



## Observational Study

### Early prediction of estrogen levels for post-hysterectomy menopausal syndrome using machine learning models with an Ayurveda approach- An observational study

[1\\*Kashavva V. Hiremath](#), [2Dharthy Budihal](#), [3T. U. Aravinth](#), [4S. Chithra](#), [5R. Thirumalai selvi](#)

#### ABSTRACT:

**Background:** *Ayurveda*, a primordial system of Indian medicine, recommends whole system approach for overall well-being of human kind. Incorporation of Artificial intelligence (AI) into *Ayurveda* can significantly ease and improve the diseases diagnosis, *prakruti* assessment, precision medicine and drug development. Women after undergoing hysterectomy will suffer from abrupt deficiency of estrogen hormone. This ailment results into post hysterectomy menopausal syndrome (PHMS). *Ayurveda* medicines rich in phytoestrogens have been traditionally used for managing the menopausal symptoms.

**Objectives:** Early prediction of serum estrogen levels in PHMS using machine learning models. **Materials & Methods:** A randomized controlled clinical trial (RCT) evaluated the efficacy of *Shatavari* (*Asparagus racemosus*) and *Shankhapushpi* (*Convolvulus pluricaulis*) powders over a period of 45 days, in managing PHMS assessed through symptom severity, hormonal changes and quality of life. Findings suggest possible efficacy of these herbs as non-hormonal medicines in managing PHMS, as serum estrogen levels ( $p < 0.001$ ) were significantly improved by *Asparagus racemosus* (*A. racemosus*) and stable estrogen levels ( $p = 0.334$ ) were maintained by *C. pluricaulis*. Further machine learning models are evaluated for predicting serum estrogen levels based on RCT outcome and demographic data. By the application of models of regression like Ridge Regression, XGBoost, Random Forest, KNN as well as Support Vector Regression (SVR) were trained and estimated via MAE, MSE, SMSE and  $R^2$  Score. **Results:** Results have shown that SVR model attains the utmost accuracy with a  $R^2$  score of 0.79, claiming it as a potential tool for prediction of hormone levels. **Conclusion:** Early prediction appliance for serum estrogen levels were provided by models of Machine learning, thus recommending these models for the selection of individualized treatment options without any trial experiments.

**KEYWORDS:** *Ayurveda*, Artificial Intelligence (AI), Serum Estrogen, *Shatavari*, *Shankhapushpi*

RECEIVED ON:

09-05-2025

REVISED ON:

30-06-2025

ACCEPTED ON:

06-07-2025

Access This Article Online:

Quick Response Code:



Website Link:

<https://jahm.co.in>

DOI Link:

<https://doi.org/10.70066/jahm.v13i6.1919>

Corresponding Author Email:

[drkvhiremath@gmail.com](mailto:drkvhiremath@gmail.com)

CITE THIS ARTICLE AS

Kashavva V. Hiremath, Dharthy Budihal, T. U. Aravinth, S. Chithra, R. Thirumalai Selvi. Early prediction of estrogen levels for post-hysterectomy menopausal syndrome using machine learning models with an Ayurveda approach- An observational study. *J of Ayurveda and Hol Med (JAHM)*. 2025;13(6):15-24



## 1. INTRODUCTION

*Ayurveda*, traditional Indian system of medicine offers natural and comprehensive care for promotion of well-being. However recent advancements in the field of technology, such as Artificial Intelligence (AI) have acquainted innovative horizons for the *Ayurveda* practice. AI simplifies the disease diagnosis, recommends accurate treatment options, forecasts future health outcomes and estimates prognosis for chronic disease ailments.

By terminating the reproduction menopause naturally occurs as a physiological transition in women usually between the ages of 45 to 56 years. [1] This phase brings in the deterioration of ovulatory function, resulting in diminished levels of female steroid hormones such as progesterone and estrogen. [2] These hormonal variations will result into various psychosomatic symptoms like hot flashes, mood swings, night sweats, and cognitive changes and sleep disorders. [3] Together all these issues by affecting the quality of life in menopausal women disturb their overall wellbeing. [4] Although menopause is a gradual process, hysterectomy- the surgical removal of the uterus can result in abrupt fall in the estrogen levels, resulting in post-hysterectomy menopausal syndrome (PHMS). This condition presents with similar symptoms of natural menopause. Current treatment options primarily focus on hormone replacement therapy (HRT), which, however, is linked with remarkable side effects. [4]

For such issues *Ayurveda* offers rejuvenate herbs that are rich in phytoestrogens, which help balancing psychosomatic health by aiming at effective management of hormonal pathologies.

