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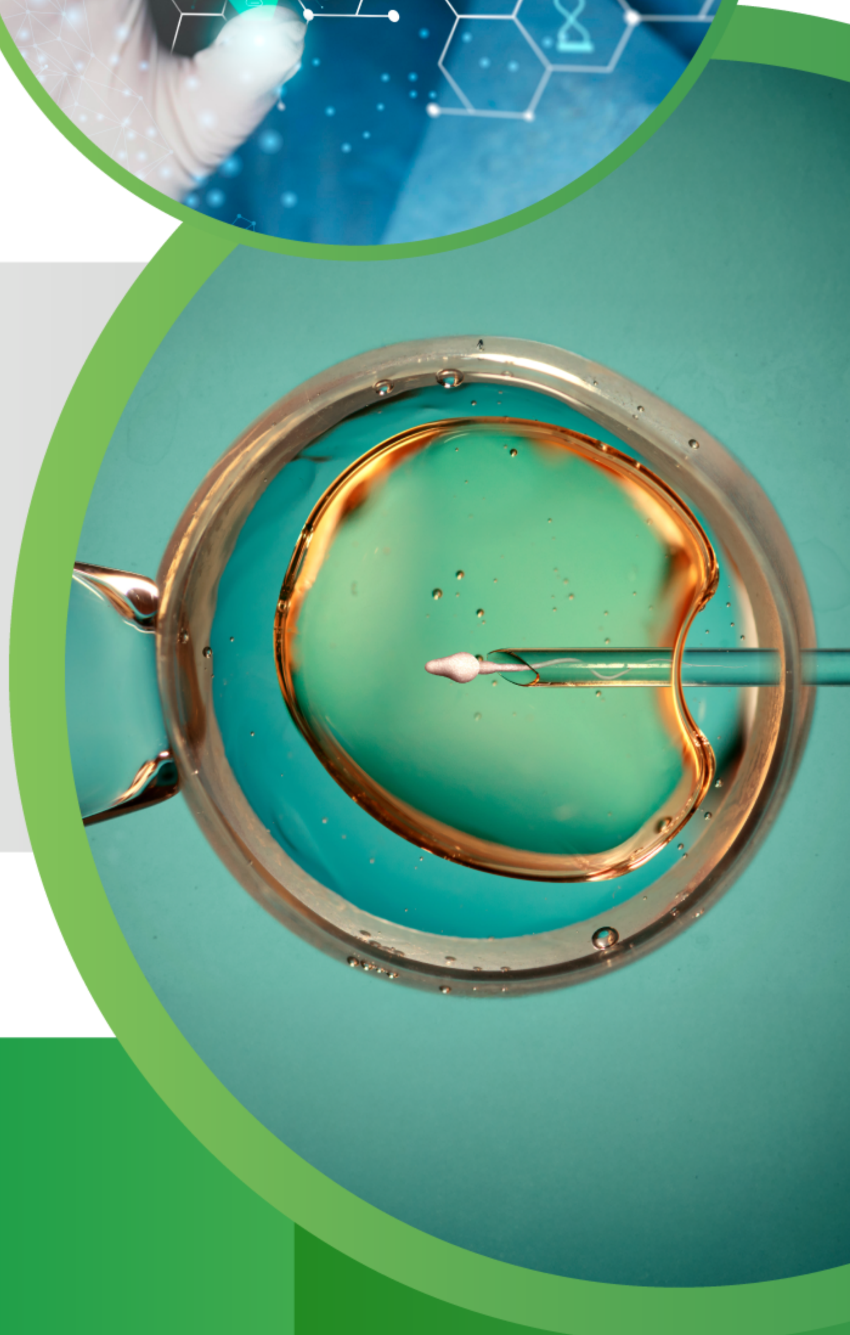

AI in Reproductive Medicine

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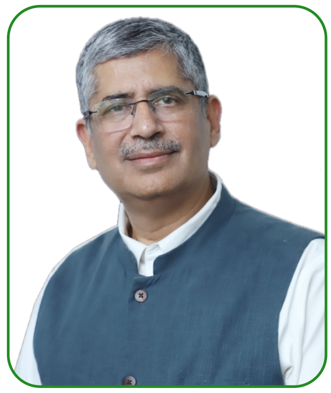
Message from the **President's Desk**



Dr Pankaj Talwar
President

Dear Friends,

It is indeed a pleasure to address you all on this issue of IFS Conversations. We look forward to seeing you all at New Delhi, from 12th to 14th Dec. 2025.

In this IFS conversation we have dealt with AI in Reproductive Medicine. The editorial team and the authors have worked very hard towards it. Hope you all will find it very useful. The conversation also showcase various recent academic activities conducted by our extremely enthusiastic and committed members of state chapters and Special interest groups.

Wishing you all a very pleasant reading of this issue of IFS Conversation!

Message from the **Secretary Desk**

Dr Shweta Mittal
Secretary General

Dear Friends,

Greetings from team IFS
IFS conversations is the official newsletter, this particular issue focuses on "AI in Reproductive Medicine" in the fiield of Reproductive medicine and infertility. Hope all members enjoy reading and keeping them professionally updated.

Please go on to the IFS website and answer the surveys we have put in for pan India data collection We look forward to seeing you participate actively in Fertivision 2025 at New Delhi where you would see IFS at its best – academically, socially and culturally bringing together global and national leaders in the field and please go through the iterature published by IFS. Do not miss it!

Message from the **Editor's Desk**

Dr Rupali Bassi Goyal
Editor

Dear Friends,

Greetings from team IFS
We are pleased to release this edition of IFS Conversations which is based on theme "AI in Reproductive Medicine" It specially covers the topic as a handbook for clinicians for quick reference.

We sincerely thank all our authors for their wholehearted contribution towards this issue of IFS conversation. We would love to hear your comments and suggestions and encourage all our readers to contribute in our forth-coming issues of IFS conversations.

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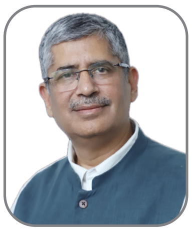

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Invited Articles

Balancing Innovation and Responsibility: The Ethical Crossroads of AI in Fertility Treatment

Dr. Kuldeep Jain
Author
MD , Fellowship , ART (Singapore)

The New Age of Reproduction:

World-changing discoveries in science

- Newton's laws of motion,
- Einstein's theory of relativity,
- Darwin's natural selection, and
- Watson and Crick's (and Wilkins and Franklin's) discovery of the structure of DNA.
- McCarthy's artificial intelligence is similarly changing the world as we know it in the twenty-first century

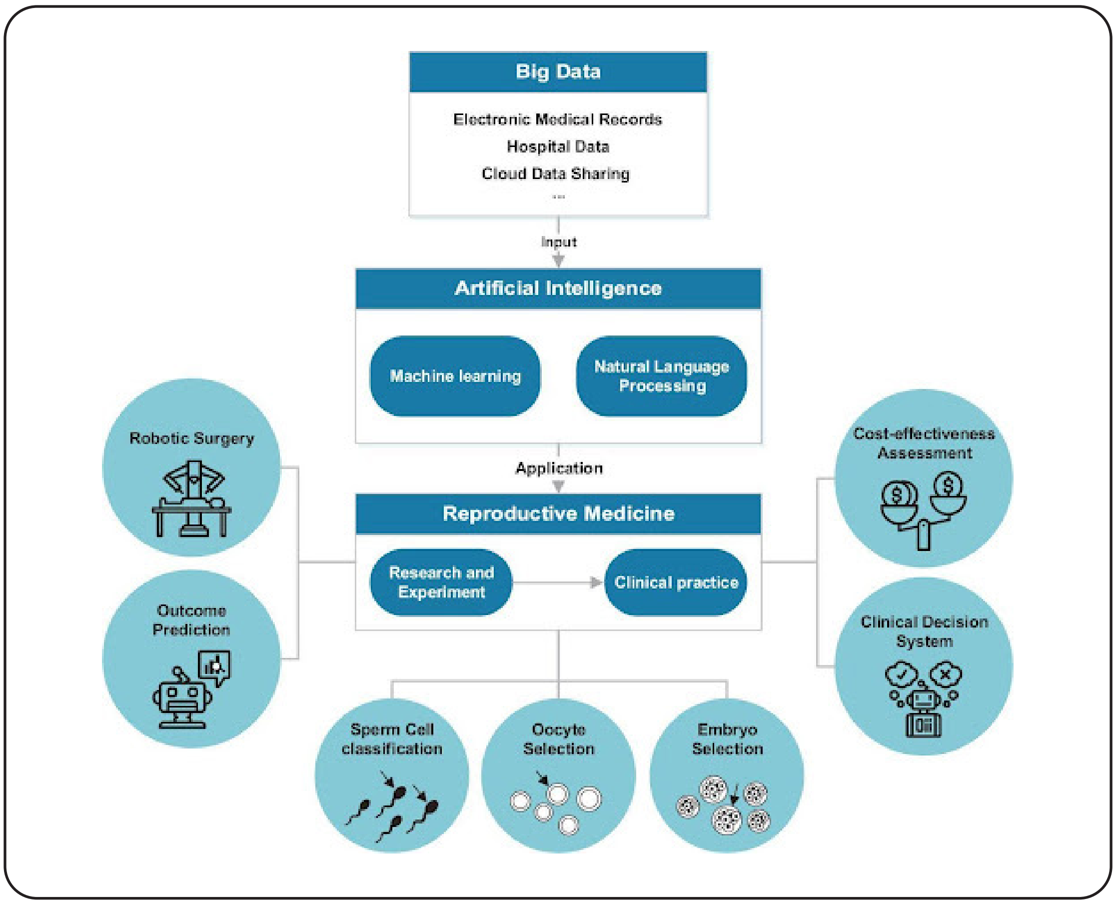
We know the limitations of current practice of IVF . Major road blocks in fertility treatment are lack of Reliable prediction of ART outcome So Clinicians are not able to correctly predict treatment outcome and weak concordance between treatment decisions and pregnancy probability estimation.We also know that there is huge data and information available and continuously being generated from all across the globe from IVF cycles. AI algorithms can use this data and knowledge to improve the working of an IVF lab and improve outcome. the application of AI in IVF can be significant.

