

AUSTRALIAN GONOCOCCAL SURVEILLANCE PROGRAMME ANNUAL REPORT, 2010

The Australian Gonococcal Surveillance Programme

Abstract

The Australian Gonococcal Surveillance Programme monitors antibiotic susceptibility testing of *Neisseria gonorrhoeae* isolated in all states and territories. In 2010 the *in vitro* susceptibility of 3,997 isolates of gonococci from public and private sector sources was determined by standardised methods. Varying antibiotic susceptibility patterns were again reported across jurisdictions and regions. Resistance to the penicillins nationally was 29% and, with the exception of the Northern Territory, ranged from 22% in Queensland to 42% in Victoria. Quinolone resistance, most at high minimal inhibitory concentration (MIC) levels, was 35% nationally (excepting the Northern Territory), ranging from 28% in Queensland to 44% in Victoria. Decreased susceptibility to ceftriaxone (MIC 0.06 mg/L or more), was found nationally in 4.8% of isolates. There has not been an isolate of *N. gonorrhoeae* with an MIC value greater than 0.125 mg/L reported in Australia. Nationally, all isolates remained sensitive to spectinomycin. Azithromycin surveillance was performed in New South Wales, Queensland, Western Australia, the Northern Territory and South Australia, and resistance was found in low numbers of gonococci with MIC values up to 16 mg/L. In larger urban centres the ratio of male to female cases was high, and rectal and pharyngeal isolates were common in men. In other centres, and in rural Australia, the male to female ratio of cases was lower, and most isolates were from the genital tract. *Commun Dis Intell* 2011;35(3):229–236.

Keywords: antimicrobial resistance; disease surveillance; gonococcal infection; *Neisseria gonorrhoeae*

Introduction

The World Health Organization (WHO) estimates that 88 million cases of gonorrhoea (*Neisseria gonorrhoeae* infection) occur annually, globally.¹ In Australia, the rate of *Neisseria gonorrhoeae* infections has increased from 35.8 per 100,000 in 2005 to 40.4 per 100,000 in 2010.² Around the world, the increasing prevalence of antimicrobial resistance (AMR) in *Neisseria gonorrhoeae* and its impact on treatment outcome is a major and growing concern^{1,3} as antibiotic treatment is fundamental to disease control at the population level.³

Emergence of resistance to the penicillins, tetracyclines; macrolides and fluoroquinolone antibiotics has necessitated the removal of these agents from standard treatment regimens.⁴ This has resulted in the replacement with extended-spectrum cephalosporin antibiotics as the recommended first line treatment for gonorrhoea in Australia and elsewhere.⁵ Unusually, but importantly in Australia however, treatments based on the penicillins remain effective in many rural centres where extremely high disease rates persist.⁴

In large centres in urban Australia, AMR in *Neisseria gonorrhoeae* has long been influenced by the introduction of multi-resistant strains from overseas.⁴ There are an increasing number of reports from overseas sources^{6,7} of treatment failures with orally administered extended-spectrum cephalosporin (ESCs). In Australia, oral extended-spectrum cephalosporin antibiotics are not available, therefore the injectable form (ceftriaxone) is recommended for use in high doses.⁵ No treatment failures have yet been reported following ceftriaxone treatment of genital-tract gonorrhoea. However there were 2 instances of failure of treatment of pharyngeal gonorrhoea after treatment with ceftriaxone 250 mg intramuscularly, reported in Sydney⁸ where elimination of intercurrent genital-tract infection with the same organism was achieved. The gonococci involved both had raised minimal inhibitory concentrations (MIC values) for ceftriaxone.

Strategies for treating and controlling gonorrhoea are based on single dose regimens effecting a cure in a minimum of 95%, and the formulation of these regimens is reliant on data derived from continuous AMR monitoring of gonococci to the antibiotics in clinical use.^{3,9} Recently, and following the reports of treatment failures with orally administered extended-spectrum cephalosporins,^{6,7} calls have been made internationally for enhanced surveillance of all forms of gonococcal AMR in order to optimise gonococcal antibiotic treatment.^{1,10}

Since 1981, the Australian Gonococcal Surveillance Programme (AGSP) has monitored the susceptibility of *N. gonorrhoeae* continuously, making it the longest, continually running national surveillance system for gonococcal AMR.¹¹ The emergence and spread of penicillin and quinolone resistant gonococci in major cities in Australia has been well documented.⁴ This analysis of AMR in *N. gonorrhoeae* in Australia

was derived from data collated by the AGSP during the 2010 calendar year. It provides information regarding the gonococcal isolates showing resistance to multiple antibiotics including those with decreased susceptibility to ceftriaxone.^{4,12}

