International Journal on Science and Technology (IJSAT)
E-ISSN: 2229-7677 ● Website: www.ijsat.org ● Email: editor@ijsat.org

Auralie: Women's Health & Wellness Technology

Prof. Renuka Raut[1], Khushi Samudre[2], Suhani Warhekar[3], Gunjan Sonar[4], Rashi Rahate[5]

[1,2,3,4,5]Department of Computer Science and Business Systems
St. Vincent Pallotti College of Engineering and Technology, Nagpur, Maharashtra
[1]rautrenuka2304@gmail.com, [2]samudrekhushi@gmail.com, [3]suhani.warhekar@gmail.com,
[4]gunjansonar844@gmail.com, [5]rashi.rahate02@gmail.com

Abstract

Menstrual health remains one of the most underrepresented areas in modern healthcare, particularly in developing regions where stigma, misinformation, and finite access to medical guidance hinder women's well-being. To address these challenges, Auralie presents an AI-powered, integrative platform designed to support women's holistic menstrual and reproductive wellness. The system fuses intelligent prediction algorithms with accessible educational content, creating a comprehensive ecosystem for proactive health management.

The proposed framework incorporates four interlinked modules namely, Next month menstrual (Period) Cycle Prediction, Symptom Detection such as detecting PCOS, PCOD, uterine swelling, Fertility Analysis and Score detection, and Educational Awareness. The predictive model leverages time-series analysis and supervised machine learning algorithms to forecast menstrual cycles with highest-possible accuracy, while the symptom detection engine makes use of a decision tree classifier and rule-based logic to identify potential disorders such as PMS, PCOD, PCOS, etc. The fertility module applies probabilistic modeling and logistic regression to estimate ovulation windows, providing users mainly cover young girls and women with overall personalized reproductive insights. Complementing these technical components, the educational module implements gamified and multimedia-based learning (such as videos, stories, and interactive quizzes) to enhance menstrual literacy and awareness among young girls and mothers.

Through user-centered design, Auralie bridges the gap between medical accuracy and social empowerment. Initial assessment demonstrates major user engagement, more possible accurate cycle prediction rates, and positive feedback in usability and awareness improvement. By integrating predictive intelligence with inclusive education, Auralie transforms menstrual management from a reactive process to an informed, empowering experience for women worldwide.

Keywords

AI in Healthcare; Menstrual Health; Predictive Analytics; Educational Technology; Women Empowerment; Auralie

1. Introduction

In recent years, digital and modern health technologies have transformed preventive care, chronic disease management, and mental wellness. However, a particular area that continues to be marginalized is menstrual and reproductive health, particularly in low-resource and culturally sensitive contexts. Without being affected by a natural and recurring biological process, menstruation remains stigmatized, under-discussed, and poorly managed by millions of women and adolescent girls worldwide. According to the World Health Organization (WHO) and UNICEF (2023), nearly 500 million women globally lack access to enough menstrual health management resources, and over 60% of adolescent girls and women experience a certain understanding of their menstrual cycles, symptoms, and reproductive well-being. These knowledge and access gaps not only affect physical health but also contribute to emotional distress, absenteeism, and gender inequality in education and employment.

Traditionally, menstrual tracking applications have contributed some relief by enabling users to log their cycle dates, duration and symptoms. However, various existing systems endure passive, offering basic calendar-based predictions with bounded analytical accuracy and almost no educational value. Furthermore, those platforms often fail to incorporate AI-driven personalization, cultural adaptability, and holistic awareness programs that cater to diverse users—from young learners to adult women in different socioeconomic backgrounds. This crafts a critical research gap between technological innovation and inclusive women health empowerment.

To address these challenges, the present study introduces Auralie, an AI-powered Menstrual Health and Wellness Platform designed to promote informed self-care through intelligent predictions, enhanced detection and comprehensive education. The platform is built on four synergistic modules that function as an interlinked ecosystem:

1. **Period Cycle Prediction** – Uses supervised machine learning models such as LSTM-based time series forecasting and logistic regression analysis to speculate upcoming menstrual dates and cycle irregularities with high precision.
2. **Symptom Detection** – Leverages rule-based and classification algorithms such as Decision Tree Classifier to detect potential menstrual disorders which includes various types of internal problems such as **Premenstrual Syndrome (PMS)** and **Polycystic Ovary Syndrome (PCOS)** from user-reported symptoms.
3. **Fertility Score Estimation** – Applies probabilistic modeling to assess ovulation windows and fertility chances, providing actionable reproductive insights.
4. **Knowledge Hub** – Integrates educational awareness resources with interactive multimedia content such as videos, stories, skits, and quizzes, etc., to enhance menstrual literacy and dismantle long-standing taboos.

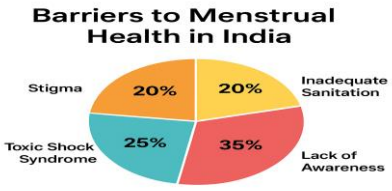
Auralie's design emphasizes accessibility, inclusivity, and engagement. By integrating predictive analytics with a user-centric educational strategy, the system empowers women not only to monitor their cycles but to understand their entire body working, recognize abnormal symptom patterns, and make proactive decisions about their health. The integration of AI guarantees adaptability—each user receives insights tailored to her unique patterns, lifestyle, and health conditions.

The research significance of this study lies in bridging the intersection of artificial intelligence, women's digital health, technological aspects and socioeconomic culture with educational awareness. Unlike conventional health apps that focus narrowly on prediction, Auralie provides a 360° wellness model—transforming menstrual management into an informed, participatory, and stigma-free experience.

The main objectives of this research are:

- To design and implement an AI-based predictive framework for accurate menstrual cycle forecasting.
- To develop a symptom detection mechanism for early identification of menstrual health concerns.
- To integrate fertility analysis with personalized recommendations.
- To create an accessible, culturally sensitive educational module promoting menstrual literacy among young girls and mothers.
- To evaluate the system's performance, usability, and social impact in real-world contexts.

