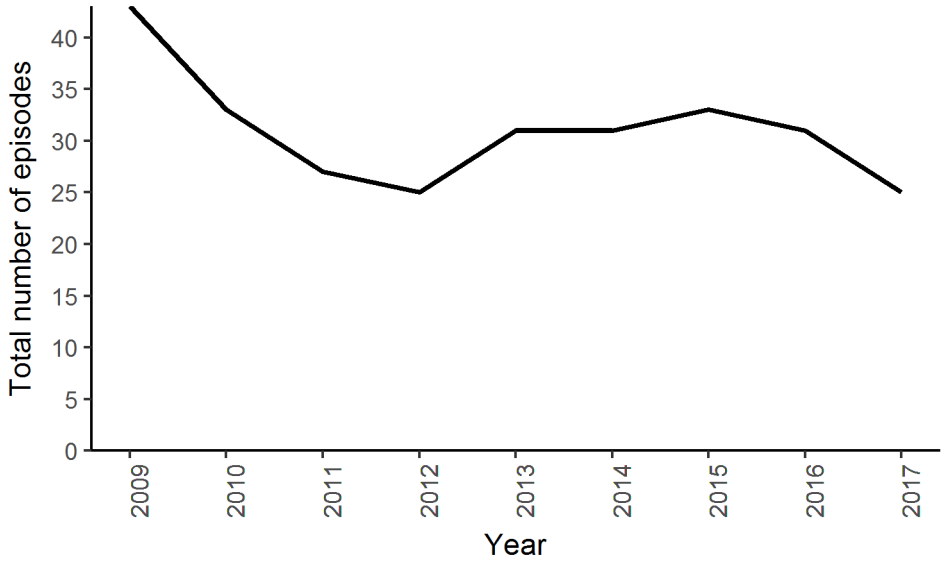


Figure 17: The number of Acinetobacter species bacteraemias reported to the Public Health Agency, 2009 - 2017

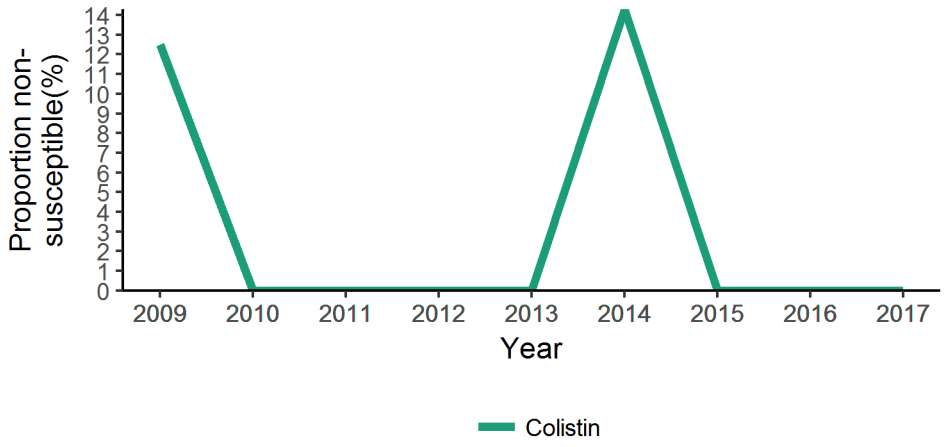


Figure 18: The proportion of Acinetobacter species bacteraemias resistant to selected antibiotics in NI, 2009 - 2017

The number of *Acinetobacter species* bacteraemias decreased from 33 cases in 2015 to 25 cases in 2017 (Figure 17). During 2017, 4 isolates were tested against colistin.

Resistance to colistin among *Acinetobacter species* has remained at zero (Figure 18).

Carbapenamse Producing Organisms

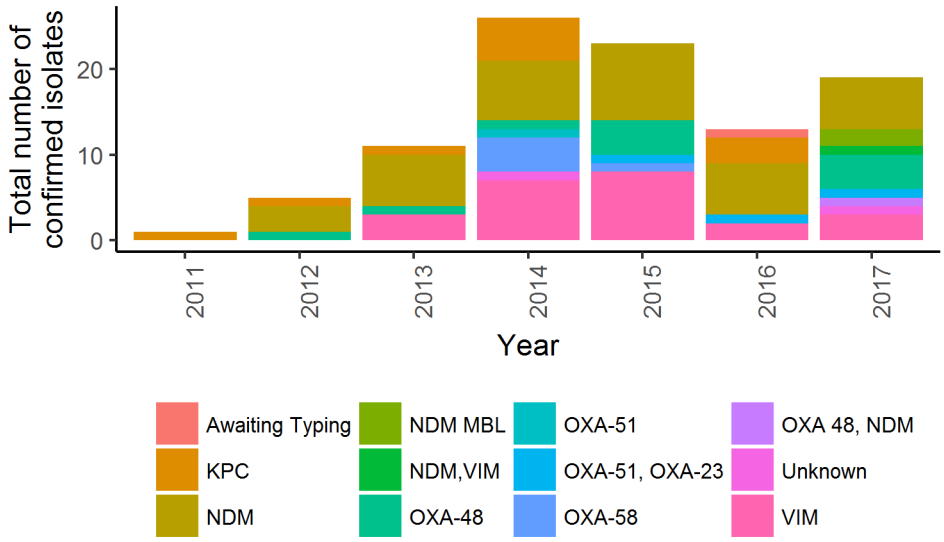


Figure 19: Carbapenamase activity among CPO confirmed isolates sent to Public Health England's AMRHAI Reference unit, 2011 - 2017

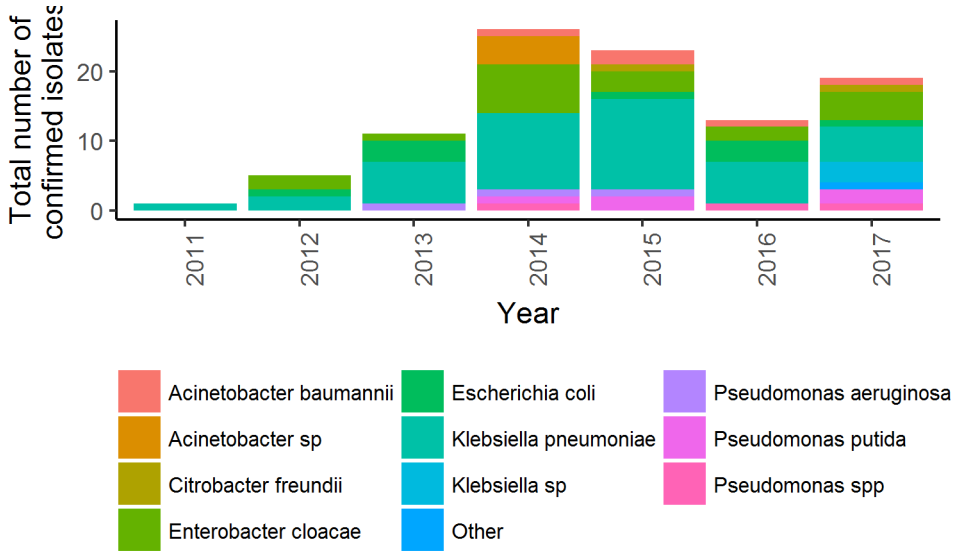


Figure 20: Organisms with confirmed carbapenamase production among isolates sent to Public Health England's AMRHAI Reference unit, 2011 - 2017

The number of CPO's voluntarily reported to the PHA increased from 1 in 2011 to 26 in 2014 but decreased between 2015-2016 (23 to 13) before increasing to 19 episodes

during 2017 (Figure 19). The most common reported resistance mechanism is New Delhi Metallo-Beta-lactamase (NDM) (37 episodes during 2011-2017; Figure 19). The most commonly reported CPO over the time period was *K. pneumoniae* (Figure 20).

Antibiotic resistance in *Neisseria gonorrhoeae*

Gonorrhoea has been identified as at risk of becoming an untreatable disease due to the emergence of antimicrobial resistance to successive standard treatments. This has necessitated changes to recommended antibiotic prescribing. In the UK, current recommended treatment guidelines include ceftriaxone with azithromycin, along with routine test of cure[5]. Third-generation cephalosporins are the last remaining effective antibiotics but reports of treatment failures and increasing minimum inhibitory concentrations (MIC) levels have raised concerns that they will no longer be a suitable treatment option[6]. Since 2015, NI has participated in the European Gonococcal Antimicrobial Surveillance Programme(Euro-GASP)[7] through the Royal Victoria Hospital, Belfast. This GUM clinic captured 61% of all gonorrhoea diagnoses made during 2017.

In 2017, gonorrhoea diagnoses accounted for 12% (679/5,728) of all new STI diagnoses made in NI GUM clinics. During the study period, 30 isolates were cultured and sent to Public Health England for inclusion in EuroGASP. Of these, *N. gonorrhoeae* was successfully retrieved from 20 isolates (67%).

From 2015 to 2017, 69 isolates were tested within the EuroGASP programme and showed similar resistance pattern to the UK overall with 10% resistant to azithromycin and 0% resistant to ceftriaxone.

The full report for this surveillance programme will be published on the PHA website.

Antibiotic consumption

Rates of antibiotic consumption by healthcare setting

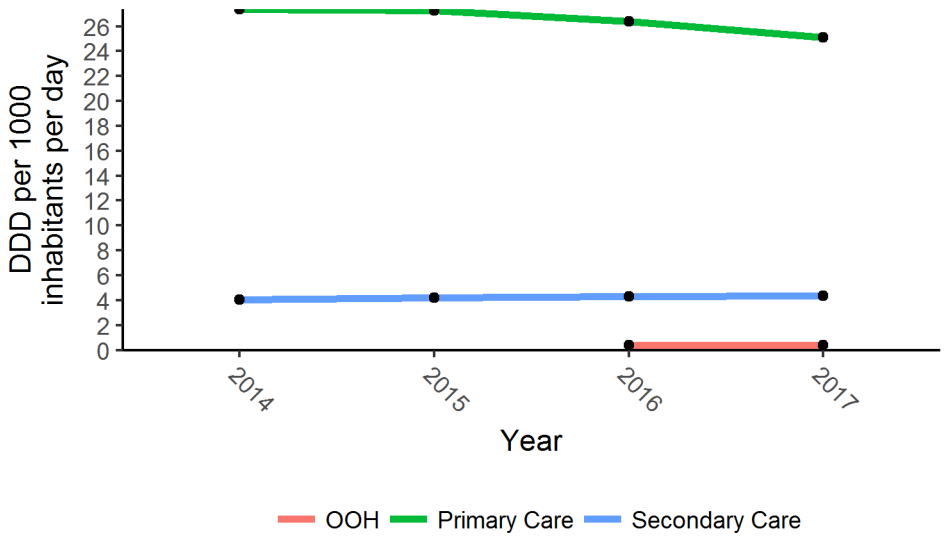


Figure 21: Total antibiotic consumption, expressed as DDD per 1000 inhabitants per day, NI, 2014-2017

In 2017, the total consumption of antibiotics in primary (including out-of-hours) and secondary care was 29.87 per 1000 inhabitants per day (31.37, 31.47 and 31.08 per 1000 inhabitants per day in 2014, 2015 and 2016 respectively).

