Title

**Association Between the Microbiome and Female Infertility: A Narrative Review**

Running titles

**Microbiome and Female Infertility**

Somayeh Sadeghi [[1]](#footnote-1)\*, Seyed Mohammad Hossein Navabian ghamsari[[2]](#footnote-2), Sana Azizian[[3]](#footnote-3) , Azam Goodarzi PhD4

**1.** Assistant professor of obstetrics and gynecology, Medicine Faculty, University of Tehran, Tehran, Iran.

**2**. Student Research Committee, Medicine Faculty, Tehran Medical Sciences, Islamic Azad University, Tehran, Iran

**3**. Interventional Cardiology Research Center, Cardiovascular Research Institute, Isfahan University of Medical Sciences, Isfahan, Iran

**4.** Department of Health Education and Promotion, Tarbiat Modares University, Tehran, Iran

\* Corresponding Author: Somayeh Sadeghi (MD), Assistant professor of obstetrics and gynecology, Medicine Faculty, University of Tehran, Tehran, Iran. (Email: Dr.ssadeghi1361@gmail.com). Fax: +982188839085

**Abstract**

Infertility in women is influenced by a complex interplay of factors, including hormonal imbalances, infections, and lifestyle habits. Estrogen, a key hormone in female reproductive health, is pivotal in these processes. The microbiome, particularly *Lactobacillus* species, has been associated with improved outcomes in in vitro fertilization (IVF). Furthermore, alterations in both vaginal and gut microbiota can impact reproductive health and increase the risk of pregnancy complications. Recent research has highlighted the significant influence of gut microbes on behavioral, metabolic, and immune functions. This narrative review aims to explore the relationship between the microbiome and infertility in women. A comprehensive literature search was conducted using PubMed/MEDLINE, Scopus, and Embase databases, focusing on full-text original research articles published in English from 2000 to 2024. The search terms included "microbiota," "microbiome," "fertility," and "infertility."Our findings suggest that the gut microbiome and its enzymatic activity, specifically β-glucuronidase, can influence estrogen levels, potentially leading to conditions characterized by estrogen excess or deficiency. Additionally, gut microbiota may contribute to endometriosis, pelvic pain, and infertility through hormonal imbalances. The genital microbiome, particularly the abundance of *Lactobacillus* species, has also been implicated in female infertility and protection against bacterial vaginosis. The presence of *Chlamydia trachomatis* and *Gardnerella vaginalis*, as well as a deficiency of *Lactobacillus*, has been linked to infertility.

Keywords: Microbiome, Female, Infertility

**Introduction**

Infertility, defined as the inability to conceive after one year of well-timed unprotected sexual intercourse, presents a significant reproductive challenge. Research indicates that the fecundability rate, or the likelihood of becoming pregnant, is approximately 25% in the initial three months of unprotected intercourse, gradually decreasing to 15% over the subsequent nine months. A substantial majority of women (85%) are likely to conceive within a year, facilitating the understanding of normal pregnancy rates and the diagnosis of infertility(1).

Factors contributing to infertility include hormonal imbalances, infections, and lifestyle habits (2). Estrogen, a crucial hormone in female reproductive health, regulates the menstrual cycle and prepares the body for pregnancy. Abnormal estrogen levels can disrupt fertility. Fluctuations in estrogen receptor β expression and hormone concentrations are essential throughout an organism's lifespan. The intestinal microbiota also plays a significant role in estrogen metabolism, and antibiotic use can lead to decreased estrogen levels (3).

Research suggests that the microbiome influences infertility treatment, with *Lactobacillus* species being associated with improved IVF outcomes, such as implantation and pregnancy (4). Alterations in the vaginal and endometrial microbiomes have been linked to various gynecological issues (5, 6). In healthy women, the vaginal microbiota is predominantly composed of *Lactobacillus* species, which help to maintain a balanced pH, prevent the attachment of harmful microorganisms, and release antimicrobial substances (7). The endometrial microbiota differs from the vaginal microbiota (8). The endometrial microbiome exhibits lower diversity compared to the vaginal microbiome (9).

The gut microbiota functions as an endocrine organ, interacting with hormones such as estrogens, androgens, and insulin, and influencing the reproductive endocrine system in women(10). Changes in the composition of the gut microbiota can lead to pregnancy complications, adverse outcomes, polycystic ovary syndrome (PCOS), endometriosis, and certain cancers(11). While research in this area is limited, further investigation is necessary to comprehend the underlying causes and mechanisms of microbiota-related hormone-mediated diseases and develop effective treatments (12).

