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Population-specific datasets are extremely important because microbiome composition can vary with geography, ethnicity, lifestyle and other host factors.

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While research on the vaginal microbiome has expanded significantly, the cervical microbiome in Indian women remains relatively underexplored. A study by researchers at ICMR-National Institute for Research on Women's Health (NIRWoH), Mumbai, maps the cervical microbiome alongside local inflammatory profiles in apparently healthy Indian women, identifying distinct microbial and cytokine signatures associated with asymptomatic bacterial vaginosis and Candida infections. The findings offer an initial foundation for developing population-specific biomarkers and understanding reproductive health beyond conventional diagnostics. In this interview with BioSpectrum India, Dr Deepti Tandon, MS (Obstetrics & Gynecology), Fellowship Assisted Reproductive Techniques (MUHS), Scientist C (Senior Scientific Officer), Department of Clinical research, ICMR-NIRWoH, and Dr Vikrant Bhor, Scientist F & Head, Department of Molecular Immunology & Microbiology, ICMR-NIRWoH discuss the study's significance, the role of sequencing and multi-omics, and the path towards clinical translation.



Your study is among the first to comprehensively map the cervical microbiome and inflammatory milieu in apparently healthy Indian women. What makes these findings particularly significant in the Indian healthcare and research context?

Dr Deepti Tandon: Microbial composition varies across populations, and the microbiota of different anatomical sites of the female genital tract, although related, are not necessarily identical. Much of the available research has focused on the vaginal or cervicovaginal microbiome, while the cervical microbiome, particularly in apparently healthy Indian women, remains relatively underexplored.

Our study specifically looked at the cervical microbiome along with the local inflammatory milieu. This is important because the cervix represents an important biological interface between the lower and upper reproductive tract. Although our study is based on a relatively small cohort, it provides an important initial dataset from an Indian community setting and highlights that apparently healthy women can have distinct microbial and inflammatory profiles that may not be evident clinically.

The study identified distinct microbial and cytokine signatures associated with asymptomatic bacterial vaginosis and *Candida* infections. How could these findings contribute to the development of next-generation diagnostic tools for women's reproductive health?

Dr Vikrant Bhor: One of the important observations was that *Lactobacillus* was the predominant genus, with *Lactobacillus iners* being the most abundant species. However, the microbial communities were not uniform across women. Women with asymptomatic bacterial vaginosis showed increased abundance of organisms such as *Prevotella* and *Streptococcus*, while *Candida* infection was associated with changes involving *Atopobium* and *Collinsella*. These microbial alterations were accompanied by changes in the local cytokine environment.

This suggests that combining microbial markers with host-response markers may eventually provide a more informative diagnostic approach than detecting individual organisms alone. However, these signatures first need validation in larger and diverse populations before they can be translated into clinical diagnostics.

Microbiome research is increasingly influencing precision medicine globally. How do you envision cervical microbiome profiling being integrated into personalised preventive and therapeutic strategies for women in India over the next decade?

Dr Deepti Tandon: We are still at an early stage. Before microbiome profiling can become part of routine reproductive healthcare, we need to understand what constitutes a healthy microbial ecosystem across different Indian populations and how it changes with age, hormonal status, reproductive events and clinical conditions.

The important shift will be from asking “Which organism is present?” to asking “What is the microbial community doing, and how is the host responding to it?” This will require longitudinal datasets, validated biomarkers and affordable technologies. Ultimately, microbiome information could help identify women at risk of particular outcomes and perhaps guide more personalised prevention or treatment, but this will require considerable clinical validation.

Your team employed nanopore sequencing alongside multiplex cytokine analysis. How important are advanced sequencing and multi-omics technologies in improving our understanding of reproductive health, and what technological gaps still need to be addressed in India?

Dr Vikrant Bhor: Technologies like sequencing provide considerably greater resolution of microbial communities than conventional diagnostic approaches. However, sequencing alone gives us only one part of the picture. When microbiome data are integrated with cytokines, host factors and eventually metabolomic or other molecular information, we can begin to understand the functional interaction between the microbial community and the host.

For India, we need greater access to sequencing facilities, standardised sample-processing and analytical protocols, trained personnel and strong bioinformatics capacity. Equally important is making these technologies affordable and reproducible across centres. Building such infrastructure will allow us to move from small descriptive studies towards clinically meaningful, multi-centre research.

