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Research Article

A Data-Driven Analysis Approach for Potential Infertility Treatments

Potnuru Rupsa[1], Subhashree Darshana[2*], Siddharth Swarup Rautaray[3], Manjusha Pandey[4]

[1,2*,3,4]School of Computer-Engineering, KIIT (Deemed) University, Bhubaneswar, Odisha, India 751024

***Corresponding Author:** Subhashree Darshana
*Email: subhashree.darshanafcs@kiit.ac.in

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ABSTRACT

Infertility in modern society poses pressing issues to couples usually rooting back to the family. Infertility in women is mainly caused by PCOS (polycystic ovary syndrome) and abnormal sperm production in men is due to undescended testicles, genetic defects, and infections such as chlamydia, gonorrhea, or HIV. Infertile couples usually demand the success of the treatment process, and they have the right to do so, it is cost-effective. Treatment methods available today are generally very expensive and cost is a major factor for these couples. We have used machine learning concepts in this paper to determine potential infertility treatments focusing mainly on PCOS.

Index Terms—Infertility, PCOS, Enzyme, Follicle, Blood Pressure, Endometrium.

INTRODUCTION

Treatments for infertility for a long time were mainly concerned with problems in the female or male reproductive systems. Still, it's becoming more and more clear that infertility can have causes other than problems with the reproductive organs. The range of probable reasons for infertility can be expanded by considering the major contributions made by hormone imbalances and underlying medical diseases such as diabetes. Given that infertility treatments are frequently expensive, it's critical to provide couples with a variety of options that fit within their financial limits. Furthermore, as our knowledge of infertility grows, previously disregarded elements such as endocrine abnormalities and systemic health must be considered when evaluating the success rates, reasons, and methods of therapy. When treating infertility, the best strategy should be to focus on efficiency, reduce problems, and lessen the possibility of patient injury.

In recent years, innovative techniques and technological advancements have been used to treat infertility. One such invention makes it possible for individuals and couples to freeze and preserve embryos, oocytes, and sperm to conserve their reproductive potential for later use. In addition, many nations — notably North America

and Europe — have developed and proposed prediction models for infertility therapies. These models employ artificial intelligence (AI) to predict outcomes of infertility treatments more precisely and increase the probability that they will be successful. For example, female polycystic ovarian syndrome (PCOS) has been linked to raised blood insulin levels, and artificial intelligence (AI) models may assess the quantity of many hormones and enzymes to aid in the diagnosis and treatment of PCOS-related infertility. The intention is to improve the efficacy and success rates of infertility treatments by using these novel strategies, adding hither to unconsidered variables, and utilizing AI, thereby assisting more individuals and couples in realizing their desire to become parents.

RELATED WORKS

- Models for infertility treatment success: The National Library of Medicine's comprehensive review of the subject provides useful information. At the Avicenna Research Institute, the investigation was carried out as a systematic review in 2015. Six data sets were searched based on WHO criteria and MESH key terms. The findings show that developing models to predict treatment effectiveness for infertility is a novel field, and as a result, there are a variety of opinions on how these models should be developed.

