Surveillance of Antimicrobial Use and Resistance in Northern Ireland Report 2019 - 2021

1 Executive summary

Background

Antimicrobial resistance (AMR) is one of the most pressing global challenges we face this century. It is listed on the UK government's National Risk Register and is among the World Health Organization's (WHO) top 10 global public health threats. In 2019, there were 4.95 million deaths associated with bacterial antimicrobial resistance across 204 countries, with 1.27 million of those directly attributed to antimicrobial resistance [1].

AMR develops when organisms develop the ability to survive exposure to antimicrobial drugs. Antimicrobials includes antibiotic, antiprotozoal, antiviral and antifungal medicines. Antibiotic consumption is the key driver for the emergence of antimicrobial resistance in healthcare. Antibiotics are prescribed across a range of settings including primary and secondary care, out-of-hours services and dental care.

The Public Health Agency (PHA) undertake surveillance of antibiotic resistance and antibiotic consumption for all healthcare settings in Northern Ireland (NI). The aim of this annual report is to describe trends in antibiotic resistance and antibiotic consumption in NI between 2019 and 2021.

Key Results

Antibiotic Resistance

Escherichia coli was the most commonly reported cause of bloodstream infection (bacteraemia) of the key selected organisms, accounting for more than 50% of those reported in 2021. Increases were also observed between 2020 and 2021 for *Enterococcus* species, *Staphylococcus aureus*, *Klebsiella oxytoca* and *Pseudomonas* species.

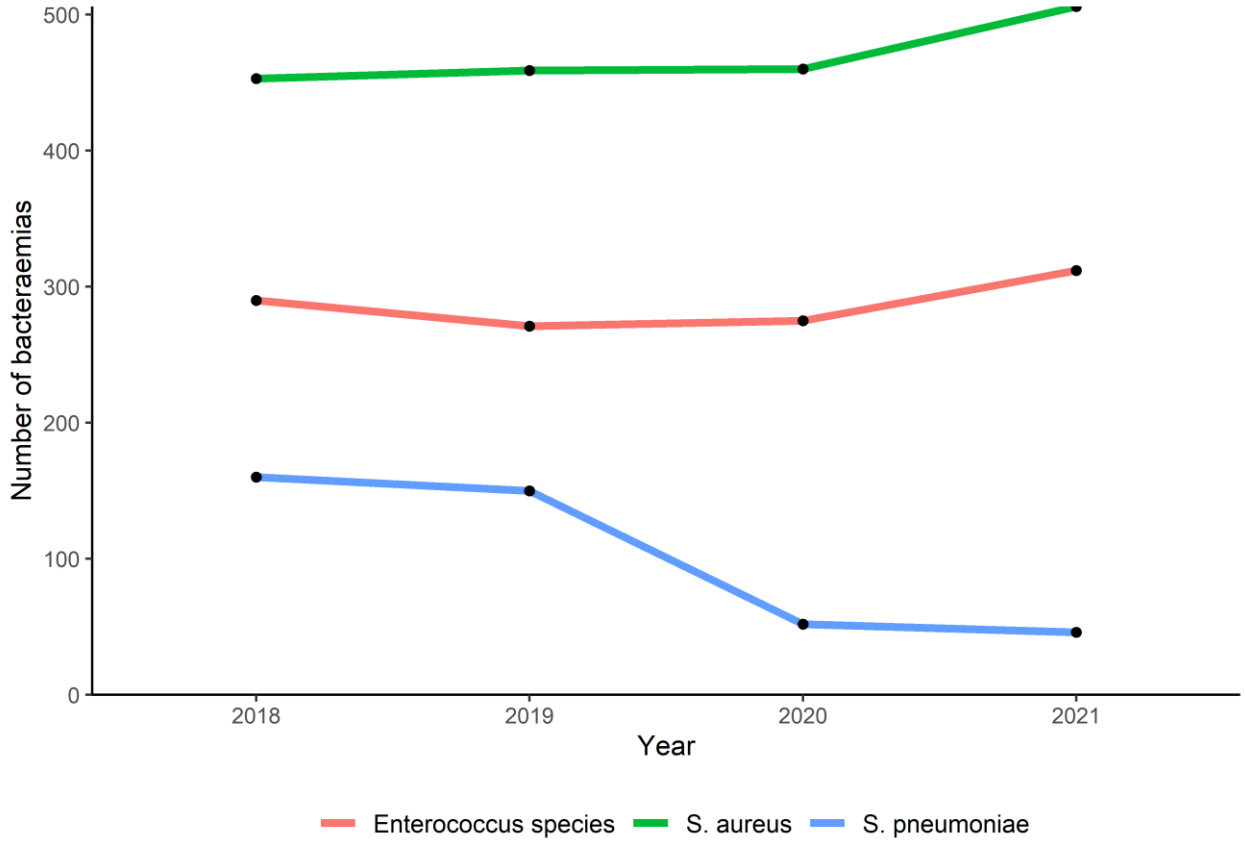

Figure 1.1: Number of Gram-positive bacteraemias reported in NI by organism, 2018 - 2021

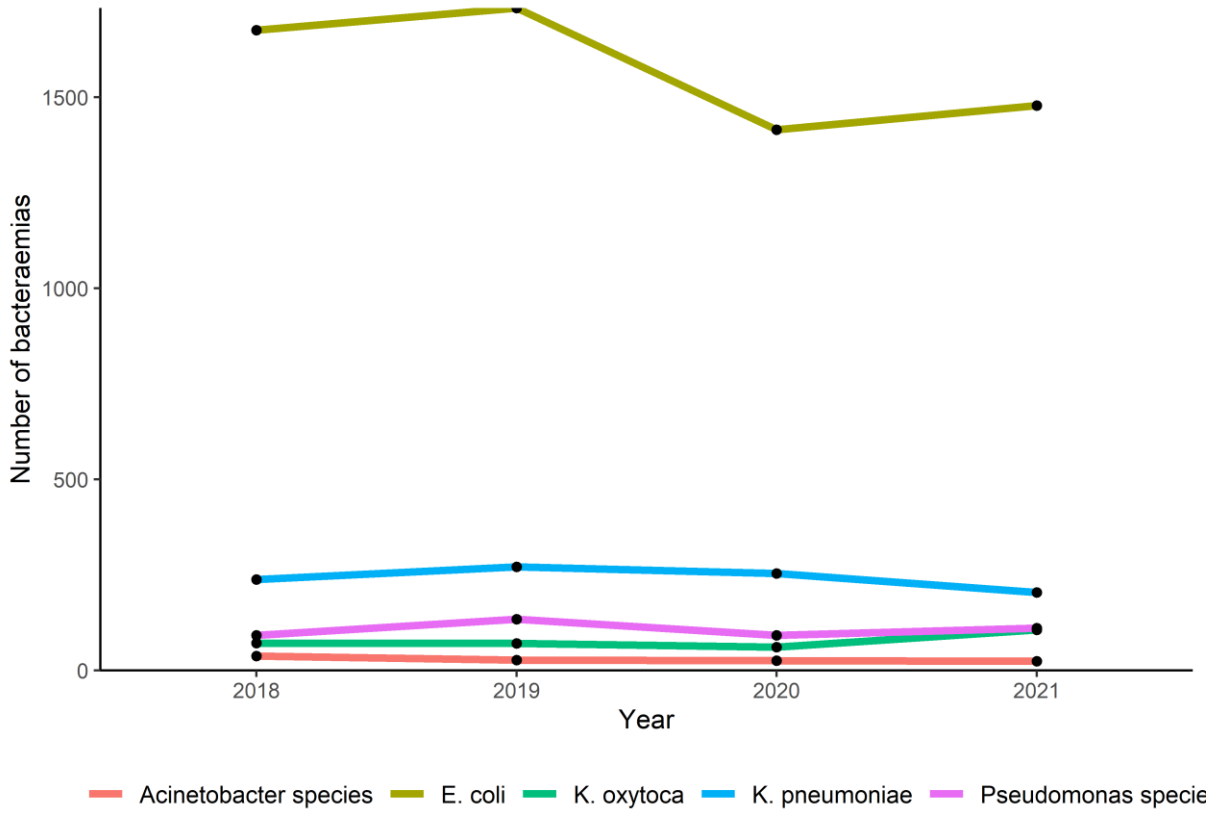

Figure 1.2: Number of Gram-negative bacteraemias reported in NI by organism, 2018 - 2021

In 2021, decreases were noted for *E. coli*, *Klebsiella pneumoniae* and *K. oxytoca* resistance to piperacillin/tazobactam, Glycopeptide-resistant *Enterococcus* (GRE) and meticillin resistant *S. aureus* (MRSA). Increases were observed for *Pseudomonas* sp resistance to piperacillin/tazobactam and *Streptococcus pneumoniae* resistance to penicillin. There have been no reported isolates of colistin resistant *Acinetobacter* since 2017.

Multi-drug resistance (resistance to three or more antibiotic classes) among the selected organisms and drug combinations increased slightly between 2018 and 2021 except for *K.oxytoca* which decreased.

K. pneumoniae were the most commonly reported carbapenemase-producing Enterobacterales (CPE) in 2021, with NDM and OXA-48 as the most commonly reported resistance mechanisms.

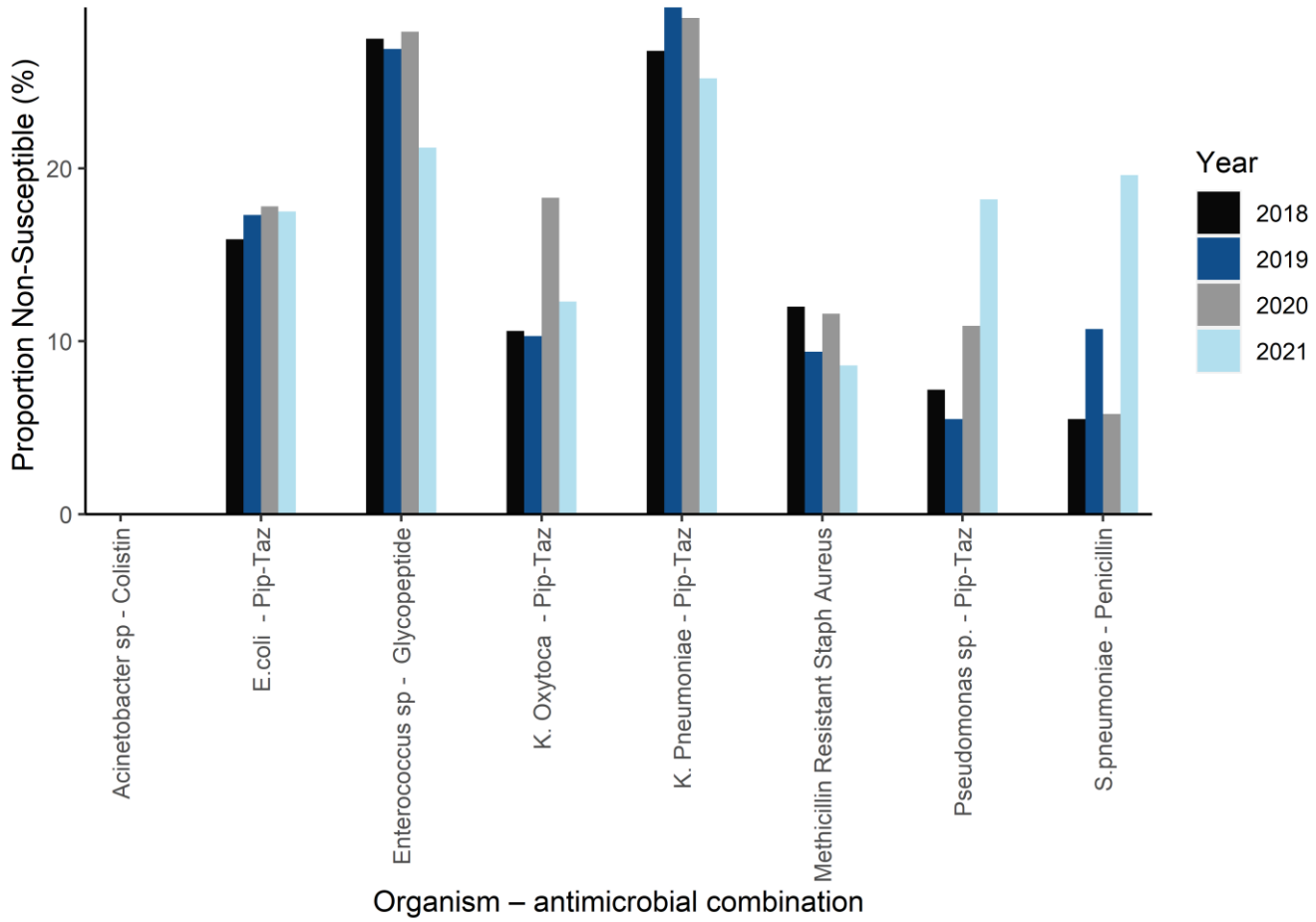

Figure 1.3: Proportion (%) of bacteraemias non-susceptible to selected antibiotics in NI, 2018 - 2021

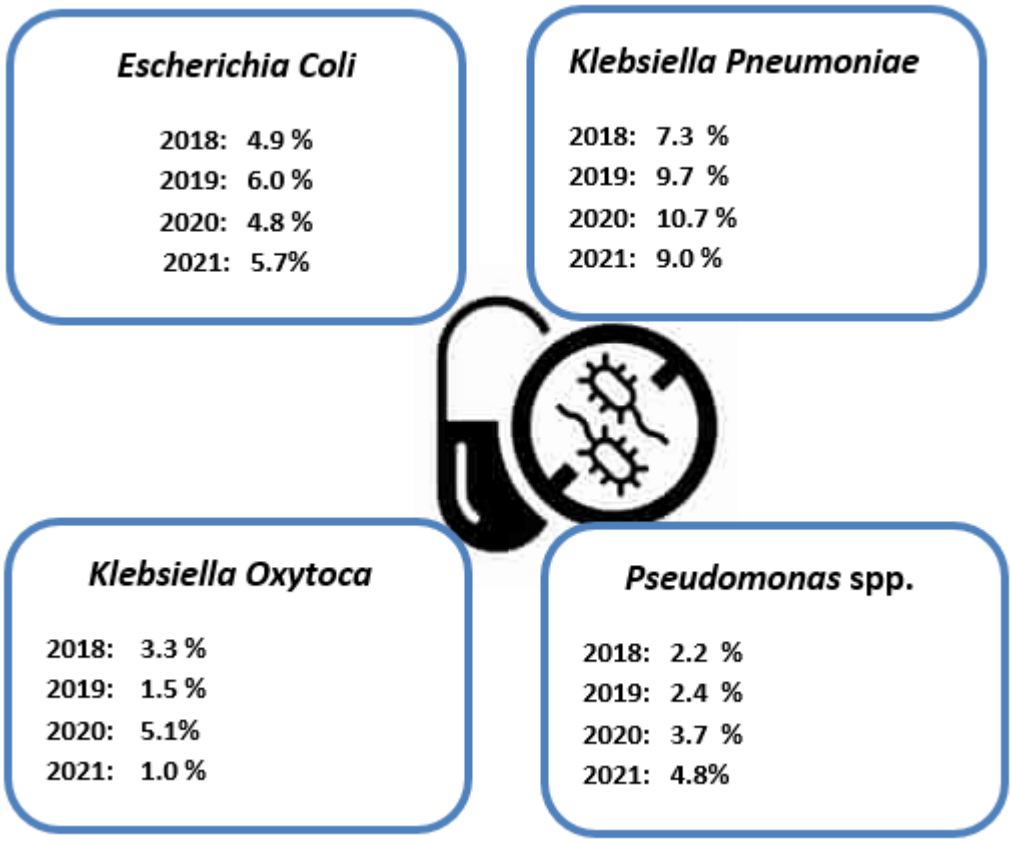

Figure 1.4: Proportion of isolates displaying multi-drug resistance (resistance to three or more antibiotic classes)

Antibiotic Consumption

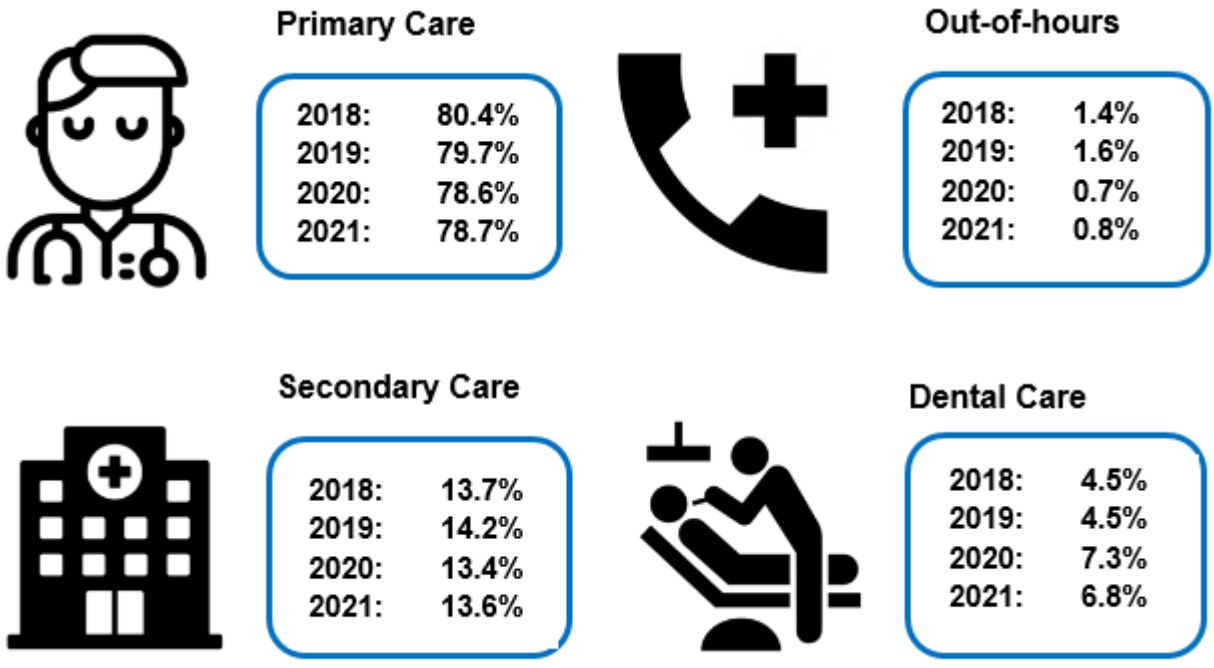

Figure 1.5: Proportion of total antibiotic consumption by setting

Total antibiotic consumption generally decreased between 2018 to 2021, with a slight increase noted from 2020 to 2021. Decreases were noted in both primary and secondary care settings with the majority of prescribing taking place in primary care. Prescribing from out-of-hours remained relatively stable between 2020 to 2021. Consumption of antibiotics in dental care accounted for less than 7% of total antibiotic consumption during 2021.