Many women with bacterial vaginosis or Candida infections remain asymptomatic. What are the broader clinical and public health implications of identifying these 'silent' infections before symptoms develop?

Dr Deepti Tandon: Our findings reinforce an important principle: the absence of symptoms does not necessarily mean the absence of biological changes. Some apparently healthy women had bacterial vaginosis or Candida infection accompanied by alterations in their microbial and inflammatory profiles.

However, we should also be careful not to equate detection of a microorganism with disease. The female genital tract has a complex microbial ecosystem, and colonisation, dysbiosis and clinically significant infection are not always synonymous. The more important question is whether particular microbial and host-response patterns are associated with clinically relevant outcomes such as recurrence, relapse or treatment failure. This is an area that requires further investigation.

From a translational research perspective, what are the key milestones that need to be achieved before discoveries such as these can be translated into routine clinical practice or commercial diagnostic solutions?

Dr Deepti Tandon: The first requirement is validation in larger, well-characterised and geographically diverse Indian populations. We then need to identify reproducible microbial or inflammatory signatures and establish whether they have genuine clinical utility rather than simply statistical association.

These signatures must subsequently be translated into tests that are accurate, reproducible, affordable and practical for different healthcare settings. Prospective and longitudinal studies will be particularly important to determine whether such markers can predict recurrence, relapse or treatment failure. Only after these steps can we realistically consider their incorporation into routine clinical practice.

India's biotechnology ecosystem is witnessing increasing investments in microbiome research. What opportunities do you see for collaborations between academic institutions, healthcare providers and biotech companies in translating cervical microbiome research into real-world applications?

Dr Vikrant Bhor: There is considerable opportunity for collaboration. India has a large and diverse population, and generating well-characterised Indian datasets should be a priority. Academic institutions can address the underlying biology, clinicians can define clinically relevant questions and outcomes, and biotechnology companies can help develop scalable and affordable technologies.

Such collaborations can also facilitate multi-centre studies and independent validation of biomarkers. The objective should be to move beyond generating microbiome datasets towards developing solutions that are clinically relevant, affordable and suitable for the Indian healthcare ecosystem.

The study provides an initial reference dataset for the cervical microbiome in Indian women. How important are population-specific microbiome reference datasets for developing accurate diagnostics and precision healthcare solutions?

Dr Vikrant Bhor: Population-specific datasets are extremely important because microbiome composition can vary with geography, ethnicity, lifestyle and other host factors. India itself has substantial diversity, so it would be inappropriate to assume that a reference profile generated in another population necessarily represents Indian women.

Our study should therefore be viewed as an initial foundation rather than a definitive reference range. Larger multi-centre and longitudinal studies are needed to understand both population-level variation and individual microbial dynamics. Such datasets will be essential for developing meaningful biomarkers and eventually precision approaches to reproductive healthcare.

Looking ahead, are there plans to expand this work through larger multi-centre studies, longitudinal follow-up, or integration with genomics, metabolomics or AI-based analytics?

Dr Deepti Tandon: Yes. Longitudinal studies involving women with recurrent, relapsing and treatment-failure bacterial vaginosis are already underway. We are combining detailed clinical information with microbiome and inflammatory markers to understand why some women respond to treatment while others experience recurrence, relapse or treatment failure.

In the future, integration of microbiome data with other molecular datasets, including metabolomics, and the use of advanced analytical approaches such as AI may help identify complex patterns that are difficult to recognise through conventional analysis. However, the biological relevance and clinical validation of these findings will remain essential.

What message would you like to share with researchers, clinicians and biotechnology innovators about the future potential of microbiome science in transforming women's healthcare in India?

Dr Vikrant Bhor: Microbiome science has enormous potential, but we are still moving from the descriptive phase towards understanding function and clinical relevance. The important question is not simply which microorganisms are present, but how microbial communities interact with the host and influence health and disease.

For India, we need collaborative, population-specific and clinically driven research, supported by longitudinal studies, standardised methodologies and validated biomarkers. There is a major opportunity to bring together clinicians, microbiologists, immunologists, bioinformaticians and biotechnology innovators. If we can make this transition from microbiome mapping to mechanistic understanding and clinical translation, microbiome science could contribute substantially to better diagnostics, prevention and treatment of women's reproductive health conditions.

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