

BMJ Open Prevalence and antibiotic resistance of *Mycoplasma genitalium* among STI clinic attendees in Western Canada: a cross-sectional analysis

Jennifer Gratrix,¹ Sabrina Plitt,² LeeAnn Turnbull,³ Petra Smyczek,^{1,4} Judith Brandley,⁴ Ron Scarrott,⁵ Prenilla Naidu,^{3,6} Penny Parker,⁴ Brenda Blore,⁵ Amy Bull,³ Sandy Shokoples,³ Lindsay Bertholet,¹ Irene Martin,⁷ Max Chernesky,⁸ Ron Read,⁵ Ameeta Singh^{4,6}

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ABSTRACT

Objectives To determine the prevalence and correlates of *Mycoplasma genitalium* (MG) infection among men and women, determine the prevalence of gene mutations conferring resistance and compare test performance of female specimen types.

Methods A cross-sectional study was conducted on specimens collected for gonorrhoea (NG, *Neisseria gonorrhoeae*) and chlamydia (CT, *Chlamydia trachomatis*) among male and female Alberta STI clinic attendees using the *M. genitalium* transcription-mediated amplification-research use only test. Positive specimens were sequenced for 23S rRNA, *parC* and *gyrA* genes. Gender-stratified analysis compared test results using χ^2 or Fisher's exact test, Mann-Whitney U test and logistic regression. Female endocervical and urine specimens were compared.

Results A total of 2254 individuals were tested; 53.8% (n=1212) were male. Male prevalence of MG was 5.3%; CT was 5.9% and NG was 1.8%. Correlates of male infection were a non-gonococcal urethritis diagnosis and NG coinfection. MG prevalence for women was 7.2%; CT was 5.8% and NG was 1.8%. Correlates of female infection were younger age, Indigenous/Other ethnicity and CT/NG coinfection. Nearly two-thirds of eligible specimens had mutations associated with macrolide resistance and 12.2% of specimens had a *parC* mutation signifying possible moxifloxacin resistance. There was high concordance (98.1%) of results between urine and endocervical swabs.

Conclusions The high prevalence of MG relative to CT and NG supports the incorporation of MG testing into routine sexually transmissible infection screening. The high rate of resistance to macrolides and moxifloxacin raises concerns about treatment options. The good concordance of results between urine and endocervical swabs supports the use of female urine specimens for testing.

BACKGROUND

Mycoplasma genitalium (MG) is an emerging sexually transmissible infection (STI) caused by bacteria belonging to the *Mollicutes* class

Strengths and limitations of this study

- The main strength of this study is that it is among the largest of global studies examining *Mycoplasma genitalium* prevalence in heterosexual men, men who have sex with men and women attending STI clinics.
- Resistance testing for macrolide and fluoroquinolone resistance was only conducted on 2/3 of *M. genitalium* positive specimens.
- Since we were only able to collect a small number of additional variables over standard clinic protocol due to time constraints, this may have limited our ability to identify additional correlates of *M. genitalium* infection.

that lack a cell wall.¹ In men, it has been implicated as an aetiological agent of non-gonococcal urethritis (NGU) and persistent or recurrent urethritis.¹ In women, available evidence suggests that MG infection is significantly associated with an increased risk of cervicitis, pelvic inflammatory disease (PID), preterm birth and spontaneous abortion, and risk of infertility is also increased.² Studies suggest that PID cases associated with MG may be similar to *Chlamydia trachomatis* (CT) in terms of severity of symptoms and signs.³ A twofold increased odds of HIV among populations with MG has also been reported.⁴

Globally, the prevalence of MG using molecular diagnostic tests ranges from 1% to 4% in men and 1% to 6% in women but is higher in those at risk for STI.⁵ In a recent Eastern Canadian study, male prevalence was 4.5% and prevalence in women was 3.2%.⁶

In Canada, access to testing for MG is currently largely limited to the referral of suitable specimens to the National Microbiology Laboratory (NML) in Winnipeg.