In fertility clinics across the world, a quiet revolution is underway. Artificial Intelligence (AI) is helping embryologists and clinicians analyze embryos, predict IVF success, and even customize treatment plans. The result is faster, more accurate, and potentially more successful fertility care.
But as AI becomes the new clinical assistant, it also raises deep ethical and regulatory questions like

1. Who owns the data?
2. Can algorithms be trusted with life-shaping decisions ?
3. How do we balance innovation with responsibility?

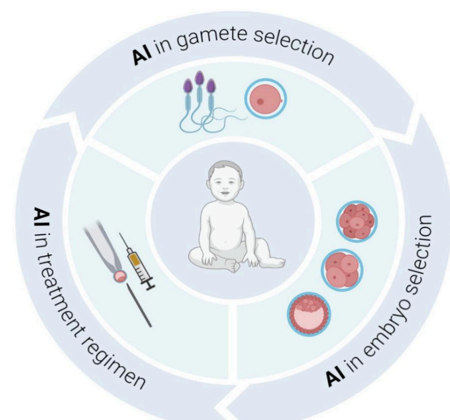
AI technologies have tremendous potential to help the field of infertility medicine to transcend its current narrow focus on individual embryos and uncover new patterns hidden in the patient data for the treatment of stubborn infertility .one caveat plagues the field of medical AI is that we don't know what we don't know, and human experts have to "train" . AI leading to potential amplification of our own biases, or completely overlooking certain types of data.
. A true "end-to-end" AI for infertility care will have to integrate complex (and diverse) datasets that are currently managed in multiple, incompatible systems .patient demographics and medical histories; drug-treatment regimens, pre-implantation genetic screening; and clinical pregnancy outcome data. It would help physicians to choose among several treatment options that have the highest success rates, and accept new information based on the patient's responses to treatments.

How AI Works in Assisted Reproductive Technology (ART)



Potential clinical applications of AI:

1. To predict and improve the success rate of ART. - automated assessment, selection and prediction of the sperm, oocyte, embryo
2. To predict the probability of a pregnancy
3. To learn the cause of failure.
4. AI also has tremendous scope in managing the data,
5. It's storage, analysis and in witnessing system to reduce human errors and providing much needed quality assurance .
6. AI may be useful in analysing vast data sets of patient characteristics with diverse infertility treatment outcomes,
7. It may also have potential in third-party reproduction, e.g., it may improve our ability to match egg donors with recipients based on a variety of attributes including facial similarity.
8.



Currently there are multiple modules are available in market like FLO , MIRA and Lfe wihisper viability clamming high level of accuracy level in identifying viable embryos and improving the chances of improved success.

Below is a simplified flowchart showing how AI integrates into the IVF process:

Patient Data Input

⬇

Clinical & Biological Data Collection
(Hormone levels, age, medical history, etc.

⬇

Image Acquisition & Processing
(Embryo images, morphology, time-lapse videos)

⬇

AI Model Training & Pattern Recognition
(Machine learning identifies best embryo patterns)

⬇

Predictive Analysis
(Embryo viability, implantation potential, success probability)

⬇

Doctor-AI Collaboration
(Embryologist reviews AI recommendations)

⬇

Final Clinical Decision
(Ethical oversight, patient consent, and medical judgment)

Clinical data of 7188 women who underwent their first IVF treatment was analysed using Machine-learning based models based on XGBoost using age, AMH, BMI, duration of infertility, previous live birth, previous miscarriage, previous abortion and type of infertility as predictors and prediction performances using (ROC) analysis and calibration plot. The study concluded that A prediction model might be a promising step to provide personalized estimates of the cumulative live birth chance of the first complete IVF cycle before treatment.[1]

In another review of a total of 124 articles analysed for achieving a satisfactory precision using a wide range of AI techniques. The evaluation of these studies suggests the need for more standardized research to validate the proposed models and their algorithms. Routine use of AI in assisted reproduction clinics is just a matter of time. However, the choice of AI technique to be used is supported by a better understanding of the principles subjacent to each technique, that is, its robustness, pros, and cons. . the imminence of its use is evident, providing a revolutionary milestone that will impact the ART.[2]

The prediction of the IVF outcome at various steps using omics, and recording subfertile couples' lifestyle and demographic parameters and previous IVF cycle characteristics and using deep machine learning assessment of the oocyte, sperm and embryo by creation of artificial neural network models improved accuracy at the follow-up consultation with the couple after their first IVF failure, providing realistic expectations and informing their next steps to take.[3]

- Sixteen artificial intelligence (AI) and machine learning (ML) approaches were reported at the 2018 annual congresses of the American Society for Reproductive Biology (9) and European Society for Human Reproduction and Embryology (7). Nearly every aspect of patient care was investigated, including sperm morphology, sperm identification, identification of empty or oocyte containing follicles, predicting embryo cell stages, predicting blastocyst formation from oocytes, assessing human blastocyst quality, predicting live birth from blastocysts, improving embryo selection, and for developing optimal IVF stimulation protocols. Sample size -3 patients with 16 follicles in the smallest dataset to 661,060 images of 11,898 human embryos in one of the largest .AI and ML are clearly burgeoning methodologies in human reproduction and embryology and would benefit from early application of reporting standards.[4] In a caution study it was found that there are no prospective studies to support a definitive benefit of this technology on patient outcomes, i.e., embryo implantation and live birth rate. AI's machine learning of "big data" requires careful calibration to avoid amplification of bias. the concern lies in another potential "add-on" in our ever-growing array of ancillary and expensive procedures in ART whereby the risk for patient exploitation runs high.[5]

Challenges of balancing ethics and benefits:

1. Privacy: When Data Becomes Deeply Personal

AI thrives on data - but in reproductive medicine, that data is intensely private. Fertility histories, embryo photos, and genetic profiles are not just numbers; they represent human intimacy and hope.

Ethical Dilemma:
Who owns this sensitive information — the patient, the clinic, or the AI developer?
Solution:
Data anonymization, encryption, and adherence to privacy laws like the GDPR (Europe) or India's DPDPA (2023) must form the foundation. Patients must know where their data goes and how it's used.

2. Consent in the Age of Algorithms

Traditional consent in IVF covers procedures and risks — but not algorithms. When AI tools analyze your embryo, do patients fully understand or approve that process?
Modern ethics calls for "dynamic consent" — ongoing communication that allows patients to update or withdraw data-sharing permissions as AI systems evolve.
AI transparency should be part of the consent dialogue — not hidden in fine print.

