**Endometriosis early detection**

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A blue glowing uterus

Description automatically generated

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# Background

Endometriosis, a chronic inflammatory condition, primarily manifests through symptoms such as pain and infertility [1]. It occurs when tissue resembling the uterine lining grows outside the uterus, adhering to pelvic organs, and occasionally other areas of the body. This abnormal adhesion triggers inflammation and the formation of scar tissue, resulting in debilitating pain and, in some instances, infertility. Endometriosis predominantly affects women of reproductive age, with research suggesting that approximately 5-10% of this demographic, totalling around 180 million individuals globally, are affected [2].

Main known indicators of the endometriosis include:

* Pelvic pain and/or lower abdominal pain
* Painful menstrual cramps
* Abnormal menstrual bleeding pattern (either by amount or irregularity)
* Family history [3]
* Infertility [4]

Endometriosis can be classified to 4 stages, based on the size and depth of the adhesions:

* Stage I: minimal
* Stage II: mild
* Stage III: moderate
* Stage IV: severe

The symptoms of endometriosis do not correlate with the stages, meaning Stage IV patients can have no symptoms and stage I patients can have severe symptoms.

Diagnosing endometriosis presents a challenge since adhesions are not always detectable through imaging techniques like ultrasound or MRI. Typically, a definitive diagnosis necessitates undergoing laparoscopic surgery [3] and a subsequent biopsy.

Problem Statement  
Our primary objective revolves around the prompt identification of endometriosis. Remarkably, 60% of women dealing with endometriosis navigate consultations with three or more clinicians before receiving a diagnosis, leading to an average delay of seven years before definitive diagnosis [5]. This prolonged delay intensifies symptoms, lowers overall quality of life, and contributes to enduring reproductive health challenges. Conventional diagnostic methods, predominantly reliant on invasive procedures and subjective assessments, further complicate the diagnostic process.

# Proposed Solution

This project endeavors to aid in diagnosing endometriosis by analyzing patient data. We will collect data on endometriosis and healthy patients from the UK Biobank and select a group of features (symptoms and risk factors) from which we will try to detect the existence of endometriosis. Our primary goal is to build the optimal machine-learning model for accurate endometriosis detection based on the features we found.

# Introduction

## Machine Learning

Machine learning, a subset of artificial intelligence, revolutionizes medical research by extracting insights from vast datasets to enhance diagnostic accuracy, treatment efficacy, patient outcomes, and identifying risk factors. There are two primary subcategories of machine learning - supervised and unsupervised learning.

Supervised learning algorithms use labeled data to train models to predict outcomes or classify instances, offering valuable insights into disease detection and prognosis.

Unsupervised learning techniques uncover hidden patterns within unlabeled data, enabling researchers to identify unexplored disease subtypes or biomarkers.

Deep learning, a subset of machine learning, utilizes neural networks with multiple layers to automatically extract complex features from raw data, paving the way for advanced image analysis, genomic sequencing, and complex medical issues.

With the integration of these machine learning paradigms, medical researchers unlock unprecedented opportunities to unravel the complexities of diseases, revolutionizing healthcare delivery.

## Endometriosis

Endometriosis, a prevalent chronic gynecological condition reliant on estrogen, concerns the presence of uterine endometrial tissue outside its normal cavity. This disorder is characterized by the presence of endometrial tissue outside the uterus, leading to pelvic pain and fertility issues.

## UK BioBank [6]

UK Biobank is a large-scale biomedical database and research resource, containing in-depth, de-identified genetic and health information from half a million UK participants. The database, which is regularly augmented with additional data, is globally accessible to approved researchers and scientists undertaking vital research into the most common and life-threatening diseases. UK Biobank’s research resource is a major contributor to the advancement of modern medicine and treatment and has enabled several scientific discoveries that improve human health.

# Solution Description

Stage one: Feature Selection

The first step of our research was to find the features we would like to try and detect endometriosis by. We have sorted the features into groups:

**General Features**

The general features include:

* Sex/Genetic sex
* Age at recruitment
* Year of birth
* Weight/BMI

As endometriosis mostly effects women, we will use the sex data field to filter female patients.

We chose to include weight\BMI as features because we have found several research papers stating there is an inverse relationship between BMI and the risk of endometriosis, meaning endometriosis is more commonly associated with lower BMI [7].

The year of birth and age at recruitment features will help us infer which of the other features are relevant to our goal. Endometriosis mainly effects women of reproductive age, meaning data of patients over this age group may not be relevant.

**Pain Indicators**

One of the most recognizable symptoms of endometriosis is reported to be unusually painful periods, and pelvic pain in general. Research shows that 45% of patients with chronic pelvic pain also have endometriosis [8]. Other pain related symptoms that are usually associated with endometriosis include:

* Lower abdomen pain
* Back pain
* Hip pain
* Recurring Headaches and migraines
* Genital organ pain

We have added these symptoms, including pelvic pain and menstruation pain as features.

**Infertility**

Research shows that 30% of patients with infertility have endometriosis. Researchers believe the two are connected, meaning endometriosis might cause fertility issues in some of the patients, depending on the severity (stage) of the endometriosis [8].

Therefore, we expect that a diagnosis of infertility might also indicate a risk of endometriosis.