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For numbered affiliations see end of article.

Correspondence to
Professor Ameeta Singh;
ameeta@ualberta.ca

Azithromycin has been recommended for treatment of MG but rising resistance has raised concerns about the use of this drug as the preferred option.⁷ Alternate treatment with moxifloxacin has been proposed but the high cost of this medication, the potential for hepatotoxicity and reports of resistance have also raised concerns.⁸

Given the anticipated wider availability of test kits to screen for MG in the future, we sought to determine the prevalence and correlates of MG infection in urogenital specimens from attendees at two Alberta STI clinics, to compare the test performance in different types of urogenital specimens from women and to determine the prevalence of mutations in genes conferring resistance to macrolides and moxifloxacin.

METHODS

Specimens collected from January to April 2016 for *Neisseria gonorrhoeae* (NG) and CT screening from urogenital sites among sequential male and female attendees (>17 years old) at two Alberta STI clinics were tested for MG. Inclusion in the study required that at least 2 months had elapsed since being treated for NG or CT to reduce the chance that the visit was related to test of cure from previous infection, and screening could not be part of patient follow-up if named as a sexual contact to an NG/CT case to remove patients more likely to test positive. All individuals attending the two STI clinics were screened for NG and CT unless they specifically declined: all men were screened using urine tests while women were either screened with urine tests (mostly asymptomatic) or with an endocervical or vaginal swab (mostly symptomatic).

Basic demographic and clinical information was collected on the laboratory requisition form and included ethnicity (Caucasian, Indigenous or Other), presence of symptoms (yes/no; for women, symptoms were defined as the presence or complaint of vaginal discharge, odour or itching, and for men, urethral discharge or dysuria), diagnosis at the time of visit for those undergoing physical examination (NGU, mucopurulent cervicitis (MPC)) and self-reported HIV status at the time of the patient visit. For male visits only, the gender of the sexual partner was recorded. For men, NGU was diagnosed if on physical examination the registered nurse (RN) found urethral discharge +/- dysuria plus urethral smear with >5 polymorphonuclear leukocytes/high-power field in five or more fields with subsequent negative CT and NG test results. For women, MPC was diagnosed based on the RN assessment of mucopurulent cervical discharge or cervical friability on vaginal speculum examination.

The *M. genitalium* transcription-mediated amplification-research use only test (Hologic Inc, San Diego, California) was used to screen endocervical, vaginal and urine specimens. Endocervical swabs are currently collected in preference to vaginal swabs in our STI clinics. For a female subpopulation, test results from endocervical and urine specimens collected on the same individuals at the same visit were compared and the proportion of

concordant results was calculated. The Hologic Aptima Combo 2 assay was used to test for CT and NG.

All positive specimens for MG were sent to the NML for additional testing. DNA was extracted from the specimens using the QIAamp Viral RNA Mini kit (Qiagen, Toronto, Ontario) or the MagNA Pure DNA and Viral Nucleic Acid kit (Roche, Laval, Quebec) as per manufacturer's instructions. Positive specimens were analysed by sequencing 23SrRNA to identify mutations associated with macrolide resistance and *parC* and *gyrA* genes associated with potential resistance to moxifloxacin.^{9,10}

Sample size was determined by budgetary costs, impact on clinic staff and an acceptable margin of error. Using a sample size of 2000, our margin of error was +/- 1% for a 5% prevalence rate with a 95% confidence interval (CI). Gender-stratified analyses were performed to compare MG test result and MG resistance testing results by demographic and clinical variables using χ^2 or Fisher's exact test for discrete variables and Mann-Whitney U test for continuous variables, excluding missing data. A two-tailed p value of <0.05 was defined as statistically significant for univariate analysis. Multivariable logistic regression was performed for both men and women separately to determine adjusted odds ratios (AOR) and 95% CI for correlates independently associated with a positive MG test result. All variables with a statistical significance of p<0.10 in univariate analysis were considered in the regression models. Variables were removed from the model if they were deemed to be non-significant or did not contribute significantly to the overall model. In addition, the results from endocervical swabs were compared with urine specimens for women and Cohen's kappa was calculated. A 95% binomial CI was calculated for each infection prevalence. Data were analysed using IBM SPSS Statistics V.19.0 (IBM). This study was approved by the University of Alberta Health Research Ethics Board.