Note: Primary care includes "in hours primary care" and out-of-hours includes "primary care out-of-hours".

Engagement Activities & Future Work

Despite barriers introduced by the COVID-19 pandemic in 2020, the PHA continued to work with healthcare trusts to monitor trends in gram-negative bloodstream infections and antibiotic prescribing and with partners within the Health and Social Care Board (now Strategic Planning and Performance Group) to deliver public campaigns and interventions to increase awareness of appropriate antibiotic use and reduce antimicrobial resistance. In 2023, the PHA will contribute to the development of the new UK National Action Plan for antimicrobial resistance and the development of a local implementation plan for NI.

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Date generated: 17/10/2023

2 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. 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, the Department of Agriculture, Environment and Rural Affairs, and the Food Standards Agency published an updated five-year action plan in 2019, using a whole system type approach to tackle antimicrobial resistance (Changing the culture 2019-2024: One Health) [2].

Policy for the reduction of antimicrobial-resistant infections and antimicrobial consumption is led by the One Health Strategic Antimicrobial Resistance and Healthcare-associated Infection (SAMRHAI) group. PHA leads a multi-agency group, the Healthcare-associated Infection and Antimicrobial Stewardship Improvement Board, for translating policy and strategy into action for human health which has a number of themed subgroups responsible for regional efforts to reduce harm from antimicrobial use and resistance in different settings.

The aim of the report is to describe trends in antibiotic resistance and antibiotic consumption in NI. The first section describes trends in antibiotic resistance using selected combinations of bacteria and antibiotics in line with those identified as key indicators as part of the UK antimicrobial resistance strategy [3]. In addition, bacteria-antibiotic combinations included in the English surveillance programme for antimicrobial utilisation and resistance (ESPAUR) report [4] were also chosen.

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

3 Results

3.1 Antibiotic resistance

3.1.1 *Escherichia coli* bacteraemia

The number of *Escherichia coli* bacteraemias has been generally increasing since 2009 but decreased between 2018 and 2021 from 1675 to 1478 (Figure 3.1). Between 2019 and 2020 the number of *E. coli* bacteraemias decreased from 1733 to 1415 before a slight increase in 2021. The proportion of isolates tested against key antibiotics during 2021 is shown in Appendix 3.

The overall proportion of *E. coli* bacteraemias non-susceptible to selected antibiotics decreased between 2018 to 2021 (19.2% to 16.7%).

Non-susceptibility to co-amoxiclav and third-generation cephalosporins remained relatively stable between 2018 and 2021 (55.9% to 53.7% and 10.8% to 10.4% respectively). Resistance to piperacillin/tazobactam has seen a slight increase over the same time period (15.9% to 17.5%). Gentamicin resistance increased from 2018 to 2019 (9.8% to 10.6%), decreased to 9.5% in 2020 before further decreasing to 8.3% in 2021. *E. coli* resistance to ciproflaxin steadily decreased from 17.9% in 2018 to 14.5% in 2021.

There were a total of five *E. coli* isolates non-susceptible to carbapenems detected from 2020 to 2021. This is an increase from the 3 non-susceptible isolates detected during the 2018-2019 reporting period (Figure 3.2).

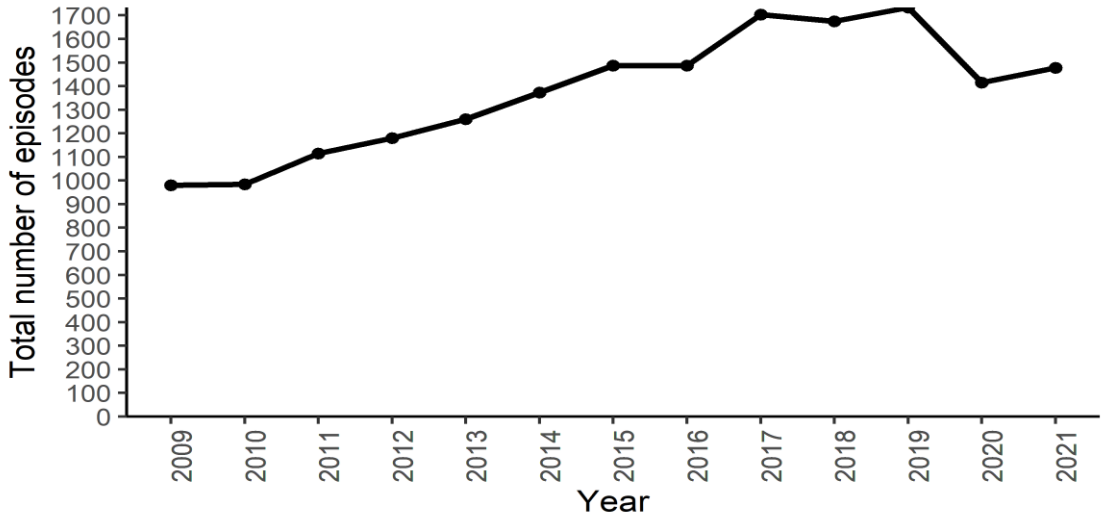

Figure 3.1: Number of *E. coli* bacteraemias reported to the PHA, 2009 - 2021

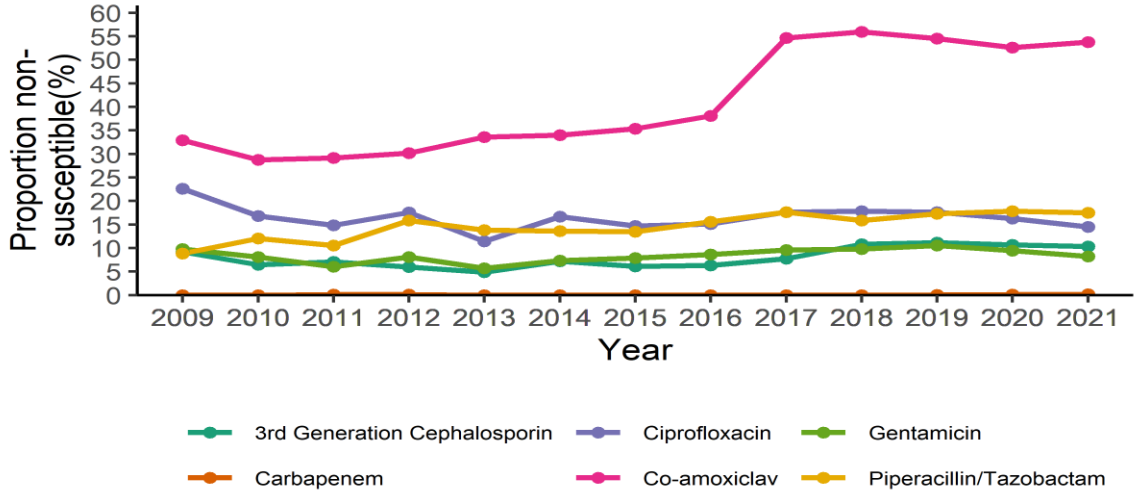

Figure 3.2: Proportion of *E. coli* bacteraemias non-susceptible to selected antibiotics in NI, 2009 - 2021

The proportion of *E. coli* bacteraemias showing multi-drug resistance slightly increased between 2018 to 2019 (4.9% to 6%), decreasing in 2020 (4.8%) before increasing to 5.7% in 2021. Within the combination of antibiotic classes, the highest proportion of non-susceptibility in 2021 was among third-generation cephalosporins, quinolones and aminglycosides (3.4%). This is a slight increase in comparison to 2020 during which 3% of *E. coli* were non-susceptible to third-generation cephalosporins, quinolones and aminoglycosides. The lowest proportion non-susceptible in 2021 was observed for third-generation cephalosporins, aminoglycosides and piperacillin/tazobactam (1.8%), remaining relatively stable in comparison to 2020 (1.5%) (Figure 3.3).

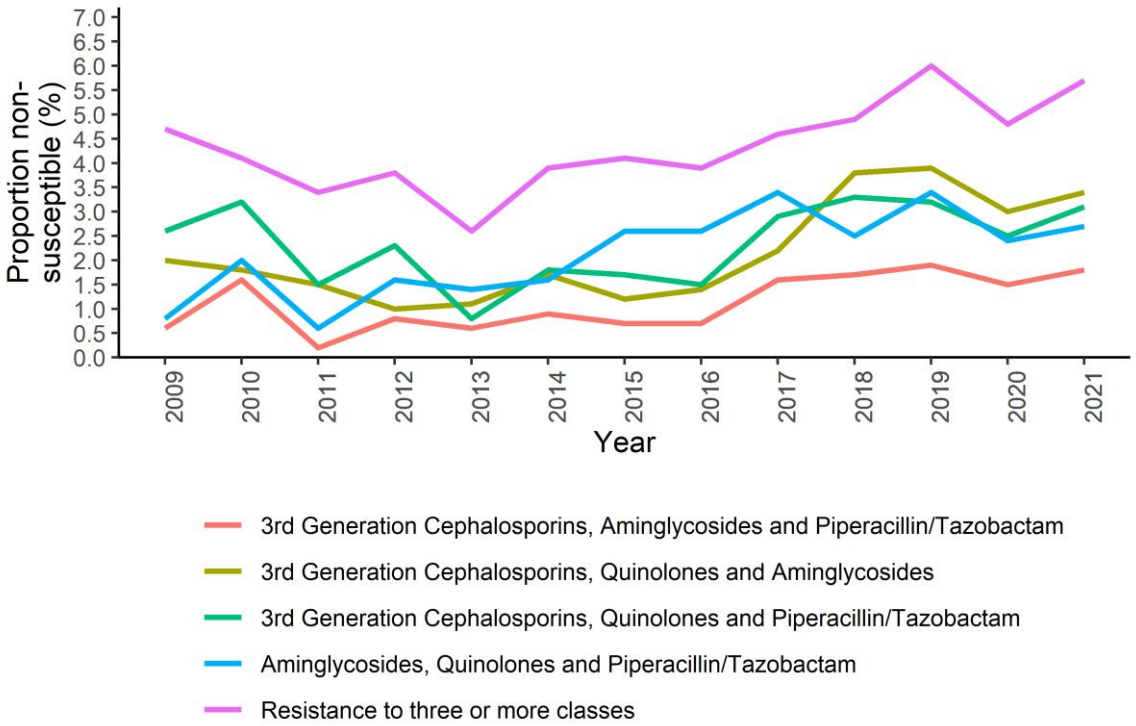

Figure 3.3: Proportion of *E. coli* bacteraemias reported to the PHA with multi-drug resistance, 2009 - 2021

3.1.2 *Klebsiella pneumoniae* bacteraemia

The number of *Klebsiella pneumoniae* bacteraemias has generally been increasing since 2009 but decreased between 2019 and 2021 from 238 cases to 204 (Figure 3.4). The proportion of isolates tested against key antibiotics during 2021 is shown in Appendix 3.

The overall proportion of *K. pneumoniae* bacteraemias non-susceptible to selected antibiotics increased from 16.5% in 2018 to 18.1% in 2020 before decreasing in 2021 (15.2%).

Specifically, resistance has decreased from 2018 to 2021 for; ciprofloxacin (19.4% to 16.3%); gentamicin (11% to 8.9%) and co-amoxiclav (29.1% to 25.9%). Cephalosporin resistance increased from 14% in 2018 to 19.8% in 2020 before decreasing to 14.5% in 2021. A similar trend was observed for piperacillin/tazobactam which also saw a slight increase in resistance from 2018 to 2020 (26.8% to 28.7%) before falling to 25.2% in 2021.

The number of isolates non-susceptible to carbapenems has increased between 2018-2021 from zero non-susceptible isolates detected in 2018 to 2 detected in 2021. In 2019, a single carbapenem non-susceptible *K. pneumoniae* isolate was detected with none detected during 2020 (Figure 3.5).

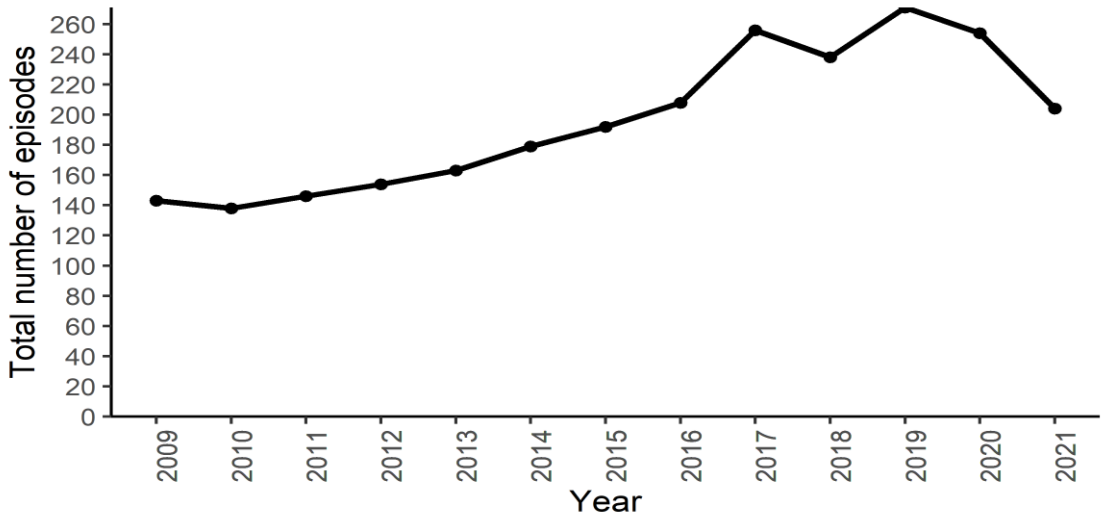

Figure 3.4: Number of *K. pneumoniae* bacteraemias reported to the PHA, 2009 - 2021

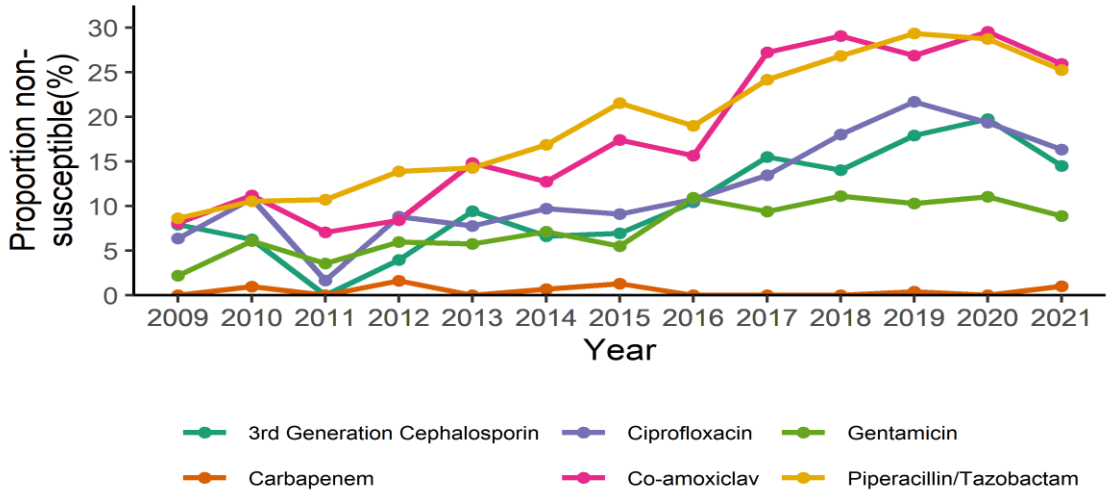

Figure 3.5: Proportion of *K. pneumoniae* bacteraemias non-susceptible to selected antibiotics in NI, 2009 - 2021

The proportion of *K. pneumoniae* bacteraemias showing multi-drug resistance increased slightly within the named antibiotic combinations from 2018 to 2019 (7.3% to 9.7%), increasing further to 10.7% in 2020 before decreasing to 9% in 2021. Within the named combinations of antibiotic classes, the highest proportion non-susceptible during 2018-2020 was observed among third-generation cephalosporins, quinolones and piperacillin/tazobactam, which increased from 5.2% in 2018 to 6% in 2020. In 2021, the highest proportion non-susceptible was observed among third-generation cephalosporins, aminoglycosides and piperacillin/tazobactam (6%).

The lowest proportion non-susceptible among the antibiotic class combinations has varied during the 2018-2021 period. In 2018, lowest proportion non-susceptible was observed for third-generation cephalosporins, aminoglycosides and piperacillin/tazobactam (4.5%), while in both 2019 and 2021 the lowest proportion non-susceptible was observed among aminoglycosides, quinolones and piperacillin/tazobactam (7.0% and 4.5% respectively). During 2020, 4.4% of *K. pneumoniae* isolates were non-susceptible to third-generation cephalosporins, quinolones and aminoglycosides (Figure 3.6).

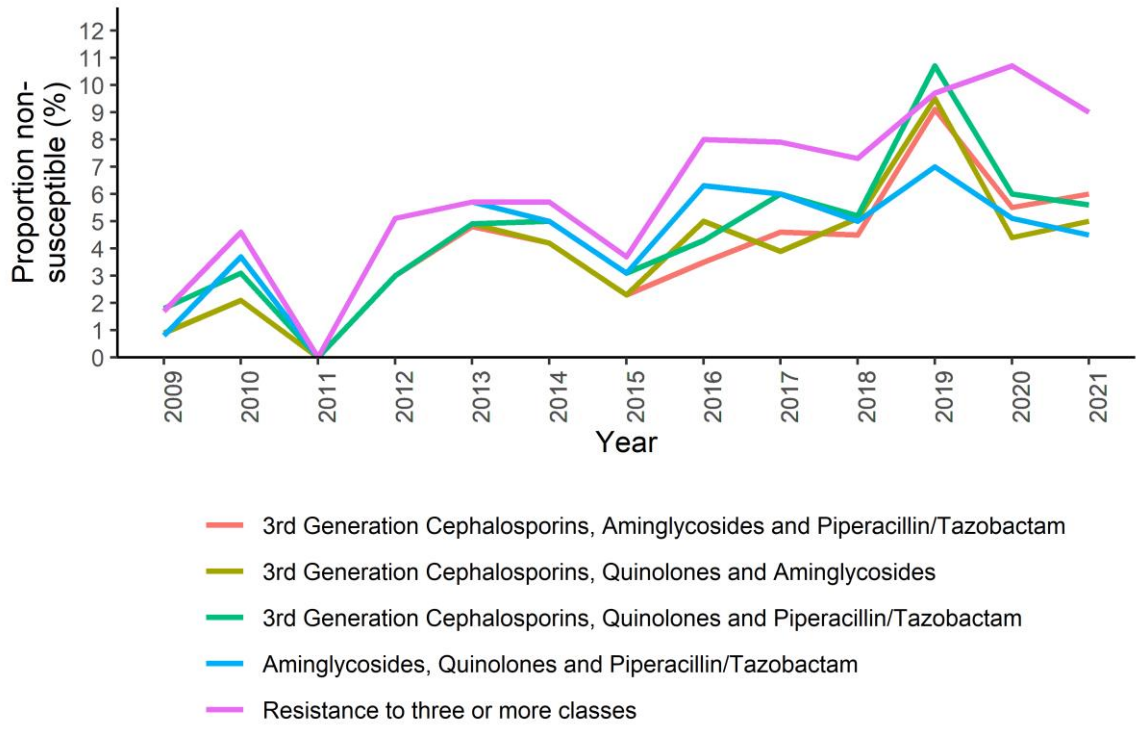

Figure 3.6: Proportion of *K. pneumoniae* bacteraemias reported to the PHA with multi-drug resistance, 2009 - 2021

3.1.3 *Klebsiella oxytoca* bacteraemia

The number of *Klebsiella oxytoca* bacteraemias had been generally stable between 2009-2017. This trend continued during 2018 and 2019 (72 and 71 isolates reported respectively) with a decrease noted in 2020 (61 reported isolates). During 2021 an increase in reported *K. oxytoca* bacteraemias was observed (106 isolates), the highest annual number reported since 2009 (Figure 3.7). The proportion of isolates tested against key antibiotics during the reporting period is shown in Appendix 3.

