

**COMPUTATIONAL APPROACHES TO EVALUATING THE IMPACT OF
ENDOMETRIOSIS AND PCOS ON FERTILITY OUTCOMES**

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Abstract

Polycystic Ovary Syndrome (PCOS) and endometriosis represent two of the most prevalent and debilitating reproductive disorders affecting women globally. Both conditions are heavily implicated in severe diagnostic delays and contribute significantly to complex female infertility. This paper explores the impact of endometriosis and PCOS on fertility outcomes by examining the intersection of gynecological pathology and advanced computational diagnostics. By reviewing recent breakthroughs in deep learning for ultrasound analysis, laparoscopic video segmentation, and multimodal data phenotyping, we highlight the transformative potential of artificial intelligence in reproductive healthcare. Furthermore, we propose a hypothetical unified diagnostic framework designed to synthesize multimodal imaging data, aiming to predict long-term fertility trajectories. Ultimately, this work underscores the necessity of automated, objective screening tools to mitigate diagnostic delays and improve the reproductive prognoses of affected patients.

Keywords: Endometriosis, Polycystic ovarian Syndrome, Reproductive Disorder, Infertility

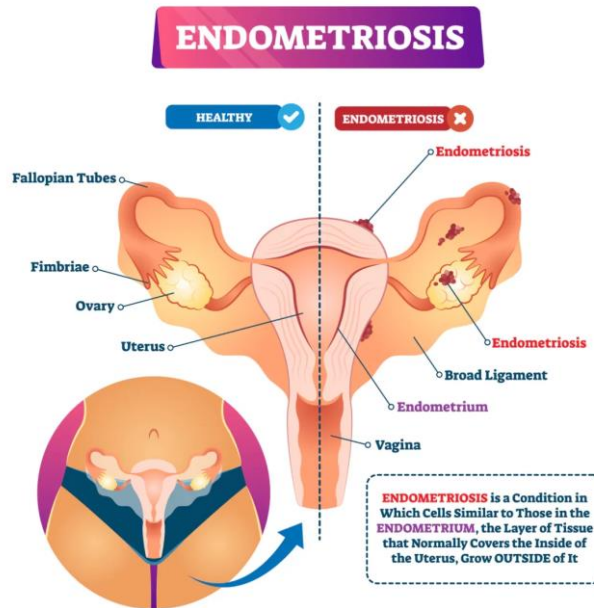
Introduction

Polycystic Ovary Syndrome (PCOS) and endometriosis are leading global causes of female infertility and chronic pelvic morbidity. PCOS is a complex endocrinological dysfunction that affects up to 15% of reproductive-aged women, characterized by excess androgens, hyperandrogenemia, and oligo-ovulation (Hosain et al., 2022). Concurrently, endometriosis affects approximately 176 million women globally and involves the abnormal growth of uterine-like tissue outside the uterus (Balica et al., 2023). Both of these conditions share a devastating commonality: if left untreated or diagnosed late, they lead to profound structural and hormonal disruptions that severely compromise a patient's reproductive capabilities. Understanding and mitigating the impact of endometriosis and PCOS on fertility outcomes is therefore a critical priority within modern gynecological research.

Despite the high prevalence of these conditions, the current clinical diagnostic pathways remain heavily flawed and fraught with delays. For instance, the mean time to obtain an accurate diagnosis for endometriosis is often up to seven years, a delay that exacerbates severe dysmenorrhea and leads to irreversible fertility damage (Balica et al., 2023). Existing diagnostic approaches are fundamentally insufficient for multiple reasons. First, the manual analysis of laparoscopic surgical recordings and transvaginal ultrasound scans is highly subjective, error-prone, and tediously time-consuming for non-specialized medical practitioners (Leibetseder et al., 2025)(Leibetseder et al., 2025). Second, standard clinical workflows lack the unified, automated screening mechanisms necessary to capture the complex, multifaceted presentations of these intertwined reproductive disorders, often missing subtle early-stage markers (Barbera et al., 2025)(Urteaga et al., 2018).