RESULTS

A total of 2294 individuals were tested. Forty patients were removed due to being <18 years (n=20) and for having more than one visit during the study period (n=20). The overall MG prevalence was 6.2% (95% CI 5.2 to 7.2). One-half (53.8%; n=1212) of the study population was men. The male prevalence of MG was 5.3% (95% CI 4.0 to 6.5); CT was 5.9% (95% CI 4.6 to 7.3) and NG was 1.8% (95% CI 1.1 to 2.6). Among MSM, the MG prevalence was 6.6% with a CT prevalence of 3.4% and NG prevalence of 1.7%. In heterosexual men, MG prevalence was 4.7% with a CT prevalence of 6.8% and NG prevalence of 2.0%. Of 73 cases of urethritis, 19.2% (n=14) were due to MG. One-third (37.0%; n=27) of NGU cases were negative for MG, CT and NG. Univariate correlates significantly associated with a higher prevalence of MG infection among men included being symptomatic (p=0.001), a diagnosis of NGU (p<0.001) and coinfection with CT or NG (p=0.005 and p<0.001, respectively) (table 1). Independent correlates of infection with MG were a diagnosis

Table 1 Characteristics of *Mycoplasma genitalium* cases (Alberta STI clinics, January to April 2016, n=2254)

| Category | Female | | | Male | | | p Value | Grand total |
|------------------------------|-----------------|------------------|--------------------|-----------------|-------------------|----------------|---------|-------------|
| | Positive (n=75) | Negative (n=967) | Total (n=1042) | Positive (n=64) | Negative (n=1148) | Total (n=1212) | | |
| Median age (IQR) | 24 (21–28) | 28 (24–34) | 27 (23–33) | 28 (25–38) | 30 (25–37) | 30 (25–37) | 0.53 | 29 (24–35) |
| Ethnicity | | | | | | | | |
| Caucasian | 33 (44.6) | 795 (75.9) | 728 (73.5) | 46 (75.4) | 762 (71.0) | 808 (71.3) | 0.72 | 1536 (72.3) |
| Indigenous | 23 (31.1) | 95 (10.4) | 118 (11.9) | 3 (4.9) | 50 (4.7) | 53 (4.7) | | 171 (8.1) |
| Other | 18 (24.3) | 126 (13.8) | 144 (14.5) | 12 (19.7) | 261 (24.3) | 273 (24.1) | | 417 (19.6) |
| Sexual partners | | | | | | | | |
| Heterosexual | – | – | – | 37 (61.7) | 758 (69.9) | 795 (69.5) | 0.18 | – |
| Same sex | – | – | – | 23 (38.3) | 326 (30.1) | 349 (30.5) | | – |
| Testing location | | | | | | | | |
| Calgary | 19 (25.3) | 415 (42.9) | 434 (41.7) | 27 (42.2) | 553 (48.2) | 580 (47.9) | 0.35 | 1014 (45.0) |
| Edmonton | 56 (74.7) | 552 (57.1) | 608 (58.3) | 37 (57.8) | 595 (51.8) | 632 (52.1) | | 1240 (55.0) |
| Symptomatic | | | | | | | | |
| No | 44 (59.5) | 567 (60.9) | 611 (60.8) | 34 (55.7) | 817 (74.9) | 851 (73.9) | 0.001 | 1462 (67.8) |
| Yes | 30 (40.5) | 364 (39.1) | 394 (39.2) | 27 (44.3) | 274 (25.1) | 301 (26.1) | | 695 (32.2) |
| Pregnant | | | | | | | | |
| No | 70 (95.9) | 903 (99.1) | 973 (98.9) | – | – | – | – | – |
| Yes | 3 (4.1) | 8 (0.9) | 11 (1.1) | – | – | – | – | – |
| HIV status | | | | | | | | |
| Negative | 58 (84.1) | 702 (79.1) | 760 (79.4) | 36 (60.0) | 644 (61.6) | 680 (61.5) | 0.64 | 1440 (69.8) |
| Positive | 0 | 4 (0.5) | 4 (0.4) | 2 (3.3) | 15 (1.4) | 17 (1.5) | | 21 (1.0) |
| Unknown | 11 (15.9) | 182 (20.5) | 193 (20.2) | 22 (36.7) | 386 (36.9) | 408 (36.9) | | 601 (29.1) |
| Coinfections | | | | | | | | |
| Chlamydia | 18 (24.0) | 42 (4.3) | 60 (5.8) | 9 (14.1) | 63 (5.5) | 72 (5.9) | 0.005 | 132 (5.9) |
| Gonorrhoea | 6 (8.0) | 13 (1.3) | 19 (1.8) | 5 (7.8) | 17 (1.5) | 22 (1.8) | <0.001 | 41 (1.8) |
| MPC/NGU | 3 (4.0) | 4 (0.4) | 7 (0.7) | 9 (15.3) | 27 (21.5) | 36 (3.2) | <0.001 | – |
| Multivariate analysis | OR | 95% CI | Adjusted OR | 95% CI | | | | |
| Male* | | | | | | | | |
| Coinfection with gonorrhoea | 5.6 | 2.0 to 15.8 | 7.2 | 2.5 to 20.4 | | | | |
| NGU diagnosis | 6.9 | 3.1 to 15.6 | 7.6 | 3.4 to 17.2 | | | | |
| Female† | | | | | | | | |

