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ANTIMICROBIAL RESISTANCE IN NEISSERIA GONORRHOEAE IN NEW ZEALAND: SURVEILLANCE REPORT 2022

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INTRODUCTION

Gonorrhoea is one of the most common sexually transmitted infections (STI) globally, with 82.4 million new cases among adults aged 15–49 in 2020(1). Untreated gonorrhoea can result in serious sequelae, including pelvic inflammatory disease, vertical transmission and increased HIV transmission(2-4).

Antimicrobial resistance (AMR) in *Neisseria gonorrhoeae (N. gonorrhoeae)* is a growing public health threat globally. *N. gonorrhoeae* resistance to tetracyclines, macrolides, sulphonamides and quinolones has been documented(5-8). As a result of increasing resistance, dual antibiotic therapy with ceftriaxone and azithromycin is the first line treatment for gonorrhoea recommended in many countries, including in New Zealand (NZ)(9-12). However, there are also a growing number of reports of resistance and treatment failures using this dual therapy(10, 13) and reduced susceptibility or resistance to ceftriaxone, the last option for first-line gonorrhoea monotherapy, has also emerged(7, 8). Evidence of sustained transmission of high-level azithromycin resistance and concern about the effects of azithromycin on other pathogens and on the microbiome has led some jurisdictions, including the United Kingdom (UK) and United States (USA), to recommend single-agent ceftriaxone treatment for uncomplicated gonorrhoea(13, 14).

HISTORY OF NEW ZEALAND AMR SURVEILLANCE

Antimicrobial susceptibility testing (AST) for *N. gonorrhoeae* has been conducted in New Zealand intermittently since 1976. Following sporadic surveys, quarterly analysis was undertaken between 2005 and 2008 due to rising resistance to ciprofloxacin, the first line antibiotic in use at that time. Annual reporting by laboratories continued from 2009 to 2012, and from 2013, AST data was collected with STI laboratory surveillance data.

From 2013 to 2016, reporting of *N. gonorrhoeae* AMR focused on penicillin and ciprofloxacin resistance. Resistance to penicillin ranged from 4.5% in 2013 to 14.9% in 2016, with decreasing numbers of isolates available for AST with a shift to nucleic acid amplification testing (NAAT) instead of culture for diagnosis over this time (422 in 2013 to 168 in 2016). Between 2013 and 2016, resistance to ciprofloxacin ranged from 26.2% to 36.3%, also with decreasing numbers of isolates tested (1055 in 2013 to 831 in 2016). Penicillin and ciprofloxacin resistance results are currently of limited clinical utility, as penicillin is not used, and ciprofloxacin is now a third line agent for gonorrhoea treatment. Isolate numbers with reduced susceptibility to ceftriaxone were reported from 2014 to 2016 (1, 8, and 4 in 2014, 2015, and 2016 respectively), with total isolates tested not reported. Azithromycin resistance was included for the first time in the 2016 Annual STI surveillance report. No resistance was detected, however only 79 isolates from three District Health Boards were tested(15). Surveillance data from 2017-2022 suggests an increasing trend in Azithromycin resistance (>1mg/L) in New Zealand during that reporting period. While a small number of isolates with reduced susceptibility to ceftriaxone were identified between 2017–2022, resistance to ceftriaxone has not yet been reported in New Zealand(16).

In addition to routine surveillance data, periodic *N. gonorrhoeae* AMR surveys have been undertaken in 2014/15 and 2018/19 when laboratories were asked to send all *N. gonorrhoeae* isolates to ESR for analysis. With increased nucleic acid amplification (NAAT)-based testing since 2015, fewer isolates have been available for AST(17). The most recent AMR survey conducted by ESR in 2018/19 included 344 isolates provided by laboratories, with most isolates coming from the Auckland region. Two (0.6%) of the 344 isolates displayed reduced susceptibility to ceftriaxone and six (1.7%) were resistant to azithromycin (17).

METHODS

The collection, collation, and initial cleaning of laboratory data for gonorrhoea are described in the methods section of the 2022 Supplementary Annual Surveillance report. The result of this process are data stored in a SQL server database. These data include AST data for *N. gonorrhoeae* for ceftriaxone, azithromycin, penicillin, ciprofloxacin, and tetracyclines. The data are extracted from SQL into R.

AMR isolate numbers, testing methods and reporting practices vary between laboratories. Results received include minimum inhibitory concentration (MIC), zone diameter (ZD) and sensitive, intermediate/reduced susceptibility, resistant (SIR) data. Free-text data are entered by many laboratories, and multiple unique responses are received. These data are cleaned in R and interpretations confirmed with individual laboratories as required.

To analyse AST results from cultures, data were restricted to individuals with a National Health Index (NHI) or personal identifier (PID). Duplicate tests, defined as having the same NHI or PID and occurring within the same month and year, were then excluded from the analysis. Next, MIC values were prioritised for AST reporting, and substituted with SIR or ZD values if missing. EUCAST breakpoints (Table 1) were used to interpret the MIC results reported here.

From 2018, laboratories began shifting azithromycin AST practices from MIC interpretations to European Committee on Antimicrobial Susceptibility Testing (EUCAST) epidemiological cut-off values (ECOFFs). Some laboratories have not reported ECOFFs to ESR, so the proportion of isolates which underwent azithromycin AST is likely to be an underestimate. An ESR survey on *N. gonorrhoeae* AMR surveillance data conducted in 2022 and completed by 7/12 major diagnostic testing laboratories in New Zealand found that 5/7 laboratories conduct susceptibility testing for Azithromycin, and 1/5 did not report Azithromycin AST results to ESR. Given not all laboratories completed the survey, the number and proportion of laboratories that test and report azithromycin AST is currently unclear.

The MIC breakpoints used to interpret AST results in this report are based on EUCAST clinical breakpoint tables, last published in January 2023(18). For ceftriaxone, we used a combination of EUCAST (to determine resistance) and World Health Organization (WHO) guidelines to determine reduced susceptibility criteria. The MIC breakpoints used to interpret AST results are displayed in Table 1.

Table 1: MIC breakpoints to interpret antimicrobial susceptibility testing results

Antimicrobial	MIC breakpoint for susceptibility (mg/L)	MIC breakpoint for reduced/intermediate[i] susceptibility (mg/L)	MIC breakpoint for resistance (mg/L)
Azithromycin	≤1.00*		>1.00*
Ceftriaxone	<0.06	≥0.06 to ≤0.125	>0.125
Ciprofloxacin	<0.03	≥0.03 to ≤0.06	>0.06
Penicillin	≤0.06	>0.06 to ≤1.00	>1.00
Tetracyclines	≤0.5	>0.5 to ≤1.00	>1.00

*Formal breakpoints for Azithromycin have not yet been determined; an epidemiological cut-off (ECOFF) is used with >1mg/L considered resistant.