A RCT evaluated the comparative effects of *C. pluricaulis* and *A. racemosus* powders in managing post hysterectomy menopausal symptoms. *C. pluricaulis* along with its nootropic, antioxidant and anti-inflammatory properties, [5] is a herbal source for regulation of estrogenic activity. By offering natural phytoestrogens, it helps in smoother transition of menopause. Similarly, *A. racemosus* supports to handle menopausal symptoms with its phytoestrogenic effects. [6]

Modern predictive models use machine learning techniques to analyze estrogen fluctuations. [7] In this study an attempt is made to apply and compare different machine learning models to identify the best approach for predicting serum estrogen by utilizing an *Ayurveda* clinical study data set.

### Related Works

**AI in Healthcare and Ayurveda:** By transforming the healthcare system from manual to automation, AI offers accuracy, efficiency, cost effectiveness and improved patient care. [8] A review study on the application of AI in the field of medicine has highlighted the significance of transparency, replicability and involvement of stakeholders in the evolution of pertinent AI systems. [9] Blending of AI ethically with healthcare has considerably enhanced the clinical outcomes through precise disease diagnosis, patient surveillance and hospital administration. [10] Implication of AI in accomplishing the health care globally, underline its acceptance in health promotion, transformation of diagnostics, individualized treatment preferences and clinical reasoning. [11]

The same is true as well with the perspective of Ayurveda Science. "Ayurvi" an AI-powered application was designed and developed to provide personalized *Ayurvedic* care, which concluded that AI chatbots and large language models can enhance doctor-patient communication, offer quick responses to health queries, and promote the accessibility of *Ayurvedic* knowledge. [12]

#### **Application of Machine Learning Models in Estrogen prediction:**

Algorithms of machine learning such as Support Vector Machines, Random Forest and Deep Neural Networks were assessed for the prediction of Estrogen receptor (ER) binding. Though the permanence was well executed by deep learning models, Random Forest a commonly used traditional algorithm also succeeded in achieving the greater accuracy, suggested the effectiveness of simple models in the prediction of ER binding. [13]

Bayesian models of machine learning were established for predicating the estrogen receptor bioactivity and possible endocrine disturbance. These models when trained using the larger datasets, they validated stronger predictive competencies, offering a powerful tool for screening of chemicals to achieve estrogenic activity. [14]

#### **Hysterectomy induced Menopausal Syndrome:**

Rapid cessation in the estrogen level followed by Hysterectomy will result in various psychosomatic conflicts and increases the risk of developing cardiovascular diseases, sexual dysfunction, osteoporosis and cognitive decline. Personal counseling and Hormone replacement therapy (HRT)

for these patients will definitely help in reducing these risks. [15]

A previous study conducted on a group of premenopausal women, those underwent hysterectomy with preserved ovaries, have shown substantial changes in 34 % of the participants with respect to ovarian volume, blood flow and even there was surge in the menopausal symptoms. This concludes that even after preserving the ovaries, hysterectomy still can result in early menopausal symptoms through reduced ovarian function. [16]

#### **Ayurveda and Menopausal Health:**

A previous study highlighted the holistic approach of *Ayurveda* in managing menopausal symptoms through *rasayana* therapy and the use of phytoestrogens, offering a non-hormonal alternative to conventional treatments. [17] Regular practice of *bhramari pranayama*, a yogic breathing technique in menopausal women can alleviate mood swings, anxiety and sleep disturbances. [18]

*C. pluricaulis* and *A. racemosus*: Mechanism of Action  
Along with nootropic effect, chemical constituents present in *C. pluricaulis* like kaempferol, [19] sitosterols, [20] and ascorbic acid, [21] etc have demonstrated estrogenic activity through phytoestrogens present in them. These phytoestrogens can bind to the estrogen receptors present in the brain by affecting the neurotransmitters like dopamine and serotonin, in addition to enzymatic functions, which can help normalize the hypothalamic activity, [22] thereby easing both vasomotor and psychological symptoms experienced by the females as a consequence of menopause, [23] followed by hysterectomy.

*A. racemosus* aids in treating the menopausal symptoms by providing the phytoestrogens, [6] which mimic as estrogen by dwelling in the estrogen receptors to stimulate the required estrogenic activity. [24] Shatavarin I-VI and other flavonoids particularly glycosides, isoflavones, asparagine, steroidal saponinsetc present in *A. racemosus* have demonstrated anti-oxidant, adaptogenic and cardio protective activity, that benefit in dealing with the somatic symptoms like exertion, multiple joint pain and even the cardiac symptoms like heart racing, heart beat skipping symptoms in the post-menopausal women. [25]

## 2. MATERIALS AND METHODS

Five machine learning algorithms namely Random Forest, XGBoost, Ridge Regression, KNN and Support Vector Regression, SVR, underpin the AI techniques applied in the research. The models are modeled through the use of *Ayurvedic* datasets that comprise patient records, herbal treatments as well as therapeutic results. After preparing the data and refining the feature, the study assessed model efficacy by using Mean Absolute Error (MAE) and  $R^2$  Score.