Methods

Ongoing monitoring of AMR in gonococci in Australia is performed by the AGSP through a collaborative program conducted by reference laboratories in each state and territory. The AGSP is a component of the National Neisseria Network of Australia and comprises participating laboratories in each state and territory. This collaborative network of laboratories obtains isolates for examination from as wide a section of the community as possible, and both public and private sector laboratories refer isolates to regional testing centres. The increasing use of non-culture-based methods of diagnosis has the potential to reduce the size of the sample of isolates available for testing. Details of the number of organisms examined are thus provided in order to indicate the AGSP sample size.

Gonococci isolated in, and referred to, the participating laboratories are examined for antibiotic susceptibility to the penicillins; quinolones; spectinomycin and third generation cephalosporins; and for high-level resistance to the tetracyclines, by a standardised methodology previously described.^{11,13} The AGSP also conducts a program-specific quality assurance program.¹⁴

Antibiotic susceptibility data from each jurisdiction are submitted quarterly to the coordinating laboratory, which collates the results and provides

individual feedback to each participating laboratory. Additionally, the AGSP collects data on the gender of the patient, and the site of isolation of gonococcal strains. Where available, data on the geographic source of acquisition of antibiotic-resistant isolates are included in analyses.

Results

Number of isolates

There were 4,100 gonococcal isolates referred to, or else isolated in, AGSP laboratories in 2010, representing 41% of the 10,014 cases of gonococcal infection notified to the Australian Government Department of Health and Ageing in 2010,² proportionally essentially unchanged from 2009 (40%) and 2008 (42%).

The source and site of infection of these isolates are shown in Table 1. In 2010, 1,328 of the 4,100 gonococcal isolates (32%) were from New South Wales; 913 (22%) were from Victoria; 840 (21%) were from Queensland; 448 (11%) were from the Northern Territory; 352 (9%) were from Western Australia and 178 (4%) were from South Australia. There were a small number in the Australian Capital Territory (30; 0.7%) and Tasmania (11; 0.3%).

Isolate numbers in 2010 increased from those reported in 2009 in most jurisdictions: New South Wales (from 949), Victoria (from 786), Queensland (from 561), the Northern Territory (from 387), and Western Australia (from 318). There was a decrease in referred isolates from the Australian Capital Territory (from 38) and similar numbers were reported from South Australia (170) and Tasmania (11).

Table 1: Source and number of gonococcal isolates, Australia, 2010, by sex, site and region

Gender	Site	State or territory								Aust
		ACT	NSW	NT	Qld	SA	Tas	Vic	WA	
Male	Urethra	8	644	297	463	93	9	468	218	2,200
	Rectal	7	328	3	80	26	0	193	37	674
	Pharynx	6	184	0	37	20	0	137	23	407
	DGI	0	8	10	2	0	0	1	1	22
	Other/NS	4	31	2	12	11	0	12	6	78
	Total	25	1,195	312	594	150	9	811	285	3,381
Female	Cervix	4	113	127	228	24	1	83	62	642
	Rectal	0	2	0	1	0	0	3	1	7
	Pharynx	0	11	0	2	0	0	11	2	26
	DGI	0	3	8	10	0	0	1	2	24
	Other/NS	1	4	1	5	4	1	4	0	20
	Total	5	133	136	246	28	2	102	67	719
Total		30	1,328	448	840	178	11	913	352	4,100

DGI Disseminated gonococcal infection.

Source of isolates

There were 3,381 strains from men (82%) and 719 (18%) from women, with the male to female (M:F) ratio of 4.7:1, which was higher than the 4.4:1 in 2009 and the 3.7:1 ratio for 2008. The number of strains from men increased from 2,622 in 2009, and the number of isolates from women increased from 596 in 2009, but the proportions of isolates from males and females were the same as in 2009: men 81% and women 19%.

The number of referred isolates from females increased in 2010 in New South Wales (from 124) and Queensland (from 121), but were essentially unchanged from Victoria (from 101); Western Australia (from 75) and the Northern Territory (134 in 2009). Small increases were also noted from the Australian Capital Territory and Tasmania. There was a continuing decrease in referred isolates from females in South Australia (from 40 in 2009, and 104 in 2008).