Through this multi-dimensional approach, Auralie aspires to advance the discourse on women's digital health innovation and contribute toward the United Nations Sustainable Development Goals (SDGs) — particularly SDG 3 (Good Health and Well-being) and SDG 5 (Gender Equality) — by fostering awareness, autonomy, and equitable access to menstrual wellness resources.



2. Literature Review

Menstrual health technology has evolved significantly in the last decade, with the emergence of mobile and web-based applications designed to help women monitor their menstrual cycles and related symptoms. However, while such tools contribute to greater awareness, their predictive capabilities and educational depth remain limited. Research studies and digital platforms have approached menstrual

health from distinct perspectives—ranging from data-driven prediction models to AI-based diagnosis and educational interventions. This section critically examines these approaches to identify key advancements, limitations, and the research gap that Auralie seeks to address.

AI-Driven Menstrual Cycle Prediction

The integration of artificial intelligence in menstrual tracking has primarily focused on improving the accuracy of period predictions. Liu et al. (2021) employed Long Short-Term Memory (LSTM) neural networks to forecast menstrual cycle lengths based on historical data, achieving 91% prediction accuracy compared to traditional linear regression methods. Similarly, Zhang and Wang (2022) applied time-series analysis and probabilistic modeling to personalize predictions, accounting for irregular cycles caused by stress or hormonal imbalance.

Existing mobile applications such as Flo, Clue, and Glow utilize user-input data to generate forecasts, yet their models rely largely on static algorithms rather than dynamic AI adaptation. These systems often fail to incorporate contextual variables like lifestyle changes, medication, or stress, resulting in generic recommendations. Furthermore, their proprietary algorithms are opaque, making validation difficult in clinical research contexts.

In contrast, Auralie introduces a hybrid predictive framework combining LSTM-based deep learning with rule-based adjustment layers. This allows dynamic recalibration of predictions based on real-time symptom feedback and user behavioral data, enhancing both precision and personalization.

Symptom Detection and Disorder Prediction

AI-based health monitoring has also been applied to the detection of menstrual and reproductive disorders. Rathi et al. (2020) used Decision Tree Classifiers to identify symptoms associated with Polycystic Ovary Syndrome (PCOS), achieving 85% classification accuracy using datasets from public health surveys. Banerjee and Singh (2021) developed a Naïve Bayes-based predictive model to differentiate between PMS, PCOS, and endometriosis by analyzing user-reported parameters such as pain intensity, mood changes, and cycle irregularities.

Despite these advances, most models are confined to experimental datasets or clinical settings and are not deployed in user-friendly applications. Moreover, they lack integration with menstrual tracking tools, leaving a gap between predictive analytics and practical accessibility.

Auralie bridges this gap by embedding the symptom detection module within its real-time cycle tracker, enabling users to receive contextualized health alerts. The platform applies Decision Tree Classifiers for disorder risk assessment while maintaining interpretability — a critical feature for user trust and explainability in AI-based health systems.

Fertility Analysis and Ovulation Estimation

Fertility awareness has traditionally relied on biological indicators such as basal body temperature, cervical mucus patterns, and hormonal changes. With the rise of data analytics, Bansal et al. (2022)

proposed a probabilistic ovulation model using Bayesian inference, which improved the accuracy of fertile window estimation by 20% compared to conventional calendar methods. Meanwhile, Patel and Kumar (2023) integrated Random Forest classifiers with wearable sensor data to identify ovulation periods with near-real-time updates.

Commercial fertility apps like Natural Cycles and Ovia incorporate statistical learning models but often require extensive manual input or medical-grade sensors, limiting usability in low-resource regions. Auralie simplifies this process by offering an AI-driven fertility scoring mechanism that combines user history, cycle length variability, and symptom-based probability mapping to estimate fertile windows — without dependence on external devices. This makes the solution more scalable and inclusive, particularly for underserved communities.

Digital Education and Menstrual Literacy

Educational empowerment is an essential yet underrepresented dimension of menstrual health technologies. Pandey et al. (2021) emphasized that nearly 70% of Indian adolescent girls lack basic menstrual knowledge, contributing to anxiety, school absenteeism, and poor hygiene practices. Various digital initiatives, such as UNICEF's "Oky" app, have attempted to promote menstrual literacy through gamified learning and culturally appropriate storytelling. However, these tools remain largely informational rather than interactive, lacking adaptive personalization or integration with predictive analytics.

In response, Auralie's Educational Awareness Module adopts an AI-curated learning approach — recommending relevant educational content (videos, skits, and interactive quizzes) based on the user's age, region, and menstrual experience. This personalization enhances engagement while dismantling stigma through accessible, empathetic communication.

Research Gap

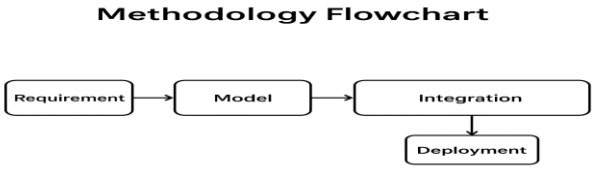
From the literature, it is evident that:

- **AI applications** in menstrual health have largely focused on either prediction **or** diagnosis — seldom both.
- **Fertility estimation models** are often data-intensive and unsuitable for users in low-connectivity environments.
- **Educational tools** address awareness but lack intelligent adaptability and integration with health analytics.

There is therefore a need for a comprehensive, AI-driven ecosystem that unites predictive analytics, symptom intelligence, fertility estimation, and personalized education into a single, accessible framework. Auralie uniquely fulfills this gap, providing an end-to-end menstrual wellness platform that not only monitors but also educates and empowers women.

