



**19th International Conference on New Findings
in Midwifery, Women, Maternity and Infertility
(ICMWWMI 2026)**

<http://icmwwmi.ir>
info@icmwwmi.ir

18 September 2026 -TBILISI GEORGIA

**Antibiotic Resistance of Genital Tract Pathogens and Its
Role in Infertility: A Review of Mechanisms, Clinical
Consequences, and Therapeutic Challenges**

Seyyed ali bolouri

Master's student in microbiology of pathogenic microorganisms, Tabriz University

Seyyedalibolouri@gmail.com

Abstract

Bacterial and protozoal genital tract infections are important preventable contributors to reproductive dysfunction and infertility in both sexes. Persistent infection can induce chronic inflammation and tissue injury in reproductive organs, while increasing antimicrobial resistance (AMR), particularly in *Neisseria gonorrhoeae* and *Mycoplasma genitalium*, further compromises treatment efficacy. AMR arises through mechanisms including target-site mutations, reduced permeability, efflux pumps, enzymatic drug inactivation, and biofilm formation, potentially resulting in treatment failure and persistent infection. Repeated antibiotic exposure may also disrupt the genital tract microbiome, promoting pathogen persistence, inflammation, and reproductive dysfunction. This review summarizes current evidence on AMR patterns and resistance mechanisms in major genital tract pathogens, their potential association with reproductive tract damage and infertility, and current diagnostic and therapeutic challenges. Emerging strategies for resistance-guided therapy, rational antimicrobial use, and microbiome preservation are also discussed.

Keywords: Antibiotic resistance; Genital tract infections; Infertility; *Mycoplasma genitalium*; *Neisseria gonorrhoeae*.

Introduction

Genital tract infections, particularly sexually transmitted infections (STIs), represent a substantial and potentially preventable threat to reproductive health in both women and men. Several bacterial pathogens, including *Chlamydia trachomatis*, *Neisseria gonorrhoeae*, and *Mycoplasma genitalium*, can initiate localized inflammatory responses that may subsequently extend to the upper reproductive tract. Conditions such as cervicitis, endometritis, salpingitis, and pelvic inflammatory disease (PID) can develop as a consequence, potentially causing progressive anatomical and functional alterations within the reproductive system. When these infections remain undetected or inadequately treated, complications such as tubal damage, impaired or complete tubal obstruction, ectopic pregnancy, and infertility may occur (Giacani et al., 2025; Smolarczyk et al., 2021). The clinical management of these infections has become increasingly complicated by the global expansion of antimicrobial resistance (AMR). Reduced susceptibility to antimicrobial agents can compromise treatment outcomes, favor prolonged pathogen



**19th International Conference on New Findings
in Midwifery, Women, Maternity and Infertility
(ICMWWMI 2026)**

<http://icmwwmi.ir>
info@icmwwmi.ir

18 September 2026 -TBILISI GEORGIA

persistence, and extend the period during which infected individuals may transmit the microorganism. Persistent infection may also increase the risk of cumulative tissue injury and subsequent reproductive complications. *Neisseria gonorrhoeae* provides a particularly important example of this phenomenon. During the past several decades, gonococci have progressively acquired resistance to multiple antimicrobial classes that have been used for clinical treatment. Of particular concern is the emergence and dissemination of isolates showing decreased susceptibility or resistance to third-generation cephalosporins, which substantially limits available therapeutic options (Tsevat et al., 2017). A similar concern has emerged with *Mycoplasma genitalium*, for which resistance to both macrolides and fluoroquinolones is increasingly recognized as a major obstacle to effective therapy. Resistance-associated genetic changes can affect antimicrobial targets, including mutations within the 23S rRNA gene associated with macrolide resistance and alterations in *gyrA* and *parC* that may reduce susceptibility to fluoroquinolones. The clinical importance of this problem is further amplified by the frequently asymptomatic or minimally symptomatic nature of *M. genitalium* infection. Consequently, individuals may remain undiagnosed for extended periods, while ineffective antimicrobial therapy can further contribute to persistence, continued transmission, and potentially delayed reproductive tract complications (Unemo et al.). The potential relationship between antimicrobial-resistant genital infections and infertility is not necessarily attributable to the direct effects of the microorganism alone. When antimicrobial treatment fails and the pathogen persists, prolonged activation of local and systemic immune pathways may occur. Continuous production of inflammatory mediators can compromise epithelial integrity, promote tissue injury, and stimulate subsequent fibrotic remodeling. In women, chronic or recurrent inflammatory processes may compromise fallopian tube integrity and interfere with normal endometrial function. In men, inflammatory involvement of the epididymis, prostate, and other reproductive tissues has been associated with alterations in semen quality, increased oxidative stress, and damage to sperm DNA, all of which may negatively influence reproductive potential (Alkan, 2021; Beni et al., 2024). Antibiotic exposure may also influence reproductive health indirectly through its effects on the genital tract microbiome. Repeated or prolonged antimicrobial administration can alter the composition and ecological stability of the resident microbial community. In the female genital tract, disruption of the normally protective *Lactobacillus*-dominated microbiota and the subsequent development of dysbiosis may modify the local environment in ways that favor the establishment or persistence of opportunistic and pathogenic microorganisms. Because the genital microbiota interacts closely with the epithelial barrier and mucosal immune system, disturbances within this microbial ecosystem may contribute to inflammatory responses and potentially affect reproductive function (Kadar, 2019). Consequently, antimicrobial resistance in genital tract pathogens should be viewed as more than an isolated challenge related to antibiotic selection. Treatment failure and pathogen persistence may form part of a broader sequence of microbiological, immunological, and inflammatory events that can progressively compromise reproductive function and fertility. Effective management therefore requires timely identification of causative pathogens, appropriate molecular assessment of resistance-associated determinants, continuous surveillance of resistance trends, and implementation of antimicrobial stewardship principles. At the same time, the development of alternative or complementary therapeutic strategies may be necessary to reduce the long-term reproductive consequences



19th International Conference on New Findings in Midwifery, Women, Maternity and Infertility (ICMWWMI 2026)

<http://icmwwmi.ir>
info@icmwwmi.ir

18 September 2026 -TBILISI GEORGIA

associated with resistant infections(Debattista et al., 2003; Rodgers et al., 2011). Against this background, the present review evaluates the current evidence concerning major pathogens responsible for genital tract infections, with particular emphasis on the molecular mechanisms responsible for antimicrobial resistance. It further examines how resistant or persistent infections may affect the female and male reproductive systems and considers the contribution of chronic inflammation and prolonged pathogen persistence to impaired fertility. Finally, current limitations in diagnosis and treatment are addressed, alongside emerging strategies aimed at controlling antimicrobial resistance while minimizing its potential consequences for reproductive health(Chemaitelly et al., 2021; Svenstrup et al., 2008).

1. Major Genital Tract Pathogens Associated with Infertility

Genital tract infections caused by diverse bacterial and protozoan pathogens can impair reproductive function through mechanisms such as ascending inflammation, persistent infection, disruption of the genital microbiota, and direct or inflammation-induced tissue damage. Among sexually transmitted bacteria, *Chlamydia trachomatis*, *Neisseria gonorrhoeae*, and *Mycoplasma genitalium* are especially important due to their potential effects on fertility. In addition, *Trichomonas vaginalis* and species of *Ureaplasma* and *Mycoplasma* have been associated with infertility and other reproductive disorders.(Rodrigues et al., 2025; Smolarczyk et al., 2021).

1.1. Chlamydia trachomatis

Chlamydia trachomatis is an obligate intracellular Gram-negative bacterium and represents one of the most prevalent bacterial sexually transmitted pathogens worldwide. Its characteristic biphasic developmental cycle alternates between infectious elementary bodies (EBs) and metabolically active, replicating reticulate bodies (RBs), a biological feature that contributes to successful intracellular survival and maintenance of infection. A substantial proportion of genital *C. trachomatis* infections produce few or no noticeable symptoms, which may delay diagnosis and treatment and consequently increase the possibility of prolonged infection(Unemo, Lahra, et al., 2019).The contribution of *C. trachomatis* to female infertility is strongly associated with its ability to produce ascending infection and inflammatory injury within the upper reproductive tract. Persistent or recurrent infection can activate both innate and adaptive immune pathways and stimulate the release of inflammatory mediators. Prolonged inflammation may damage the tubal epithelium and promote tissue remodeling, adhesion formation, and partial or complete obstruction of the fallopian tubes. Such structural and functional abnormalities can interfere with the normal movement of spermatozoa, oocytes, and embryos and consequently increase the risk of tubal-factor infertility and ectopic pregnancy (Giacani et al., 2025). Although review studies generally support an association between *C. trachomatis* infection and female infertility, the magnitude of this relationship has differed among investigations and may be influenced by variables such as the duration of infection, characteristics of the studied population, and the diagnostic approach used (Ciccarese et al., 2024). The reproductive consequences of *C. trachomatis* are not restricted to women. In men, infection may involve the urethra, epididymis, and other genital tract structures, resulting in conditions such as urethritis and epididymitis. Inflammatory responses, together with increased oxidative stress and possible interactions



19th International Conference on New Findings in Midwifery, Women, Maternity and Infertility (ICMWWMI 2026)

<http://icmwwmi.ir>
info@icmwwmi.ir

18 September 2026 -TBILISI GEORGIA

between the pathogen and spermatozoa, have been proposed as mechanisms through which infection may negatively affect semen quality and sperm function. Evidence from meta-analytic studies has also demonstrated a notable occurrence of *C. trachomatis* infection among infertile men and suggested an elevated risk of infertility among infected individuals(Keikha et al., 2023).

