

Female Infertility and its Early detection: A Systematic Review

Sahana Devi.K.J¹

Asst .Prof,Department of Computer Science and Engineering
Sri Krishna Institute of Technology,
Bengaluru, Karnataka.
sahanadevice@skit.org.in

Dr.Shantaram Nayak²

Prof. and HOD, Department of Computer Science and Engineering
Sri Krishna Institute of Technology,
Bengaluru, Karnataka.
csehod@skit.org.in

Abstract—Infertility is one of society's physical, social, and psychological difficulties. "Failure to obtain a clinical pregnancy after 12 months or more of regular unprotected sexual intercourse," according to the definition. Ovulation induction has remained a watershed moment in the lives of women. Infertility is a prevalent problem that is sometimes misunderstood. Because of its effects on families, its importance to study in related fields such as fertility trends and reproductive health, and its implications for practitioners who work with individuals and couples facing infertility. Infertility is an important topic for family scientists. Inability or difficulty in conceiving is a physically and psychologically draining experience for a woman. Polycystic Ovary Syndrome (PCOS) has been determined as one of the serious health problems in women that affects the fertility of women and leads to significant health conditions. Therefore, early diagnosis of polycystic ovary syndrome can be effective in the treatment process

Keywords—infertility; hormones; clinical data, PCOS, adolescence ,harmone

I. INTRODUCTION

Infertility is described as a condition of the reproductive system defined by the failure to produce clinical pregnancy after 12 months or more of frequent unprotected sexual intercourse, according to the World Health Organization. Female infertility is a major disorder that has changed people's lives in terms of lack of conception and reproducibility, a stressful environment, excessive radiation, a lack of biological food, genetically disorder, changing lifestyles, and increased electronic discharge.

The female reproductive system

The internal and external sex organs that operate in the reproduction of new children make up the female reproductive system as shown in figure 1. The female reproductive system in humans is immature at birth and matures at puberty in order to produce gametes and carry a foetus to full term. The female reproductive system serves a variety of purposes. The egg cells, known as ova or oocytes, are produced by the ovaries. The oocytes are subsequently transferred to the fallopian tube, where they may be fertilised by sperm. The fertilised egg is subsequently transferred to the uterus, where the uterine lining has expanded in response to the reproductive cycle's typical hormones. The fertilised egg can implant into the thicker uterine lining and continue to develop once inside the uterus.

The uterine lining is lost as menstrual flow if implantation does not occur. The female reproductive system also produces female sex hormones, which help to keep the reproductive cycle going.

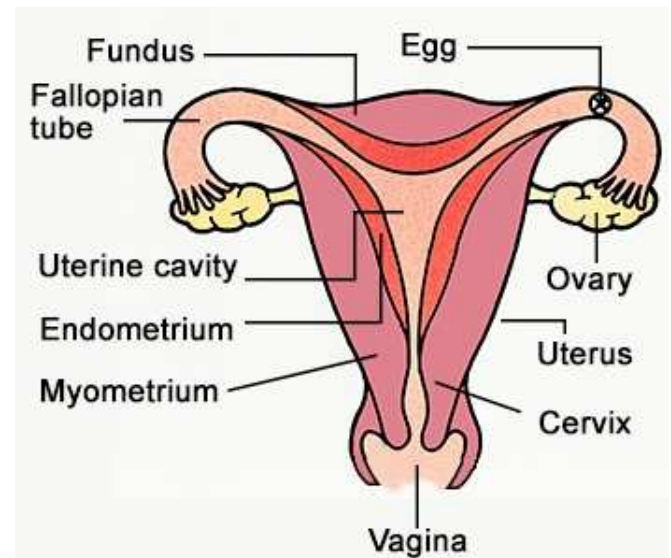


Figure 1: Female reproductive system (captured from oncofertility consortium)

Pregnancy will occur in roughly 85 percent of young and healthy heterosexual couples who have frequent intercourse, with 93 percent of attempts at conception.

This guideline does not apply to couples in which the female is above 35 years old or when one or both partners have a history of reproductive issues. If the lady is above 35 and has been trying unsuccessfully for more than 6 months, she should seek additional counsel regarding investigation and therapy. If the female has a history of gynaecological difficulties, or if the partner's sperm count is known to be low, they should consult a fertility specialist right away. Women aged 40 and up should begin their inquiry and treatment after three months.

Female Infertility

Female infertility is a prevalent cause of infertility in both men and women. A female spouse will be present in at least half of all infertility consultations. In the past, the female partner was expected to do the majority of the work and must shoulder most of the responsibility, and just approximately 5%

of couples was assumed that seeking assistance with having a baby is desirable.

Infertility and childlessness cause a lot of pain and anguish in people's lives. In both men and women, female infertility is a common cause of infertility. At least half of all infertility consults will include a female partner.

Factors for female Infertility:

Infertility in women can be caused by a variety of factors, including: problems with a fertilized egg or embryo surviving once attached to the uterine lining. Problems with the eggs' ability to attach to the uterine lining.

