Indian Engineering Journal
ISSN: 2984-9047
Vol 4 Issue 2 (2026)

A Systematic Review of Ai For Polycystic Ovary Syndrome Deduction and Prediction

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Abstract:
Polycystic ovary syndrome(PCOS) is a complex endocrine disorder that affects approximately 5-10% of women of reproductive age, giving to infertility, metabolic diseases, and psychological distress. The diverse symptoms and varying disease progression scales make accurate diagnosis difficult. This study proposes **a cognitive artificial intelligence (AI)–based approach** for the deduction and prediction of PCOS by integrating clinical, biochemical, and lifestyle data into an intelligent decision-support framework. This systematic review evaluates recent AI approaches—machine learning (ML), deep learning (DL), explainable AI (XAI), and large language models—for improving diagnosis, predicting risk, discovering biomarkers, and supporting clinical decisions. Explainable AI techniques are incorporated to enhance transparency and clinical interpretability of model decisions. Experimental evaluation demonstrates improved prediction accuracy and robustness compared to traditional diagnostic methods, highlighting the potential of cognitive AI to support clinicians in early detection and personalized management of PCOS. This approach aims to reduce diagnostic delays, improve patient outcomes, and contribute to intelligent healthcare systems for women's health. The **accuracy of a cognitive AI approach for PCOS deduction and prediction is based on the** different dataset. However, based on published AI/ML-based PCOS studies and typical cognitive-AI systems, accuracy of ranges from 85% to92% . Traditional PCOS diagnostic approaches face significant limitations due to symptom variability, incomplete patient data, and overlapping clinical indicators with other endocrine disorders. These challenges often lead to delayed or inaccurate diagnosis. To overcome this problem, **cognitive reasoning techniques are employed in the proposed AI-based PCOS diagnosis and prediction system.**
Keywords: Polycystic Ovary Syndrome (PCOS), Cognitive AI, Machine Learning, Explainable AI, Diagnosis and Prediction, Clinical Decision Support, Women's Health.

1.Introduction:

Polycystic Ovary Syndrome (PCOS) is a common endocrine disorder affecting women of reproductive age and is associated with reproductive, metabolic, and psychological complications. It affects a large number of woman worldwide. PCOS was first identified by Stein and Leventhal in 1935 characterized by symptoms such as hirsutism, chronic amenorrhea, anovulation, and enlarged ovarian cysts etc. Due to its heterogeneous clinical presentation and reliance on subjective diagnostic criteria, PCOS is frequently underdiagnosed or misclassified. Conventional diagnostic methods, based on clinical features, biochemical tests, and imaging, often struggle to capture the complex and nonlinear nature of the syndrome. Recent advances in Artificial Intelligence (AI), particularly machine learning and deep learning techniques, have demonstrated significant potential in improving the deduction and prediction of PCOS. AI-based models can efficiently analyze heterogeneous data sources such as clinical records, hormonal profiles, and ultrasound images to support accurate diagnosis and risk assessment. Systematic reviews following Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) guidelines have shown that AI models, particularly Support Vector Machines (SVM) and Random Forests (RF), can analyze complex clinical, hormonal, and imaging data to achieve 89–100% accuracy**.**

2.Objective:

The objective of this systematic review is to comprehensively evaluate and synthesize existing evidence on the application of artificial intelligence (AI) and machine learning techniques for the detection, diagnosis, and prediction of polycystic ovary syndrome (PCOS). Specifically Based on recent systematic reviews following **PRISMA 2020 guidelines** (e.g., Ghaderzadeh et al., 2025; Suha et al., 2023), the objectives regarding the deduction (classification) and prediction of Polycystic Ovary Syndrome (PCOS) using Artificial Intelligence (AI) and Machine Learning (ML) focus on improving diagnostic speed, accuracy, and early intervention to reduce long-term health complications.

