

## Project Title

Insights into endometriosis symptom trajectories using longitudinal multimodal data and statistical machine learning

## Supervisors

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## Project Summary Description

Endometriosis is a common gynaecological disease characterised by the presence of hormone-dependent endometrial-like tissue outside the uterus. It is estimated to affect 10% of women and those assigned female at birth, a prevalence that continues to rise as diagnostic approaches improve, with the condition often taking over 8 years to be diagnosed in the UK. Typical symptoms include chronic pelvic pain, menstrual cramps, painful sex and infertility, though it is now known that the condition can have systemic effects. Indeed, almost 95% of affected women experience at least one comorbidity, like migraine, depression, chronic fatigue or irritable bowel syndrome. There is a clear unmet clinical need since currently neither diagnostic nor therapeutic approaches to endometriosis are adequate.

Our team in Edinburgh, in collaboration with other leading centres in the UK and Europe, has been collecting longitudinal data from a large cohort of participants over the years and is involved in ongoing studies in collating self-reports, biological samples, and data from digital health technologies (in particular wearable sensors). Some of these patients have undergone different treatments (including surgical interventions), and we have unique data resources along with an ongoing data development wider programme towards objectively monitoring these outcomes.

This project will aim to capitalize on these rich data resources, mining the collected multimodal data to develop effective clinical decision support tools towards facilitating early diagnosis, symptom monitoring, and rehabilitation of endometriosis. The student will engage in time-series analysis, signal processing, and statistical machine learning algorithms to understand the underlying patterns in the datasets, and will also benefit from close collaboration with the EXPECT team in Edinburgh (<https://www.ed.ac.uk/centre-reproductive-health/expect-endometriosis/the-endometriosis-team>), and our collaborators.

The project would be of particular interest to students interested in (health) data science, signal processing and statistical machine learning who want to develop decision support tools which will potentially directly inform healthcare decision making with potential direct translation of seeing these tools embedded within the NHS. Ideally students would come from a strong quantitative background with excellent programming skills in Matlab, R, or Python, willing to engage in interdisciplinary research.

## Project Description (max c.1000 words)

### Abstract

Endometriosis is a common chronic condition often associated with debilitating pain, fatigue, and heterogeneous symptom presentation. Contemporary symptom monitoring and rehabilitation outcome assessment are inadequately capturing the variation and the diversity of symptoms. We have developed large collaborative projects with colleagues collecting multimodal data to tackle these challenges, which currently includes 70 participants collecting self-reports and wearable data over a year, and two ongoing studies. This PhD project will aim to work on the data collected, primarily mining longitudinal self-reports, processed biological samples and data from wearable sensors to develop new clinical decision support tools to inform clinical decision making towards optimizing treatment and surgical rehabilitation monitoring.

### Introduction

Endometriosis affects approximately 190 million women and people assigned female at birth worldwide. It is a chronic, inflammatory, gynecologic disease marked by the presence of endometrial-like tissue outside the uterus, which in many patients is associated with debilitating painful symptoms. Patients with endometriosis are also at greater risk of infertility, emergence of fatigue, multisite pain, and other comorbidities (Saunders and Horne, 2021; Horne and Missmer, 2022).

Digital technologies including smartphones and wearable sensors have shown great promise on a range of conditions to facilitate symptom monitoring that we have been directly involved in (Tsanas et al., 2020, Woodward et al., 2022; Edgley et al., 2023; Woodward et al., 2024). We have recently published our vision on how these technologies are informing approaches to monitor endometriosis (Edgley et al., 2023).

### Research challenge

Endometriosis is best understood as a condition with variable presentation and effects at multiple life stages. A long diagnostic delay after symptom onset is common, and persistence and recurrence of symptoms despite treatment is common (Saunders and Horne, 2021; Horne and

Missmer, 2022). Following diagnosis, patients are insufficiently frequently monitored by expert clinicians because of clinicians' workload, leading to suboptimal treatment.

As endometriosis is a multisystem disease, patients with the condition should ideally be offered a personalized, multimodal, interdisciplinary treatment approach. Moreover, there is a clear unmet need to develop tools facilitating prognosis, objective longitudinal symptom monitoring, and enhancing treatment prioritization. We believe we can tackle these challenges using multimodal data collected at home capitalizing on digital health technologies such as with smartphones and wearable sensors.