There were 46 referred isolates from disseminated gonococcal infection; 22 in men (0.7% of all referred isolates from men), essentially unchanged from 2009: 23 isolates 0.9% of all referred isolates. In females there were 24 isolates in 2010 (3% of referred isolates, an increase from the 4 isolates (0.7%) referred from females in 2009). Although not all infected sites were identified, isolates from urine samples were regarded as genital tract isolates and most of the other unidentified isolates were probably from this source, although they were not specified.

Antibiotic susceptibility patterns

Three thousand nine hundred and ninety-seven of the 4,100 referred gonococcal isolates in 2010 (97%) remained viable for susceptibility testing. These were examined by the AGSP reference laboratories for susceptibility to penicillin (representing this group of antibiotics), ceftriaxone (representing later generation cephalosporins), ciprofloxacin (representing quinolone antibiotics), spectinomycin, and for high level resistance to tetracycline (TRNG). As in past years, the patterns of gonococcal antibiotic susceptibility differed between the various states and territories. For this reason data are presented by region as well as aggregated for Australia as a whole.

Penicillins

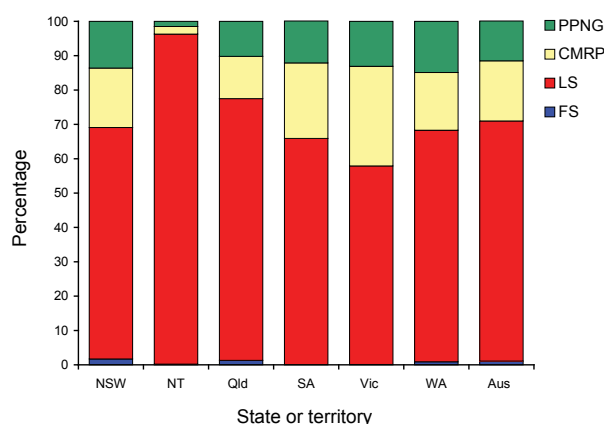
The categorisation of gonococci isolated in Australia in 2010 by penicillin MIC is shown in Figure 1. Infections unlikely to respond to treatment with the penicillin group of antibiotics (penicillin, ampicillin and amoxicillin with or without clavulanic acid), are caused by penicillinase-producing *N. gonorrhoeae* (PPNG) and /or *N. gonorrhoeae*

that are chromosomally resistant to penicillin (CMRP). Resistance in the PPNG group results from the production of beta-lactamase, and in the CMRP group by the aggregation of chromosomally-controlled resistance mechanisms.³ Chromosomal resistance is defined by a MIC to penicillin of 1 mg/L or more.^{3,13} The MIC is the least amount of antibiotic that inhibits *in vitro* growth under defined conditions. Infections with gonococci classified as fully sensitive (MIC \leq 0.03 mg/L) or less sensitive (MIC 0.06–0.5 mg/L) would be expected to respond to standard penicillin treatments, although response to treatment may vary at different anatomical sites.

Nationally, of those gonococci available for susceptibility testing 1,161 (29%) were penicillin resistant by one or more mechanisms in 2010, a decrease in the proportion of isolates resistant to this group of antibiotics recorded in 2009 (36%) and 2008 (44%). In 2010, there were 699 CMRP (17%) and 462 PPNG (12%) identified. In 2009 there were 22% CMRP, and 15% PPNG showing that the decrease in penicillin resistance nationally in 2010 was due to a decrease in the proportion of gonococci with both chromosomally-mediated resistance and penicillinase production, whereas in 2008 and 2009 the reduction was predominantly due to chromosomally-mediated resistance.

The proportion of penicillin-resistance of all gonococcal isolates was highest in Victoria 42% (CMRP 29%: PPNG 13%); South Australia 34% (CMRP 22%: PPNG 12%); Western Australia 32% (CMRP 17%: PPNG 15%); New South Wales 31% (CMRP 17%:PPNG 14%) and in Queensland 22% (CMRP 12%:PPNG 10%).

Figure 1: Penicillin resistance of gonococcal isolates, Australia, 2010, by region



FS	Fully sensitive to penicillin, MIC \leq 0.03 mg/L
LS	Less sensitive to penicillin, MIC 0.06–0.5 mg/L
CMRP	Chromosomally mediated resistant to penicillin, MIC \geq 1 mg/L
PPNG	Penicillinase-producing <i>Neisseria gonorrhoeae</i>

Proportions were lower than those reported in 2009 in Victoria and South Australia and New South Wales. In Western Australia and Queensland the proportions were essentially unchanged from 2009. There were 4 CMRP and 3 PPNG identified in the Australian Capital Territory; and 3 CMRP and 1 PPNG in Tasmania. In the Northern Territory, there were 15 PPNG, which was unchanged from 2009: 9 CMRP (3 from Alice Springs and 6 from Darwin) and 6 PPNG (all from Darwin) representing a total of 3.6% of strains that were penicillin-resistant in 2010 (4.2% in 2009, 3.9% in 2008, 4.1% in 2007, 4.6% in 2006).