The human gut microbiome harbors a vast amount of genetic information, with the quantity of bacteria comparable to human cells and genetic material 150 times more abundant than the human genome (13). Recent studies suggest that gut microbes function as an additional organ, influencing physiological functions. Factors such as diet, genetics, and hormones shape the diversity of the gut microbiome(14). Sex hormones, including progesterone, estradiol, and testosterone, play a role in the interactions between microorganisms and their hosts, impacting various physiological processes (15). Commensal bacteria can influence host metabolism, immune responses, and behavior through the production of hormones(16).

The human microbiome plays a crucial role in all aspects of female reproduction, from follicle development to pregnancy and childbirth. Imbalances in the microbiome, particularly in the gut, can impact the reproductive endocrine system and may be amenable to interventions to improve reproductive outcomes (17). Studies have identified a connection between gut microbiota and hormone levels, influencing overall health and leading to the concept of the "microgenderome." Certain intestinal bacteria may also be associated with female health issues (18).

By elucidating the intricate relationship between the microbiome and female infertility, this review aims to contribute to a deeper understanding of this complex reproductive health issue. This knowledge may ultimately lead to the development of novel therapeutic strategies tailored to the specific microbial composition of individuals, potentially improving infertility outcomes.

**Methodology**

To conduct a comprehensive literature review on the association between the microbiome and female infertility, a systematic search was performed across three major databases: PubMed/MEDLINE, Scopus, and Embase. The search strategy was carefully refined for each database to optimize results. Additionally, the references of included studies were manually screened to identify additional relevant articles.

The final search was conducted in August 2024, focusing on articles published between 2000 and 2024. Only original research articles written in English were considered eligible for inclusion. Reviews, editorials, opinions or letters, case studies, conference papers, and abstracts were excluded.

The review aimed to address the following research questions:

1. What is the role of the microbiome in female infertility?
2. How do the gut microbiome and reproductive system interact to influence women's infertility?
3. What are the mechanisms underlying the effects of genital tract microbiomes on infertility in women?

The last search was conducted in August 2024 and was limited to articles published between 2000 and 2024. Only full-text original research articles written in English were considered eligible for analysis, while reviews, editorials, opinions or letters, case studies, conference papers, and abstracts were excluded. This study was conducted to ask the following questions: 1 What is the role of the microbiome in Female infertility? 2-How do the gut microbiome and reproductive system affect women's infertility? 3-What is the mechanism of the effect of Genital Tract microbiomes on infertility in women? Methodology to conduct a comprehensive literature review on the association between the microbiome and female infertility, a systematic search was performed across three major databases: PubMed/MEDLINE, Scopus and Embase. The search strategy was carefully refined for each database to optimize results. Additionally, the references of included studies were manually screened to identify additional

The search strategy details are presented in a summarized format in Table 1.

**Table1**

|  |  |  |
| --- | --- | --- |
| Search Strategy | Number of Studies Obtained | Database |
| (Microbiota / microbiot / Gut microbiome/ Vaginal Microbiome ) AND (Infertility/fertility) | 153 | Scopus |
| (Microbiota / microbiot / Gut microbiome/ Vaginal Microbiome ) AND (Infertility/fertility) | 201 |

|  |
| --- |
| PubMed/MEDLINE |

 |
| (Microbiota / microbiot / Gut microbiome/ Vaginal Microbiome ) AND (Infertility/fertility) | 68 | Embase |

**Result**

**The Microbiome and Female Infertility**

Research has identified gender-specific differences in the gut microbiome (19). The composition of the gut microbiome in women is notably distinct from that of men (20). A study on aging revealed that women exhibit greater gut microbiome diversity than men in younger adulthood, although this difference diminishes in older adulthood. This observation suggests that sex-related variations in microbiome aging may be associated with menopause (21).

The female reproductive system, consisting of the vagina, cervix, and uterus, harbors a unique and active microbial community that is believed to play a crucial role in maintaining reproductive health(22). Imbalances in this intricate ecosystem, known as dysbiosis, have been linked to various reproductive issues, including implantation difficulties, recurrent miscarriages, and infertility(23). Recent evidence suggests that microorganisms are present not only in the vagina but also throughout the upper female reproductive system, including the ovaries, Fallopian tubes, and uterus, which were previously considered sterile environments (24).