Continued

Table 1 Continued

| Multivariate analysis | OR | 95% CI | Adjusted OR | 95% CI |
|----------------------------|------|--------------|-------------|--------------|
| Age (increase in one year) | 0.91 | 0.87 to 0.95 | 0.92 | 0.87 to 0.96 |
| Indigenous ethnicity† | 5.1 | 2.9 to 9.1 | 4.3 | 2.7 to 8.1 |
| Other ethnicity‡ | 3.0 | 1.6 to 5.5 | 2.8 | 1.5 to 5.3 |
| Chlamydia coinfection | 7.0 | 3.8 to 12.9 | 5.1 | 2.6 to 10.2 |
| Gonorrhoea coinfection | 5.8 | 2.0 to 16.6 | 3.5 | 1.0 to 11.8 |

Missing data: ethnicity (female=52, male=78), symptomatic (female=37, male=60), HIV status (female=85, male=107), pregnant=58, sexual partners=68.

*Symptoms and *Chlamydia trachomatis* coinfection were not retained in the final model due to lack of significance.

†Testing location, pregnancy and MPC diagnosis were not retained in the final model due to lack of significance.

‡Referent group is Caucasian ethnicity.

MPC, mucopurulent cervicitis; NGU, non-gonococcal urethritis.

of NGU (AOR)=7.6, 95% CI 3.4 to 17.2) and coinfection with NG (AOR=7.2, 95% CI 2.5 to 20.4).

The overall MG prevalence for women, using any positive test result from endocervical/vaginal or urine results, was 7.2% (95% CI 5.6 to 8.8). CT prevalence was 5.8% (95% CI 4.3 to 7.2) and NG was 1.8% (95% CI 1.0 to 2.6). Seven cases (0.7%) of MPC were diagnosed.