Data on acquisition were available for 104 (23%) infections with PPNG. Sixty-two (13%) of these were acquired locally and 42 (9%) by overseas contact. These external contacts were principally in Western Pacific or South East Asian countries with those reported from Thailand; the Philippines; Indonesia and Vietnam the most numerous. Additionally, China, India, Singapore and, more widely the United Kingdom, were named as countries of acquisition.

Ceftriaxone

From 2001 onwards, low numbers of gonococcal isolates with raised ceftriaxone MIC values (in the range 0.06–0.125 mg/L, referred to as having decreased susceptibility) have been found in Australia. The proportion has increased incrementally with the data from recent years showing a rise from 0.6% in 2006, 0.8% in 2007, and 1.1% in 2008; to 2.0% in 2009. In 2010 an increase of isolates with decreased susceptibility to ceftriaxone was observed nationally: 191 of 3,997 (4.8%). There has not been an isolate of *N. gonorrhoeae* with an MIC value greater than 0.125 mg/L reported in Australia.

In South Australia 19 of 164 isolates (11.6%) had decreased susceptibility to ceftriaxone, and there were 52 of 908 (5.7%) from Victoria; 74 of 1,321 (5.6%) from New South Wales; 17 of 328 (5.2%) from Western Australia; and 26 of 823 (3.2%) from Queensland. There were 2 of 30 (6.7%) from the Australian Capital Territory; and 1 of 412 (0.2%) from the Northern Territory. There were no isolates with decreased susceptibility to ceftriaxone reported from Tasmania.

In 2010, there was a significant increase from 2009 in gonococci with decreased susceptibility to ceftriaxone in all jurisdictions with the exception of the Northern Territory and Tasmania, as shown in Table 2.

Table 2: Gonococcal isolates with decreased susceptibility to ceftriaxone,* Australia, 2010 and 2009, by state or territory

	2010		2009	
	n	%	n	%
Australian Capital Territory	2	6.7	2	5.3
New South Wales	74	5.6	16	1.7
Northern Territory	1	0.2	1	0.2
Queensland	26	3.2	10	1.8
South Australia	19	11.6	9	5.3
Tasmania	0	0.0	0	0.0
Victoria	52	5.7	17	2.2
Western Australia	17	5.2	9	3.1
Australia	191	4.8	64	2.0

* MIC value 0.06–0.125 mg/L

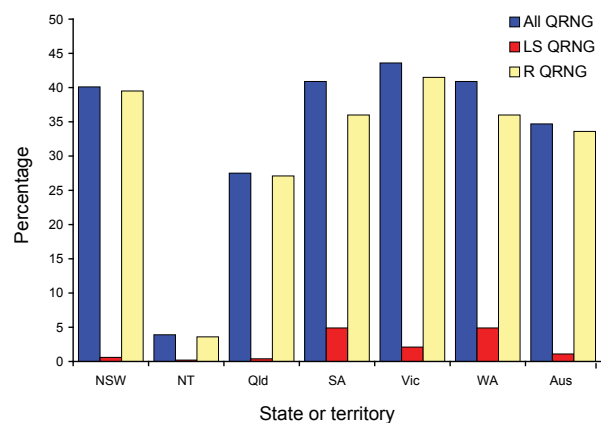
Spectinomycin

All isolates from all jurisdictions were again susceptible to this injectable antibiotic.

Quinolone antibiotics

Figure 2 shows the distribution of gonococci with altered susceptibility to quinolones nationally and by jurisdiction. Thus far resistance to the quinolone antibiotics in *N. gonorrhoeae* is mediated only by chromosomal mechanisms so that incremental increases in MIC values are observed. The AGSP uses ciprofloxacin as the representative quinolone and

Figure 2: Percentage of gonococcal isolates less sensitive to ciprofloxacin* or with higher level ciprofloxacin resistance† and all strains with altered quinolone susceptibility, Australia, 2010, by state or territory



* LS QRNG: MIC 0.06–0.5 mg/L

† R QRNG: MIC 1 mg/L or more

defines altered susceptibility as an MIC of 0.06 mg/L or more.¹³ Treatment with currently recommended doses of 500 mg of ciprofloxacin is effective for strains with a lower level of resistance, viz. 0.06–0.5 mg/L, in about 90% of cases, but lower doses of the antibiotic will result in treatment failure more often. At higher levels of resistance i.e. a MIC of 1 mg/L or more, rates of failed treatment rise rapidly. At MIC levels of 4 mg/L or more treatment failure approaches 100%, even with higher ciprofloxacin doses.

