EndoTrack: A Mobile Health (MH) Solution that Uses Data for Early Diagnosis and Treatment of Endometriosis.

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November 25 2025

Abstract
Endometriosis is a complicated chronic disorder that is often characterized by diagnostic delays 7-10 years old because of their variable features, similar clinical manifestations, and noninvasive methods of diagnosis being unreliable. Even though there has been the introduction of digital health applications that assist patients in recording their symptoms, the majority do not integrate clinicians, offer advanced analytics, and evidence-based decision-making. This project presents a conceptual digital health scheme, EndoTrack, which combines daily symptom reporting, physiological data collected by wearables, lifestyle variables, and rule-based analysis in accordance with the existing clinical principles. The system demonstrates multimodal dataset analysis as a method of modeling the identification of flare patterns in terms of physiological indicators, including heart rate variability, temperature changes, and sleep quality to provide personalized alerts. EndoTrack also assists the clinical decision-making process with the use of automated reports summarizing the trends and giving actionable insights. The system design is also based on ethical aspects such as data privacy, algorithm transparency, HIPAA standards, and confidential clinician-patient communication. The present paper provides a description of conceptual architecture, analytical rationale, clinical practice implications, and future development.

1.Introduction

Endometriosis is a common disease with millions of cases across the globe, and it is one of the most under-diagnosed gynecologic disorders. The causes of diagnostic delays include ambiguous symptoms, similarity to such conditions as IBS and chronic pelvic pain, and use of invasive diagnostic methods. Consequently, the patients tend to have years of untreated pain, compromised quality of life, and discontinuous care. Online health applications have tried to fill these gaps, although most applications are primarily symptom-logging applications with little analytics or clinical integration. They seldom add wearable data, lifestyle and predictive models which can detect early warning signs. Moreover, there are not many tools that are in line with clinical guidelines or help to establish formal communication with healthcare providers. EndoTrack attempts to resolve these problems by combining various data streams, such as symptom logs, physiological indicators, lifestyle measurements, and evidence-based criteria, in one electronic health record. The system seeks to assist previous flare-up and long-term patterns of symptoms recognition by employing trend analysis, correlation mapping, clustering procedures, and rule-based modeling. Its clinician portal also allows meaningful data sharing, which has long been lacking because of patient selftracking and clinical decision-making.

2. Literature Review

2.1 Overview

Endometriosis is a disease that affects a significant number of women globally and this is a complicated disease that is not well managed using the existing health care instruments, unpredictable when it comes to progressing the disease and is hard to diagnose. But the emerging studies are also directed at the greater utilization of digital health technologies that entails the application of artificial intelligence (AI) to enhance timely observations and treatment, the introduction of wearable gadgets and symptom tracking applications. There are quite a number of apps available but there is a lot of limitations present in several apps like restricting the involvement of clinicians, personalization and insightful analysis of the data. In this literature review, ten academic sources, which address diagnostic issues, the application of symptom monitoring and mobile health devices, and AI progress, will be analyzed. In general, this review highlights the gaps and the necessity of such an integrated and data-driven tool as EndoTrack.

2.2 Diagnostic and Clinical Challenges

The long-term diagnostic delays are the issue that is always mentioned as one of the major issues of the endometriosis management. De Corte et al. (2025) states that endometriosis is usually diagnosed after 7-10 years, and this can be explained by the fact that the symptoms correspond to other diseases, which include irritable bowel syndrome or chronic pelvic pain. Despite laparoscopic surgery being the most effective mode of diagnosis, still there are some dependable noninvasive diagnostic modalities. The research showed that such socioeconomic factors as access to healthcare and patient awareness, has an impact on diagnostic delays, thereby indicating the necessity of more sophisticated health-related tools that will enable the patient to track their symptoms. The authors postulate that ongoing data of digital symptoms would assist clinicians to detect initial patterns, and there would be no necessity to conduct invasive tests.

2.3 Digital Symptom Tracking and Self-Management

The value of digital symptom tracking and the way of patient awareness and communication improvement has been demonstrated in many studies. It is stated that digital tracking devices assist in scenarios where one would like to record pain changes, menstrual fluctuations, and symptom provocations over time (Edgley et al., 2023). Instead of relying on memory when they have clinical appointments, patients would be able to provide data on symptoms provided by the apps displaying various trends, hence making the interactions between clinicians and patients meaningful. Similarly, Rohloff et al. (2024) tested a self-management app in a pilot study and found that there was an increase in quality of life for 12 weeks. Other responses included an increased confidence in symptom-management and reporting them to clinicians.