There are issues with the eggs moving from the ovary to the uterus. With Obstacles to egg production in the ovaries women are delaying having children until their 30s and 40s at an increasing rate. In fact, over 20% of women in the United States have their first child after the age of 35.

As a result, age is becoming a more common source of infertility issues. Fertility issues affect about a third of couples with a woman over the age of 35.

Woman infertility and aging: Aging decreases the chances of having a baby in the following ways:

With age, a woman's ovaries' ability to release eggs suited for fertilization decreases. The health of a woman's eggs deteriorates as she gets older. A woman's health is more prone to deteriorate as she grows older. As a woman gets older, her chances of having a miscarriage increase.

Ovulation:

A major cause of infertility among women is that there is no cycle, no bleeding, no ovulation, and no baby. Low levels of LH and FSH (sex hormones) can cause it, resulting in low oestrogen and progesterone levels. Anovulation is accompanied by elevated FSH levels in certain women, indicating primary ovarian failure. Turners (XO) syndromes affect a lot of women. Hyperprolactinaemia (high production of prolactin, which is used as a form of contraception in nursing mothers) can also trigger ovulation. This hormone stimulates the production of milk in the breasts. Ovulation is also suppressed by prolactin. Variable oligomenorrhoea can occur during ovulation.

Symptoms

The inability to conceive is the most common sign of infertility. You may not be ovulating if your menstrual cycle is excessively lengthy (35 days or more), too short (less than 21 days), irregular, or missing. There may be no further symptoms or indicators visible to the naked eye. 5, diagnosing the female patients at an early stage is vital concern for everyone.

Types of Female Infertility

1. Primary Infertility

2. Secondary Infertility

1. Primary infertility: A couple's inability to conceive is referred to as primary infertility.

Endometriosis: Affects mostly women in their 30s and 40s, with roughly 40% of women suffering from endometriosis. This occurs when uterine lining is discovered outside of the uterus. Endometriosis will make it difficult to conceive. Scarring and adhesions that form a blockage appear to be the main cause of infertility in women with endometriosis 6.

PCOS (Polycystic Ovarian Syndrome): The bad news about PCOS is that it is one of the most common causes of infertility in women, but it is also one of the most underdiagnosed (less than 25% of women with PCOS are diagnosed). One of the main reasons it isn't diagnosed is that the syndrome's symptoms don't appear to be related to one another. PCOS is usually discovered only after a woman has difficulty getting pregnant and seeks expert treatment. Weight gain, acne, irregular or nonexistent periods, infertility, and failure to ovulate are all indications of PCOS. A battery of blood tests can be used to diagnose PCOS. It can be readily managed with the help of technology.

Ovulatory Disorders: Ovulation issues, such as irregular periods or failure to ovulate at all, account for about 40% of female fertility issues. These disorders can be brought on by a variety of factors.

POF (Premature Ovarian Failure): This is a distressing diagnosis because it indicates you are no longer menstruating despite being under the age of 40.

POF can be caused by birth defects (such as a chromosomal issue that results in faulty ovaries) or when your ovaries become resistant to your body's natural hormones in your 20s and 30s.

POF has also been linked to pelvic surgery, chemotherapy, and radiation. POF is only found in a small percentage of women's families.

Uterine Factors: This area includes any uterine issues you may have. If you've undergone reproductive testing, you'll almost certainly be given a particular diagnosis of the problem. Uterine fibroids, uterine didelphys (when your uterus is made up of two parts with a wall dividing them), a complete lack of a uterus, scar tissue in the uterus, or exposure to DES in the womb (DES was a drug given to pregnant women up until the late 1960s) are all possible factors that can affect your uterus and your ability to conceive. Children born to women who used this medicine had a high rate of birth abnormalities, including an abnormally formed uterus.

Multiple Miscarriages: Suffering from a miscarriage is terrible at any time, but it's especially difficult when you've been trying to conceive for months. While genetic disorders in the fetus are the most common cause of miscarriage, it can also be caused by difficulties with the uterus or cervix, atypical hormone levels, infections, or chemicals in the environment.

Luteal Phase Defect (LPD): This can be caused by two reasons, both of which involve the development of progesterone in your body. The initial reason of LPD is a lack of progesterone secretion by your ovaries. The second cause could be that your endometrium isn't responding to pregnancy

or isn't properly prepared for it, resulting in either fertility issues or an early miscarriage.

2.Secondary Infertility

Secondary infertility describes situations in which a couple has been successful in conceiving at least once but has failed to do so again. It's critical to maintain open lines of communication with your spouse so that you both understand what the other wants, aspires for, and is ready to do (or not do) in order to become parents again.

Causes for Indian women to be infertile

Infertility affects 50 to 80 million couples worldwide at some time during their reproductive lives. The infertility situation in poor countries differs significantly from that in rich countries. A significant proportion of women suffers from preventable problems such as sexually transmitted infections, postpartum infections, post abortion infections, previous contraceptive complications, tubal damage, polycystic ovary syndrome (PCOS), and pelvic inflammatory diseases, in addition to anatomical, genetic, endocrinological, and immunological issues (PIDs).