Nationally in 2010, 1,385 of gonococci examined (35%) had some level of resistance to quinolones (QRNG), representing a further decrease in the proportion of quinolone resistance from 43% in 2009 and 54% in 2008. Most of the QRNG found in 2010 (1,342; 97%) had resistance at a higher level i.e. MICs \geq 1 mg/L and the many of these had MIC levels of 8–64 mg/L.

In Victoria, 396 (44%) of all isolates examined were QRNG; with 67 (41%) in South Australia; 530 (40%) in New South Wales; 131, (40%) in Western Australia, and 226 (28%) in Queensland. In other jurisdictions, the number of QRNG remained low: in the Australian Capital Territory there were 18 (60%) QRNG isolated; 16 (4%) from the Northern Territory and 1 QRNG from Tasmania.

Information on country of acquisition of QRNG was available for 55 (4%) of the 1,385 cases. Forty-one of these (3%) were acquired locally and 14 (1%) from overseas from sources referred to under PPNG acquisition and with contacts additionally reported from the United States of America.

High-level tetracycline resistance

The spread of high-level tetracycline resistance in *N. gonorrhoeae* (TRNG) is examined as an epidemiological marker even though tetracyclines are not a recommended treatment for gonorrhoea and are rarely, if ever, used for treatment of gonorrhoea in Australia. Despite the lack of use of this antibiotic group, the proportion of TRNG detected continues to increase. In 2006, 12% of referred isolates were TRNG; increasing in 2007 (505 TRNG 16.6%) and again in 2008 (553 TRNG, 18%). In 2009, this increase continued with 650 (21%) TRNG detected, and this proportion was unchanged in 2010 (822 TRNG: 21%).

TRNG were present in all jurisdictions, with the highest proportion in the Northern Territory (111 TRNG, 27%); Western Australia (77 TRNG, 24%); New South Wales (310 TRNG 24%) and South Australia (34, 21%). Lower proportions of TRNG were present in Victoria (148, 16%) and Queensland (134, 16%). In the Australian Capital Territory there were 7 TRNG and 1 in Tasmania.

Discussion

World Health Organization recommendations for standardised treatment regimens for gonorrhoea are based on data from epidemiological surveys of both the distribution and extent of AMR in gonococci.³ Antimicrobial resistance at a rate of 5% or more in gonococci sampled in a general population is the 'threshold' for removal of an antibiotic from treatment schedules and substitution with another, effective, agent.^{3,15} Programs such as the AGSP seek to determine the proportion of antimicrobial resistance in gonococcal strains isolated in a defined patient population and relate these findings to the likely efficacy of current treatment schedules.^{3,5,9,13,15} Surveillance strategies are dependent on quality AMR data, and the requirements for *in vitro* growth and AMR testing of the fastidious *N. gonorrhoeae* complicate this process. An important aspect of surveillance is to obtain and examine a sufficient and representative sample of isolates.^{3,13,15} In 2010, the strains examined by the AGSP were sourced from the public and private health sectors, constituting a comprehensive sample that meets these requirements, in spite of the increasing use of nucleic acid amplification testing for diagnosis of gonorrhoea in Australia. The AGSP distributes reference panels for use in internal quality control practice and for External Quality Assurance Schemes,^{14,16} which are necessary for validation of gonococcal AMR data.

The overall number of gonococcal strains examined by the AGSP in 2010 (3,997) was higher than the number examined in 2009 (3,220) and 2008 (3,192), but proportionally unchanged from approximately 40% of gonococcal case notifications in Australia. Isolate numbers in 2010 increased from those reported in 2009 in most jurisdictions excepting the Australian Capital Territory, and were unchanged for South Australia and Tasmania.