Univariate correlates significantly associated with a higher prevalence of MG infection (table 1) among women were younger age ($p<0.001$), Indigenous ethnicity ($p<0.001$), Other ethnicity ($p<0.001$), the Edmonton clinic testing location ($p=0.003$), being pregnant ($p=0.04$), CT or NG coinfection ($p<0.001$ for both) and MPC diagnosis ($p=0.01$). Independent correlates of infection with MG were younger age (AOR=0.92, 95% CI 0.87 to 0.96), Indigenous ethnicity (AOR=4.3, 95% CI 2.7 to 8.1) and Other ethnicity (AOR=2.8, 95% CI 1.5 to 5.3) (vs Caucasian), coinfection with CT (AOR=5.1, 95% CI 2.6 to 10.2) and NG (AOR=3.5, 95% CI 1.0 to 11.8).

Macrolide resistance data provided through 23SrRNA sequencing data were available for two-thirds (66.2%; $n=92$) of the 139 positive MG specimens. No significant differences were found between specimens that were and were not sequenced for age, gender, symptoms, same sex partners (for male cases only), NG or CT results. There was a significant difference in ethnicity, with fewer specimens from Indigenous cases being typed (46.2%) than from non-Indigenous cases (70.6%; $p=0.02$). However, when stratified by gender, the significance was lost (women: $p=0.17$, men=0.17). Over one-half (56.5%; $n=52$) of specimens were found to have mutations associated with macrolide resistance. Of the 73.4% ($n=47$) positive male specimens sequenced, nearly two-thirds (63.8%; $n=30$) were found to have mutations in either A2058T ($n=3$), A2058G ($n=12$) or A2059G ($n=15$). There were no variables significantly associated with macrolide resistance, although MSM was marginally associated with resistance among men (83.3% vs 51.9%; $p=0.06$; table 2). Resistance to moxifloxacin was assessed by markers *gyrA* and *parC*. Nearly two-thirds (64.1%; $n=41$) of positive male specimens had *parC* sequences available and five (12.2%) specimens had a *parC* mutation (Ser→Ile83, $n=4$) and (Asp→Tyr87, $n=1$) signifying possible moxifloxacin resistance. *gyrA* sequencing was performed on 46 specimens and no *gyrA* mutations were identified.

Among women, 23SrRNA sequencing data were available for 60.0% (45/75) of positive specimens. Nearly one-half (48.9%; $n=22$) had a 23SrRNA mutation associated with macrolide resistance in A2058G ($n=11$), A2058T ($n=5$), A2059G ($n=6$) or A2059C ($n=1$). In univariate analysis, younger median age (22 years (IQR: 20–26) vs 26 years (IQR: 22–29); $p=0.04$; table 3) was the only variable significantly correlated with macrolide resistance. One-half (50.7%; $n=38$) of positive specimens had *parC* sequencing available and only one specimen had a mutation signifying potential moxifloxacin resistance (Asp→Tyr87); no *gyrA* mutations were identified.

Table 3 Concordance of MG results from cervical and urine screening among women

| | | Cervix | | |
|-------|-------------|-------------|-------------|-------|
| | | MG positive | MG negative | Total |
| Urine | MG positive | 22 | 3 | 25 |
| | MG negative | 4 | 333 | 337 |
| | Total | 26 | 336 | 362 |

$22+333/362=98.1\%$ concordance between cervical and urine results.

Kappa, 0.85 (95% CI 0.75 to 0.96).

MG, *Mycoplasma genitalium*.

Among the subpopulation of women who had both endocervical swabs and urine collected, there was high concordance of results (98.1%; table 3; kappa was 0.85) (95% CI 0.75 to 0.96), representing excellent agreement. Only three vaginal swabs were collected during the study period, therefore concordance with urine specimens was not calculated. This subpopulation of women was more likely to have symptoms (61.1%) than those with urines only (27.5%; $p<0.001$).