### Collection of Data:

**Methodology of RCT:** Since no studies have reported the effective management of hysterectomy induced menopausal syndrome till date, a RCT study was planned and piloted between September 2023 and June 2024. The study was initiated after obtaining approval from Institutional Ethics Committee (BMK/2021/PG/RV/1) and CTRI (CTRI/2022/11/047631) registration. CONSORT guidelines were followed for reporting the study. Thirty eligible samples were randomly recruited into

two groups in the ratio of 1:1 through random number table generated from computer. Informed consent was obtained from all the participants, before they were enrolled from OPD and IPD of the Institutional hospital. 15 patients assigned in control group and 15 assigned in intervention group were treated with *Asparagus racemosus* (*A. racemosus*) powder and *C. pluricaulis* powder respectively, with a dose of 6gms twice daily after meals with lukewarm water. Treatment outcome was assessed through Menopause Rating Scale (MRS), Modified Kupperman's Index (MKI) and Menopause Specific Quality of life (MS-QoL) on 0<sup>th</sup>, 15<sup>th</sup>, 30<sup>th</sup> and 45<sup>th</sup> day, whereas Serum estrogen and Hamilton Anxiety Rating scale (HARS) on 0<sup>th</sup> and 45<sup>th</sup> day.

Normality testing for data distribution was assessed by Shapiro-Wilk test ( $p = 0.517$  for *A. racemosus* group and  $p = 0.271$  for *C. pluricaulis* group). Results were calculated statistically through Independent and Dependent t-tests. Study revealed that, serum estrogen levels ( $p < 0.001$ ) were significantly improved by *A. racemosus* and stable estrogen levels ( $p = 0.334$ ) were maintained by *C. pluricaulis*.

**Machine Learning Methodology:** As an extension to this RCT, Computer science based machine learning methods are applied and results are observed by processing the clinical dataset (outcome of the RCT) with demographic features using the target variable as serum estrogen (pg/ml).

The data underwent preprocessing, including missing value handling, outlier removal (top 5% values removed), categorical encoding, feature scaling, and dimensionality reduction using Principal Component Analysis (PCA). Size of the dataset contained total of

33 rows and 122 columns (Sample data set is shown in Image No. 1).

The entire dataset was put into 80% for training the model and 20% for validating it. Also, 5-fold cross-

validation was carried out to check accuracy and to avoid over fitting. SVR applied RBF kernels to deal with nonlinear relationships, but the other models are optimized its parameters as usual.

Subject No.	Patient Identifier no.	Pt Initials	Group	Age in years	Gender	Religion	OPD No	Date of enrollment	Address	Educational status: (1) Below 10th (2)	Present Occupation	Socio-economic status: Upper Class	Marital status: Married (1), (1), R	Habitat (1), R			
1	KLE230020745	GM	A	47	Female	Hindu	OP230044334	05.09.23	Sambra, Belagavi	12th	2	House wife	Middle class	2	Married	1	Rural
2	KLE230021818	RSK	B	50	Female	Hindu	OP230044774	05.09.23	une Belagavi, Belagavi	10th	2	worker	Lower	3	Married	1	Urban
3	KLE210009069	AZ	A	44	Female	Hindu	OP230044776	05.09.23	nagar, Vadagoan, Be	Graduate	3	Lab technician	Middle class	2	Married	1	Urban
4	KLE230021938	PAD	B	37	Female	Hindu	OP230045010	06.09.23	naka Das Nagar, Bela	7th std	1	Home maker	Middle class	2	Married	1	Urban
5	KLE230021489	SCT	A	38	Female	Hindu	IP230004860	12.09.23	Mugalkod, Belagavi	SSLC	2	Home maker	Middle class	2	Married	1	Rural
6	KLE230024206	PPD	B	38	Female	Hindu	OP230049815	28.09.23	Bage Galli, Belagavi	NTTC	3	Teacher	Middle class	2	Married	1	Urban
7	KLE230015235	SKM	B	43	Female	Muslim	OP230057204	13.10.23	Azam Nagar, Belagavi	10th	2	Home maker	Middle class	2	Married	1	Urban
8	KLE230025967	NU	A	48	Female	Hindu	OP230053721	15.10.23	Vadagoan, Belagavi	10th	2	Home maker	Middle class	2	Married	1	Urban
9	KLE210002428	GMH	A	49	Female	Hindu	OP230053629	17.10.23	Khasbhag, Belagavi	B Sc	3	Home maker	Middle class	2	Married	1	Urban
10	KLE230031846	MMK	B	49	Female	Hindu	OP230066715	10.12.23	Uchagoan, Belagavi	4th	1	Home maker	Lower class	3	Married	1	Rural
11	KLE230031848	SGK	A	48	Female	Hindu	OP230066718	10.12.23	Uchagoan, Belagavi	5TH	1	Home maker	Middle class	2	Married	1	Rural
12	KLE230031847	NSK	B	45	Female	Hindu	OP230066717	10.12.23	Uchagoan, Belagavi	4TH	1	Home maker	Lower class	3	Married	1	Rural
13	KLE20018874	JRA	B	41	Female	Hindu	OP230066714	10.12.23	Khasbhag, Belagavi	3RD	1	worker	Lower class	3	Married	1	Urban
14	KLE20014733	AAP	A	42	Female	Hindu	OP240005280	25.01.24	Bhagya nagar, Belagavi	10th	2	delivery care	Middle class	2	Married	1	Urban
15	KLE240004390	SBK	A	40	Female	Hindu	OP240010786	20.02.24	K. K. Koppa, Belagavi	3rd	1	Farmer	Lower class	3	Married	1	Rural
16	KLE240004391	TG	B	50	Female	Hindu	OP240010787	20.02.25	K. K. Koppa, Belagavi	4TH	1	Home maker	Lower class	3	Married	1	Rural
17	KLE240004392	RSG	B	50	Female	Hindu	OP240010788	20.02.26	K. K. Koppa, Belagavi	3RD	1	Farmer	Lower class	3	Married	1	Rural
18	KLE240004393	SBT	A	38	Female	Hindu	OP2400010789	20.02.27	Halaga, Belagavi	10 std	2	Farmer	Lower class	3	Married	1	Rural
19	KLE240004394	CSK	A	49	Female	Hindu	OP240010790	20.02.28	K. K. Koppa, Belagavi	5th	1	Home maker & Fa	Lower class	3	Married	1	Rural
20	KLE240004395	KC	B	50	Female	Hindu	OP240010791	20.02.29	K. K. Koppa, Belagavi	12	2	home maker	Middle class	2	Married	1	Rural
21	KLE240008118	GSB	B	45	Female	Hindu	OP240019422	29.03.2024	Shahapur, Belagavi	Graduate	3	Home maker	Middle class	2	Married	1	Urban