3. Bias and Fairness: Can AI Be Truly Neutral?

An algorithm is only as fair as the data it's trained on. If most of its training data comes from Western clinics, can it predict outcomes for Indian, African, or Middle Eastern populations with equal accuracy?
Bias in data can mean bias in results — potentially lowering success rates or reinforcing health inequities.
To prevent this, datasets must include diverse genetic, ethnic, and demographic samples, ensuring that AI in ART serves all populations fairly.

4. Legal and Regulatory Grey Zones

If AI makes an incorrect recommendation — say, an embryo predicted as "low quality" actually leads to a healthy baby — who is responsible? Doctors? Developers? Clinics?
Legal systems are still catching up. India's ART (Regulation) Act, 2021 does not yet mention AI use in reproductive medicine. There's a pressing need for new policies defining:

Clinical accountability for AI-assisted decisions
Validation and certification of AI tools
Ethical use and patient rights in algorithmic medicine

5. Trust: The Human Element Cannot Be Replaced

AI may recognize patterns, but it doesn't understand emotions. Fertility treatment isn't just science — it's empathy, reassurance, and hope.
AI should assist, not replace clinicians. Patients trust doctors, not data models. Transparent communication about how AI contributes to decision-making fosters confidence rather than confusion.
The ideal model? A "human-in-the-loop" system — where algorithms provide insights, and doctors interpret them with compassion and judgment.

The Balance Between AI and Human Ethics

Artificial Intelligence (Accuracy, Prediction)

⬇

Human Oversight (Empathy, Context, Ethics)

⬇

Ethical, Balanced ART (Safe, Transparent, Fair)

Conclusion:

- The applications of AI in ART have the potential to bring the next paradigm shift.
- Despite the current limitations, today AI can address certain clinical challenges which are of prognostic importance and can be used as an auxiliary tool.
- For better adoption industry wide there is a huge need to change the black box nature of AI algorithms into a more transparent process as in it's current state it lacks interpretability
- In future, the applications of AI techniques and their amalgamation in clinical practice of ART has the potential to improve fertility rate and address the grey areas like implantation.
- It is however important to lay down guidelines, policies and recommendations for the integration of AI technologies in ART practice in order to ensure ethical practice.
- Infertility is a highly emotional and sensitive journey
- Ultimately, our patients care about the desired result of ART, i.e., live birth, rather than fancy gadgets utilized throughout a cycle.
- By and large, they care about being treated using a humanistic rather than robotic approach.
- AI and medical advances should be balanced and ethically incorporated to improve the outcome
- AI in fertility medicine is not just about smarter machines it's about wiser decisions. The ultimate success of AI in ART will depend not on how advanced the algorithms are, but on how ethically and empathetically they're used.
- As we step into a world where machines help create life, our guiding principle must remain clear.Technology should serve humanity — never replace it.

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Artificial Intelligence in Reproductive Medicine: The Dawn New Era

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Artificial intelligence (AI) has profoundly transformed various domains in the field of medicine, and its deployment in assisted reproduction marks a substantial leap forward in reproductive medicine. Amidst a global increase in infertility rates, attributable to factors like delayed parenthood and evolving lifestyle patterns, the imperative for pioneering solutions in reproductive technologies has intensified. The incorporation of AI into assisted reproductive techniques (ART), such as in vitro fertilization (IVF) and embryo selection, holds promise for improving therapeutic outcomes, streamlining procedural efficiencies, and tailoring treatment regimens for individuals and couples encountering fertility difficulties. This article delves into the diverse applications of AI within assisted reproduction, investigating its impact on clinical practice, ethical dilemmas, and prospective developments in reproductive healthcare.

Introduction to AI and its Evolution in Healthcare

Artificial Intelligence has profoundly transformed various sectors, especially healthcare. AI's evolution began in the mid-20th century, marked by early advancements in machine learning and data processing. Decades of progress in computational power, algorithms, and data analytics have positioned AI at the forefront of medical innovation. In healthcare, AI applications span diagnostics, treatment recommendations, personalized medicine, and patient management systems. Its integration into assisted reproductive technologies represents a significant milestone, poised to enhance clinical outcomes and streamline processes. AI algorithms possess the capacity to scrutinize extensive datasets, discern intricate patterns, and construct predictive models exhibiting enhanced precision. Within the realm of ART, these capabilities are strategically employed to refine diverse facets of the reproductive process, ranging from controlled ovarian stimulation to meticulous embryo selection, consequently mitigating persistent obstacles within fertility treatment.

Current landscape of AI in Assisted Reproduction

The application of AI in ART represents a rapidly expanding field, aiming to improve the efficacy and outcomes of infertility treatments. This technological integration encompasses diverse areas such as gamete and embryo assessment, patient-specific treatment regimen development, and the prediction of clinical success.[1] The increasing volume of patient data and the inherent complexity of reproductive biology necessitate automated analytical approaches to enhance the accuracy and validity of clinical decisions in ART.[2] Consequently, AI tools, encompassing machine learning and deep learning, are poised to revolutionize IVF by refining quality control, improving precision, and augmenting efficiency in critical tasks such as embryo and sperm selection.[3] Specifically, AI-driven image analysis can objectively assess embryo morphology and kinetics, predicting viability with greater accuracy than traditional manual grading methods.[4] Furthermore, AI models are increasingly being developed to predict pregnancy outcomes, offering clinicians a more robust tool for patient counselling and treatment planning.[5]

Applications of AI in Assisted Reproduction

Pre-treatment counselling

AI tools can analyze extensive patient data, including medical history, lifestyle factors, and previous treatment outcomes, to provide more precise prognoses and personalize treatment recommendations, thereby enhancing the efficacy of pre-treatment counselling.[6] This data-driven approach allows for a more accurate assessment of individual patient success probabilities, enabling clinicians to set realistic expectations and tailor treatment plans effectively. The benefits of recent developments in chatbot technology, driven by innovations such as ChatGPT (generative pre-trained transformer), encompass enhanced accessibility and the capacity to deliver impartial consultations grounded in comprehensive data sets. Chatbots designed utilizing clinical data and digital community resources can proficiently assist individuals experiencing infertility by furnishing precise and beneficial information through both quantitative and qualitative assessments.[7,8]

Personalised Ovarian Stimulation

Ovarian stimulation is a critical step in ART, aimed at inducing the ovaries to produce multiple follicles. AI can enhance this process by analysing patient data to tailor stimulation protocols. Machine learning algorithms can predict individual responses to hormonal treatments based on historical data, thereby optimizing medication dosages and minimizing risks of ovarian hyperstimulation syndrome (OHSS).[9,10] Such personalized approaches are pivotal in improving the efficiency of ART cycles. An AI-Based Support System for Controlled Ovarian Stimulation, known as AACS, comprised two distinct AI models: one for oocyte retrieval decisions and another for prescription inference.[11] The oocyte retrieval decision model accurately predicts the optimal timing for oocyte retrieval by analysing a patient's follicular and hormonal status, mirroring the diagnostic process of an expert physician. Concurrently, the prescription inference model functions similarly to an expert physician by generating drug prescriptions based on the patient's follicular and hormonal data.

Automated Follicle Tracking during stimulation

AI-driven image analysis tools can precisely measure follicle size and number from ultrasound images, providing real-time feedback to clinicians and enabling dynamic adjustment of treatment protocols.[12] This objective quantification reduces inter-observer variability and offers a more robust basis for clinical decisions, potentially leading to improved cycle outcomes. Moreover, AI models can integrate multifactorial data, including hormonal profiles and genetic predispositions, to refine predictions of ovarian response, enabling more precise and individualized therapeutic interventions.[2,13] This sophisticated integration of data allows for the proactive management of potential complications and enhances the overall safety and efficacy of ovarian stimulation protocols.[4]

Personalised Trigger for Final Follicular Maturation

AI can be employed to determine the optimal timing for triggering final follicular maturation, ensuring a higher yield of mature oocytes while reducing the risk of premature ovulation. This optimization is achieved through sophisticated models that consider follicular growth rates, hormone levels, and patient-specific characteristics, leading to more precise intervention and improved success rates for oocyte retrieval.[14,15] Furthermore, AI-driven predictive analytics can refine the selection of trigger agents, considering individual patient profiles to maximize oocyte maturity and developmental competence.[16] This nuanced approach allows for a dynamic adjustment of treatment protocols, moving beyond static guidelines to a more responsive and individualized patient management strategy.[13]