The overall proportion of *K. oxytoca* bacteraemias non-susceptible to selected antibiotics increased between 2018-2020, from 5.7% to 10.8%, before decreasing to 4.5% in 2021.

K. oxytoca resistance to co-amoxiclav remained relatively stable between 2018-2019 (10.7% and 10.3% respectively) before more than doubling to 24.6% in 2020. This trend however sharply decreased again in 2021, returning to the levels previously observed (10.6%). A similar trend was observed for *K. oxytoca* resistance to piperacillin/tazobactam which was relatively stable between 2018-2019 (10.6% and 10.3% respectively) before increasing in 2020 (18.3%), then decreasing again to 12.3% in 2021.

Within the combination of antibiotic classes, a decrease in resistance was observed between 2018 and 2021 for; third-generation cephalosporins (10.3% to 3.8%), ciprofloxacin (6.7% to 1% respectively), co-amoxiclav (24.6% to 10.6%) and piperacillin/tazobactam (18.3% to 12.3%). The number of *K. oxytoca* bacteraemias non-susceptible to gentamicin has fluctuated across the 2018-2021 period from zero to one in 2018-2019, increasing to 3 non-susceptible isolates in 2020. There were no *K. oxytoca* isolates non-susceptible to gentamicin reported in 2021. Carbapenem

non-susceptible isolates remained at zero during the 2018 to 2021 period (Figure 3.8).

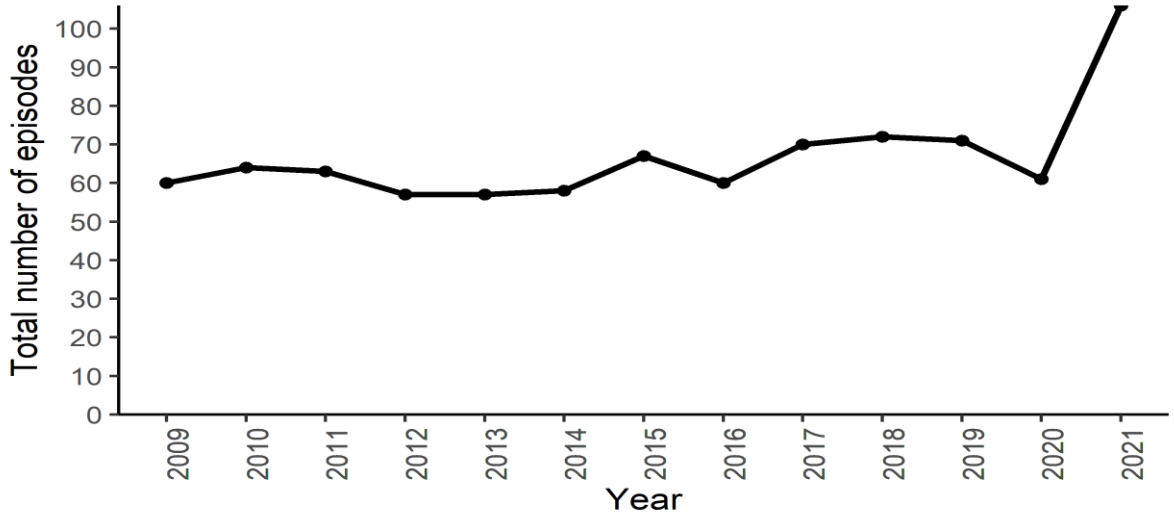

Figure 3.7: Number of *K. oxytoca* bacteraemias reported to the PHA, 2009 - 2021

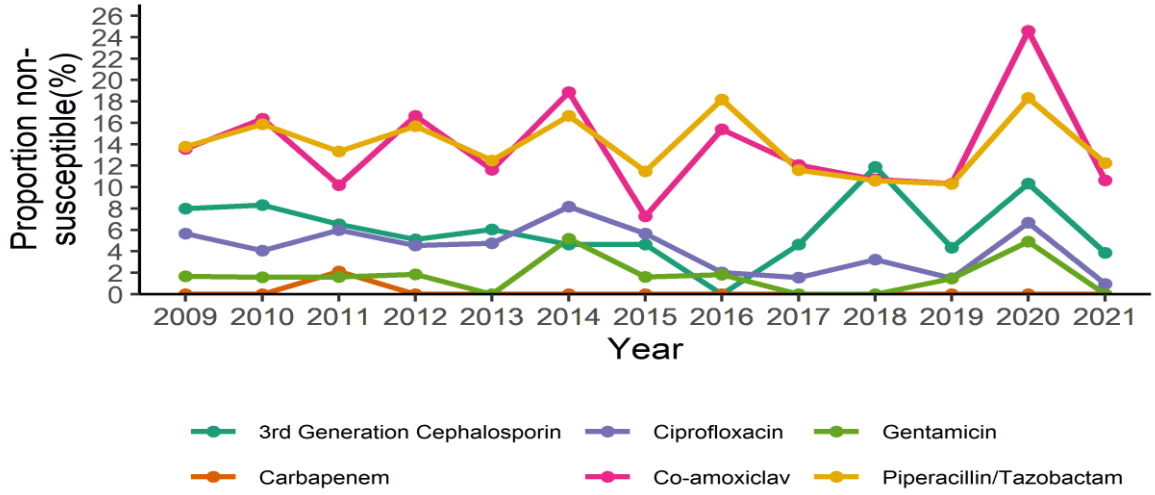

Figure 3.8: Proportion of *K. oxytoca* bacteraemias non-susceptible to selected antibiotics in NI, 2009 - 2021

3.1.4 *Pseudomonas* species bacteraemia

The number of reported *Pseudomonas* species bacteraemias increased from 92 cases in 2018 to 134 cases in 2019, decreasing again to 92 in 2020. During 2021 an increase in the number of *Pseudomonas* species bacteraemias was observed with 111 isolates reported to the PHA (Figure 3.9). The proportion of isolates tested against key antibiotics during 2021 is shown in Appendix 3.

The overall proportion of *Pseudomonas* species bacteraemias non-susceptible to selected antibiotics has slightly increased from 2018 to 2021 (10.2% to 13.3%). There has been a steady decrease in the proportion of *Pseudomonas* species isolates non-susceptible to gentamicin during the 2018-2021 period (6.9% to 1.9%), with a decrease observed in ciprofloxacin resistance (18.4 to 16.4%). *Pseudomonas*

species resistance to pipercillin/tazobactam decreased from 7.2% to 5.5% during 2018-2019, increasing in 2020 to 10.9% and further in 2021 to 18.2%. A similar trend was noted for isolates non-susceptible to third-generation cephalosporins. The proportion of *Pseudomonas* species bacteraemias non-susceptible to cephalosporins decreased during 2018-2019 (6.9% to 2.4%), before increasing during both 2020 and 2021 to 9.9 and 16.4% respectively. *Pseudomonas* resistance to carbapenems fluctuated between 2018 to 2021, increasing between 2018-2019 (11.5 to 18.7%) before decreasing in 2020 to 16.3% and further to 13.6% in 2021 (Figure 3.10).

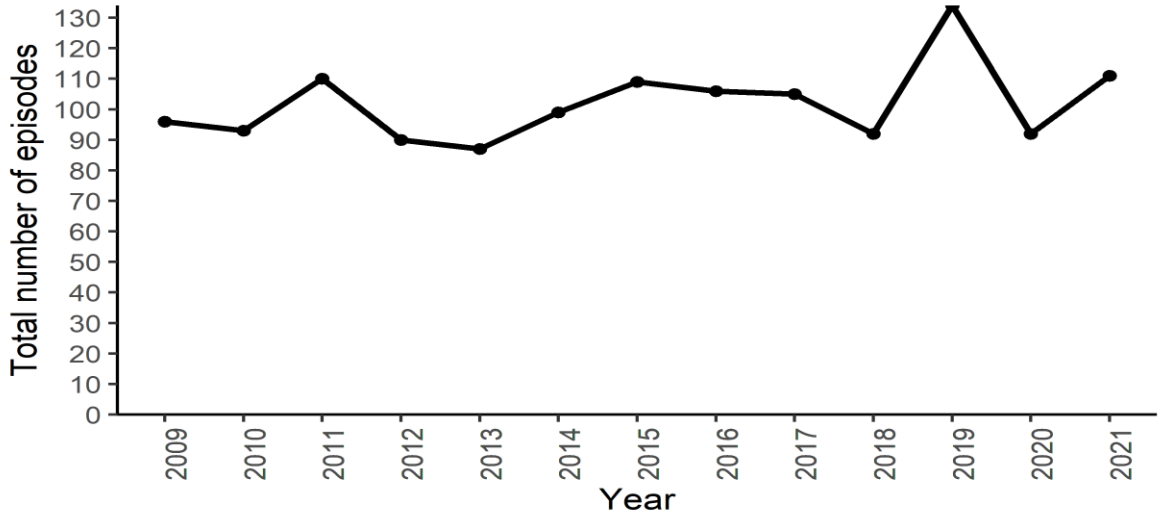

Figure 3.9: Number of *Pseudomonas* species bacteraemias reported to the PHA, 2009 - 2021

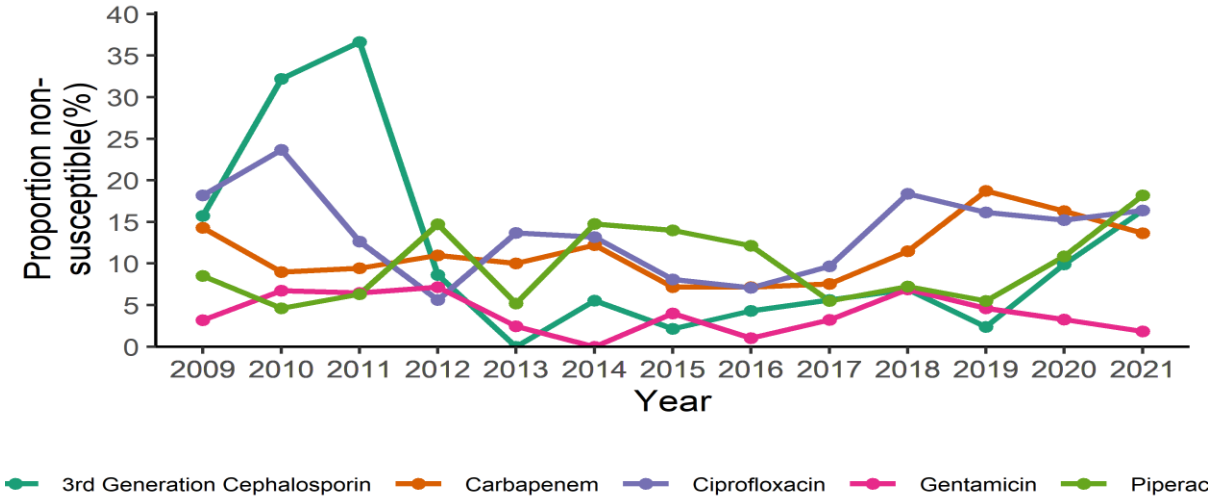

Figure 3.10: Proportion of *Pseudomonas* species bacteraemias non-susceptible to selected antibiotics in NI, 2009 - 2021

3.1.5 *Staphylococcus aureus* bacteraemia

The number of *Staphylococcus aureus* bacteraemias reported to the PHA has been increasing since 2014. The number reported increased from 453 in 2018 to 506 in

2021 (Figure 3.11). The proportion of isolates tested against key antibiotics during 2021 is shown in Appendix 3.

The proportion of *S. aureus* isolates non-susceptible to meticillin (MRSA) has steadily decreased from 2009 and remained below 12% during 2018-2021, with a low of 8.6% in 2021. A slight increase in the proportion of meticillin non-susceptible episodes was observed between 2019 to 2020 (9.4% in 2019 to 11.6% in 2020) before decreasing in 2021.

There were no *S. aureus* isolates non-susceptible to glycopeptides (eg. vancomycin or teicoplanin) detected during 2018 and 2019, with one reported in 2020 and 2021 respectively (Figure 3.12).

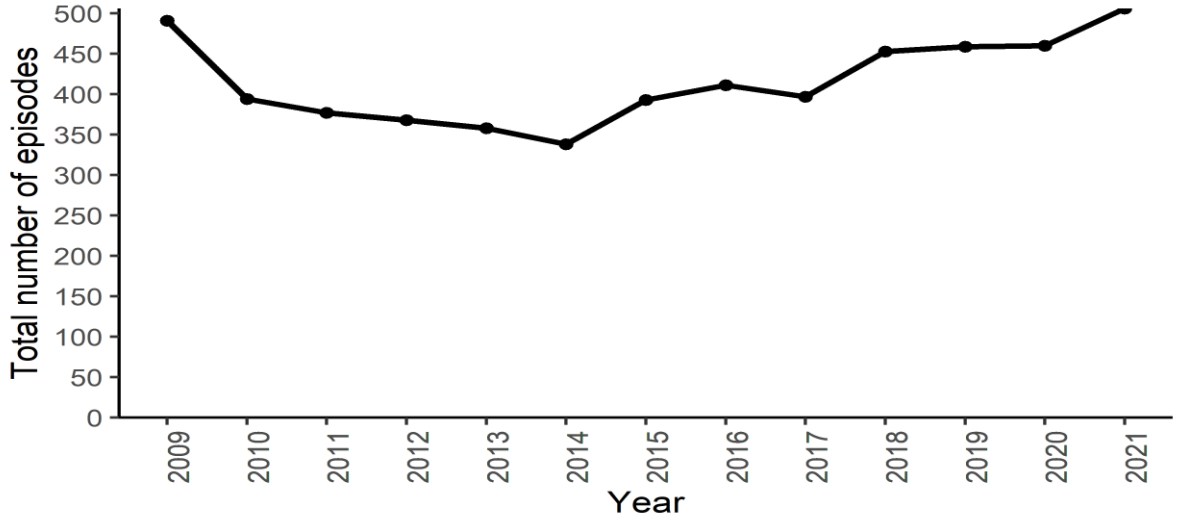

Figure 3.11: Number of *S. aureus* bacteraemias reported to the PHA, 2009 - 2021

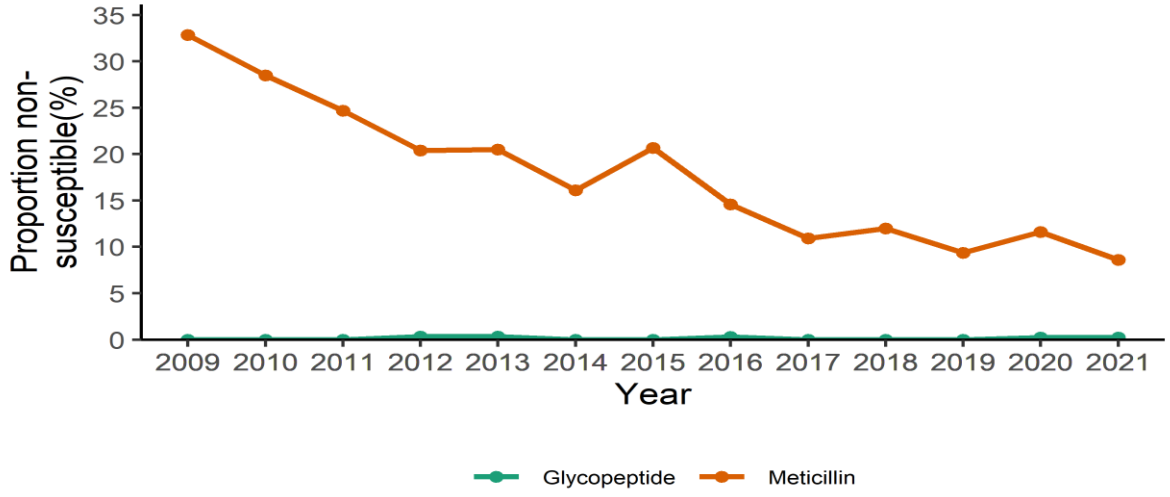

Figure 3.12: Proportion of *S. aureus* bacteraemias non-susceptible to selected antibiotics in NI, 2009 - 2021

3.1.6 *Enterococcus* species bacteraemia

The number of *Enterococcus* species bacteraemias has been generally increasing since 2009 but decreased slightly between 2018-2019 from 290 to 271 reported episodes. During 2020 and 2021 the number reported increased, to 275 in 2020 and further to 312 in 2021 (Figure 3.13). The proportion of *Enterococcus* species bacteraemias non-susceptible to glycopeptides remained relatively stable around 27% between 2018 and 2020, decreasing to 21.2% in 2021 (Figure 3.14).