With this in mind, the current study aimed to focus on the current infertility issue in India and its states, as well as to investigate the risk factors for infertility among women in India's high-infertility districts. The study also aims to discover how women seek therapy for their infertility issues, as well as the impact of infertility on fertility as shown in **Table1**.

Table 1:WHO statistics

SL No.	Type of disorder	Percentage
1	Ovulatory disorders((OD)	25%
2	Endometriosis	15%
3	Pelvic adhesions	12%
4	Tubal blockage	11%
5	Uterini abnormalities	1%
6	Hyperprolactinemia	7%

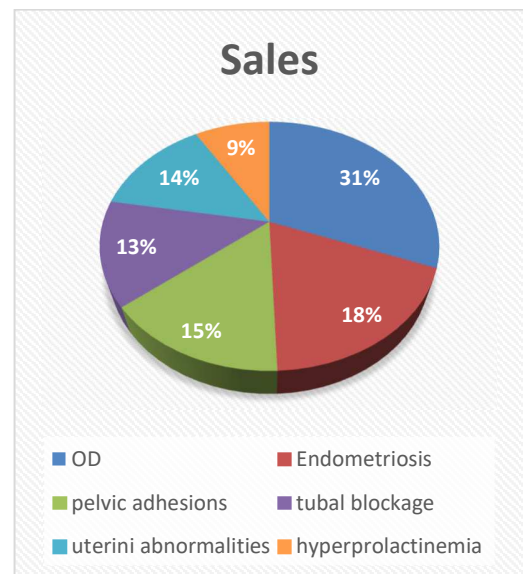


Figure 2:Causes for fertility[Data from WHO]

As shown in Figure 2 Ovulatory abnormalities account for 25% of all known causes of infertility in women. Because no oocyte is released monthly, oligo-ovulation or anovulation causes infertility. There is no chance of fertilisation or pregnancy in the absence of an oocyte.

The majority of cases of infertility are caused by ovulating infrequently or not at all. Ovulation abnormalities can be caused by issues with the hypothalamus or pituitary gland's management of reproductive hormones, as well as issues with the ovary.

Polycystic ovarian syndrome (PCOS) is a type of polycystic ovary (PCOS). PCOS results in a hormonal imbalance that interferes with ovulation. PCOS is linked to insulin resistance, obesity, abnormal facial or body hair growth, and acne. It's the most common cause of infertility in women.

Dysfunction of the hypothalamus. The pituitary gland produces two chemicals that stimulate ovulation each month: follicle-stimulating hormone (FSH) and luteinizing hormone (LH) (LH). Excessive physical or emotional stress, an extremely high or extremely low body weight, or a recent significant weight gain or loss can all alter hormone production and have an impact.

Primary ovarian insufficiency is a condition in which the ovary is not functioning properly. Premature ovarian failure, also known as autoimmune ovarian failure, is caused by an autoimmune response or the premature loss of eggs from your ovary, which can be caused by genetics or chemotherapy. In women under the age of 40, the ovary no longer produces eggs and oestrogen production is reduced.

There's too much prolactin in your system. Excess prolactin production (hyperprolactinemia) by the pituitary gland lowers oestrogen production and can lead to infertility. It's also possible that meds you're taking for another ailment are causing this.

Risk factors

Factors that are at risk

Infertility can be exacerbated by a number of circumstances, including:

Age. The quality and quantity of a woman's eggs start to deteriorate as she gets older. The rate of follicle loss accelerates in the mid-30s, leading in fewer and lower-quality eggs. This makes it more difficult to conceive and raises the chances of miscarriage.

When you should seek help can vary depending on your age:

Most doctors advocate attempting to conceive for at least a year before testing or therapy till you're 35 years old.

If you're between the ages of 35 and 40, talk to your doctor after six months of trying.

If you're over 40, your doctor may recommend that you start testing or treatment right away.

Smoking. Smoking raises your chances of miscarriage and ectopic pregnancy, in addition to harming your cervix and fallopian tubes. It's also known to prematurely age your ovaries and reduce your eggs. Before starting fertility treatment, you should quit smoking.

Weight. Ovulation might be hampered by being overweight or considerably underweight. Increasing the frequency of ovulation and the likelihood of conception by achieving a healthy body mass index (BMI).

History of sexual relations. The fallopian tubes can be damaged by sexually transmitted illnesses including chlamydia and gonorrhea. Having unprotected intercourse with several partners raises your risk of contracting a sexually transmitted infection, which can lead to fertility issues in the future.

Alcohol. Excessive alcohol use might have a negative impact on fertility.

Changes in the texture of cervical mucus or abnormal cervix shape might make sperm migration from vagina to uterus extremely difficult.

II. FACTORS FOR INFERTILITY

Polycystic ovarian syndrome (PCOS)

PCOS, also known as polycystic ovarian syndrome, is a common health disease caused by a hormonal imbalance in the female reproductive system. The ovaries experience issues as a result of the hormonal imbalance. Each month, as part of a healthy menstrual cycle, the ovaries produce an egg that is discharged. The egg may not grow properly or be released during ovulation as it should be if you have PCOS.