The majority of antibiotic prescribing took place in primary care (84% during 2017; Figure 21). In primary care, rates were stable between 2014 and 2015, decreasing slightly in 2016 and 2017. In 2017 the overall rate of prescribing in primary care was 25.09 per 1000 inhabitants per day. There has been little change in the overall rate of antibiotic prescribing in secondary care (4.38 per 1000 inhabitants per day) during 2017 from 4.29 during 2016. Prescribing data for out-of-hours centres (OOH) was available for 2016 and 2017 during which the rate remained stable at 0.4 per 1000 inhabitants per day; Figure 21).

Rates of antibiotic consumption in Secondary care

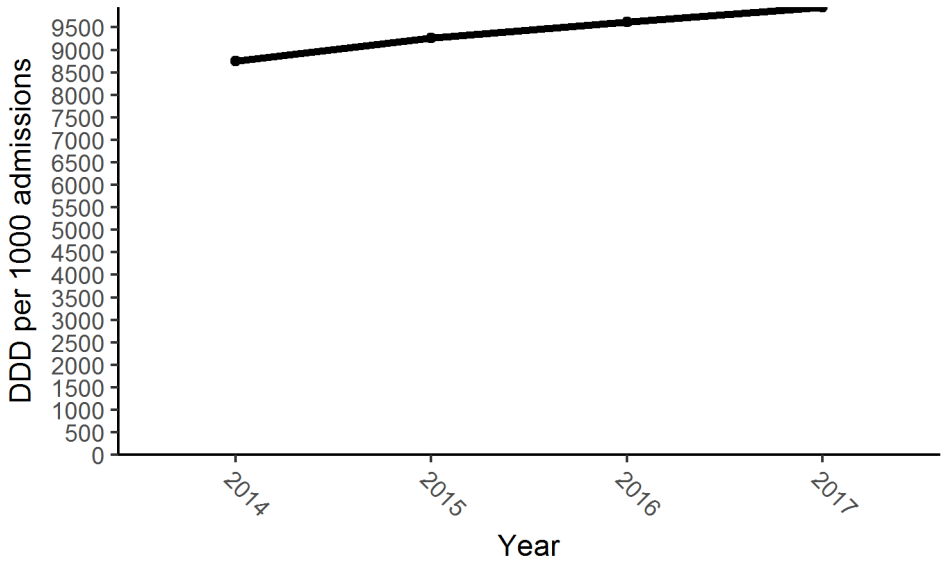


Figure 22: Total antibiotic consumption, expressed as DDD per 1000 admissions, NI, 2014-2017

There has been a gradual year on year increase in the rate of antibiotic consumption expressed as DDD per 1000 admissions: (8758 in 2014 to 9944 DDD per 1000 admissions in 2017 (Figure 22).

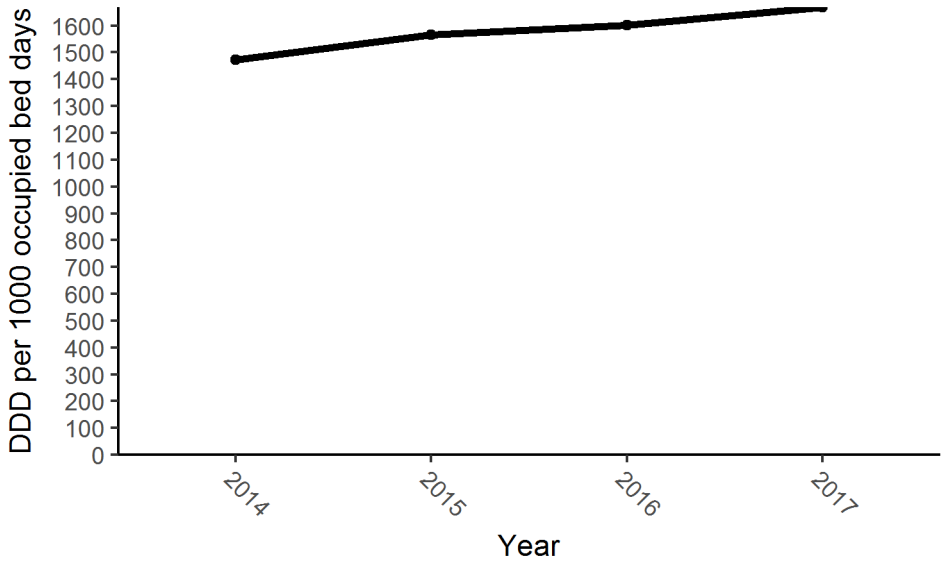


Figure 23: Total antibiotic consumption, expressed as DDD per 1000 occupied bed days, NI, 2014-2017

Like the admissions data, the rate of antibiotic consumption per 1000 occupied bed days has been gradually increasing year on year: 1473 in 2014 to 1668 DDD per 1000 occupied beddays in 2017 (Figure 23).

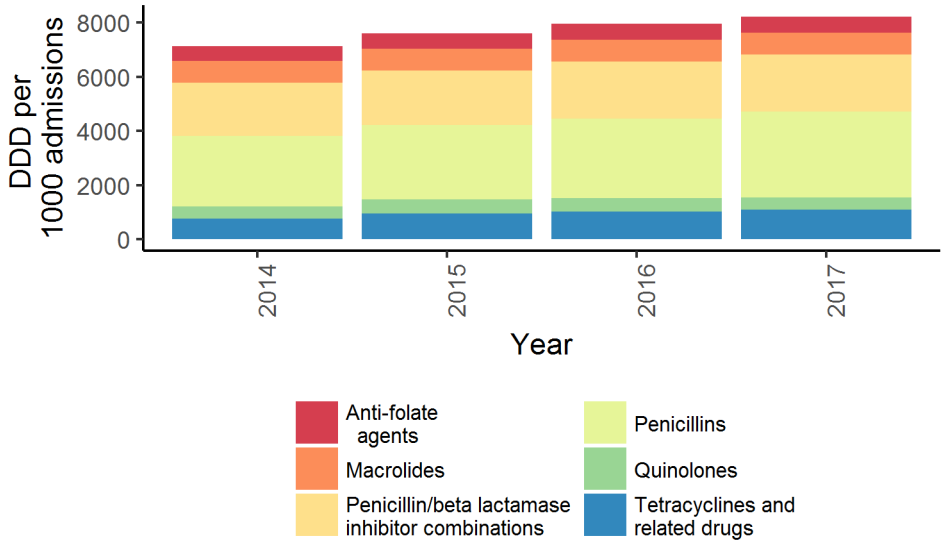
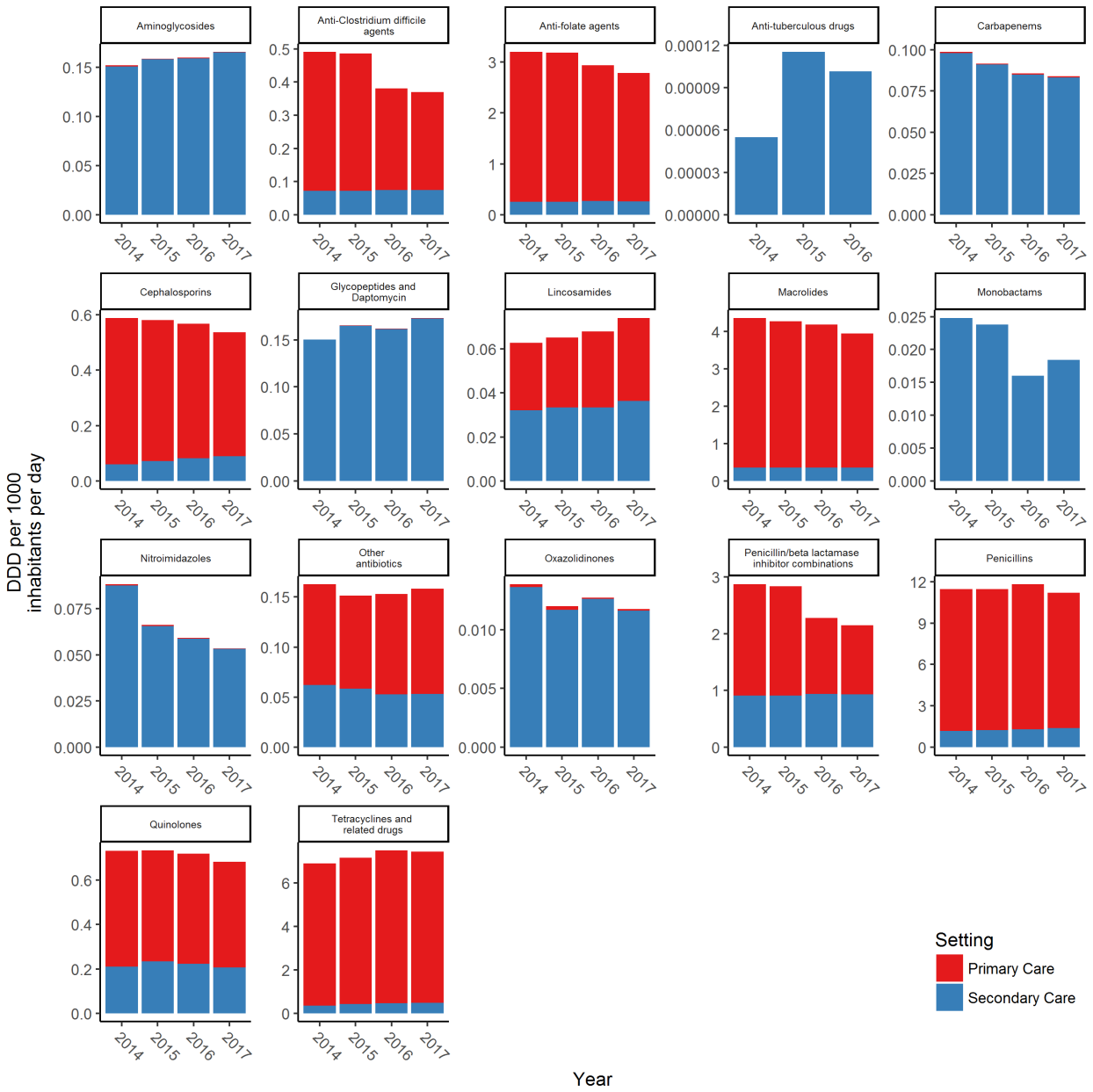


Figure 24: Total antibiotic consumption by key agents in secondary care, expressed as DDD per 1000 admissions, NI, 2014-2017

This figure shows the top 6 key agents prescribed in secondary care. During 2017, the highest rates for antibiotic consumption were penicillins (3145 DDD per 1000 admissions), Penicillin/beta lactamase inhibitor combinations (2115 DDD per 1000 admissions) and tetracyclines and related drugs (1090 DDD per 1000 admissions; Figure 24).