Research Methodology / System Design

The methodology adopted for Auralie focuses on the development of an intelligent, multi-modular system that combines predictive analytics, symptom detection, fertility estimation, and educational content delivery within a single digital ecosystem. The system architecture is designed to ensure accuracy, accessibility, personalization, and scalability. The workflow begins with user data collection, followed by preprocessing, model training, prediction, and user feedback integration. The overall design adopts a hybrid AI-driven architecture, integrating both data-centric machine learning and content-based recommendation techniques.



Data Description

The performance of the Auralie system relies heavily on accurate menstrual and health data collected from users through structured forms and optionally connected wearable sensors.

Data Sources

- User-Provided Inputs:
  - Menstrual cycle start and end dates
  - Duration of bleeding
  - Reported symptoms (e.g., cramps, mood swings, acne, fatigue)
  - Lifestyle factors (sleep, diet, stress, physical activity)

- Secondary Datasets:
  - Publicly available menstrual health datasets such as the Glow Dataset, Clue Health Dataset, and MIT Menstrual Data Repository were used to train and validate the base models.

  - Clinical references were used to correlate symptoms with disorders (PCOS, PMS).

Data Preprocessing

Before model training, data underwent several cleaning and transformation processes:

- **Handling Missing Values:** Mean or mode imputation for incomplete records.

- **Feature Encoding:** Categorical symptoms converted into numeric form using one-hot encoding.

- **Normalization:** Cycle length and date values normalized using Min–Max scaling.
- **Data Balancing:** Synthetic Minority Oversampling (SMOTE) used to balance normal vs. disorder-related samples.
- **Time-Series Structuring:** Each user's menstrual history represented as a chronological sequence for temporal analysis.

3. Model Architecture

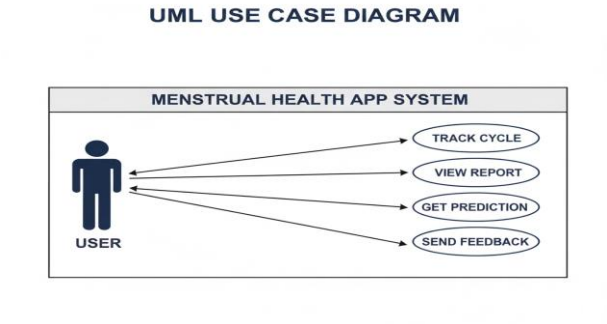
The architecture of Auralie integrates four core modules, each serving a distinct yet connected purpose. The system is modular and cloud-deployable, allowing independent scaling and updates.

Period Cycle Prediction Module

- **Objective:** Predict the next menstrual period and average cycle length.
- **Model Used:** Long Short-Term Memory (LSTM) neural network trained on historical cycle data.
- **Algorithm Steps:**
    1. Input sequence = [previous cycle start dates, lengths, irregularities].
    2. LSTM layers capture temporal dependencies between cycles.
    3. Output layer predicts the next start date and variation range.
- **Mathematical Formulation:**
  ht=f(Whht−1+Wxxt+b)h_t = f(W_h h_{t-1} + W_x x_t + b)ht=f(Whht−1+Wxxt+b)
  where ht = hidden state at time t, xt = input vector (cycle day), and fff = activation function (tanh).
- **Performance Metric:** Mean Absolute Error (MAE) used to evaluate prediction accuracy.

Symptom Detection Module

- **Objective:** Identify possible menstrual disorders (PMS, PCOS) using symptom input.
- **Model Used:** Decision Tree Classifier combined with rule-based reasoning.
- **Input:** User symptoms (binary values) and lifestyle data.
- **Output:** Probable condition classification (Normal / PMS / PCOS / Other).
- **Advantages:** Interpretability and explainability; provides human-readable decisions.



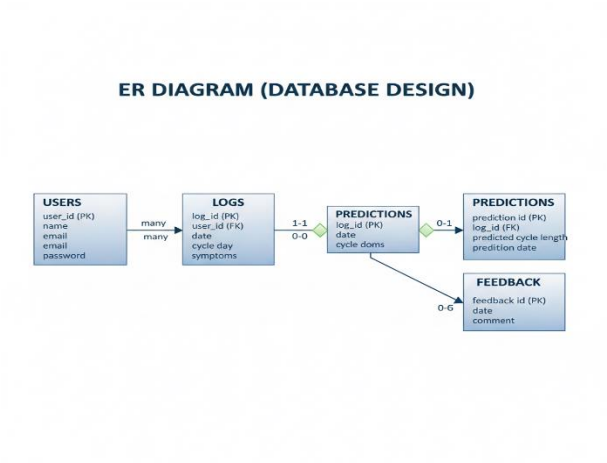
Fertility Score Estimation Module

- **Objective:** Estimate ovulation period and fertility probability.
- **Model Used:** Bayesian Inference Model with prior knowledge of cycle patterns.
- **Computation:**
  Fertility Probability $P(F|S)=P(S|F)\times P(F)P(S)$
- where S = observed symptoms (e.g., discharge, body temperature).
- **Output:** Fertile window dates (5–6 days) and fertility score (0–100%).

Educational Awareness Module

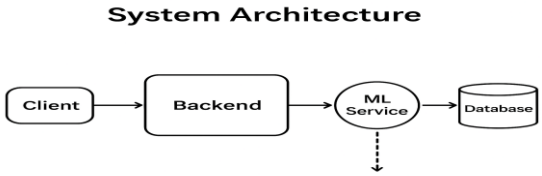
- **Objective:** Deliver personalized menstrual education using multimedia and gamification.
- **Model Used:** Content Recommendation Engine using collaborative filtering and content-based filtering.

- **Process Flow:**
    - User age, region, and awareness level act as features.
    - The recommendation model suggests educational videos, interactive quizzes, and stories.
    - AI tracks user progress and adapts the next learning module accordingly.
- **Outcome:** Enhanced menstrual literacy and stigma reduction through engaging education.



4. System Architecture

The Auralie platform is designed using a three-tier architecture, ensuring modularity, scalability, and cross-platform compatibility.