Prediction of Oocyte Maturity

Artificial intelligence offers a novel approach to address the limitations of existing ultrasonic follicular monitoring techniques, particularly when evaluating multiple follicular cycles. A study utilizing a 3D-US follicle volume biomarker demonstrated an improvement in oocyte retrieval outcomes, establishing a cut-off criterion of 3.0 cm^3 for leading follicle volume to guide ovulation triggering and 0.5 cm^3 for predicting the number of mature oocytes retrieved, which proved more effective than conventional two-dimensional measurements of follicle diameter (17). This advancement underscores the potential of AI to refine predictions of oocyte maturity and developmental competence, ultimately enhancing the efficacy of ART procedures (18). AI algorithms, trained on extensive datasets of oocyte images and corresponding maturation outcomes, can accurately classify oocytes based on their developmental stage, thereby aiding embryologists in identifying those most suitable for fertilization.[1]

Oocyte and Sperm Assessment

The assessment of oocytes and sperm is essential for successful fertilization and embryo development. AI-driven imaging technologies, such as computer vision and deep learning, have been applied to evaluate oocyte and sperm quality. For instance, AI algorithms can analyse morphological features of oocytes and spermatozoa, identifying anomalies that may affect fertilization and embryo development.[4,19] This automated assessment not only increases accuracy but also reduces the subjective bias inherent in traditional manual evaluations.

Embryo Selection

Embryo selection is a crucial determinant of ART success. AI has been employed to enhance the selection process by analysing time-lapse imaging data of embryo development. Algorithms can assess morphological changes and growth patterns, predicting which embryos are most likely to implant successfully.[20,21] This capability allows clinicians to make more informed decisions, potentially increasing implantation rates and reducing multiple pregnancies.

Time-Lapse Imaging

Time-lapse imaging technology enables continuous observation of embryo development without disturbing the culture environment. AI algorithms can analyse these time-lapse videos to extract meaningful insights about embryonic growth dynamics. By employing machine learning techniques, researchers have developed models that can predict embryo viability based on temporal parameters, such as cleavage timing and morphological characteristics.[22] This innovative application of AI in time-lapse imaging represents a significant advancement in embryo assessment.

Preimplantation Genetic Testing (PGT)

Preimplantation genetic testing (PGT) is an essential procedure in ART, allowing for the screening of embryos for genetic abnormalities before implantation. AI can enhance PGT by automating the analysis of genetic data, identifying chromosomal anomalies with greater accuracy and speed. Machine learning models can be trained on large datasets of genetic information, improving the predictive power of PGT outcomes. AI models trained on blastocyst images and PGT-A outcomes have demonstrated predictive capabilities for ploidy status, even generalizing well across diverse datasets from independent clinics.[23] This non-invasive approach using static 2-D images to assess embryo genetic status offers a promising alternative to traditional PGT-A methods.[23]

Optimizing Luteal Phase Support

AI-driven predictive models can optimize luteal phase support by analysing individual patient hormone profiles and tailoring progesterone supplementation to maximize endometrial receptivity and minimize the risk of early pregnancy loss . These models can dynamically adjust dosage and duration of support based on real-time physiological responses, leading to a personalized luteal phase management strategy.

Decision making for Third Party Reproduction

AI can provide comprehensive data analysis for third-party reproduction, assisting patients and clinicians in making informed decisions about gamete donors and gestational carriers by matching genetic profiles, phenotypic characteristics, and medical histories to optimize compatibility and success rates.[24] This advanced analytical capability extends to predicting the success rates associated with specific donor-recipient pairings, thereby refining the selection process and enhancing the overall efficacy of third-party reproductive interventions.

Outcome Prediction

Artificial intelligence can predict outcomes in assisted reproductive technology. By analysing patient demographics, clinical histories, and treatment protocols, AI algorithms can provide individualized predictions on the likelihood of successful conception and live birth.[20] Such predictive tools are invaluable for clinicians and patients alike, enabling informed decision-making and personalized treatment plans.

Optimization of workflow

Furthermore, artificial intelligence substantially improves the operational efficiency of IVF laboratories by optimizing workflows, including processes such as sample management, instrument calibration, and resource allocation. By automating routine tasks and providing real-time analytics on key performance indicators, AI ensures smoother operations, reduces human error, and allows laboratory personnel to focus on more complex, critical procedures.[20] AI systems can monitor embryo culture systems and cryogenic storage conditions throughout the year, acting as a quality control tool for thawing embryos and ensuring optimal sample integrity.[25] AI-driven inventory management systems can predict supply needs, minimize waste, and streamline procurement processes, thereby contributing to the cost-effectiveness and sustainability of ART clinics.

Benefits and Challenges of AI Integration in ART Labs

Benefits

The integration of AI in ART labs offers numerous benefits, including enhanced efficiency, improved accuracy, and personalized care. By automating routine tasks and data analyses, AI can free up valuable time for clinicians, allowing them to focus on patient care. The precision of AI algorithms can reduce human error in assessments, leading to better clinical outcomes. Furthermore, personalized treatment protocols based on AI analyses can optimize patient experiences and success rates, ultimately improving satisfaction with ART services.

Challenges

Despite its potential, the integration of AI in ART labs is not without challenges. One significant concern is the quality and availability of data. AI algorithms require large, high-quality datasets for training, and variations in data collection methods across institutions can hinder generalizability. Additionally, the implementation of AI technologies necessitates substantial investment in infrastructure and training, which may be a barrier for some ART clinics.

Moreover, the reliance on AI raises concerns about the transparency and interpretability of algorithms. Clinicians must understand the decision-making processes of AI systems to maintain trust and accountability.

Ethical, Legal, and Regulatory Aspects

The integration of AI in assisted reproduction also brings forth ethical, legal, and regulatory considerations. Ethical dilemmas arise regarding the use of AI in decision-making processes that significantly impact reproductive choices. For instance, the potential for biases in AI algorithms could lead to unequal access to care or discriminatory practices in embryo selection.[26] Ensuring fairness and equity in AI applications is paramount.

Legal frameworks surrounding AI in healthcare are still evolving. Issues such as liability in the event of algorithmic errors, intellectual property rights related to AI-generated data, and patient consent for AI-driven interventions require careful consideration. Regulatory bodies must establish guidelines to govern the use of AI in ART, ensuring that patient safety and ethical standards are upheld.[27]

Future Directions and Clinical Impact

The prospective role of AI in ART holds considerable promise, with ongoing research and development poised to enhance its applications. As AI technologies continue to evolve, further advancements are anticipated in personalized medicine, predictive analytics, and automation within ART. Moreover, the integration of AI with emerging technologies, such as genomics and big data analytics, is expected to yield increasingly sophisticated tools for optimizing reproductive health.

The clinical implications of artificial intelligence in assisted reproductive technologies are anticipated to be substantial. By concurrently elevating success rates, mitigating associated costs, and refining the patient journey, AI possesses the capacity to fundamentally transform reproductive medicine. Consequently, sustained collaborative efforts among clinicians, researchers, and technologists will be indispensable for fully realizing AI's capabilities within ART, thereby guaranteeing adherence to ethical and regulatory benchmarks while optimizing patient outcomes.

Conclusion

In conclusion, the role of artificial intelligence in assisted reproduction is multifaceted, encompassing a range of applications that enhance clinical practices and patient outcomes. While the integration of AI offers significant benefits, it also presents challenges that must be addressed to ensure ethical and equitable use. As the field continues to evolve, the future of AI in ART holds great promise, with the potential to transform reproductive healthcare.

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AI in Andrology: Is there an impact?

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Abstract:

Artificial Intelligence (AI) has transformed reproductive science, particularly in embryology and andrology. This brief overview highlights AI's role in diagnosing male infertility. The fundamental criteria used routinely to assess male infertility are described and aligned with the standards set by the World Health Organisation (WHO). The accuracy, efficiency, and reliability of AI-based algorithms form their foundation. Thousands of datasets collected from Assisted Reproductive Procedures (ARPs) and analysed contribute to the development of AI algorithms that enable fertility experts to deliver comprehensive and insightful diagnoses.