Image No. 1: Showing sample data set

**Data Pre-Processing Steps:**

Step 1: Data acquisition and pre-processing (metadata stripping, column names adjustments).

Step 2: Detection and collection of important predictors such as age, group, symptoms, and levels of estrogen.

Step 3: Setting a new outcome measure to include the shifts to estrogen values.

Step 4: Categorical predictors are transformed (Group A/B → Numbers)

Step 5: Feature selection (Reduction of 121 to a set of 121 key features)

Step 6: Scaling data (Standardize numerical features)

**Key Predictors Identified** are given below, as shown in Image No. 2

- Information about personal characteristics of patients, such as, age, weight, socio economic

condition, pattern of menstrual cycle and other aspects related to their hysterectomy were registered.

- Menopausal symptom severity was assessed using the Menopausal Rating Scale (MRS) and the Modified Kupperman Index (MKI).
- Assessing the menopausal quality of life by means of the Menopausal-Specific Quality of Life (MS-QoL) questionnaire.
- Participant’s anxiety was measured with Hamilton Anxiety Rating Scale (HARS).
- Levels of serum estrogen determined by blood sampling were measured before beginning the study (Day 0) and after the completion of the intervention (Day 45).

MENOPAUSAL RATING SACLE				MODIFIED KUPPERMAN INDEX				MENOPAUSAL SPECIFIC QUALITY OF LIFE				HAMILTON ANXIETY RATING SCALE		SERUM ESTROGEN	
0TH DAY	15TH DAY	30TH DAY	45TH DAY	0TH DAY	15TH DAY	30TH DAY	45TH DAY	0TH DAY	15TH DAY	30TH DAY	45TH DAY	0TH DAY	45TH DAY	0TH DAY	45TH DAY
26	19	14	11	39	33	23	15	116	97	74	67	30	13	19.9	21.3
22	16	15	8	31	29	19	13	100	84	71	56	29	9	13.9	16.1
26	24	19	11	41	37	26	19	92	81	77	59	33	11	17.6	19.1
25	20	16	13	32	25	22	17	90	77	67	57	24	10	16.9	18.1
28	26	19	15	38	35	25	25	102	100	83	73	28	12	13.3	15.1
39	34	31	22	51	45	35	29	119	113	102	88	38	19	10.1	10.9
33	29	25	21	52	48	39	35	109	105	96	84	35	18	9.6	10.1
26	24	20	17	31	25	22	22	103	98	88	74	32	19	22	26
38	37	28	22	43	41	30	28	119	115	102	80	37	19	8.3	10.9
32	28	22	11	39	35	25	19	100	88	79	62	31	14	14.2	13.9
30	29	22	16	37	33	27	19	120	104	97	83	30	13	13.2	15.6
30	25	20	15	52	48	38	30	104	94	87	63	31	14	8.9	7.5
32	26	22	14	48	40	31	21	114	100	86	69	36	16	8.9	6.3
26	22	15	12	33	31	20	19	107	98	84	71	37	14	13.6	16.2
28	22	17	12	37	31	20	14	100	90	79	69	36	15	9.9	12.6
30	24	19	11	45	37	29	23	113	97	80	72	31	15	11.6	12.1
31	28	21	16	49	41	38	29	113	103	89	74	33	16	11.6	10.5
27	18	14	11	30	23	18	17	94	81	74	63	27	12	12.6	14.9
31	26	18	16	44	36	30	21	116	105	90	75	29	17	8.9	11.3
31	26	22	17	46	41	34	30	123	106	96	83	34	17	10.3	10.9
37	32	29	22	45	42	34	30	107	100	88	80	36	20	8.2	9.3
36	28	26	20	45	39	34	33	124	115	108	96	40	23	12.2	16.9
35	30	25	19	40	34	28	27	119	109	102	88	32	18	6.2	8.1
31	26	20	15	39	35	29	23	120	103	92	80	36	21	12.3	11.9