In 2010, 29% of gonococci nationally were resistant to the penicillins, and 35% to the quinolone antibiotics. These proportions were reduced from those reported nationally in 2009 (penicillin resistance, 36%; quinolone resistance, 43%), and in 2008 (penicillin resistance, 44%; quinolone resistance, 54%), where previously they have increased each year since 2003.⁴ In 2010, there were decreased numbers of gonococci with both chromosomally-mediated resistance to penicillin and penicillinase production, whereas in 2008 and 2009 the reduction in penicillin resistance was primarily accounted for by the reduction of CMRP rates. Aggregated data have shown a predominant clone of CMRP coupled with high-level quinolone resistance circulating with increasing frequency annually since 2003.^{4,12} It is possible that the

continued reduction in resistance to both penicillin and the quinolones in 2010 continues to reflect a 'clonal shift' in gonococcal isolates.

In 2010, the level in Australia of gonococci with high-level tetracycline resistance was low but stable despite low exposure to these antibiotics in Australia.⁴ Evidence of the 'rural-urban divide',⁴ in gonococcal resistance was maintained (Figures 1 and 2), underscoring the necessity for disaggregated information rather than pooled national data to define treatment regimens appropriate for the various jurisdictions. Remote areas in some jurisdictions with high disease rates continue to be able to use penicillin-based treatments, but effective use of this inexpensive and acceptable treatment is contingent on vigilant monitoring of resistance patterns.

Recent AGSP reports have drawn attention to the emergence and spread of gonococci in Australia that exhibit decreased susceptibility to the later generation cephalosporin antibiotics, also referred to as the extended spectrum cephalosporins. These gonococci have also been found in increasing numbers in the WHO Western Pacific Region.¹⁷ In 'urban' Australia, the injectable agent ceftriaxone is now the standard treatment for gonorrhoea in public sector clinics, and is currently given by intramuscular injection in a dose of 500 mg. This dose is higher than the 250 mg dose that is more commonly used throughout the Western Pacific Region,⁵ but 500 mg is the smallest volume vial currently available in Australia.

Decreased susceptibility to the ESCs has been accompanied by an increasing number of reports of treatment failures with the orally administered members of this group.⁵⁻⁷ The decreased susceptibility to ESCs is quantified by the determination of the MIC value, and encompasses the range 0.06–0.125 mg/L. To date, there have been no strains of *N. gonorrhoeae* reported in Australia with an MIC value greater than 0.125 mg/L; nor substantiated reports of treatment failure in genital tract gonorrhoea following ceftriaxone therapy. However, concerns are escalating locally and globally as increasing proportions of strains with decreased susceptibility are reported. In Australia in 2010, the number of gonococcal isolates with decreased susceptibility to the ESCs (4.8%) more than doubled from 2009 (2%). This alarming increase underscores the need for continued high quality surveillance of AMR in *N. gonorrhoeae* with MIC values. Further, sentinel site surveillance in high risk populations is critically important to monitor instances of treatment failure. Sentinel site surveillance programs involve patient follow-up and test of cure (TOC) cultures after treatment of *N. gonorrhoeae* infections, in particular those in oropharyngeal sites. Sentinel site surveillance for AMR in *N. gonorrhoeae* is currently

conducted in a very limited number of settings in Australia and needs to be expanded throughout all jurisdictions as a matter of priority.

There has been recent clarification of the mechanisms of resistance that are responsible for the MIC increases to ceftriaxone in gonococci. Attention has been paid particularly to the presence of 'mosaic' *penA* genes in gonococci with raised ESC MIC values. *penA* encodes penicillin binding protein 2 (PBP2), the major site of action of ceftriaxone and mosaic PBP2 are altered to reduce this activity. Additional gene polymorphisms that affect antibiotic access to the organism complement these PBP2 changes and further increase ESC MICs. Of recent interest has been an extension of a study from 2001 to 2005 on the dynamics of the spread of mosaic PBP2-containing gonococci (mPBP2-GC) in Australia. This initial investigation suggested that mPBP2-GC found locally were also present in Hong Kong (where they were associated with treatment failure with an oral ESC, ceftibuten),⁷ and Japan.⁶ Continuing studies in 2007 and 2008 showed that the subtypes of the mPBP2-GC present in Australia had altered markedly and that these strains had increased as a proportion of all gonococci tested.¹⁸

Also of relevance have been local studies that showed that other non-mosaic lesions in *penA* were also responsible for increases in ceftriaxone MIC values similar to those found in mosaic PBP2 containing gonococci.¹⁹ These lesions were single nucleotide polymorphisms that represented mutations occurring in the *penA* of *N. gonorrhoeae*. This contrasted with the mosaic *penA* alteration, which results from acquisition of 'foreign' DNA by the gonococcus.²⁰ Despite these advances, not all the increases detected in ESC MIC levels can be explained by the molecular mechanisms described so far. This poses difficulties in developing reliable laboratory methods for the detection of ESC 'resistant' gonococci.