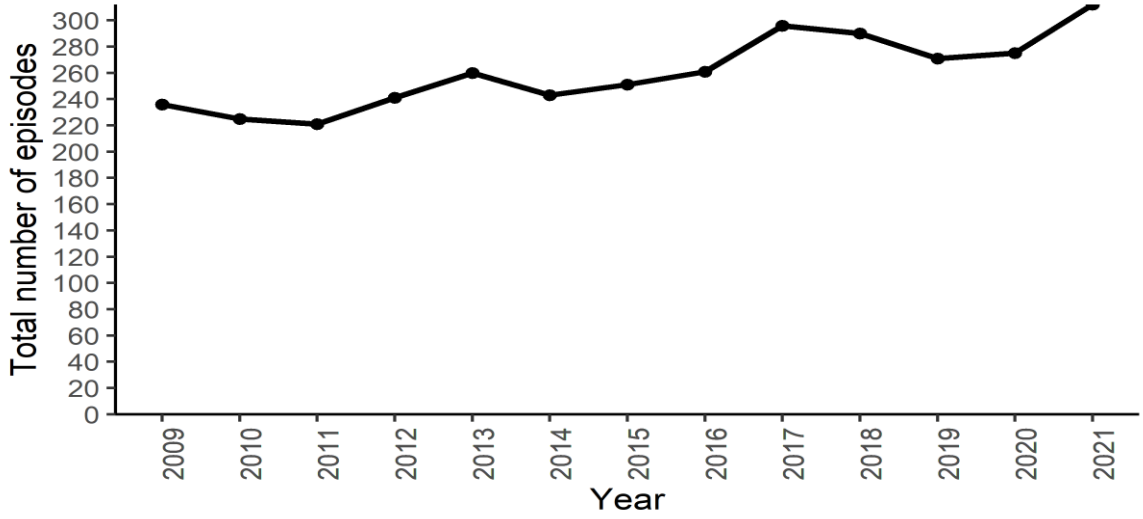

Figure 3.13: Number of *Enterococcus* species bacteraemias reported to the PHA, 2009 - 2021

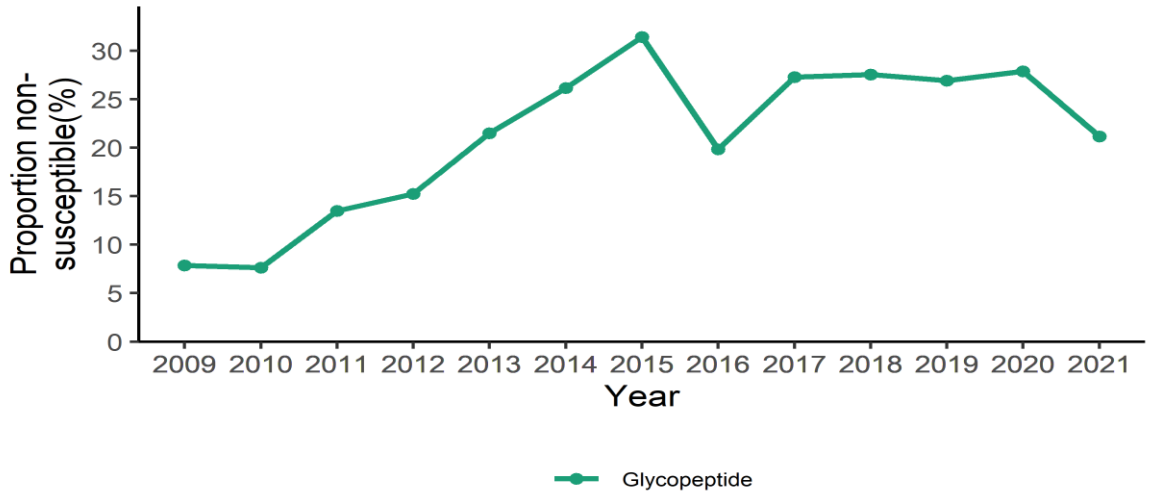

Figure 3.14: Proportion of *Enterococcus* species bacteraemias non-susceptible to selected antibiotics in NI, 2009 - 2021

Amongst the two key *Enterococcus* species, resistance to teicoplanin and vancomycin decreased for both *Enterococcus faecium* and *Enterococcus faecalis* between 2019 and 2021. No resistance to linezolid was detected among *Enterococcus faecalis* isolates during 2018 to 2021, with linezolid resistance detected amongst *Enterococcus faecium* isolates during only 2020 (0.78%) and 2021 (0.7%) (Figure 3.15).

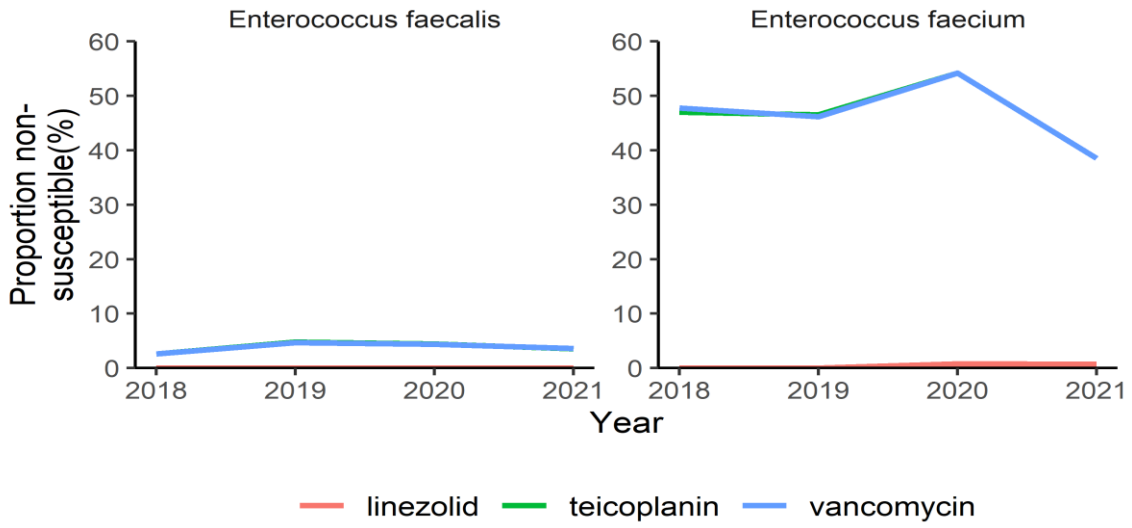

Figure 3.15: Proportion of *Enterococcus faecium* and *faecalis* species bacteraemias non-susceptible to selected antibiotics in NI, 2009 - 2021

3.1.7 *Streptococcus pneumoniae* bacteraemia

The number of *Streptococcus pneumoniae* bacteraemias reported to PHA had been generally increasing between 2012 to 2019 but decreased sharply in 2020 (from 150 to 52 episodes), decreasing further to 46 episodes in 2021 (Figure 3.16). The proportion of isolates tested against key antibiotics during the reporting period is shown in Appendix 3.

The proportion of *S. pneumoniae* non-susceptible to macrolides decreased between 2018 and 2021 (8.2% to 5%). The proportion of isolates non-susceptible to penicillin has fluctuated throughout the same time period, doubling between 2018-2019 (5.5% to 10.7% of tested isolates) before decreasing to 5.8% in 2020, then increasing in 2021 (19.6%) (Figure 3.17).

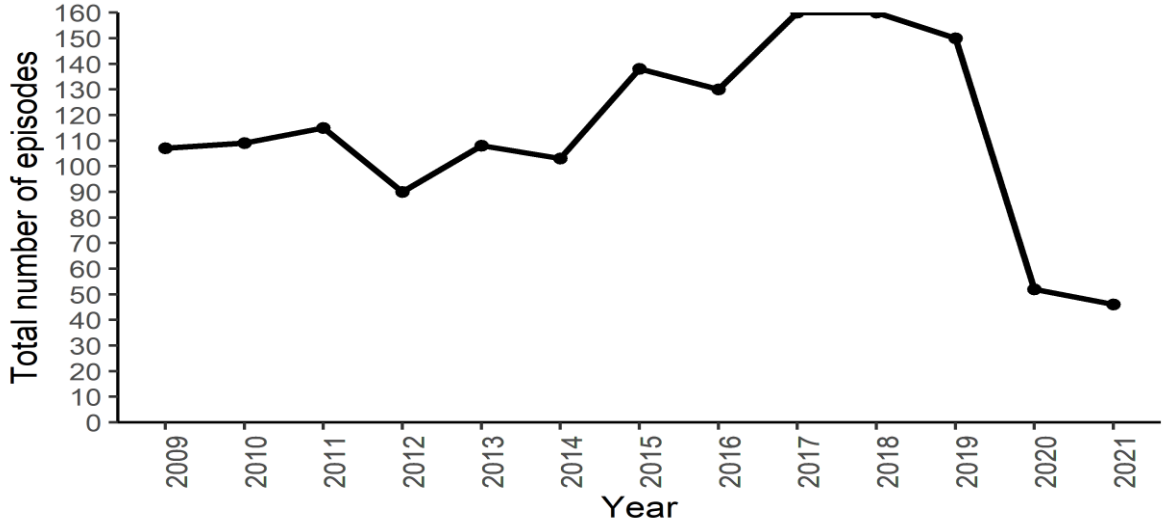

Figure 3.16: Number of *S. pneumoniae* bacteraemias reported to the PHA, 2009 - 2021

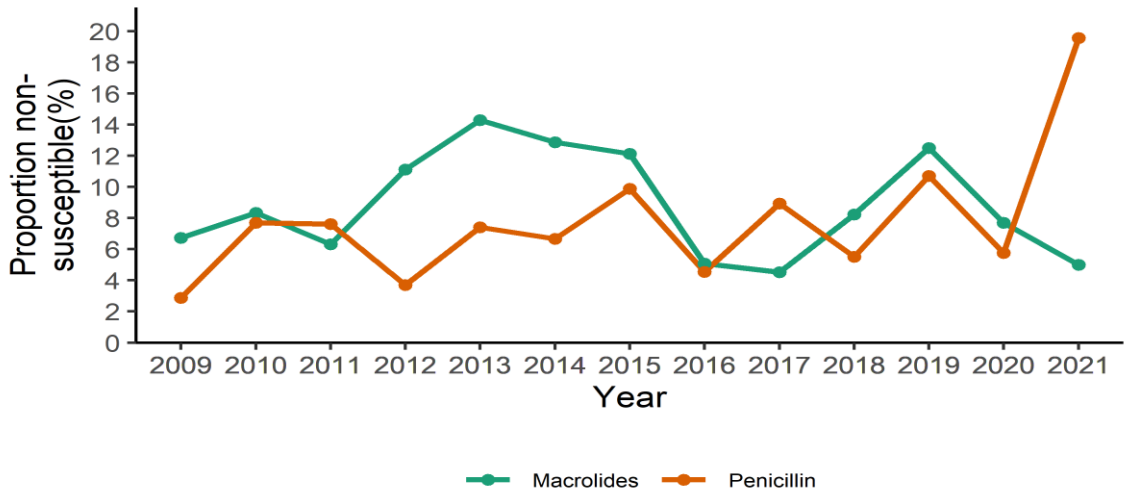

Figure 3.17: Proportion of *S. pneumoniae* bacteraemias non-susceptible to selected antibiotics in NI, 2009 - 2021

3.1.8 *Acinetobacter* species bacteraemia

The number of *Acinetobacter* species bacteraemias has decreased between 2009 and 2021, staying relatively stable from 2012 with a small spike observed during 2018. Between 2018 and 2021 the number of reported *Acinetobacter* species has steadily decreased, with 24 episodes in 2021 (Figure 3.18). There have been no *Acinetobacter* species isolates non-susceptible to colistin reported since 2017 (Figure 3.19).

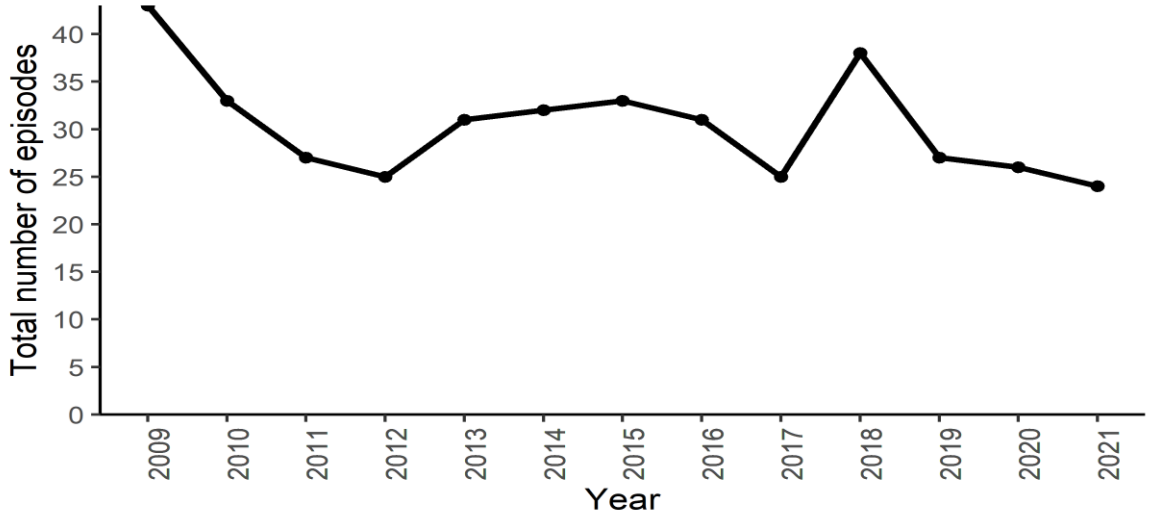

Figure 3.18: Number of *Acinetobacter* species bacteraemias reported to the PHA, 2009 - 2021

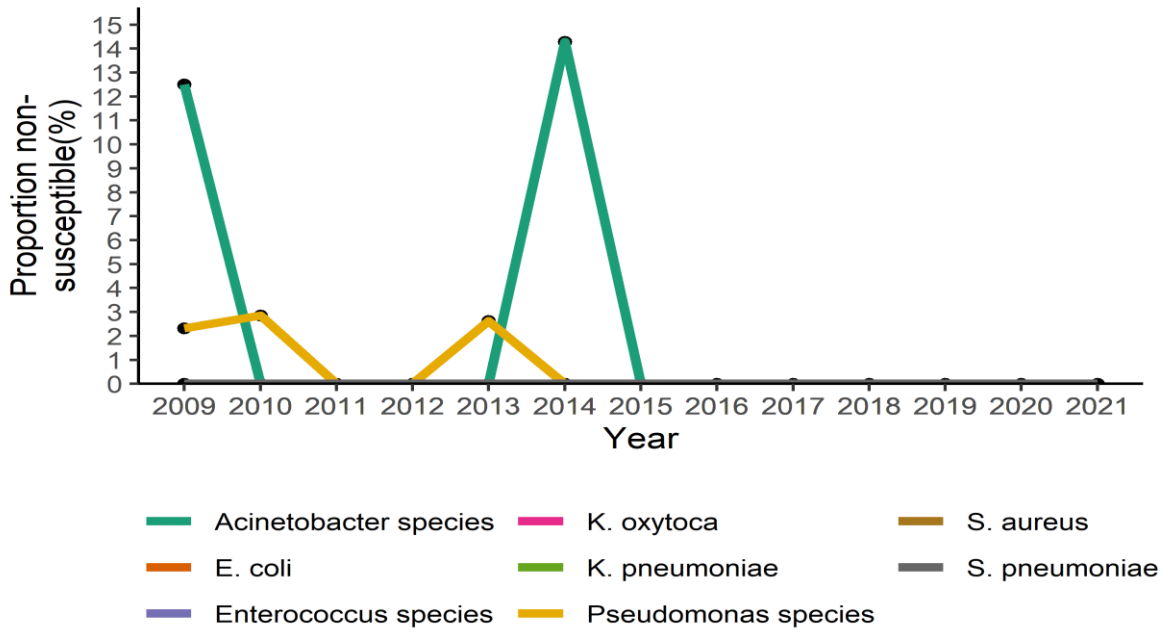

Figure 3.19: Proportion of selected bacteraemias non-susceptible to colistin in NI, 2009 - 2021

3.1.9 Carbapenamase-Producing Enterobacterales

The number of carbapenamase-producing Enterobacterales (CPE) voluntarily reported to the PHA increased between 2018 to 2019 but decreased during both 2020 and 2021.There were 24 CPE episodes reported during 2019, decreasing to 9 in 2020 and further to 5 episodes in 2021 (Figure 3.20).

In 2019 the most commonly reported mechanism of carbapenem resistance was New Delhi Metallo-β-lactamase (NDM) (11 episodes) while in 2020 the mechanism of resistance was mostly unknown. In 2021, NDM and OXA-48 were the most commonly reported resistance mechanisms (2 episodes each) with no reports of IMP (Imipenemase producers) or VIM (Verona integron-encoded Metallo-β-lactamase) mechanisms during 2021.

Similar to 2018, the most commonly reported CPE organism during both 2020 and 2021 was *Klebsiella pneumoniae* (3 episodes, respectively). In 2019, *Enterobacter cloacae* was the most commonly reported CPE (7 episodes) (Figure 3.21).

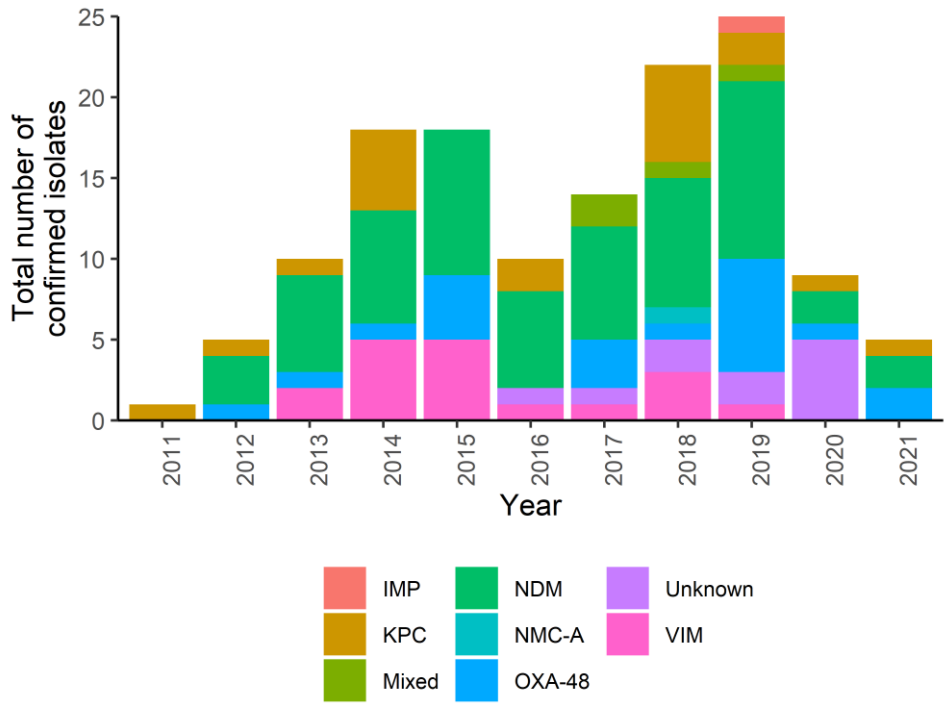

Figure 3.20: Number of carbapenemase-producing Enterobacterales confirmed isolates, by resistance mechanism, 2011 - 2021

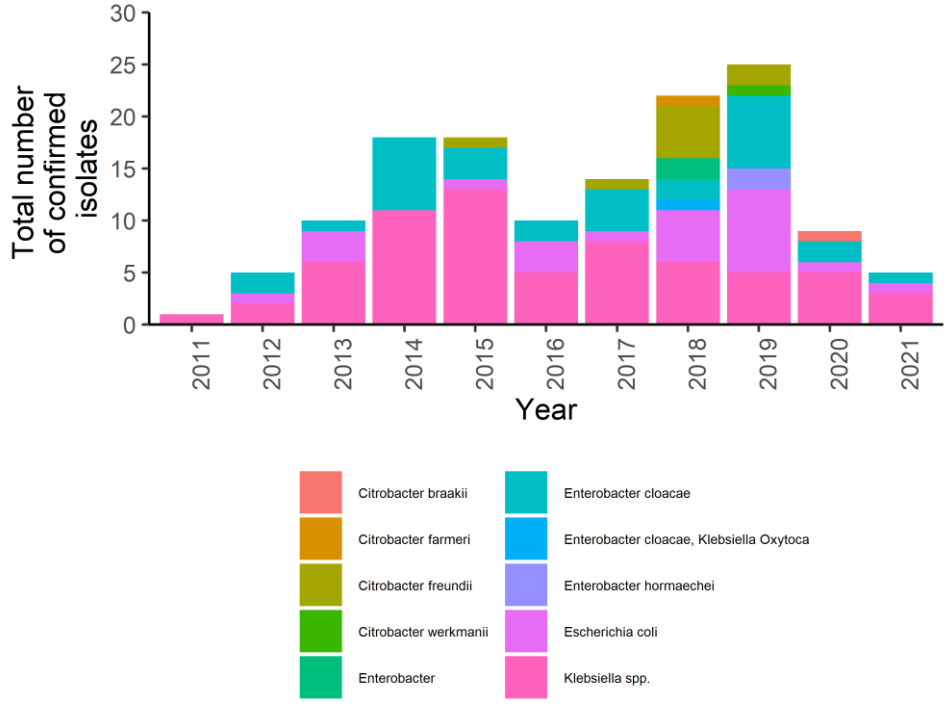

Figure 3.21: Carbapenamase-producing Enterobacterales confirmed isolates, 2011 - 2021

3.1.10 Antibiotic resistance in *Neisseria gonorrhoeae*

Gonorrhoea has been identified as at risk of becoming an untreatable disease due to the emergence of resistance to successive standard treatments [5]. This has necessitated changes to recommended antibiotic prescribing. In the UK, current

recommended treatment guidelines include the extended spectrum cephalosporin (ESC), ceftriaxone, along with routine test of cure [6]. Azithromycin is no longer recommended as co-treatment. 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 [7]. From 2021, PHA submitted *N. gonorrhoeae* antimicrobial susceptibility information directly to the WHO GLASS (Global Antimicrobial Resistance and Use Surveillance System) programme [8].