Image No. 2: Showing key predictors

**Machine Learning Models:** This research used the following techniques for the analysis of regression:

- **Ridge Regression:** A linear model with L2 regularization.
- **Random Forest:** An ensemble of decision trees.
- **XGBoost:** Boosted gradient learning with a focus on a design that would make computational efficiency and speed better.
- **K-Nearest Neighbors (KNN):** An approach that is self-adjusting to the structure of the distribution of the data, requiring no prior setup.
- **Support Vector Regression (SVR):** A regression method to use kernels to solve such problems.

**Evaluation Metrics:** The performance was measured on the following evaluation criteria:

- **Mean Absolute Error (MAE):** Determines the average deviation in absolute values from the results measured to the forecasted.
- **Mean Squared Error (MSE):** Calculates the mean value by squaring the difference between real and

represented values, in which greater errors result in heavier penalties.

- **Standardized Mean Squared Error (SMSE):** SMSE is a deviation from MSE where variance in the target variable is considered, hence allowing the comparison between the different datasets.
- **R<sup>2</sup> Score:** Indicates the degree of modeling the fluctuations exhibited in the target variable by the model.

### 3. RESULTS AND DISCUSSION

The literature on machine learning for estrogen prediction is considered, pointing out that past models mainly dealt with screens of chemicals and bioactivity in deep learning. In this research, standard results from *Ayurvedic* therapy are linked with the outcome of ML models used on clinical records. Because it works well in predicting effectiveness, SVR can help Ayurveda, closing one barrier between using natural treatments and personalized treatments using AI.

Both the *Ayurvedic* medications were effective in handling PHMS, with comparable results in between

the groups and within the groups both have produced significant improvement ( $p < 0.001$ ) in all the outcome measures MRS, MKI, MS-QoL and HARS. Simultaneously serum estrogen levels ( $p < 0.001$ ) were significantly improved by *A. racemosus* and stable estrogen levels ( $p = 0.334$ ) were maintained by *C. pluricaulis*.

Though the RCT involved multiple outcome measures, as the study had relatively few data due to being a small pilot, it instead put greater focus on exploration. In future, more such trials can make use of statistical studies to improve the strength of the conclusion.

ML models gave good results and both SVR and Random Forest performed better with high  $R^2$  score. The synergy between ML predictions and therapeutic

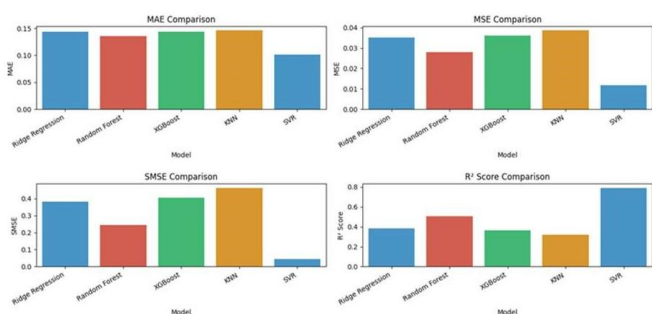
treatment in Ayurveda gives a convenient approach to individualization of patients' care, reducing the need to rely on trial-and-error in accruing optimal therapies.

MAE, MSE, SMSE, and  $R^2$  Score represent the measure of the predictive efficiency of models. Support Vector Regression was the best method and scored 0.79 of  $R^2$  Score, a robust predictive performance. (As shown in Table No. 1)

Though the  $R^2$  Score is 0.79 in this study, since 95% confidence interval (CI) ranges from 0.641 to 0.939, indicating that the model possibly explains a substantial proportion of outcome variation and still there is meaningful uncertainty, which perhaps is due to small sample size.