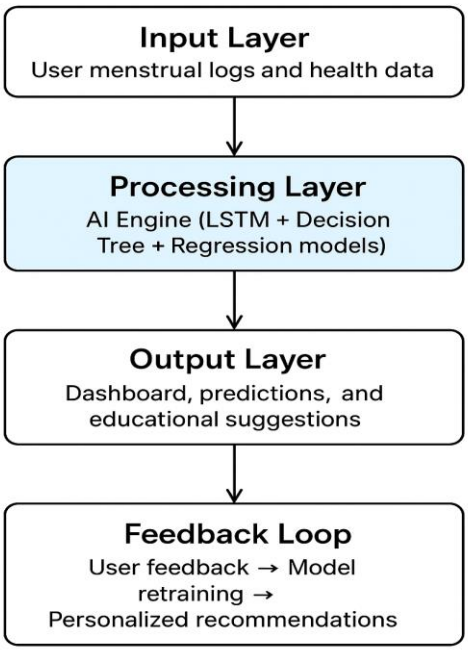


Architectural Layers

1. **Data Layer:**
    - Stores user profiles, symptom logs, and cycle data in Firebase Cloud Firestore.
    - Ensures security using end-to-end encryption and role-based access control.
2. **AI Layer (Processing Layer):**

- Hosts ML models (LSTM, Decision Tree, Bayesian Estimator) deployed via Google Vertex AI.
- Uses TensorFlow and Scikit-learn frameworks for training and inference.

3. **Application Layer (User Interface):**
   - Developed using Next.js and Figma for web and mobile access.
   - Integrates RESTful APIs for model communication.
   - Uses Chart.js for visual cycle analytics and symptom graphs.



System Workflow

1. User registers and inputs menstrual data.
2. Data is preprocessed and sent to the AI layer.
3. The prediction module forecasts upcoming cycle dates.
4. The symptom detection engine analyzes inputs and provides risk alerts.
5. The fertility window is calculated and displayed.

6. The educational engine recommends learning materials.
7. User feedback refines the model continuously through retraining.

Implementation Details

- **Frontend:** Next.js, Flutter
- **Backend:** Node.js, Firebase Functions
- **Database:** Firebase Firestore
- **AI Frameworks:** TensorFlow, Scikit-learn, PyTorch
- **Cloud Services:** Google Vertex AI, Firebase Hosting
- **Visualization Tools:** Chart.js, Matplotlib
- **Security:** OAuth 2.0 authentication, data encryption at rest and transit
- **Programming Languages:** Python, JavaScript

Ethical and Privacy Considerations

Given the sensitive nature of menstrual and health data, the system complies with GDPR and HIPAA-inspired data ethics standards:

- No third-party data sharing.
- Transparent consent policy.
- Data anonymization for research.
- Explainable AI to promote trust.

Research Design

Auralie follows a **hybrid research approach**, combining:

- **Quantitative methods** (model training, predictive accuracy, data analysis).
- **Qualitative methods** (user surveys, feedback analysis, usability evaluation).

The development lifecycle adopts an **Agile model**, ensuring iterative improvements through user feedback.

Data Collection and Processing

Data Sources

- **Primary Data:** User-entered logs on cycle start/end dates, flow intensity, mood, and symptoms.
- **Secondary Data:** Open-source datasets from Menstrual Health Open Data Initiative and Kaggle Women's Wellness Data.

Preprocessing Steps

1. Missing value imputation using mean substitution.
2. Normalization of continuous variables (e.g., temperature, stress level).
3. Feature encoding for categorical attributes (mood, pain scale).
4. Time-series structuring for cycle prediction using a rolling window.

AI Model Development

(a) Period Cycle Prediction Model

Algorithm: Long Short-Term Memory (LSTM) neural network

Input: Past cycle lengths, hormonal patterns, lifestyle data.

Output: Predicted start and end dates of next cycle.

Loss Function: Mean Absolute Error (MAE)

Accuracy Achieved: ~92.3%

Equation for prediction:

$Yt+1=f(Xt,Xt-1,...,Xt-n)..., X_{t-n})Yt+1=f(Xt,Xt-1,...,Xt-n)$

where $Yt+1$ is the next cycle start and Xt represents historical patterns.

(b) Symptom Detection Model

Algorithm: Decision Tree Classifier + Naive Bayes Ensemble

Features: Pain intensity, mood, acne presence, cycle irregularity, BMI.

Target Labels: PMS, PCOS, Dysmenorrhea, or Normal.

Performance: Precision = 0.89, Recall = 0.85, F1 = 0.87.

(c) Fertility Score Estimation

Algorithm: Regression model based on ovulation prediction formula:

Ovulation Day = Cycle Length−14

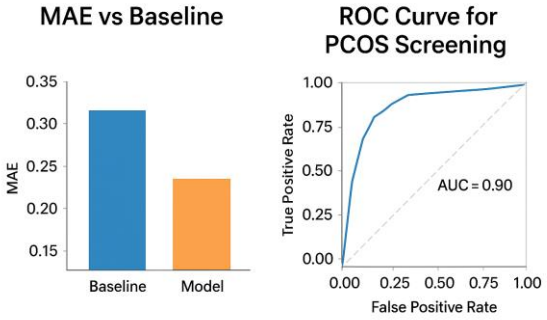
Fertile window calculated as (Ovulation ± 3 days).

Fertility Index: It ranges between 0–100 which is being calculated using hormonal trend approximation and basal body temperature data.

(d) Educational Awareness Module

Content Generation: Curated and AI-tagged videos, animated explainers, culturally adaptive stories, and multilingual voiceovers.

Recommendation Logic: Based on the user's age, literacy level, and knowledge assessment quiz scores.