During 2021, 652 *Neisseria gonorrhoeae* diagnoses were made in Northern Ireland and sent to UKHSA for inclusion in GUMCAD (Genitourinary Medicine Clinic Activity Dataset). This is an increase in diagnoses in comparison to 2020, which saw 455 diagnoses. In 2021, 177 patients' samples were cultured and tested for antibiotic susceptibility. No isolates were resistant to ceftriaxone and 20.7% were resistant to azithromycin.

3.2 Antibiotic consumption

3.2.1 Rates of antibiotic consumption by healthcare setting

The total consumption of all antibiotics declined between 2018-2020 with the rate steadily decreasing from 28.5 DDD per 1000 inhabitants per day in 2018 to 23.99 DDD per 1000 inhabitants per day in 2020. During 2021, the total consumption rate slightly increased to 25.04 DDD per 1000 inhabitants per day.

The majority of antibiotic consumption between 2018 and 2021 took place in the primary care setting. While primary care has remained the highest prescriber of antibiotics, the proportion of total consumption accounted for by primary care continued to decline from 83.3% in 2014 to 78.7% in 2021. The proportion of total antibiotic consumption accounted for by dental settings remained relatively low and stable from 2014 (4.8%) to 2019 (4.5%). However, an increase was noted in 2020 (7.3%) before a slight decrease in 2021 (6.8%). Out-of-hours consumption decreased from 1.4% in 2018 to 0.8% in 2021.

The proportion of total antibiotic consumption accounted for by secondary care increased slightly from 11.4% in 2014 to 13.6% in 2021 (Figure 3.22). The proportion of antibiotic consumption accounted for by primary care remained relatively stable between 2020 and 2021 (78.6% and 78.7% respectively), while the primary care consumption rate increased from 18.85 per 1000 inhabitants per day in 2020 to 19.71 DDD per 1000 inhabitants per day in 2021. The secondary care antibiotic consumption rate remained relatively stable between 2014 and 2021 (3.43 to 3.41 DDD per 1000 inhabitants per day). Dental prescribing rates saw a steady decrease from 2014-2019 (1.44 to 1.26 DDD per 1000 inhabitants per day) before increasing in 2020 (1.76 DDD per 1000 inhabitants per day) but remaining relatively stable in 2021 (1.71 per 1000 inhabitants per day). Fluctuations were observed for prescribing rates in the out-of-hours setting with steady rates of 0.4 per 1000 inhabitants noted for 2017-2019, before decreases in 2020 and 2021 (to 0.16 and 0.2 per 1000 inhabitants per day respectively).

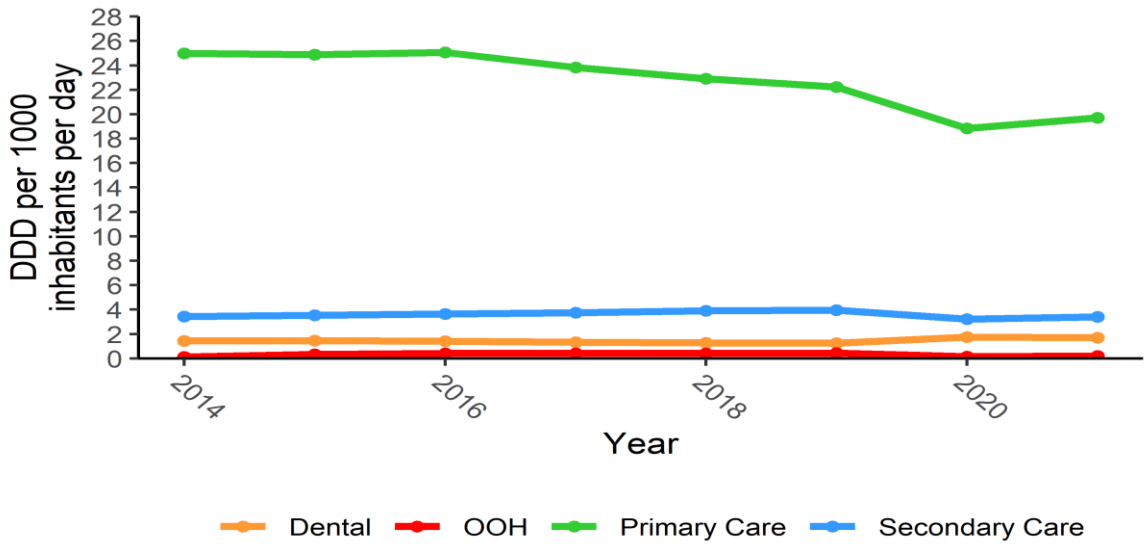

Figure 3.22: Total antibiotic consumption, expressed as DDD per 1000 inhabitants per day, NI, 2014 - 2021

Rates of antibiotic consumption in Secondary care

There has been a general increase in the rate of secondary care antibiotic consumption expressed as DDD per 1000 admissions between 2018-2021, with the rate increasing from 9138 DDD per 1000 admissions in 2018 to 9626 DDD per 1000 admissions in 2021. The secondary care antibiotic consumption rate had been relatively stable between 2019 and 2020 (9398 to 9379 DDD per 1000 admissions respectively) (Figure 3.23).

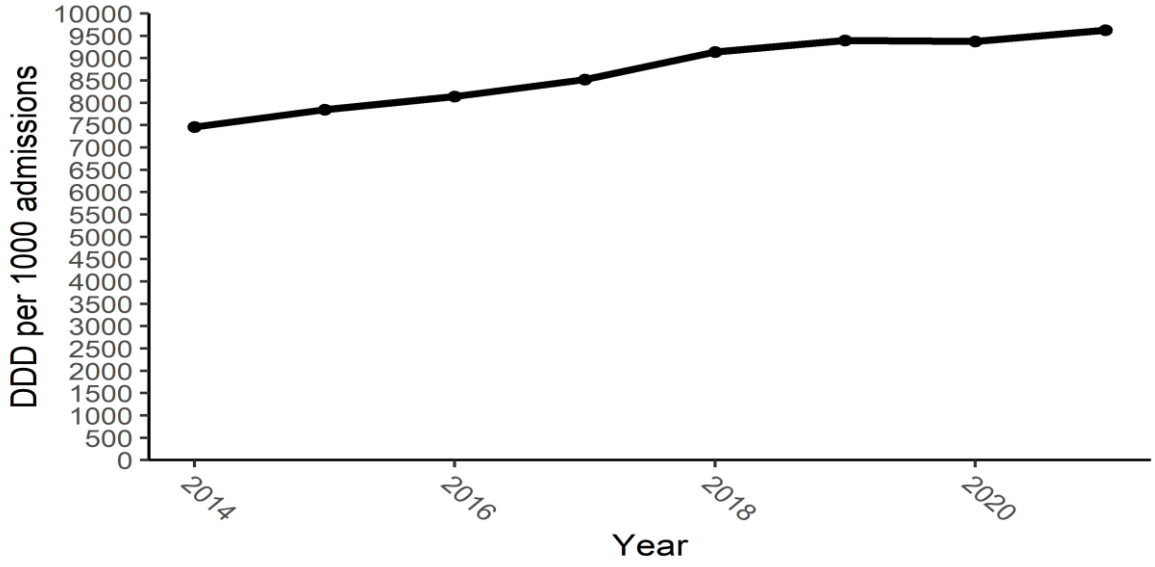

Figure 3.23: Total antibiotic consumption, expressed as DDD per 1000 admissions, NI, 2018 - 2021

The secondary care antibiotic consumption rate per 1000 occupied bed days decreased between 2018-2021 from 1502 to 1457 DDD per 1000 occupied bed days. The rate had increased slightly between 2018 and 2019 (1501 to 1542 DDD per 1000 occupied bed days), decreasing steadily between 2019 and 2021 (Figure 3.24).

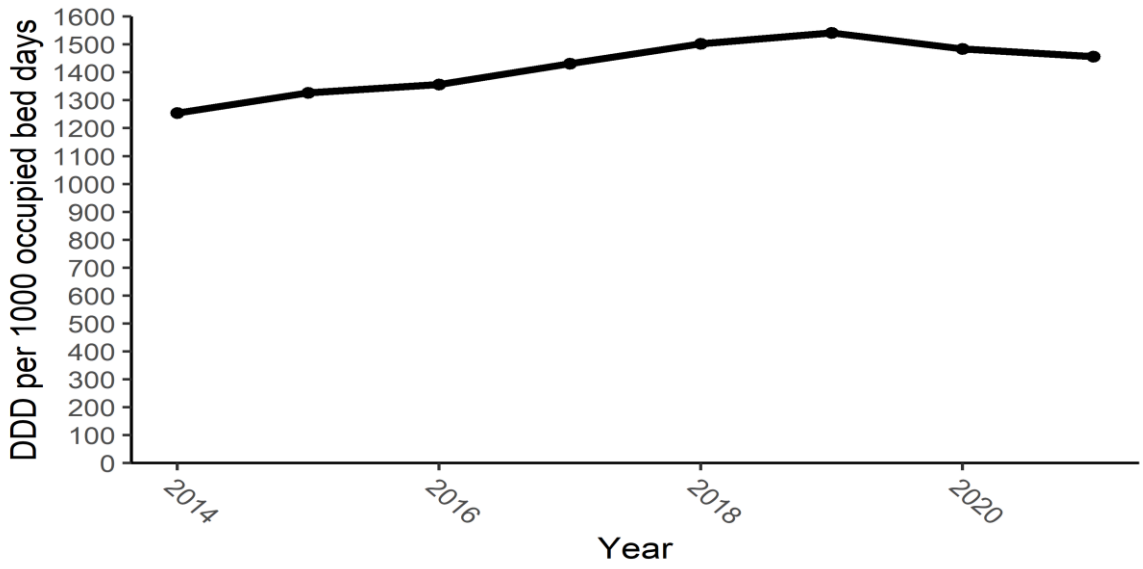

Figure 3.24: Total antibiotic consumption, expressed as DDD per 1000 occupied bed days, NI, 2014 - 2021

Figure 3.25 shows the top 6 antibiotics prescribed in secondary care. In 2021, the highest rates of antibiotic consumption were for penicillins, although penicillin usage has decreased from 2469 in 2018 to 2277 DDD per 1000 admissions in 2021. Penicillin/beta lactamase inhibitor combinations have increased from 1642 to 1858 DDD per 1000 admissions, while the use of tetracyclines and related drugs have also increased from 1223 in 2018 to 1415 DDD per 1000 admissions in 2021.

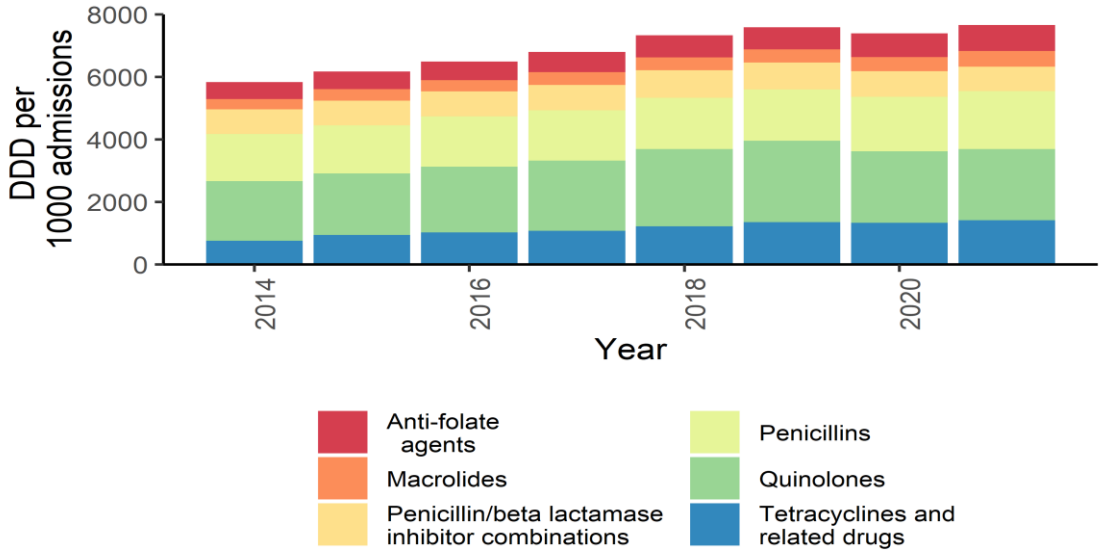

Figure 3.25: Total antibiotic consumption in secondary care, expressed as DDD per 1000 admissions, NI, 2014 - 2021

3.2.2 Antibiotic consumption by key agents

During 2021, the most frequently used antibiotics in both primary and secondary care in NI were penicillins (37.6% and 23.7% respectively), followed by tetracyclines and related drugs (29% and 14.7% respectively). This is similar to the trends observed in 2018 when penicillins were also the most frequently consumed antibiotic

class in both primary and secondary care (38.7% and 27.0% respectively) (Figure 3.26).

Note: Oral/rectal preparations for metronidazole (ATC P01AB01) and vancomycin (ATC A07AA09) are included in the anti-clostridium difficile agents and do not appear in the nitroimidazoles or glycopeptides categories respectively. Anti-tuberculosis drugs include only streptomycin (ATC J01GA01).

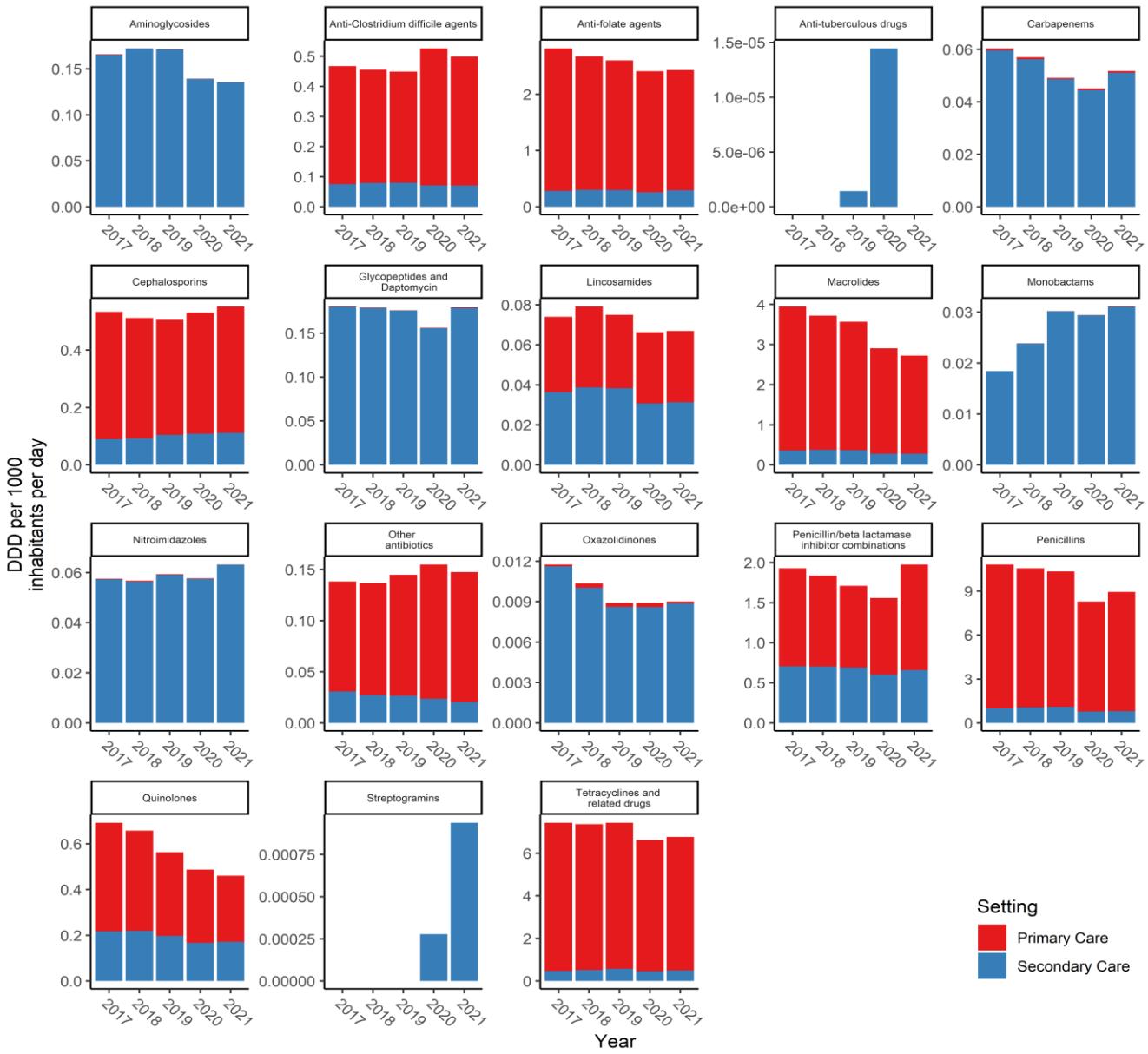

Figure 3.26: Total antibiotic consumption by key antibiotic groups, expressed as DDD per 1000 inhabitants per day, NI, 2014 - 2021

Note: differing scales on y-axis.