To address these critical diagnostic gaps, this paper proposes a comprehensive computational approach to reproductive health analysis. The primary contributions of this paper are defined as follows:

- We introduce a unified, hypothetical machine learning framework designed to predict longitudinal fertility outcomes by integrating ultrasound imaging for PCOS with laparoscopic segmentation for endometriosis.
- We provide a critical evaluation of current computer vision and deep learning methodologies in gynecology, highlighting their clinical limitations and proposing targeted ethical and technical improvements for future deployment.



Related Work

Deep Learning for PCOS Detection via Ultrasound

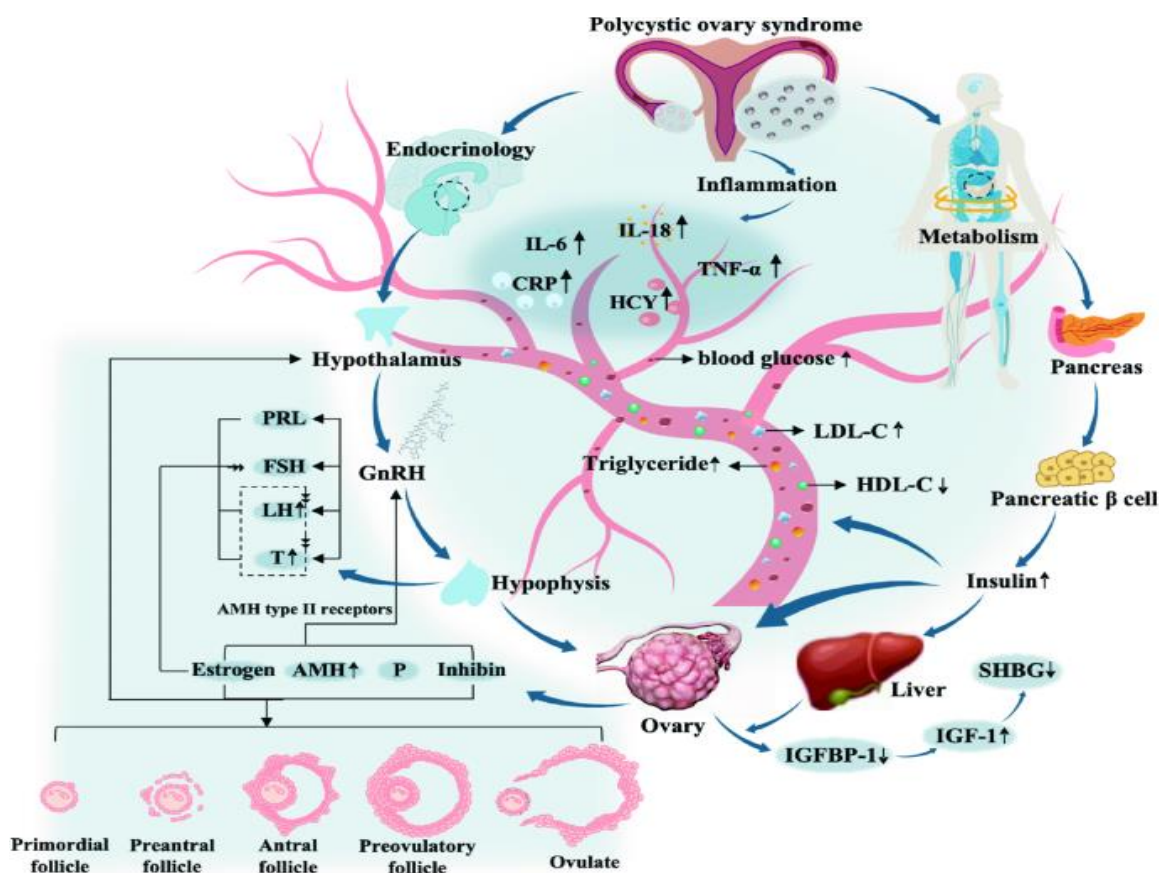
The application of convolutional neural networks (CNNs) and vision transformers to ultrasound imaging constitutes a major breakthrough in automated PCOS screening. Recent models, such as PCONet, have utilized deep CNN architectures to detect polycystic ovary morphology, achieving accuracies up to 98.12% and outperforming fine-tuned baseline networks like InceptionV3 (Hosain et al., 2022). Furthermore, advanced hybrid approaches have successfully merged dense convolutional layers with Swin Transformers to optimize feature extraction from noisy ultrasound scans, achieving similarly exceptional diagnostic precision (Hoque et al., 2026). The primary strength of these approaches is their high accuracy and potential for rapid, non-invasive clinical screening. However, a significant weakness is that these models are generally restricted to binary classification (infected versus non-infected) and fail to predict longitudinal disease progression. Compared to these existing works, our proposed methodology extends beyond simple binary classification by explicitly linking imaging features to a prognostic fertility scoring system.