[i] "Intermediate resistance" is used for penicillin while "reduced susceptibility" is used for ceftriaxone. These describe isolates which are not fully susceptible but also do not meet the definition for resistance.

RESULTS

CULTURE AND ANTIMICROBIAL SUSCEPTIBILITY TESTING

A detailed breakdown of gonorrhoea infection and culture numbers for 2022 is presented in Table 2. In 2022, 1,677 (24%) of the 6,969 reported gonococcal cases had a culture test. Of these, 1,328 were positive for gonorrhoea, and AST was undertaken and reported to ESR for 1,265 (95%) isolates for ceftriaxone and 821 (62%) isolates for azithromycin.

Te Waipounamu (South Island) and Te Manawa Taki (Waikato and surrounding districts) reported the highest proportion of culture testing among positive cases (31% each) and AST for ceftriaxone (98% each). Te Manawa Taki reported the highest proportion of AST for azithromycin (94%).

Table 2: Total number of gonococcal infections, culture tests, positive culture results, ceftriaxone AST results and azithromycin AST results by region: 2022

Region	No. of infections[1]	No. of culture tests[2]	No. of positive culture results[3]	No. of Azithromycin AST results[4]	No. of Ceftriaxone AST results[4]
Central North Island	937	156 (17%)	110	0[5]	99 (90%)
Northern North Island	3749	820 (22%)	606	371 (61%)	566 (93%)
Te Manawa Taki	1241	379 (31%)	313	293 (94%)	307 (98%)
Te Waipounamu South Island	1042	322 (31%)	299	157 (53%)	293 (98%)
Total	**6969**	**1677 (24%)**	**1328**	**821 (62%)**	**1265 (95%)**

[1] Infections exclude multiple positive results within a defined period of time.

[2] Deduplicated to exclude multiple positive results within the same episode. % of infections among individuals with a known NHI or PID (personal identifier) who had a culture test.
A 'period of testing' created for results with known NHI or PID and in the same year and month. Those with unknown NHI/PID removed.
All 'periods of testing' without a positive result removed.
All episodes/cases of gonorrhoea with a culture test taken in the same 'period of testing' included, with PCR only episodes removed.
Calculated number of gonorrhoea cases per region with a known NHI/PID where a culture test was taken (regardless of result)

[3] Of all the culture tests taken, these returned a positive result. A person with a gonococcal infection may return a negative culture test for several reasons, including: an extended transport time resulting in an unviable isolate; testing during the same infection but after treatment has started; and testing from a different anatomical site of the infection.

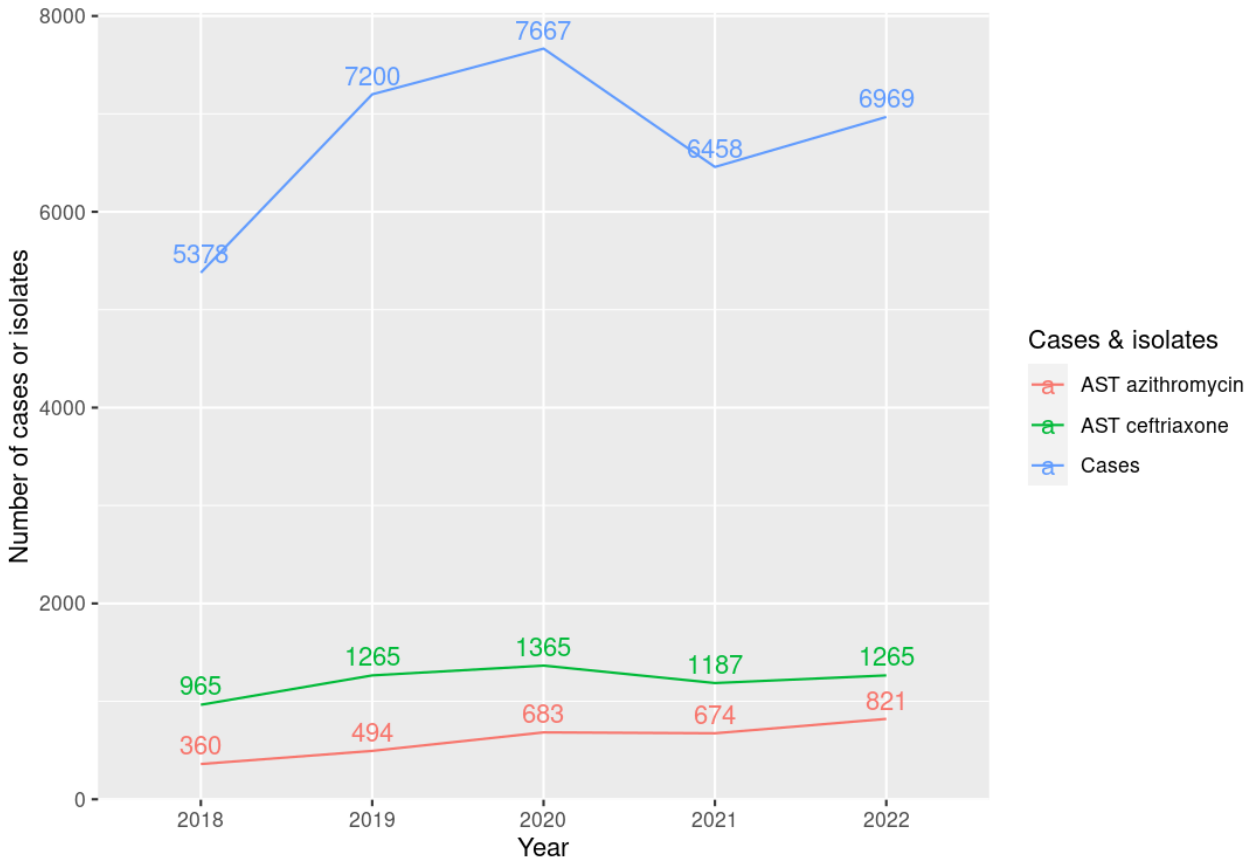
[4] Includes all positive culture results received with completed Antimicrobial Susceptibility Testing (AST) data in order of preference from minimum inhibitory concentration (MIC) to SIR results (Susceptible; increased exposure/Intermediate/reduced susceptibility, Resistant) to disk diffusion results. % of AST results from no. of positive culture results.