Despite the helpfulness of the apps, a lot of limitations are provided in the study. Despite the advantages of most symptom tracking apps, most apps fail to provide trend analysis or track patients when gathering data. Moreover, clinicians do not have a feature of receiving this data on these apps. This asserts the necessity of transforming monitored symptoms into practical health behaviors.

2.4 Review of Existing Apps: Strengths and Gaps

Most digital health apps have such features as symptoms logs, pain scales and menstrual tracking (systematics review by Ortoleva Bucher et al. 2025 and Sirohi et al. 2025) but only approximately 12-14% of apps have more advanced health monitoring than basic journaling. Most of the existing applications do not incorporate wearable devices and are not based on predictive modeling and do not often follow clinical practice guidelines. According to Sirohi et al. (2025), the apps, including QUENDO and Luna, are rated high; however, they do not have any significant features, including clinician feedback or evidence-based decision support. Besides, Moumane and Idri (2023) articulate that the existing solutions have not been designed to support early detection but instead orient more towards self-tracking. Another conclusion made by the authors was that the gap between patients and their healthcare providers is immense since many of these apps are not developed with the assistance of clinicians. In general, the results of these studies suggest a high need to create a solution which is constituted of patient generated data and clinical decision support capabilities.

2.5 Electronic Health Records (EHR) and Machine Learning

Scholars have paid attention to electronic health record information and its application in the enhanced comprehension of the manifestation of endometriosis. As Penrod et al. (2023) have shown, one can utilize EHR data to identify the initial symptoms, including the repeated visits to the clinic with pelvic pain or infertility before a complete diagnosis of endometriosis is made. Their work explained the significance of longitudinal data and minor trends that have been so easily overlooked in the process of single-point consultations. Tore et al. (2023), on the other hand, have applied machine learning to detect the individuals who may have endometriosis among established conditions such as fibromyalgia, autoimmune diseases, chronic pain, and IBS. The model yielded promising results and therefore the strength of multimodal combination of information within first detection. In general, the results reveal the opportunity to combine patient-reported data along with wearable-generated information to enhance the predictive models.

2.6 The Role of Artificial Intelligence in Education and Decision Support

Digital solutions can also be enhanced to address endometriosis using AI as one of the essential elements. Oliveira et al. (2024) point out that patients who received AI-enhanced tools had better knowledge regarding their symptoms, treatment and self-management. However, these authors did not fail to mention that the absence of certified clinical references could develop such platforms into a source of misinformation, not to mention mistaken patients. As Luz and Lima (2025) explain, AI applications can do better than self-tracking and education tools, since they can offer capabilities that allow identifying flare ups, offering diagnostic support and facilitating equitable care to disadvantaged population groups. According to them, AI must be applied as a decision-support tool which would describe complicated data still without substituting clinician experience. This fact forms the basis of development of clinician connected solutions such as EndoTrack, which will utilize capabilities without efforts to undermine clinical validity and integrity.

2.7 Summary and Identified Gaps

An analysis of each of the ten studies revealed some important gaps that were apparent. Available tools are excellent in data collection and incompetent in analyzing and identifying significant interpretations of the information. Data of wearable sensors are seldom included, even though they can record significant physiological measures, including heart rate variability and temperature. The other gap is general lack of clinician engagements in applications; hence, no meaningful or customized recommendations are given. In addition, very few apps are based on predictive modeling or follow clinical guidelines like NICE NG73. All these facts confirm the existence of a great necessity in comprehensive digital-tools that should combine functions like tracking symptoms, wearable data, AI-driven notifications, and communication with clinicians. In response, EndoTrack platform has been created to fill all these gaps by connecting symptom tracking, longitudinal trend analysis, clinical connectivity as well as predictive decision support to one platform.