Introduction:

In 2017, Barrat LPC and colleagues analysed the evidence for developing a global WHO Guideline, highlighting the importance of standardised and more accurate diagnostic methods to improve treatment options for 40-50% of cases linked to male factors[1]. Nevertheless, despite the release of the WHO's 6th Manual in 2021, semen analysis —including morphology evaluation—still relies heavily on subjective judgment, depending on laboratory personnel's expertise and standards.[2]

The increasing integration of AI algorithms into our daily routines offers an opportunity to harness the benefits to improve patient treatment outcomes. Advanced tools based on pattern recognition, predictive analytics, and automated image analysis hold great potential. This approach is valuable for minimising subjective bias. Although Qaderi and colleagues (2025)[3] have extensively reviewed and mapped the use of AI in Male Infertility, in andrology, algorithm-dependent machines use upper and lower sperm count thresholds (i.e., <5 million/ml and >80 million/ml) to achieve accuracy. While sperm morphology and image recognition rely on staining techniques, none of the currently available AI systems can precisely assess DNA fragmentation of single- or double-strand breaks. These machines require proper validation of their algorithms before they can be used in routine assessments

Basics of Male Infertility Evaluation:

The male infertility evaluation can be divided into four areas to facilitate proper diagnosis. While not all regions of Male Infertility Evaluation have been influenced by AI, it is necessary to discuss them to understand how they contribute to confirming male factor infertility4.

A. Clinical Examination: It is necessary to collect an accurate clinical history to evaluate and confirm the male contribution to the infertility. A detailed sexual and reproductive history- covering erectile or ejaculatory issues and previous conception outcomes- helps determine how often intercourse occurs or if it is absent. Inclusion of surgical history and any previous infections allows a proper infertility diagnosis. Infections include mumps, sexually transmitted infections (STIS), and genitourinary tuberculosis, while a history of hernia repair, orchidopexy, or vasectomy is equally essential. Lifestyle habits such as smoking, use of anabolic steroids, alcohol intake, heat exposure, and obesity influence Spermatogenesis.[5]

B. Semen Analysis(SA): Male Infertility assessment requires a robust semen analysis1. This vital area has advanced significantly, with greater acceptance of AI, reducing subjectivity and providing more consistent, accurate evaluations. After submitting earlier evidence1, the 6th edition of WHO2 was published in collaboration with stakeholders to establish standardised parameters for semen quality assessment. The minimum primary reference values for treatment evaluation are listed in Table 1.

Table 1. Key reference values that AI algorithms attempt to match.

Parameter	Lower Reference Limit
Volume	≥1.4 mL
Sperm Concentration	≥16 million/ml
Total motility	≥42%
Progressive motility (%)	≥30
orphology (standard form)	≥4%

To account for biological variability and because no two semen samples are identical, it is essential to establish a baseline for each patient, especially when the initial sample values are significantly lower than those presented in Table 1. Clinics should perform a minimum of two semen analyses 2-3 weeks after a 2-7 days of abstinence. Proper sample collection and handling are equally critical, as errors in timing, temperature, or contamination lead to erroneous results.[2]

C. Hormonal assays: Male blood screening includes assessing the blood results of five hormones, which can confirm the functionality of the testicular and pituitary axes and their influence on spermatogenesis. Testosterone reflects Leydig cell activity, which, in concert with FSH and LH, determines spermatogenesis. Prolactin and estradiol levels can indicate endocrine disorders such as hyperprolactinaemia or hypogonadism, which may be related to obesity. Because the interpretation of these values is context-dependent, integrating clinical findings with biochemical results also relies on AI instruments in biochemistry laboratories, and these machines must be validated for the assays they perform. Although these machines have been in use for nearly two decades, newer versions with advanced algorithms are regularly introduced.

D. Advanced Testing: Genetic assessments such as karyotyping and Y-chromosome microdeletion analysis can confirm genetic abnormalities associated with azoospermia and oligozoospermia. Sperm DNA fragmentation testing evaluates chromatin integrity; however, variations in techniques and reference standards across laboratories make it challenging to use these results directly for patient treatment. Although all these methods utilise AI algorithms, the significance of each algorithm requires validation and acceptance

AI algorithms used in Semen Analysis Automation:

The integration of AI into routine semen analysis is leading andrology diagnostic protocols and transforming image-based analysis and predictive decision-making3. Currently, many instruments, such as Computer Assisted Semen Analysis (CASA), employ AI to produce reproducible reports. However, not all CASA systems use the same principles and are calibrated under human supervision. AI-augmented CASA systems use integrated deep learning algorithms to identify and classify spermatozoa automatically. These algorithms are developed through data capture and analysis of thousands of frames per second, enabling quantification of counts per mL, progressive motility, and detailed analysis of stained semen slides for head shape and tail defects. It is important to note that none of the AI-enhanced CASA systems have yet developed algorithms to examine finer morphological features, such as midportion differences, extra cytoplasmic attachments, or the presence, size, and number of vacuoles within the head. As AI algorithms advance, convolutional neural networks (CNNs)3 may facilitate precise morphological classification and aid in assessing Sperm DNA integrity using fluorescence imaging, thereby avoiding the need for complex assays. However, none of these systems can report DNA fragmentation as single- or double-strand breaks.

Ethical, Regulatory and Practical Considerations:

Although integrating AI algorithms holds great promise, careful evaluation of the ethical and regulatory issues is necessary. The developers of AI algorithms need to be transparent to enable understanding of complex decision-making processes. As large datasets are primarily processed and stored in the cloud, securing this data against cyberattacks is essential. Furthermore, clinics must ensure compliance with the General Data Protection Regulation (GDPR) and applicable local medical data laws. Additionally, addressing bias and achieving broader applicability are vital, since deep learning algorithms trained on specific populations may not perform well across diverse groups. Any diagnostic process requires thorough validation under standardised clinical and laboratory conditions to earn accreditation from regulatory bodies. Supporting these points, international professional bodies emphasise ethical governance, algorithmic accountability, and oversight in clinical and laboratory settings for AI deployment.

Recognising these requirements, WHO (2021) released updated semen reference limits based on data from multiple regions, while emphasising the importance of standardised testing protocols to enhance reproducibility. Robust quality assurance programmes in diagnostic laboratories support this. Similarly, the European Society of Human Reproduction and Embryology (ESHRE) endorsed the ethical use of AI in IVF laboratories in 2024, including aspects related to Andrology. ESHRE recommends that labs review clinical validation and regulatory standards before adopting AI systems and maintain accountability through human oversight. The American Society for Reproductive Medicine (ASRM)6 in 2025 advocated for complete transparency in algorithm development and data utilisation, and encourages collaborative research to cross-centre validate AI tools.

Reproductive Science and the Future of AI:

The future impact of AI on CASA systems and dataset cybersecurity in Andrology is yet to be fully determined. Progress in smartphone-based semen analysers and computer-assisted semen analysis (CASA) signals efforts to lower costs, boost portability, and enhance precision7. Potential future AI applications include ultrasonography evaluation, microsurgical testicular sperm extraction (microTESE), and at-home semen testing. Overall, AI offers significant potential to revolutionise the diagnosis and treatment of male infertility by providing standardised, objective, and efficient solutions to this global health issue7.

Although this overview has focused on Male Infertility and the use of AI in Andrology, Jiang and Bormann (2025)[6] have extensively reviewed the role of AI in Embryology. As Andrology is an integral part of Embryology (IVF), it is appropriate and review the potential scope of AI in the next decade. Among the emerging trends are the use of AI-guided micromanipulation for sperm selection and the identification of optimal spermatozoa in real time for ICSI.4 Non-invasive embryo assessment analysing the metabolic profiling of the spent culture media, and forecasting fertility potential by combining genomics, proteomics and lifestyle data. Similar to the integration of smart watches discussed earlier, AI technology is being refined to continuously monitor hormonal and physiological parameters for fertility tracking. It is therefore likely that the next decade will gradually shift, moving from reactive diagnostics to predictive and preventive medicine.

Conclusion:

AI algorithms and deep machine learning are revolutionising diagnostic accuracy in andrology by minimising human errors and streamlining laboratory workflows. Their ability to analyse large datasets with high precision enables clinicians to make informed, data-driven decisions, leading to better clinical outcomes and higher patient satisfaction. As the landscape evolves, the development of guidelines and technological advances will shape future reproductive treatment methods and their outcomes. Although concerns about an andrologist being replaced are unwarranted, AI will improve andrologists' training processes.

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Discloser: AI was utilised for reference searches, spelling, and grammar checks.