- In an impending report in the Diary of the American Measurable Affiliation, Carlson School of The Board Collaborator Teacher Xuan Bi and his partners look at existing information on 1,376 ladies with polycystic ovary disorder (PCOS). This model scaffolds three phases to take a gander at the entire pregnancy cycle to see if various elements, like treatment or liquor use, may influence the opportunity of live birth. This model could ultimately be formed into a clinical man-made consciousness instrument utilized by specialists as a subsequent assessment.
- Analysts Karina M. Shreffler, Arthur L. Greil, and Julia McQuillan concluded in Answering Barrenness: Examples from a Developing Group of Exploration and Proposed Rules for Training that the current state of Knowledge and Research regarding fruitlessness has significant implications for public awareness, social strategy, and future research. Other family planning techniques and resources for managing reception costs should be considered in addition to infertility therapy.
- The focus of the study by Fauzia Tabassum, Chandra Jyoti, Hemali Heidi Sinha, Kavita Dhar, and Md Sayeed Akhtar is on how polycystic ovarian disease affects women's pleasure with age progression, basal metabolic file, training, and marriage. discovered truly striking differences between PCOS and HC in terms of maturity (P0.020), BMI (P0.001), educational attainment (P0.001), and conjugal in all, 97% of PCOS cases compared to 78% of control cases involved individuals under 30 years of age.
- Clinically generated and patient-reported data have long served as the basis for the data-driven decisions made by medical professionals. Increasing usage of patient-generated health data (PGHD) is bringing new types of data into the medical field and changing patient-provider collaboration. We examined the application of PGHD and related data practices in the context of fertility, a complex, uncertain, and data-intensive health concern. In addition to fourteen patients who are or have been infertile, we also spoke with five medical specialists who specialize in infertility. Our findings show that while physicians and patients employ PGHD in different ways, they are all aiming to investigate" the unknown," which is the ambiguity surrounding reproduction. Providers examine patient data logically to pinpoint probable causes of infertility and determine the best line of action. Patients have difficulty interpreting statistics and learning about their bodies by using data in a far more emotional way. We investigate the concepts that underlie the differences between the different data practices and clarify how each distinct group uniquely benefits from them through an examination of those activities. We then suggest that fertility technologies should consider these concepts, highlight the gap between patients' and providers' data practices, and focus on bridging rather than integrating them to promote collaboration and maintain their unique advantages.

METHODOLOGY

Datasets on I beta-HCG (mIU/mL), II beta-HCG (mIU/mL), AMH (ng/mL), blood pressure levels, follicle number and size, and endometrium (mm) were gathered for this recommended topic. We have also considered the consumption of fast food and frequent exercise. We must first examine the acquired data and create subsets from it to achieve the best prediction outcomes. After that, to determine if the patient has PCOS, we must apply some machine learning algorithms with exhaustive combinations. The K Neighbours Clutch, Decision Tree Classifier, and Naive Bayes Classifier algorithms were utilized in this work.

DATA SOURCE

- By I beta-HCG (mIU/mL): This enzyme a.k.a serum beta HCG is related to pregnancy. An HCG level of less than 5mlU/mL is negative for pregnancy and above 25 ml (about 0.85 oz) U/mL is considered positive for pregnancy. HCG level between 6 to 24 ml (about 0.81 oz)/mL is not deterministic and further tests are required. PCOS does not directly affect HCG levels as studies have shown.

  By II beta-HCG (mIU/mL): Serial beta HCG is measured at least twice with a 48–72-hour gap. The basic difference between I beta-HCG and II beta-HCG is the timing in which they are measured.

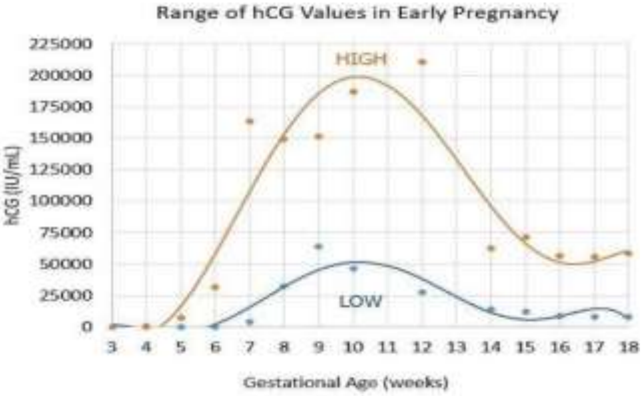

Fig 1: Range of HCG Values in Early Pregnancy

By AMH (ng/mL): The cells that round the eggs in the ovaries create an enzyme known as anti-Mullerian hormone (AMH). Its primary job is to control the growth of the follicles, or egg-containing structures, in the ovaries. An indicator of ovarian reserve, or the quantity of eggs remaining in a woman, might be the blood's AMH levels. Because their ovaries contain more tiny follicles than normal, women with PCOS frequently have AMH levels that are greater than normal. The ovaries may also generate more AMH than usual due to the elevated androgen levels. Therefore, determining AMH levels can be a helpful method for PCOS diagnosis and PCOS severity assessment.