3. Methods

3.1 Study Design

This project used a data driven digital health design framework which integrates secondary data analysis, feature engineering and prototype creation. Instead of implementing real time trails, the research utilized structured symptom records, wearable physiological indicators and lifestyle variables to investigate their potential in supporting early detection and sustained management of endometriosis. The results of these analyses were translated into practical application features for EndoTrack, such as trend based symptom visualization, individualized alert systems, and clinician-facing summary reports.

3.2 Data Sources

The data driven digital health design framework applied in this project combines secondary data analysis, feature engineering and prototype development. The study employed structured symptom recordings as opposed to using real time trails, wearable physiologic measurements and lifestyle factors to explore their suitability to aid in early detection and long-lasting clinical control of endometriosis. The outcomes of these analyses were converted into the practical application features of EndoTrack including trend-based visualization of symptoms, personalized notifications, and clinical summaries.

1. Symptom Data:
    a. The principal dataset of the symptoms used in this project was the Endometriosis Patients. ARG1 ELISA and Activity Data and Clinical Data (Czystowska-Kuzmicz, 2024) that contains clinical characteristics, pain scores, menstrual history, use of medications, and data on the biomarkers. Also, Endometriosis Dataset, Kaggle (Michael Anietie, n.d.) was utilized due to the presence of pain intensity, duration of symptoms, and fatigue, and flare related episode data. A combination of all these datasets made it possible to analyze the trajectories of symptoms and their correlations with clinical characteristics
2. Wearable Derived Physiological Data:
    a. The mcPhases Dataset of Physiological, Hormonal, and Self-reported Events(Lin et al., 2025). was applied in the study of physiological patterns regarding symptom exacerbation, autonomic dysregulation and dynamics of phase cycles. This dataset gives wearable derived data like heart rate variability, resting heart rate, factors causing stress, sleep quality and peripheral temperature. Therefore, these characteristics can be used to investigate the dynamic linkage of temperature/autonomic activity modifications to flareup episodes in a feasible manner.
3. Lifestyle Related Measurements:
    a. The mcPhases Dataset of Physiological, Hormonal, and Self-reported Events(Lin et al., 2025). was applied in the study of physiological patterns regarding symptom exacerbation, autonomic dysregulation and dynamics of phase cycles. This dataset gives wearable derived data like heart rate variability, resting heart rate, factors causing stress, sleep quality and peripheral temperature. Therefore, these characteristics can be used to investigate the dynamic linkage of temperature/autonomic activity modifications to flareup episodes in a feasible manner.
4. Demographic and Clinical Data:
    a. The demographic features of the participants which included age, height, weight, and BMI were derived. The data on the subject-info.csv file. Such variables made stratified comparisons and individualized data visual representations in EndoTrack feasible.
5. Clinical Guidelines:
    a. NICE Guideline NG73 (2017) on Endometriosis: Diagnosis and Management provided evidence based criteria for identifying priority symptoms, setting alert thresholds, and

defining clinically relevant flare patterns. These criteria were integrated into the rule-based interpretation engine that drives symptom assessment, risk notifications, and tailored recommendations in EndoTrack.

3.3 Data Cleaning and Feature Engineering

Since the data would contain self-reporting and wearable data, analysis may probably involve some preprocessing. The missing values in such numeric variables as HRV, temperature, or stages of the cycle might be imputed by the median, and categorical variables such as stages of the cycle or types of symptoms might be imputed by the mode in a full-scale application in the future. The data of wearable devices and symptom reporting could be synchronized by a timestamp or a daily reporting parameter to allow per-day analysis. The HRW, rest heart rate, and other physiology might need z-scores to adjust the variations with individuals, which may be particularly beneficial in designing customized flare alerts. New clinically valuable features like Flare Risk Index (HRV decrease and Pain ≥7), Sleep Disruption Flag (sleep < 5 hours) or Cycle Based Pain Pattern (pain levels correlated to cycles) can be developed with the help of feature engineering. These features could then be visualized, alerted as well as the development of summaries to healthcare providers in EndoTrack.