Polycystic ovary syndrome (PCOS) is the leading cause of infertility in women nowadays, especially for those who are entering adolescence. A significant proportion of the female population suffers from PCOS, which is one of the most common yet overlooked illnesses of in recent times. Approximately 9-13% of women in reproductive age (the

ability to get pregnant) experience PCOS, while 9-20% of young females have this disorder [1].

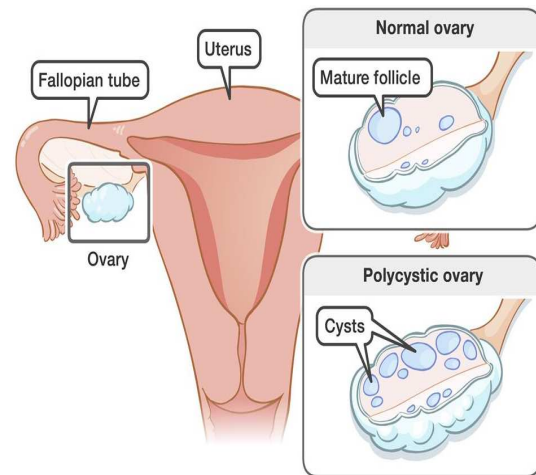


Figure 3: Blockage of the ovary by the PCOS [Image retrieved from Ref-1]

Basically, PCOS is a health condition or body disorder in women that forms a cyst in the ovaries, preventing egg cells from entering the ovaries [2]. Figure 3 shows blockage in the ovary during PCOS. A closer analysis reveals that, there is not much difference between a mature follicle and a PCOS cyst.

Therefore, multiple tests for PCOS will be inconclusive because there is not much difference between the hormonal test results for a female person who is ovulating and a female with PCOS.

Besides infertility, females with PCOS also suffer from hormonal imbalance, hair loss, and other serious illnesses like high blood pressure, heart disease, diabetes, mental disorders, and many more [3][29]. However, timely care and early treatment, PCOS can still be treated successfully, and infertility can be avoided so that women can have a normal pregnancy. Treatment of PCOS involves clinical examination and analysis of some cardinal symptoms that includes anovulation, signs of hyperandrogenism, hirsutism, androgens, pelvic pain and menstrual irregularities. According to studies conducted in the United States, black women are more likely to develop PCOS than white women which has been reported at nearly 8% and 5%, respectively [5-6]. These women are mostly affected by high blood pressure, obesity, cardiovascular disease, endocrine disorders, abnormal vaginal bleeding, gynecological cancers, and diabetes (type-2). To prevent any serious effects of PCOS, diagnosing the female patients at an early stage is vital concern for everyone. Menstrual periods may be skipped or irregular as a result of PCOS. Periods that are irregular can result in:

Infertility is a problem that many couples face (inability to get pregnant). PCOS is, in fact, one of the most common reasons of female infertility. Cysts (small fluid-filled sacs) form in the ovaries.

A recent development in machine learning techniques has contributed to early detection of diseases, consenting for early treatment and reduced mortality. However, high dimensional data often results in under fitting issues and complex

computations, which affects the accuracy of machine learning algorithms. In this paper the study aims to predict PCOS using ensemble learning mechanism applied on clinical dataset [7-8]. Therefore, selecting the most significant data reduces over fitting risk and improves the performance of the classification models [9-10]. The main contributions of this work as follows:

- Selection of the vital attributes using feature selection mechanism from the given clinical dataset of the PCOS patient.
- Unlike existing works, modelling a unique machine learning classifier using decision tree and an approach

of neural network and apply on the selected vital attributes of the clinical dataset.

- Comparing the performance of proposed model with existing ensemble classifiers to justify the scope of the proposed system.

III. RELATED WORK

Table 2: PCOS and statistics

Author and year	Name of Journal	Findings	Statistics and data sets
[21] Palvi et. al	“Review of Polycystic Ovary Syndrome Along with Data Mining” .IJSRD	Polycystic ovarian syndrome (PCOS) is a complicated multi-factional, multi-genetic, strong homorganic and effect of environmental disease	A recent study has revealed that about 18% of the women in India , mostly from the East, suffer from this syndrome. In future research, a new algorithm using Data Mining techniques is to be proposed for effective classification, accuracy of the positive factors causing Polycystic Ovarian Syndrome.
[26] Harman deep Gill et. al	“Prevalence of polycystic ovary syndrome in young women from North India: A Community-based study”	The study was aimed to assess the prevalence of PCOS in women 18-25 years of age, conducted in college girls from Lucknow, North India.	1052 Girls from 3 different colleges were approached. Calculated prevalence of PCOS in women between the ages of 18-25 years from Lucknow, north India, is 3.7%. Majority of these girls were lean but have abdominal obesity.
[27] R. Vidya Bharathi et al, 2017	“An epidemiological survey: Effect of predisposing factors for PCOS in Indian urban and rural population” Middle East Fertility Society Journal	PCOS as a lifestyle disorder highly prevalent among middle and high income urban population as compared to rural population.	Data collected from two areas with contrasting life style in Tamil Nadu, India: Chennai for Urban population with “sedentary” lifestyle and Eliambedu & Oddanchatram for rural population with “active” lifestyle. A total of 502 and 572 young girls in the age group 18–24 were willing to respond to the survey from urban and rural population respectively. Attributes such as regular physical activities, daily diet, exposure to stress and family history
[24] Preeti Chauhan et. al, 2021	“Comparative Analysis of Machine Learning Algorithms for Prediction of PCOS” IEEE Explorer	It is seen that most women overlook the common indication of PCOS and visit the doctor only when they face difficulty conceiving. If not diagnosed in time, the condition can cause serious health issues	Questionnaires using Google forms Around 267 women of different groups have responded. The data collected was normally distributed over age, lifestyle, and regions (urban, rural)