Antibiotic consumption by key agents



Note: differing scales on y-axis

During 2017, the most frequently used antibiotics in both primary and secondary care in NI were Penicillins (38.5% and 31.6% respectively), tetracyclines and related drugs (27.3% and 11% respectively) and macrolides (14.1% and 8.1% respectively). Overall, the rate of antibiotic prescribing has remained relatively stable across all groups (**??**).

Antibiotic consumption by class and individual antibiotics

Penicillins

Table 1: Total rate of Penicillins DDD per 1000 inhabitants per day, NI, 2014-2017.

Year	Class	DDD	Population	rate
2014	Penicillins	7708992	1840500	11.48
2015	Penicillins	7755516	1851600	11.48
2016	Penicillins	8030224	1862100	11.81
2017	Penicillins	7654114	1870800	11.21

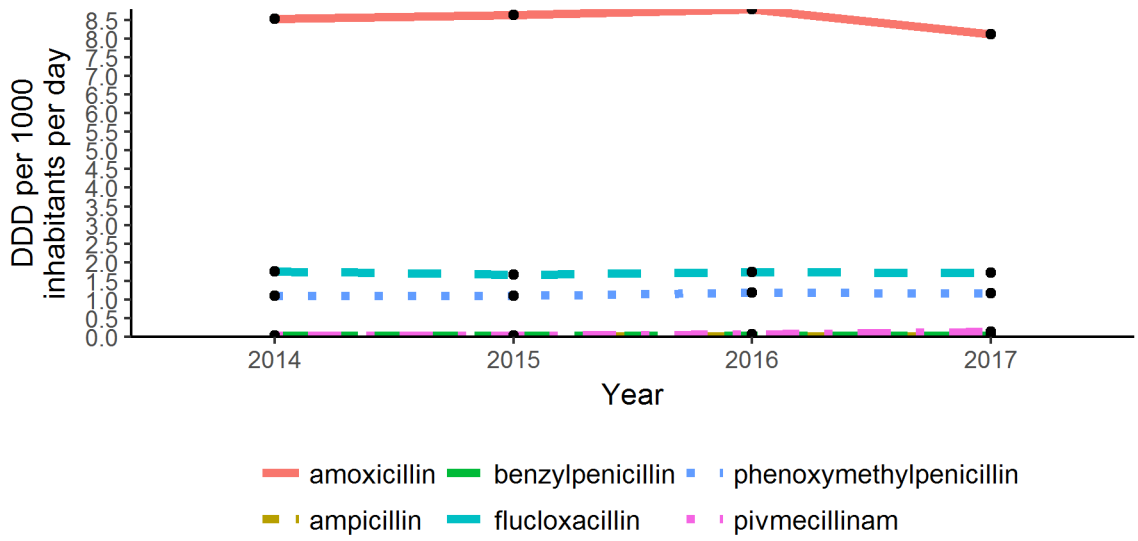


Figure 25: Consumption of most commonly used penicillins expressed per 1000 inhabitants per day, NI, 2014 - 2017

The figure represents the top six antimicrobial agents used in the Penicillins class. Penicillins accounted for 37.5% of antibiotic consumption in 2017. The rate of penicillin consumption has slightly decreased to a rate of 11.21 per 1000 inhabitants per day during 2017. The highest rate was for amoxicillin (8.13 DDD per 1000 inhabitants per day in 2017; Figure 25).

Cephalosporins

Table 2: Total rate of Cephalosporins DDD per 1000 inhabitants per day, NI, 2014-2017.

Year	Class	DDD	Population	rate
2014	Cephalosporins	394892	1840500	0.59
2015	Cephalosporins	392427	1851600	0.58
2016	Cephalosporins	386024	1862100	0.57
2017	Cephalosporins	366426	1870800	0.54

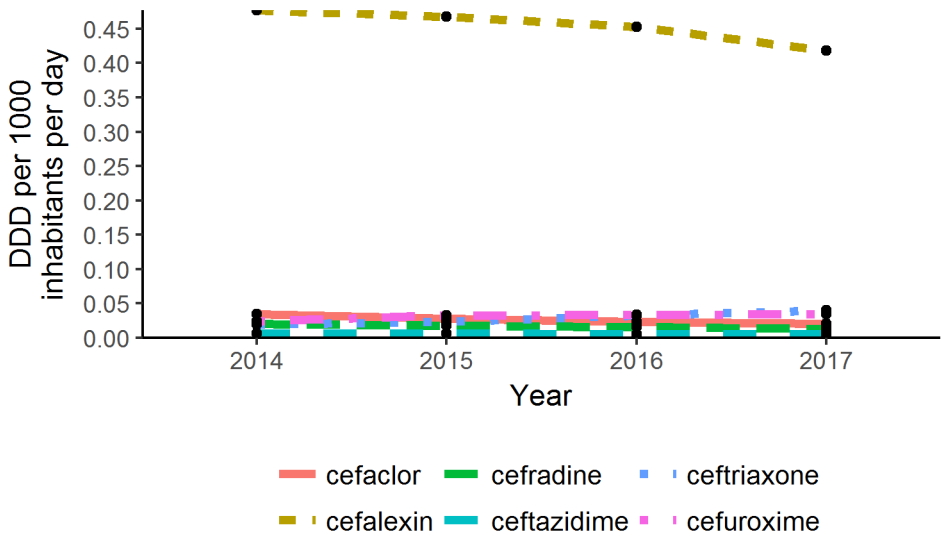


Figure 26: Consumption of most commonly used cephalosporins expressed per 1000 inhabitants per day, NI, 2014 - 2017

The figure represents the top six agents used in the Cephalosporins class. The rate of cephalosporin consumption has remained relatively stable with a rate of 0.54 DDD per 1000 inhabitants per day during 2017. The highest rate was for cefalexin, the rate of which has decreased over time (0.42 DDD per 1000 inhabitants per day during 2017; Figure 26).

Tetracyclines and related drugs

Table 3: Total rate of tetracyclines and related drugs consumption expressed as DDD per 1000 inhabitants per day, NI, 2014-2017.

Year	Class	DDD	Population	rate
2014	Tetracyclines and related drugs	4637310	1840500	6.90
2015	Tetracyclines and related drugs	4840373	1851600	7.16
2016	Tetracyclines and related drugs	5088909	1862100	7.49
2017	Tetracyclines and related drugs	5084036	1870800	7.45

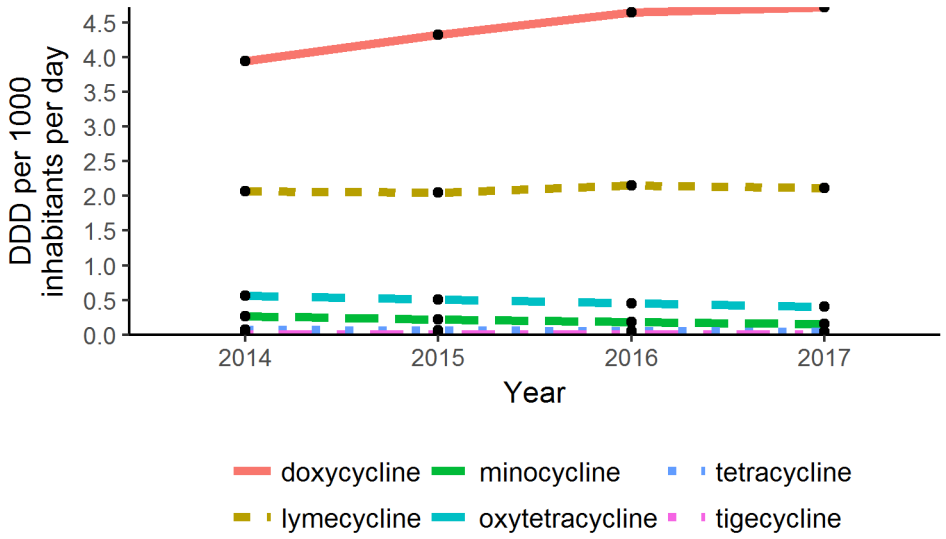


Figure 27: Consumption of most commonly used tetracyclines and related drugs[2] expressed per 1000 inhabitants per day, NI, 2014 - 2017

The figure represents the top six agents used in the tetracyclines and related drugs class. Tetracyclines and related drugs accounted for 24.9% of all antibiotic consumption in 2017. The rate of tetracyclines and related drugs consumption has generally increased during 2014 - 2017 with a rate of 7.45 DDD per 1000 inhabitants per day during 2017. The highest rate was for doxycycline, the rate of which has increased over time (3.94 to 4.72 DDD per 1000 inhabitants per day from 2014 to 2017; Figure 27).

[2]While demeclocycline and lymecycline are not primarily used for their antimicrobial effects they have been included as they can still be considered drivers of resistance.

Quinolones

Table 4: Total rate of Quinolones consumption expressed as DDD per 1000 inhabitants per day, NI, 2014-2017.