1.2. Neisseria gonorrhoeae

Neisseria gonorrhoeae is a Gram-negative diplococcus that causes gonorrhea and represents an important genital tract pathogen. After colonizing mucosal surfaces, it can trigger substantial inflammation and potentially ascend to the upper reproductive tract. In women, untreated or inadequately treated infection may progress from cervicitis to endometritis, salpingitis, and pelvic inflammatory disease. Tubal inflammation can result in scarring and adhesions, impairing fallopian tube function and consequently increasing the risk of infertility and ectopic pregnancy. (Waites et al., 2026). Among men, gonorrhea most commonly presents as urethritis; however, infection can occasionally extend to deeper reproductive structures and result in epididymitis or inflammation of other components of the genital tract. Such inflammatory involvement may interfere with normal reproductive function. In addition to direct tissue injury, persistent or inadequately controlled infection may promote oxidative stress and alter the physiological activity of cells within the reproductive tract (Cutoiu & Boda, 2024). The significance of *N. gonorrhoeae* in the context of reproductive health is further intensified by its exceptional ability to acquire and disseminate antimicrobial resistance. Historically, gonococci have progressively developed resistance to multiple antimicrobial groups, including penicillins, tetracyclines, fluoroquinolones, and macrolides. The emergence of isolates with decreased susceptibility to third-generation cephalosporins is particularly concerning because these agents have played a central role in contemporary gonorrhea treatment. Consequently, antimicrobial resistance can increase the probability of therapeutic failure and prolonged infection, potentially extending the duration of inflammatory exposure and reproductive tract injury(Zhang et al., 2022).

1.3. Mycoplasma genitalium

Mycoplasma genitalium is a highly specialized urogenital bacterium that lacks a conventional cell wall. Its minimal genome, slow growth, and demanding culture requirements have made conventional laboratory cultivation challenging, limiting diagnostic and research applications. Clinically, it is associated with urethritis in men and cervicitis and pelvic inflammatory disease in women. Persistent infection may maintain chronic genital tract inflammation and contribute to reproductive tissue damage, potentially affecting fertility.(Mielczarek & Blaszkowska, 2016). A major therapeutic challenge associated with *Mycoplasma genitalium* is the rapid accumulation of antimicrobial resistance. Macrolide resistance is mainly driven by mutations in region V of the 23S rRNA gene, which modify the drug target and decrease antimicrobial susceptibility. Reduced susceptibility to fluoroquinolones is primarily linked to mutations in *parC* and, less frequently, *gyrA*. The increasing prevalence of these resistance mechanisms limits empirical treatment options and may lead to repeated use of ineffective antimicrobials, thereby sustaining selective pressure and promoting further resistance(Marques-Silva et al., 2021). The potential role of *Mycoplasma genitalium* in infertility is thought to involve persistent infection and chronic genital



19th International Conference on New Findings in Midwifery, Women, Maternity and Infertility (ICMWMI 2026)

<http://icmwmi.ir>
info@icmwmi.ir

18 September 2026 -TBILISI GEORGIA

tract inflammation. Clinical and epidemiological findings indicate an association between *M. genitalium* and pelvic inflammatory disease, suggesting that prolonged inflammation may damage reproductive tissues. However, evidence directly linking *M. genitalium* to infertility remains less conclusive than for *Chlamydia trachomatis*. Further well-designed prospective studies are needed to determine whether persistent or antimicrobial-resistant *M. genitalium* infection independently contributes to infertility risk (Abavisani & Keikha, 2023; Rivero et al., 2023).

1.4. *Ureaplasma* spp. and Other Mycoplasmataceae

Ureaplasma spp. and some *Mycoplasma* species may constitute part of the normal urogenital microbiota; therefore, their detection does not necessarily indicate active infection. Their clinical relevance depends on factors such as microbial load, co-infections, host susceptibility, and mucosal barrier integrity. In certain conditions, these organisms may contribute to persistent inflammation and reproductive dysfunction. Proposed mechanisms include chronic inflammatory activation, alteration of the genital tract microenvironment, and potential impairment of sperm quality and function (Huang et al., 2015). The absence of a peptidoglycan-containing cell wall makes *Ureaplasma* and *Mycoplasma* intrinsically resistant to β -lactam antibiotics, which target bacterial cell-wall synthesis. Consequently, treatment relies on antimicrobials with alternative targets, particularly tetracyclines, macrolides, and fluoroquinolones. The emergence of resistance to these drug classes can further restrict therapeutic options and complicate the management of clinically relevant infections (Venneri et al., 2022).

1.5. *Trichomonas vaginalis*

Trichomonas vaginalis is a flagellated protozoan responsible for trichomoniasis and differs from the bacterial pathogens discussed above in its antimicrobial management. Treatment mainly relies on 5-nitroimidazoles, particularly metronidazole and tinidazole. Infection can promote genital mucosal inflammation, modify local immune responses, and disrupt the reproductive tract microenvironment. Although higher rates of *T. vaginalis* infection have been reported in some infertile populations, a direct causal association with infertility remains unconfirmed and requires further investigation (Franasiak & Scott Jr, 2015; Moreno & Simon, 2018). Male infection has also attracted attention because *T. vaginalis* may be associated with inflammation of the male urogenital tract and potentially with impaired sperm function. The mechanisms proposed to explain these effects include local inflammatory injury, interactions between the parasite and host reproductive cells, and direct or indirect alterations in sperm physiology (Chen et al., 2026; Chen et al., 2023). Resistance to 5-nitroimidazole agents, particularly metronidazole, represents an additional challenge in the management of trichomoniasis. Proposed mechanisms include reduced activity of enzymes responsible for activation of the drug as well as changes in metabolic pathways involved in electron transport and cellular antioxidant defenses. Consequently, resistant or recurrent infections may be difficult to eradicate and can prolong exposure of genital tissues to the pathogen and its associated inflammatory stimuli (Bradshaw et al., 2008). Overall, genital tract pathogens may impair reproductive health through persistent infection, chronic inflammation, epithelial damage, microbiome disruption, and antimicrobial resistance. The



19th International Conference on New Findings in Midwifery, Women, Maternity and Infertility (ICMWWMI 2026)

<http://icmwwmi.ir>
info@icmwwmi.ir

18 September 2026 -TBILISI GEORGIA

associations of *Chlamydia trachomatis* and *Neisseria gonorrhoeae* with reproductive tract injury are well established, while *Mycoplasma genitalium* is increasingly concerning because of its evolving resistance and link to genital tract inflammation. The contributions of *Trichomonas vaginalis* and other Mollicutes to infertility remain less certain and require further experimental and longitudinal investigation (Peumans et al., 1997).

2. Mechanisms of Antibiotic Resistance in Genital Tract Pathogens

Antimicrobial resistance in genital tract pathogens arises through genetic variation, selective pressure from antimicrobial exposure, horizontal gene transfer, and cellular adaptation. Resistance may be intrinsic or acquired through mutations or uptake of resistance determinants from other microorganisms. Key mechanisms include alteration of drug targets, reduced membrane permeability, increased efflux, enzymatic drug inactivation, and metabolic adaptation. In pathogens such as *Neisseria gonorrhoeae* and *Mycoplasma genitalium*, chromosomal mutations are major contributors to clinically significant resistance, although mobile genetic elements may also facilitate the spread of resistance-associated genes (Giacani et al., 2025; Llaca-Díaz & Casillas-Vega, 2026).

2.1. Intrinsic and Acquired Resistance

Intrinsic antimicrobial resistance results from inherent structural or biological features that make a microorganism naturally insensitive to specific drugs. For example, *Mycoplasma genitalium* and *Ureaplasma* spp. lack a peptidoglycan cell wall, rendering β -lactam antibiotics ineffective because these agents target bacterial cell-wall synthesis. In contrast, acquired resistance develops through genetic mutations or acquisition of resistance determinants and can become more prevalent under antimicrobial selective pressure (Fernández-Huerta et al., 2025; Unemo & Shafer, 2014). In *Mycoplasma genitalium*, repeated or inappropriate use of macrolides and fluoroquinolones can promote the survival and expansion of resistant strains. Evidence suggests that prior macrolide exposure is associated with a higher prevalence of macrolide-resistance mutations, emphasizing the significant role of antimicrobial selective pressure in driving resistance patterns. (Li et al., 2020).

2.2. Mutations in Antibiotic Target Sites

Alteration of the cellular structure to which an antimicrobial agent binds is a major molecular strategy through which microorganisms can evade antibiotic activity. Even relatively small genetic changes may modify the conformation of an antimicrobial target sufficiently to reduce drug binding and preserve the biological function of the affected cellular component. This mechanism has particular relevance in *M. genitalium* (Manhart et al., 2011). Macrolide resistance in *M. genitalium* is mainly associated with point mutations located in region V of the 23S rRNA gene. Well-characterized substitutions,



19th International Conference on New Findings in Midwifery, Women, Maternity and Infertility (ICMWWMI 2026)

<http://icmwwmi.ir>
info@icmwwmi.ir

18 September 2026 -TBILISI GEORGIA

including A2058G and A2059G, modify the macrolide-binding region of the 50S ribosomal subunit. As a result, the affinity of macrolides for the ribosome is reduced, allowing protein synthesis to continue despite antimicrobial exposure. These mutations are therefore widely recognized as important molecular indicators of macrolide resistance (Unemo et al., 2025). Resistance to fluoroquinolones involves a different set of molecular targets. In *M. genitalium*, fluoroquinolones act primarily by interfering with DNA gyrase and topoisomerase IV. Genetic alterations in *parC* and *gyrA*, especially mutations located within the quinolone-resistance-determining region (QRDR), can modify the DNA–topoisomerase complex and decrease the ability of fluoroquinolones to inhibit these enzymes. Among the reported mutations, the S83I substitution in ParC has been repeatedly identified as an important determinant associated with reduced fluoroquinolone susceptibility and treatment failure (Unemo, Lahra, et al., 2021). Target modification is also an important component of resistance in *N. gonorrhoeae*. Changes in the *penA* gene can alter the structure of penicillin-binding protein 2 (PBP2), reducing the activity of third-generation cephalosporins against the organism. Furthermore, mutations in the 23S rRNA gene contribute to azithromycin resistance, while changes involving additional ribosomal targets may affect susceptibility to other antimicrobial agents that inhibit bacterial protein synthesis (Unemo, Lahra, et al., 2019; Unemo, Ross, et al., 2021).