By Exercise and fast-food intake: In obese subjects (no regular exercise and heavy fast-food intake), mean

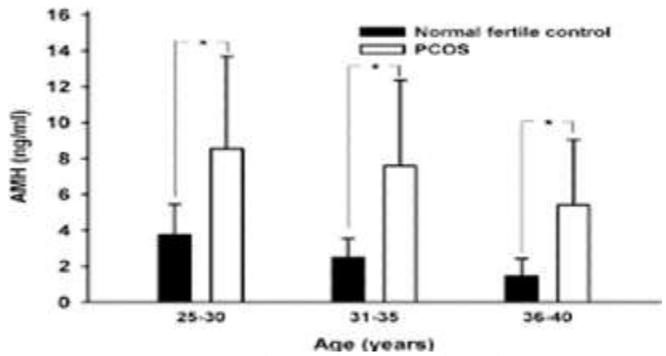

Fig. 2: Normal Fertile control and PCOS

BMI varied fundamentally among PCOS and non-PCOS ladies (29.3±3.3 kg/m2 versus 27.8±2 kg/m2, P=0.03). In lean subjects, there was no measurably tremendous contrast with regards to BMI among PCOS and non-PCOS ladies (21.4 ± 1.9 kg/m2 versus 21.2 ± 2 kg/m2, P¿0.05).

- By blood pressure: It is estimated that more than 30% of women with PCOS have BP ¿ 130/85 mm (about the length of the long edge of a credit card) Hg. However, according to research papers, whether hypertension is associated with PCOS independent of obesity remains controversial.
- Follicle size and numbers: Research has shown that the responsiveness of 79.49% and explicitness of 90.67% was accomplished with a cut-off of 8 mL as ovarian volume. A cut-off worth of 9 follicles to recognize PCOS and control ladies yielded responsiveness of 82.35% and particularity of 92.0% while a follicular size of 5 mm (about 0.2 in) yielded awareness and explicitness of 74.67% and 78.15% individually. With every one of the three boundaries responsiveness was 87.39% and particularity 87.84% with 92.04% PPV (positive prescient qualities) and 81.25% NPV (Negative prescient qualities) from a sum of 119 ladies.
- Endometrium(mm): The mean thickness of the endometrium was genuinely higher in the PCOS bunch (11.1mm), and in the IR bunch (9.6mm), contrasted and the benchmark group (6.2mm) (F=13.1, p¡0.001).
- Analyzing PCOS Factors with Correlation Matrix: Polycystic ovary syndrome (PCOS) is a complex hormonal disorder affecting women of reproductive age. To understand the potential relationships between various factors and PCOS, researchers often utilize correlation matrices. These matrices depict the strength and direction of association between each variable. A value of +1 indicates a perfect positive correlation, where both variables increase together. Conversely, -1 signifies a perfect negative correlation, meaning one increases as the other decreases. A value of 0 suggests no correlation. In the context of PCOS, a correlation matrix can reveal factors potentially associated with the condition. For instance, a positive correlation between weight and PCOS might suggest a higher likelihood of PCOS in overweight women. However, it's crucial to remember that correlation does not imply causation. Just because two factors are correlated doesn't establish a cause-and-effect relationship.
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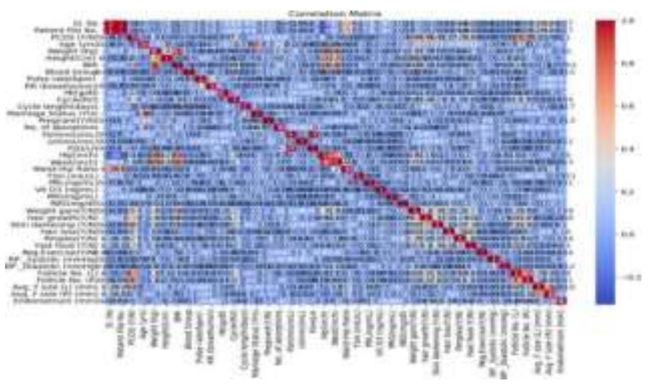