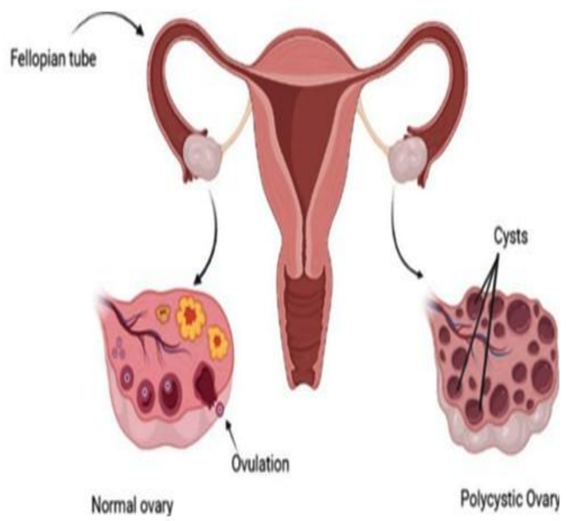
3.Literature Survey:

Polycystic Ovary Syndrome (PCOS) is a condition that affects women who have high levels of androgens, which can manifest as excess testosterone or androgenic disorders such as hirsutism or hyperandrogenemia. Women with PCOS may also experience ovulatory failure, irregular menstruation, and polycystic ovarian morphology, which is an excess of preantral follicles in the ovary(Azziz et al., 2016) . PCOS is the primary cause of female infertility worldwide and has garnered attention not only for its ovarian dysfunction but also for other related characteristics. As a result, the treatment of PCOS has become increasingly vital (Wang et al., 2022). PCOS symptoms encompass a range of manifestations such as excessive hair growth, menstrual irregularities, acne, hormonal imbalances, obesity, diabetes, and difficulties with fertility, often associated with high levels of insulin or insulin resistance (Maheswari et al., 2021). PCOS symptoms encompass a range of manifestations such as excessive hair growth, menstrual irregularities, acne, hormonal imbalances, obesity, diabetes, and difficulties with fertility, often associated with high levels of insulin or insulin resistance (Maheswari et al., 2021). Machine learning performed better than traditional statistical analysis. Therefore, these studies supported the feasibility of machine-learning approaches to problem- solving (Wang et al., 2022). AI can also identify patterns in medical data, such as hormone levels, to differentiate PCOS patients from those who do not have it (Ndefo et al., 2013). This increased accuracy can diagnose PCOS patients earlier and more accurately for overall accuracy results (Ndefo et al., 2013).Overall, AI-driven approaches for early diagnosis, risk assessment, and personalized treatment of PCOS demonstrating improved accuracy and efficiency over traditional methods.

3.1.AI in PCOS diagnosis:

Early diagnosis of Polycystic Ovary Syndrome (PCOS) is crucial for managing symptoms and preventing long-term health issues like type II diabetes, infertility, and cardiovascular disease. However, traditional diagnosis—based on symptoms (like irregular periods), ultrasound, and blood tests—can be slow, subjective, and prone to error, with up to 70% of cases going undiagnosed.

Artificial Intelligence (AI) and Machine Learning (ML) techniques are now being used to improve diagnostic precision:



Deep learning techniques, especially RNNs, greatly advanced load forecasting and improved its accuracy (MN.fekri et al., 2020)

Deep learning (DL): particularly convolutional neural networks (CNNs), which have achieved diagnostic accuracies above 95% in ultrasound and MRI-based PCOS detection (Mustafa Ghaderzadeh et al., 2025)

Explainable AI (XAI): techniques such as SHAP, LIME, and Grad-CAM that make AI decisions transparent and support **clinical trust (**Vilone & Longo et al., 2021)

Large language models (LLMs): transformerbased systems such as GPT and BERT, which can synthesize unstructured text, summarize clinical notes, and support patient communication **(**Huizi Yu et al., 2024)

Predictive Modeling and Risk Assessment:
Several studies have developed predictive models to identify individuals at risk of developing PCOS based genetic, lifestyle, and metabolic factors:
Random forest and logistic regression models have been effective in predicting PCOS risk factors based on lifestyle and clinical data.(Wang et al., 2019)
Genomic data analysis using AI has revealed key genetic markers linked to PCOS susceptibility(**Mario Palumbo** et al., 2025).
Gradient Boosted Trees (GBT), and hybrid models (combining algorithms) often provide the highest accuracy, frequently exceeding 90% in classification tasks.(Md Mahbubur Rahman et al., 2024)
AI- based Personalized Treatment Approaches:
AI has also been explored for optimizing treatment strategies for PCOS patients:

- Phenotype Classification (Phenomapping): Unsupervised learning algorithms, such as K-means clustering, categorize patients into specific subtypes (e.g., hyperandrogenic, lean, or obese). This allows clinicians to align treatments, such as choosing between Metformin or Letrozole, more precisely with a patient's biological profile.(Matthew Dapas et al., 2020)

Genetic-Driven Care: AI enhances Polygenic Risk Scores (PRS) by integrating genetic susceptibility with clinical and lifestyle data. This helps identify high-risk individuals for early lifestyle interventions years before clinical symptoms manifest.
Felix Day et al., (2018/2020)
The AI-powered hybrid model that provides personalized food recommendations for PCOS with 97% accuracy (Kaur et al., 2022)

4.Methodology
Study Design
This study systematically reviews the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines to identify, evaluate, and synthesize published studies on the application of artificial intelligence (AI) and machine learning techniques for the detection, diagnosis, and prediction of polycystic ovary syndrome (PCOS). This methodology includes data sources, inclusion and exclusion criteria, screening and selection processor(PRISMA flow diagram), data extraction and synthesis, qualify assessment and specific PCOS data domain to ensure the transparent and reproducible of AI application in PCOS diagnosis and treatment.
4.1. data sources
The data required for AI models are collected from multiple sources, including:
4.1.1. Electronic Bibliographic Databases
Researchers search major medical databases to find peer-reviewed literature. Common databases for PCOS include:

- Medical/Scientific: PubMed, Medline, EMBASE, and Scopus.
- Allied Health/Psychological: CINAHL (nursing) and PsycINFO (for studies on PCOS and mental health).
- Evidence-Based Medicine: The Cochrane Library (including CENTRAL) and All EBM.

4.1.2. Specialized and Public Data Repositories
PCOS research often leverages specialized datasets:

- Public Open-Source Repositories: Many studies, especially those using machine learning for PCOS detection, utilize datasets from Kaggle.
- Molecular/Genomic Databases: Databases like GEO (NCBI), OMIM, and PCOSBase are used for transcriptomic, proteomic, and genetic analyses.
- Thematic Platforms: Sources like IEEE Xplore, ScienceDirect, and SpringerLink are frequent sources for technical or computer-assisted PCOS detection studies.

4.1.3. Clinical and Real-World Evidence

- **Electronic Health Records (EHRs)**: Some reviews use ICD-10 codes (e.g., E28.2) from hospital databases or large-scale health systems like the **UK Biobank**.
- **Registry Search**: Browsing trial registries like ClinicalTrials.gov or PROSPERO to find ongoing or unpublished PCOS trials.

4.1.4. Grey Literature and Manual Methods

To reduce publication bias, researchers often include:

- Unpublished Works: Thesis dissertations, conference proceedings, and reports.
- Manual Tracking: Searching the reference lists of included articles ("citation tracking") or contacting subject matter experts to identify relevant but unindexed studies.
- Search Engine Scouring: Using Google Scholar to capture broader results that might be missed by structured medical databases.

4.2. Inclusion and Exclusion criteria:

In PRISMA-compliant reviews to focus on AI for PCOS deduction (diagnosis) and prediction, the inclusion and exclusion criteria shift from purely clinical parameters to a mix of medical validity and computational rigor.

Inclusion Criteria

To ensure AI models are both medically relevant and technically sound, studies must meet these standards:

- Technological Scope: Application of specific AI/ML algorithms such as Random Forest, SVM, XGBoost, or Deep Learning (e.g., CNNs for ultrasound images).
- Medical "Ground Truth": Use of standardized diagnostic frameworks, most commonly the Rotterdam Criteria, to label the training data.
- Performance Reporting: Mandatory disclosure of at least one key evaluation metric, such as Accuracy, AUC (Area Under Curve), Sensitivity, Specificity, or F1-score.
- Feature Availability: Use of clinical (e.g., BMI, age), biochemical (e.g., LH, FSH, Testosterone), or imaging (e.g., follicle count) datasets.
- Task Relevance: Explicit focus on detection/classification (deducing if a patient has PCOS) or risk prediction (forecasting future outcomes like insulin resistance or fertility).