[5] Numbers of azithromycin AST results reported from the Central North Island were low compared to other regions between 2019 and 2021. This may be due to differences in reporting rather than testing practices.

Numbers of gonorrhoea cases and isolates undergoing azithromycin and ceftriaxone AST from 2018 to 2022 are shown in Figure 1. Annual gonorrhoea notifications climbed by 42.6% between 2018 to 2020, decreased by 15.8% in 2021, then increased nearly 8% in 2022. Between 2018 and 2021, a culture test was reported for 22% to 24% of all reported cases.

The percentage of cases undergoing ceftriaxone AST has remained relatively steady between 2018 to 2022, ranging from 17.6% to 18.4%. The percentage of cases undergoing ceftriaxone AST in 2022 was 18.2% (1,265/6,969). The proportion of azithromycin cases undergoing azithromycin testing increased from 6.7% in 2018 (360/5378) to 18.2% in 2022 (1265/6969). It is not clear whether this increase is due to increased testing or increased reporting.

Figure 1: Number of gonorrhoea cases reported and isolates subsequently undergoing antimicrobial susceptibility testing for azithromycin and ceftriaxone in New Zealand: 2018–2022



AZITHROMYCIN & CEFTRIAXONE RESISTANCE

Figure 2: Proportion of *Neisseria gonorrhoeae* isolates with resistance (or reduced susceptibility) to ceftriaxone and azithromycin in New Zealand: 2018–2022

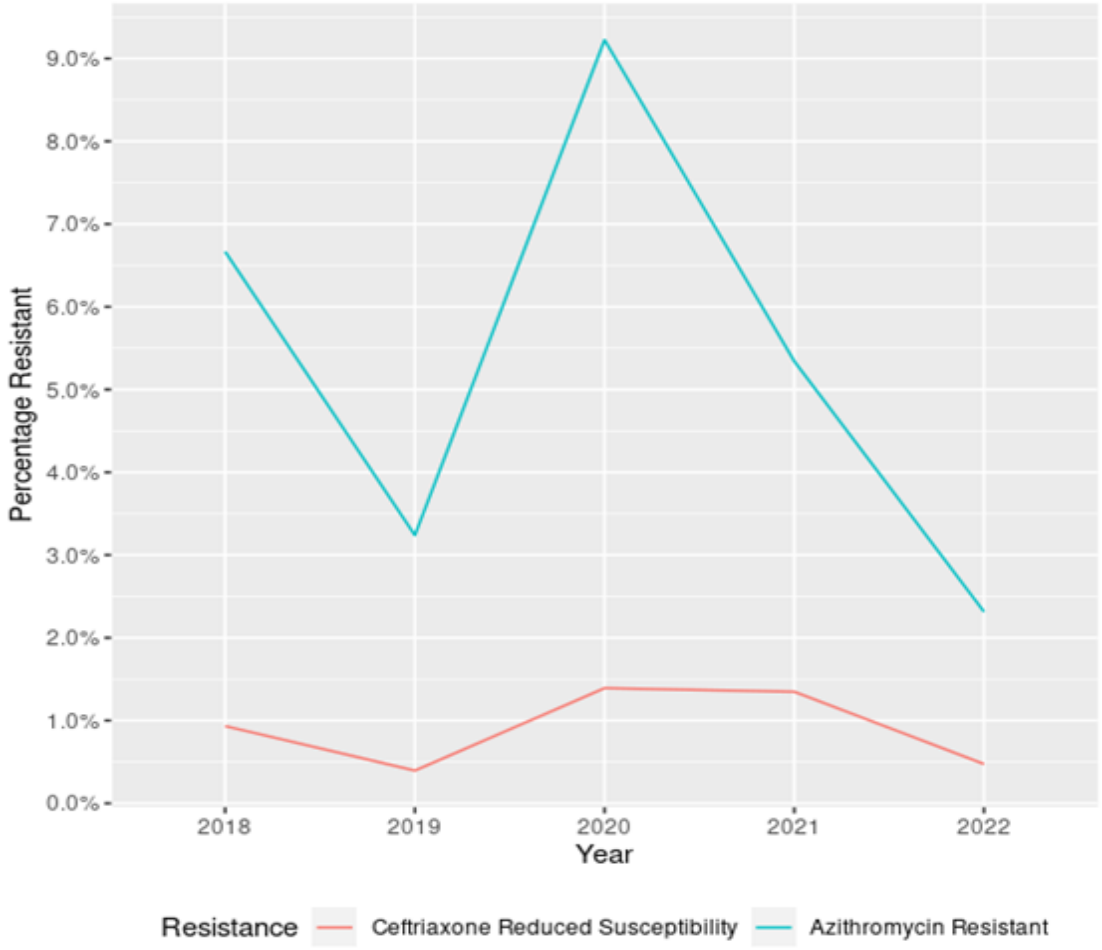


Table 3: Resistance to ceftriaxone and azithromycin for *Neisseria gonorrhoeae* in New Zealand: 2018–2022

	2018	2019	2020	2021	2022
Ceftriaxone Reduced Susceptibility	0.9% 9/965	0.4% 5/1265	1.4% 19/1365	1.3% 16/1187	0.5% 6/1265
Azithromycin Resistant	6.7% 24/360	3.2% 16/494	9.2% 63/683	5.3% 36/674	2.3% 19/821

Figure 2 and Table 3 show the proportion of deduplicated gonorrhoea isolates (rather than gonorrhoea cases) with resistance to azithromycin and reduced susceptibility to ceftriaxone.

No isolates have been reported as resistant to ceftriaxone. The percentage of isolates with reduced susceptibility to ceftriaxone remains low, fluctuating between 0.4% and 1.4% between 2018 and 2022.

Due to very few isolates with reduced susceptibility to ceftriaxone, trends are difficult to identify (Appendix Table 1). By sex, the same number of isolates with reduced susceptibility to ceftriaxone were reported for males (3, 0.3%) and females (3, 1.3%). No clear differences were discernible by age and ethnicity. By region, all isolates with reduced susceptibility were reported from the upper North Island, with three in the Northern North Island, and three in Te Manawa Taki. The highest number of resistant isolates were from urogenital sites (4, with 1 each from anorectal and pharyngeal specimens).

Resistance to azithromycin has also fluctuated between 2018 and 2022, with a peak of 9.2% in 2020, and the lowest reported resistance since 2017 of 2.3% in 2022 (Appendix Table 2).