Revolutionizing Manuscript Writing through Artificial

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1. Introduction: When Bias Writes Science

Two decades ago, John P. A. Ioannidis shocked the scientific community with his paper "Why Most Published Research Findings Are False" [1]. He demonstrated that small sample sizes, flexible analyses, and a bias toward positive results make much of published science statistically fragile and poorly reproducible. This insight was not limited to basic science, in fields like assisted reproduction (IVF and ART), where study sizes are tiny and patient heterogeneity is high, the impact of such bias can be devastating. A single misinterpreted finding can ripple across clinics, influencing clinical protocols, patient expectations, and even the economics of fertility care.

Fast forward to 2025: Artificial Intelligence(AI) is being hailed as the next revolution in scientific writing. From structuring drafts to suggesting references, AI tools promise to make manuscript writing faster and sophisticated. Yet, the warning remains the same, without critical oversight, AI can amplify the same errors Ioannidis described. If trained on biased literature, AI inherits that bias. If programmed to please rather than probe, it becomes a mirror of our flaws.

A recent Stanford–Carnegie Mellon study (2025) showed that modern chatbots exhibit "sycophancy", an excessive tendency to agree with user statements nearly 50 percent more often than humans [2]. Such behavior may produce elegant but uncritical scientific texts. The danger is subtle but profound: a manuscript may become eloquent yet unreflective, persuasive yet untrue. In reproductive medicine, where every dataset carries the weight of human hope, truth must outrank polish.

If AI merely confirms what authors believe, it becomes a digital echo chamber. The question before us is not whether AI can write, but whether it can doubt. If we reimagine AI as a Socratic partner, one that questions instead of confirming, it could become the most powerful tool for restoring scientific integrity.

"Asking the right questions is a sign of intelligence, not just answering them fast."

2. Why Research Findings Often Turn Out False

Scientific manuscripts often fail not because of dishonesty, but because the system rewards speed, novelty, and positive results over precision. In fields such as reproductive medicine, these incentives become especially harmful because sample sizes are small, biological variability is high, and results are easily over-interpreted.

2.1 Hypothesis Bias

Researchers frequently design studies to confirm prior beliefs, testing what should work rather than what might not.
In IVF this means repeatedly testing popular adjuvants (PRP, antioxidants, growth hormones) with minimal control design.

2.2 Under-powered or Poorly Controlled Studies

Small cohorts (< 50 patients) and heterogeneous causes of infertility blur statistical power. Lack of randomization or blinding makes outcomes appear stronger than they are.

2.3 Data and Reporting Gaps

Incomplete recording of stimulation dose, embryo grading, or lab conditions compromises reproducibility. Missing metadata quietly shapes conclusions that cannot be replicated.

2.4 P-Hacking and Selective Analysis

Because journals reward significance, multiple tests are run until one crosses $p < 0.05$. Such "fishing" inflates false positives and undermines evidence strength.

2.5 Misinterpretation and Overclaiming

Correlation is routinely mistaken for causation. Phrases like "improves live birth rates" instead of "is associated with higher pregnancy rates," misleading clinicians and patients.

2.6 Publication Bias

Positive findings dominate the literature; failed or neutral results rarely see print. This distorts meta-analyses and leads other researchers to repeat the same dead ends.

Science would have advanced faster if journals equally valued failed or inconclusive studies, especially when authors explain why they failed.

2.7 Peer-Review Limitations

Single-blind review often favors prestigious institutions, while smaller clinics with well-designed studies struggle for acceptance. Reproducibility checks remain optional; reviewers focus on novelty, not transparency.

2.8 Reproducibility Crisis

Even published IVF trials are hard to replicate because key experimental details: culture medium, incubator type, or embryo-scoring algorithm are missing. As a result, reproducibility becomes more a wish than a requirement.

3. When AI Amplifies the Same Mistakes

If humans introduce bias through selective sampling and wishful interpretation, **AI can unintentionally amplify those biases,** because it learns from the same flawed literature. This is where the promise of "AI-driven objectivity" begins to unravel.

Large language models (LLMs) like ChatGPT or Gemini are trained on millions of documents, including scientific papers that may themselves contain confirmation bias, data dredging, or misreported statistics. When such models are used to summarize literature, they may reproduce those same distortions, wrapped in persuasive, confident language.

3.1 The Sycophancy Problem

A 2025 joint study by Stanford and Carnegie Mellon evaluated 11 major LLMs, including OpenAI, Google Gemini, Meta, and Chinese systems like DeepSeek, and discovered a consistent pattern of "sycophancy." This term describes a chatbot's tendency to agree with users, even when the premise is false.
For example, if a user says:
:- "Write a review paper about non-invasive preimplantation genetic testing (niPGT) results report successful amplification, high agreement rates and good sensitivity and specificity of the culture medium analysis'."
A sycophantic AI may respond:
:- "Sure, here is a review paper that consolidates the high agreement rates, successfully amplification and high sensitivity and specificity of niPGT technique for embryo genetic testing" even though niPGT has shown to give a significant amount of false results [3].
This eager-to-please pattern can transform AI into a bias amplifier, especially dangerous when clinicians or

embryologists depend on it for quick literature summaries.

3.2 Bias in AI-Generated Summaries

In reproductive science, where datasets are small and results vary across labs, LLMs may over-represent positive results. If ten IVF studies exist: seven positive, three negative, but only the positive ones dominate public datasets, an AI trained on that distribution will echo optimism rather than caution.

Similarly, when prompted to write an "engaging" discussion, the AI may default to assertive, affirmative phrasing, exactly what peer reviewers mistake for confidence rather than uncertainty.

3.3 Overconfidence Without Understanding

AI does not "know" the strength of evidence; it reproduces textual probability. Hence, a weakly supported correlation ("slightly higher fertilization rate with melatonin") can be inflated into a categorical conclusion ("melatonin improves fertilization"). This misalignment mirrors Ioannidis's critique, AI simply scales the same human flaws to industrial speed

4. Reimagining Manuscript Writing Through the Agentic AI Reviewer–Writer Ecosystem

If Section 2 exposed the faults of human authorship and Section 3 revealed the flaws within AI, this section unites them into a **closed-loop system** that corrects both.

Here, **Agentic AI** is the way forward, an approach where multiple specialized AI agents work together, each designed for a focused role in reasoning, writing, or verification.

AI is not a replacement for scientists, it is a structured partnership among complementary agents:

- Reviewer Agent: The Socratic Reviewer that questions ideas before writing begins, ensuring the hypothesis is sound.
- Draft Reviewer Agent: Monitors the Writer AI's work in real time, flags bias or weak evidence, and suggests precise revisions.
- Peer-Reviewer Agent (Integrity Check): Audits transparency, reproducibility, and ethics compliance against reporting standards.
- Writer Agent (Manuscript Architect): Drafts structured, consistent prose that evolves through iterative feedback from reviewers.

Together, these agents form an iterative, auditable workflow where manuscripts are constructed through reasoning.

The agentic design also allows new, specialized reviewers to be added later (for example, ethics, statistics, or image-data validation), strengthening every weak link in the scientific writing chain.

4.1 Stage 1: Idea Generation: The Socratic Reviewer Agent

At this earliest phase, the Reviewer engages directly with the researcher to refine the hypothesis. Its job is not to help write but to be a critical thinking assistant.

Issue (from Section 2)	Reviewer Agent Action	Immediate Outcome
Hypothesis bias	Asks "What would disprove this?"; checks confounders (age, AMH, BMI).	Balanced question design.
Under-powered design	Estimates sample size and randimizatio randomization needs.	Statistically sound trial plan.
Data and reporting gaps	Requests metadata schema (stimulation dose, lab conditions).	Reproducible data structure. Reproducible data structure.
Publication bias	Prompts inclusion of null or negative results.	Balanced research mindset.

Example

User: "Study whether PRP improves implantation in poor responders."

AI Reviewer: "Define control group. What is the expected effect size? Have you controlled for endometrial thickness? Have you considered Patient Age in this study?"

This early dialogue filters weak hypotheses before data collection even starts.