3.2.3 Antibiotic consumption by class and individual antibiotics

Penicillins

Figure 3.27 shows the top six antimicrobial agents used in the penicillins class. Penicillins accounted for 35.7% of total antibiotic consumption in 2021. Penicillin consumption has decreased from 10.56 DDD per 1000 inhabitants per day in 2018 to 8.94 DDD per 1000 inhabitants per day in 2021, although a slight increase was observed between 2020 and 2021 (from 8.29 to 8.94 DDD per 1000 inhabitants per day). The highest rate among antibiotics in the penicillins class was for amoxicillin, which has steadily decreased between 2018-2021 (7.39 to 5.95 DDD per 1000 inhabitants per day), remaining relatively stable between 2020 and 2021.

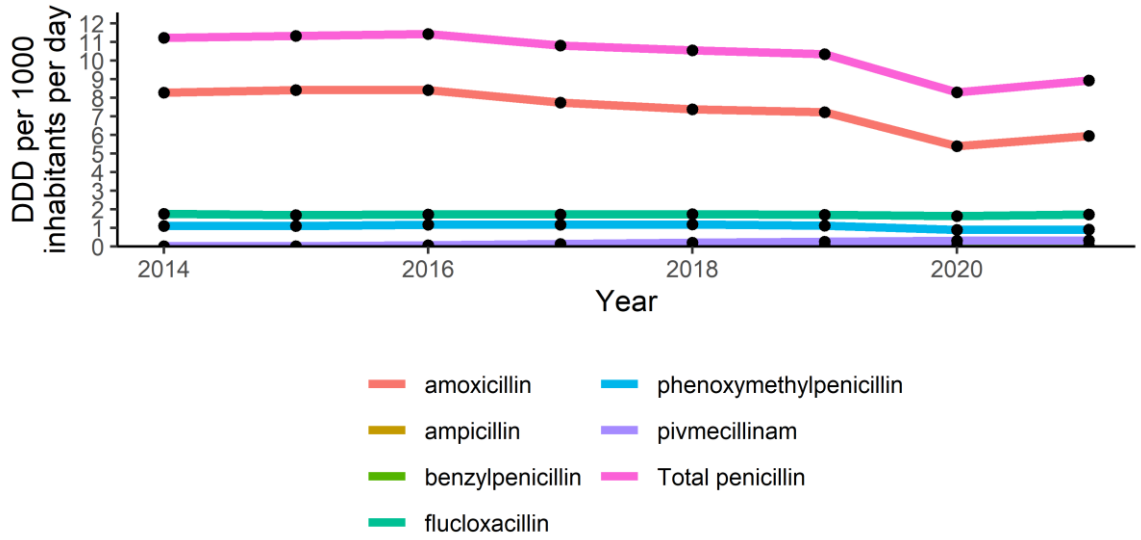

Figure 3.27: Consumption of most commonly used penicillins expressed per 1000 inhabitants per day, NI, 2014 - 2021

Cephalosporins

Figure 3.28 displays the top six agents used in the cephalosporins class. The overall rate of cephalosporin consumption remained relatively stable between 2018 and 2021 (0.51 to 0.55 DDD per 1000 inhabitants per day). The highest rate among antibiotics in the cephalosporins class was for cefalexin, which also remained relatively stable between 2018 and 2021 (0.4 to 0.44 DDD per 1000 inhabitants per day).

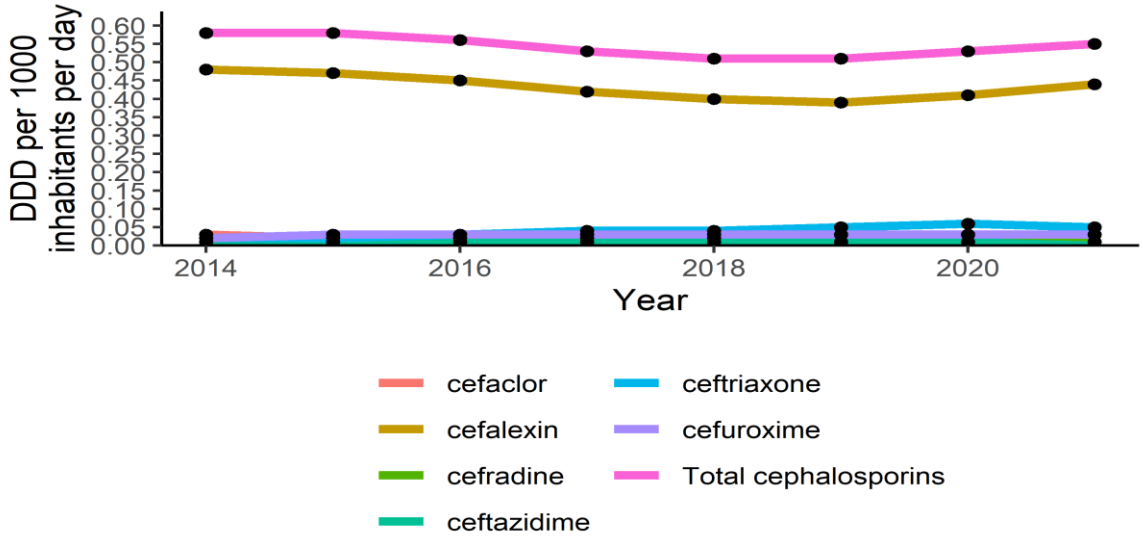

Figure 3.28: Consumption of most commonly used cephalosporins expressed per 1000 inhabitants per day, NI, 2014 - 2021

Tetracyclines and related drugs

Figure 3.29 shows the top six agents used in the tetracyclines and related drugs class. The proportion of total antibiotic consumption accounted for by tetracyclines and related drugs has remained relatively stable between 2020 and 2021 (27.6% in 2020 and 27% in 2021).

Consumption of tetracyclines and related drugs decreased between 2018 and 2021 (from 7.36 to 6.77 DDD per 1000 inhabitants per day) although a slight increase was observed from 2020 (6.62 DDD per 1000 inhabitants per day) to the rate observed in 2021.

Within the tetracyclines and related drugs class, the highest usage rate was for doxycycline, which has increased slightly between 2020 and 2021 (from 4.41 to 4.66 DDD per 1000 inhabitants per day). Despite this increase, doxycycline consumption remained lower in 2021 than during 2018 (4.78 DDD per 1000 inhabitants per day).

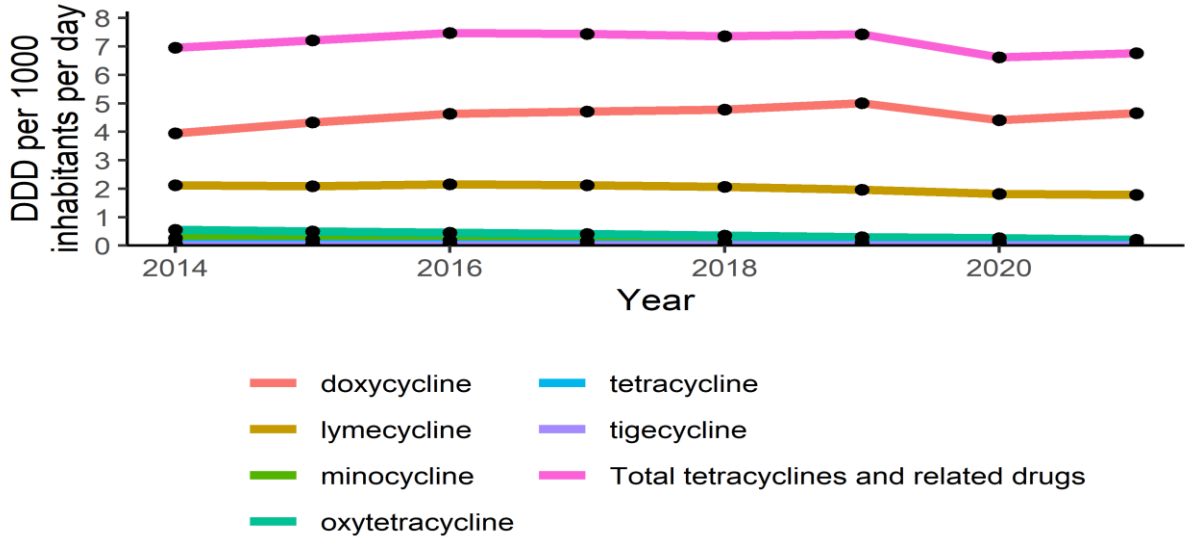

Figure 3.29: Consumption of most commonly used tetracyclines and related drugs expressed per 1000 inhabitants per day, NI, 2014 - 2021

Note: 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

Consumption of quinolones steadily decreased from 0.66 DDD per 1000 inhabitants per day in 2018 to 0.46 DDD per 1000 inhabitants per day in 2021. Within the quinolones class, the highest consumption rate was for ciprofloxacin. Ciprofloxacin consumption also decreased from 2018 (0.54 DDD per 1000 inhabitants per day) to 0.36 DDD per 1000 inhabitants per day in 2021 (Figure 3.30).

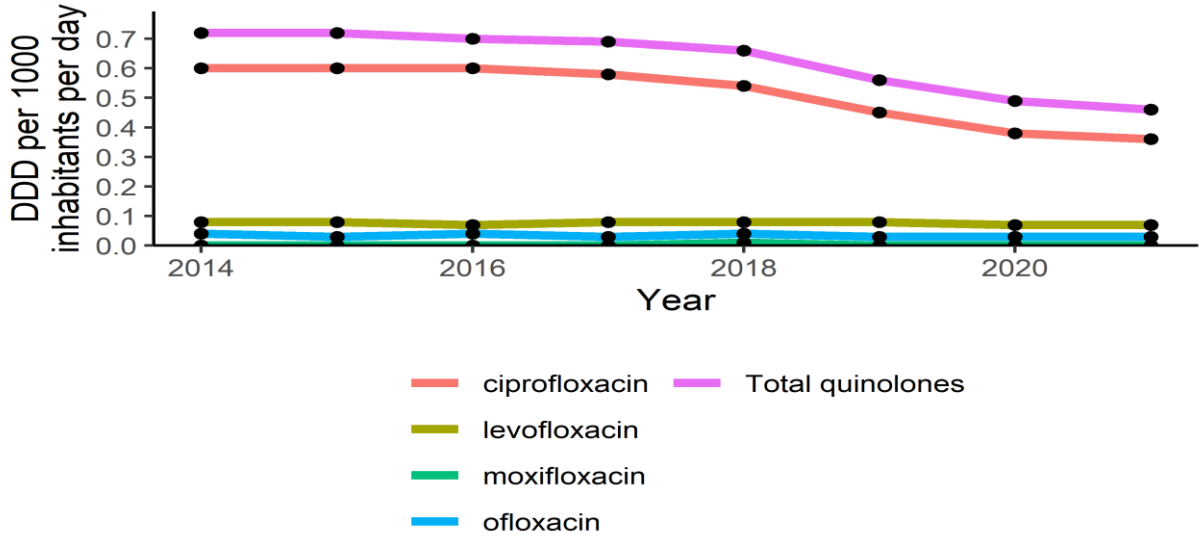

Figure 3.30: Consumption of most commonly used quinolones expressed per 1000 inhabitants per day, NI, 2014 - 2021

Macrolides

Macrolides accounted for 10.9% of total antibiotic consumption in 2021. Consumption of macrolides decreased from 3.72 DDD per 1000 inhabitants per day in 2018 to 2.73 DDD per 1000 inhabitants per day in 2021.

Within the macrolide class the highest usage was for clarithromycin, for which consumption remained relatively stable during 2020 and 2021 (1.56 DDD per 1000 inhabitants per day in 2020 and 1.5 DDD per 1000 inhabitants per day in 2021). Clarithromycin consumption in 2020 and 2021 was lower than in both 2018 (2.35 DDD per 1000 inhabitants per day) and 2019 (2.19 DDD per 1000 inhabitants per day) (Figure 3.31).

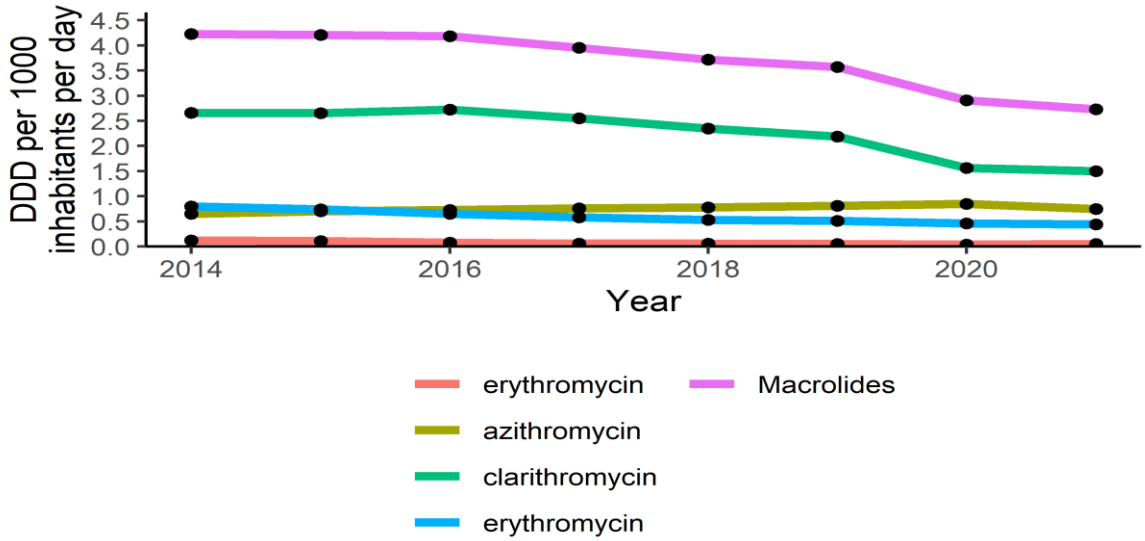

Figure 3.31: Consumption of most commonly used macrolides expressed per 1000 inhabitants per day, NI, 2014 - 2021

Carbapenems

The rate of carbapenem consumption remained low and relatively stable from 2018 to 2021 at 0.06 and 0.05 DDD per 1000 inhabitants per day, respectively. The highest comsumption rate within the class was for meropenem, which has also remained stable between 2018 and 2021 (around 0.05 DDD per 1000 inhabitants per day) (Figure 3.32).

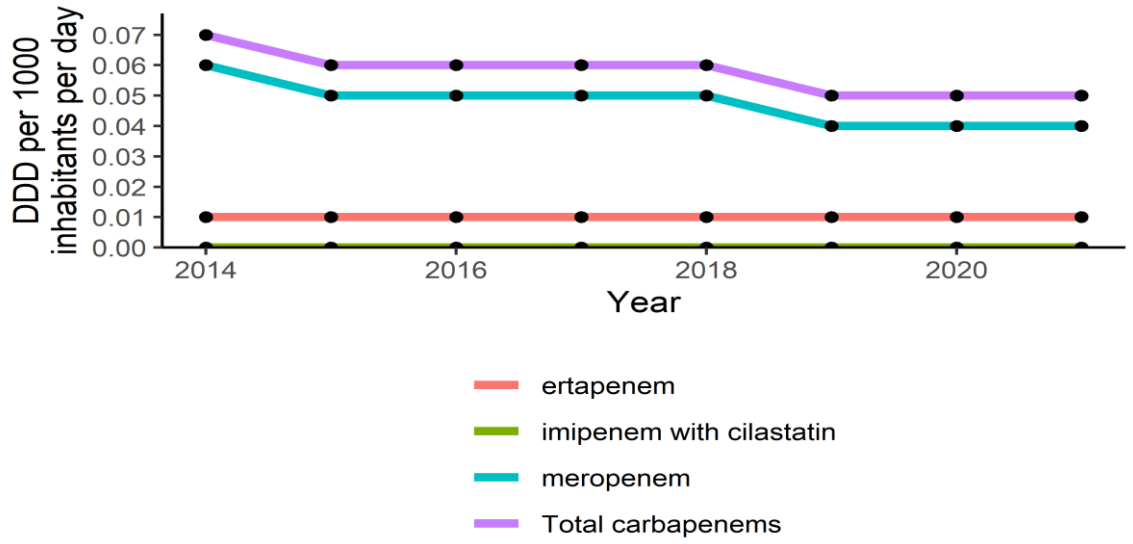

Figure 3.32: Consumption of most commonly used carbapenems expressed per 1000 inhabitants per day, NI, 2014 - 2021

Penicillin/beta lactamase inhibitor combinations

Consumption of penicillin/beta lactamase inhibitor combinations steadily decreased between 2014 and 2020. During the 2018-2020 period the consumption rate decreased from 1.84 to 1.56 DDD per 1000 inhabitants per day. A slight rise in consumption of penicillin/beta lactamase inhibitor combinations was however observed between 2020 and 2021 (to 1.98 DDD per 1000 inhabitants per day in 2021).

The highest consumption rate within the class was for co-amoxiclav which followed a similar trend to the penicillin/beta lactamase inhibitor combinations class overall, decreasing from 1.65 in 2018 to 1.40 DDD per 1000 inhabitants per day in 2020, before increasing to 1.8 DDD per 1000 inhabitants per day in 2021. The use of piperacillin/tazobactam has remained relatively stable during 2018-2021 with rates remaining below 0.19 DDD per 1000 inhabitants per day (Figure 3.33).