[28] <i>Amsy Denny et. la 2019</i>	IEEE Explorer	Polycystic ovary syndrome (PCOS), is one of the relevant, most prevalent hormonal disorder seen among the women of childbearing age. This is a heterogeneous endocrine disorder.	<p>541 cases were available for study, which was collected from various infertility treatment centers at Thrissur.</p> <p>Real time data gathering or from repository platforms like Kaggle and UCI machine learning repository.</p>
[6] <i>sumia Islam et.al 2021</i>	IEEE Explorer	PCOS is defined by a series of clinical expressions such as irregular period cycle, having cyst, hormonal imbalance, fatness and many more	<p>Out of 550 data 83% data was collected from Bangladesh.</p> <p>15.27% data was 0.90% data collected from the USA. 0.36% people fill up from Sri Lanka and Australia.</p>
[7] <i>Yash Upadhyay,2020</i>	Asia journal of pharmaceutical research	Symptoms of PCOS include weight gain, acne, and irregular or absent periods, infertility, and failure to ovulate. PCOS can be diagnosed through a series of blood test	Review reveals extensively all the major reasons and causes for infertility
[8] <i>Shraboni Patra,2017</i>	Global journal of medicine	In India, the prevalence of infertility problem ever experienced by currently married women was 8.8%, of which 6.7% women had ever experienced primary infertility and 2.1% women had ever experienced secondary infertility. The prevalence of currently infertile women was 4.6%	The problem of infertility is more common among women from the disadvantaged socio-economic background
[23] <i>RABIA FAROOQ et al,2020</i>	“Short Review on Polycystic Ovarian Syndrome”	Early diagnosis and treatment along with weight loss may reduce the risk of long-term complications.	India is PCOS capital of the world. PCOS management is necessary to reduce its long time complications.
[4] <i>Nitin et la</i>	“Study on the proportion and determinants of polycystic ovarian syndrome among health sciences students in South India”	This study was done to assess the proportion of university students with PCOS and to study its risk factors	<p>Of the 480 participants, 39 (8.1%) were already diagnosed with PCOS. Out of the remaining 441 participants, 40 (9.1%) were at high risk, and 401 (90.9%) were at low risk for PCOS.</p> <p>Data were collected from students of a private medical, dental, and nursing college using a self-administered questionnaire.</p>

Table 3:PCOS Infertility and Environmental factors

Ref No.	Identified factors	Features
[30]	The industrialized food system has been recognized as a major contributor to the introduction of toxic chemicals into the environment that may influence reproductive health	food sources such as starchbased and dairy foods have been found to promote exaggerated insulinogenic responses in women with PCOS
[1]	The Grading of Recommendations, Assessment, Development, and Evaluation (GRADE) framework used for feature selection	Irregular Menstrual cycle,age,pelvictest,Antimullerienharmone

[31]	Human polycystic ovary syndrome (PCOS) is a highly heritable disease regulated by genetic and environmental factors.	Systematic analysis os properties of human PCOS genes,protein intake
[32]	PCOS is significant and diverse clinical implications	life stage, genotype, ethnicity , lifestyle and bodyweight,obesity,menstrual disorder
[33]	Purpose of review Polycystic ovary syndrome (PCOS) is often difficult to diagnose in adolescents	based on clinical and biochemical signs of hyperandrogenism and presentation with irregular menses.

Machine learning Techniques in PCOS detection

The application of machine learning (ML) is being explored since many years for solving complex problems and automating the predictive tasks. It is being observed that PCOS detection using ML approaches has received less attention from the researchers from the viewpoint of computational task. A user desired key word (PCOS + machine learning) is used for the data extraction for conducting review of literature from various digital library. It is found the PCOS detection becomes an active research area in the recent years. However, it has been analyzed that there is total 33 research paper published on IEEE digital library to date. Among 32 are conference and only 1 research paper belongs to journal. Therefore, the proposed work considers springer, science direct, and some other useful sources to extract data for the review of literature.

A recent work carried out by Thakre et al. [11] in the context of PCOS detection using ML have implemented 5 supervised classifiers. This study uses clinical dataset available on Kaggle which consists of 45 raw features. The authors have applied chi-square technique for the selection of optimal features which further leads to generate 30 top features significant to PCOS. The comparative analysis shows effectiveness of random forest (RF) classifier with accuracy rate 90.9% compared to other classifiers such as logistic regression, K-neighbor classifier, linear and radial support vector classifier (SVC). However, feature selection is limited, needs more optimization concerning higher prediction accuracy and less time complexity.