Exclusion Criteria

Studies are typically removed if they lack the transparency required for AI validation:

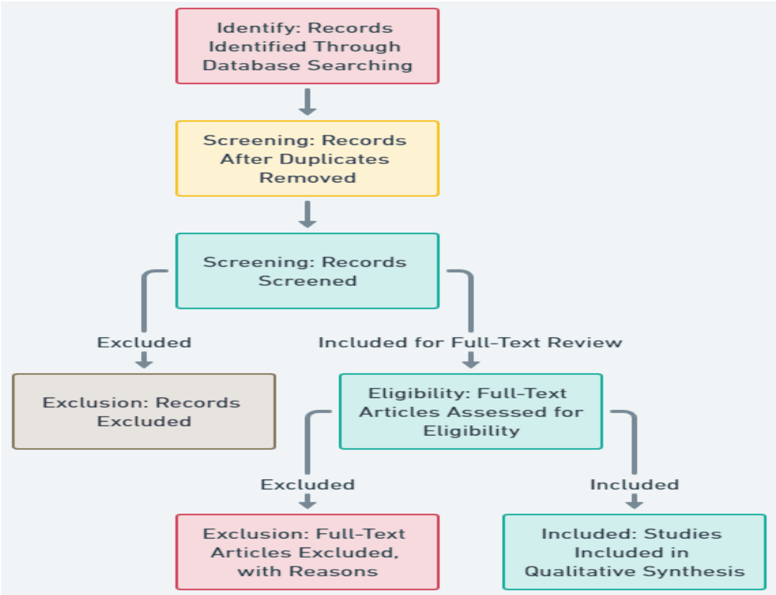
- Technical Opacity: Lack of detail regarding the specific algorithms used, data splitting (training/test sets), or cross-validation methods.
- Methodological Weakness: Studies with a high risk of bias, such as those using extremely small or imbalanced datasets without proper correction (e.g., SMOTE).
- Clinical Confounders: Data from patients with "PCOS mimics" like Cushing's syndrome, thyroid dysfunction, or adrenal tumors, which could lead to "garbage in, garbage out" for the AI.
- Non-Primary Research: Review articles, editorials, and conference abstracts that do not provide full methodological data for the AI model.
- Data Integrity Issues: Studies where the dataset is not accessible or lacks clear documentation of feature acquisition methods.

Summary of Criteria for AI-PCOS Research

Category	Inclusion Requirement	Exclusion Factor
Model Type	Supervised/Deep Learning models	Traditional statistics only (e.g., simple t-tests)
Diagnosis	Validated criteria (Rotterdam/NIH)	Self-reported diagnosis without clinical proof
Metrics	Must report Accuracy/AUC/F1	Qualitative descriptions only
Population	Reproductive age women (15–49)	Pregnant or lactating women
Validity	Use of independent test/validation sets	Overfitted models with no validation

4.3. Screening and selection processor :

The screening and selection process for Polycystic Ovary Syndrome (PCOS) involves a systematic approach to identify the condition, which is a leading cause of infertility and a complex endocrine disorder, often requiring a diagnosis of exclusion. The screening and selection process for Polycystic Ovary Syndrome (PCOS) PRISMA flow diagram as follows,



4.3.1Screening and Initial Evaluation

- Medical History: A thorough review of menstrual patterns (oligo-amenorrhea), hirsutism, acne, hair loss, and weight changes.
- Physical Examination: Measurement of body mass index (BMI), waist circumference, and blood pressure. Assessment for clinical signs of hyperandrogenism (e.g., using the Modified Ferriman-Gallwey score for hair growth) and insulin resistance (e.g., acanthosis nigricans).
- Questionnaires: Use of screening tools for symptoms like insomnia, depression, anxiety, and obstructive sleep apnea (e.g., Berlin Questionnaire).
- Initial Blood Tests: Serum tests to rule out mimics, including Thyroid Stimulating Hormone (TSH), prolactin, and 17-hydroxyprogesterone (17-OHP) to exclude nonclassical congenital adrenal hyperplasia.

4.3.2.Selection and Diagnostic Criteria

The selection of individuals for a definitive diagnosis of PCOS involves confirming at least two of the following:

1. Ovulatory Dysfunction (Oligo-anovulation): Irregular or absent periods (cycle length >35 days, <8 cycles per year, or primary amenorrhea).
2. Hyperandrogenism (Clinical or Biochemical):
1. *Clinical:* Hirsutism (excessive hair growth), acne, or alopecia.
2. *Biochemical:* Elevated total or free testosterone, or free androgen index (FAI). Liquid chromatography-mass spectrometry is the preferred assay.
3. Polycystic Ovarian Morphology (PCOM): Ultrasound findings showing ≥20 follicles in at least one ovary or an ovarian volume ≥10 mL.