All gonococcal isolates tested in Australia in 2010, including those with altered cephalosporin susceptibility, were susceptible to spectinomycin. A low proportion of gonococci were also found to be resistant to azithromycin in 2010. Azithromycin has been suggested as a possible component of treatment for gonorrhoea that uses dual antibiotic treatment.²¹ Resistance to azithromycin, widely used as an anti-chlamydial agent in conjunction with gonococcal treatment, has been reported with increasing frequency overseas. MIC levels in azithromycin-resistant gonococci have reached very high levels in Europe, but these strains have not been detected in Australia.

The emergence and spread of anti-microbial resistance in *N. gonorrhoeae* is a global public health issue, and evolving problems of emergence and

spread of resistance are complex and require attention to both disease control strategies and rational use of antibiotics.^{10,22,23} Critically, both disease control strategies and the understanding of the global scope of AMR are informed by surveillance programs of AMR nationally and internationally. Continuing commitment and vigilance to surveillance of AMR in *N. gonorrhoeae* means that maintenance of culture-based systems will be required while this surveillance is still based on testing of gonococcal isolates.

Acknowledgements

We remember Professor John Tapsall AM who established the AGSP and who, in his clinical, laboratory and research work widely and generously collaborated with, and kindly taught and supported, scientists and clinicians in Australia and around the world.

The AGSP thanks the Australian Government Department of Health and Ageing for continued financial support and the many laboratories, private and public, throughout Australia for submission of isolates for testing.

Members of the Australian Gonococcal Surveillance Programme in 2010 (and to whom isolates should be referred) were: John Bates, and Vicki Hicks, (Queensland Health Scientific Services, Coopers Plains, Queensland); Athena Limnios, Sanghamitra Ray, Tiffany Hogan, Anne Lam, Monica Lahra and John Tapsall, (Department of Microbiology, The Prince of Wales Hospital, Randwick, New South Wales); Kerrie Stevens, Janet Strachan, Mark Veitch, and Geoff Hogg, (The Microbiological Diagnostic Unit (PHL), Department of Microbiology and Immunology, University of Melbourne, Parkville, Victoria); Andrew Lawrence and Kathryn Whetter, (SA Pathology at Women's and Children's Hospital, Adelaide, South Australia); Julie Pearson and Hui leen Tan, (Department of Microbiology and Infectious Diseases, PathWest Laboratory Medicine, Royal Perth Hospital, Western Australia.); Mark Gardam and Belinda Chamley, (Department of Microbiology and Infectious Diseases, Royal Hobart Hospital, Hobart, Tasmania); Paul Southwell and microbiology staff, (Microbiology Laboratory, Royal Darwin Hospital, Casuarina, Northern Territory); Susan Bradbury, Angelique Clyde-Smith and Peter Collignon, (Microbiology Department, Canberra Hospital, Garran, Australian Capital Territory).

Author details

Corresponding author: Ms Monica M Lahra, Microbiology Department, SEALS. The Prince of Wales Hospital, Randwick NSW 2031. Telephone: +61 2 9382 9084, Facsimile: +61 2 9398 4275, Email: monica.lahra@sesiahs.health.nsw.gov.au