DISCUSSION

Our study underscores the significance of *M. genitalium* as a medically significant pathogen from urogenital sites. In our male population, the prevalence of MG was 5.3%, within the range of 3.1%–17.2% reported in men from other STI clinics.^{6 11–13} A diagnosis of NGU was significantly correlated with MG infection among men in our study population, in accordance with previous studies reporting a strong association between MG and NGU independent of chlamydia infection.^{1 5} In a meta-analysis of studies completed up to 2010, MG was associated with a pooled OR of 5.5 (95% CI 4.4 to 7.0) for NGU.¹

The overall MG prevalence for women was 7.2% (95% CI 5.6 to 8.8), higher than the range of 3.2%–6% reported in most studies of female STI clinic attendees.^{6 12 14 15} In women, MG has been associated with significant morbidity including MPC, PID and infertility, but the association between MG and symptoms is less clear.^{10 16 17} Among female STI clinic attendees in some studies, 40%–75% were asymptomatic^{14 15} but a 1994–1996 French study reported a very high prevalence of MG of 38% among symptomatic female STI clinic attendees.¹⁶ The presence of symptoms was not an independent correlate of MG infection in our study.

An independent correlate of female infection with MG in our study was younger age, in contrast to two other studies which reported that the prevalence of MG peaked approximately 5 years later for both men and women and remained higher in older age groups.^{18 19} Coinfection with CT and NG was common in our patients, confirming the role of MG as a sexually transmitted pathogen and the probable overlap in behavioural and demographic characteristics for these STIs.

Indigenous (First Nations, Inuit, Metis) ethnicity and other non-Caucasian ethnicity were also significant correlates of MG infection. Other studies have reported higher rates of MG in non-Caucasian populations.^{20 21} Our finding of disproportionately high rates of MG among Indigenous persons is in keeping with the higher estimated STI prevalence in Canadian Indigenous persons when compared with the overall general population.^{22 23} First Nations persons represent an estimated 3.8% of the overall Canadian population but chlamydia rates are estimated to be seven times higher among First Nations adults than the overall population.²² The reasons for the observed disproportionately high rates of STIs are unclear but Indigenous persons in Canada are also over-represented in adolescent pregnancy and under-represented in sexual health research.²⁴ A recent First Nations Regional Health Survey stressed the importance of colonial history, barriers to healthcare services and socioeconomic disadvantage.²²

It is very likely that appropriate treatment of MG infections will result in reduced sexual transmission as well as prevention of complications.² Alternates to macrolides and moxifloxacin, the antibiotics usually proposed for the treatment of MG, are limited since the lack of a cell wall in MG precludes the use of penicillins and other beta lactam antibiotics.²⁵ Further complicating this is that mycoplasmas can develop resistance either by gene mutation or by acquisition of a resistance gene.²⁶ Since azithromycin has been proposed as the preferred first-line agent for the treatment of MG infections,^{27 28} the high rate of mutations (~2/3 of eligible specimens) conferring resistance to azithromycin in our study is particularly alarming. Strains of *M. genitalium* began to develop resistance to azithromycin and have continued to do so through mutations in region V of the 23S ribosomal RNA gene.²⁹ Macrolide resistance rates vary significantly by geographic region with 58% resistance reported in the only published Canadian study conducted in Eastern Canada.⁶ This level of resistance is well above the threshold of 5% resistance above which the WHO typically recommends against the routine use of a drug for first-line treatment of an STI.³⁰ A recent review reported that the efficacy of azithromycin 1g for the treatment of urogenital MG has decreased from 85% prior to 2009 to 60% in early 2015.⁷ This had been postulated to be due to increasing prevalence of macrolide resistance due to the widespread use of azithromycin for the treatment of CT, NGU and MPC.^{7 31–33} In a recent meta-analysis, persistent MG was associated with a pooled OR of 26 (95% CI 11 to 57) for persistent urethritis, demonstrating that failure to eradicate MG leads to persistent or recurrent signs and symptoms of urethritis in the majority of men.⁷ The observation of MG as a significant pathogen in both NGU and MPC has generated much discussion around whether azithromycin, and especially single-dose azithromycin should continue to be recommended as the preferred agent for these STI syndromes.³¹ Instead it has been proposed that doxycycline be used as the first-line

agent because even though it is in only 30%–40% effective against MG, it does not induce the development of antimicrobial resistance.³¹