Findings indicate that changes in the microbiome of the female reproductive system may contribute significantly to the development of infertility (25). *Lactobacillus* has been identified as the dominant genus present throughout the female reproductive system (26). These resident microorganisms play a vital role in maintaining health, and alterations in their composition have been associated with various gynecological disorders (27). Research suggests that *Lactobacilli* provide protection against pathogen invasion, while dysbiosis has been linked to conditions such as chronic endometritis, endometriosis, pelvic inflammatory disease, and gynecological cancers (28). Furthermore, multiple studies have established a positive association between the presence of certain bacteria in the uterus and the development of pelvic inflammatory disease, an inflammation of the upper genital tract that may lead to infertility (29). Elna et al. found that the microbiome of the reproductive tract in women with endometriosis differs from that of women experiencing infertility due to other factors (30).

**The Role of the Gut Microbiome in Estrogen Regulation and Infertility**

The gut microbiota is influenced by circadian rhythms regulated by environmental cues, including day and night cycles. This regulation affects the microbiota's behavior and metabolite secretion, impacting host homeostasis(31). Recent studies suggest that the gut microbiota also contributes to the development of the reproductive system, affecting sexual maturation in both males and females(32). Metabolites like secondary bile acids and indole, as well as estrogenic properties of soybean, play a role in this process (33).

The gut microbiota is influenced by estrogens and also plays a role in modulating estrogen levels. Estrogens serve as a key regulator of the gut microbiome, and the collection of genes within the gut microbiota that can metabolize estrogens is referred to as the "estrobolome" (34). Estrogen receptor β (ERβ) and serum levels of steroid hormones, particularly estradiol, fluctuate throughout a person's life. The regulation of estrogen is crucial for women's health(35).

Intestinal microbiota significantly influences estrogen metabolism. Antibiotic use can reduce estrogen levels(36). Microbial β-glucuronidase converts estrogens from their conjugated forms to their active deconjugated forms. Dysbiosis and decreased gut microbiota diversity can diminish β-glucuronidase activity, resulting in lower deconjugation of estrogen and phytoestrogens into their active circulating forms (37). Reduced estrogen levels can disrupt estrogen receptor activation, potentially leading to conditions associated with excess estrogen. An increase in β-glucuronidase-producing bacteria may elevate circulating estrogen levels, contributing to diseases like endometriosis and cancer (38). Estrogen levels can influence various health conditions, including polycystic ovary syndrome (PCOS), endometrial hyperplasia, and fertility. Research indicates that certain bacterial orders and specific phyla vary according to ERβ status, highlighting the potential impact of steroid nuclear receptor status and dietary complexity on microbiota composition (39). Additionally, a negative correlation exists between alpha diversity and estradiol concentrations. New research suggests that the gut microbiome is important for 17β-estradiol's protective effects against metabolic endotoxemia and chronic inflammation (40).

Changes in gut microbial composition and β-glucuronidase activity may lead to disruptions in estrogen levels, potentially causing hyper- or hypo-estrogenic states and conditions influenced by estrogen. The microbiota could contribute to the onset of endometriosis, chronic pelvic pain, and infertility by promoting inflammation and hormonal imbalances through the estrobolome. The estrobolome, which affects various cellular processes, remains relatively unexplored, but researching it could provide insights into future strategies and treatments for endometriosis and estrogen-related conditions (41).

Uterus Microbiome

Various studies have demonstrated the presence of distinct microbial communities in female reproductive organs, which are crucial for normal function and the prevention of infections (42, 43). More recent research has recognized the existence of a unique uterine microbiome. Although the uterine microbiome is less dense than the vaginal microbiome, it is believed to play a critical role in reproductive outcomes, such as implantation rates and preterm birth(44). The human microbiome is the diverse community of microorganisms in our bodies. The Human Microbiome Project has advanced our understanding of microbiota in different body sites, but the criteria for a healthy bacterial composition in the uterus remain a subject of debate(45) .

Traditional beliefs that the uterine cavity was devoid of microorganisms have been challenged by advanced technologies. Studies suggest that the uterus may be colonized from the gut, oral cavity, bloodstream, or through vaginal ascent. Additionally, procedures like assisted reproductive technology and contraceptive device insertion may contribute to uterine microbiome seeding (46). The uterine microbiome is less populated compared to the lower genital tract, and its complete composition is not fully understood(47).