References

1. World Health Organization. Fact sheet: Emergence of multi-drug resistant *Neisseria gonorrhoeae*. Accessed on 19 July 2011. Available from: http://whqlibdoc.who.int/hq/2011/WHO_RHR_11.14_eng.pdf
2. Australian Government Department of Health and Ageing. National Notifiable Diseases Surveillance System data for meningococcal disease. Report number 3: Notifications of selected disease by state and territory and year. [online]. Accessed on 19 July 2011. Available from: http://www9.health.gov.au/cda/source/Rpt_3.cfm
3. Tapsall JW, Ndowa F, Lewis DA, Unemo M. Meeting the public health challenge of multi-drug- and extensively drug resistant *Neisseria gonorrhoea*. *Expert Rev Anti Infect Ther* 2009;7(7):821–834.
4. Tapsall JW, Limnios EA, Murphy DM, Australian Gonococcal Surveillance Programme. Analysis of trends in antimicrobial resistance in *Neisseria gonorrhoeae* isolated in Australia, 1997–2006. *J Antimicrob Chemother* 2008;61(1):150–155.
5. Tapsall JW. Implications of current recommendations for third-generation cephalosporin use in the WHO Western Pacific Region following the emergence of multiresistant gonococci. *Sex Transm Infect* 2009;85(4):256–258.
6. Yokoi S, Deguchi T, Ozawa T, Yasuda M, Ito S, Kubota Y, et al. Threat to cefixime treatment for gonorrhoea. *Emerg Infect Dis* 2007;13(8):1275–1277.
7. Lo JY, Ho KM, Leung AO, et al. Ceftibuten resistance and treatment failure of *Neisseria gonorrhoeae* infection. *Antimicrob Agents Chemother* 2008;52(10):3564–3567.
8. Tapsall JW, Read P, Carmody C, Bourne C, Ray S, Limnios A, et al. Two cases of failed ceftriaxone treatment in pharyngeal gonorrhoea verified by molecular microbiological methods. *J Med Microbiol* 2009;58(Pt 5):683–687.
9. Tapsall JW. Monitoring antimicrobial resistance for public health action. *Commun Dis Intell* 2003;27 Suppl:S70–S74.
10. Workowski KA, Berman SM, Douglas JM Jr. Emerging antimicrobial resistance in *Neisseria gonorrhoeae*: urgent need to strengthen prevention strategies. *Ann Intern Med* 2008;148(8):606–613.
11. Australian Gonococcal Surveillance Programme. Penicillin sensitivity of gonococci in Australia: the development of an Australian Gonococcal Surveillance Programme. *Br J Vener Dis* 1984;60(4):226–230.
12. Australian Gonococcal Surveillance Programme. Annual report of the Australian Gonococcal Surveillance Programme, 2007. *Commun Dis Intell* 2008;32(2):227–231.
13. Tapsall J, National *Neisseria* Network of Australia. Antimicrobial testing and applications in the pathogenic *Neisseria*. In: Merlino J, ed., *Antimicrobial susceptibility testing: methods and practices with an Australian perspective*. Australian Society for Microbiology, Sydney, 2004. pp 175–188.
14. Australian Gonococcal Surveillance Programme. Use of a quality assurance scheme in a long-term multicentric study of antibiotic susceptibility of *Neisseria gonorrhoeae*. *Genitourin Med* 1990;66(1):437–444.
15. WHO Collaborating Centre for STD, Sydney. Rationale and applications for the current (2008) WHO panel of *Neisseria gonorrhoeae* for antimicrobial resistance surveillance for public health purposes, and instructions for their use. Technical document D007-0408-1#1 2008.

16. Unemo M, Fsth O, Fredlund H, Limnios A, Tapsall J. Phenotypic and genetic characterization of the 2008 WHO *Neisseria gonorrhoeae* reference strain panel intended for global quality assurance and quality control of gonococcal antimicrobial resistance surveillance for public health purposes. *J Antimicrob Chemother* 2009;63(6):1142–1151.
17. WHO Western Pacific and South East Asian Gonococcal Antimicrobial Surveillance Programmes. Surveillance of antibiotic resistance in *Neisseria gonorrhoeae* in the WHO Western Pacific and South East Asian Regions, 2009. *Commun Dis Intell* 2011;35(1):2–7.
18. Tapsall JW, Ray S, Limnios A. Characteristics and population dynamics of mosaic *penA* allele-containing *Neisseria gonorrhoeae* isolated in Sydney, Australia, 2007–2008. *Antimicrob Agents Chemother* 2010;54(1):554–556.
19. Whiley DM, Limnios EA, Ray S, Sloots TP, Tapsall JW. Diversity of *penA* alterations and subtypes of *Neisseria gonorrhoeae* less susceptible to ceftriaxone from Sydney, Australia. *Antimicrob Agents Chemother* 2007;51(9):3111–3116.
20. Whiley DM, Goire N, Lambert SB, Ray S, Limnios EA, Nissen MD, et al. Reduced susceptibility to ceftriaxone in *Neisseria gonorrhoeae* is associated with mutations G542S, P551S, P551L in the gonococcal penicillin-binding protein 2. *J Antimicrob Chemother* 2010;65(8):1615–1618.
21. Newman LM, Moran JS, Workowski KA. Update on the management of gonorrhea in adults in the United States. *Clin Infect Dis* 2007;44 Suppl 3:S84–S101.
22. Tapsall JW. *Neisseria gonorrhoeae* and emerging resistance to extended spectrum cephalosporins. *Curr Opin Infect Dis* 2009;22(1):87–89.
23. Tapsall JW. Multi-resistant *Neisseria gonorrhoea*. *CMAJ* 2009;180(3):268–269.