Year	Class	DDD	Population	rate
2014	Quinolones	491422	1840500	0.73
2015	Quinolones	495643	1851600	0.73
2016	Quinolones	488675	1862100	0.72
2017	Quinolones	465618	1870800	0.68

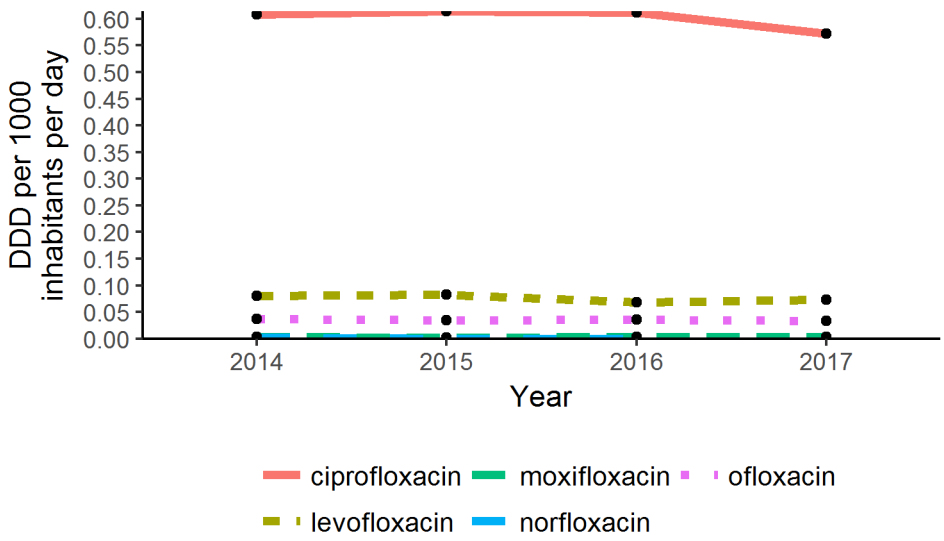


Figure 28: Consumption of most commonly used quinolones expressed per 1000 inhabitants per day, NI, 2014 - 2017

The rate of Quinolones consumption remained stable during 2014 - 2016, decreasing slightly to a rate of 0.68 DDD per 1000 inhabitants per day during 2017. The highest rate was for ciprofloxacin which has also been stable between 2014-2016 but decreased to 0.57 DDD per 1000 inhabitants per day in 2017; Figure 28).

Macrolides

Table 5: Total rate of Macrolides consumption expressed as DDD per 1000 inhabitants per day, NI, 2014-2017.

Year	Class	DDD	Population	rate
2014	Macrolides	2927767	1840500	4.36
2015	Macrolides	2887666	1851600	4.27
2016	Macrolides	2844342	1862100	4.18
2017	Macrolides	2696486	1870800	3.95

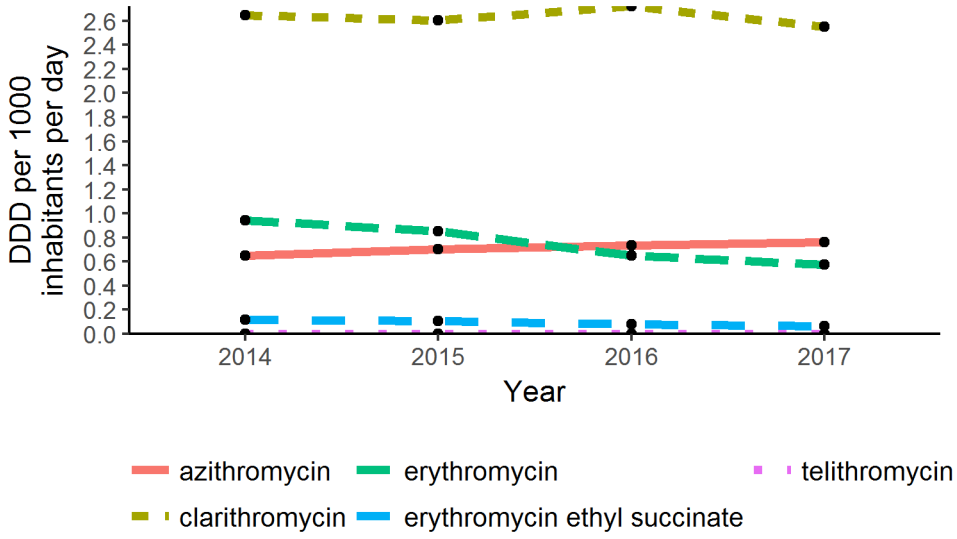


Figure 29: Consumption of most commonly used macrolides expressed per 1000 inhabitants per day, NI, 2014 - 2017

Macrolides accounted for 13.2% of all antibiotic consumption in 2017. The rate of Macrolides consumption has generally remained stable across the period, with a slight decline noted in 2017 (3.95 DDD per 1000 inhabitants per day). The highest rate was for clarithromycin which has been stable between 2014-2016 but decreased slightly to 2.55 DDD per 1000 inhabitants per day in 2017; (Figure 29).

Carbapenems

Table 6: Total rate of Carbapenems consumption expressed as DDD per 1000 inhabitants per day, NI, 2014-2017.

Year	Class	DDD	Population	rate
2014	Carbapenems	66280	1840500	0.10
2015	Carbapenems	61872	1851600	0.09
2016	Carbapenems	58135	1862100	0.09
2017	Carbapenems	57294	1870800	0.08

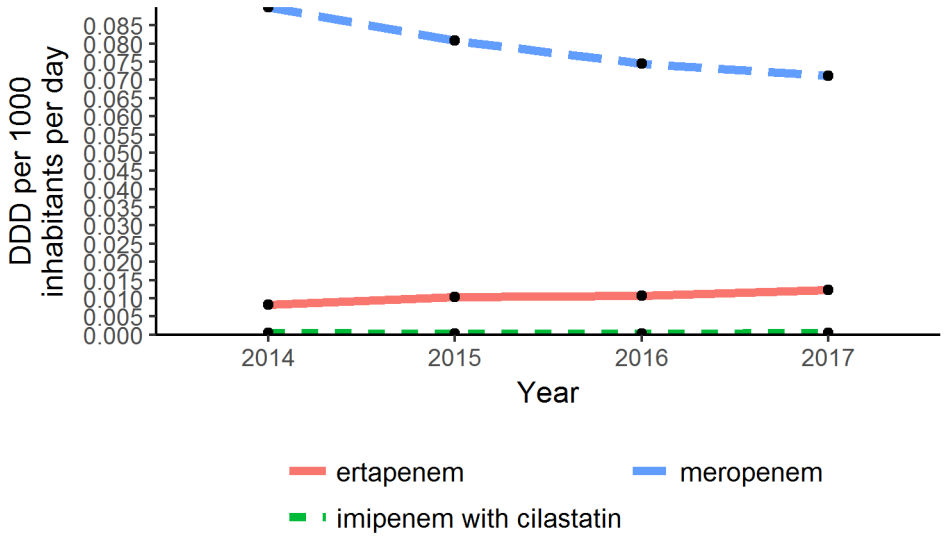


Figure 30: Consumption of most commonly used carbapenems expressed per 1000 inhabitants per day, NI, 2014 - 2017

The rate of Carbapenems consumption has remained stable during 2014 - 2017 with a rate of 0.08 DDD per 1000 inhabitants per day in 2017. The highest rate was for meropenem which has decreased slightly over time (0.09 in 2014 to 0.07 DDD per 1000 inhabitants per day in 2017; Figure 30).

Penicillin/beta lactamase inhibitor combinations

Table 7: Total rate of Penicillin/beta lactamase inhibitor combinations consumption expressed as DDD per 1000 inhabitants per day, NI, 2014-2017.

Year	Class	DDD	Population	rate
2014	Penicillin/beta lactamase inhibitor combinations	1929077	1840500	2.87
2015	Penicillin/beta lactamase inhibitor combinations	1915479	1851600	2.83
2016	Penicillin/beta lactamase inhibitor combinations	1546893	1862100	2.28
2017	Penicillin/beta lactamase inhibitor combinations	1469779	1870800	2.15

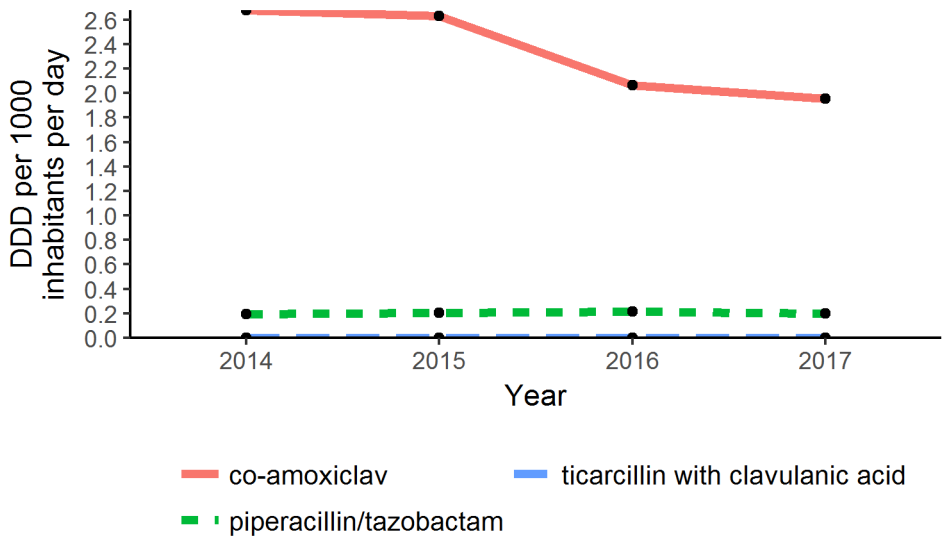


Figure 31: Consumption of most commonly used Penicillin/beta lactamase inhibitor combinations expressed per 1000 inhabitants per day, NI, 2014 - 2017

The rate of Penicillin/beta lactamase inhibitor combinations consumption has decreased during 2014 - 2017 with a rate of 2.15 DDD per 1000 inhabitants per day in 2017. The highest rate was for co-amoxiclav which has decreased over time (2.68 to 1.95 DDD per 1000 inhabitants per day from 2014 to 2017). The use of piperacillin/tazobactam has been stable over time (0.2 DDD per 1000 inhabitants per day in 2017; Figure 31).

Glycopeptides and daptomycin

Table 8: Total rate of glycopeptides and daptomycin consumption expressed as DDD per 1000 inhabitants per day, NI, 2014-2017.