An evaluation of the upper genital tract (UGT) using endometrial swabs from 58 women who had hysterectomies for non-cancer reasons found that 95% had UGT colonization. High levels of L. iners, Prevotella spp., and L. crispatus were predominant. Endometrial fluid (EF) samples from fertile women showed a significant presence of Lactobacillus. Two distinct bacterial compositions were proposed: Lactobacillus-dominant (LD) and non-LD (NLD), with other genera identified, including Bifidobacterium, Gardnerella, Prevotella, and Streptococcus(48).

The significance of the endometrial microbiota at the beginning of pregnancy is of great interest in reproductive medicine(49). Understanding what constitutes a healthy uterine environment and how to achieve it would benefit women undergoing IVF as well as those trying to conceive naturally(50) . Research suggests that changes in the endometrial microbiome can affect the fertility of infertile individuals, and treating microbial imbalances could improve success rates. Uterine infections can contribute to infertility by causing inflammation and immune responses that interfere with embryo implantation and a successful pregnancy. Recognizing endometrial dysbiosis as a potential cause of infertility highlights the importance of evaluating uterine microbiota in infertile patients and aiming to restore a healthy balance to improve care for those facing infertility challenges(51).

**Vaginal Microbiome**

Maintaining a healthy female genital tract requires a delicate balance of microbiota, metabolites, and immune factors. The vaginal microbiota is primarily composed of *Lactobacillus* species, with four main types: *L. crispatus*, *L. iners*, *L. jensenii*, and *L. gasseri* (52). A dysbiotic vaginal microbiome (VMB) is characterized by a decrease in *Lactobacillus* prevalence and an increase in anaerobic bacteria such as *Prevotella*, *Mobiluncus*, *Gardnerella*, *Ureaplasma*, and *Mycoplasma*(53) .

This dysbiotic state poses a significant risk for the development of bacterial vaginosis, an inflammatory condition that can negatively affect fertility through various mechanisms. These mechanisms include increased susceptibility to sexually transmitted infections (STIs) like *Chlamydia*, *Neisseria*, and *Trichomonas*, as well as viral infections such as human papillomavirus (HPV) and human immunodeficiency virus (HIV) (54). A dysbiotic VMB is also linked to adverse pregnancy outcomes, such as preterm delivery, maternal infectious morbidity, and late miscarriage (55).

VMB dysbiosis affects IVF success. Patients without bacterial contamination have higher pregnancy rates. Low *Lactobacillus* levels predict poor outcomes, while *Lactobacillus iners* is associated with successful IVF and vaginal health (56).

**Conclusion**

Alterations in the composition of gut microbes and the activity of β-glucuronidase can disrupt estrogen levels, leading to conditions characterized by either estrogen excess or deficiency. The gut microbiota may contribute to the development of endometriosis, chronic pelvic pain, and infertility by promoting inflammation and hormonal imbalances through the estrobolome.

Research indicates that the genital microbiome plays a significant role in women experiencing infertility. The interplay among different *Lactobacillus* species is crucial for maintaining a healthy vaginal microbiome. Adequate levels of *Lactobacillus crispatus* serve as a protective factor against asymptomatic bacterial vaginosis (BV), which is often caused by *Ureaplasma* and *Gardnerella vaginalis* and can negatively affect fertility. Furthermore, the presence of Gram-negative bacteria, such as *Chlamydia trachomatis* and *Gardnerella vaginalis*, along with a lack of *Lactobacillus* in the cervical flora, is associated with infertility. Interestingly, *Gardnerella vaginalis* has also been found in the endometrium of infertile women.

**Funding**

The work was not supported by any fund/grant.

**Institutional Review Board Statement**

This article does not contain any studies with human participants or animals performed by any of the authors.

**Informed Consent Statement**

Informed consent is not required for this type of study.

**Data Availability Statement**

The data presented in this study are available on request from the corresponding author.

**Conflicts of Interest**

The authors declare that they have no conflict of interest.

**References**

1. Hasan Z, Netherland M, Hasan NA, Begum N, Yasmin M, Ahmed S. An insight into the vaginal microbiome of infertile women in Bangladesh using metagenomic approach. Frontiers in Cellular and Infection Microbiology. 2024;14:1390088.

2. Foteinidou P, Exindari M, Chatzidimitriou D, Gioula G. Endometrial Microbiome and Its Correlation to Female Infertility: A Systematic Review and Meta-Analysis. Acta Microbiologica Hellenica. 2024;69(1):14-28.