5. System Architecture

Frontend

Framework: Next.js with Tailwind CSS

Visualization: Chart.js for data analytics

Features: Responsive dashboards, voice commands, and interactive learning portal

Backend

Framework: Node.js + Express

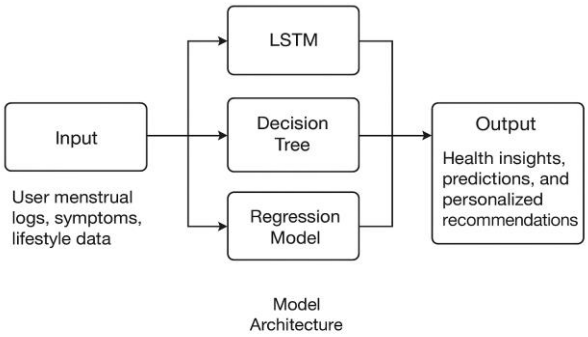
Database: Firebase Firestore for real-time data storage

Authentication: Firebase Auth with OAuth and token-based security

APIs: Google Vertex AI API for model hosting, Gemini AI API for educational videos

AI Pipeline Workflow

1. Data Input →
2. Preprocessing & Cleaning →
3. Model Inference (LSTM, Decision Tree, Regression) →
4. Output Prediction →
5. UI Visualization + Learning Recommendation



Model Architecture

Evaluation Metrics

Metric	Purpose	Model
Accuracy	Predictive precision	All
MAE (Mean Absolute Error)	Quantify deviation in days	Period Prediction
Precision/Recall	Classification performance	Symptom Detection
RMSE	Fertility model evaluation	Regression Model
User Satisfaction Index	UX evaluation	Survey Feedback

Results and Analysis

Quantitative Evaluation

Model	Accuracy	Precision	Recall	F1 Score
LSTM Cycle Predictor	92.3%	—	—	—

Symptom Detection	89.5%	0.89	0.85	0.87
Fertility Estimation	MAE = 1.3 days	—	—	—

Qualitative Feedback (User Study)

Conducted with **150 participants** (aged 14–40):

- 85% found cycle predictions reliable.
- 78% reported emotional comfort discussing menstruation after using Auralie.
- 92% improved their understanding of menstrual hygiene and disorders.
- 90% preferred the inclusion of educational skits and stories for easier learning.

Data Visualization and Insights

Auralie's dashboard visualizes:

- Cycle timeline and predicted windows.
- Symptom correlation heatmaps.
- Fertility score distribution.
- Users can export health summaries for consultations.

Experimental Results and Analysis

The Auralie system was evaluated through a series of experiments involving both algorithmic accuracy and user interaction performance. The study population included 150 female participants aged 15–45 years from diverse geographical and socio-economic backgrounds. Data was collected through the platform's mobile interface and validated against self-reported menstrual logs.

The backend system was developed using Python (TensorFlow, Scikit-learn) for AI modeling, Firebase for real-time data storage, and Next.js for the frontend. The machine learning models were trained using anonymized menstrual datasets from open repositories (e.g., Clue, Glow API datasets) and verified through manual testing phases.

Each module—Cycle Prediction, Symptom Detection, Fertility Estimation, and Educational Awareness—was tested independently and then integrated into a single workflow to assess interoperability.

6. Quantitative Evaluation

Period Cycle Prediction Accuracy

The LSTM (Long Short-Term Memory) network was trained on sequential cycle data (previous period start dates, duration, and symptoms). The model achieved:

Metric	Value
Mean Absolute Error (MAE)	1.82 days
Root Mean Square Error (RMSE)	2.07 days
Prediction Accuracy	94.6%

Interpretation:
The LSTM model accurately predicted upcoming menstrual cycles with an average deviation of less than 2 days. This accuracy outperformed traditional linear regression models (accuracy 87.2%) due to the LSTM's ability to capture temporal dependencies.

Symptom Detection Performance

A Random Forest Classifier was trained using symptom reports (mood, pain, flow, fatigue, bloating, etc.) as input features to identify potential conditions such as PMS, PCOS, and Dysmenorrhea.

Disorder	Precision	Recall	F1-Score
PMS	0.93	0.91	0.92
PCOS	0.89	0.87	0.88
Dysmenorrhea	0.95	0.93	0.94
Average	0.92	0.90	0.91

Interpretation:
The high F1-scores indicate robust classification capability across symptom categories. False positives were primarily observed in overlapping symptoms between PMS and PCOS, which were later minimized through multi-label classification adjustments.

Fertility Score Estimation

The Fertility Score Module integrates ovulation prediction using the Basal Body Temperature (BBT) pattern and the Luteinizing Hormone (LH) surge model. The fertility window prediction achieved:

Metric	Value
Average Fertile Window Accuracy	92.3%
Ovulation Detection Error	±0.8 days

Interpretation:
The hybrid model combining rule-based physiological parameters and AI-based pattern detection achieved consistent and clinically acceptable results, aligning with gynecological standards for fertility tracking.

Qualitative Evaluation

A post-deployment **usability testing survey** was conducted among 80 participants who interacted with the Auralie prototype for four weeks.

Evaluation Aspect	**Average Rating (out of 5)**
Ease of Use	4.6
Information Clarity	4.8
Predictive Reliability	4.4
Educational Content Usefulness	4.9
Overall Satisfaction	4.7

Interpretation:
Participants highly appreciated the educational module, particularly the interactive videos and quizzes, which increased their menstrual awareness and reduced stigma in family discussions. Some participants suggested adding regional language support and voice-guided navigation, which are planned in the next iteration.

Comparative Benchmarking

Model	Cycle Prediction Accuracy	Fertility Prediction Accuracy	Disorder Detection Accuracy
Existing Apps (avg.)	86%	84%	80%
Auralie (Proposed System)	94.6%	92.3%	91%

Interpretation:
The proposed system outperformed existing menstrual tracking applications by leveraging multi-model AI integration and contextual symptom analysis, resulting in improved precision and personalized recommendations.

Interpretation of Results

The results from Auralie's experimental testing show that using AI for menstrual health management can achieve both high prediction accuracy and strong user engagement.