Further trends in azithromycin resistance are shown in Appendix Table 2. Trends by sex have varied between 2018 and 2022. Between 2019 and 2021, a higher proportion isolates from males were found to be resistant, ranging from two and four times the proportion of resistant isolates from females. In 2022, this trend was reversed, with 3.3% of isolates from females reported to be resistant to azithromycin compared to 2.1% of isolates from males. By age, azithromycin resistance in 2022 was highest among those aged 40+ years (3.3%), followed by those 25-29 years (3.1%). A higher prevalence of azithromycin resistance in older age groups has also been seen in previous years, with 14% and 7.2% of isolates from people aged 40+ reported to be resistant to azithromycin in 2020 and 2021 respectively. There were no differences in resistance to azithromycin by ethnicity.

In 2022, the highest percentage of azithromycin resistant isolates were reported in Te Manawa Taki (3.8%), followed by Te Waipounamu South Island (2.5%). As in previous years, Central North Island did not report azithromycin AST results. By specimen site, the highest number of specimens with azithromycin AST reported were from urogenital sites (621, 75.6%), followed by anorectal sites (129, 15.7%) and the pharynx (64, 7.8%). The highest proportion of resistant isolates was found in anorectal specimens (5/129, 3.9%) followed by urogenital specimens (13/621, 2.1%) and pharyngeal specimens (1/64, 1.6%).

PENICILLIN & CIPROFLOXACIN RESISTANCE

Figure 3: Proportion of *Neisseria gonorrhoeae* isolates with resistance (or intermediate resistance) to penicillin and ciprofloxacin in New Zealand: 2018-2022

Resistance to penicillin decreased from 10.8% in 2019 to 5.2% in 2020 (Figure 3), then remained steady between 2021 (6.9%) and 2022 (6.9%). Intermediate resistance to penicillin has also remained steady but very high (>85%) for all reporting years.

Further trends in resistance to penicillin are shown in Appendix Table 3. By sex, intermediate resistance to penicillin was highest among females in 2022 at 95%. Intermediate resistance to penicillin ranged between 82 and 95% among isolates from females and between 86 and 88% among isolates from males between 2018 and 2022. By age and ethnicity, intermediate resistance to penicillin has fluctuated (see Appendix Table 3).

Little AST for penicillin is reported from the Central and Northern North Island. Penicillin AST methods differ across laboratories, with some using disc diffusion and others MIC gradient strip testing, with different brands of strip tests. These differences in methods may yield different results across laboratories.

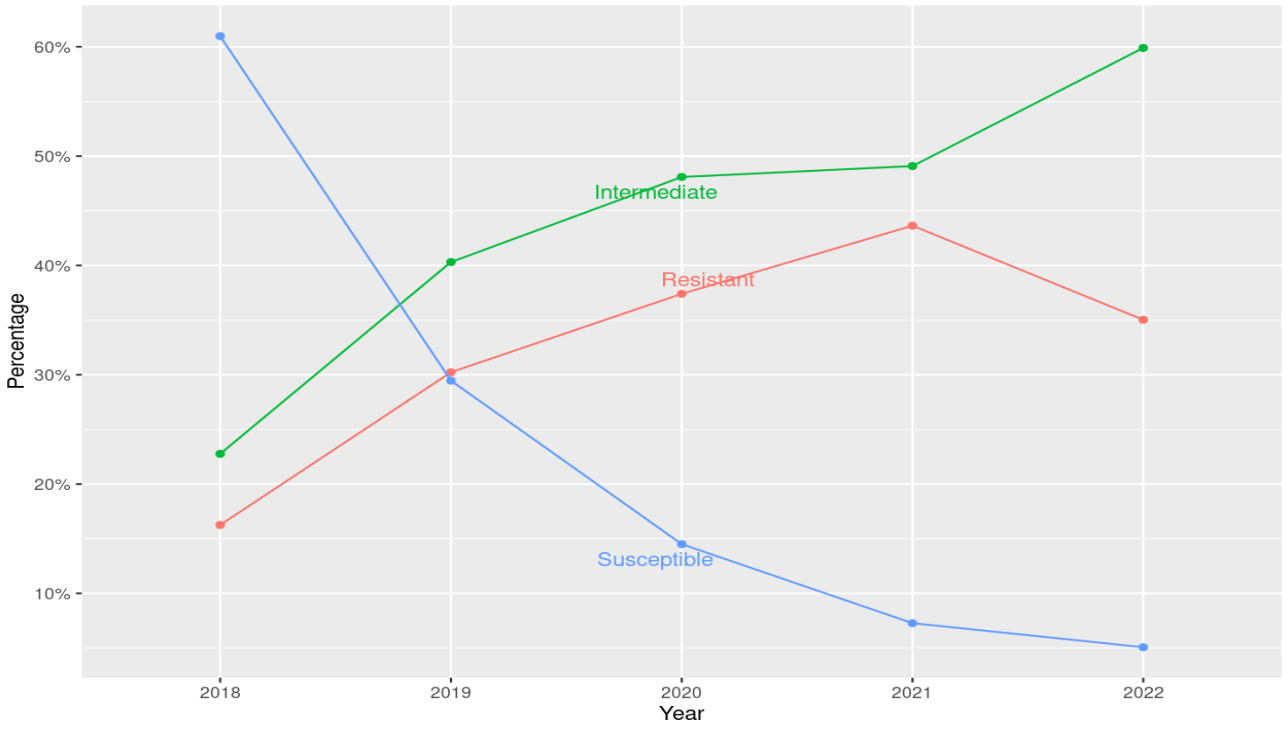
Ciprofloxacin resistance has increased steadily from 21% in 2018, to 42% in 2022 (Appendix Table 4). By sex, resistance to ciprofloxacin was similar from 2018 to 2019 but resistance in isolates from males has since increased to a greater extent, and in 2022 26% of isolates were resistant to ciprofloxacin among females and 45% among males.

In 2022, resistance to ciprofloxacin across age groups ranged from 36% (20–24-year-olds) to 45% (40+ year-olds). A higher proportion of isolates resistant to ciprofloxacin among adults aged over 30 was also seen in 2020 and 2021, with a general pattern of increased resistance with age. By ethnicity in 2022 the highest proportion of resistant isolates were seen among isolates from people of Asian ethnicity followed by people of European and other ethnicities (49%). Intermediate resistance to ciprofloxacin was under 1% throughout the reporting period and is not included in Figure 3.