2.3. Alterations in Cell Membrane Permeability

Limiting the amount of antimicrobial compound that enters a bacterial cell provides another mechanism for reducing antibiotic activity. This phenomenon is particularly relevant to Gram-negative organisms because their outer membrane represents an additional permeability barrier between the extracellular environment and intracellular targets. In *N. gonorrhoeae*, porin proteins, particularly PorB, regulate the passage of various molecules across the outer membrane. Structural or functional alterations in these proteins can decrease antibiotic influx and consequently reduce intracellular drug concentrations (Unemo et al., 2020). A reduction in antibiotic uptake can therefore impair treatment even when the molecular target of the drug remains unchanged. If the intracellular concentration falls below the level required for effective inhibition, bacterial growth and survival may continue. Decreased permeability can also operate together with other resistance mechanisms, such as active efflux, and thereby contribute to a broader multidrug-resistant phenotype (Ayala et al., 2022).

2.4. Increased Efflux Pump Activity

Efflux pumps are specialized membrane-associated transport systems that actively export potentially harmful compounds from bacterial cells. Because many of these



19th International Conference on New Findings in Midwifery, Women, Maternity and Infertility (ICMWWMI 2026)

<http://icmwwmi.ir>
info@icmwwmi.ir

18 September 2026 -TBILISI GEORGIA

transporters can recognize structurally diverse substrates, their increased activity may simultaneously reduce susceptibility to several antimicrobial classes. In *N. gonorrhoeae*, the MtrCDE efflux system is particularly important in this regard. Enhanced activity of this transporter lowers intracellular antibiotic concentrations and can consequently increase resistance across multiple antimicrobial groups (Graves et al., 2020). The expression of the MtrCDE system is controlled by regulatory mechanisms involving factors such as MtrR. Mutations affecting mtrR, including alterations in regulatory regions, may increase transcription of the mtrCDE operon and consequently enhance efflux activity. Importantly, the MtrCDE system is not restricted to the removal of antibiotics. It can also transport certain antimicrobial substances produced by the host, suggesting that increased efflux may provide a dual advantage by improving bacterial survival within the genital tract while simultaneously reducing antimicrobial susceptibility (Mayr et al., 2024; Rasoloson et al., 2002).

2.5. Enzymatic Inactivation of Antibiotics

Another established mechanism of antimicrobial resistance is the enzymatic destruction or chemical modification of antibiotic molecules. In *N. gonorrhoeae*, plasmid-mediated production of β -lactamases, particularly TEM-1, can hydrolyze the β -lactam ring of penicillin-class antibiotics and render them inactive. The localization of such resistance determinants on transferable plasmids is especially important because it creates an opportunity for rapid dissemination of resistance traits between bacterial populations (Melendez et al., 2024; Onofrio & MacLennan, 2026). Enzymatic drug inactivation may also occur alongside chromosomal mechanisms that independently reduce antimicrobial susceptibility. When β -lactamase production is combined with decreased permeability or enhanced efflux, the resulting phenotype may be considerably more resistant than that produced by any single mechanism. Such combinations can substantially increase the probability of unsuccessful antimicrobial treatment (Bradford et al., 2020; Sawatzky et al., 2022).

2.6. Horizontal Gene Transfer of Resistance Determinants

Horizontal gene transfer (HGT) allows bacteria to acquire genetic material from non-parental sources and plays a major role in the spread of antimicrobial resistance. Depending on the organism and genetic element, HGT may occur through transformation, conjugation, or transduction. *Neisseria gonorrhoeae* has a strong capacity to take up extracellular DNA and integrate foreign sequences into its chromosome. This ability contributes to the emergence of mosaic penA alleles, which are strongly associated with decreased susceptibility to cephalosporins (Shaskolskiy et al., 2016). Resistance determinants may also be carried on plasmids or other mobile genetic



19th International Conference on New Findings in Midwifery, Women, Maternity and Infertility (ICMWWMI 2026)

<http://icmwwmi.ir>
info@icmwwmi.ir

18 September 2026 -TBILISI GEORGIA

elements, allowing resistance traits to spread more rapidly within microbial communities. Accordingly, the emergence of antimicrobial resistance should not be considered solely as an independent process occurring separately in each bacterial lineage. Genetic exchange between microbial populations can accelerate the accumulation and dissemination of resistance-associated characteristics (Salmerón Menendez, 2024; Shaskolskiy et al., 2016).

2.7. Biofilm and Phenotypic Resistance

Biofilm formation can markedly increase microbial tolerance to antimicrobial agents. In these structured communities, an extracellular matrix limits antibiotic penetration and creates localized environments with altered physiological conditions. In addition to restricted drug diffusion, reduced metabolic activity, persister cells, and altered gene expression can further decrease antimicrobial susceptibility and promote microbial persistence (Lewis, 2014; Wi et al., 2017). In the genital tract, biofilm-like structures and microbial microcolonies can create protected niches that facilitate persistent colonization. This phenomenon is particularly important in recurrent or chronic infections, as antimicrobial concentrations effective against planktonic cells may be insufficient to eliminate organisms within structured communities. Surviving cells may subsequently repopulate the genital tract after treatment, increasing the likelihood of infection recurrence (Unemo, Seifert, et al., 2019).

2.8. Metabolic Alterations and Resistance to 5-Nitroimidazoles in *Trichomonas vaginalis*

The biological basis of antimicrobial resistance in *Trichomonas vaginalis* differs substantially from the mechanisms described for bacterial pathogens. Metronidazole and related 5-nitroimidazole compounds function as prodrugs and require intracellular reduction to generate reactive intermediates responsible for their antimicrobial effects. Therefore, changes that decrease the efficiency of drug activation can reduce the formation of toxic metabolites and allow the parasite to survive treatment (Quillin & Seifert, 2018; Sánchez-Busó et al., 2019). Several metabolic enzymes have been implicated in this process, including pyruvate:ferredoxin oxidoreductase, ferredoxin, hydrogenase, nitroreductase, and flavin reductase. Decreased expression or activity of these enzymes can interfere with the metabolic activation of metronidazole. Changes in intracellular oxygen regulation and antioxidant defense mechanisms may further influence the susceptibility of the parasite to 5-nitroimidazole compounds (Yahara et al., 2018b). Proteomic investigations have additionally suggested that reduced expression of flavin reductase 1 may occur frequently among resistant isolates obtained from both clinical and laboratory settings. Alteration of this pathway may influence resistance through



19th International Conference on New Findings in Midwifery, Women, Maternity and Infertility (ICMWMI 2026)

<http://icmwmi.ir>
info@icmwmi.ir

18 September 2026 -TBILISI GEORGIA

effects on iron metabolism and the intracellular activation of metronidazole(Yahara et al., 2018a). These observations suggest that resistance in *T. vaginalis* is likely to involve coordinated alterations in several metabolic and protective pathways rather than a single genetic or biochemical event(Miari et al., 2024).

2.9. Role of Antibiotic Selective Pressure

Antimicrobial selective pressure is a central evolutionary force driving the enrichment of resistant microbial populations. Repeated, inappropriate, or incomplete antimicrobial exposure can eliminate susceptible organisms while allowing less-susceptible variants to survive. These surviving organisms may subsequently expand and become a larger component of the microbial population. This phenomenon is especially relevant to *M. genitalium*, where previous macrolide exposure has been associated with an increased frequency of resistance-associated mutations (Jensen et al., 2008).The problem may be intensified when treatment regimens expose pathogens to antimicrobial concentrations that suppress growth but fail to achieve complete eradication. Such exposure can create an environment in which organisms with reduced susceptibility have a survival advantage. Consequently, unsuccessful treatment can have consequences beyond the individual episode of infection, potentially contributing to the selection and subsequent transmission of resistant strains(Jensen & Bradshaw, 2015).

2.10. Multidrug Resistance and Its Consequences for Genital Tract Infections

The accumulation of multiple resistance mechanisms within a single pathogen can lead to a multidrug-resistant (MDR) phenotype. In *Neisseria gonorrhoeae*, target modification may coexist with reduced membrane permeability, enhanced efflux, and acquisition of resistance determinants, resulting in resistance to several antimicrobial classes. Similarly, simultaneous macrolide and fluoroquinolone resistance in *Mycoplasma genitalium* can markedly limit available effective treatment options(Sethi et al., 2017; Yu et al., 2023). From a reproductive health perspective, multidrug resistance is concerning because treatment failure can prolong infection and increase the duration of exposure to pathogens and inflammatory mediators. Persistent or ascending infections may sustain chronic inflammation and progressive reproductive tissue damage. Thus, antimicrobial resistance may indirectly promote reproductive dysfunction through a cycle of ineffective treatment, pathogen persistence, prolonged inflammation, and tissue injury(Llangarí et al., 2020). Overall, antimicrobial resistance in genital tract pathogens arises through a diverse set of interconnected mechanisms, including modification of antimicrobial targets, altered membrane permeability, enhanced efflux, horizontal acquisition of resistance determinants, metabolic adaptation, and biofilm-associated tolerance. A detailed understanding of these processes is important for selecting appropriate antimicrobial

therapy and for developing molecular methods capable of identifying resistance-associated genetic markers. Early recognition of resistance determinants may facilitate more individualized treatment, reduce the use of ineffective antibiotics, and limit the selective pressure that promotes further emergence and dissemination of resistant pathogens(Durukan et al., 2020; Manhart et al., 2013).