Year	Class	DDD	Population	rate
2014	Glycopeptides and Daptomycin	101105	1840500	0.15
2015	Glycopeptides and Daptomycin	111767	1851600	0.17
2016	Glycopeptides and Daptomycin	110060	1862100	0.16
2017	Glycopeptides and Daptomycin	118262	1870800	0.17

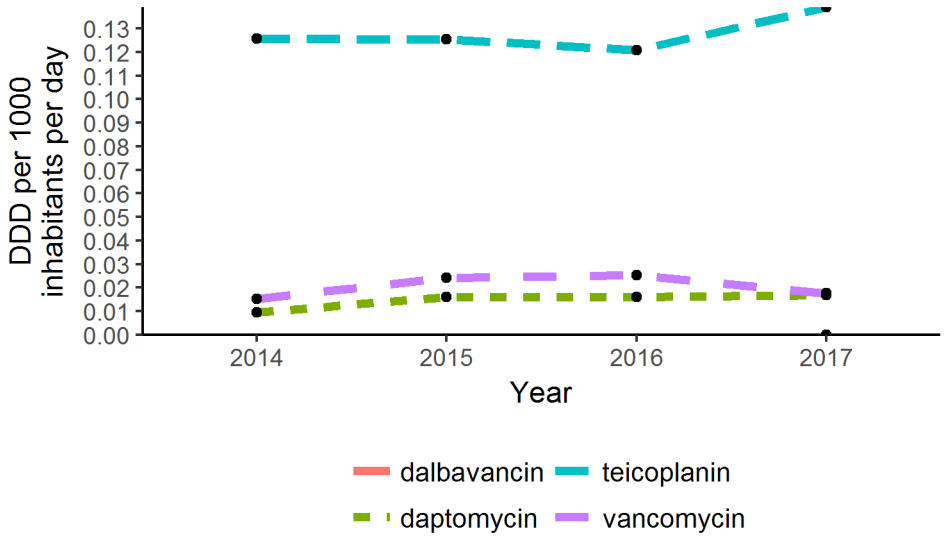


Figure 32: Consumption of most commonly used glycopeptides and daptomycin expressed per 1000 inhabitants per day, NI, 2014 - 2017

The rate of glycopeptide and daptomycin consumption has remained stable during 2014 - 2017 with a rate of 0.17 DDD per 1000 inhabitants per day in 2017. The highest rate was for teicoplanin which has been generally stable over time (0.14 DDD per 1000 inhabitants per day in 2017; Figure 32).

Anti-folate agents

Table 9: Total rate of Anti-folate agents consumption expressed as DDD per 1000 inhabitants per day, NI, 2014-2017.

Year	Class	DDD	Population	rate
2014	Anti-folate agents	2148805	1840500	3.20
2015	Anti-folate agents	2153624	1851600	3.19
2016	Anti-folate agents	1995188	1862100	2.94
2017	Anti-folate agents	1903605	1870800	2.79

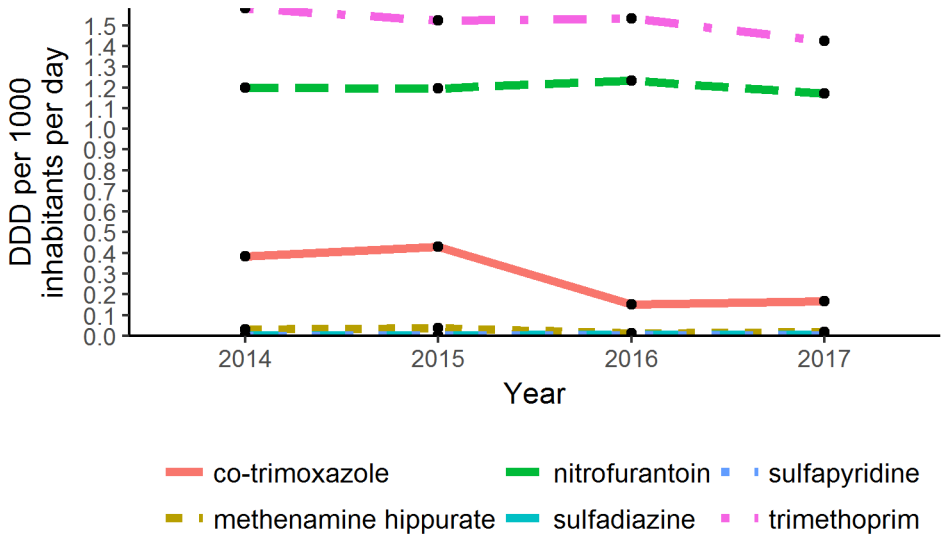


Figure 33: Consumption of most commonly used anti-folate agents expressed per 1000 inhabitants per day, NI, 2014 - 2017

Anti-folate agents accounted for 9.3% of all antibiotic consumption in 2017. The rate of Anti-folate agents consumption has remained stable during 2014 - 2016 but decreased slightly to a rate of 2.79 DDD per 1000 inhabitants per day in 2017. The highest rate was for trimethoprim which has decreased slightly over time (1.58 to 1.43 DDD per 1000 inhabitants per day from 2014 to 2017; Figure 33).

Antibiotic consumption of key agents by healthcare setting

Trimethoprim

Table 10: Total rate of trimethoprim consumption expressed as DDD per 1000 inhabitants per day, NI, 2014-2017.

Year	Antibiotic	DDD	Population	rate
2014	trimethoprim	1062533	1840500	1.58
2015	trimethoprim	1029756	1851600	1.52
2016	trimethoprim	1041346	1862100	1.53
2017	trimethoprim	973778	1870800	1.43

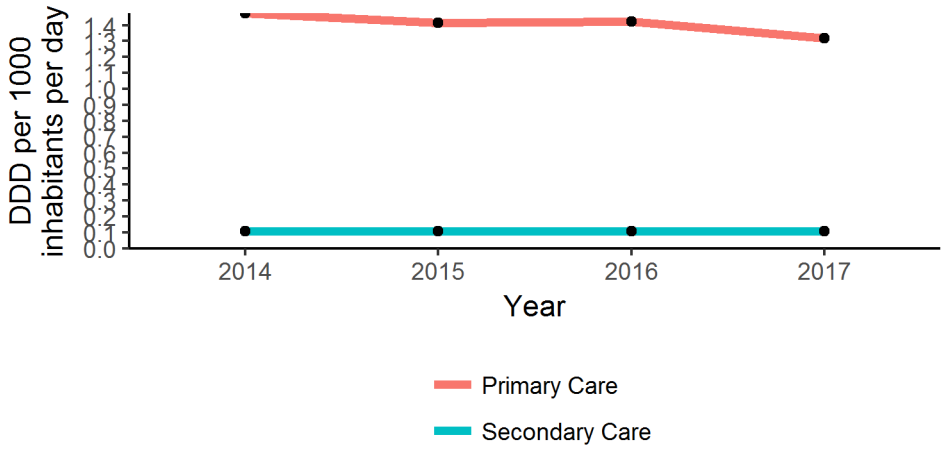


Figure 34: Consumption of trimethoprim by prescriber location expressed per 1000 inhabitants per day, NI, 2014 - 2017

Overall, the rate of trimethoprim consumption has decreased slightly during 2014 - 2017 with a rate of 1.43 DDD per 1000 inhabitants per day during 2017. This trend is influenced by generally stable rates of trimethopim consumption in primary care during 2014 - 2017 (1.47 to 1.32 DDD per 1000 inhabitants per day) with no change in secondary care during 2014-2017 (0.11 to 0.11 DDD per 1000 inhabitants per day; Figure 34).

Nitrofurantoin

Table 11: Total rate of nitrofurantoin consumption expressed as DDD per 1000 inhabitants per day, NI, 2014-2017.

Year	Antibiotic	DDD	Population	rate
2014	nitrofurantoin	804657	1840500	1.20
2015	nitrofurantoin	808025	1851600	1.20
2016	nitrofurantoin	838472	1862100	1.23
2017	nitrofurantoin	799471	1870800	1.17

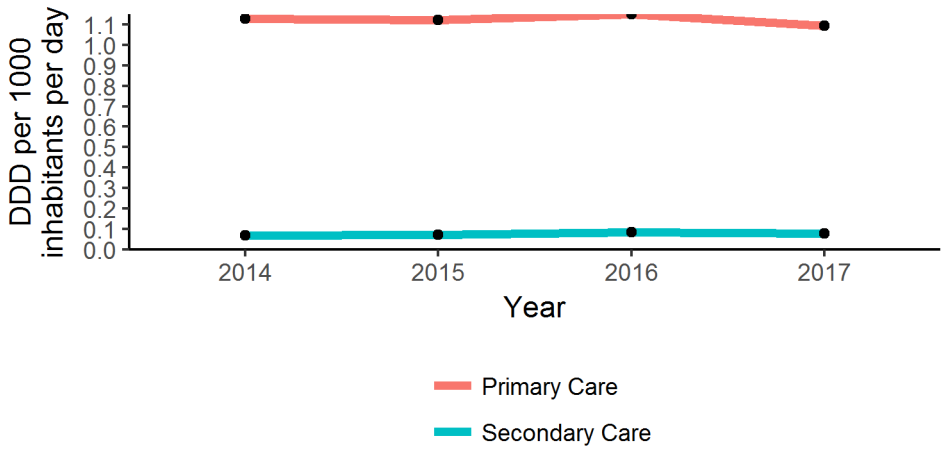


Figure 35: Consumption of nitrofurantoin by prescriber location expressed per 1000 inhabitants per day, NI, 2014 - 2017

Overall, the rate of nitrofurantoin consumption remained stable during 2014 - 2016, decreasing slightly to a rate of 1.17 DDD per 1000 inhabitants per day in 2017. Rates in primary care have remained generally stable- with a slight decrease in 2017- while rates in secondary care have not changed during 2014 - 2017 (1.13 to 1.09 DDD per 1000 inhabitants per day in primary care and 0.07 to 0.08 DDD per 1000 inhabitants per day in secondary care; Figure 35).

Aminoglycosides

Table 12: Total rate of Aminoglycosides consumption expressed as DDD per 1000 inhabitants per day, NI, 2014-2017.