TETRACYCLINE RESISTANCE

As in previous years, Tetracycline AST results for 2022 were received from only one region (Te Waipounamu), with the exception of one isolate received from the Northern North Island (Appendix Table 5). Resistance has increased from 16% in 2018 to 35% in 2022 in Te Waipounamu. The number of isolates tested in 2022 (197) has increased compared to previous years, from 123 isolates in 2018 and 110 isolates in 2021. In 2022, resistance among females (42%) was higher compared to males (33%), in contrast to trends of slightly higher resistance among males between 2018 and 2021. Given low numbers, trends in resistance by age and ethnicity are unclear.

Figure 4: Proportion of *Neisseria gonorrhoeae* isolates by susceptibility to tetracycline in New Zealand: 2018-2022



DISCUSSION AND LIMITATIONS

To date there have been no reported gonococcal isolates that are resistant to ceftriaxone in New Zealand, and levels of reduced susceptibility remain low, at 0.5% in 2022. Almost all gonococcal isolates (90-98%) which are cultured undergo AST for ceftriaxone. Due to low numbers of isolates with reduced susceptibility to ceftriaxone, further descriptive analysis of these isolates is limited.

Azithromycin resistance (>1mg/L) has fluctuated over time, with the proportion resistant dropping from 9.2% in 2020 to 2.3% in 2022. No isolates with high-level resistance to azithromycin (>256mg/L) have been reported in New Zealand to date, and the MIC of resistant isolates were all <8.0mg/L, except for one isolate in 2020 and one in 2022, both with MIC of 16.0mg/L.

While the relatively low levels of ceftriaxone and azithromycin resistance in New Zealand in 2022 are reassuring, continued vigilance is required to detect and monitor the spread of resistant *N. gonorrhoeae* and maintain the effectiveness of current gonorrhoea treatment in New Zealand. This is particularly important in the context of the increases in ceftriaxone-resistant and azithromycin-resistant *N. gonorrhoeae* globally(1). In addition to molecular testing for diagnosis, ongoing bacterial culture of *N. gonorrhoeae* is required for monitoring AMR. In 2022, culture was undertaken for 24% of gonococcal infections, with an isolate available for AST for 19% of gonococcal infections. This was stable compared to 2021 (23%) and 2018-2020 (22-24%). This is similar to that reported in Australia (23%)(19, 20). Comparison with UK and US AMR surveillance is difficult due to different sentinel systems in use(21, 22).

New Zealand *N. gonorrhoeae* AMR data are not systematically sampled and are influenced by swabbing practices. Cultures are primarily taken in sexual health services, with sampling bias potentially affecting generalisability of resistance profiles. An improved understanding of the demographics of those swabbed, including through the integration of clinical and laboratory data, may provide insight. To fully understand site of infection, sexual behaviour is an important consideration, however this is not collected with laboratory data and cannot currently be routinely linked with clinical notifications collected. There are a number of known challenges with the quality of New Zealand *N. gonorrhoeae* AMR data, including a lack of standardisation of results, transcription errors resulting from the manual data entry process, and random errors. Efforts were made to confirm results with all laboratories, particularly resistance results, however some errors may persist. Further, the small number of isolates tested, and differential reporting practices across laboratories limits the identification of spatial patterns in resistance. Finally, inconsistencies in AST methods between laboratories, and changes in AST practices that occurred between 2018– 2022 may have influenced the results presented in this report. These include differences in testing methodologies, materials, and interpretation standards used for each antibiotic across many labs.

There is work underway to enhance AMR data collection and this will also enable more timely reporting.

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APPENDIX

Appendix Table 1: Number & proportion(%) of gonococcal isolates with reduced susceptibility to ceftriaxone, New Zealand, 2018–2022 by sex, age, ethnicity and region

	2018	2019	2020	2021	2022
Variable	**Reduced Susceptibility**, N = 9[1]	**Reduced Susceptibility**, N = 5[1]	**Reduced Susceptibility**, N = 19[1]	**Reduced Susceptibility**, N = 16[1]	**Reduced Susceptibility**, N = 6[1]
Sex	**965**	**1,265**	**1,365**	**1,187**	**1,265**
Female	5 (2.1%)	2 (0.6%)	10 (3.1%)	7 (3.4%)	3 (1.3%)
Male	4 (0.6%)	3 (0.3%)	9 (0.9%)	9 (0.9%)	3 (0.3%)
Age group	**950**	**1,226**	**1,344**	**1,186**	**1,265**
0–14	1 (11%)	0	0	0	0
15–19	1 (0.8%)	0	2 (1.9%)	0	0
20–24	2 (0.9%)	1 (0.4%)	4 (1.4%)	4 (1.8%)	1 (0.3%)
25–29	2 (0.9%)	1 (0.3%)	6 (1.9%)	3 (1.1%)	3 (1.1%)
30–39	2 (0.9%)	1 (0.3%)	1 (0.3%)	5 (1.4%)	2 (0.6%)
40+	1 (0.7%)	2 (1.1%)	4 (1.7%)	4 (1.8%)	0
Unknown	0	0	2	0	
Ethnicity	**965**	**1,265**	**1,365**	**1,187**	**1,265**
Asian	2 (3.5%)	0 (0%)	1 (0.9%)	1 (0.8%)	2 (1.7%)
European/Other	1 (0.3%)	3 (0.6%)	3 (0.6%)	4 (0.9%)	1 (0.2%)
Māori	3 (1.3%)	1 (0.3%)	6 (1.8%)	6 (2.0%)	1 (0.3%)
Pacific	2 (1.7%)	0 (0%)	0 (0%)	1 (0.6%)	2 (1.0%)
Unknown	1 (0.6%)	1 (0.5%)	9 (3.8%)	4 (2.8%)	0 (0%)
Region	**965**	**1,265**	**1,365**	**1,187**	**1,265**
Central North Island	0	0	3 (2.0%)	1 (1.0%)	0
Northern North Island	5 (1.2%)	3 (0.5%)	4 (0.6%)	6 (1.0%)	3 (0.5%)
Te Manawa Taki	4 (2.6%)	1 (0.4%)	12 (3.9%)	9 (3.3%)	3 (1.0%)
Te Waipounamu South Island	0	1 (0.3%)	0	0	0
Site of Infection					
Ano-rectal	0	1 (1.2%)	2 (1.7%)	1 (0.7%)	1 (0.7%)
Other/Unknown	2 (2.9%)	0	0	2 (4.2%)	0
Pharyngeal	0	0	0	1 (1.9%)	1 (1.6%)
Urogenital	7 (0.9%)	4 (0.4%)	17 (1.5%)	12 (1.3%)	4 (0.4%)