Another work in the same line of research is carried out by the authors in the study of Mehr and Polat [12]. This study also has considered Kaggle clinical PCOS dataset which were introduced to ML classifiers. The features were reduced to 33, 30 and 28 by applying pearson method, sequential backward and RF embedded method respectively. The study has implemented three classifiers such as RF, extra tree and Adaboost. The study outcomes show RF has achieved good performance concerning prediction accuracy (98%) and feature optimization (28) when compared to other classifiers. Although, this study lacks novelty part since the implementation is done on the existing baseline approaches and no customization is done in the design principle of the classifier or feature engineering task. The study opens a scope for the feature optimization.

Silva et al. [23], evaluated the effectiveness of different classifiers such as SVM, RF, LR and gaussian naive bias on

PCOS Kaggle dataset. The outcome reveals that RF could surpass other classifiers by achieving the accuracy and precision rate of 95% and 96% respectively. Similarly, the work of Munjal et al. [24] implemented three ML techniques such as extratrees, RF and decision tree (DT) and genetic algorithms (GA) for the feature optimization. The implemented model is evaluated on Kaggle PCOS dataset with 9 optimal features. The comparative analysis demonstrated better performance has been achieved by extra trees with accuracy rate 88%. Another work on Kaggle PCOS dataset is done by Bharati et al. [21]. In this study the authors have applied univariate feature selection mechanism to optimize the input feature vector. Moreover, gradient boosting, RF, LR and a combined approach of RF and LR is presented to predict PCOS with ten optimal features. The performance assessment and outcome declare that combination of RF and LR is better than the other classifiers with accuracy and recall rate of 91.01% and 90% respectively.

The above discussed literatures are the similar to the proposed context. There are other research works presented by researchers in the context of PCOS detection considering different dataset. The study of Xie et al. [16] have presented a ML model by combining RF and artificial neural network (ANN) for the PCOS detection using to gene biomarkers. The presented model was evaluated on Gene Expression Omnibus database. The study outcome shows that proposed model has achieved AUC of 0.7273 and 0.6488 in microarray and RNA-seq dataset respectively. Guleken et al. [17] have attempted to detect PCOS using raman spectroscopy and multivariate analysis. The work of Katarya et al. [18] presented automated diagnostic system PCOS detection on clinical data using ML technique. The authors have implemented swarm optimization technique for the Feature optimization. The study outcome exhibits 90.74% accuracy achieved by the presented system.

Eliyani et al. [19] computational model for the detection of follicles of form medical image. This study has performed pre-processing, speckle noise reduction, follicular segmentation, feature extraction, feature selection, and calculate the diameter of number follicles. Gopalakrishnan and Iyapparaja [20] introduced automated PCOS classification system from the ultrasound images. Gaussian low pass filter, is applied for image enhancement and multilevel thresholding is used for the segmentation. The result shows RF has achieved higher accuracy 91% compared to the other ML classifiers. The study of Denny et al. [20] applied principal component analysis (PCA) for feature optimization. The result shows the superiority of RF with PCA with 89.02% accuracy compared to the other ML classifiers. Prapty and Shitu [25] applied DT to select top features related to PCOS. The authors have also applied RF, SVM, NB and KNN to predict PCOS. The results

shows effectiveness RF that it outperform other ML classifiers with accuracy score of 93.5%.

Issue with existing literature being reviewed

Based on the review analysis on the existing literature, it has been identified that most of the studies are carried out in the similar manner or context. Most of them have focused on accuracy rather concentrating on the computational complexity

Also, there are few significant work on the feature optimization towards reducing computational complexity and enhancing perception performance. However, such approaches are limited to specific model design and feature optimization technique. They considered single feature selection technique which can not address the problem associated with both categorical and numerical feature in the dataset.

Proposed Road Map for Research

The research is intended to help the therapists in order to diagnose the PCOS in early stage. The results physical examination of the patient gives the hormone levels. These hormone levels may vary due to various reasons. The proposed road map as shown in Figure4 can accurately predict the pattern behind it and inform the therapist whether the cause of imbalance is PCOS or not

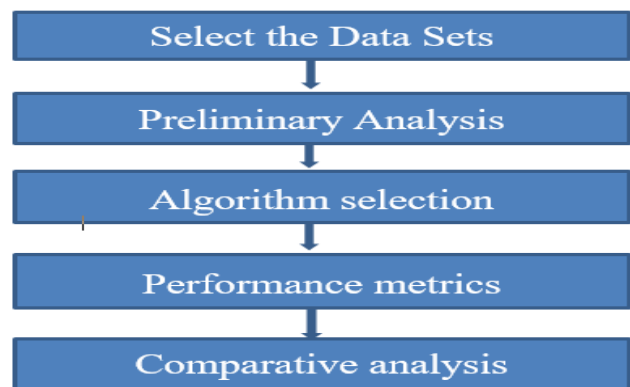


Figure 4: Road Map for Research

V. Conclusion

PCOS is a complicated reproductive, metabolic, and psychological illness with a wide range of clinical indications and is one of the leading causes of infertility. A serious health problem in women that affects fertility and leads to fatal health conditions is polycystic ovarian syndrome (PCOS). Hence, early diagnosis of PCOS is effective in the treatment process. Currently, existing methods and treatments do not provide adequate early detection or prediction of PCOS. The scholar needs to identify unique approach of learning model with feature optimization process to assist with the early detection and prediction of PCOS treatment to overcome this issue using a clinical dataset.