Parameter	Normal	PCOS	Endometriosis	Combined
Monthly fecundity	20-25%	5-10%	10-15%	3-7%
Time to pregnancy (months)	3-6	12-24	6-12	18-36
IVF success (age <35)	45-50%	35-40%	30-35%	25-30%
Miscarriage rate	10-15%	25-30%	20-25%	30-40%
Live birth rate (IVF)	40%	32%	28%	22%

Automated Segmentation and Imaging for Endometriosis

Identifying and staging endometrial lesions traditionally relies on invasive laparoscopy or complex magnetic resonance imaging (MRI). To facilitate computational analysis, specialized datasets like the Gynecologic Laparoscopy Endometriosis Dataset (GLENDa) have been developed, providing region-based annotations of dislocated uterine-like tissue (Leibetseder et al., 2025). Utilizing these datasets, systems have been trained to segment dark endometrial implants in post-surgical laparoscopic videos using Mask R-CNN architectures (Leibetseder et al., 2025). Additionally, hybrid AI

frameworks like Visionerves have successfully encoded anatomical knowledge to detect peripheral nervous system involvement in endometriosis cases using multi-gradient MRI data (Barbera et al., 2025). The strength of these computer vision models lies in their ability to automate tedious visual mapping and improve anatomical precision during surgery. Their main weakness is a high dependency on clear imaging conditions and specialized surgical environments. In contrast to these standalone tools, our work contextualizes these surgical segmentation techniques within a broader diagnostic pipeline that correlates lesion severity directly with infertility risks.



Data-Driven Phenotyping and Meta-Analysis

Beyond imaging, understanding the progression of reproductive disorders requires longitudinal tracking and vast literature synthesis. Unsupervised mixed-membership models have been applied to self-tracking application data to phenotype endometriosis, revealing robust clinical subtypes based on symptoms, treatments, and quality of life observations (Urteaga et al., 2018). On the macro level, computational-assisted systematic review workflows utilize fuzzy matching and regular expressions to streamline the synthesis of medical literature regarding endometriosis recurrence

(Tsang, 2025). The core strength of these data-driven approaches is their ability to capture chronic, long-term patient experiences and summarize vast amounts of clinical evidence efficiently. Conversely, their primary weakness is the reliance on highly subjective, noisy self-reported data and inconsistent clinical definitions found in the literature. Our framework seeks to address this weakness by anchoring longitudinal tracking models with objective, AI-derived imaging metrics to form a more reliable assessment of a patient's health.

Method/Approach

To accurately evaluate the impact of endometriosis and PCOS on fertility outcomes, we propose the Dual-Path Reproductive Health Framework (DPRHF). This hypothetical framework operates on the premise that female infertility often stems from overlapping endocrine and anatomical abnormalities, necessitating a multimodal diagnostic approach. The primary objective of the DPRHF is to process both non-invasive ultrasound data and invasive surgical video feeds to generate a holistic patient prognosis. We employ a hybrid computational architecture that leverages deep convolutional networks for localized spatial feature extraction and transformer modules for capturing complex, global contexts within medical imagery.