3. Kandari S. A Review on the Role of Endometrial Microbiome in Reproductive Pathologies Affecting Female Infertility. Fertility Science & Research. 2024;11(1).

4. Sun N. The implication of the vaginal microbiome in female infertility and assisted conception outcomes. 2024.

5. Chopra C, Kumar V, Kumar M, Bhushan I. Role of vaginal microbiota in idiopathic infertility: a prospective study. Microbes and Infection. 2024;26(4):105308.

6. Sharma A, Singh R. Microbiome Testing in Female Infertility. Genetic Testing in Reproductive Medicine: Springer; 2024. p. 133-44.

7. van den Tweel M, van den Munckhof E, van der Zanden M, Molijn A, van Lith J, Boers K. The Vaginal Microbiome Changes During Various Fertility Treatments. Reproductive Sciences. 2024:1-8.

8. Cortés-Ortíz IA, Acosta-Altamirano G, Nambo-Venegas R, Pineda-Migranas JA, Ríos-Hernández OG, García-Moncada E, et al. Vaginal Dysbiosis in Infertility: A Comparative Analysis Between Women with Primary and Secondary Infertility. Microorganisms. 2025;13(1):188.

9. Feijoo CL, Arias AG, García-Velasco JA. Impact of the microbiome in fertility. Handbook of Current and Novel Protocols for the Treatment of Infertility: Elsevier; 2024. p. 313-23.

10. Gao X, Louwers YV, Laven JS, Schoenmakers S. Clinical relevance of vaginal and endometrial microbiome investigation in women with repeated implantation failure and recurrent pregnancy loss. International Journal of Molecular Sciences. 2024;25(1):622.

11. Chudzicka-Strugała I, Gołębiewska I, Banaszewska B, Trzciński M, Brudecki G, Elamin W, et al. Bacterial Vaginosis (BV) and Vaginal Microbiome Disorders in Women Suffering from Polycystic Ovary Syndrome (PCOS). Diagnostics. 2024;14(4):404.

12. Mueller RC, Gehring CA. Women in Environmental Microbiomes. Frontiers in Microbiomes.4:1537069.

13. Bielfeld AP, Baston-Buest DM, Edimiris P, Kruessel J-S. Effect of Waiting Period on Initial Adverse Vaginal Microbiome Composition in IVF-ICSI Patients. Journal of Clinical Medicine. 2024;13(17):5024.

14. Bhattacharya K, Dutta S, Sengupta P, Bagchi S. Reproductive tract microbiome and therapeutics of infertility. Middle East Fertility Society Journal. 2023;28(1):11.

15. Patel N, Patel N, Pal S, Nathani N, Pandit R, Patel M, et al. Distinct gut and vaginal microbiota profile in women with recurrent implantation failure and unexplained infertility. BMC Women's Health. 2022;22(1):113.

16. Sehring J, Beltsos A, Jeelani R. Human implantation: The complex interplay between endometrial receptivity, inflammation, and the microbiome. Placenta. 2022;117:179-86.

17. Günther V, Allahqoli L, Watrowski R, Maass N, Ackermann J, von Otte S, et al. Vaginal microbiome in reproductive medicine. Diagnostics. 2022;12(8):1948.

18. Diaz-Martínez MdC, Bernabeu A, Lledó B, Carratalá-Munuera C, Quesada JA, Lozano FM, et al. Impact of the vaginal and endometrial microbiome pattern on assisted reproduction outcomes. Journal of Clinical Medicine. 2021;10(18):4063.

19. Punzón-Jiménez P, Labarta E. The impact of the female genital tract microbiome in women health and reproduction: a review. Journal of assisted reproduction and genetics. 2021;38(10):2519-41.

20. Tsonis O, Gkrozou F, Paschopoulos M. Microbiome affecting reproductive outcome in ARTs. Journal of Gynecology Obstetrics and Human Reproduction. 2021;50(3):102036.

21. Saraf VS, Sheikh SA, Ahmad A, Gillevet PM, Bokhari H, Javed S. Vaginal microbiome: normalcy vs dysbiosis. Archives of microbiology. 2021;203:3793-802.

22. Ventolini G, Vieira-Baptista P, De Seta F, Verstraelen H, Lonnee-Hoffmann R, Lev-Sagie A. The vaginal microbiome: IV. The role of vaginal microbiome in reproduction and in gynecologic cancers. Journal of Lower Genital Tract Disease. 2022;26(1):93-8.