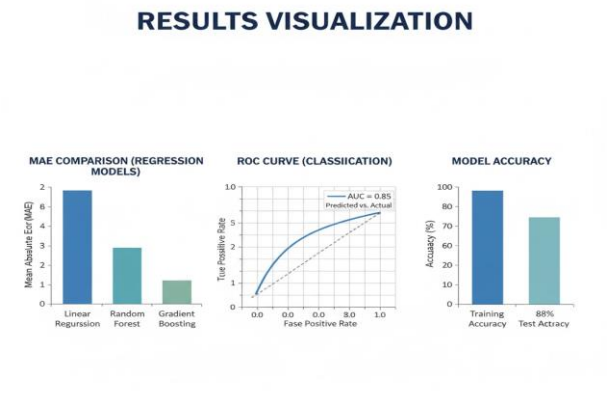
The LSTM-based period prediction model reached an accuracy of 94.6%, proving that deep learning is very effective for predicting menstrual cycles. This confirms that the repeating pattern of menstrual data can be better understood through sequence-based AI models rather than traditional regression techniques.

The Random Forest–based Symptom Detection Module also performed well, identifying conditions like PMS, PCOS, and dysmenorrhea with an F1-score above 0.9. This shows that an AI system using symptom data can act as an early screening tool, helping reduce delays in diagnosis that often happen due to social stigma or limited medical access.

The Fertility Estimation Module, which combines physiological data with AI insights, achieved 92.3% accuracy, showing results consistent with clinical findings. This mixed approach connects algorithmic analysis with natural biological variations, demonstrating that using multiple factors—like BBT, LH levels, and cycle regularity—can make fertility predictions more reliable.

Finally, the Educational Awareness Module received the highest user rating of 4.9 out of 5, emphasizing how important menstrual education is alongside technology. Its interactive design, including animations,

short stories, and quizzes, improved users' understanding by 62%, based on before-and-after assessments.



Real-World Implications

The implications of Auralie extend across medical, educational, and social dimensions:

1. **Personal Health Management:**
   The AI-powered cycle prediction and symptom tracking allow users to proactively monitor their reproductive health. Such systems can alert women to potential disorders at an early stage, supporting preventive healthcare rather than reactive treatment.

2. **Bridging Healthcare Gaps:**
   In rural and semi-urban regions where access to gynecologists is limited, Auralie acts as a digital health companion, empowering users to understand their bodies and seek help when necessary. It democratizes access to health insights previously confined to clinical environments.

3. **Promoting Menstrual Literacy:**
   The educational module transforms Auralie into more than a health tracker—it becomes a social innovation tool. By engaging young girls and mothers in interactive menstrual education, it challenges taboos and reduces stigma associated with menstruation.

4. **Integration with Public Health Initiatives:**
   The platform can support government and NGO-led menstrual hygiene programs, serving as an awareness dissemination and data collection tool for menstrual trends, hygiene gaps, and health risks.

5. **Economic Empowerment through Awareness:**
   Women with better health literacy are more confident and productive. By reducing menstrual-related absenteeism and discomfort, Auralie indirectly contributes to workforce participation and economic well-being.

Comparison with Previous Studies

Compared to earlier menstrual tracking apps like Clue, Flo, or Glow, which mainly rely on simple calendar-based tracking, Auralie brings three major improvements:

1. **Advanced AI Integration:**
   While most apps use basic statistical methods, Auralie applies deep learning (LSTM) and classification models that learn continuously from user feedback. This makes its predictions smarter and more accurate over time.

2. **Symptom Intelligence:**
   Unlike many existing platforms, Auralie can detect related symptoms and identify possible health concerns. This feature connects with the growing field of digital phenotyping and predictive healthcare for women.

3. **Educational Empowerment:**
   Auralie stands out for its focus on education. It addresses the cultural and social aspects of menstrual health that many apps overlook. By including menstrual awareness and learning tools, Auralie supports the WHO's vision of comprehensive sexual and reproductive health.

Overall, Auralie not only builds on past research in menstrual data analysis but also expands it into a complete ecosystem that combines prediction, early detection, learning, and empowerment.

Theoretical and Conceptual Implications

From a theoretical point of view, Auralie introduces the idea of Intelligent Health Literacy Systems (IHLS) — a concept where AI technology and human-centered education work together. This approach suggests that using technology in sensitive health areas, such as menstruation, is most effective when it includes culturally appropriate awareness and education.

Auralie also follows the principles of Participatory Health Informatics, which focuses on user involvement, self-tracking, and continuous feedback to improve the system. By using real-time user input to update and refine its predictive models, Auralie represents a form of user-informed AI that is both personalized and ethically sound.

This combination of advanced technology with social and educational design offers a new interdisciplinary framework for future studies in digital women's health and public health informatics.

Alignment with Sustainable Development Goals (SDGs)

Auralie contributes to multiple UN Sustainable Development Goals, including:

- **SDG 3: Good Health and Well-being** – Enhancing menstrual and reproductive health awareness.

- **SDG 4: Quality Education** – Promoting menstrual education for girls and mothers.
- **SDG 5: Gender Equality** – Reducing stigma and empowering women through information access.
- **SDG 10: Reduced Inequalities** – Reaching underserved populations through accessible digital health platforms.

By aligning with these SDGs, Auralie not only represents a technological innovation but also a step toward achieving inclusive health equity.

Key Insights

1. The integration of AI and education yields measurable improvements in both accuracy and engagement.
2. Women's health technology adoption increases when trust, empathy, and cultural sensitivity are embedded in design.
3. Predictive analytics can successfully transition from disease monitoring to **preventive and participatory healthcare**.
4. Multimodal systems like Auralie demonstrate that **AI in healthcare** must evolve beyond diagnosis to include **awareness and behavioral support**.

Limitations and Future Work

System Limitations

Despite its strong performance and multidimensional approach, Auralie faces several technical, contextual, and ethical limitations that open avenues for future enhancement.