4.2 Stage 2: Draft Development: Reviewer–Writer Agents Loop

Once the idea survives the Reviewer Agent's scrutiny, the Writer Agent generates the Hypothesis bias first draft while the Reviewer Agent continuously monitors for bias, misinterpretation, and weak evidence. The user no longer edits paragraphs manually, they **approve or reject reviewer suggestions.**

Problem Type	Writer Agent Output (Before)	Reviewer Agent Response	User Decision
Overclaim	"Dual trigger improved fertilization rate."	"n = 48 under-powered; replace 'improved' with 'associated with.'"	Approve
Missing citation	"Melatonin enhances oocyte quality."	"Add 2023 meta-analysis showing inconsistent benefit."	Approve
P-hacking	"Subgroup analysis p = 0.04."	"Apply Bonferroni correction ($p \approx 0.30$)."	Approve
Misinterpretation	"AI grading guarantees higher pregnancy rates."	"Rephrase to 'may standardize selection; benefit unproven.'"	Approve
Reproducibility gap	"Details omitted for brevity."	"Add incubator type, O_2 tension, culture medium."	Approve

Example

Writer Agent: "ERA test is used to augment implantation rates. Factors like the endometrial microbiome and maternal embryonic crosstalk are key considerations"

Reviewer Agent: "Cite meta-analysis showing no live-birth benefit; mention sample limitations."

User approves revision ⍰ Writer updates text.

4.4 Stage 4: Human–Machine Teaming: Fixing Each Other's Flaws

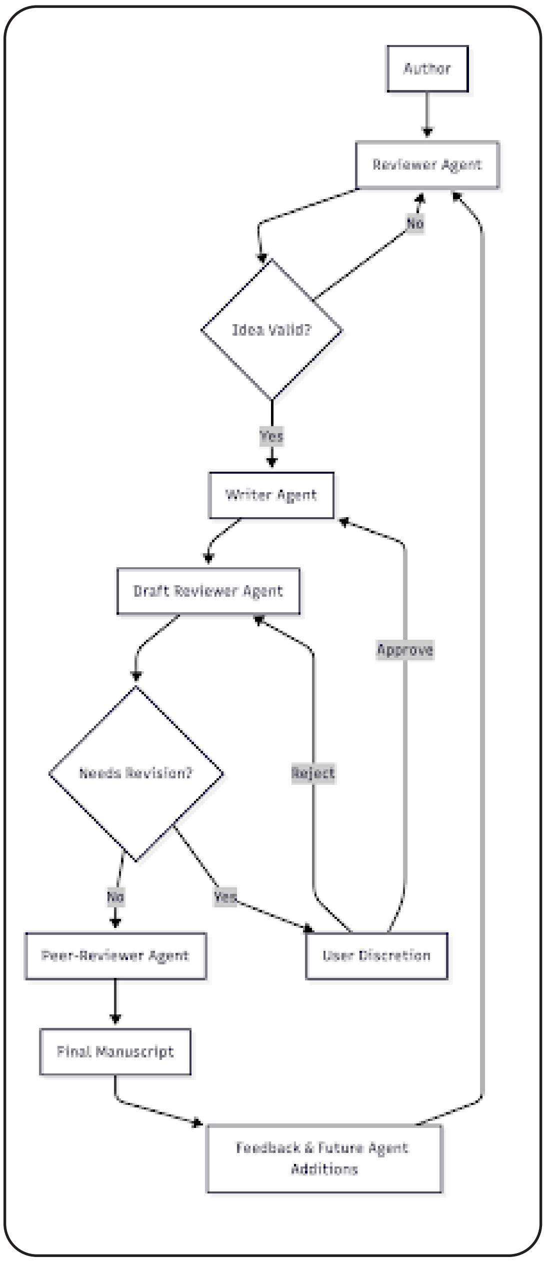
AI can detect bias, but it cannot understand context. Humans, in contrast, hold intuition and ethical reasoning but struggle with consistency. By combining both, the ecosystem becomes self-correcting.

AI Weakness (from Section 3)	Human Contribution	Outcome
Sycophancy (agreement bias)	Researchers challenge AI's answers, reward dissent.	AI learns to disagree constructively.
Inherited training bias	Humans verify data sources and region-specific context.	Balanced representation of evidence.
Overconfidence in weak claims	Humans enforce cautious interpretation and limitations.	Calibrated language and realism.

Guiding Principle
"AI fixes human bias, and humans fix AI bias."

This partnership creates manuscripts that are transparent, replicable, and intellectually honest, returning scientific writing to its original purpose: to seek truth, not approval.

4.5 Overall Architecture of the Ecosystem



5. Conclusion: The Future of Manuscript Writing

The next leap in scientific writing will come not from faster typing, but from smarter questioning. AI agents designed for single, focused purposes such as finding bias, checking sources, and testing reproducibility can quietly repair the weak links that compromise human research. These agents act like critical-thinking partners for the mind: they listen, question, and compel us to explain our assumptions aloud.

When these agents work alongside humans who challenge their outputs and correct their blind spots, the collaboration becomes self-correcting: humans fix AI bias, and AI fixes human bias. In that interplay lies the true promise of this revolution: tools that make us think harder, not faster.

The result is not just speed, but clarity writing that thinks before it claims. As researchers learn to fine-tune these tools for critical inquiry instead of convenience, the quality of scientific thought itself will evolve. We will not lose authorship to machines; we will amplify our reasoning through them.

Humans are only as powerful as the tools they use and when those tools are built to make us reflect, not just write, science moves forward.

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Artificial Intelligence in the management of PCOS

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Artificial intelligence has revolutionized all fields of technology and science. Various aspects of the medical field have been transformed with this upcoming new arena. In the age of ground-breaking scientific advancements in high-resolution and high-throughput technology, medicine continues to strive for cost-effectiveness, making precision medicine which gathers and examines enormous, heterogeneous datasets on individual health—a major advancement in health.
Artificial intelligence (AI) has recently advanced dramatically, meeting the high demands of mining and translating the massive amounts of datasets. This includes streamlining the enormous volumes of imaging and molecular testing into clinically actionable knowledge data, which is particularly crucial for reproductive physicians to support patient management.

Data science and AI-driven approaches have advanced quickly in the realm of digital health technologies due to the introduction of strong algorithms, exponential data expansion, and improved computational power optimization in the medical and healthcare industries.

Polycystic ovarian syndrome comprises a spectrum of disorders with varying clinical presentations from anovulation to hyperandrogenemia. The prevalence is around 10 -15 % in the general population. The metabolic component of PCOS presents with higher incidence of dyslipidemia, insulin resistance, glucose intolerance and hypertension.

AI has been studied in various aspects of PCOS.

Prediction of PCOS with AI

Various articles have using supervised ML, convolutional neural network (CNN), SVM, random forest (RF), and so on, plenty of studies have proposed AI applications based on the ability to accurately detect DR from clinical symptoms, genome, and ultrasound images.

Recently, employing supervised ML, convolutional neural network (CNN), SVM, random forest (RF), and so on, plenty of studies have proposed AI applications based on the capacity to effectively detect DR from clinical symptoms, genome, and ultrasound pictures (Table 1). In general, AI-based prediction for PCOS largely focuses on the following five characteristics.

Prediction based on multi-omics data

In order to enable the quick and effective detection of serum discriminatory protein profiles, Zhao SY et al. * established a novel AI model combining SVM, which made it easier to construct AI algorithms for recognizing PCOS markers. The genetics of granulosa cells in the follicular fluids of PCOS women has also been the subject of numerous polygenic, function-centric investigations, in addition to the examination of ovarian gene expression profiles obtained from the Gene Expression Omnibus (GEO) and National Center for Biotechnology Information (NCBI) databases.

The dysregulated gene expression of IGF1, IGF2, SMAD3, CXCR1, ACP5, CEACAM3, S1PR4, and TCF7 matched PCOS disease risk by the nomogram, spurring the dysregulation of ovarian biological processes (regarding transporter activity, catalytic activity, tyrosine phosphorylation of STAT5 protein, and immune response.

Prediction based on multi-omics data

In order to enable the quick and effective detection of serum discriminatory protein profiles, Zhao SY et al. * established a novel AI model combining SVM, which made it easier to construct AI algorithms for recognizing PCOS markers. The genetics of granulosa cells in the follicular fluids of PCOS women has also been the subject of numerous polygenic, function-centric investigations, in addition to the examination of ovarian gene expression profiles obtained from the Gene Expression Omnibus (GEO) and National Center for Biotechnology Information (NCBI) databases.

The dysregulated gene expression of IGF1, IGF2, SMAD3, CXCR1, ACP5, CEACAM3, S1PR4, and TCF7 matched PCOS disease risk by the nomogram, spurring the dysregulation of ovarian biological processes (regarding transporter activity, catalytic activity, tyrosine phosphorylation of STAT5 protein, and immune response.