**Table No. 1: Showing performance metrics for various models**

Algorithm	MAE (pg/ml)	MSE (pg/ml) <sup>2</sup>	SMSE (unitless ratio)	$R^2$ Score (% of the variance)
Ridge Regression	0.1442	0.0351	0.3814	0.3824
Random Forest	0.136	0.028	0.2435	0.5065
XGBoost	0.1437	0.0361	0.4036	0.3647
KNN	0.1462	0.0359	0.4027	0.316
SVR	0.101	0.0118	0.0433	0.7919



**Fig. No. 1: Showing error and performance metrics for model assessment**

The results indicate that SVR performed the best, achieving the lowest MAE (0.101), lowest MSE (0.011),

lowest SMSE (0.043), and the highest  $R^2$  score (0.79), as shown in Fig. No.1. It is possible that the use of the Radial Basis Function (RBF) kernel in SVR could have been central to its improved ability to model complex relationships in the dataset. The Random Forest model was effective, but struggling with a generalization of its findings to more extended contexts. SVR was observed as superior for early estimation of estrogen levels in this study. Its great performance is because SVR can handle nonlinearities and is beneficial for clinical data set with 33 rows and

122 features. In situations where there are not many data points, SVR with an RBF kernel usually generalizes better than decision tree-based models do. Using SVR in Ayurveda, physicians can still accurately identify outcomes since it doesn't require extensive records. Thus the results proved that the study can include AI-assisted treatment in traditional medical settings.

#### 4. CONCLUSION

In this paper, we discussed the synergies between the *Ayurvedic* approach and the application of Machine Learning (ML) for better assessment of post hysterectomy menopausal syndrome. The *Ayurvedic* interventions *A. racemosus* demonstrated beneficial effects in improving serum estrogen levels and *C. Pluricaulis* helped in maintaining stable serum estrogen levels. Both interventions also helped in managing menopausal symptoms and anxiety over 45 days.

On the other hand, the machine learning models (Random Forest, XGBoost, Ridge Regression, KNN, SVR) applied to predict serum estrogen levels based on MRS, MKI, and HAM-A scores along with other patient attributes, provided an early prediction mechanism, enabling personalized treatment recommendations and reducing the dependency on trial-and-error methods.

This study points out that the encouraging results were obtained from a limited number of cases within an educational institution. Validity of the treatment for more cases can be checked by conducting multi-centric trials and including diverse population.

**Limitations of the study:** The small size of the data collected may have impacted the low R<sup>2</sup> value. As can

be expected, a larger dataset almost always leads to more information and better predictability, which helps model training and a more significant generalization, so the R<sup>2</sup> value can even increase.

It points out that the encouraging results come from a limited number of cases within an educational institution. Validity of a treatment for more cases can be checked by conducting multi-centric trials and including various populations.

**Scope for further study:** Future research can be aimed at augmenting the number of the patients in the dataset and introducing additional biomarkers along with confirming the ML-based predictions in real-world clinical settings to combine Ayurveda with modern healthcare more comfortably.

#### Abbreviations:

XGBoost (eXtreme Gradient Boosting)

KNN (K-Nearest Neighbors)

SVR (Support Vector Regression)

PCA (Principal Component Analysis)

MAE (Mean Absolute Error)

MSE (Mean Squared Error)

SMSE (Standardized Mean Squared Error)

RBF (Radial Basis Function)

#### Acknowledgement:

We are thankful to Dr. Sasi Bhusan, for providing *Shankhapushpi* (*Convolvulus pluricaulis* Choisy) raw drug, to Dr. Giridhar Vedantam, Dr. Suketha Kumari, Dr. Usharani Sanu and to all study participants for their extended support throughout the study.

#### Authors details:

<sup>1\*</sup>Professor, Department of Rasayana evam Vajikarana, KLE Academy of Higher Education and Research, Deemed to be University, Shri BMK Ayurveda Mahavidyalaya, Shahpur, Belagavi, Karnataka, India – 590003

<sup>2</sup>Consultant, Ayurveda Health Care Clinic, Mohol, Solhapur, Maharashtra- 413213

<sup>3</sup>PG Scholar, Department of Rasayana evam Vajikarana, KLE Academy of Higher Education and Research, Deemed to be University, Shri BMK Ayurveda Mahavidyalaya, Shahpur, Belagavi, Karnataka, India– 590003

<sup>4</sup>Assistant Professor, PG & Research Department of Computer Science, Government Arts College (Autonomous), Nandanam, Chennai- 600035

<sup>5</sup>Associate Professor, PG & Research Department of Computer Science, Government Arts College (Autonomous), Nandanam, Chennai- 600035

#### Authors Contribution:

Conceptualization and management: Dr. KH

Data collection and literature search: Dr. DB

Writing – original draft: Dr. SC, Dr. RTS, Dr. TUA

Reviewing & editing: Dr. KH, Dr. TUA

Approval of final manuscript: All authors.

**Conflict of Interest** – The authors declare no conflicts of interest.

**Source of Funding:** The authors declare no source of Funding.

**Source of Support:** Dabur Pharmacy, Gaziabad, Uttar Pradesh, India has provided *Shankhapushpi* (*Convolvulus pluricaulis* Choisy) raw drug for the clinical study.