Year	Class	DDD	Population	rate
2014	Aminoglycosides	102169	1840500	0.15
2015	Aminoglycosides	107463	1851600	0.16
2016	Aminoglycosides	108889	1862100	0.16
2017	Aminoglycosides	113280	1870800	0.17

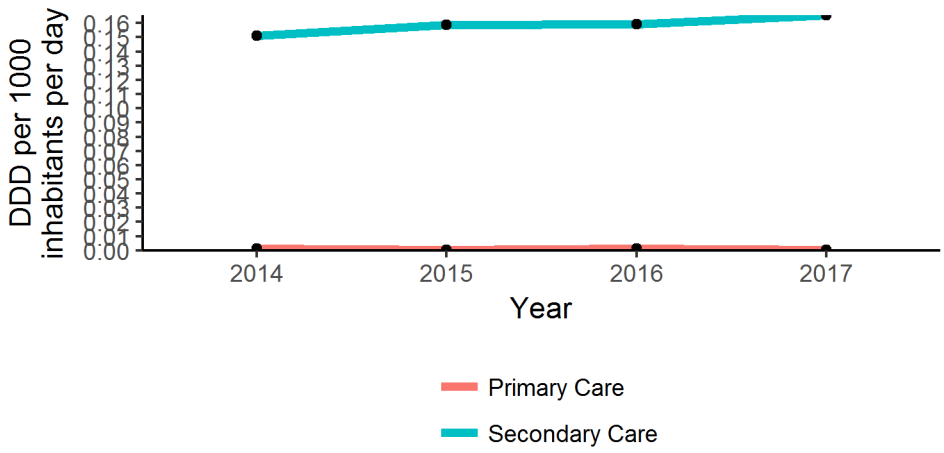


Figure 36: Consumption of aminoglycosides by prescriber location expressed per 1000 inhabitants per day, NI, 2014 - 2017

Overall, the rate of Aminoglycosides consumption has remained stable during 2014 - 2017 with a rate of 0.17 DDD per 1000 inhabitants per day in 2017. This trend is influenced by stable rates in primary care during 2014 - 2017 (0 DDD per 1000 inhabitants per day during 2017) and a slight increase in secondary care (0.15 to 0.17 DDD per 1000 inhabitants per day; Figure 36).

Glycopeptides and daptomycin

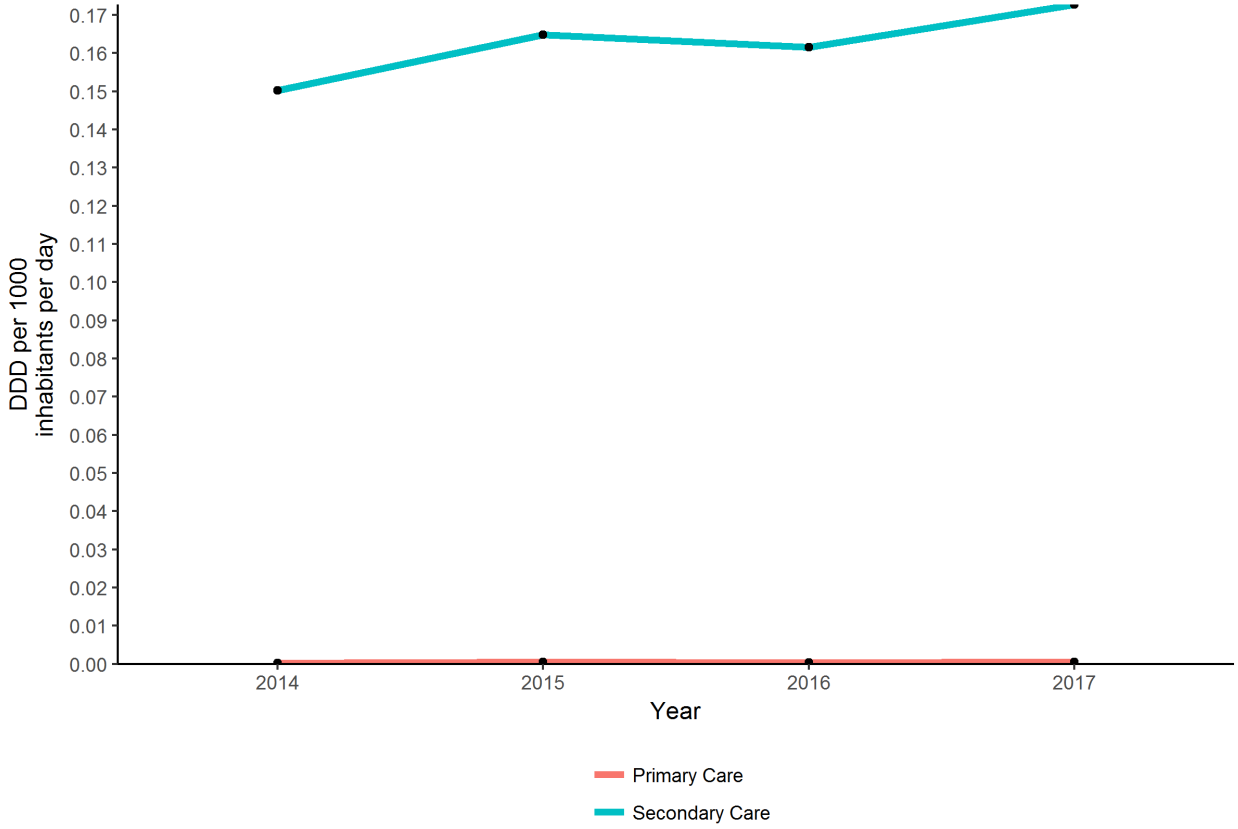


Figure 37: Consumption of glycopeptide and daptomycin by prescriber location expressed per 1000 inhabitants per day, NI, 2014 - 2017

The consumption rates of glycopeptides and daptomycin have been stable in primary care during 2014 - 2017 (0 DDD per 1000 inhabitants per day during 2017) with a slight increase in secondary care to (0.17 DDD per 1000 inhabitants per day in 2017. *Please note that DDDs in primary care are not absolute zero*; Figure 37).

Colistin

Table 13: Total rate of colistin consumption expressed as DDD per 1000 inhabitants per day, NI, 2014-2017.

Year	Antibiotic	DDD	Population	rate
2014	colistin	60158	1840500	0.09
2015	colistin	55889	1851600	0.08
2016	colistin	61758	1862100	0.09
2017	colistin	66645	1870800	0.10

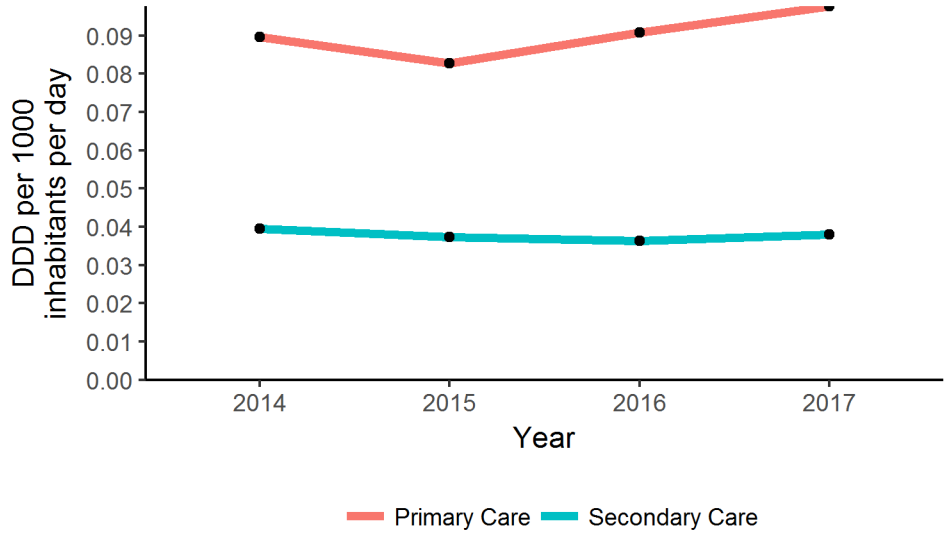


Figure 38: Consumption of colistin by prescriber location expressed per 1000 inhabitants per day, NI, 2014 - 2017

Overall, the rate of colistin consumption has remained stable during 2014 - 2017 with a rate of 0.1 DDD per 1000 inhabitants per day in 2017. This trend is influenced by stable rates in primary care during 2014 - 2017 (0.09 in 2014 to 0.1 DDD per 1000 inhabitants per day during 2017) and in secondary care (0.04DDD per 1000 inhabitants per day during 2017; Figure 38).