Moxifloxacin has been proposed as the drug of choice for treatment failures with azithromycin^{27–28} but our finding of potentially 12.2% resistance to moxifloxacin as assessed by markers *gyrA* and *parC* is also above the 5% threshold set by the WHO.³⁰ Earlier studies reported cure rates of 100% with moxifloxacin.^{32–34–35} However, more recently Tagg *et al* reported macrolide resistance-associated mutations in the 23S rRNA gene in 43% of samples and mutations in *parC* or *gyrA* sequences in 15% of samples.³⁶ Touati *et al* reported a point mutation in the 23S rRNA gene in 14.2% of samples.³⁷

Despite the relatively high prevalence of MG in both men and women in ours and other studies, the potential for significant morbidity and enhanced HIV transmission, global recommendations for MG screening are currently very diverse in part due to lack of access to good tests for MG. In the absence of a Food and Drug Administration-approved test for MG, the US CDC-STD Treatment Guidelines suggest that MG be suspected in cases of persistent/recurrent urethritis, cervicitis and PID.²⁷ Canada has a single Health Canada-approved test for MG (Seegene Inc, Seoul, Korea) which is not widely available. The Europeans currently have the broadest recommendations for screening for MG including persons with STI symptoms and those engaging in high-risk sexual behaviour, with a strong recommendation that all positive tests be followed by an assay capable of detecting macrolide resistance mutations.²⁸

The optimal specimen type for MG testing remains unresolved with urine specimens considered acceptable in men and women, and in women vaginal swabs are also considered suitable.²⁵ In our study, the excellent agreement between the test performance in female endocervical swabs and urine is reassuring and supports the use of less invasive urine specimens for testing in women. It should be noted, however, that the comparison of test positivity in female urine and female endocervical swabs is likely biased since the subpopulation included in this calculation was more likely to be symptomatic than those not included. Organism burden may play a role in whether a woman is symptomatic or asymptomatic, and organism burden is also likely associated with test positivity.³⁸

Our study has a few limitations. First, our specimens were collected in STI clinic patients in Western Canada and may not be generalisable to other STI clinics and are likely to be higher than rates reported in non-STI clinic populations. Second, although the specimens were collected prospectively, we were only able to collect a limited number of additional variables in addition to standard data collection at the clinics due to time constraints; this may have limited our ability to identify additional correlates of MG. Third, as tetracycline resistance-associated mutations have not so far been identified in *M. genitalium*,³⁹ we did not test our samples for resistance

to doxycycline; this information may have been useful in guiding empirical treatment regimens for NGU and cervicitis in our region.

In summary, our study found an MG prevalence of 6.2% in attendees at two Western Canadian STI clinics, within the range reported in other studies, but higher than that for chlamydia (in women) and gonorrhoea (in both genders). Over one-half of tested isolates were resistant to macrolides. These findings together with the high proportion of asymptomatic carriers who could facilitate the spread of infection, the potential for significant morbidity and the potential for enhanced HIV transmission support recommendations for broader screening for MG. The high prevalence of macrolide resistance also supports the recommendation to follow all positive tests with an assay that can detect macrolide resistance mutations.²⁸ Judicious use of antibiotics for the empirical treatment of NGU and MPC is needed to mitigate the further development of resistance to currently used antibiotics and to optimise treatment of CT, NG and MG. In order to facilitate this, wider access to testing for MG and adaptation of most existing guidelines will be necessary.

Author affiliations

¹STI Centralized Services, Alberta Health Services, Edmonton, Alberta, Canada

²Public Health Agency of Canada, Ottawa, Ontario, Canada

³Provincial Laboratory for Public Health, Edmonton, Alberta, Canada

⁴Edmonton STI Clinic, Alberta Health Services, Edmonton, Alberta, Canada

⁵Calgary STI Clinic, Alberta Health Services, Calgary, Alberta, Canada

⁶University of Alberta, Edmonton, Canada

⁷National Microbiology Laboratory, Winnipeg, Canada

⁸McMaster University, Hamilton, Canada

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