[1]n (%)

Appendix Table 2:Number & proportion (%) of gonococcal isolates with resistance to azithromycin, New Zealand, 2018-2022 by sex, age, ethnicity and region

	2018, N = 360	2019, N = 494	2020, N = 683	2021, N = 674	2022, N = 821
Variable	**Resistant**, N = 24[1]	**Resistant**, N = 16[1]	**Resistant**, N = 63[1]	**Resistant**, N = 36[1]	**Resistant**, N = 19[1]
Sex					
Female	5 (6.8%)	1 (0.9%)	6 (4.5%)	3 (2.6%)	5 (3.3%)
Male	19 (6.6%)	15 (4.0%)	57 (10%)	33 (5.9%)	14 (2.1%)
Age group					
0–14	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (NA%)
15–19	3 (8.6%)	0 (0%)	2 (4.5%)	3 (6.4%)	0 (0%)
20–24	7 (9.6%)	5 (5.0%)	10 (6.9%)	6 (5.4%)	3 (1.5%)
25–29	4 (4.9%)	2 (1.6%)	14 (8.2%)	5 (3.1%)	5 (3.1%)
30–39	5 (5.3%)	6 (4.3%)	20 (10.0%)	12 (5.6%)	6 (2.4%)
40+	5 (6.9%)	3 (3.8%)	17 (14%)	10 (7.2%)	5 (3.3%)
Ethnicity					
Asian	2 (8.7%)	0 (0%)	3 (5.0%)	3 (4.1%)	2 (2.7%)
European/Other	11 (8.0%)	9 (4.5%)	33 (15%)	17 (6.9%)	8 (2.5%)
Māori	6 (9.2%)	3 (3.2%)	13 (8.6%)	8 (4.7%)	5 (2.2%)
Pacific	0 (0%)	0 (0%)	3 (3.9%)	2 (2.5%)	1 (0.8%)
Unknown	5 (4.3%)	4 (3.6%)	11 (6.2%)	6 (5.9%)	3 (3.3%)
Region					
Central North Island	3 (30%)	0 (0%)	1 (100%)	0 (0%)	0 (NA%)
Northern North Island	9 (9.1%)	10 (4.3%)	17 (5.2%)	24 (7.0%)	4 (1.1%)
Te Manawa Taki	6 (4.6%)	3 (2.1%)	11 (4.8%)	7 (3.1%)	11 (3.8%)
Te Waipounamu South Island	6 (5.0%)	3 (2.5%)	34 (27%)	5 (4.8%)	4 (2.5%)
Site of Infection					
Ano-rectal	10 (16%)	4 (5.7%)	18 (17%)	9 (7.2%)	5 (3.9%)
Other/Unknown	1 (7.7%)	1 (10%)	1 (10%)	1 (5.9%)	0
Pharyngeal	1 (9.1%)	0	9 (26%)	6 (12%)	1 (1.6%)
Urogenital	12 (4.4%)	11 (2.7%)	35 (6.6%)	20 (4.1%)	13 (2.1%)

[1]n (%)

Appendix Table 3: Number & proportion (%) of gonococcal isolates by susceptibility to penicillin, New Zealand, 2018-2022 by sex, age, ethnicity and region

	2018, N = 276			2019, N = 296			2020, N = 407			2021, N= 303			2022, N 376		
	Res, N = 21[1]	Int, N = 239[1]	Sus, N = 16[1]	Res, N = 32[1]	Int, N = 262[1]	Sus, N = 2[1]	Res, N = 21[1]	Int, N = 346[1]	Sus, N = 40[1]	Res, N = 21[1]	Int, N = 261[1]	Sus, N = 21[1]	Res, N = 27[1]	Int, N = 335[1]	Sus, N = 14[1]
Sex															
Female	8 (12%)	56 (84%)	3 (4.5%)	6 (7.5%)	72 (90%)	2 (2.5%)	5 (5.0%)	83 (82%)	13 (13%)	1 (2.0%)	44 (88%)	5 (10%)	5 (6.4%)	73 (94%)	0
Male	13 (6.2%)	182 (88%)	13 (6.2%)	26 (12%)	189 (88%)	0	16 (5.2%)	262 (86%)	27 (8.9%)	20 (7.9%)	216 (86%)	16 (6.3%)	21 (7.1%)	262 (88%)	14 (4.7%)
Unknown	0	1 (100%)	0	0	1 (100%)	0	0	1 (100%)	0	0	1 (100%)	0	1 (100%)	0	0
Age group															
0–14	1 (100%)	0	0	0	4 (100%)	0	0	3 (75%)	1 (25%)	0	1 (100%)	0	0	0	0
15–19	5 (19%)	20 (77%)	1 (3.8%)	0	14 (100%)	0	2 (8.7%)	18 (78%)	3 (13%)	0	15 (94%)	1 (6.2%)	0	26 (96%)	1 (3.7%)
20–24	4 (6.2%)	56 (86%)	5 (7.7%)	5 (9.3%)	49 (91%)	0	3 (3.5%)	70 (81%)	13 (15%)	3 (6.1%)	45 (92%)	1 (2.0%)	6 (6.9%)	76 (87%)	5 (5.7%)
25–29	2 (3.6%)	52 (93%)	2 (3.6%)	8 (12%)	56 (88%)	0	7 (9.0%)	65 (83%)	6 (7.7%)	5 (7.8%)	53 (83%)	6 (9.4%)	6 (8.2%)	66 (90%)	1 (1.4%)
30–39	7 (10%)	58 (83%)	5 (7.1%)	10 (14%)	62 (85%)	1 (1.4%)	5 (4.1%)	108 (89%)	9 (7.4%)	10 (10%)	79 (81%)	9 (9.2%)	7 (6.7%)	93 (89%)	5 (4.8%)
40+	0	41 (93%)	3 (6.8%)	8 (13%)	53 (85%)	1 (1.6%)	3 (4.1%)	63 (86%)	7 (9.6%)	3 (4.1%)	67 (91%)	4 (5.4%)	8 (9.5%)	74 (88%)	2 (2.4%)
Unknown	2	12	0	1	24	0	1	19	1	0	1	0	0	0	0
Ethnicity															
Asian	0	6 (100%)	0	4 (29%)	10 (71%)	0	1 (9.1%)	9 (82%)	1 (9.1%)	3 (25%)	8 (67%)	1 (8.3%)	0	15 (100%)	0
European/Other	3 (3.0%)	94 (93%)	4 (4.0%)	12 (10%)	104 (89%)	1 (0.9%)	5 (3.8%)	114 (86%)	14 (11%)	10 (8.8%)	99 (88%)	4 (3.5%)	11 (6.1%)	163 (91%)	6 (3.3%)
Māori	7 (14%)	41 (82%)	2 (4.0%)	4 (8.0%)	45 (90%)	1 (2.0%)	4 (4.4%)	79 (87%)	8 (8.8%)	5 (5.8%)	74 (86%)	7 (8.1%)	10 (7.1%)	123 (88%)	7 (5.0%)
Pacific	1 (14%)	6 (86%)	0	1 (50%)	1 (50%)	0	3 (17%)	15 (83%)	0	1 (6.7%)	11 (73%)	3 (20%)	3 (21%)	11 (79%)	0
Unknown	10 (8.9%)	92 (82%)	10 (8.9%)	11 (9.7%)	102 (90%)	0	8 (5.2%)	129 (84%)	17 (11%)	2 (2.6%)	69 (90%)	6 (7.8%)	3 (11%)	23 (85%)	1 (3.7%)
Region															
Central North Island	0	6 (100%)	0	2 (67%)	1 (33%)	0	4 (6.2%)	48 (74%)	13 (20%)	0	9 (64%)	5 (36%)	1 (17%)	4 (67%)	1 (17%)
Northern North Island	1 (7.7%)	12 (92%)	0	0	16 (100%)	0	2 (13%)	11 (73%)	2 (13%)	0	12 (67%)	6 (33%)	1 (20%)	4 (80%)	0
Te Manawa Taki	7 (6.9%)	81 (79%)	14 (14%)	8 (6.5%)	114 (93%)	1 (0.8%)	7 (4.2%)	138 (84%)	20 (12%)	4 (2.7%)	133 (90%)	10 (6.8%)	4 (2.4%)	147 (90%)	13 (7.9%)
Te Waipounamu South Island	13 (8.4%)	140 (90%)	2 (1.3%)	22 (14%)	131 (85%)	1 (0.6%)	8 (4.9%)	149 (92%)	5 (3.1%)	17 (14%)	107 (86%)	0	21 (10%)	180 (90%)	0