Fig. 3: correlation matrix which shows the relationship between various factors and Polycystic ovary syndrome

- Relationship Between TSH and PCOS: The image you sent shows a line graph titled" Relationship between TSH and PCOS." The x-axis labeled" TSH" likely refers to Thyroid thyroid-stimulating hormone levels in the blood. The y-axis labeled "PCOS" presumably indicates the presence or absence of Polycystic Ovary

Syndrome. The graph itself doesn't show a clear relationship between TSH levels and PCOS.
It seems to be a scatter plot, where each data point represents the TSH level of one individual and whether they have PCOS. Without a trendline or other statistical analysis, it is difficult to say if there is a positive, negative, or neutral correlation between TSH and PCOS based on this graph alone.

- The image shows a bar graph depicting the distribution of PCOS diagnoses. The x-axis labeled" PCOS (0/1)" represents whether someone has PCOS (1) or not (0). The y-axis labeled" Count" represents the number of people in each category.
  The bars show a clear imbalance between the two categories. There are significantly more people who do not have PCOS (0) compared to those who do (1). This suggests that PCOS is a less common condition in the population represented by this data.

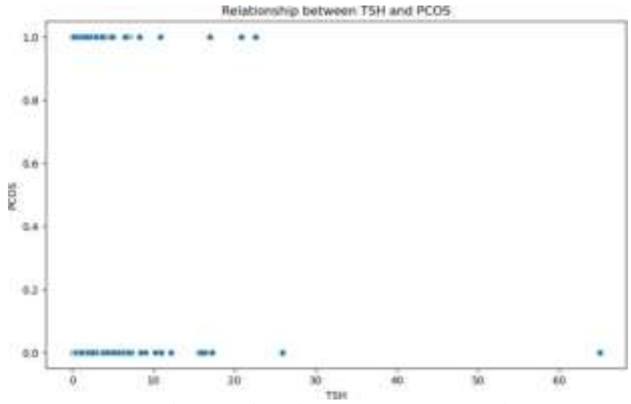

Fig. 4: Relationship between TSH and PCOS

It is important to note that without additional information about the data source and methodology, it is difficult to draw definitive conclusions about the prevalence of PCOS in the general population.