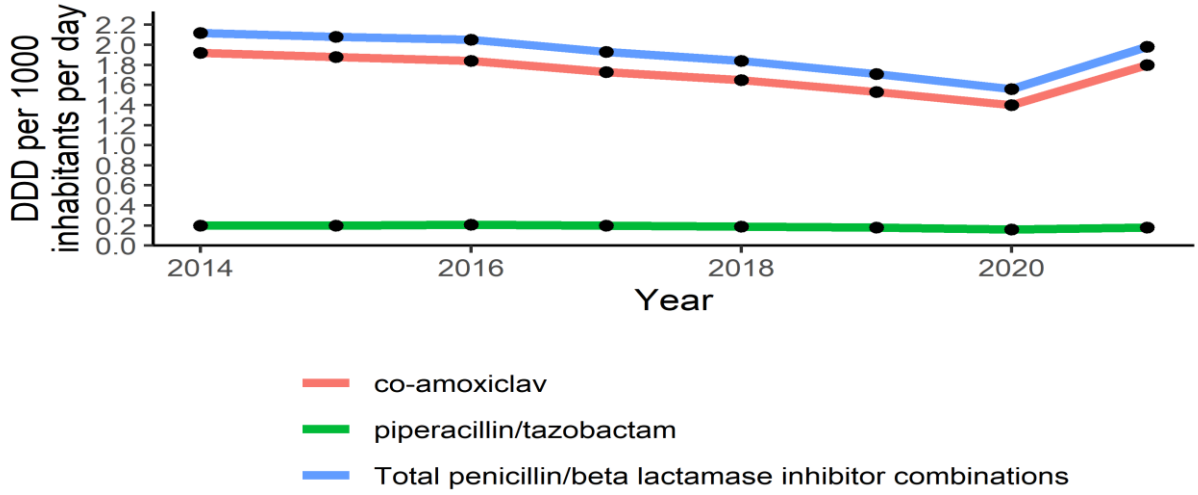

Figure 3.33: Consumption of most commonly used penicillin/beta lactamase inhibitor combinations expressed per 1000 inhabitants per day, NI, 2014 - 2021

Glycopeptides and daptomycin

Glycopeptides and daptomycin consumption remained stable between 2018 and 2021 at 0.18 DDD per 1000 inhabitants per day. During 2020, the consumption rate slightly decreased to 0.16 DDD per 1000 inhabitants per day before increasing again in 2021. The highest consumption rate within the class was for teicoplanin, which followed a similar trend to overall glycopeptide and daptomycin consumption. Teicoplanin use remained stable between 2018-2019 at 0.14 DDD per 1000 inhabitants per day, decreasing slightly to 0.12 DDD per 1000 inhabitants per day in 2020 before increasing to 0.14 DDD per 1000 inhabitants per day in 2021 (Figure 3.34).

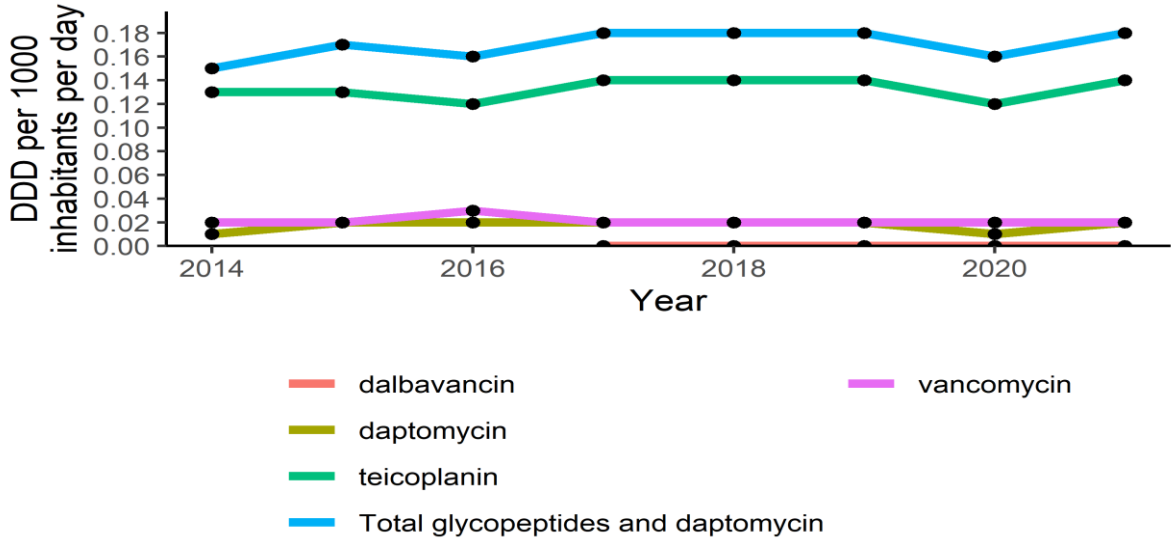

Figure 3.34: Consumption of most commonly used glycopeptides and daptomycin expressed per 1000 inhabitants per day, NI, 2014 - 2021

Anti-folate agents

Anti-folate agents accounted for 9.7% of total antibiotic consumption in 2021. The consumption rate of anti-folate agents has steadily declined from 2.67 DDD per 1000 inhabitants per day in 2018 to 2.43 DDD per 1000 inhabitants per day in 2021. The highest consumption rate within the class during 2021 was for nitrofurantoin. Nitrofurantoin use slightly decreased from 1.13 DDD per 1000 inhabitants per day in 2018 to 1.1 DDD per 1000 inhabitants per day in 2021. Prior to 2021, the highest consumption rate within the anti-folate agent class was for trimethoprim (Figure 3.35).

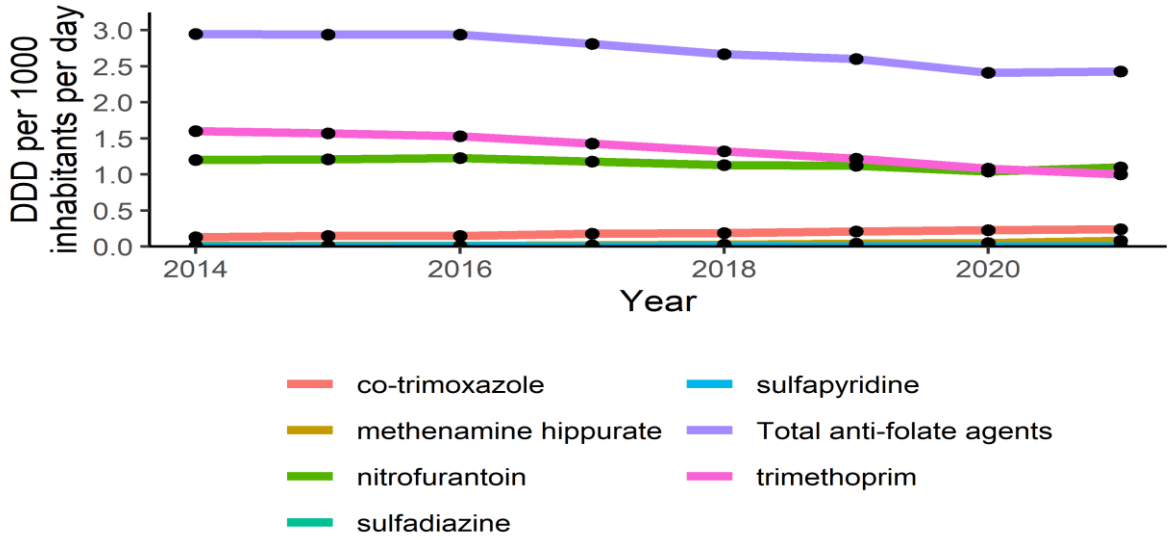

Figure 3.35: Consumption of most commonly used anti-folate agents expressed per 1000 inhabitants per day, NI, 2014 - 2021

3.2.4 Antibiotic consumption of key agents by healthcare setting

Trimethoprim

Trimethoprim use in primary and secondary care combined continued to decrease from 1.32 DDD per 1000 inhabitants per day in 2018 to 1 DDD per 1000 inhabitants per day in 2021.

Consumption of trimethoprim was stable between 2018 to 2019 (1.2 DDD per 1000 inhabitants per day in primary care and 0.1 DDD per 1000 inhabitants per day in secondary care) prior to a slight decrease across both sectors in 2020 (1.01 DDD per 1000 inhabitants per day and 0.07 DDD per 1000 inhabitants per day respectively). In primary care, trimethoprim use decreased further in 2021 to 0.93 DDD per 1000 inhabitants per day, while secondary care use remained unchanged (0.07 DDD per 1000 inhabitants per day) (Figure 3.36).

Nitrofurantoin

Consumption of nitrofurantoin in primary and secondary care combined decreased steadily from 2018 (1.13 DDD per 1000 inhabitants per day) to 2020 (1.04 DDD per 1000 inhabitants per day), before increasing slightly in 2021 (to 1.10 DDD per 1000 inhabitants per day).

Nitrofurantoin use displayed a similar pattern across the sectors, with a decrease noted from 2018 (1.04 DDD per 1000 inhabitants per day in primary care and 0.09 in secondary care) to 2020 (0.96 and 0.08 DDD per 1000 inhabitants per day respectively). In 2021, a slight increase in nitrofurantoin use was noted in both sectors, to 1.01 DDD per 1000 inhabitants per day in primary care and 0.10 DDD per 1000 inhabitants per day in secondary care (Figure 3.36).

Aminoglycosides

Aminoglycosides were used predominantly in the secondary care sector. Consumption of aminoglycosides was stable between 2017-2019 at 0.17 DDD per 1000 inhabitants per day, before decreasing to 0.14 in 2020 and holding stable in 2021 (Figure 3.36).

Glycopeptides and daptomycin

Consumption of glycopeptides and daptomycin in primary and secondary care combined has remained relatively stable from 2018 to 2021. Glycopeptides and daptomycin use in primary care remained at 0 DDD per 1000 inhabitants per day from 2018 onwards, with secondary care use also remaining stable during the same time period (0.18 DDD per 1000 inhabitants per day. A slight decrease was noted in the consumption of glycopeptides and daptomycin in secondary care during 2020 (0.16 DDD per 1000 inhabitants per day) before returning to 2018 levels in 2021 (0.18 DDD per 1000 inhabitants per day) (Figure 3.36).

Colistin

Colistin use in primary and secondary care combined remained relatively stable from 2014 to 2019 (0.09 to 0.11 DDD per 1000 inhabitants per day) with a slight increase noted during 2020 to 0.13 DDD per 1000 inhabitants per day. In 2021, colistin slightly decreased again to 0.12 DDD per 1000 inhabitants per day but remained higher than during 2018 (0.10 DDD per 1000 inhabitants per day).

Rates of colistin consumption in primary care increased from 0.10 in 2018 to 0.13 DDD per 1000 inhabitants per day in 2020, followed by a slight decrease in 2021 (to 0.12 DDD per 1000 inhabitants per day). Colistin use within secondary care remained unchanged between 2018 and 2020 (0.02 DDD per 1000 inhabitants per day), followed by a slight decrease to 0.01 DDD per 1000 inhabitants per day in 2021 (Figure 3.36).

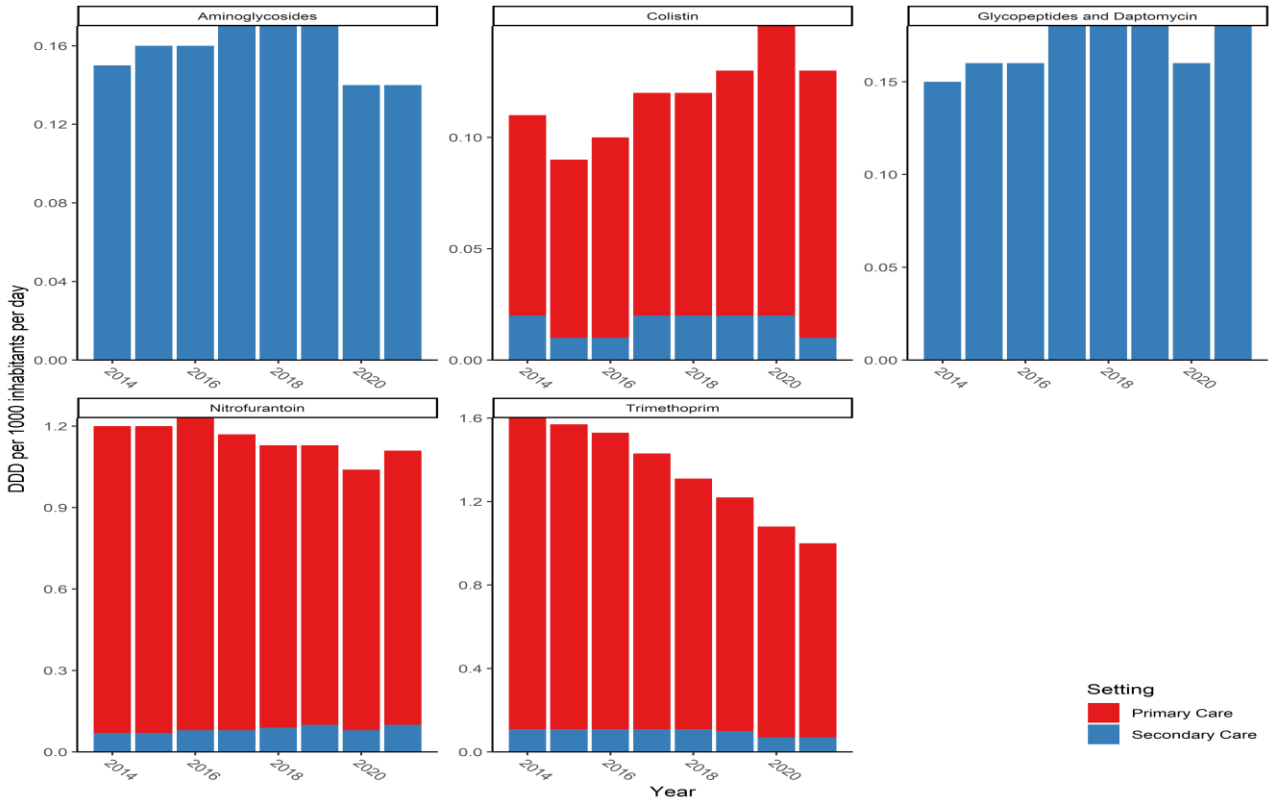

Figure 3.36: Total antibiotic consumption of key antibiotic groups by healthcare setting, expressed as DDD per 1000 inhabitants per day, NI, 2014 - 2021

Note: differing scales on y-axis. DDDs in primary care for aminoglycosides and glycopeptides/daptomycin are not truly zero.

3.2.5 Antibiotic consumption by WHO AWaRe Category

The World Health Organization (WHO) classifies antibiotics into three stewardship groups known as the AWaRe categories; Access, Watch and Reserve. Antibiotics in the Access group include antibiotics that can be utilised for a range of common susceptible pathogens and have a lower potential for resistance. The Watch group contains those with an increased potential for resistance and should be used in a restricted manner and includes most high priority agents. The Reserve group contains antibiotics which are to be treated as 'last resort' when other treatments have failed or there are no alternatives available. Adapted WHO AWaRe categories are used in NI with several national and trust level antibiotic consumption targets based on these which will stand for the remainder of the current target period (2019-2024).

The highest proportion of total antibiotic consumption during each year covered by this report was from antibiotics within the Access category, which increased across the period 2018-2021 (65.49% to 66.4%). The proportion of total consumption accounted for by antibiotics from the Watch group decreased slightly from 33.56% in 2018 to 32.22% in 2021. Consumption of antibiotics from the Reserve category slightly increased from 0.82% to 1% in 2021. Antibiotics not assigned to any of the AWaRe categories- denoted here as 'unknown'- accounted for less than 1% of total consumption in each year between 2018 and 2021 (Figure 3.37).

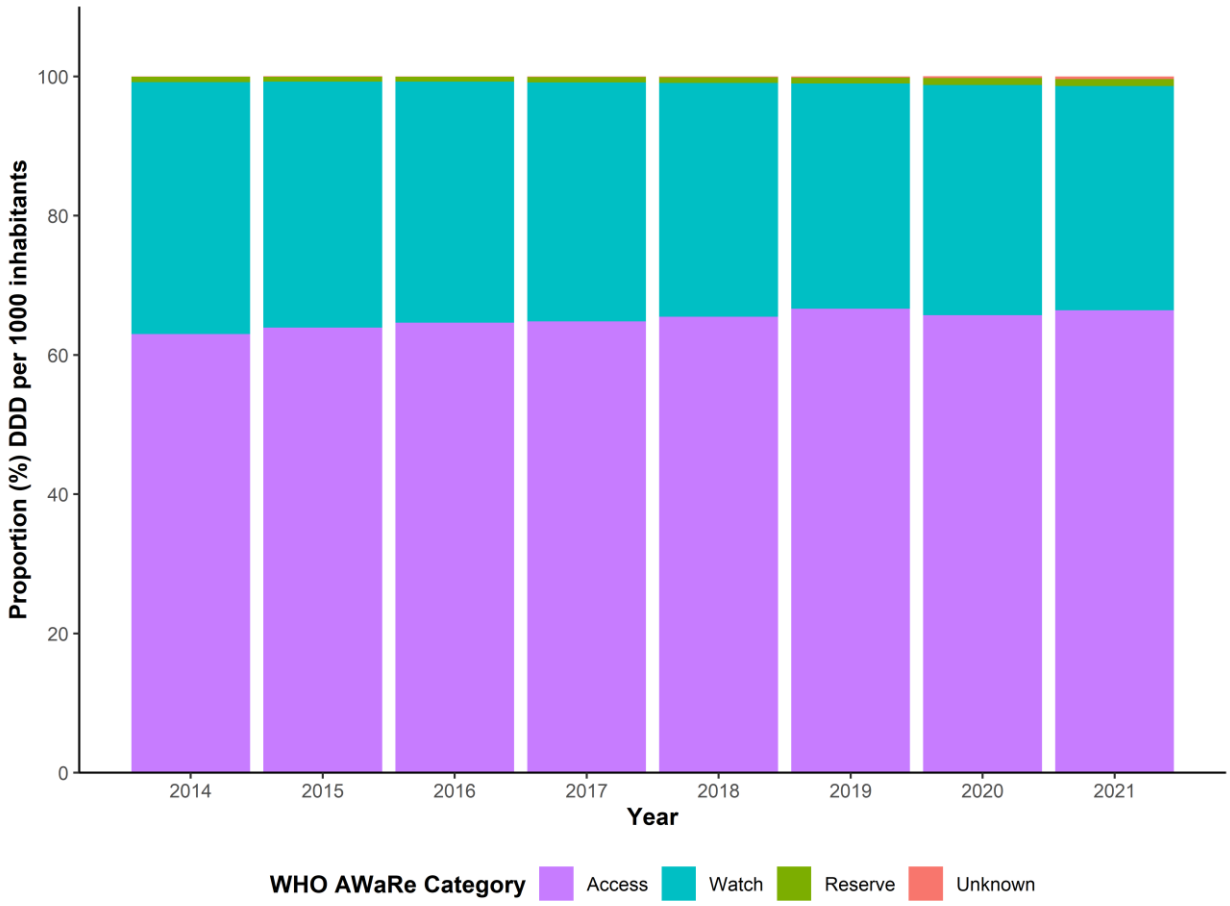

Figure 3.37: Proportion of DDDs per 1000 inhabitants by WHO AWaRe category, NI, 2014 - 2021

3.3 Engagement activities

3.3.1 Engagement with the public and health and social care colleagues

The PHA, in collaboration with the Strategic Planning and Performance Group (SPPG), formerly Health and Social Care Board (HSCB), engaged in several communications projects during 2021 with the aim of sharing key messages surrounding antibiotic resistance with the public. These included a campaign to 'keep antibiotics working' along with press and social media activity. The HSCB/SPPG engaged in several communications with primary care services during 2020-2021 specifically around World Antibiotic Awareness Week, with HSCB staff and Family Practitioner Services (FPS) namely, general practice, community pharmacy, dental and optometry. Key messages highlighted simple steps that individuals can take to keep antibiotics working, encouraging them to become 'Antibiotic Guardians' and highlighting the TARGET Toolkit (TARGET) resources. They also included messages around antibiotic resistance, encouraging safe disposal of antibiotics and raising awareness of appropriate penicillin allergy labelling.