#### Additional Information:

Authors can order reprints (print copies) of their articles by visiting:

<https://www.akinik.com/products/2281/journal-of-ayurveda-and-holistic-medicine-jahm>

#### Publisher's Note:

Atreya Ayurveda Publications remains neutral with regard to jurisdictional claims in published maps, institutional affiliations, and territorial designations. The publisher does not take any position concerning legal status of countries, territories, or borders shown on maps or mentioned in institutional affiliations.

#### References:

1. Mangione CM, Barry MJ, Nicholson WK, Cabana M, Caughey AB, Chelmos D. *et al.* Hormone Therapy for the Primary Prevention of Chronic Conditions in Postmenopausal Persons: US Preventive Services Task Force Recommendation Statement. *JAMA*. 2022 Nov 01;328(17):1740-1746. doi: <https://doi.org/10.1001/jama.2022.18625>.
2. Davis SR, Pinkerton J, Santoro N, Simoncini T. Menopause-Biology, consequences, supportive care, and therapeutic options. *Cell*. 2023 Sep 14;186(19):4038-58. doi: <https://doi.org/10.1016/j.cell.2023.08.016>.
3. Talaulikar V. Menopause transition: Physiology and symptoms. *Best Pract Res Clin Obstet Gynaecol*. 2022 May;81:3-7. doi: <https://doi.org/10.1016/j.bpobgyn.2022.03.003> PMID: 35382992.
4. Mehta J, Kling JM, Manson JE. Risks, Benefits, and Treatment Modalities of Menopausal Hormone Therapy: Current Concepts. *Front Endocrinol (Lausanne)*. 2021 Mar 26;12:564781. doi: <https://doi.org/10.3389/fendo.2021.564781>. PMID: 33841322; PMCID: PMC8034540.
5. Balkrishna A, Thakur P, Varshney A. Phytochemical Profile, Pharmacological Attributes and Medicinal Properties of *Convolvulus prostratus* - A Cognitive Enhancer Herb for the Management of Neurodegenerative Etiologies. *Front Pharmacol*. 2020 Mar 3;11:171. doi: <https://doi.org/10.3389/fphar.2020.00171>. PMID: 32194410; PMCID: PMC7063970.
6. Gudise VS, Dasari MP, Kuricheti SSK. Efficacy and Safety of Shatavari Root Extract for the Management of Menopausal Symptoms: A Double-Blind, Multicenter, Randomized Controlled Trial. *Cureus*. 2024 Apr 8;16(4):e57879. doi: <https://doi.org/10.7759/cureus.57879>. PMID: 38725785; PMCID: PMC11079574.
7. Zorn KM, Foil DH, Lane TR, Russo DP, Hillwalker W, Feifarek DJ. *et al.* Machine Learning Models for Estrogen Receptor Bioactivity and Endocrine Disruption Prediction. *Environ Sci Technol*. 2020 Oct 6;54(19):12202-12213. doi: <https://doi.org/10.1021/acs.est.0c03982> PMID: 32857505; PMCID: PMC8194504.
8. Crossnohere NL, Elsaid M, Paskett J, Bose-Brill S, Bridges JFP. Guidelines for Artificial Intelligence in Medicine: Literature Review and Content Analysis of Frameworks. *J Med Internet Res*. 2022 Aug 25;24(8):e36823. doi: <https://doi.org/10.2196/36823>. PMID: 36006692; PMCID: PMC9459836.
9. Shiferaw KB, Roloff M, Balaur I, Welter D, Waltemath D, Zeleke AA. Guidelines and standard frameworks for artificial intelligence in medicine: a systematic review. *JAMIA Open*. 2025 Jan 3;8(1):ooae155. doi: <https://doi.org/10.1093/jamiaopen/ooae155>. PMID: 39759773; PMCID: PMC11700560.
10. Alowais, S.A., Alghamdi, S.S., Alsuhebany, N. *et al.* Revolutionizing healthcare: the role of artificial intelligence in clinical practice. *BMC medical education*. 2023 Sep 22;23(1):689. doi: <https://doi.org/10.1186/s12909-023-04698-z>.
11. Nori LP, Lohitha M, Vadapalli RR, Bonthagarala B, Nagineni SR, Kalidindi VR. Revolutionizing Healthcare: The Impact of AI on Precision Medicine. *International Journal of Pharmaceutical Investigation [Internet]*. 2025 Feb 12;15(2):334-43. doi: <https://doi.org/10.5530/ijpi.20250100>.
12. Nandihal P, Reddy BA, Sahaj G, Bhuvan AM, Reddy AS. Artificial Intelligence and Large Language Models in Disease Diagnosis and Personalized Ayurvedic Care. *Journal of Image Processing and Artificial Intelligence*. 2025 Jan 23;11(1):15-22. <https://matjournals.net/engineering/index.php/JOIPAI/article/view/1332>.