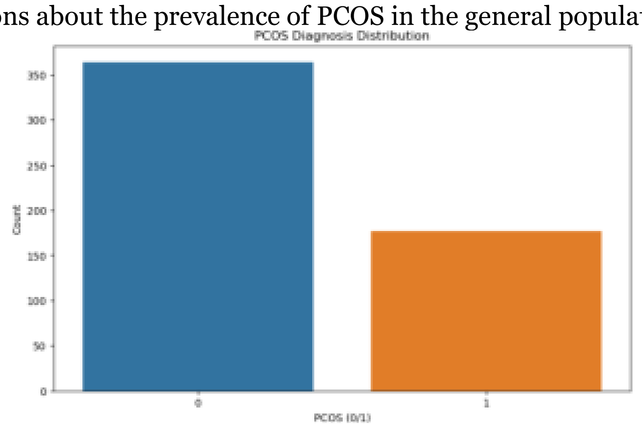

Fig. 5: PCOS Diagnosis Distribution

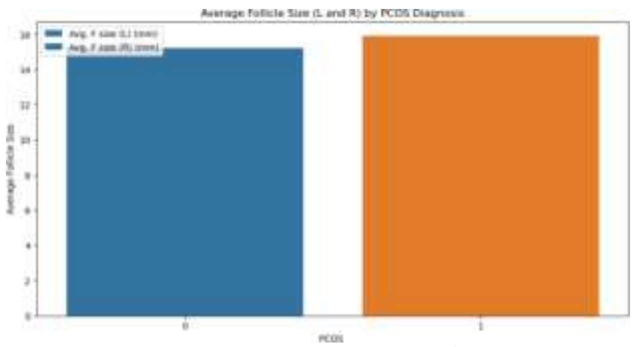

Fig. 6: PCOS Diagnosis Distribution

- The image shows a line graph with two lines representing the average follicle size in the left and right ovaries. The x-axis labeled" PCOS" indicates whether someone has PCOS or not. The y-axis labeled" Avg. F size (mm)" represents the average follicle size in millimeters.
  The graph shows that the average follicle size is larger in women with PCOS compared to those without PCOS for both left and right ovaries.
  It is important to note that this graph only shows a correlation between PCOS diagnosis and average follicle size. It does not necessarily mean that having PCOS causes larger follicles. More research would be needed to determine if there is a causal relationship.

B. K Neighbors Clutch:

The k-nearest neighbor algorithm is one of the most widely used, fastest, and easiest-to-use classification techniques for statistical pattern recognition [2,3]. To classify an unknown observation, x, into the jth class if x Xj, it constricts the sample space X, X1, X2..., XJ. The performance of the closest neighbor classifier is dependent on the value of the neighborhood parameter k and the distance function. The Minkowski, Euclidean, Canberra, Chebyshev, Bray Curtis (Sorensen), and City Block (Manhattan) distances are among the techniques used to calculate the distance between two places. It is significant to remember that the Euclidean distance technique is often used by the k-NN algorithm. If the observations are not of comparable units and scales, it is meaningful to standardize them before using the Euclidean distance. Applying this to the given data we get an accuracy of 87.962%

C. Decision Tree Classifier

A typical tree contains leaves, branches, and subterranean root development. a - It has leaf hubs, branches, and rooibos. A quality test is in each inner hub, the branch displays the experimental result, and the leaf hub displays the resulting class mark [3, 4]. A root hub is the topmost hub in a tree and the parent of all other hubs, as its name suggests. A choice tree is a tree in which every leaf addresses the result (a classification or progressing with esteem), every hub addresses a quality, and every connection addresses a standard [4]. Due to decision trees' ability to mimic human thought processes, gathering information and creating a few insightful experiences is quite easy. The entire thought is to make a tree like this for the whole information and interaction a solitary result at each leaf.
Applying this to the given data we get an accuracy of 84.259%

D. Naive Bayes Classifier

Bayesian classifiers relegate the most probable class to a given model portrayed by its element vector. Learning such classifiers can be significantly worked on by accepting that elements are free given class, that is

$$P(X|C) = \prod_{i=1}^{n} P(X_i|c) \qquad (1)$$

where $x = (x_1, ..., x_n)$ is a feature vector and C is a class. Despite this unreasonable supposition, the subsequent classifier known as gullible Bayes is surprisingly effective practically speaking, frequently contending with substantially more refined methods [6; 8; 4; 2]. Guileless Bayes has demonstrated viability in numerous down-to-earth applications, including text characterization, clinical analysis, and framework execution the executives [2; 9; 5]. Applying this to the given data we get an accuracy of 88.89%

RESULT

A. K Neighbors Clutch:

This model gave an accuracy of 87.962% with the provided data set. Such a high degree of accuracy not only reflects the meticulousness of the model's construction but also hints at its potential for real-world applications. This accuracy rate showcases the model's ability to make accurate predictions and informed classifications, further solidifying its value in contributing to accurate decision-making and insightful analyses in various domains.