Antibiotic guardians

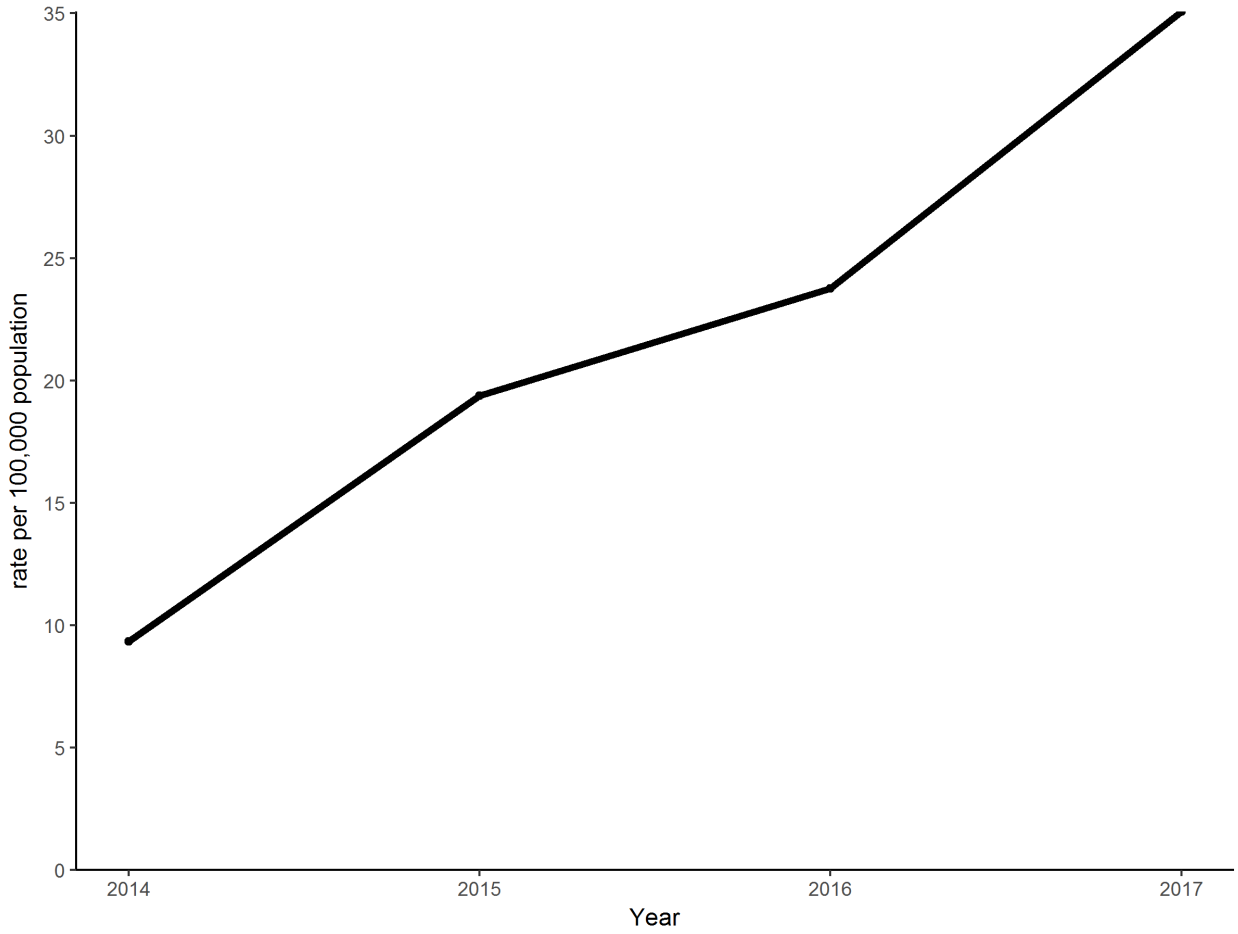


Figure 39: Cumulative rate of antibiotic guardians per 100,000 population, NI, 2014 - 2017

There has been a year on year increase in the cumulative rate of antibiotic guardians in Northern Ireland. During 2017, there were 656 individuals registered (35 individuals per 100,000 population; Figure 39).

Discussion

This is the second report of antimicrobial resistance and antimicrobial consumption in Northern Ireland. As with the prevous report, we have aimed to keep the content generally comparable with the ESPAUR report for England[3]. In future reports, we aim to be able to access, analyse and report more detailed information about antimicrobial use and resistance in specific healthcare settings.

Antimicrobial resistance

The focus for the antimicrobial resistance section was the organism-antibiotic combinations that were identified as part of the UK AMR strategy[2]. The data for this report has been extracted from the regional laboratory system. As of 2017 *Staphylococcus aureus*, and gram negative bloodstream infections (*E.coli*, *K. pneumoniae* and *Pseudomonas sp.*) are subject to mandatory surveillance.

The information presented in this report demonstrates increasing incidence and increasing resistance of many bloodstream infections, particularly *E. coli*, *K. pneumoniae* and glycopeptide-resistant enterococci.

E. coli and *K. pneumoniae* bloodstream infections have been targeted as part of the UK governments ambition to reduce healthcare-associated gram-negative bloodstream infections by 50% by 2020. In order to reduce the number of these infections, local teams will need timely information about the characteristics of the patients who are affected, the risk factors that contributed to the infection and which healthcare settings were responsible. In recognition of this, mandatory surveillance of gram-negative bloodstream infections was introduced in April 2018. These new data will be an important source of business intelligence for Health and Social Care Trusts as they aim to improve the quality and safety of the care that they provide. The success of this new programme will require Trusts to take steps to implement new data collection arrangements quickly for the benefit of their patients.

Antimicrobial resistance in most of the selected organisms has remained relatively stable since 2009, with increases noted in both *E. coli* and *K. pneumoniae* resistance to co-amoxiclav and Glycopeptide resistant enterococci. The number of Carbapenem Producing Organisms (CPOs) preported to the PHA have increased in 2017 after declining from 2014-2016, however this likely reflects the voluntary nature of reporting (case ascertainment) as

well as local developments in the ability to test for CPO. Comparable data for England is available in their 2018 ESPAUR report. While the proportion of isolates that are resistant to key antibiotics has not changed very much over time, the absolute number of resistant infections has increased because of the overall rising number of infections. As antimicrobial resistance is a transmissible global problem, PHA will continue to collaborate with Public Health England and the Scottish, Welsh and Irish public health organisations, to contribute to the European Antimicrobial Resistance Surveillance Network (EARS-Net) and the World Health Organisation's Global Antimicrobial Resistance Surveillance System (GLASS). This will ensure standardised information on antimicrobial resistance is available to inform comparisons and drive improvement.

Antibiotic consumption

Total antibiotic consumption in Northern Ireland has slightly declined in 2017 to 29.87 DDD per 1,000 inhabitants after remaining largely unchanged for the previous three years. Little overall change was noted in secondary care witha slight decrease in primary care in 2016 and 2017. Despite this, the rate of antimicrobial consumption in secondary care per admission or per occupied bed day has continued to steadily increase, perhaps suggesting that the case-mix of hospital inpatients has become more severe over time. This relative stasis is in contrast with the situation in England, where antibiotic consumption has continued to fall, and was measured at 21.1 DDD per 1,000 inhabitants per day in 2017. By this measure, Northern Ireland's total antibiotic consumption is 41% higher than that of England.

Penicillins, tetracyclines and macrolides were the most commonly prescribed antibiotics in both settings. There has been little change in penicillins or tetracyclines in either setting but macrolide consumption in primary care has slightly declined over time. The use of carbapenems, and meropenem in particular have also declined over time in Northern Ireland, which is an encouraging trend. Use of co-amoxiclav also fell further in 2017, and trimethoprim use fell slightly. In general, however, comparison with antimicrobial use in England continues to highlight substantially higher use in Northern Ireland. Piperacillin/tazobactam consumption remained unchanged in 2017 at 0.20 DDD per 1,000 inhabitants per day, which is more than three times the declining rate in England (0.065 DDD per 1,000 inhabitants per day). It should be noted however, the 2017 decrease in piperacillin/tazobactam use in England is partly due to an international supply shortage with an increase in the use of alternative antibiotics as a result. In 2018/19, piperacillin/tazobactam will be the focus of a reduction target as part of the UK ambition to recuce inappropriate prescribing. The rate of cephalosporin use was steady at 0.57 DDD per 1,000 inhabitants per day, which is twice the English rate of 0.33 DDD per 1,000 inhabitants per day. The use of tetracyclines, particularly doxycycline, continued to increase in Northern Ireland to 7.49 DDD per 1,000 inhabitants per day, which was much higher than the English rate of 4.7 DDD per 1,000 inhabitants per day. The use of quinolones and macrolides has remained unchanged over the last 3 years in Northern Ireland, during which time macrolide use has decreased in England, but quinolone use has slightly increased.

Colistin is an antibiotic of last resort that is used for multidrug-resistant infections and also as an inhaled therapy for people with cystic fibrosis. Colistin consumption in Northern Ireland has been steady for the last three years, but rates are higher than in England (0.13

DDD per 1,000 inhabitants per day in 2017 in NI and 0.078 DDD per 1,000 inhabitants per day in 2017 in England).

The amount of antimicrobial use in Northern Ireland remains markedly higher than England. Understanding the reasons for the difference is a complex task. Most antibiotics were prescribed in the primary care setting. In order to understand and address the factors that lead to antibiotic consumption, we need information about the characteristics of the people who are prescribed them. During 2018 the PHA collaborated with the Health and Social Care Board, the Innovation Lab at the Department of Finance and other primary care stakeholders to fill this information gap, producing a report of their findings. In the secondary care setting, investigating the reasons for differences is vastly more difficult because antimicrobial consumption is measured at ward level, not at patient level, and therefore there is no routine source of information that links antibiotic use to individual patient details. Health and Social Care Northern Ireland has committed to developing a new electronic health care record ("Encompass"), which will ultimately include electronic prescribing, which will provide a rich source of information about the factors influencing antimicrobial consumption. However, over-use of antibiotics is already causing harm to patients, and we cannot afford to wait years before addressing the challenges of inappropriate antimicrobial prescribing. Reducing antimicrobial consumption safely is the complex challenge that faces all of us. One way of engaging clinicians (as well as other professionals and the public) in this challenge, is to encourage them to sign up to an Antibiotic Guardian pledge. There were more new Antibiotic Guardians in 2017 (n= 216) than in the previous three years, an encouraging sign.

Public communication

The O'Neill report recommended a major global information campaign to raise awareness about the future harms likely to occur if antibiotic use was not reduced. PHA has developed a communications plan to communicate with people in Northern Ireland about the potential harms related to inappropriate antibiotic use. This will involve running engagement events, social media and news releases at key points. Highlights include:

- Ongoing significant press and social media activity is planned and implemented specifically around World Antibiotic Awareness Week. These included an animation to inform the public on the threat of AMR, and the actions they can take to keep antibiotics working; videos of professionals including medics, pharmacists and scientists explaining the threat of AMR; and a series of antibiotic mythbusters. The issue was highlighted on news bulletins on several local radio stations.
- 100 primary and post-primary teachers in Northern Ireland have attended an e-Bug training workshop. This is a free NICE endorsed educational resource for classrooms that helps teachers educate their pupils on microbes, their spread, treatment and prevention of infection.
- As part of WAAW activities for 2019 PHA, in partnership with Stranmillis University College, will train approximately 90 primary school teachers on e-Bug.
- A significant mass media campaign to inform and engage the public on how to keep antibiotics working is currently being developed and will be launched in 2019.

Changing prescribing behaviour

Safely reducing antimicrobial use is a complex challenge that will require an understanding of the capacity, opportunity and motivation of prescribers to decide when not to prescribe antibiotics. Initiatives to reduce antimicrobial consumption in 2018 have included:

- Publication in March 2018 of the results of a survey with GPs about the factors that influence their antibiotic prescribing decisions and with stakeholders about their current understanding of the problem and ideas for solutions.
- TARGET toolkit workshops for GPs were delivered throughout Northern Ireland during the year.
- Collaborative work on a systematic review of behavioural science interventions for antimicrobial stewardship continues between the Innovation Lab and PHA.
- Evaluation of a pilot point-of-care CRP testing for respiratory infections in primary care was undertaken, with results due in the coming months.