3.3.2 Antibiotic guardians

There were 184 new antibiotic guardians registered in NI during 2021. To the end of 2021 there was a total of 1305 individuals registered as antibiotic guardians (69 individuals per 100,000 population) (Figure 3.38).

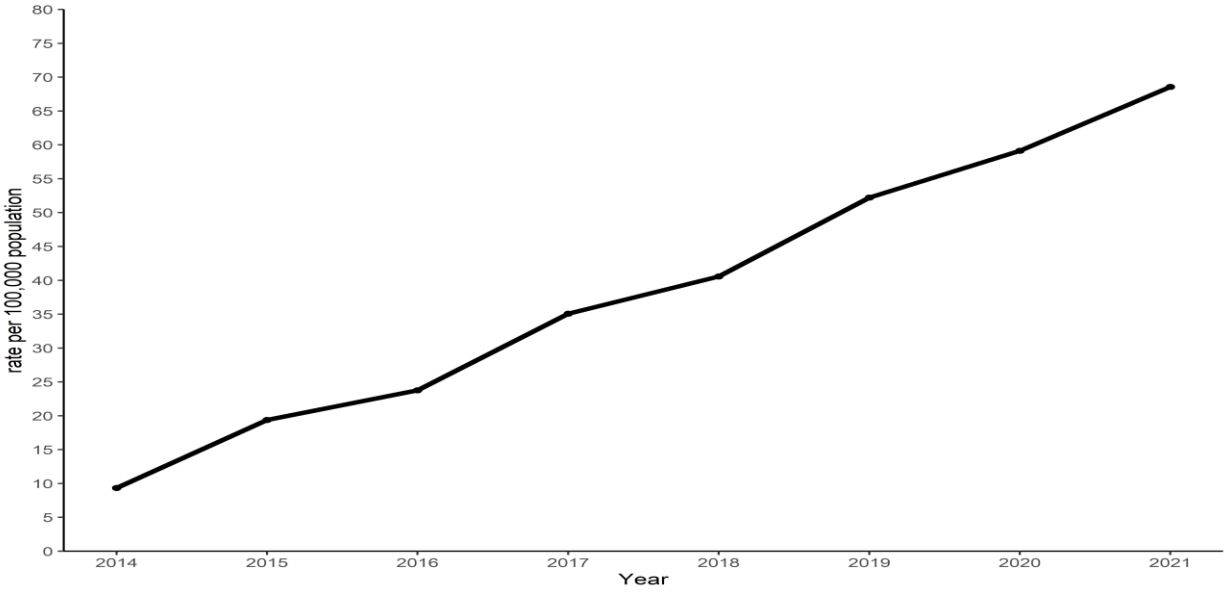

Figure 3.38: Cumulative rate of antibiotic guardians per 100,000 population, NI, 2014 - 2021

3.3.3 Changing prescribing behaviour

HSCB/SPPG engaged in a number of campaigns to help change prescribing behaviour during 2020-2021 including:

- Socially distanced workshops on antimicrobial stewardship delivered to primary care in May 2021. They included GPs, pharmacists and nurses. Recordings of the session were uploaded to the NICPLD and Medicines NI websites to increase accessibility.
- An ECHO session delivered in April 2021 to community pharmacists providing the Pharmacy First for Uncomplicated Lower Urinary Tract Infections (LUTIs) in women aged 16 to 64 years. A recording of which was made available to increase accessibility.
- Evaluation of a community pharmacy C-reactive protein (CRP) point-of-care testing pilot [9]
- Supporting GP out-of-hours services in reducing inappropriate antibiotic prescriptions.

3.3.4 Future work

Planned future work will include:

- Contributing to the development of the new UK National Action Plan for antimicrobial resistance and the development of a local implementation plan for NI.

- Continued provision of prescribing trend information to primary and secondary care prescribers.
- Further refinement of secondary care data capture and reporting processes to allow more timely and comprehensive information to help focus and reduce antibiotic use in secondary care services.
- Continued engagement in awareness activities during the European Antibiotic Awareness Day (EEAD) and World Antibiotic Awareness Week (WAAW).

4 Discussion

This is the fourth report of antibiotic resistance and antibiotic consumption in NI. As a result of the COVID-19 pandemic it was not feasible for the agency to undertake an annual report covering 2019-2020. Figures for this time period are included within the current report. As with previous reports, we have aimed to keep the content generally comparable with the ESPAUR report for England [4]. 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.

4.1 Antibiotic resistance

The focus for the antibiotic resistance section was the antibiotic-pathogen combinations that were identified as part of the UK 5-year national action plan for antimicrobial resistance 2019 to 2024 (NAP) [3]. The data for this report has been extracted from the Northern Ireland Lab Information System (NILIS). *S. aureus* and Gram negative bloodstream infections including; *E. coli*, *K.pneumoniae* and *Pseudomonas* species are subject to mandatory surveillance.

E. coli and *K. pneumoniae* bloodstream infections have been targeted as part of the UK government's ambition to reduce healthcare-associated gram-negative bloodstream infections by 50% by 2024. 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 NI in April 2018. These new data are 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.

During the period since the last report (2018 to 2021) the number of bloodstream infections due to *E. coli*; *K. pneumoniae*, *S. pneumoniae* and *Acinetobacter* decreased while reports of *Enterococcus*, *K. oxytoca*, *Pseudomonas* sp. and *S. aureus* increased. The trends observed during the 2018-2021 period are broadly similar to those noted in England during the same time period with the exception of *Acinetobacter* which increased in England between 2018-2021 [4].

During the first year of the COVID-19 pandemic (2020), a decrease in the number of bacteraemias was observed for all of the key organisms with the exception of *Enterococcus* which continued to increase and *S. aureus* which remained stable. During 2021, the number of bacteraemias increased for five of the eight key

organisms, with decreases continuing for only *Acinetobacter*, *K. pneumoniae* and *S. pneumoniae* . The observed decreases during 2020 are similar to the trends reported in England [4] and are likely associated with changes in healthcare activity and interventions against COVID-19 including social distancing measures, enhanced infection control procedures within the healthcare setting and deferral of non-urgent surgery. The noted increase in bloodstream infections due to *Enterococcus* in 2020 was also observed in England [4].

Increases in antibiotic resistance were noted for a number of antibiotic-pathogen combinations between 2018-2021 including; *E. coli*, *K. oxytoca* and *pseudomonas* sp. resistance to piperacillin-tazobactam; *pseudomonas* sp. and *K. pneumoniae* resistance to third-generation cephalosporins; *E. coli* and *K. pneumoniae* resistance to carbapenems and *S. pneumoniae* resistance to penicillin. The proportion of non-susceptible isolates decreased for *K. pneumoniae* against piperacillin-tazobactam; *E. coli* against third-generation cephalosporins; *K. pneumoniae* and *E. coli* against co-amoxiclav with *K. oxytoca* resistance to co-amoxiclav remaining stable. Reductions in number of bloodstream infections during 202-2021 are likely to be at least partly attributable to changes in healthcare activity during the COVID-19 pandemic.

Reports to the PHA of CPE had been increasing year-on-year from 2016-2019 but decreased in 2020 and further in 2021. A similar trend was observed in England [4]. Some of the increase likely reflects the voluntary nature of reporting and local developments in the ability to test for CPE, while recent decreases may be at least partly attributable to changes in hospital activity and increased focus on infection prevention and control in healthcare settings during the pandemic

As antimicrobial resistance is a transmissible global problem, PHA will continue to liaise with UK Health Security Agency and the Scottish, Welsh and Irish public health organisations and the World Health Organization’s Global Antimicrobial Resistance Surveillance System (GLASS). This will ensure standardised information on antimicrobial resistance is available to inform comparisons and drive improvement.

4.2 Antibiotic consumption

Total antibiotic consumption in NI continued to decline between 2018 and 2021 with notable reductions particularly during 2020 and 2021. Primary care antibiotic usage has been steadily decreasing since 2016. Changes in access to primary care services during the pandemic are a likely driver of the recent reductions and we will continue to monitor antibiotic usage in primary care as we emerge from the pandemic. Antibiotic consumption in secondary care has also decreased between 2018-2021, with the most noticeable reductions observed during 2020 and 2021. Again, this may be partially attributable to changes in healthcare activity. When the change in admissions during 2020-2021 are accounted for, the prescribing trend in secondary care remained stable in 2020 and increased slightly in 2021. Consumption of antibiotics within the dental sector also increased during 2020 - 2021, the only setting to do so during the pandemic. A similar trend was observed in England [4].

In general, antibiotic consumption in NI remains higher than in England (25.04 compared with 15.95 DDD per 1000 inhabitants per day) during 2021. By this measure, NI’s total antibiotic consumption in 2021 is 57% higher than that of England. Penicillins, tetracyclines and macrolides remained the most commonly

prescribed antibiotics in both settings. There has been a decrease in the usage of a number of antibiotic classes in both settings including penicillins, tetracyclines, macrolides and anti-folate agents. The consumption of penicillin/beta-lactamase inhibitor combinations, cephalosporins and anti-C. difficile agents have increased. Co-amoxiclav use had been decreasing between 2014-2020 but increased in 2021. Piperacillin-tazobactam consumption while relatively stable was more than twice the rate in England during 2021 (0.08 DDD per 1,000 inhabitants per day). Similarly, third-generation cephalosporin use in NI (between 0.51 and 0.55 DDD per 1,000 inhabitants per day during 2018-21) is higher than in England (0.31 DDD per 1,000 inhabitants per day in 2021). Tetracycline use has generally decreased in NI from 2019 but was higher than in England during 2021 (6.77 compared with 4.33 DDD per 1,000 inhabitants per day). Macrolide and quinolone consumption steadily decreased between 2018-2021 in NI, similar to trends in England. Colistin is an antibiotic of last resort, used for multidrug-resistant infections and also as an inhaled therapy for people with cystic fibrosis. Colistin consumption in NI has been steady since 2014, but rates are higher than in England (0.12 DDD per 1,000 inhabitants per day in 2021 in NI and 0.038 DDD per 1,000 inhabitants per day in 2021 in England).

The general trend of consumption across the WHO AWaRe categories is encouraging, with antibiotics from the Access category consistently accounting for approximately two thirds of total consumption per year between 2014 and 2021. This may reflect consistent antimicrobial stewardship practices led by pharmacists in primary and secondary care.

The amount of antibiotic use in NI has reduced but still remains markedly higher than England. Understanding the reasons for the difference is complex. During 2018 the PHA collaborated with the HSCB, the Innovation Lab at the Department of Finance and other primary care stakeholders to fill this information gap, producing a report of their findings which included eight recommendations for how antibiotic prescribing could be addressed in the future [10].

Investigating the reasons for differences in secondary care is more difficult because antibiotic consumption is measured at ward rather than patient level. Future work will also investigate the effect of the COVID-19 pandemic on antibiotic consumption in both primary and secondary care and the appropriateness of prescribing during this time. Health and Social Care NI is adopting a new electronic healthcare record (“Encompass”), which will include electronic prescribing and provide a rich source of information about the factors influencing antimicrobial consumption.

To engage with professionals and the public, the PHA encourages readers to sign up here to become an Antibiotic Guardian.

5 Method

5.1 Antibiotic resistance

5.1.1 Data sources

Testing for bacteria in human specimens and their susceptibility to antibiotics is conducted in the laboratories of five Health and Social Care Trusts in NI. Infections that meet certain criteria, usually the most severe that occur in the blood

(bacteraemias), are reported voluntarily to the PHA's "NILIS" 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 - 2021 (presented by calendar year).

Detections of carbapenemase-producing organisms (CPOs) are reported to the PHA as part of a voluntary reporting service. In cases where a microbiology laboratory suspects a CPO, the specimen is submitted to UK Health Security Agency's (UKHSA) 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. For the purposes of this report however, the focus will be on carbapenemase-producing Enterobacterales (CPE) only.

5.1.2 Definitions

The term "antimicrobial" refers to drugs used to treat infections caused by a range of microbes including; bacteria, viruses, fungi and parasites. While this term is used throughout the report, the data presented only reflects antibiotics which are utilised to treat bacterial infections.

Hospital microbiology laboratories report antimicrobial susceptibility test results as "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". The terms "non-susceptible" and "resistant" are used interchangeably throughout the report when referring to "intermediate" or "resistant" antibiotic susceptibility tests. For analysis of resistance to more than one antibiotic, multi-drug resistance (MDR) was defined as acquired non-susceptibility to at least one agent in three or more antimicrobial classes.

5.2 Antibiotic consumption

5.2.1 Data sources

Consumption data for primary and secondary care was obtained using the data submitted to the Central Asian and European of Antimicrobial Resistance Network (CAESAR). The primary care antibiotic consumption data were extracted from the Electronic Prescribing Database by the Health and Social Care Board. The data includes health and social care prescribing from: general practitioners within general practice and out-of-hours centres; nurse, pharmacy and allied health professionals; and, dentists. The secondary care antibiotic 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 all settings are available from 2014-2021 and are presented by calendar year.

Different to in England, outpatient medications in NI 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 NI as opposed to secondary care in England. There is currently no way of separating these

prescriptions from the rest of primary care prescribing in NI. In England, outpatient prescribing accounts for 6.5% of secondary care antimicrobial prescribing [11].

Data from out-of-hours settings was extracted from multiple sources. For pre-packed antibiotics the JAC Medicines Management System and a private pharmaceutical company are responsible for over-labelling of antibiotic packs. All other out-of-hours data is received from the BSO Pharmaceutical Payment System.

5.2.2 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) [12]. The data for both settings in this report include ATC classification groups J01, A07 and P01, please refer to Appendix 2 for specific inclusions.

5.2.3 Denominator

Mid-year population estimates for 2018-2021 were obtained from the (NI Statistics and Research Agency) prior to the June 2023 rebased figures . The population of 2021 utilizes figures from the 2021 Census (NISRA) 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.

5.2.4 WHO Defined Daily Doses

Antibiotic consumption is measured here using the 2019 WHO Classification of Defined Daily Doses (DDDs). The World Health Organization updates the DDDs on a semi-regular basis and these changes are applied to data retrospectively [13].

6 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 Nizam Damani for his input into the content of this year's annual report.

6.0.1 Image credits

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7 Appendices

7.1 Appendix : AMR surveillance categories

Table 7.1: 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

Table 7.1: Antibiotic names (trade and generic) and assigned surveillance group for the antimicrobial resistance data

Antibiotic surveillance group	Individual antibiotic name
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
Macrolides	erythromycin
Macrolides	azithromycin
Macrolides	erythrocin
Macrolides	erythromid
Meticillin	cefoxitin
Meticillin	flucloxacillin
Meticillin	floxapen
Meticillin	oxacillin
Meticillin	meticillin
Meticillin	celbenin

Table 7.1: Antibiotic names (trade and generic) and assigned surveillance group for the antimicrobial resistance data

Antibiotic surveillance group	Individual antibiotic name
Meticillin	cloxacillin
Meticillin	orbenin
Penicillin	apsin
Penicillin	benzylpenicillin
Penicillin	phenoxymethylpenicillin
Penicillin	penicillin
Penicillin	penidural
Piperacillin/Tazobactam	tazocin
Piperacillin/Tazobactam	piperacillin/tazobactam

7.2 Appendix : AMC data categories

Table 7.2: 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

Table 7.2: Antibiotic names, ATC codes and assigned surveillance group for the antimicrobial consumption data

Antibiotic surveillance group	Individual antibiotic name	ATC codes
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
Carbapenems	meropenem	J01DH52
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
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

Table 7.2: Antibiotic names, ATC codes and assigned surveillance group for the antimicrobial consumption data

Antibiotic surveillance group	Individual antibiotic name	ATC codes
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

Table 7.2: Antibiotic names, ATC codes and assigned surveillance group for the antimicrobial consumption data

Antibiotic surveillance group	Individual antibiotic name	ATC codes
Penicillins	flucloxacillin	J01CF05
Penicillins	co-fluampicil	J01CR50
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
Tetracyclines and related drugs	minocycline	A01AB23

7.3 Appendix : Testing data

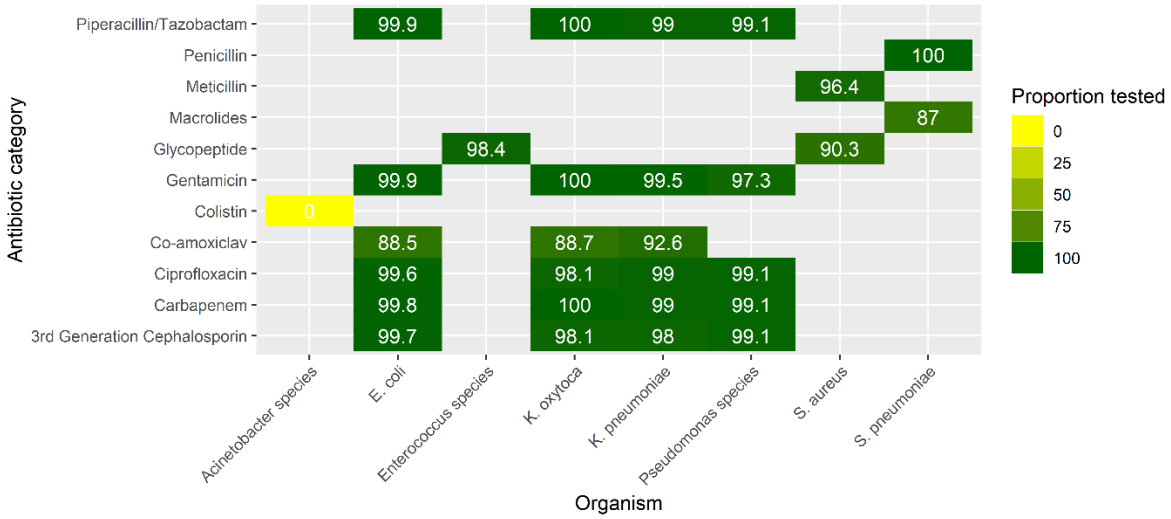

Figure 7.1: The proportion of key bacteraemias where selected antibiotic susceptibility results were reported to the PHA in 2021

7.4 Appendix : Antibiotic-pathogen combinations monitored

Table 7.3: Antibiotic-pathogen 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, linezolid, teicoplanin, vancomycin
Streptococcus pneumoniae	Macrolides, penicillin
Acinetobacter species	Colistin

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