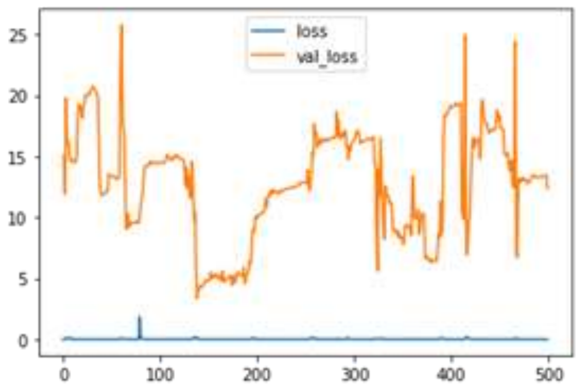

Fig. 7: K Neighbour Clutch

B. Decision Tree Classifier:

Using the given data set, this model yielded an accuracy of 84.259%. This accomplishment highlights how well the model understands and captures the complex relationships present in the dataset. The obtained accuracy rate indicates the model's potential usefulness in real-world applications by demonstrating its ability to produce accurate forecasts and well-informed classifications. This degree of accuracy is indicative of the model's ability to identify patterns and trends, which attests to its value in supporting wise decisions and perceptive assessments in a variety of sectors.

C. Naive Bayes Classifier:

With the given data set, the accuracy of this model was 88.89%. This result demonstrates how well the model can detect and decipher complex patterns and relationships in the data. The model's ability to make precise predictions and well-informed classifications is demonstrated by its high accuracy rate, which also highlights the model's potential for practical use. This degree of precision demonstrates the model's ability to identify underlying patterns and variances, highlighting its value in supporting accurate decision-making and perceptive analysis in a variety of fields.

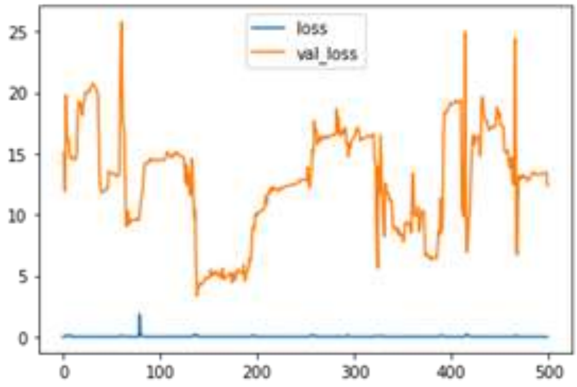

Fig. 8: Decision Tree Classifier

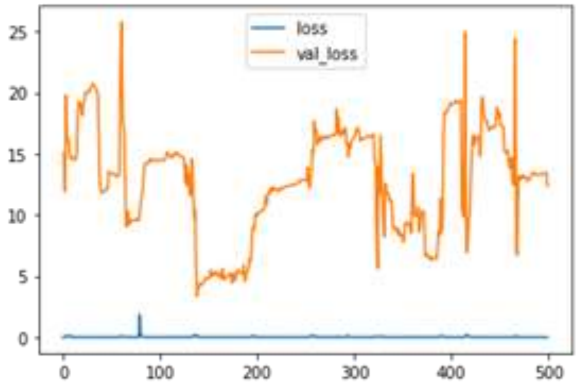

Fig. 9: Naive Bayes Classifier

D. Observations

The average values of the dataset for important factors provide useful information about the characteristics of individuals with and without Polycystic Ovary Syndrome (PCOS) and may be used to determine whether there is a relationship between the illness and these variables.

- **I beta-HCG (mIU/mL):**

1. Total Dataset: 664.549 mIU/mL is the average I beta- HCG level for the whole dataset.
2. Patients with Negative PCOS: The average I beta- HCG level is greater (728.982 m IU/mL) in those without PCOS.
3. Patients with Positive PCOS: The average I beta- HCG level is 532.042 mIU/mL, which is lower in PCOS patients.

Although further study is required to establish a definitive association, the variations in I beta-HCG levels between persons with and without PCOS may suggest a possible correlation between this hormone and the disorder.