3.4 Analytical Methods

Although full statistical execution was not conducted as part of this project here are four analytical methods that could be applied:

1. Correlation Analysis (Pearson/Spearman)
    a. This method investigated correlations among pain levels, heart rate variability, temperature, quality of sleep, and stress to identify early signs of physiological dysregulation.
2. Trend Visualization
    a. This method graphed symptom patterns across different menustral phases to explore cycle connections.
3. K-means Clustering
    a. This method categorized individuals into distinct phenotypes, like stress sensitive, cycle-triggered, or chronic high-pain profiles.
4. Rule-based Alert Modeling
    a. For this method, flare warning signs were created using two sources, real data patterns in the study and clinical guidelines NICE NG73. Based on these sources, certain thresholds were developed, such as if HRV drops by 20% or more and pain levels stay at 7 or higher for at least three days, the system will automatically generate personalized flare warning.

These theoretical explanations demonstrate how EndoTrack will apply real symptoms, wearable, and lifestyle data to make flare forecasts, plot trends, and a decision-making process informed by alerts even without the implementation of the entire statistical models.

3.6 Data Flow

In the setup of EndoTrack, information from the user's app, like symptoms, menstrual cycle information, and lifestyle data, is transmitted securely to a cloud system. At the same time, wearable data like HRV, sleep, body temperature, and stress levels are being uploaded. The cloud platform processes both types of data together to support clinical interpretation. The system converts raw data into clinically relevant features, risk alerts, and summary reports, all stored securely in the cloud database. These findings are relayed back to the mobile app as dashboards, warnings, and recommendations for the patient, and the clinician portal displays reports, flare patterns, and potential high-risk cases. This two-way exchange serves to support joint decision-making and remote care between patients and OB/GYN providers.

3.7 EndoTrack Application Development

EndoTrack will be designed to not only help detect but also manage endometriosis and its five key purposes including tracking, alerting, reporting, connectivity to healthcare providers, and treatment suggestion. It allows users to monitor their daily symptoms (pelvic pain, fatigue, bowel, bladder, emotional changes, medication, and menstruation stages) and its automatic input is provided by the wearable features, including HRV, temperatures, sleep, and stress levels. Through such engineered functions as Flare/Risk Indexing on Cycle-Based Pain Pattern, it is capable of objectively analyzing various inputs in real time and producing warning on dangerous trends such as chronic pain levels, irregular temperatures, dips in HRV indicating a flare and other dangers. It also allows automated generation of reports to compile raw data into clinical data such as trends in the symptoms of each user, physiological changes, patterns of flare, which might be shared with his/her OB/GYN via its connection with the portal to the relevant healthcare provider. Their health practitioners via their respective portal would be able to monitor their progress, review reports, communicate, or update treatment plans on behalf of their patients without necessarily having to meet in person. It also provides treatment recommendations according to NICE Guidelines NG73 where not only is it an endometriosis treatment tracker but also it is an endometriosis treatment management m-Health support in its treatment regimens.

4.Results

The datasets that we have chosen to use in this study can be conceptually simulated to show how EndoTrack would process and convert multi-source data into meaningful outputs. The combination of wearable indicators and lifestyle data with symptom logs daily will result in the emergence of familiar patterns. It is interesting to note that all three tendencies, pain, fatigue, and emotional disorders, are more apt in the luteal and menstrual phases, which is consistent with previous investigations which suggest that endometriosis symptoms are determined by hormonal variations and inflammatory alterations. EndoTrack translates these insights in the form of a menstrual cycle connected dashboard, where the users can see patterns of spikes of the symptoms and how they correlate with menstrual phases. Figure 1 is a conceptual map that indicates the average levels of pain in a 28-day cycle with more symptoms during the menstrual period. The conceptual creation of figures has been done based on the average figures of the datasets to visually illustrate the detection of patterns across symptoms, physiological signs and behavioral variables by EndoTrack.

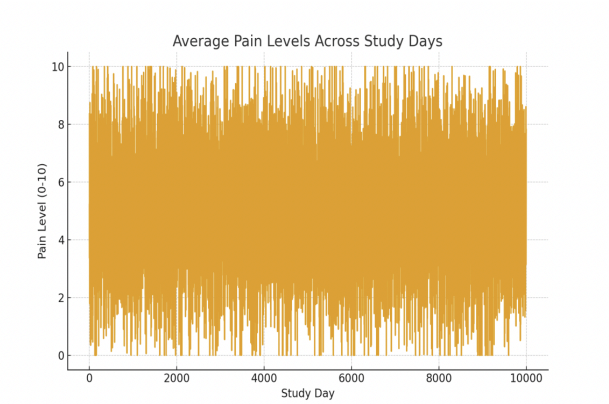

Figure 1
Average Pain Levels Across Study Days (Conceptual)