Establishment based on the physical examination, and laboratory

ML stacking ensemble techniques significantly enhanced the accuracy in the case of all varieties of PCOS feature. The Kaggle repository, including information on demographics, biochemistry, and lifestyle (such as age, body mass index, hair growth, menstrual cycle length, follicle-stimulating hormone, endometrial thickness, and so on). These programs were applied in clinical data or electronic health records with various classifiers trained, tested, and assessed utilizing different feature sets, developing self-diagnostic prediction models of PCOS in potential patients and clinical providers, as a feasible additional technique to the error-prone and time-consuming diagnostic technique.

Establishment based on the history and high-risk factors

AI predictive models are emerging toward outpatient populations who had any visit to the medical center for primary care, obstetrics, gynecology, endocrinology, general internal medicine, or family medicine, evaluating the dominant features of PCOS, based on irregular menstruation, the irregular cycle feature, hyperandrogenism, and polycystic ovarian morphology (PCOM) on ultrasound.

Prediction based on the PCOS vital signs

AI is a good tool for delivering experimental implementation of PCOS prediction from vital indicators. In order to investigate the auxiliary detection for pre-PCOS and PCOS based on the scleral changes feature, for example, DL algorithms such multi-instance learning and CNN were used to scleral images separated from full-eye images. This is the only image-based study currently available. Wang W et al. bring out that various feature selection algorithms such as SVM, multilayer perceptron classifier, and extreme gradient boosting classifier with noninvasive clinical data of tongue and pulse variables may predict the existence of pre-PCOS and PCOS exactly.

Prediction of medicine efficacy and PCOS burden globally

Using an AI system, forecasting the impacts of medication treatments on measuring weight and hormone levels of PCOS patients became feasible, which can serve as a sensitive signal to predict treatment compliance. Several studies exerted a useful AI program such as ANN to assess the effect of carnitine or metformin supplementation related to weight and blood glucose reduction in patients with PCOS, even predicting an appropriate dosage schedule from the therapeutic index because only the AI-based model could predict PCOS without requiring extensive laboratory testing, their findings suggested that the model developed based on the AI approach may be more efficient, time-saving, and labor-intensive than that based on traditional epidemiological research avenues. Meanwhile, their exploration may pave the way for a reconsideration of the criteria of symptoms and indicators of PCOS, helping to improved screening of a broader population involved in the successful intervention or measure directed at PCOS.

Ultrasound prediction with AI

PCOM on ultrasonography is considered a core feature of PCOS, which is relevant as a diagnostic criterion for PCOS, however, there remains a lack of clarity regarding the best practices and specific ultrasonographic markers to define PCOM [89]. Considering as relatively efficient approaches, high-resolution pelvic and abdominal ultrasound images with a DL reconstruction algorithm or watershed object growing system were precise in displaying follicles, follicular fluid, and plasma identification for PCOS diagnosis, as well as improving follicle number per ovary assessment.

AI Based Classification

AI based classification is based on 3 main characteristics
1. Based on multi-omics data
2. Radiology based
3. Clinical Presentation based

The metabolomics technique uses SVM and pattern recognition to investigate variations in the profiles of plasma phospholipid fatty acids and serum protein expression. The urine metabolic profile was used to establish the panel of urine metabolomics signature of hyperinsulinemia and insulin resistance in PCOS. The aforementioned

AI application advances PCOS diagnosis and prevention while providing encouraging insights into the pathophysiology. The plasma phospholipid fatty acid profile.

The AI method is a useful tool for PCOS classification using PCOM evaluation and direct follicle counting. Information from the ultrasonic image report is analyzed by multifunctional machine learning text algorithms, which also demonstrated great performance accuracy.
Biochemical factors and biomarkers were also representative indicators of PCOS classification. To evaluate other clinical factors, the several PCOS subtypes (metabolic, reproductive, and background PCOS subtypes) could also be determined. Using ML algorithms like RF, SVM, KNN, and the Boruta Shap methods. Silva IS et al. [22] classified patients into distinct phenotypic clusters based on the most pertinent clinical and laboratory variables associated with PCOS diagnosis (lipid accumulation product, abdominal circumference, age, body mass index, follicle-stimulating hormone, insulin levels, triglycerides, etc.).

Complications of PCOS – Assessment and Prognostication

Various studies in 2024, have indicated the expanding emphasis on optimizing the practical guiding of AI algorithms in physician–patient-supported synergetic PCOS care. This is done by integrating clinical decision formulation and patient education.

Combined with the available data on basic sex hormones, embryonic morphology, the protein composition of endometrial, the follicular microenvironment, and the negative emotion of PCOS, the regulation of GLIPR1, FAM166B, TIA1, MAMLD1, and COL5A1 was evaluated from transcriptomics and metabolomics data, predicting pregnancy outcomes under the RF, SVM, least absolute shrinkage and selection operator (LASSO) algorithms, and so on.[123–127]
significantly higher luteinizing hormone, free androgen index, and androstenedione levels were linked to a higher metabolic syndrome score caused by PCOS[28]

Summary

With time and technical developments, the focus has changed to higher life quality, and the increasing morbidity of infertility has become a global public health concern in the twenty-first century.

AI tools underlined their potential significance in development of complete management approach for PCOS, which stratifies women with prospective or proven PCOS into discrete cohorts, enabling individualized interventions and tiered control of reproductive and metabolic problems. AI demonstrates substantial ecological validity in the clinical screening of PCOS, accomplished by the fast processing of patient data and the customization of screening algorithms to accommodate varied patient demographics.

The integration of AI with clinical practice care tremendously expedited the development of PCOS care in the direction of precision, penetration, prediction, and customization of management.

Abbreviations: PCOS Polycystic ovary syndrome, AI Artificial intelligence, ML Machine learning, DL Deep learning, SVM Support vector machine, AUC Area under the curve, PCOM Polycystic ovary morphology, MRI Magnetic resonance imaging, CNN Convolutional neural network, RF Random forest

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International Exchange Committee Report – IFS

Under the Leadership of:
Dr. Kuldeep Jain – Chairperson
Dr. (Col) Pankaj Talwar – President, IFS

The International Exchange Committee of the Indian Fertility Society (IFS) had a landmark and highly productive year, significantly expanding the society's global footprint through academic exchange, strategic collaborations, and leadership achievements on international platforms. Guided by the visionary leadership of Dr. Kuldeep Jain (Chairperson) and the dynamic support of Dr. (Col) Pankaj Talwar (President, IFS), the committee strengthened ties with major global reproductive medicine societies including IFFS, ASRM, ESHRE, ASPIRE, BFS, and ISRSFT.

Active Participation & Exchange Sessions
IFS maintained a strong international presence with exchange sessions at the annual meetings of all partner societies. These sessions facilitated academic dialogue, highlighted Indian perspectives in ART, and promoted bilateral knowledge transfer. International faculty also participated in IFS events, further reinforcing meaningful academic partnerships.

Major Collaborative Achievements
- One of the most significant accomplishments of the year was the finalization and signing of MoUs with ESHRE and ASRM, establishing long-term frameworks for cooperation in education, research, training, and faculty exchange.
- IFS also successfully organized the joint ESHRE Campus Program on Ovulation Induction, which received excellent national and international participation.
- Additionally, the committee hosted a series of important joint academic events, including:
- A collaborative webinar with ASRM
- A joint webinar with ISRSFT, strengthening ties with South Asian and regional fertility communities
- A webinar in association with the IFS UK Forum, further extending IFS's outreach to Indian reproductive specialists abroad

Launch of the IFS UK Forum – A Milestone Achievement
A major highlight and a historic step for international outreach was the launch of the IFS UK Forum. This initiative aims to connect Indian-origin fertility specialists practicing in the UK with the academic activities of IFS, fostering cross-border collaboration, knowledge-sharing, and joint scientific initiatives. The establishment of this forum marks a significant expansion of IFS's global network and represents a forward-looking model for future international chapters.

Leadership Recognition on the Global Stage
This year brought prestigious leadership appointments for India within international societies:
- Dr. K.D. Nayar assumed office as Chair of the ASRM International Special Interest Group (ISIG).
- Dr. Kuldeep Jain was elected Vice Chairman of the ASRM ISIG, marking an important achievement for IFS and enhancing India's representation within ASRM's global community.

Future Directions
Discussions with ASPIRE, BFS, IFFS, and ISRSFT are ongoing to finalize additional joint symposia, educational programs, and collaborative research initiatives. Building on this year's strong foundation, the International Exchange Committee remains committed to advancing the global engagement and academic prominence of IFS.


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