- **II beta-HCG (mIU/mL):** 1. Total Dataset: 238.229 mIU/mL is the average II beta-HCG level for the whole dataset.

2. Patients with Negative PCOS: The average II beta-HCG level is lower in those without PCOS, at 223.975 mIU/mL.
3. Patients with Positive PCOS: The average II beta-HC level is greater in PCOS patients, measuring 267.543 mIU/mL.

II beta-HCG levels differ between those with and without PCOS, like I beta-HCG, indicating a possible correlation with the illness.

- **AMH (ng/mL):** 1. Whole Data Set: The average AMH level for the entire dataset is 5.624 ng/mL.
2. Patients with Negative PCOS: Individuals without PCOS have a lower average AMH level of 4.541 ng/mL.
3. Patients with Positive PCOS: Those with PCOS have a higher average AMH level of 7.884 ng/mL.
Increased AMH levels in PCOS patients may suggest a connection between this hormone and the illness. Given that AMH and ovarian function are known to be related, this might explain why PCOS patients have greater AMH levels.

- **Fast food intake:** 1. Whole Data Set: The average fast-food intake for the entire dataset is 0.515.
2. Patients with Negative PCOS: Individuals without PCOS have a slightly lower average fast-food intake of 0.382.
3. Patients with Positive PCOS: Those with PCOS have a slightly higher average fast-food intake of 0.786.

Even while there isn't much of a difference in the two groups' fast-food intake, it does point to a possible dietary component that might be connected to PCOS.

- **Regular exercise:** 1. Whole Data Set: The average regular exercise for the entire dataset is 0.247.
2. Patients with Negative PCOS: Individuals without PCOS have a slightly lower average regular exercise level of 0.228.
3. Patients with Positive PCOS: Those with PCOS have a slightly higher average regular exercise level of 0.286.

The differences in the amount of regular exercise that people with and without PCOS engage in may provide insight into how physical activity affects the illness's course or treatment.
1. Blood Pressure (Systolic and Diastolic): Total Data Set: 114.662 mmHg is the average systolic blood pressure, and 76.924 mmHg is the average diastolic blood pressure.
2. Patients with negative PCOS: Those without PCOS have somewhat lower average blood pressure values at the systolic (114.620 mmHg) and diastolic (76.780 mmHg) points.
3. Patients with Positive PCOS: The average systolic and diastolic blood pressure of PCOS patients is somewhat higher, at 114.747 mmHg and 77.219 mmHg, respectively.

Though the differences are rather slight, the blood pressure values between the two groups may indicate a relationship between blood pressure and PCOS.

- **Follicular Characteristics:** The provided data provides the average values of major follicular characteristics for the entire dataset in addition to the specific results for those with positive PCOS and those with negative PCOS. These follicular characteristics are critical to understanding the potential changes associated with PCOS (polycystic ovarian syndrome).
1. Number of Follicles (Left and Right Ovary):
The average number of follicles in the left ovary is 6.129 for the whole dataset, whereas the average number in the right ovary is 6.641.
The average number of follicles in the left and right ovaries is significantly greater in patients with positive PCOS, with values of 9.764 and 10.738, respectively.
The average number of follicles in the left ovary and the right ovary in patients with negative PCOS is 9.764 and 10.738 respectively, which is the same as in patients with positive PCOS.
2. Average Size of Follicles (Left and Right Ovary):
The average follicle size for the total dataset is 15.456 mm for the right ovary and 15.024 mm for the left ovary.

The average follicle diameters in the left and right ovaries of patients with positive PCOS are somewhat bigger, measuring 15.713 mm and 15.927 mm, respectively.
The typical follicle diameters in patients with negative PCOS are 15.713 mm in the left ovary and 15.927 mm in the right ovary, which are identical to those in patients with positive PCOS.