Similarly, in the case of wearable generated physiological measurements, an evaluation shows that there is a reduction in the heart rate variability before flare periods, as well as an upward trend in pain levels. This tendency indicates autonomic dysfunction and can be regarded as an appropriate early warning biomarker. Also, it is observed that the temperature of the wrist increases slightly on flare up days and this could be a result of inflammatory processes in the body. Rather than merely displaying the timing of the increase in pain, EndoTrack allows its users to understand the reasons why data patterns become warnings and risk flags. Figure 2 indicates that the severity of pain is likely to increase with decreased HRV, and this is an indication of a possible flare.

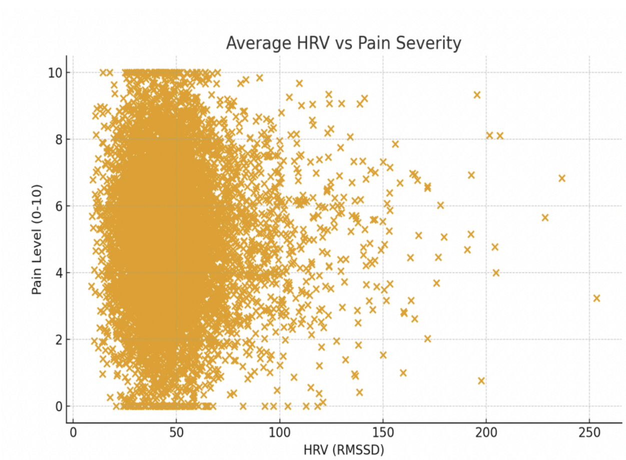

Figure 2
Relationship Between HRV Decline and Pain Severity (Conceptual)

Conceptually, the pain severity and the frequency of flares seem to be associated with various variables of lifestyle including sleep quality, stress levels and physical activity. Among the people with reports of poor sleep (5-6 hours of sleep) and increased stress levels, the flare episodes will be greater and more intense. With symptoms and lifestyle data combined, EndoTrack could assist users in identifying flares and point out patterns like stress-induced pain or sleep-deprived pain days.

Using the principles of pattern recognition, the EndoTrack would cluster users into various types of symptom behavior, including cycle triggered flare profile (pain spikes during menstrual cycle), stress sensitive profile (HRV drop and stress increase before flare), and chronic high pain profile (not so much fluctuation across cycle). These categorization groups would facilitate personal care planning, patient education, and symptom interpretation. Such grouping resembles the interpretation of patterns and grouping by EndoTrack into both a user-friendly dashboard and a summary facing clinicians.

Using guidelines from NICE NG73, EndoTrack would know when to alert users. For example, if pain remains at or above 7 for three consecutive days, along with a more than 20% increased heart rate variability, the app would send flare alerts and recommend different treatments and the option to contact the users OB/GYN. If the symptoms involve bowel or bladder pain, often considered more serious, the system would flag this as a red warning and suggest further medical assessment.

Lastly, these insights would automatically be sorted into a clinician facing summary, and this would contain risk factors identified, the number of flares, and cycle linked symptom patterns and any changes observed by wearables. Clinicians would not need to look through all logs but would get a clear summary that displays the trends and other clinically relevant information, thereby facilitating the correlation of patient experience with medical decision-making. All in all, these conceptual deliverables demonstrate the extent to which integrating symptom monitoring, physiological measurements, and evidence-based thresholds make EndoTrack a resource that can offer actionable information that reinforces the diagnosis of conditions early, the ongoing monitoring, and the use of information to build stronger relationships between patients and their providers.