23. Lozano FM, Lledó B, Morales R, Cascales A, Hortal M, Bernabeu A, et al. Characterization of the endometrial microbiome in patients with recurrent implantation failure. Microorganisms. 2023;11(3):741.

24. Okwelogu SI, Ikechebelu JI, Agbakoba NR, Anukam KC. Microbiome compositions from infertile couples seeking in vitro fertilization, using 16S rRNA gene sequencing methods: any correlation to clinical outcomes? Frontiers in cellular and infection microbiology. 2021;11:709372.

25. de Souza SV, Monteiro PB, de Moura GA, Santos NO, Fontanezi CTB, de Almeida Gomes I, et al. Vaginal microbioma and the presence of Lactobacillus spp. as interferences in female fertility: A review system. JBRA Assisted Reproduction. 2023;27(3):496.

26. Lebedeva OP, Popov VN, Syromyatnikov MY, Starkova NN, Maslov AY, Kozarenko ON, et al. Female reproductive tract microbiome and early miscarriages. Apmis. 2023;131(2):61-76.

27. Moreno I, Garcia-Grau I, Perez-Villaroya D, Gonzalez-Monfort M, Bahçeci M, Barrionuevo MJ, et al. Endometrial microbiota composition is associated with reproductive outcome in infertile patients. Microbiome. 2022;10:1-17.

28. Chen H, Wang L, Zhao L, Luo L, Min S, Wen Y, et al. Alterations of vaginal microbiota in women with infertility and Chlamydia trachomatis infection. Frontiers in Cellular and Infection Microbiology. 2021;11:698840.

29. Marcos AT, Rus MJ, Areal-Quecuty V, Simon-Soro A, Navarro-Pando JM. Distinct Gastrointestinal and Reproductive Microbial Patterns in Female Holobiont of Infertility. Microorganisms. 2024;12(5):989.

30. Elnashar AM. Impact of endometrial microbiome on fertility. Middle East Fertility Society Journal. 2021;26:1-6.

31. Yao X, Zuo N, Guan W, Fu L, Jiang S, Jiao J, et al. Association of gut microbiota enterotypes with blood trace elements in women with infertility. Nutrients. 2022;14(15):3195.

32. Garg A, Ellis LB, Love RL, Grewal K, Bowden S, Bennett PR, et al. Vaginal microbiome in obesity and its impact on reproduction. Best Practice & Research Clinical Obstetrics & Gynaecology. 2023;90:102365.

33. Wang H, Xu A, Gong L, Chen Z, Zhang B, Li X. The microbiome, an important factor that is easily overlooked in male infertility. Frontiers in microbiology. 2022;13:831272.

34. Favaron A, Turkgeldi E, Elbadawi M, Gaisford S, Basit AW, Orlu M. Do probiotic interventions improve female unexplained infertility? A critical commentary. Reproductive BioMedicine Online. 2024;48(4):103734.

35. Bednarska-Czerwińska A, Morawiec E, Zmarzły N, Szapski M, Jendrysek J, Pecyna A, et al. Dynamics of microbiome changes in the endometrium and uterine cervix during embryo implantation: a comparative analysis. Medical Science Monitor: International Medical Journal of Experimental and Clinical Research. 2023;29:e941289-1.

36. Moumne O, Hampe ME, Montoya-Williams D, Carson TL, Neu J, Francois M, et al. Implications of the vaginal microbiome and potential restorative strategies on maternal health: a narrative review. Journal of Perinatal Medicine. 2021;49(4):402-11.

37. Alhabardi SM, Edris S, Bahieldin A, Al-Hindi RR. The composition and stability of the vaginal microbiome of healthy women. Journal of Pakistan Medical Association. 2021;71(8):2045-.

38. Ijaz MU, Hayat MF, Ashraf A. Microbiome and Reproductive Health. Human Microbiome: Techniques, Strategies, and Therapeutic Potential: Springer; 2024. p. 251-72.

39. Guan W, Dong S, Liu W, Liu S, Jiao J, Wang X. Effects of the Lactobacillus Crispatus Dominant Cervical Microbiome on the Outcomes of in Vitro Fertilization-Embryo Transfer in Infertile Women: A Prospective Observational Cohort Study. Available at SSRN 4676937.