[1]n (%)

Res = Resistant

Int = Intermediate

Sus = Susceptible

Appendix Table 4: Number & proportion (%) of gonococcal isolates with resistance to ciprofloxacin, New Zealand, 2018-2022 by sex, age, ethnicity and region

	2018	2019	2020	2021	2022
Variable	**Resistant**, N = 211[1]	**Resistant**, N = 333[1]	**Resistant**, N = 420[1]	**Resistant**, N = 481[1]	**Resistant**, N = 554[1]
Sex	990	1,268	1,344	1,181	1,317
Female	50 (21%)	86 (24%)	85 (28%)	39 (20%)	61 (26%)
Male	159 (21%)	243 (27%)	335 (32%)	440 (45%)	485 (45%)
Unknown	2 (40%)	4 (80%)	0 (0%)	2 (40%)	8 (67%)
Age group	973	1,227	1,320	1,179	1,316
0–14	2 (22%)	4 (27%)	2 (17%)	0 (0%)	0 (NA%)
15–19	25 (20%)	20 (17%)	22 (22%)	19 (20%)	41 (39%)
20–24	56 (24%)	73 (26%)	64 (22%)	69 (30%)	117 (36%)
25–29	54 (25%)	66 (22%)	100 (31%)	118 (43%)	114 (40%)
30–39	47 (20%)	96 (29%)	146 (40%)	163 (45%)	174 (48%)
40+	25 (16%)	57 (30%)	80 (33%)	112 (53%)	108 (45%)
Unknown	2	17	6	0	0
Ethnicity	990	1,268	1,344	1,181	1,317
Asian	20 (33%)	33 (34%)	38 (34%)	71 (59%)	68 (56%)
European/Other	78 (20%)	170 (33%)	201 (42%)	215 (48%)	265 (49%)
Māori	47 (19%)	59 (19%)	88 (27%)	90 (30%)	142 (41%)
Pacific	30 (26%)	17 (10%)	25 (14%)	55 (33%)	53 (26%)
Unknown	36 (21%)	54 (29%)	68 (28%)	50 (35%)	26 (24%)
Region	990	1,268	1,344	1,181	1,317
Central North Island	17 (12%)	19 (14%)	33 (22%)	45 (44%)	57 (55%)
Northern North Island	134 (32%)	117 (20%)	187 (30%)	284 (49%)	268 (47%)
Te Manawa Taki	24 (16%)	79 (35%)	78 (26%)	77 (28%)	123 (40%)
Te Waipounamu South Island	36 (13%)	118 (37%)	122 (46%)	75 (32%)	106 (32%)

[1]n (%)

Appendix Table 5: Number & proportion(%) of gonococcal isolates by susceptibility to tetracycline, New Zealand, 2018-2022 by sex, age, ethnicity and region