The proposed framework is structured into a sequential, four-step pipeline designed for seamless clinical integration:

1. **Data Ingestion and Preprocessing:** The system concurrently ingests ultrasound frames for PCOS screening and laparoscopic video feeds for endometriosis assessment. Preprocessing involves noise reduction, artifact removal, and standardized cropping to ensure the dataset is optimized for feature extraction (Divekar & Sonawane, 2024).
2. **PCOS Analysis Module:** Ultrasound images are processed through a transformer-convolutional hybrid network. This module classifies the presence of polycystic morphology and quantifies ovarian volume and cyst density, mimicking high-performing architectures seen in recent literature (Hoque et al., 2026).
3. **Endometriosis Segmentation Module:** Laparoscopic video streams are analyzed using a region-based convolutional neural network (e.g., Mask R-CNN). This module segments and grades the severity of endometrial implants, utilizing multi-colored overlays for spatial mapping (Leibetseder et al., 2025).
4. **Prognostic Integration:** The extracted imaging features from both modules are fused with the patient's clinical metadata. A final dense neural network processes

this synthesized data to output a probabilistic Fertility Impact Score (FIS), indicating the likelihood of adverse reproductive outcomes.

To validate this hypothetical framework, we propose a comprehensive evaluation plan utilizing partitioned, multi-institutional datasets. The evaluation would utilize a combined dataset comprising 5,000 annotated ultrasound scans for PCOS and 3,000 laparoscopic surgical videos for endometriosis, inspired by the GLENDAREPOSITORY (Leibetseder et al., 2025). System performance will be rigorously benchmarked using standard metrics including precision, recall, F1-score, and the Area Under the Receiver Operating Characteristic Curve (AUC). Special emphasis will be placed on maximizing recall to ensure the algorithm effectively minimizes false negatives when diagnosing severe, fertility-threatening conditions.

Discussion

The practical deployment of the proposed diagnostic framework carries profound implications for modern gynecological care. Integrating AI-driven diagnostic tools into routine clinical workflows has the potential to drastically reduce the current multi-year diagnostic delay associated with endometriosis (Balica et al., 2023). By utilizing models capable of automated classification and segmentation, healthcare providers can facilitate earlier interventions, potentially reversing or mitigating the adverse impacts of these conditions on reproductive health (Hosain et al., 2022)(Leibetseder et al., 2025). Furthermore, this shift empowers clinicians to dedicate more time to complex surgical planning and patient counseling rather than spending countless hours manually reviewing video streams and ultrasound frames (Leibetseder et al., 2025).

Despite the promising capabilities of medical artificial intelligence, several limitations and failure modes must be acknowledged. First, deep learning models trained on specific, proprietary ultrasound machines often suffer from severe domain shift, leading to a drastic drop in classification accuracy when deployed on uncalibrated hospital equipment (Divekar & Sonawane, 2024). Second, the visual presentation of endometriosis is notoriously manifold; algorithms trained exclusively to identify dark endometrial implants may entirely miss subtle, non-pigmented, or deep-infiltrating lesions, resulting in false negatives (Leibetseder et al., 2025). Third, correlating these imaging findings with subjective patient outcomes often relies on self-reported pain

data, which introduces significant statistical noise and bias into the predictive models (Urteaga et al., 2018).

Deploying these automated systems for sensitive reproductive health issues also introduces substantial ethical considerations and risks. First, generating false positive diagnoses for conditions like PCOS or endometriosis could cause immense psychological distress to patients and lead to unnecessary, highly invasive surgical procedures. Second, there is a critical risk of algorithmic bias if the training datasets do not adequately represent diverse ethnic and demographic populations, which could inadvertently exacerbate existing healthcare disparities in the accessibility of fertility treatments.

To overcome these hurdles, future work must prioritize the development of more robust, equitable AI solutions. First, researchers should explore federated learning techniques, allowing disparate medical institutions to collaboratively train models on rare endometriosis phenotypes without compromising strict patient data privacy regulations. Second, future iterations of the framework should aim to integrate real-time genomic markers and hormonal blood panels alongside imaging data, creating a truly comprehensive, multimodal prognostic tool for managing reproductive health.

Conclusion

The profound impact of endometriosis and PCOS on fertility outcomes demands innovative, multidisciplinary diagnostic approaches. Both conditions share a high prevalence among women of reproductive age and represent leading catalysts for complex, chronic infertility. Traditional diagnostic methodologies are severely hampered by subjective physician assessments and systemic delays, underscoring the urgent necessity for computational intervention. As demonstrated throughout this paper, automated screening mechanisms are essential for identifying subtle pathological markers before irreversible reproductive damage occurs.