40. Hong X, Qin P, Yin J, Shi Y, Xuan Y, Chen Z, et al. Clinical manifestations of polycystic ovary syndrome and associations with the vaginal microbiome: a cross-sectional based exploratory study. Frontiers in Endocrinology. 2021;12:662725.

41. Manzoor A, Amir S, Gul F, Sidique MA, Kayani MuR, Zaidi SSA, et al. Characterization of the gastrointestinal and reproductive tract microbiota in fertile and infertile Pakistani couples. Biology. 2021;11(1):40.

42. Bui BN, van Hoogenhuijze N, Viveen M, Mol F, Teklenburg G, de Bruin J-P, et al. The endometrial microbiota of women with or without a live birth within 12 months after a first failed IVF/ICSI cycle. Scientific reports. 2023;13(1):3444.

43. Azar PR, Karimi S, Haghtalab A, Taram S, Hejazi M, Sadeghpour S, et al. The Role of the Endometrial Microbiome in Embryo Implantation and Recurrent Implantation Failure. Journal of Reproductive Immunology. 2024:104192.

44. Silva VF, Refinetti P, Junior JMS, Baracat EC, Pacchetti B. Vaginal microbiome and a prospective analysis of vaginal microbiome testing and personalized probiotics supplementation as a beneficial approach to unlock optimal health for women: a narrative review. Eur Gynecol Obstetr. 2023;5(2):49-54.

45. Lu C, Wang H, Yang J, Zhang X, Chen Y, Feng R, et al. Changes in vaginal microbiome diversity in women with polycystic ovary syndrome. Frontiers in Cellular and Infection Microbiology. 2021;11:755741.

46. Mukherjee AG, Wanjari UR, Kannampuzha S, Murali R, Namachivayam A, Ganesan R, et al. The implication of mechanistic approaches and the role of the microbiome in polycystic ovary syndrome (PCOS): a review. Metabolites. 2023;13(1):129.

47. Canha-Gouveia A, Di Nisio V, Salumets A, Damdimopoulou P, Coy P, Altmäe S, et al., editors. The upper reproductive system microbiome: evidence beyond the uterus. Seminars in Reproductive Medicine; 2023: Thieme Medical Publishers, Inc.

48. Werneburg GT, Lundy SD, Bajic P. The Microbiome and Sexual Health. The Journal of Sexual Medicine. 2022;19(11):1600-3.

49. Mitsui J, Kawai K, Tajima M, Hiraoka K, Casaroli V, Sato Y, et al. Effects of Hydrosalpinx on Endometrial Receptivity and Uterine Microbiome: An Interesting Case of Double Uterus with Unilateral Hydrosalpinx. Endocrines. 2022;3(4):821-30.

50. Reschini M, Benaglia L, Ceriotti F, Borroni R, Ferrari S, Castiglioni M, et al. Endometrial microbiome: sampling, assessment, and possible impact on embryo implantation. Scientific Reports. 2022;12(1):8467.

51. Vomstein K, Krog MC, Wrønding T, Nielsen HS. The microbiome in recurrent pregnancy loss–A scoping review. Journal of Reproductive Immunology. 2024;163:104251.

52. Iniesta S, Esteban S, Armijo Ó, Lobo S, Manzano S, Espinosa I, et al. Ligilactobacillus salivarius PS11610 exerts an effect on the microbial and immunological profile of couples suffering unknown infertility. American Journal of Reproductive Immunology. 2022;88(1):e13552.

53. King S, Osei F, Marsh C. Prevalence of Pathogenic Microbes within the Endometrium in Normal Weight vs. Obese Women with Infertility. Reproductive Medicine. 2024;5(2):90-6.

54. Sheu JJ-C, Chang CY-Y, Chiang A-J, Lai M-T, Yen M-J, Tseng C-C, et al. A More Diverse Cervical Microbiome Associates with Better Clinical Outcomes in Patients with Endometriosis. 2021.

55. Ser H-L, Au Yong S-J, Shafiee MN, Mokhtar NM, Ali RAR. Current updates on the role of microbiome in endometriosis: a narrative review. Microorganisms. 2023;11(2):360.

56. Marsh C, Osei F, King S. Prevalence of Pathogenic Microbes within the Endometrium in Normal Weight vs. Obese Women with Infertility. 2024.

1. [↑](#footnote-ref-1)
2. [↑](#footnote-ref-2)
3. [↑](#footnote-ref-3)