	2018, N = 123			2019, N = 129			2020, N = 131			2021, N = 110			2022, N = 197		
	Res, N = 20[1]	**Int**, N = 28[1]	**Sus**, N = 75[1]	**Res**, N = 39[1]	**Int**, N = 52[1]	**Sus**, N = 38[1]	**Res**, N = 49[1]	**Int**, N = 63[1]	**Sus**, N = 19[1]	**Res**, N = 48[1]	**Int**, N = 54[1]	**Sus**, N = 8[1]	**Res**, N = 69[1]	**Int**, N = 118[1]	**Sus**, N = 10[1]
Sex															
Female	4 (14%)	4 (14%)	21 (72%)	7 (25%)	6 (21%)	15 (54%)	8 (31%)	16 (62%)	2 (7.7%)	4 (31%)	9 (69%)	0 (0%)	14 (42%)	18 (55%)	1 (3.0%)
Male	16 (17%)	24 (26%)	54 (57%)	32 (32%)	46 (46%)	23 (23%)	41 (39%)	47 (45%)	17 (16%)	44 (45%)	45 (46%)	8 (8.2%)	54 (33%)	100 (61%)	9 (5.5%)
Unknown	0	0	0	0	0	0	0	0	0	0	0	0	1 (100%)	0	0
Age group															
0–14	0	0	0	0	0	2 (100%)	0	0	0	0	0	0	0	0	0
15–19	3 (25%)	4 (33%)	5 (42%)	1 (50%)	1 (50%)	0	3 (60%)	2 (40%)	0	1 (25%)	3 (75%)	0	4 (36%)	7 (64%)	0
20–24	6 (22%)	6 (22%)	15 (56%)	8 (33%)	8 (33%)	8 (33%)	9 (39%)	9 (39%)	5 (22%)	7 (44%)	7 (44%)	2 (12%)	17 (38%)	24 (53%)	4 (8.9%)
25–29	2 (7.1%)	10 (36%)	16 (57%)	10 (28%)	14 (39%)	12 (33%)	10 (37%)	14 (52%)	3 (11%)	7 (47%)	7 (47%)	1 (6.7%)	14 (33%)	28 (65%)	1 (2.3%)
30–39	8 (26%)	3 (9.7%)	20 (65%)	15 (37%)	16 (39%)	10 (24%)	17 (37%)	22 (48%)	7 (15%)	16 (41%)	20 (51%)	3 (7.7%)	19 (37%)	30 (59%)	2 (3.9%)
40+	1 (4.0%)	5 (20%)	19 (76%)	5 (21%)	13 (54%)	6 (25%)	10 (33%)	16 (53%)	4 (13%)	17 (47%)	17 (47%)	2 (5.6%)	15 (32%)	29 (62%)	3 (6.4%)
Ethnicity															
Asian	0	0	6 (100%)	3 (38%)	3 (38%)	2 (25%)	3 (38%)	5 (62%)	0	6 (75%)	2 (25%)	0	4 (36%)	7 (64%)	0
European/Other	10 (16%)	15 (24%)	37 (60%)	22 (28%)	39 (49%)	19 (24%)	29 (40%)	33 (46%)	10 (14%)	26 (38%)	39 (57%)	3 (4.4%)	41 (36%)	67 (59%)	6 (5.3%)
Māori	3 (14%)	3 (14%)	15 (71%)	5 (24%)	3 (14%)	13 (62%)	11 (35%)	14 (45%)	6 (19%)	13 (52%)	10 (40%)	2 (8.0%)	15 (31%)	30 (62%)	3 (6.2%)
Pacific	1 (17%)	3 (50%)	2 (33%)	1 (100%)	0 (0%)	0 (0%)	3 (43%)	2 (29%)	2 (29%)	2 (33%)	1 (17%)	3 (50%)	1 (20%)	4 (80%)	0 (0%)
Unknown	6 (21%)	7 (25%)	15 (54%)	8 (42%)	7 (37%)	4 (21%)	3 (23%)	9 (69%)	1 (7.7%)	1 (33%)	2 (67%)	0 (0%)	8 (42%)	10 (53%)	1 (5.3%)
Region															
Central North Island	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Northern North Island	0	1 (100%)	0	0	0	0	0	0	0	0	0	0	1 (100%)	0	0
Te Manawa Taki	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Te Waipounamu South Island	20 (16%)	27 (22%)	75 (61%)	39 (30%)	52 (40%)	38 (29%)	49 (37%)	63 (48%)	19 (15%)	48 (44%)	54 (49%)	8 (7.3%)	68 (35%)	118 (60%)	10 (5.1%)

[1]n (%)
Res = Resistant
Int = Intermediate
Sus = Susceptible

Appendix Table 6:Number & proportion (%) of all gonococcal isolates undergoing susceptibility to azithromycin, New Zealand, 2018-2022 by specimen site and sex

	2018, N = 1,040		2019, N = 1,338		2020, N = 1,494		2021, N = 1,252		2022, N = 1,317	
Specimen Site	**Female, N = 262**	**Male, N =778**	**Female, N = 390**	**Male, N = 948**	**Female, N = 356**	**Male, N = 1,138**	**Female, N = 228**	**Male, N = 1,204**	**Female, N = 237**	**Male, N = 1,080**
Ano-rectal	2 (0.8%)	89 (11%)	5 (1.3%)	83 (8.8%)	7 (2.0%)	127 (11%)	4 (1.8%)	149 (15%)	6 (2.5%)	139 (13%)
Other/Unknown	28 (11%)	48 (6.2%)	44 (11%)	55 (5.8%)	33 (9.3%)	46 (4.0%)	17 (7.5%)	38 (3.7%)	5 (2.1%)	46 (4.3%)
Pharyngeal	0 (0%)	12 (1.5%)	5 (1.3%)	8 (0.8%)	3 (0.8%)	38 (3.3%)	5 (2.2%)	56 (5.5%)	5 (2.1%)	66 (6.1%)
Urogenital	232 (89%)	629 (81%)	336 (86%)	802 (85%)	313 (88%)	927 (81%)	202 (89%)	781 (76%)	221 (93%)	829 (77%)

[1]n (%)

Note: these results are not deduplicated and include results for all isolates that underwent AST. Thus isolate numbers will be higher than those reported in Appendix Table 1 and Appendix Table 2 as those report one result per episode.

Appendix Table 7: Number & proportion (%) of all gonococcal isolates undergoing susceptibility to ceftriaxone, New Zealand, 2018-2022 by specimen site and sex

	2018, N = 360		2019, N = 494		2020, N = 683		2021, N = 674		2022, N = 821	
Specimen Site	**Female, N = 74[1]**	**Male, N = 286[1]**	**Female, N = 117[1]**	**Male, N = 377[1]**	**Female, N = 133[1]**	**Male, N = 550[1]**	**Female, N = 114[1]**	**Male, N = 560[1]**	**Female, N = 152[1]**	**Male, N = 669[1]**
Ano-rectal	0 (0%)	64 (22%)	0 (0%)	70 (19%)	5 (3.8%)	101 (18%)	4 (3.5%)	121 (22%)	5 (3.3%)	124 (19%)
Other/Unknown	5 (6.8%)	8 (2.8%)	2 (1.7%)	8 (2.1%)	2 (1.5%)	8 (1.5%)	1 (0.9%)	16 (2.9%)	1 (0.7%)	6 (0.9%)
Pharyngeal	0 (0%)	11 (3.8%)	2 (1.7%)	6 (1.6%)	2 (1.5%)	32 (5.8%)	4 (3.5%)	46 (8.2%)	5 (3.3%)	59 (8.8%)
Urogenital	69 (93%)	203 (71%)	113 (97%)	293 (78%)	124 (93%)	409 (74%)	105 (92%)	377 (67%)	141 (93%)	480 (72%)

[1]n (%)

Note: these results are not deduplicated and include results for all isolates that underwent AST. Thus isolate numbers will be higher than those reported in Appendix Table 1 and Appendix Table 2 as those report one result per episode.

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