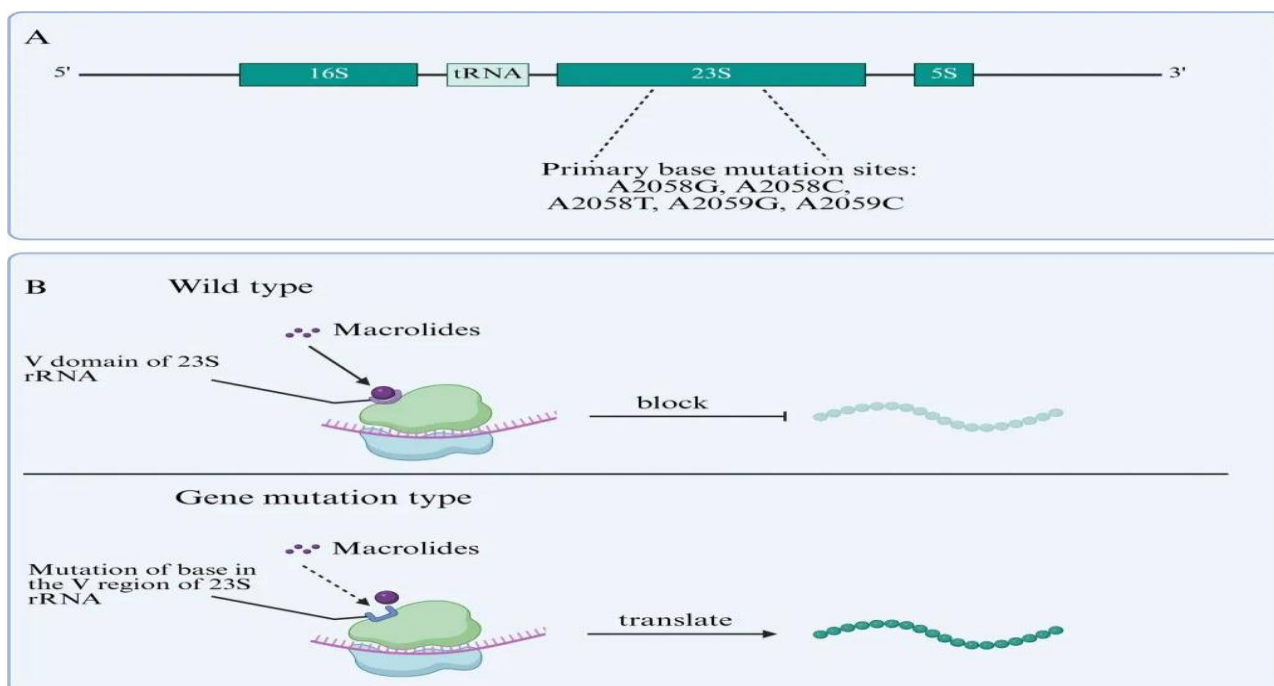


Figure 1. Molecular mechanism underlying macrolide resistance in *Mycoplasma genitalium*.

In susceptible *Mycoplasma genitalium* strains, azithromycin targets domain V of 23S rRNA within the 50S ribosomal subunit, inhibiting bacterial translation. Macrolide resistance is primarily associated with mutations at A2058 and A2059, including A2058G/C/T and A2059G/C, which modify the ribosomal binding site and reduce drug affinity. Consequently, bacterial protein synthesis and growth may continue despite therapeutic azithromycin exposure, increasing the risk of treatment failure. The growing prevalence of these mutations supports the use of molecular resistance detection and resistance-guided therapy in *M. genitalium* infections.(Ouyang et al.).

3. Mechanisms Linking Antimicrobial Resistance to Infertility

Antimicrobial resistance in genital tract pathogens extends beyond treatment failure and may contribute to reproductive dysfunction through persistent infection and prolonged host inflammatory responses. Delayed eradication of resistant pathogens can increase microbial burden, prolong exposure to microbial antigens, and facilitate transmission or



19th International Conference on New Findings in Midwifery, Women, Maternity and Infertility (ICMWMI 2026)

<http://icmwmi.ir>
info@icmwmi.ir

18 September 2026 -TBILISI GEORGIA

reinfection. Continuous immune activation may subsequently promote progressive reproductive tissue damage and increase the risk of infertility.(Htaik et al., 2026; Lis et al., 2015).

3.1. Persistent Infection and Chronic Inflammation

Persistent infection and chronic inflammation are key mechanisms linking antimicrobial resistance to infertility. Effective treatment of susceptible strains can rapidly reduce pathogen load, limit immune stimulation, and resolve inflammation. In contrast, reduced antimicrobial efficacy against resistant strains may allow continued pathogen survival and sustain prolonged activation of innate and adaptive immune responses(Hafner, 2015; Ling et al., 2022). Persistent stimulation of epithelial cells and immune cells such as macrophages and neutrophils can enhance the secretion of pro-inflammatory mediators, including IL-1 β , IL-6, IL-8, and TNF- α . Prolonged inflammatory signaling may result in epithelial damage and activate pathways associated with aberrant tissue repair and fibrosis. Therefore, antimicrobial resistance can act as an upstream driver of a pathogenic cycle in which treatment failure facilitates persistent infection, sustained inflammation promotes tissue remodeling, and progressive reproductive tissue damage may ultimately impair fertility.(Bi et al., 2023; Ma et al., 2021).

3.2. Fallopian Tube Damage and Tubal-Factor Infertility

In women, ascending genital tract infections can cause significant damage to the fallopian tubes. Chlamydia trachomatis and Neisseria gonorrhoeae are major causes of pelvic inflammatory disease, and delayed or inadequate treatment may lead to salpingitis, fibrosis, pelvic adhesions, and tubal obstruction. In C. trachomatis infection, persistent or recurrent inflammation can promote fibrotic remodeling and extracellular matrix alterations, ultimately causing narrowing or blockage of the fallopian tube lumen and increasing the risk of reproductive dysfunction(Agarwal et al., 2021).Within this framework, antimicrobial resistance may increase the probability of prolonged infection by reducing the effectiveness of standard therapy. Extended exposure of reproductive tissues to microbial antigens can consequently intensify and prolong local inflammation. Thus, AMR should not be interpreted as a direct cause of tubal obstruction; rather, it may act as an important amplifying factor within the sequence of events that ultimately produces tubal damage and infertility(Smolarczyk et al., 2021; Tsevat et al., 2017).

3.3. Role of Mycoplasma genitalium in Reproductive Tract Damage

Mycoplasma genitalium has gained increasing attention because of its potential role in reproductive tract pathology. Although it is a recognized cause of urethritis and cervicitis, evidence also suggests involvement in upper genital tract infections. A meta-analysis of



19th International Conference on New Findings in Midwifery, Women, Maternity and Infertility (ICMWWMI 2026)

<http://icmwwmi.ir>
info@icmwwmi.ir

18 September 2026 -TBILISI GEORGIA

19 studies found a significant association between *M. genitalium* infection and pelvic inflammatory disease (PID), with infected individuals having approximately 1.67-fold higher odds of PID than uninfected individuals. The organism was detected in about 10.3% of PID cases, supporting its possible contribution to ascending genital tract disease (Baud et al., 2011). The increasing prevalence of macrolide and fluoroquinolone resistance in *Mycoplasma genitalium* is concerning because it may promote treatment failure and prolonged infection. Persistent colonization of the reproductive tract can sustain local inflammation and potentially contribute to tissue damage. Meta-analyses have also reported an association between *M. genitalium* infection and adverse reproductive outcomes, including female infertility. However, the strength of this relationship varies across studies, and further longitudinal research is required to determine whether persistent *M. genitalium* infection independently contributes to infertility (Baud et al., 2008).

3.4. Fibrotic Changes and Abnormal Tissue Remodeling

Chronic infection can disrupt the balance between extracellular matrix degradation and tissue repair, promoting abnormal remodeling. In the genital tract, persistent inflammatory signaling may activate fibroblasts and modify the activity of matrix metalloproteinases and their inhibitors, leading to excessive extracellular matrix deposition. In *Chlamydia trachomatis* infection, TGF- β signaling and epithelial–mesenchymal changes have been proposed as mechanisms contributing to tubal fibrosis and pathological tissue remodeling (Wiesenfeld et al., 2012). Fibrotic damage may remain irreversible even after successful pathogen eradication. Therefore, managing antimicrobial-resistant genital infections should extend beyond achieving microbiological clearance. Early diagnosis and prompt initiation of effective antimicrobial therapy are crucial to limiting persistent inflammation and preventing permanent structural damage (Haggerty et al., 2003).

3.5. Disruption of the Genital Microbiome and Mucosal Barrier

Antimicrobial resistance may also influence reproductive health indirectly through its effects on the genital microbial ecosystem. Repeated treatment attempts, prolonged antimicrobial exposure, changes in therapeutic regimens, and the use of broad-spectrum agents may disturb the composition and stability of the genital microbiota. In particular, depletion of protective lactic acid-producing bacteria belonging to the genus *Lactobacillus* may weaken colonization resistance and create ecological conditions that favor the persistence, colonization, or overgrowth of potentially pathogenic microorganisms (Taylor et al., 2013). Such alterations may establish a self-perpetuating cycle in which infection leads to antimicrobial exposure, antimicrobial exposure disrupts the microbiota,



19th International Conference on New Findings in Midwifery, Women, Maternity and Infertility (ICMWWMI 2026)

<http://icmwwmi.ir>
info@icmwwmi.ir

18 September 2026 -TBILISI GEORGIA

microbiome instability reduces colonization resistance, and the resulting ecological imbalance increases susceptibility to recurrent or secondary infections. Therefore, AMR management should incorporate microbiome preservation as an important consideration rather than focusing exclusively on elimination of the target pathogen(Workowski & Bolan, 2015).