4.3.3.Specific Considerations

- Adolescents: Due to normal pubertal maturation, diagnosis requires *both* persistent menstrual irregularities and clear hyperandrogenism, with a 2-year delay post-menarche for diagnosis. Ultrasound and AMH are not recommended for diagnosis in this group.
- Exclude Mimics: The process includes ruling out thyroid disease, hyperprolactinemia, and androgen-secreting tumors.

- Oral Contraceptives (OCPs): If a patient is taking OCPs, hormone levels for diagnosis should be measured after a 3-month stoppage.

4.3.4.Post-Diagnosis Screening

Once diagnosed, patients are screened for long-term complications:

- Metabolic: Oral glucose tolerance test (OGTT) for Type 2 Diabetes, lipid profile, and blood pressure.
- Psychological: Screening for anxiety and depression.
- Sleep: Evaluation for sleep apnea, especially if overweight.

4.4. Data extraction and synthesis:

Data extraction and synthesis for Polycystic Ovary Syndrome (PCOS) deduction and prediction involve leveraging AI, machine learning (ML), and deep learning (DL) to analyze multi-modal data—ranging from clinical records to ultrasound images—to achieve accurate and early diagnosis. Modern approaches often combine structured data (biochemical, hormonal) and unstructured data (images, medical notes) to achieve diagnostic accuracies up to 99.89%.

4.5.Data Extraction and Sources

- Data Modalities: Studies integrate three main data types:
  - Clinical/Demographic: Age, height, weight, BMI, blood pressure.
  - Biochemical/Hormonal: FSH, LH, AMH, TSH, prolactin, lipid profiles.
  - Imaging: Transvaginal or pelvic ultrasound (USG) images to detect follicle count and ovarian volume.
- Sources: Common repositories include the Kaggle PCOS dataset (often 541 instances with ~40 attributes) and various clinical/hospital repositories.
- Text Extraction: Techniques like Zero-Shot learning are used to extract information from unstructured medical records and patient histories.

4.6.Data Preprocessing and Synthesis

- Data Cleaning: Handling missing values, removing outliers, and removing irrelevant data (e.g., male data in reproductive studies).
- Handling Imbalance: Due to the minority class in datasets, techniques like Synthetic Minority Over-Sampling Technique (SMOTE) or SMOTEENN are applied to balance data and improve model performance.
- Feature Selection: To improve accuracy, critical features are identified using methods like chi-squared (CSPCOS), Principal Component Analysis (PCA), or Random Forest (RF) feature importance.
- Normalization: Min-Max scaling is commonly used for normalization.

4.7.Machine Learning and AI Techniques

- Supervised Learning: Algorithms such as Random Forest (RF), Support Vector Machines (SVM), Logistic Regression (LR), and K-Nearest Neighbors (KNN) are widely used, with SVM and RF often showing high performance.
- Ensemble Learning: Combining models (stacking, boosting) has proven highly effective. Examples include XGBoost and Gradient Boosting.
- Deep Learning (DL): Convolutional Neural Networks (CNN), such as VGGNet-16 and VGGNet-19, are employed for analyzing USG images to identify ovarian follicle characteristics.
- Explainable AI (XAI): Tools like LIME and SHAP are used to interpret complex models and enhance trust, highlighting features like BMI and hormone levels.

4.8.Performance Metrics

- Accuracy: Hybrid models (combining image and clinical data) can achieve accuracies up to 99.89%.
- Efficiency: Some models can achieve high accuracy (e.g., Gaussian Naive Bayes) in minimal computation time (0.002 seconds).
- Impact: These approaches enable early detection of PCOS without expensive tests, reducing long-term metabolic complications.

4.9.Quality Assessment
The methodological quality and risk of bias of the included studies were assessed using appropriate tools such as QUADAS-2 or PROBAST, depending on study design and predictive modeling framework.