REFERENCES

- [1] Peña AS, Witchel SF, Hoeger KM, Oberfeld SE, Vogiatzi MG, Misso M, Garad R, Dabadghao P, Teede H. Adolescent polycystic ovary syndrome according to the international evidence-based guideline. *BMC Med.* 2020;18(72).
- [2] Ajmal N, Khan SZ, Shaikh R. Polycystic Ovary Syndrome (PCOS) and genetic predisposition: A review article. *Eur J Obstet Gynecol Reprod Biol.* 2019;3: 100060. <https://doi.org/10.1186/s12916-020-01516-x>.
- [3] Soucie K, Samardzic T, Schramer K, Ly C, Katzman R. The diagnostic experiences of women with Polycystic Ovary Syndrome (PCOS) in Ontario, Canada. *Qual Health Res.* 2021;31(3):523–34.
- [4] Nithin. et la, adhitya, divya roy, vishaka patel. © 2016 Journal of Natural Science, Biology and Medicine | Published by Wolters Kluwer - Medknow
- [4] Zhu T, Cui J, Goodarzi MO. Polycystic ovary syndrome and risk of type 2 diabetes, coronary heart disease, and stroke. *Diabetes.* 2021;70(2):627–37. <https://doi.org/10.2337/db20-0800>.
- [5] Prasanth S, Thanka MR, Edwin ER, Ebenezer V. Prognostication of diabetes diagnosis based on diferent machine learning classification algorithms. *Annals of R.S.C.B.* 2021;25(5):372–95. ISSN:1583–6258.
- [6] Smadja NP, Rawson TM, Ahmad R, Buchard A, Georgiou P, Lescure FX, Birgand G, Holmes AH. Machine learning for clinical decision support in infectious diseases: A narrative review of current applications. *Clin Microbiol Infect.* 2020;26(5):584–95. <https://doi.org/10.1016/j.cmi.2019.09.009>.