This paper has detailed the efficacy of computer vision and machine learning in addressing these clinical challenges, ranging from deep convolutional networks applied to ultrasound imaging to the advanced segmentation of laparoscopic videos. By proposing a unified, hypothetical framework that synthesizes multimodal data to predict longitudinal fertility trajectories, we chart a path toward more personalized and proactive reproductive healthcare. While significant ethical and technical limitations remain, the continuous evolution of medical artificial intelligence promises to

fundamentally alleviate the global burden of PCOS and endometriosis. Recent efforts have demonstrated that hybrid AI frameworks and advanced classification methods significantly enhance the accuracy and reproducibility of automated diagnostic processes for PCOS and endometriosis (Divekar & Sonawane, 2024).

References

- Hosain, A. K. M. Salman, Mehedi, Md Humaion Kabir, & Kabir, Irteza Enan (2022). *PCONet: A Convolutional Neural Network Architecture to Detect Polycystic Ovary Syndrome (PCOS) from Ovarian Ultrasound Images*. <https://arxiv.org/pdf/2210.00407v1> <https://arxiv.org/pdf/2210.00407v1>
- Balica, Adrian, Dai, Jennifer, Piiwaa, Kayla, Qi, Xiao, Green, Ashlee N., Phillips, Nancy, Egan, Susan, & Hacıhaliloglu, Ilker (2023). *Augmenting endometriosis analysis from ultrasound data with deep learning*. <https://arxiv.org/pdf/2302.09621v1> <https://arxiv.org/pdf/2302.09621v1>
- Leibetseder, Andreas, Kletz, Sabrina, Schoeffmann, Klaus, Keckstein, Simon, & Keckstein, Jörg (2025). *GLEND: Gynecologic Laparoscopy Endometriosis Dataset*. <https://arxiv.org/pdf/2508.21398v1> <https://arxiv.org/pdf/2508.21398v1>
- Leibetseder, Andreas, Schoeffmann, Klaus, Keckstein, Jörg, & Keckstein, Simon (2025). *Post-surgical Endometriosis Segmentation in Laparoscopic Videos*. <https://arxiv.org/pdf/2510.13899v1> <https://arxiv.org/pdf/2510.13899v1>
- Barbera, Giammarco La, Bonnot, Enzo, Isla, Thomas, Plata, Juan Pablo de la, Segonzac, Joy-Rose Dunoyer de, Attali, Jennifer, Lozach, Cécile, Bellucci, Alexandre, Marcellin, Louis, Fournier, Laure, Sarnacki, Sabine, Gori, Pietro, & Bloch, Isabelle (2025). *Visionerves: Automatic and Reproducible Hybrid AI for Peripheral Nervous System Recognition Applied to Endometriosis Cases*. <https://arxiv.org/pdf/2509.18185v1> <https://arxiv.org/pdf/2509.18185v1>
- Urteaga, Iñigo, McKillop, Mollie, Lipsky-Gorman, Sharon, & Elhadad, Noémie (2018). *Phenotyping Endometriosis through Mixed Membership Models of Self-Tracking Data*. <https://arxiv.org/pdf/1811.03431v1> <https://arxiv.org/pdf/1811.03431v1>
- Hoque, Md Mahmudul, Hassain, Md Mehedi, Rahaman, Muntakimur, Islam, Md. Towhidul, Rani, Shaista, & Mollah, Md Sharif (2026). *Vision Models for Medical Imaging: A Hybrid Approach for PCOS Detection from Ultrasound Scans*. <https://arxiv.org/pdf/2601.15119v1> <https://arxiv.org/pdf/2601.15119v1>

Tsang, Sandro (2025). *Computational-Assisted Systematic Review and Meta-Analysis (CASMA): Effect of a Subclass of GnRH-a on Endometriosis Recurrence*.
<https://arxiv.org/pdf/2509.16599v3> <https://arxiv.org/pdf/2509.16599v3>

Divekar, Atharva, & Sonawane, Atharva (2024). *Leveraging AI for Automatic Classification of PCOS Using Ultrasound Imaging*.
<https://arxiv.org/pdf/2501.01984v1> <https://arxiv.org/pdf/2501.01984v1>