3.6. Association Between Resistant Infection and Male Infertility

In men, genital tract infections may adversely affect reproductive function through inflammatory involvement of the epididymis, prostate, and other components of the male reproductive system. Chronic inflammation can increase the local production of reactive oxygen species (ROS), interfere with sperm mitochondrial activity, impair sperm motility, and promote DNA damage(Manhart, 2013). A number of studies have reported associations between genital infections caused by *Chlamydia trachomatis*, *Mycoplasma genitalium*, *Mycoplasma hominis*, and selected *Ureaplasma* species and alterations in semen quality or sperm parameters. Meta-analyses evaluating genital mollicutes have similarly suggested relationships between certain infections, particularly those involving *M. genitalium*, *M. hominis*, and *U. urealyticum*, and male reproductive dysfunction or infertility(Manhart et al., 2011). When antimicrobial resistance prevents complete pathogen clearance, the inflammatory and oxidative environment may persist for an extended period. Prolonged exposure to inflammatory mediators and ROS can consequently increase the likelihood of functional sperm impairment. Local inflammation may also facilitate recruitment of inflammatory cells and further enhance ROS generation, potentially compromising sperm membrane integrity, mitochondrial function, and genomic stability(Manhart et al., 2007).

3.7. Role of Oxidative Stress and Sperm DNA Damage

Oxidative stress constitutes an important biological pathway connecting chronic genital tract inflammation with impaired male fertility. Excessive ROS generation within an inflammatory environment can induce lipid peroxidation of sperm membranes, modify structural proteins, and interfere with mitochondrial function. Because mature spermatozoa possess relatively limited mechanisms for repairing oxidative damage, sustained ROS accumulation may ultimately result in sperm DNA fragmentation(Manhart et al., 2007). In antimicrobial-resistant infections, continued pathogen persistence can prolong both inflammation and oxidative stress. AMR may therefore exert an indirect detrimental effect on sperm quality by extending the duration of exposure to ROS and inflammatory mediators. Over time, these processes may impair sperm function and reduce the probability of successful fertilization(Htaik et al., 2026).

3.8. Persistent Infection, Sexual Transmission, and the Reinfection Cycle



19th International Conference on New Findings in Midwifery, Women, Maternity and Infertility (ICMWWMI 2026)

<http://icmwwmi.ir>
info@icmwwmi.ir

18 September 2026 -TBILISI GEORGIA

Prolonged pathogen persistence associated with antimicrobial resistance can also increase the duration during which an infected individual remains capable of transmitting the pathogen to sexual partners. When treatment is ineffective, incomplete eradication may allow infection to continue and increase the probability of reinfection within sexual networks. At the individual or couple level, inadequate treatment of one partner can contribute to a recurrent cycle characterized by treatment, persistence or recurrence, reinfection, and renewed inflammation (Yu et al., 2023). This mechanism is particularly relevant to pathogens such as *M. genitalium*, for which macrolide resistance has become increasingly prevalent. Accordingly, the consequences of AMR extend beyond the affected individual. By prolonging infectiousness and facilitating transmission of resistant organisms, antimicrobial resistance may contribute to the wider dissemination of resistant strains and complicate infection control at the population level (De Carvalho et al., 2020).

3.9. Association Between Antimicrobial Resistance and Irreversible Reproductive Damage

An important aspect of the relationship between AMR and infertility is that therapeutic failure may occur after pathological tissue changes have already been initiated. Even when an alternative antimicrobial regimen eventually eliminates the pathogen, established tubal fibrosis, pelvic adhesions, genital tract obstruction, or persistent sperm damage may not be fully reversible (Cohen et al., 2005). The effect of AMR on fertility should therefore be understood as the result of an interaction among pathogen-related characteristics, the duration of infection persistence, and the magnitude and persistence of the host inflammatory response. As resistant organisms prolong infection and delay effective treatment, the probability of progression from a potentially controllable infectious process to permanent structural or functional reproductive damage may increase (Taylor-Robinson & Jensen, 2011). Overall, a pathophysiological framework can be proposed in which antimicrobial resistance contributes to delayed or unsuccessful treatment, which in turn promotes pathogen persistence and prolonged inflammation. Sustained inflammatory activity may subsequently cause reproductive tract injury through epithelial damage, fibrotic remodeling, adhesion formation, microbiome disruption, and oxidative stress. In men, prolonged inflammation and oxidative stress may additionally compromise sperm function and genomic integrity. This interconnected model emphasizes that controlling antimicrobial resistance among genital tract pathogens is important not only for improving treatment success and reducing transmission but also for protecting reproductive health and preserving fertility in both women and men (Witkin et al., 1995).

4. Role of the Genital Tract Microbiome in Antimicrobial Resistance and Infertility



19th International Conference on New Findings in Midwifery, Women, Maternity and Infertility (ICMWWMI 2026)

<http://icmwwmi.ir>
info@icmwwmi.ir

18 September 2026 -TBILISI GEORGIA

The genital tract microbiome is a complex and dynamic microbial ecosystem that plays an important role in maintaining reproductive health through continuous interactions among microorganisms, epithelial tissues, and host immune responses. In healthy women, the vaginal microbiota is frequently characterized by a predominance of *Lactobacillus* species, particularly *L. crispatus*, *L. jensenii*, and *L. gasseri*. These beneficial bacteria contribute to microbial protection by producing lactic acid and other antimicrobial substances, thereby maintaining a relatively acidic vaginal environment and limiting the colonization and proliferation of potential pathogens (Kadar, 2019).

4.1. Dysbiosis and Increased Susceptibility to Infection

Disruption of the normal vaginal microbial community, characterized by depletion of *Lactobacillus* species and increased abundance and diversity of anaerobic bacteria, can result in vaginal dysbiosis. Such ecological alterations may increase vaginal pH, weaken colonization resistance, facilitate biofilm development, and modify mucosal immune responses, consequently increasing susceptibility to genital tract infections (Petrova et al., 2015). Dysbiosis may also contribute to persistent activation of inflammatory signaling pathways, including nuclear factor kappa B (NF- κ B), accompanied by increased production of pro-inflammatory mediators such as IL-1 β , IL-6, and IL-8. Persistent activation of these pathways may create a local inflammatory environment that favors the establishment or maintenance of chronic genital tract infection (Marsh, 2017).

4.2. The Microbiome and Antimicrobial Resistance

The genital tract microbiome may function as an ecological reservoir for antimicrobial resistance (AMR) determinants. High microbial density, together with repeated exposure to antimicrobial agents—particularly broad-spectrum antibiotics—can exert substantial selective pressure on microbial communities. This pressure may favor the survival and expansion of resistant organisms and contribute to an increased prevalence of antimicrobial resistance within the genital tract ecosystem (Ravel et al., 2011). The dissemination of resistance determinants can also be facilitated by horizontal gene transfer mechanisms, including conjugation and transformation, allowing resistance-associated genetic elements to spread among microbial populations. Conversely, antimicrobial exposure can substantially alter the composition of the genital microbiota by eliminating susceptible bacterial populations and disturbing protective *Lactobacillus* communities (France et al., 2020). These reciprocal effects may generate a self-reinforcing cycle in which antimicrobial exposure promotes dysbiosis, dysbiosis increases susceptibility to infection, recurrent infections lead to additional antimicrobial treatment, and repeated treatment further intensifies selective pressure for resistant



19th International Conference on New Findings in Midwifery, Women, Maternity and Infertility (ICMWWMI 2026)

<http://icmwwmi.ir>
info@icmwwmi.ir

18 September 2026 -TBILISI GEORGIA

microorganisms. Thus, microbiome disruption may both result from and contribute to the broader problem of AMR(Gootenberg et al., 2018).

4.3. Association Between the Microbiome and Infertility

Alterations in the genital tract microbiome may influence reproductive function through several interconnected mechanisms, including increased local inflammation, impairment of epithelial barrier integrity, and greater susceptibility to ascending infections. In women, changes in the vaginal and endometrial microbial communities have been associated with inflammatory alterations and disruption of the endometrial environment. Some studies have also reported relationships between microbiome composition and implantation success or outcomes of assisted reproductive technologies. Nevertheless, the available evidence remains heterogeneous, and a definitive causal relationship between microbiome dysbiosis and infertility has not yet been established(Ma et al., 2012). In men, alterations in the genital microbial environment and an increased abundance of potentially pathogenic microorganisms may adversely affect sperm function. Local inflammatory responses and elevated production of reactive oxygen species (ROS) can potentially impair sperm motility, disrupt mitochondrial activity, and compromise sperm DNA integrity(Srinivasan et al., 2012).

4.4. Interrelationship Among AMR, the Microbiome, and Infertility

Taken together, the genital tract microbiome may represent an important biological link between antimicrobial resistance and reproductive dysfunction. Resistant infections are more likely to persist and may require prolonged, repeated, or alternative antimicrobial treatment. At the same time, repeated exposure to antibiotics can disturb microbial community structure, reduce protective *Lactobacillus* populations, and weaken natural colonization resistance(Muzny et al., 2019).