- [7] Omar KS, Mondal P, Khan NS, Rizvi RK, Islam N. A machine learning approach to predict autism spectrum disorder. In: The International Conference on Electrical, Computer and Communication Engineering (ECCE). IEEE, Cox's Bazar, Bangladesh. 2019. <https://doi.org/10.1109/ECACE.2019.8679454>. 8.
- [8] Raghavendra S, Santosh KJ. Performance evaluation of random forest with feature selection methods in prediction of diabetes. *Int J Elect Comput Eng (IJECE)*. 2019;10(1):353–9. <https://doi.org/10.11591/ijece.v10i1.pp353-359>.
- [9] Wissel T, Pfeifer T, Frysch R, Knight RT, Chang EF, Hinrichs H, Rieger JW, Rose G. Hidden Markov model and support vector machine based decoding of finger movements using electrocorticography. *J Neural Eng*. 2013;10(5): 056020. <https://doi.org/10.1088/1741-2560/10/5/056020>.
- [10] Mathur P, Kakwani K, Diplav, Kudavelly S, Ramaraju GA. Deep learning based quantification of ovary and follicles using 3D transvaginal ultrasound in assisted reproduction. In: The 42nd Annual International Conference of the IEEE Engineering in Medicine & Biology Society (EMBC), Montreal, QC, Canada. 2020. <https://doi.org/10.1109/EMBC44109.2020.9176703>.
- [11] Vedpathak, Shreyas & Thakre, Vaidehi. (2020). PCOcare: PCOS Detection and Prediction using Machine Learning Algorithms. *Bioscience Biotechnology Research Communications*. 13. 240-244. [10.21786/bbrc/13.14/56](https://doi.org/10.21786/bbrc/13.14/56).
- [12] Danaei Mehr, H. and Polat, H., 2022. Diagnosis of polycystic ovary syndrome through different machine learning and feature selection techniques. *Health and Technology*, 12(1), pp.137-150.
- [13] Neto C, Silva M, Fernandes M, Ferreira D, Machado J. Prediction models for Polycystic Ovary Syndrome using data mining. In: Antipova T. (eds) *Advances in Digital Science. ICADS 2021. Adv Intell Syst Comput*. 2021;1352. https://doi.org/10.1007/978-3-030-71782-7_19.
- [14] Munjal A, Khandia R, Gautam B. A machine learning approach for selection of polycystic ovarian syndrome (PCOS) attributes and comparing different classifier performance with the help of WEKA and PyCaret. *Int J Sci Res*. 2020;59–63. <https://doi.org/10.36106/ijsr>.
- [15] Bharati S, Podder P, Mondal MRH. Diagnosis of polycystic ovary syndrome using machine learning algorithms. In: The Proceeding of IEEE Region 10 Symposium (TENSYP). IEEE, Dhaka, Bangladesh. 2020.
- [16] Xie, N.N., Wang, F.F., Zhou, J., Liu, C. and Qu, F., 2020. Establishment and analysis of a combined diagnostic model of polycystic ovary syndrome with random forest and artificial neural network. *BioMed Research International*, 2020.
- [17] Guleken, Z., Bulut, H., Bulut, B., Paja, W., Orzechowska, B., Parlinska-Wojtan, M. and Depciuch, J., 2022. Identification of polycystic ovary syndrome from blood serum using hormone levels via Raman spectroscopy and multivariate analysis. *Spectrochimica Acta Part A: Molecular and Biomolecular Spectroscopy*, p.121029.
- [18] Katarya R., Jindal A., Duggal A., Shah A. (2021) A Novel Polycystic Ovarian Syndrome Diagnostic System Using Machine Learning. In: Abraham A., Castillo O., Virmani D. (eds) *Proceedings of 3rd International Conference on Computing Informatics and Networks. Lecture Notes in Networks and Systems*, vol 167. Springer, Singapore.
- [19] Eliyani, Hartati S., Musdholifah A. (2019) Machine Learning Assisted Medical Diagnosis for Segmentation of Follicle in Ovary Ultrasound. In: Berry M., Yap B., Mohamed A., Köppen M. (eds) *Soft Computing in Data Science. SCDS 2019. Communications in Computer and Information Science*, vol 1100. Springer, Singapore.
- [20] Gopalakrishnan, C., Iyapparaja, M. Multilevel thresholding based follicle detection and classification of polycystic ovary syndrome from the ultrasound images using machine learning. *Int J Syst Assur Eng Manag* (2021).
- [21] Palvi soni..Review of Polycystic Ovary Syndrome Along with Data Mining (IJSRD/Vol. 6/Issue 04/2018/363)
- [22] Prapty AS, Shitu TT. An efficient decision tree establishment and performance analysis with different machine learning approaches on Polycystic Ovary Syndrome. In: The 23rd International Conference on Computer and Information Technology (ICCIT). DHAKA, Bangladesh. 2020.
- [23] Rabia farooq.2018.Short Review on Polycystic Ovarian Syndrome. *J Medicine* 2018; 19: 49-53
- [24] Preeti Chauhan,pooja patil,neha Rane,Dr.pooja Raundle,Harshil kanakia.Comparative Analysis of Machine Learning Algorithms for Prediction of PCOS.2021 *International Conference on Communication information and Computing Technology (ICCICT) | 978-1-6654-0430-3/21/\$31.00 ©2021 IEEE | DOI: 10.1109/ICCICT50803.2021.9510101*
- [25] A. Denny, A. Raj, A. Ashok, C. M. Ram and R. George, "i-HOPE: Detection And Prediction System For Polycystic Ovary Syndrome (PCOS) Using Machine Learning Techniques," *TENCON 2019 - 2019 IEEE Region 10 Conference (TENCON)*, 2019, pp. 673-678
- [26] Gill, et al.: Prevalence of polycystic ovary syndrome. *Indian Journal of Endocrinology and Metabolism / Vol 16 /*
- [27] R. Vidya Bharathi et al., An epidemiological survey: Effect of predisposing factors for PCOS in Indian urban and rural population, *Middle East Fertil Soc J* (2017), <http://dx.doi.org/10.1016/j.mefs.2017.05.007>
- [28] Amsy Denny, Anita Raj, Ashi Ashok, Maneesh Ram C, Remya George. i-HOPE: Detection And Prediction System For Polycystic Ovary Syndrome (PCOS) Using Machine Learning Techniques, 78-1-7281-1895-6/19/\$31.00 c 2019 IEEE.
- [29] Zhu T, Cui J, Goodarzi MO. Polycystic ovary syndrome and risk of type 2 diabetes, coronary heart disease, and stroke. *Diabetes*. 2021;70(2):627–37. <https://doi.org/10.2337/db20-0800>.
- [30] Sharon Stein, Fertility and Sterility® Vol. 106, No. 1, July 2016 0015-0282/\$36.00 Copyright ©2016 American Society for Reproductive Medicine, Published by Elsevier Inc. <http://dx.doi.org/10.1016/j.fertnstert.2016.05.011>
- [31] Xing-Zhong Zhang¹, Yan-Li Pang³, XianWang¹ & Yan-Hui Li², Computational characterization and identification of human polycystic ovary syndrome genes. *SClenTfHC RePOrS* (2018) 8:12949 | DOI:10.1038/s41598-018-31110-4
- [32] H Teede^{1,2}, A Deeks¹ and L Moran. Review Polycystic ovary syndrome: a complex condition with psychological, reproductive and metabolic manifestations that impacts on health across the lifespan. *BMC Medicine* 2010, 8:41 <http://www.biomedcentral.com/1741-7015/8/41>
- [33] Selma F. Witchela, Anne Claire Burghardb, Rachel H. Taob, and Sharon E. Oberfieldb, The diagnosis and treatment of PCOS in adolescents: an update. *Curr Opin Pediatr* 2019, 31:562–569 DOI:10.1097/MOP.0000000000000778.