Future Actions

- Continue to monitor the progress of the national ambition to reduce healthcare-associated Gram-negative bacteraemias and assess the impact on the burden of AMR in terms of the numbers of resistant infections
- Further improve our understanding of the epidemiology and incidence of antibiotic-resistant infections with a view to improving their management and prevent onward transmission
- Standardise the approach to investigation and treatment of suspected urinary tract infection in care homes in Northern Ireland
- To lead and coordinate efforts in undergraduate and postgraduate training, continuing professional development, and staff training related to Antimicrobial Stewardship, Antimicrobial Resistance and Infection Prevention and Control
- Continue to monitor trends in antibiotic prescribing across primary and secondary care and explore opportunities to improve benchmarking and quality improvement.
- Conduct a study to understand the factors affecting primary care antibiotic prescribing
- Continue to develop, pilot and validate tool to assess appropriateness of antibiotic prescriptions in acute hospitals and facilitate data collection and analysis of data in
- Plan and implement cascade training workshops for school-teachers about the e-Bug resources
- To work closely with innovation lab to complete a systematic review of interventions for reducing antibiotic prescribing in primary care and development of an intervention
- To work closely with stakeholders to focus and further improve dental prescribing across Northern Ireland

Appendix 1: AMR surveillance categories

Table 14: Antibiotic names (trade and generic) and assigned surveillance group for the antimicrobial resistance data

Antibiotic surveillance group	Individual antibiotic name
3rd Generation Cephalosporin	cefotaxime
3rd Generation Cephalosporin	claforan
3rd Generation Cephalosporin	ceftazidime
3rd Generation Cephalosporin	fortum
3rd Generation Cephalosporin	cefpodoxime
3rd Generation Cephalosporin	ceftizoxime
3rd Generation Cephalosporin	ceftriaxone
Carbapenem	meronem
Carbapenem	meropenem
Carbapenem	imipenem
Carbapenem	ertapenem
Ciprofloxacin	ciprofloxacin
Ciprofloxacin	low level ciprofloxacin
Ciprofloxacin	ciproxin
Co-amoxiclav	co-amoxiclav
Co-amoxiclav	amoxicillin/clavulanate
Co-amoxiclav	augmentin
Colistin	colistin
Colistin	colomycin
Gentamicin	gentamicin
Gentamicin	lugacin
Gentamicin	cidomycin
Gentamicin	genticin
Gentamicin	garamycin
Gentamicin	high_level gentamicin
Glycopeptide	vancocin
Glycopeptide	vancomycin
Glycopeptide	teicoplanin
Macrolides	clarithromycin

Antibiotic surveillance group	Individual antibiotic name
Macrolides	erythromycin
Macrolides	azithromycin
Macrolides	erythrocin
Macrolides	erythromid
Methicillin	cefoxitin
Methicillin	flucloxacillin
Methicillin	floxapen
Methicillin	oxacillin
Methicillin	meticillin
Methicillin	celbenin
Methicillin	cloxacillin
Methicillin	orbenin
Penicillin	apsin
Penicillin	benzylpenicillin
Penicillin	phenoxymethylpenicillin
Penicillin	penicillin
Penicillin	penidural
Piperacillin/Tazobactam	tazocin
Piperacillin/Tazobactam	piperacillin/tazobactam

Appendix 2: AMC data categories

Table 15: Antibiotic names, ATC codes and assigned surveillance group for the antimicrobial consumption data

Antibiotic surveillance group	Individual antibiotic name	ATC codes
Aminoglycosides	tobramycin	J01GB01
Aminoglycosides	gentamicin	J01GB03
Aminoglycosides	neomycin	J01GB05
Aminoglycosides	amikacin	J01GB06
Anti-Clostridium difficile agents	vancomycin	A07AA09
Anti-Clostridium difficile agents	fidaxomicin	A07AA12
Anti-Clostridium difficile agents	metronidazole	G01AF01
Anti-Clostridium difficile agents	metronidazole	P01AB01
Anti-folate agents	trimethoprim	J01EA01
Anti-folate agents	sulfapyridine	J01EB04
Anti-folate agents	sulfadiazine	J01EC02
Anti-folate agents	sulphamethoxypyridazine	J01ED05
Anti-folate agents	co-trimoxazole	J01EE01
Anti-folate agents	nitrofurantoin	J01XE01
Anti-folate agents	methenamine	J01XX05
Anti-tuberculous drugs	streptomycin	J01GA01
Carbapenems	meropenem	J01DH02
Carbapenems	ertapenem	J01DH03
Carbapenems	imipenem with cilastatin	J01DH51
Cephalosporins	cefalexin	J01DB01
Cephalosporins	cefazolin	J01DB04
Cephalosporins	cefadroxil	J01DB05
Cephalosporins	cefradine	J01DB09
Cephalosporins	cefoxitin	J01DC01
Cephalosporins	cefuroxime	J01DC02
Cephalosporins	cefaclor	J01DC04
Cephalosporins	cefotaxime	J01DD01
Cephalosporins	ceftazidime	J01DD02
Cephalosporins	ceftriaxone	J01DD04

Antibiotic surveillance group	Individual antibiotic name	ATC codes
Cephalosporins	cefixime	J01DD08
Cephalosporins	cefpodoxime	J01DD13
Cephalosporins	ceftazidime_with_avibactam	J01DD52
Cephalosporins	ceftaroline	J01DI02
Glycopeptides and Daptomycin	vancomycin	J01XA01
Glycopeptides and Daptomycin	teicoplanin	J01XA02
Glycopeptides and Daptomycin	dalbavancin	J01XA04
Glycopeptides and Daptomycin	daptomycin	J01XX09
Lincosamides	clindamycin	J01FF01
Macrolides	erythromycin	J01FA01
Macrolides	clarithromycin	J01FA09
Macrolides	azithromycin	J01FA10
Macrolides	telithromycin	J01FA15
Monobactams	aztreonam	J01DF01
Nitroimidazoles	metronidazole	J01XD01
Nitroimidazoles	tinidazole	P01AB02
Other antibiotics	chloramphenicol	J01BA01
Other antibiotics	quinupristin	J01FG02
Other antibiotics	colistin	J01XB01
Other antibiotics	fucidic_acid	J01XC01
Other antibiotics	fosfomycin	J01XX01
Oxazolidinones	linezolid	J01XX08
Oxazolidinones	tedizolid	J01XX11
Penicillins	ampicillin	J01CA01
Penicillins	amoxicillin	J01CA04
Penicillins	pivmecillinam	J01CA08
Penicillins	temocillin	J01CA17
Penicillins	co-fluampicil	J01CA51
Penicillins	benzylpenicillin	J01CE01
Penicillins	phenoxymethylpenicillin	J01CE02
Penicillins	benzathine-benzylpenicillin	J01CE08
Penicillins	procaine	J01CE09
Penicillins	flucloxacillin	J01CF05
Penicillins	co-fluampicil	J01CR50

Antibiotic surveillance group	Individual antibiotic name	ATC codes
Penicillins with beta lactamase inhibitors	co-amoxiclav	J01CR02
Penicillins with beta lactamase inhibitors	ticarcillin with clavulanic_acid	J01CR03
Penicillins with beta lactamase inhibitors	piperacillin/tazobactam	J01CR05
Quinolones	ofloxacin	J01MA01
Quinolones	ciprofloxacin	J01MA02
Quinolones	norfloxacin	J01MA06
Quinolones	levofloxacin	J01MA12
Quinolones	moxifloxacin	J01MA14
Tetracyclines and related drugs	doxycycline	J01AA02
Tetracyclines and related drugs	lymecycline	J01AA04
Tetracyclines and related drugs	oxytetracycline	J01AA06
Tetracyclines and related drugs	tetracycline	J01AA07
Tetracyclines and related drugs	minocycline	J01AA08
Tetracyclines and related drugs	tigecycline	J01AA12

Appendix 3: Testing data

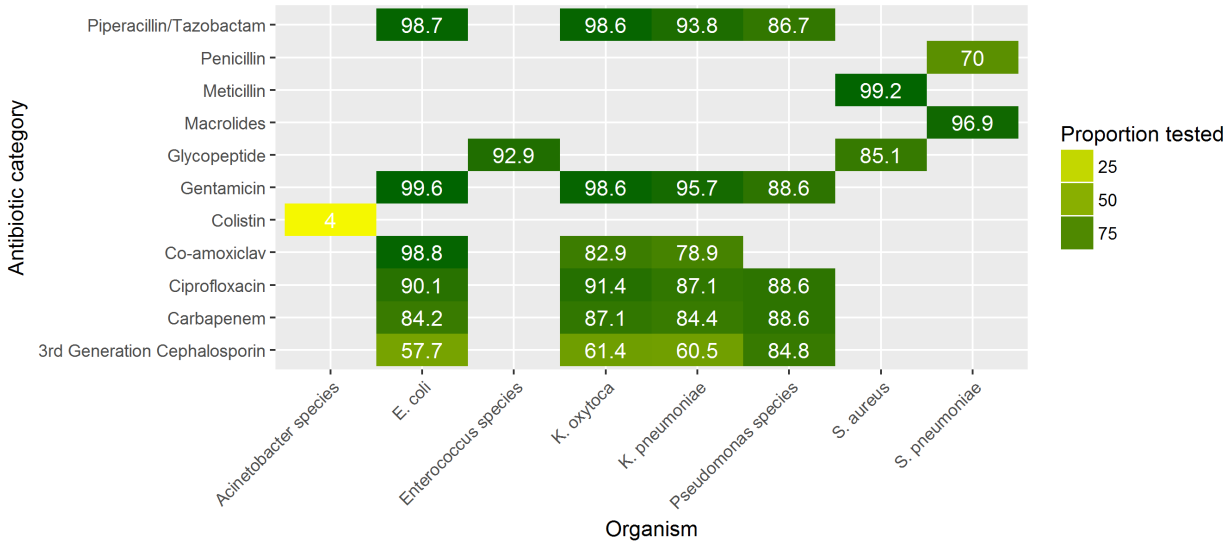


Figure 40: The proportion of key bacteraemias where selected antibiotic susceptibility results were reported to the PHA

Appendix 4: Drug/bug combinations monitored

Bacteria	Antibiotics
Escherichia coli	Third-generation cephalosporins, carbapenems, co-amoxiclav, ciprofloxacin, gentamicin, piperacillin/tazobactam
Klebsiella pneumoniae	Third-generation cephalosporins, carbapenems, co-amoxiclav, ciprofloxacin, gentamicin, piperacillin/tazobactam
Pseudomonas species	Third-generation cephalosporins, carbapenems, ciprofloxacin, gentamicin, piperacillin/tazobactam
Staphylococcus aureus	Glycopeptide, meticillin
Enterococcus species	Glycopeptide
Streptococcus pneumoniae	Macrolides, penicillin
Acinetobacter species	Colistin

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