5. Diagnostic and Therapeutic Challenges of Resistant Genital Tract Infections

Diagnosis of genital tract infections is challenging because many cases are asymptomatic or present with nonspecific symptoms, particularly infections caused by *Chlamydia trachomatis* and *Mycoplasma genitalium*. Nucleic acid amplification tests (NAATs) provide sensitive pathogen detection but generally do not determine antimicrobial susceptibility. For *Neisseria gonorrhoeae*, culture with antimicrobial susceptibility testing (AST) remains important, especially when treatment failure is suspected. In contrast, molecular detection of resistance-associated mutations is increasingly preferred for *M. genitalium* because its conventional culture is technically difficult and unsuitable for routine clinical use(Durukan et al., 2020; Workowski et al., 2021). The growing prevalence of antimicrobial resistance has increased the importance



19th International Conference on New Findings in Midwifery, Women, Maternity and Infertility (ICMWWMI 2026)

<http://icmwwmi.ir>
info@icmwwmi.ir

18 September 2026 -TBILISI GEORGIA

of treatment strategies that are guided by the resistance profile of the infecting pathogen. In *M. genitalium*, mutations within the 23S rRNA gene are strongly associated with macrolide resistance, whereas alterations in genes such as *parC* and *gyrA* may contribute to reduced susceptibility to fluoroquinolones. Identification of these resistance determinants can support resistance-guided therapy, reducing the use of antimicrobial regimens that are unlikely to be effective and thereby increasing the probability of successful treatment. For *N. gonorrhoeae*, resistance detection and AST are likewise particularly important following suspected treatment failure, as they can assist clinicians in selecting an appropriate alternative antimicrobial regimen (Jensen et al., 2008; Unemo, Lahra, et al., 2021). From a reproductive health perspective, the objective of treatment extends beyond simple pathogen eradication. Effective management should also minimize the duration of infection and prevent persistent inflammation and subsequent tissue injury. Delayed or unsuccessful treatment can allow pathogens to persist, prolong inflammatory responses, and increase the risk of reproductive tract complications. Conversely, unnecessary or repeated antimicrobial exposure may disrupt the genital microbiome, promote dysbiosis, and contribute to a continuing cycle of antimicrobial resistance and reinfection. Accordingly, accurate pathogen detection, timely identification of resistance, selection of targeted therapy, and appropriate investigation of treatment failure are essential components of AMR management and may help reduce its long-term reproductive consequences (Agarwal et al., 2021; Htaik et al., 2026).

6. Strategies for the Control and Prevention of Antimicrobial Resistance

Effective control of antimicrobial resistance (AMR) in genital tract pathogens depends on accurate diagnosis, appropriate antimicrobial selection, and minimizing unnecessary antibiotic exposure. Molecular diagnostic techniques and resistance testing can facilitate the identification of resistant infections, reduce the use of ineffective treatments, and limit the selection and spread of resistant strains (Workowski et al., 2021). For *Mycoplasma genitalium*, resistance-guided therapy can improve the likelihood of successful treatment by enabling antimicrobial selection according to the detected resistance profile. In *Neisseria gonorrhoeae*, ongoing surveillance of resistance patterns and antimicrobial susceptibility testing, particularly in cases of treatment failure, remain essential for guiding alternative therapy. In addition, appropriate management of sexual partners, prevention of transmission, and preservation of the genital tract microbiome are important complementary measures for limiting recurrent infection and the spread of resistance (Manhart et al., 2011; Unemo et al.). Overall, combining rapid and accurate diagnosis with resistance-guided treatment, continuous epidemiological surveillance, and rational antimicrobial use provides an effective framework for controlling AMR and minimizing its potential impact on reproductive health (Venneri et al., 2022).

Conclusion

Antimicrobial resistance (AMR) among genital tract pathogens may indirectly contribute to reproductive dysfunction and infertility by prolonging infection, reducing treatment effectiveness, and sustaining chronic inflammatory responses. Pathogens such as *Neisseria gonorrhoeae* and *Mycoplasma genitalium* pose significant therapeutic challenges because of their ability to develop and acquire antimicrobial resistance. At the same time, disruption of the genital tract microbiome may further intensify this process by weakening natural colonization resistance and increasing susceptibility to recurrent infection and inflammation. Effective AMR control therefore requires a comprehensive approach that combines rapid and accurate diagnosis, rational antimicrobial use, resistance-guided treatment, and continuous surveillance of resistance patterns. Preservation of genital tract microbiome health, appropriate management of sexual partners, and prevention of pathogen transmission should also be considered important components of reproductive health protection. In addition, the development of rapid resistance-detection technologies, novel therapeutic strategies, and robust surveillance systems will be essential for addressing the growing challenge of AMR and minimizing its long-term impact on reproductive health and fertility.

References:

- Abavisani, M., & Keikha, M. (2023). Global analysis on the mutations associated with multidrug-resistant urogenital mycoplasmas and ureaplasmas infection: a systematic review and meta-analysis. *Annals of Clinical Microbiology and Antimicrobials*, 22(1), 70.
- Agarwal, A., Baskaran, S., Parekh, N., Cho, C.-L., Henkel, R., Vij, S., Arafa, M., Selvam, M. K. P., & Shah, R. (2021). Male infertility. *The Lancet*, 397(10271), 319-333.
- Alkan, M. L. (2021). *Hemoplasma haemohominis*, a new human pathogen. In (Vol. 72, pp. 641-642): Oxford University Press US.
- Ayala, J. C., Balthazar, J. T., & Shafer, W. M. (2022). Transcriptional regulation of the mtrCDE efflux pump operon: importance for *Neisseria gonorrhoeae* antimicrobial resistance. *Microbiology*, 168(8), 001231.
- Baud, D., Goy, G., Jaton, K., Osterheld, M.-C., Blumer, S., Borel, N., Vial, Y., Hohlfield, P., Pospischil, A., & Greub, G. (2011). Role of *Chlamydia trachomatis* in miscarriage. *Emerging infectious diseases*, 17(9), 1630.
- Baud, D., Regan, L., & Greub, G. (2008). Emerging role of *Chlamydia* and *Chlamydia*-like organisms in adverse pregnancy outcomes. *Current opinion in infectious diseases*, 21(1), 70-76.
- Beni, F. A., Saffarfar, H., Elhami, A., & Kazemi, M. (2024). Gut microbiota dysbiosis: a neglected risk factor for male and female fertility. *Cellular Microbiology*, 2024(1), 7808354.
- Bi, H., Zhang, D., & Xiao, B. (2023). Association between human papillomavirus infection and common sexually transmitted infections, and the clinical significance of different *Mycoplasma* subtypes. *Frontiers in Cellular and Infection Microbiology*, 13, 1145215.
- Bradford, P. A., Miller, A. A., O'Donnell, J., & Mueller, J. P. (2020). Zoliflodacin: an oral spiroprolactinone antibiotic for the treatment of *Neisseria gonorrhoeae*, including multi-drug-resistant isolates. *ACS infectious diseases*, 6(6), 1332-1345.
- Bradshaw, C. S., Chen, M. Y., & Fairley, C. K. (2008). Persistence of *Mycoplasma genitalium* following azithromycin therapy. *PLoS one*, 3(11), e3618.
- Chemaitelly, H., Majed, A., Abu-Hijleh, F., Blondeel, K., Matsaseng, T. C., Kiarie, J., Toskin, I., & Abu-Raddad, L. J. (2021). Global epidemiology of *Neisseria gonorrhoeae* in infertile populations: systematic review, meta-analysis and meta-regression. *Sexually transmitted infections*, 97(2), 157-169.
- Chen, H., Lou, G., Meng, F., Zhang, Y., Kuang, H., & Yang, D. (2026). Critical role of reproductive tract microbiota and derived metabolites in inflammation, tumor immunity, and tumorigenesis of gynecological cancers: a narrative review. *Frontiers in Immunology*, 17, 1734792.
- Chen, J., Chen, J., Fang, Y., Shen, Q., Zhao, K., Liu, C., & Zhang, H. (2023). Microbiology and immune mechanisms associated with male infertility. *Frontiers in Immunology*, 14, 1139450.
- Ciccarese, G., Serviddio, G., Herzum, A., & Drago, F. (2024). Antimicrobial resistance in genital mycoplasmas infections.
- Cohen, C., Mugo, N., Astete, S., Odonato, R., Manhart, L., Kiehlbauch, J., Stamm, W., Waiyaki, P., & Totten, P. (2005). Detection of *Mycoplasma genitalium* in women with laparoscopically diagnosed acute salpingitis. *Sexually transmitted infections*, 81(6), 463-466.
- Cutoiu, A., & Boda, D. (2024). An overview regarding the relationship between Mollicutes, infertility and antibiotic resistance. *Biomedical reports*, 21(2), 119.
- De Carvalho, N. S., Palu, G., & Witkin, S. S. (2020). *Mycoplasma genitalium*, a stealth female reproductive tract. *European Journal of Clinical Microbiology & Infectious Diseases*, 39(2), 229-234.
- Debatista, J., Timms, P., Allan, J., & Allan, J. (2003). Immunopathogenesis of *Chlamydia trachomatis* infections in women. *Fertility and sterility*, 79(6), 1273-1287.
- Durukan, D., Read, T. R., Murray, G., Doyle, M., Chow, E. P., Vodstrcil, L. A., Fairley, C. K., Aguirre, I., Mokany, E., & Tan, L. Y. (2020). Resistance-Guided Antimicrobial Therapy using doxycycline-moxifloxacin and doxycycline-2.5 g azithromycin for the treatment of *Mycoplasma genitalium* infection: Efficacy and tolerability. *Clinical Infectious Diseases*, 71(6), 1461-1468.
- Fernández-Huerta, M., Moure, Z., Torrecillas, M., Fidalgo, B., Fernández, I., Lagarejos, E., Trejo-Zahinos, J., Piñeiro, L., Serra-Pladevall, J., & Ando, N. (2025). Contribution of ParC-and GyrA-mutations to fluoroquinolone treatment failures in *Mycoplasma genitalium*: a systematized review. *Sexually Transmitted Diseases*, 10.1097.
- Fransasiak, J. M., & Scott Jr, R. T. (2015). Reproductive tract microbiome in assisted reproductive technologies. *Fertility and sterility*, 104(6), 1364-1371.
- France, M. T., Ma, B., Gajer, P., Brown, S., Humphrys, M. S., Holm, J. B., Waetjen, L. E., Brotman, R. M., & Ravel, J. (2020). VALENCIA: a nearest centroid classification method for vaginal microbial communities based on composition. *Microbiome*, 8(1), 166.
- Giacani, L., Bradshaw, C. S., Muzny, C. A., Graves, K. J., Pasricha, S., Jordan, S. J., & Allan-Blitz, L.-T. (2025). Antimicrobial resistance in curable sexually transmitted infections. *Current HIV/AIDS Reports*, 22(1), 14.
- Gootenberg, D. B., Mitchell, C. M., & Kwon, D. S. (2018). Cervicovaginal microbiota and reproductive health: the virtue of simplicity. *Cell host & microbe*, 23(2), 159-168.
- Graves, K. J., Novak, J., Secor, W. E., Kissinger, P. J., Schwelke, J. R., & Muzny, C. A. (2020). A systematic review of the literature on mechanisms of 5-nitroimidazole resistance in *Trichomonas vaginalis*. *Parasitology*, 147(13), 1383-1391.
- Hafner, L. M. (2015). Pathogenesis of fallopian tube damage caused by *Chlamydia trachomatis* infections. *Contraception*, 92(2), 108-115.
- Haggerty, C. L., Ness, R. B., Amortegui, A., Hendrix, S. L., Hillier, S. L., Holley, R. L., Peipert, J., Randall, H., Sondheim, S. J., & Soper, D. E. (2003). Endometritis does not predict reproductive morbidity after pelvic inflammatory disease. *American journal of obstetrics and gynecology*, 188(1), 141-148.
- Htaik, K., Vodstrcil, L. A., Plummer, E. L., Sfameni, A. M., Machalek, D. A., Manhart, L. E., & Bradshaw, C. S. (2026). Systematic review and meta-analysis of the association between *Mycoplasma genitalium* and pelvic inflammatory disease (PID). *Clinical Infectious Diseases*, 82(2), e371-e379.
- Huang, C., Zhu, H., Xu, K., Wang, S. Y., Fan, L., & Zhu, W. (2015). *Mycoplasma* and ureaplasma infection and male infertility: a systematic review and meta-analysis. *Andrology*, 3(5), 809-816.
- Jensen, J. S., & Bradshaw, C. (2015). Management of *Mycoplasma genitalium* infections—can we hit a moving target? *BMC infectious diseases*, 15(1), 343.
- Jensen, J. S., Bradshaw, C. S., Tabrizi, S. N., Fairley, C. K., & Hamasuna, R. (2008). Azithromycin treatment failure in *Mycoplasma genitalium*—positive patients with nongonococcal urethritis is associated with induced macrolide resistance. *Clinical Infectious Diseases*, 47(12), 1546-1553.
- Kadar, N. (2019). Rediscovering Ignaz Philipp Semmelweis (1818–1865). *American journal of obstetrics and gynecology*, 220(1), 26-39.
- Keikha, M., Hosseini-Nasab-Nodoushan, S.-A., & Sahebkar, A. (2023). Association between *Chlamydia trachomatis* infection and male infertility: a systematic review and meta-analysis. *Mini Reviews in Medicinal Chemistry*, 23(6), 746-755.
- Lewis, D. A. (2014). Global resistance of *Neisseria gonorrhoeae*: when theory becomes reality. *Current opinion in infectious diseases*, 27(1), 62-67.
- Li, Y., Su, X., Le, W., Li, S., Yang, Z., Chaisson, C., Madico, G., Gong, X., Reed, G. W., & Wang, B. (2020). *Mycoplasma genitalium* in symptomatic male urethritis: macrolide use is associated with increased resistance. *Clinical Infectious Diseases*, 70(5), 805-810.
- Ling, H., Luo, L., Dai, X., & Chen, H. (2022). Fallopian tubal infertility: The result of *Chlamydia trachomatis*-induced fallopian tubal fibrosis. *Molecular and Cellular Biochemistry*, 477(1), 205-212.
- Lis, R., Rowhani-Rahbar, A., & Manhart, L. E. (2015). *Mycoplasma genitalium* infection and female reproductive tract disease: a meta-analysis. *Clinical Infectious Diseases*, 61(3), 418-426.