- **Endometrium:** The data provided displays the mean endometrial thickness values (in mm) for each person in the dataset, regardless of whether they have PCOS (positive or negative). The thickness of the endometrium is important for reproductive health and conception.
1. The average endometrial thickness for the whole dataset is 8.474 mm, as shown in endometrial Thickness (Entire Dataset).
2. Endometrial Thickness (Patients with Negative PCOS): - The average endometrial thickness for patients with negative PCOS is 8.315 mm.
3. Endometrium Thickness (Patients with Positive PCOS): - Patients with positive PCOS have an average endometrium that is 8.800 mm thick, which is somewhat thicker than other patients.

According to the data, endometrial thickness varies between those with positive PCOS and those without it. Patients with positive PCOS frequently have an endometrium that is somewhat thicker than those with negative PCOS. Notably, the endometrium has a major impact on both fertility and the menstrual cycle. It takes sufficient endometrial thickness to facilitate successful embryo implantation and to ensure healthy pregnancies. Changes in endometrial thickness may therefore affect fertility and reproductive outcomes in PCOS patients. Further research and clinical evaluation may be necessary to determine the impact of these changes in endometrial thickness on the fertility and reproductive health of people with PCOS.

Table. 1: Average Values of Important Factors in Individuals with and without PCOS

PARAMETER	TOTAL DATASET	PATIENTS WITH NEGATIVE PCOS	PATIENTS WITH POSITIVE PCOS
I beta-HCG (mIU/mL)	664.549	728.982	532.042
II beta-HCG (mIU/mL)	238.229	223.975	267.543
AMH (ng/mL)	5.624	4.541	7.884
Fast Food Intake	0.515	0.382	0.786
Regular Exercise	0.247	0.228	0.286
Blood Pressure			
- Systolic (mmHg)	114.662	114.620	114.747
- Diastolic (mmHg)	76.924	76.780	77.219
Follicular Characteristics			
- Number of Follicles (Left Ovary)	6.129	9.764	9.764
- Number of Follicles (Right Ovary)	6.641	10.738	10.738
- Average Follicle Size (Left Ovary, mm)	15.024	15.713	15.713
- Average Follicle Size (Right Ovary, mm)	15.456	15.927	15.927
Endometrial Thickness (mm)	8.474	8.315	8.800

E. Conclusion and Future Work

In conclusion, identify potential infertility causes and specify a course of treatment. Patients struggle with data interpretation, using data in a much more emotional approach to learning about their bodies. Through an analysis of various data practices, we explore the underlying ideas that underpin their variations and explain how each group benefits from them specifically. We then propose that to faster cooperation and preserve their separate advantages, fertility technologies should take these ideas into account, draw attention to the current divide between patients' and providers' data practices, and concentrate on bridging rather than integrating them. couples with choices to preserve their ability to procreate for future use. Furthermore, artificial intelligence (AI)-powered prediction models for infertility treatments have surfaced in several countries, with the potential to increase treatment outcomes. For example, by evaluating the abundance of different enzymes and hormones, AI models can assist in the diagnosis and treatment of conditions such as polycystic ovary syndrome (PCOS). The goal is to improve the efficacy and success rates of infertility treatments, ultimately assisting more individuals and couples in realizing their dream of becoming parents, by implementing these cutting-edge strategies, considering hitherto unconsidered factors, and utilizing the power of artificial intelligence.

K Neighbors Clutch, Decision Tree Classifier, and Naive Bayes are the three machine learning models whose performance is explained by the data and analysis presented. Couples with choices to preserve their ability to procreate for future use. Furthermore, artificial intelligence (AI)-powered prediction models for infertility treatments have surfaced in several countries, with the potential to increase treatment outcomes. For example, by evaluating the abundance of different enzymes and hormones, AI models can assist in the diagnosis and treatment of conditions such as polycystic ovary syndrome (PCOS). The goal is to improve the efficacy and success rates of infertility treatments, ultimately assisting more individuals and couples in realizing their dream of becoming parents, by implementing these cutting-edge strategies, considering hitherto unconsidered factors, and utilizing the power of artificial intelligence.

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