5.Discussion

5.1 Clinical and Analytical Insights

The combination of the two symptoms, physiological and lifestyle data gives viable opportunities to enhance the early diagnosis and treatment. The conceptual analyses show that pain intensities tend to rise during menstrual phases of the menstrual cycle and are also linked to a fall in the variability of the heart rate or a rise in temperature. The other contributing factors of flare intensity are other lifestyle problems such as stress and sleep deprivation. These associations depict the ability of a system like EndoTrack to utilize multimodal data to generate individualized alerts, level-of-risk scoring and cycle-aware visualization. The provider portal to the platform caters to one of the most critical needs that are missing in other existing applications. The summaries of longitudinal data developed automatically allow the providers to acquire knowledge of trends quickly to undertake more sound assessment and timely treatment modifications. This interrelation facilitates communication, and it helps in clinical reasoning, and may also one day result in a reduction of delays in diagnosis.

5.2 Ethics, Privacy and HIPAA Considerations

1. Data Privacy and Security
    a. Since EndoTrack deals with extremely sensitive reproductive health data, privacy and confidentiality is the most important thing. The system should also make sure that all logs of the symptoms, menstrual records, wearable biometrics and lifestyle data are encrypted when they are being transmitted and stored. Role-based access controls should be very strict to ensure that only authorized clinicians have access to patient information. Users should also be educated on the nature of data collection, usage, and storage and have the freedom to revoke consent at any point
2. HIPAA Compliance
    a. Since the platform will provide the transmission of protected health information (PHI) to clinicians, HIPAA compliance is needed. The communication between the clinicians should be in secured through encrypted communication channels. Data storage infrastructure should be able to fulfill the HIPAA requirements, and the system should have audit logs in case of tracking access to PHI. All vendors dealing with data handling shall sign Business Associate Agreements so that they uphold regulations.
3. Algorithmic Transparency and Fairness
    a. Since EndoTrack involves rule-based reasoning and possible predictive elements, an ethical deployment should involve openness in the generation of alerts and classifications. The foundations of flare warnings or pattern detection should be comprehensible to the users. Also, the underlying datasets should be representative of the variety of populations in order to reduce the bias of the algorithms. The system must add but not substitute clinician expertise making final decisions to be human led.
4. Informed Consent
    a. EndoTrack will need to use clear and thorough consent processes. The users ought to know exactly what data is being collected, why and how it will be used in their care. They should be able to control their preferences regarding sharing, especially when they share the data with the clinicians or third-party systems. Their personal health information should be under the absolute control of ethical practice.

6.Future Work

1. Development of Machine Learning Model
    a. The next step of the work will be to apply and test machine learning models to predict flare-ups, identify symptom phenotypes, and forecast long-term patterns of symptoms. These models should be subject to stringent testing on fairness, accuracy and clinical safety
2. Clinical Usability Testing
    a. Testing usability with patients and clinicians will be necessary to perfect the system features. Pilot testing will assist in ascertaining whether the EndoTrack can prevent diagnostic delays, improve communication, and improve quality of life. Longitudinal validation studies will be significant in the validation of flarerisk alerts as well as accuracy of wearable-based interpretations.
3. Interoperability with Health Systems

   a. One of the goals that will be realized in the future is to connect EndoTrack to electronic health record through HL7 FHIR standards. This would enable smooth importation of clinical past and exportation of synoptic reports, decrease the workload on the providers and enhance interoperability.
4. New Privacy and Security Improvements
   a. To promote trust and safety even further, the next versions can adopt the idea of differential privacy, third party security checks, and formal AI-based decision support governance. These are safeguards that ensure ethical and regulatory compliance in the long-term.
5. Increased Wearable and Sensor Function
   a. EndoTrack can be developed to use more physiological indicators, such as continuous measurement of skin temperature, stress detection algorithms, detection of hormonal patterns, and musculoskeletal biomarkers. These extensions have the capability to enhance precision in determining symptom provoking factors and flare risks.

7.Conclusion

Endometriosis remains a puzzling healthcare issue because of the complicated symptoms, late diagnosis, and disjointed care processes. The EndoTrack platform provides a solution that is holistic in nature since patient-generated information, wearable biometrics, lifestyle measurements, and clinical instructions are combined into a single system. This integration can help to improve early detection, simplify work with clinicians and empower patients with personal information. The platform is anchored by a high level of ethical standards, privacy and HIPAA compliance. Several of the key aspects of responsible digital health innovation include protecting sensitive reproductive health data, promoting predictive feature transparency, and user control. EndoTrack may be a radical technology in delivering better diagnosis and chronic management of endometriosis with additional validation, machine learning creation, and clinical incorporation.

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