19th International Conference on New Findings in Midwifery, Women, Maternity and Infertility (ICMWWMI 2026)

18 September 2026 -TBILISI GEORGIA

- Llaca-Díaz, J., & Casillas-Vega, N. (2026). Antimicrobial resistance in *Mycoplasma genitalium* and *Mycoplasma hominis*: a systematic review in urology. *Archives of Italian Urology & Andrology/Archivio Italiano di Urologia Andrologia*, 98(1), 1.
- Llangari, L. M., Zhou, L., Cooper, P. J., Rodas, A. L., Sandoval, N. R., & Sadiq, S. (2020). Single gene targeted nanopore sequencing enables simultaneous identification and antimicrobial resistance detection of sexually transmitted infections.
- Ma, B., Forney, L. J., & Ravel, J. (2012). Vaginal microbiome: rethinking health and disease. *Annual review of microbiology*, 66(1), 371-389.
- Ma, C., Du, J., Dou, Y., Chen, R., Li, Y., Zhao, L., Liu, H., & Zhang, K. (2021). The associations of genital mycoplasmas with female infertility and adverse pregnancy outcomes: a systematic review and meta-analysis. *Reproductive Sciences*, 28(11), 3013-3031.
- Manhart, L. E. (2013). *Mycoplasma genitalium*: an emergent sexually transmitted disease? *Infectious Disease Clinics*, 27(4), 779-792.
- Manhart, L. E., Broad, J. M., & Golden, M. R. (2011). *Mycoplasma genitalium*: should we treat and how? *Clinical Infectious Diseases*, 53(suppl_3), S129-S142.
- Manhart, L. E., Gillespie, C. W., Lowens, M. S., Khosropour, C. M., Colombara, D. V., Golden, M. R., Hakhu, N. R., Thomas, K. K., Hughes, J. P., & Jensen, N. L. (2013). Standard treatment regimens for nongonococcal urethritis have similar but declining cure rates: a randomized controlled trial. *Clinical Infectious Diseases*, 56(7), 934-942.
- Manhart, L. E., Holmes, K. K., Hughes, J. P., Houston, L. S., & Totten, P. A. (2007). *Mycoplasma genitalium* among young adults in the United States: an emerging sexually transmitted infection. *American Journal of Public Health*, 97(6), 1118-1125.
- Marques-Silva, M., Lisboa, C., Gomes, N., & Rodrigues, A. (2021). *Trichomonas vaginalis* and growing concern over drug resistance: a systematic review. *Journal of the European Academy of Dermatology and Venereology*, 35(10), 2007-2021.
- Marsh, M. (2017). Guilt, blame, litigation and training. In (Vol. 124, pp. 539-540): Wiley Online Library.
- Mayr, A.-L., Paunkov, A., Hummel, K., Razzazi-Fazeli, E., & Leitsch, D. (2024). Comparative proteomic analysis of metronidazole-sensitive and resistant *Trichomonas vaginalis* suggests a novel mode of metronidazole action and resistance. *International Journal for Parasitology: Drugs and Drug Resistance*, 26, 100566.
- Melendez, J. H., Edwards, V. L., Muniz Tirado, A., Hardick, J., Mehta, A., Aluvathingal, J., D'Mello, A., Gaydos, C. A., Manabe, Y. C., & Tettelin, H. (2024). Local emergence and global evolution of *Neisseria gonorrhoeae* with high-level resistance to azithromycin. *Antimicrobial agents and chemotherapy*, 68(12), e00927-00924.
- Miari, V. F., Bonnin, W., Smith, I. K., Horney, M. F., Saint-Geris, S. J., & Stabler, R. A. (2024). Carriage and antimicrobial susceptibility of commensal *Neisseria* species from the human oropharynx. *Scientific reports*, 14(1), 25017.
- Mielczarek, E., & Blaskowska, J. (2016). *Trichomonas vaginalis*: pathogenicity and potential role in human reproductive failure. *Infection*, 44(4), 447-458.
- Moreno, I., & Simon, C. (2018). Relevance of assessing the uterine microbiota in infertility. *Fertility and sterility*, 110(3), 337-343.
- Muzny, C. A., Taylor, C. M., Swords, W. E., Tamhane, A., Chattopadhyay, D., Cerca, N., & Schwabe, J. R. (2019). An updated conceptual model on the pathogenesis of bacterial vaginosis. *The Journal of Infectious Diseases*, 220(9), 1399-1405.
- Onofrio, I., & McLennan, C. A. (2026). *Neisseria gonorrhoeae*: mechanisms of immune evasion, antimicrobial resistance, and vaccine development challenges. *Frontiers in Microbiology*, 17, 1824540.
- Ouyang, Y., Zhang, Y., Long, Z., Wu, X., Li, N., Liu, X., Lin, J., Niu, Y., Chen, J., & Tang, J. Drug resistance of *Mycoplasma genitalium*: mechanism and regional distribution. *Frontiers in Cellular and Infection Microbiology*, 16, 1789671.
- Petrova, M. I., Lievens, E., Malik, S., Imholz, N., & Lebeer, S. (2015). *Lactobacillus* species as biomarkers and agents that can promote various aspects of vaginal health. *Frontiers in physiology*, 6, 81.
- Peumans, M., Meerbeek, B. V., Lambrechts, P., & Vanherle, G. (1997). The 5-year clinical performance of direct composite additions to correct tooth form and position: I. Esthetic qualities. *Clinical oral investigations*, 1(1), 12-18.
- Quillin, S. J., & Seifert, H. S. (2018). *Neisseria gonorrhoeae* host adaptation and pathogenesis. *Nature reviews microbiology*, 16(4), 226-240.
- Rasoloson, D., Vanacova, S., Tomkova, E., Razga, J., Hrdy, I., Tachezy, J., & Kulda, J. (2002). Mechanisms of in vitro development of resistance to metronidazole in *Trichomonas vaginalis*. *Microbiology*, 148(8), 2467-2477.
- Ravel, J., Gajer, P., Abdo, Z., Schneider, G. M., Koenig, S. S., McCulle, S. L., Karlebach, S., Gorle, R., Russell, J., & Tacket, C. O. (2011). Vaginal microbiome of reproductive-age women. *Proceedings of the National Academy of Sciences*, 108(supplement_1), 4680-4687.
- Rivero, M.-J., Kulkarni, N., Thirumavalavan, N., & Ramasamy, R. (2023). Evaluation and management of male genital tract infections in the setting of male infertility: an updated review. *Current opinion in urology*, 33(3), 180.
- Rodgers, A. K., Budrys, N. M., Gong, S., Wang, J., Holden, A., Schenken, R. S., & Zhong, G. (2011). Genome-wide identification of *Chlamydia trachomatis* antigens associated with tubal factor infertility. *Fertility and sterility*, 96(3), 715-721.
- Rodrigues, R., Sousa, C., Barros, A., & Vale, N. (2025). *Chlamydia trachomatis*: from urogenital infections to the pathway of infertility. *Genes*, 16(2), 205.
- Salmerón Menéndez, P. (2024). Estudio sobre la infección por *Neisseria gonorrhoeae* en España: sensibilidad antibiótica y dinámica poblacional.
- Sánchez-Busó, L., Golparian, D., Corander, J., Grad, Y. H., Ohnishi, M., Flemming, R., Parkhill, J., Bentley, S. D., Unemo, M., & Harris, S. R. (2019). The impact of antimicrobials on gonococcal evolution. *Nature microbiology*, 4(11), 1941-1950.
- Sawatzky, P., Demczuk, W., Lefebvre, B., Allen, V., Diggle, M., Hoang, L., Van Caesele, P., Haldane, D., Minion, J., & Mulvey, M. R. (2022). Increasing azithromycin resistance in *Neisseria gonorrhoeae* due to NG-MAST 12302 clonal spread in Canada, 2015 to 2018. *Antimicrobial agents and chemotherapy*, 66(3), e01688-01621.