13. Russo DP, Zorn KM, Clark AM, Zhu H, Ekins S. Comparing Multiple Machine Learning Algorithms and Metrics for Estrogen Receptor Binding Prediction. *Mol Pharm*. 2018 Oct 1;15(10):4361-4370. doi: <https://doi.org/10.1021/acs.molpharmaceut.8b00546>. PMID: 30114914; PMCID: PMC6181119.
14. Zorn KM, Foil DH, Lane TR, Russo DP, Hillwalker W, Feifarek DJ. *et al*. Machine Learning Models for Estrogen Receptor Bioactivity and Endocrine Disruption Prediction. *Environ Sci Technol*. 2020 Oct 6;54(19):12202-12213. doi: <https://doi.org/10.1021/acs.est.0c03982>. Epub 2020 Sep 15. PMID: 32857505; PMCID: PMC8194504.
15. Secoşan C, Balint O, Pirtea L, Grigoraş D, Balulescu L, Ilina R. Surgically Induced Menopause-A Practical Review of Literature. *Medicina (Kaunas)*. 2019 Aug 14;55(8):482. doi: <https://doi.org/10.3390/medicina55080482>. PMID: 31416275; PMCID: PMC6722518.
16. Maiti GD, Wayzade D, Tangri MK, Gupta S, Chatterjee V. Assessment of ovarian function by clinical, hormonal and sonological parameters in post hysterectomy premenopausal women. *age*. 2018 Apr 1;1:2. doi: <https://doi.org/10.18203/2320-1770.ijrcog20181022>.
17. Kumari, M., Dixit, M., &Meena, N. K. (2021). Ayurveda and modern perspective on Rajonivrittiv.s.r. to menopause: Review based on literary study. *International Research Journal of Ayurveda & Yoga*, 4(9):1-5. doi: <https://doi.org/10.48165/>
18. Turkane CN, Jain SS. Psychological benefits of Bhramari Pranayama in Menopausal Women: A Review. *Journal of Ayurveda and Integrated Medical Sciences*. 2024;9(10):201-5. doi: <https://doi.org/10.21760/jaims.9.10.33>.
19. Amjad E, Sokouti B, Asnaashari S. A systematic review of anti-cancer roles and mechanisms of kaempferol as a natural compound. *Cancer Cell International*. 2022 Aug 20;22(1):260. doi: <https://doi.org/10.1186/s12935-022-02673-0>.
20. Correa EM, Osorio J, Osorio A, Fernandez J, Cruz W, Moya E, et al. The effect of a natural supplement containing glucosinolates,  $\beta$ -sitosterol and citrus flavonoids over menopausal symptoms in postmenopausal women. *Maturitas*. 2017 Sep 1;103:90. doi: <https://doi.org/10.1016/j.maturitas.2017.06.008>.
21. Shi L, Rath M, Niedzwiecki A. Dietary Vitamin C and Age-Induced Lipid and Hormonal Metabolic Changes in a Humanized Mouse Model Not Synthesizing Vitamin C and Producing Lipoprotein (a)[Gulo (-/-); Lp (a)+]. *Journal of Nutrition and Metabolism*. 2021;2021(1):5591697. doi: <https://doi.org/10.1155/2021/5591697>.
22. Krolick KN, Zhu Q, Shi H. Effects of Estrogens on Central Nervous System Neurotransmission: Implications for Sex Differences in Mental Disorders. *ProgMolBiolTransl Sci*. 2018;160:105-171. doi: <https://doi.org/10.1016/bs.pmbts.2018.07.008>. PMID: 30470289; PMCID: PMC6737530.
23. Hairi HA, Shuid AN, Ibrahim N', Jamal JA, Mohamed N, Mohamed IN. The Effects and Action Mechanisms of Phytoestrogens on Vasomotor Symptoms During Menopausal Transition: Thermoregulatory Mechanism. *Curr Drug Targets*. 2019;20(2):192-200. <https://doi.org/10.2174/1389450118666170816123740>. PMID: 28814228.
24. Kuwar KK, Chate VA. A Clinical Study to Assess the Efficacy of Satavari Yoga in Perimenopausal Syndrome. *Journal of Ayurveda*. 2021 Jan 1;15(1):9-13. doi: 10.4103/joa.joa\_94\_20. [https://journals.lww.com/joay/fulltext/2021/15010/a\\_clinical\\_study\\_to\\_assess\\_the\\_efficacy\\_of.3.aspx](https://journals.lww.com/joay/fulltext/2021/15010/a_clinical_study_to_assess_the_efficacy_of.3.aspx).
25. Akhtar S, Gupta AK, Naik B, Kumar V, Ranjan R, Jha AK, et al. Exploring pharmacological properties and food applications of *Asparagus racemosus* (Shatavari). *Food Chemistry Advances*. 2024 Jun 1;4:100689. doi: <https://doi.org/10.1016/j.focha.2024.100689>.