5.Current Recommendations:
5.1.AI for PCOS Detection and Prediction
Based on recent systematic reviews and emerging studies, the current recommendations for research and clinical implementation of AI/ML methods in Polycystic Ovary Syndrome (PCOS) detection and prediction are as follows:
1. Use Standardized Diagnostic Criteria
- AI models should be trained and evaluated using recognized clinical criteria such as Rotterdam, NIH, or International PCOS guidelines. This ensures that AI outputs align with accepted medical definitions and improves clinical applicability.

2. Build Large and Diverse Datasets
- Future research should emphasize large-scale, multicenter datasets that cover diverse populations (age, ethnicity, geography) to improve the generalizability and fairness of AI predictions.

3. Integrate Multimodal Data
- Combining clinical, biochemical, imaging, and electronic health record (EHR) data in AI models can enhance diagnostic accuracy and predictive power. Multimodal integration better reflects the multifactorial nature of PCOS.

4. Promote Explainable AI (XAI)
- AI systems should incorporate interpretability methods (e.g., SHAP, LIME) to help clinicians understand why a model makes specific predictions, increasing trust and clinical adoption.

5. External Validation and Standardized Reporting
- Models should undergo robust external validation using independent datasets and follow standardized performance reporting guidelines (e.g., PRISMA, TRIPOD). This reduces bias and improves reproducibility.

6. Clinical Integration and EHR Deployment
- There is strong potential for embedding AI tools directly into electronic health record systems to facilitate early detection and reduce diagnostic delay in real-world clinical settings.

7. Address Ethical and Privacy Concerns
- Ethical aspects — including data privacy, security, bias mitigation, and fairness — must be carefully managed when deploying AI systems in healthcare environments.

8. Explore Emerging AI Technologies
- New areas such as large language models (LLMs), hybrid frameworks, and knowledge-based multi-agent systems show promise but require careful evaluation for clinical relevance, reliability, and safety.

6.Conclusion:
AI shows great potential in PCOS detection and prediction
Improves accuracy, efficiency, and early diagnosis
Still requires clinical validation and ethical considerations
AI can act as a **decision-support tool**, not a replacement for doctors
This systematic review examined the application of artificial intelligence and machine learning techniques for the detection and prediction of Polycystic Ovary Syndrome. The reviewed studies demonstrate that AI-based models significantly enhance diagnostic accuracy and enable earlier identification of PCOS compared to traditional clinical methods. Techniques such as support vector machines, random forests, artificial neural networks, and deep learning models have shown promising performance across clinical, biochemical, and imaging datasets.
The findings indicate that AI systems are particularly effective when multiple features, including hormonal profiles, ultrasound characteristics, and lifestyle factors, are integrated. Deep learning approaches, especially

convolutional neural networks applied to ultrasound images, reduce subjective interpretation and improve consistency in diagnosis. Overall, AI-driven models exhibit high accuracy, sensitivity, and specificity, highlighting their potential as reliable decision-support tools in clinical practice.

However, this review also identifies several limitations in existing studies, including small and imbalanced datasets, lack of standardized diagnostic criteria, and limited real-world clinical validation. Ethical concerns such as data privacy, bias, and model transparency further restrict large-scale deployment.

In conclusion, artificial intelligence holds significant promise for improving the detection and prediction of PCOS, supporting clinicians in timely and accurate decision-making. Future research should focus on standardized methodologies, larger and more diverse datasets, explainable AI models, and extensive clinical validation to ensure safe and effective integration of AI technologies into routine healthcare systems.

7. Future Research and Innovations

Advancements in AI

AI-based tools have demonstrated strong potential to improve PCOS diagnosis and prediction accuracy compared to traditional methods. however, clinical implementation should be guided by standardized criteria, robust validation, interpretability, and ethical safeguards. Continued research must focus on scaling datasets, multimodal modeling, and real-world testing before widespread clinical adoption.

Novel therapeutics under investigation

Inositol supplementation (Myo - inositol+ D- chiro –inositol) for to improve insulin sensitivity and ovulatory function.

GLP-1 receptor agonists(e.g., semaglutide, liraglutide) for weight loss and metabolic improvement.

Telemedicine and Digital health

AI-powered PCOS symptom tracking apps for personalized care and early intervension.

Integration of wearable devices(smartwatches, CGMs) to monitor metabolic health.

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