- Sethi, S., Zaman, K., & Jain, N. (2017). *Mycoplasma genitalium* infections: current treatment options and resistance issues. *Infection and drug resistance*, 283-292.
- Shaskolskiy, B., Dementieva, E., Leinsso, A., Runina, A., Vorobyev, D., Plakhova, X., Kubanov, A., Deryabin, D., & Gryadunov, D. (2016). Drug resistance mechanisms in bacteria causing sexually transmitted diseases and associated with vaginosis. *Frontiers in Microbiology*, 7, 747.
- Smolarczyk, K., Mlynarczyk-Bonikowska, B., Rudnicka, E., Szukiewicz, D., Meczekalski, B., Smolarczyk, R., & Pieta, W. (2021). The impact of selected bacterial sexually transmitted diseases on pregnancy and female fertility. *International journal of molecular sciences*, 22(4), 2170.
- Srinivasan, S., Hoffman, N. G., Morgan, M. T., Matsen, F. A., Fiedler, T. L., Hall, R. W., Ross, F. J., McCoy, C. O., Bumgarner, R., & Marrazzo, J. M. (2012). Bacterial communities in women with bacterial vaginosis: high resolution phylogenetic analyses reveal relationships of microbiota to clinical criteria. *PloS one*, 7(6), e37818.
- Svenstrup, H. F., Fedder, J., Kristoffersen, S. E., Trolle, B., Birkelund, S., & Christiansen, G. (2008). *Mycoplasma genitalium*, *Chlamydia trachomatis*, and tubal factor infertility—a prospective study. *Fertility and sterility*, 90(3), 513-520.
- Taylor-Robinson, D., & Jensen, J. S. (2011). *Mycoplasma genitalium*: from Chrysalis to multicolored butterfly. *Clinical microbiology reviews*, 24(3), 498-514.
- Taylor, B. D., Darville, T., & Haggerty, C. L. (2013). Does bacterial vaginosis cause pelvic inflammatory disease? *Sexually Transmitted Diseases*, 40(2), 117-122.
- Tsevat, D. G., Wiesenfeld, H. C., Parks, C., & Peipert, J. F. (2017). Sexually transmitted diseases and infertility. *American journal of obstetrics and gynecology*, 216(1), 1-9.
- Unemo, M., Clarke, E., Boiko, I., Patel, C., Patel, R., & Group, E. C. (2020). Adherence to the 2012 European Gonorrhoea guideline in the WHO European region according to the 2018–19 international union against sexually transmitted infections European collaborative clinical group Gonorrhoea survey. *International journal of STD & AIDS*, 31(1), 69-76.
- Unemo, M., Lahra, M., Cole, M., Marcano Zamora, D., Jacobsson, S., Galarza, P., Martin, I., Kreisel, K., Galas, M., & Bertagnolio, S. WHO Global Gonococcal Antimicrobial Surveillance Programme Reports High Resistance to the Last Gonorrhoea Treatment Options, 2019-22: A Retrospective Observational Study.
- Unemo, M., Lahra, M., Cole, M., Galarza, P., Ndowa, F., Martin, I., Dillon, J.-A. R., Ramon-Pardo, P., Bolan, G., & Wi, T. (2019). World Health Organization Global Gonococcal Antimicrobial Surveillance Program (WHO GASP): review of new data and evidence to inform international collaborative actions and research efforts. *Sexual health*, 16(5), 412-425.
- Unemo, M., Lahra, M., Cole, M., J. Zamora, D. M., Jacobsson, S., Galarza, P., Martin, I., Kreisel, K. M., Galas, M., & Bertagnolio, S. (2025). WHO global gonococcal antimicrobial surveillance programmes, 2019–22: a retrospective observational study. *The Lancet Microbe*, 6(10).
- Unemo, M., Lahra, M. M., Escher, M., Eremin, S., Cole, M. J., Galarza, P., Ndowa, F., Martin, I., Dillon, J.-A. R., & Galas, M. (2021). WHO global antimicrobial resistance surveillance for *Neisseria gonorrhoeae* 2017–18: a retrospective observational study. *The Lancet Microbe*, 2(11), e627-e636.
- Unemo, M., Ross, J., Serwin, A., Gomberg, M., Cusini, M., & Jensen, J. S. (2021). Background review for the '2020 European guideline for the diagnosis and treatment of gonorrhoea in adults'. *International journal of STD & AIDS*, 32(2), 108-126.
- Unemo, M., Seifert, H. S., Hook III, E. W., Hawkes, S., Ndowa, F., & Dillon, J.-A. R. (2019). Gonorrhoea. *Nature reviews Disease primers*, 5(1), 79.
- Unemo, M., & Shafer, W. M. (2014). Antimicrobial resistance in *Neisseria gonorrhoeae* in the 21st century: past, evolution, and future. *Clinical microbiology reviews*, 27(3), 587-613.
- Venneri, M., Franceschini, E., Sciarra, F., Rosato, E., D'etorre, G., & Lenzi, A. (2022). Human genital tracts microbiota: dysbiosis crucial for infertility. *Journal of Endocrinological Investigation*, 45(6), 1151-1160.
- Waites, K. B., Xiao, L., Atkinson, T. P., & Geisler, W. M. (2026). The Role of Antimicrobial Susceptibility and Resistance Testing for *Mycoplasma genitalium* in Clinical Care. *Open Forum Infectious Diseases*.
- Wi, T., Lahra, M. M., Ndowa, F., Bala, M., Dillon, J.-A. R., Ramon-Pardo, P., Eremin, S. R., Bolan, G., & Unemo, M. (2017). Antimicrobial resistance in *Neisseria gonorrhoeae*: global surveillance and a call for international collaborative action. *PloS medicine*, 14(7), e1002344.
- Wiesenfeld, H. C., Hillier, S. L., Meyn, L. A., Amortegui, A. J., & Sweet, R. L. (2012). Subclinical pelvic inflammatory disease and infertility. *Obstetrics & Gynecology*, 120(1), 37-43.
- Witkin, S., Kligman, I., & Bongiovanni, A. (1995). Relationship between an asymptomatic male genital tract exposure to *Chlamydia trachomatis* and an autoimmune response to spermatozoa. *Human reproduction*, 10(11), 2952-2955.
- Workowski, K. A., Bachmann, L. H., Chan, P. A., Johnston, C. M., Muzny, C. A., Park, I., Reno, H., Zenilman, J. M., & Bolan, G. A. (2021). Sexually transmitted infections treatment guidelines, 2021. *MMWR. Morbidity and Mortality Weekly Report. Recommendations and Reports*, 70(4), 1.
- Workowski, K. A., & Bolan, G. A. (2015). Sexually transmitted diseases treatment guidelines, 2015. *MMWR. Morbidity and Mortality Weekly Report. Recommendations and Reports*, 64(3), 1.
- Yahara, K., Nakayama, S.-I., Shimuta, K., Lee, K.-I., Morita, M., Kawahata, T., Kuroki, T., Watanabe, Y., Ohya, H., & Yasuda, M. (2018a). Corrigendum: Genomic surveillance of *Neisseria gonorrhoeae* to investigate the distribution and evolution of antimicrobial-resistance determinants and lineages. *Microbial genomics*, 4(9), e000215.
- Yahara, K., Nakayama, S.-I., Shimuta, K., Lee, K.-I., Morita, M., Kawahata, T., Kuroki, T., Watanabe, Y., Ohya, H., & Yasuda, M. (2018b). Genomic surveillance of *Neisseria gonorrhoeae* to investigate the distribution and evolution of antimicrobial-resistance determinants and lineages. *Microbial genomics*, 4(8), e000205.
- Yu, J., Zhou, Y., Luo, H., Su, X., Gan, T., Wang, J., Ye, Z., Deng, Z., & He, J. (2023). *Mycoplasma genitalium* infection in the female reproductive system: Diseases and treatment. *Frontiers in Microbiology*, 14, 1098276.
- Zhang, Z., Li, Y., Lu, H., Li, D., Zhang, R., Xie, X., Guo, L., Hao, L., Tian, X., & Yang, Z. (2022). A systematic review of the correlation between *Trichomonas vaginalis* infection and infertility. *Acta tropica*, 236, 106693.