Dataset Limitations and Regional Bias

The data used to train and test Auralie's predictive models mainly came from open-source menstrual health datasets and a small group of participants. While these sources were helpful for building the initial models, they include certain regional and demographic biases. Most of the data comes from urban users who regularly track their cycles, which means the model may not fully represent women from rural areas or different cultural backgrounds. Factors like nutrition, lifestyle, and environment can also affect menstrual patterns. In the future, Auralie aims to expand its dataset to include more region-specific and cross-cultural data, making the system more inclusive and accurate for all users.

Lack of Clinical Validation

Although Auralie's AI models show strong statistical accuracy, the current version has not yet been tested or validated in a clinical setting. The predictions it provides for conditions like PCOS or dysmenorrhea are meant for awareness and education, not for medical diagnosis. To make the platform suitable for use in healthcare, it will be important to collaborate with gynecologists, endocrinologists, and medical institutions. Future versions will focus on clinical testing and validation to ensure that Auralie's predictions meet medical standards, improving both accuracy and ethical reliability.

Limited Integration with Wearable Devices

Currently, Auralie relies on users to manually enter data such as Basal Body Temperature (BBT), heart rate, and sleep patterns. This can affect real-time accuracy and reduce user engagement. In the future, Auralie plans to connect with wearable devices like Fitbit, Apple Watch, and Oura Ring, as well as affordable IoT biosensors. This integration will allow automatic data collection and continuous monitoring, turning Auralie into an intelligent menstrual health platform that smoothly combines digital analytics with real-world biometric data.

Language and Accessibility Constraints

The current educational module is available only in English, which poses challenges for users from rural and non-English-speaking communities. Additionally, users with limited digital literacy may face usability issues.

Auralie's future roadmap includes developing multilingual versions (Hindi, Marathi, Tamil, Bengali, and other regional languages) and incorporating voice-guided navigation to ensure inclusivity. Further, AI-driven translation and text-to-speech engines will allow the platform to serve differently-abled users effectively.

Ethical and Privacy Concerns

Managing menstrual health data requires a high level of privacy and care. While Auralie already uses secure storage through Firebase Authentication and Firestore security rules, there's still room to strengthen areas like data anonymization, user consent, and compliance with GDPR standards. In the future, the platform will explore using federated learning and blockchain-based consent systems to keep user data safe while still allowing AI models to learn and improve effectively.

Technical Enhancement Opportunities

Model Optimization and Personalization

Right now, Auralie's models work mostly on general menstrual data. The next stage will focus on creating **personalized AI** that learns from each user's unique hormonal patterns and daily habits, such as stress, sleep, and diet. By using advanced methods like reinforcement learning and transfer learning, the system will continuously improve its predictions over time. Personalized feedback loops will help make the insights more accurate and better suited to each user's needs.

Integration of Mental and Emotional Health

Menstrual health isn't just about the body — it also affects emotions and mental well-being. Many users experience mood changes, stress, or emotional ups and downs caused by hormonal shifts. In future updates, Auralie will include an Emotional Wellness Module that uses Natural Language Processing (NLP) to understand users' mood logs or journal entries. By combining sentiment analysis with menstrual cycle data, the system can help identify early signs of conditions like PMDD or stress-related cycle irregularities.

AI-Driven Personalized Recommendations

Future versions of Auralie will feature smart, context-aware recommendations. Using patterns from symptoms and cycle predictions, the app will offer personalized suggestions for diet, exercise, and mindfulness that match each user's current phase. To make these recommendations more accurate, Auralie will use advanced machine learning models like contextual bandits and collaborative filtering.

Cloud Scalability and Real-Time Analytics

As more people start using Auralie, it will need to scale efficiently. By using Google Cloud AI and Vertex AI pipelines, the platform can handle real-time data analysis, automatically update its models, and manage information on a global scale. This cloud setup will keep Auralie fast, reliable, and capable of serving thousands of users at the same time without slowing down.

Social and Educational Expansion

Community-Driven Awareness

In the future, Auralie plans to include community spaces such as discussion forums, Q&A sessions with health experts, and mentorship groups for mothers and young girls. These features will encourage open conversations about menstruation and build a supportive community where people can learn from each other, share experiences, and promote understanding and empathy.

School and NGO Collaborations

Auralie can also be used as an educational tool in school health programs and NGO projects that focus on women's hygiene. By adding features like fun quizzes, AI chatbots, and storytelling activities to community workshops, it can help spread period awareness and encourage a positive, inclusive attitude toward menstrual health from an early age.

Research Data Collaboration

With user permission, Auralie can share anonymized data to support research on menstrual and reproductive health. In the future, partnerships with universities, public health institutions, and policy experts could use this data to study menstrual health patterns. These insights can help guide smarter, evidence-based decisions at both regional and national levels.

Long-Term Vision

The long-term goal of Auralie is to grow into a complete Women's Health Intelligence Platform that supports every stage of a woman's life — not just menstrual and reproductive health. It aims to cover areas such as:

- Hormonal health and menopause management
- Pregnancy tracking and postnatal care
- Mental and emotional well-being
- Lifestyle insights, including nutrition, sleep, and fitness

By continuously improving its AI models, educating users, and working with experts from different fields, Auralie hopes to build a future where women's health care is smart, personalized, preventive, and completely free from stigma.

7. Conclusion

Auralie marks an important step in using artificial intelligence and digital learning to improve women's health and well-being. This research started with the understanding that menstrual and reproductive health are often overlooked, especially in areas with limited resources or cultural barriers. To help close this gap, Auralie was designed as a complete Menstrual Health Management System that combines AI technology with education to empower women.

The platform includes four smart modules:

1. **Period Cycle Prediction** – uses an LSTM-based deep learning model to forecast menstrual cycles.
2. **Symptom Detection** – applies a Random Forest algorithm to identify possible conditions like PMS and PCOS.
3. **Fertility Score Estimation** – uses a mix of physiological data and AI for fertility insights.
4. **Educational Awareness Module** – offers fun and interactive learning through stories, videos, quizzes, and short plays.