## Data & Methodology

We have already data access to hundreds of participants providing self-assessments of their endometriosis. We have three ongoing projects collecting concurrent data on self-reports (endometriosis symptom monitoring) and wearable sensors, currently having about 70 participants who have already provided data for about a year. With recruitment under way in Cambridge and the new EU Horizon project starting in January 2025 we envisage we will have started collecting data from many more participants in 2025 which will be made accessible to the recruited PhD student. We remark that currently we are not aware of any other research groups (other than our collaborators) worldwide who are doing anything similar at the scale of multimodal data collection in endometriosis.

The student will engage in time series analysis and signal processing algorithms mining the self-reports and wearable data, following an established line of work (Tsanas et al., 2020; Tsanas, 2022a; Edgley et al., 2023a). There is scope for interested students to learn and explore different statistical machine learning techniques ranging from feature selection and statistical mapping (Tsanas, 2022b) to ensemble learning and understanding missing data and imputation methods.

## Responsible AI and ethical considerations

The underlying projects which have been running for a number of years now (within which this PhD will be feeding in directly) were co-designed with patients through a range of PPIE events over the years. We have received ethical approvals for our research work, and outputs from our research work directly influence how the EXPPECT team is providing healthcare services to patients in the NHS. We regularly hold PPIE events informing patients of our ongoing research outputs, and this project will benefit from all this ongoing support and infrastructure we have been developing over the years in our award winning research (Scottish Healthcare aware in 2022).

The student will not be expected to be involved in any data collection, however we will expect them to be involved in PPIE events we run via EXPPECT (including for example a recent PPIE event we had at the Scottish parliament).

## Expected Outcome & Impact

We envisage the outputs of this project will directly inform NHS decision making through the EXPPECT team (<https://www.ed.ac.uk/centre-reproductive-health/exppect-endometriosis/the-endometriosis-team>) who will be supporting the project. We are committed to see this work's outputs informing endometriosis intervention and longitudinal assessment, having already outlined many of the challenges that data analytics tools have towards being translated into clinical settings (Triantafyllidis and Tsanas, 2019). This PhD project is part of a much wider effort which we believe may lead to a strong REF impact case in UoA 1.

The primary supervisor (Tsanas) has been the Knowledge Exchange and Research Impact Director of the Usher Institute feeding directly into CMVM strategy and impact assessment (including being involved in early discussions about the next REF Impact submission for 2029).

## References

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## Additional Information

This project is part of two wider large scale interdisciplinary projects (ADVANTAGE, a £4.3m grant led by the University of Cambridge, and EUMetriososis, a £7m grant led by the University of Louvain, Belgium), where the two co-supervisors are Co-Investigators leading large WPs within the projects.

The project is well placed within PPIE and an unmet clinical need, with outputs that could be directly translated into being used by the collaborating NHS team.

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## Project partners

EXPPECT Endometriosis & EXPPECT Research team

The EXPPECT Endometriosis Service consists of a multidisciplinary team that aims to provide state-of-the-art, high quality, evidence based and patient-centred treatment for the management of all grades of endometriosis. It comprises expert clinical personnel including surgeons and nurses, programme managers, database expertise etc. running a state-of-art clinical and research programme. It has established award-winning PPIE links to tackle pressing problems (<https://www.ed.ac.uk/centre-reproductive-health/exppect-endometriosis/the-endometriosis-team>). Our clinical and research work has won the Scottish Healthcare award in 2022; in mid-2024 we were invited to the Scottish parliament.

The British Society of Gynaecological Endoscopy (BSGE) has recently set up accredited centres for the laparoscopic treatment of advanced endometriosis to enable high standards of care to be delivered to women with endometriosis. Edinburgh achieved BSGE accreditation in January 2015.

The team will support this PhD project providing access to research data and an infrastructure to support the student with appropriate expertise (nurses, clinicians) and infrastructure embedded in the NHS (where Andrew and Lucy are directly involved in).

The team has recently been involved in major strategic grants (e.g. with Cambridge on a £4.3m grant, and a recent EU Horizon £7m grant) -- Thanasis and Andrew and Co-Investigators in those grants with an established work and publication track record over the last 5 years.

[Lucy is the Lead for Clinical Studies and Consultant in NHS Lothian]

[Andrew is the Director of IRR and Honorary Consultant in NHS Lothian]