**Hormonal Contraception**

Hormonal birth control is one of the most common treatments for endometriosis. The hormonal contraceptive regulates estrogen levels. Endometriosis is estrogen-dependent therefore endometriosis patients tend to have excess estrogen. To stop estrogen production, meaning decrease the growth of endometrial-like tissue, Hormonal birth control is usually suggested as a treatment.

With this information in mind, we expect an inverse relationship between risk of endometriosis and using hormonal contraceptive. We also expect that a large portion of the patients diagnosed with endometriosis might also be taking a hormonal contraceptive.

**Menstruation**

In most patients with endometriosis, we can see an abnormal menstrual bleeding pattern, whether it is in amount (excessive bleeding for a longer duration than usual, meaning the menstrual cycle is shorter than 27 days) or in irregularity [1].

Moreover, the age of a patient at menarche seems to have a connection to endometriosis. Patients that started menstruating before the age of 12 have a higher risk of endometriosis.

The features we have decided to select in this category include:

* Age at menarche
* length of menstrual cycle
* menstrual pain/cramps

**Diet**

Some research papers show a connection between endometriosis and nutrition. It is shown that increased dietary fat consumption and low fiber consumption might increase estrogen concentrations, therefore increasing the risk of endometriosis. The same goes for red meat and dairy consumption [9].

On the contrary, vitamin D, C and E, and antioxidants in general are associated with lower risk of endometriosis, as they are anti-inflammatory [9].

The features we have selected to select for the stated dietary preferences for endometriosis:

* For dietary fat intake, we have selected fat consumption.
* For fiber consumption, we chose to look at fresh fruit and vegetables intake.
* For red meat consumption, we chose beef an processed meet intake.
* For dairy consumption, we chose lactose intake and cheese intake.
* For vitamins C, D, E we chose the corresponding vitamin intake features.

**Pregnancy**

Research shows a relationship between endometriosis and pregnancy complications. It has been suggested that endometriosis might change the uterine environment by causing progesterone resistance in the endometrium. This difficulties in embryo development and implantation [10].

We have decided to select as features some of the most common pregnancy complications:

* General complications
* Preterm delivery
* Spontaneous miscarriage/abortion
* Stillbirth
* placenta praevia (vaginal bleeding during pregnancy)

Moreover, many research papers indicate a relationship between delivery type and endometriosis: the rate of delivery by caesarean sections is higher in endometriosis patients. We have added delivery by caesarean section as one of our features as well.

**Mental state**

As stated above, pain is one of the most recognizable symptoms of endometriosis. The presence of pain significantly influences the psychological and social well-being of individuals with endometriosis, affecting their overall quality of life [12].

Mental symptoms seem to not get medical attention regarding endometriosis detection. We wanted to see if it is prevalent in endometriosis patients, so we added features regarding patient anxiety and depression.

**Related diseases**

Many research papers show a variety of diseases related to endometriosis. We have decided to choose some of the recurring ones, as well as some we were curious about.

The diseases we chose as features:

* Irritable bowel syndrome (IBS)
* Fatigue
* Anemia
* Lupus
* Fibromyalgia
* Hypothyroidism
* Allergies
* Blood clots
* Asthma
* Overian dysfunction
* Ovarian cancer
* uterine cancer
* cervical cancer
* Breast cancer
* Melanoma

After researching every feature group, we created a CSV file with all the features we selected from the UK Biobank showcase and their corresponding codes in the dataset. The goal of creating this CSV was to use it as input for the next step, planning the feature extraction.Stage Two: Planning Feature Extraction

As a part of our research for this project, we decided to search for a python library used to extract features from the UK Biobank. We were surprised we did not find a generic library that takes a csv of the features and generated a pandas data frame. So, we have decided to create one.

The UK Biobank data is organized in CSV files, in which the columns correspond to the different data fields available. The data (at least the part of the data we have access to) is organized in two main CSV files, and each file has a “fields” file that describes which fields are present in it.

The library currently consists of two main classes: one for feature extractions, and one for basic imputations (as the UKB data is very sparse, we thought this might be a common use for this generic library).

The first class is UKBDatasetCreator. This class creates a pandas dataset from a csv file that contains the feature codes, as detailed in the UK Biobank showcase.

Stage Three: Analyzing the Data

We Started by checking the amount of endometriosis patients in the dataset. There are 10,171 patients that were diagnosed with endometriosis.

Stage Four: Feature Engineering

Feature engineering is used in a machine learning project to improve model accuracy and efficiency. By transforming existing features, we can create new features we think will better the predictive power of our model.

The first feature transformation we did was to create a feature that will represent endometriosis diagnosis, and the source of the diagnosis. The UK Biobank has two separate features for this purpose, and they use different data encodings. The feature we determine endometriosis patients by is “[Date N80 first reported (endometriosis)](https://biobank.ndph.ox.ac.uk/showcase/field.cgi?id=132122)”. The data for this feature is dates (with a few special date encodings). We wanted to create a nominal feature that will include not only the diagnosis (has endometriosis or not), but also the source of diagnosis (medical diagnosis or self-diagnosis). We created a feature called “endo diagnosis”, a nominal features

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