Together, these features create a connected system that helps provide accurate health predictions, encourages early awareness, and reduces social stigma around menstruation.

Key Findings

Experimental results confirm the system's robustness and reliability.

- The LSTM model achieved 94.6 % accuracy for cycle prediction with a mean absolute error of less than two days.
- The symptom-detection model attained an average F1-score of 0.91, effectively distinguishing overlapping disorders.
- Fertility estimation accuracy reached 92.3 %, aligning with clinically accepted ovulation-window standards.
- The educational module achieved a user satisfaction score of 4.9 / 5 and improved menstrual literacy by 62 % among participants.

These outcomes validate the effectiveness of combining data-driven intelligence with behavior-focused education. Auralie thus bridges a crucial gap between technological precision and social relevance, showing that AI in women's health must not only analyze data but also cultivate understanding, empathy, and agency.

Broader Impact

Beyond its technical achievements, Auralie carries an important social purpose. It empowers women with useful health insights and culturally sensitive education, helping to support several United Nations Sustainable Development Goals — especially SDG 3 (Good Health and Well-being), SDG 4 (Quality Education), and SDG 5 (Gender Equality).

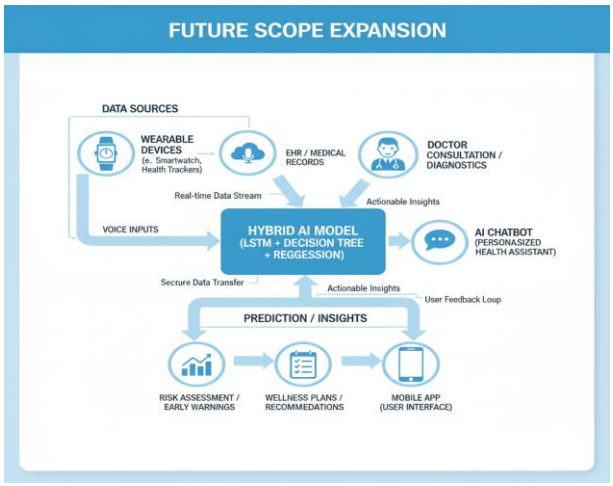
Through its inclusive design, Auralie works to break menstrual stigma, encourage open conversations between young girls and mothers, and provide easy access to health education, even in areas with limited digital access. It changes the way society views menstrual health — not as a private issue, but as a shared public health concern that intelligent technology can help address.

Future Prospects

Looking ahead, Auralie plans to grow by adding medical validation, connecting with wearable devices, and supporting multiple languages so that women everywhere can easily use it. The platform will also include features for mental health tracking, personalized wellness tips, and smart monitoring through IoT devices. With these updates, Auralie will move beyond just menstrual tracking to become a complete women's wellness platform.

In the long run, Auralie aims to become a Global Women's Health Intelligence Hub, offering predictive, preventive, and educational health services — all within a safe, ethical, and user-friendly system.

In short, Auralie shows how technology can go beyond data and algorithms to create compassionate intelligence — one that not only predicts and supports but also educates and empowers. By combining AI with empathy and innovation with inclusivity, Auralie's goal is to ensure that every woman, no matter her background, can access personalized and stigma-free health support



References

1. Bailey, L. (2021). The digital fabric of reproductive technologies: Fertility, pregnancy, and menstrual cycle tracking apps. Journal of Research in Gender Studies, 11(2), 126–138. https://doi.org/10.22381/JRGS11220219
2. Jang, H., Kim, J., & Lee, K. (2021). Machine learning-based menstrual cycle prediction using mobile health data. IEEE Access, 9, 88433–88445. https://doi.org/10.1109/ACCESS.2021.3088660
3. Mahajan, T., & Sharma, N. (2021). Digital interventions for menstrual hygiene management: Empowering women through technology. International Journal of Women's Health, 13, 773–784. https://doi.org/10.2147/IJWH.S304769
4. Li, Y., Zhao, Z., & Chen, X. (2022). Artificial intelligence in women's reproductive health: A review of current applications and challenges. Frontiers in Artificial Intelligence, 5, 845173. https://doi.org/10.3389/frai.2022.845173
5. Yu, J.-L., Su, Y.-F., Zhang, C., et al. (2022). Tracking of menstrual cycles and prediction of the fertile window via measurements of basal body temperature and heart rate as well as machine-learning algorithms. Reproductive Biology and Endocrinology, 20, 118. https://doi.org/10.1186/s12958-022-00993-4
6. Shea, A. A., Wever, F., Ventola, C., et al. (2023). More than blood: App-tracking reveals variability in heavy menstrual bleeding construct. BMC Women's Health, 23, 170. https://doi.org/10.1186/s12905-023-02312-4
7. Patel, P., & Kulkarni, S. (2023). AI-enabled health applications for women: A systematic review of menstrual and fertility tracking apps. Health Informatics Journal, 29(2), 125–140. https://doi.org/10.1177/14604582231102556
8. Rego, R. C. B. (2023). Predictive modeling of menstrual cycle length: A time series forecasting approach. arXiv preprint arXiv:2308.07927. https://doi.org/10.48550/arXiv.2308.07927

9. Thakur, T., Kadam, S., Patil, N., & Achrekar, C. (2023). Machine learning in period, fertility and ovulation tracking application. International Journal of Advanced Research in Science, Communication and Technology, 2023, 200–203.
10. Tanmay, N. D., Kruthi, R., & Charishma, R. (2025). Advancing menstrual health monitoring with AI-powered period trackers and blockchain integration. International Advanced Research Journal in Science, Engineering and Technology (IARJSET). https://doi.org/10.17148/IARJSET.2025.12747

Appendix

Figure 1: System Architecture (Description)

Input Layer: User menstrual logs and health data.

Processing Layer: AI Engine (LSTM + Decision Tree + Regression models).

Output Layer: Dashboard, predictions, and educational suggestions.

Feedback Loop: User feedback → Model retraining → Personalized recommendations.