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A Review And Analysis Of The Role Of Machine Learning Techniques To Predict Health Risks Among Women During Menopause

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Abstract

Objectives: In this paper, we have analyzed the research articles published in the last decade to find the menopause stage symptoms and women health risks during midlife transition. We also discussed detailed description of the various research studies and their findings using machine learning techniques for analyzing and predicting menopause stage health risks among women.

Methods: The research papers and articles are from online libraries such as NCBI, PubMed, Google Scholar, Scopus, and Elsevier databases. The articles mainly focus on the search criteria "Health risk prediction using machine learning techniques during menopause".

Findings: The reviewed articles explained that machine learning techniques are the best technique to find menopause risk factors, and risks include heart disease, osteoporosis, cancer, and depression during the menopause stage. The menopause stage symptoms and risks diminish the quality of life based on severity. With more severity, it damages life. This review can give an idea of the menopause stage health risks. It also provides a detailed description of the various machine learning techniques suitable for analyzing and predicting it.

Novelty: The techniques and tools applied in the reviewed articles are helpful to support research scholars, especially in health risk prediction among women using machine learning techniques.

Keywords: Menopause, Health-risks, Machine Learning Techniques**.**

1. Introduction

In the current digital era, artificial intelligence-based applications play an important role in

business, medical, and scientific domains. One of the subsets of artificial intelligence techniques is the machine learning technique. Machine learning is a technique that combines a collection of scientific algorithms and statistical methods. In the medical world, disease prediction is a difficult task. It needs more clinical tests to predict the disease efficiently and correctly. Large amounts of healthcare information are available in the medical world, but they are not used to predict invisible information for successful decision-making. An effective automated system or model is needed to avoid the high cost of clinical testing. The tool or system associated with implicit instructions defined by the machine learning technique performs a specific task relying on patterns [1]. The machine learning techniques based tool or system is able to determine the early prediction of health risks among women during menopause.

"Menopause is a natural process by which a woman stops being pregnant" [2]. Menopause is the last stage of the reproductive age of a woman. The word can define all the changes a woman undergoes before or after a cycle has stopped, marking the end of the reproductive years. Menstruation ceases only if an egg is not released each month by the ovaries. This stage is the menopause stage. It is a midlife transition in a woman's life, and it will happen only after the age of forty. It is a natural part of life and not a disease or disorder. But some women face extreme menopause symptoms and may have encountered multiple risks in the postmenopausal stage [3].

Menopause symptoms include irregular menstruation, vaginal dryness, hot flashes, chills, night sweats, sleep issues, mood swings, weight gain, and metabolic slowing. Menopause symptoms differ from one person to another[4]. Heart disease, strokes, osteoporosis, cancer, depression, and other urinary incontinence may occur if extreme symptoms and risk factors are present. Treatment for severe symptoms during menopause includes hormone therapy and lifestyle changes.

Menopause women may need treatment if the symptoms are extreme or are affecting their quality of life. Hormone therapy is one of the most effective treatments for reducing or managing hot flashes, vaginal dryness, sleep disturbances, night sweats, and osteoporosis in women under sixty years of age [5]. Women in the menopause stage can reduce minor-to-moderate menopause symptoms by using natural remedies and making lifestyle changes [5].

They may follow the following steps regularly:

- Keeping fresh and staying comfortable
- Get enough sleep
- Practice relaxation techniques
- Eat a balanced diet
- Physical Exercise

This paper provides a detailed description of the various research studies and their findings using machine learning techniques for analyzing and predicting menopause stage symptoms and

health risks among women. This paper also covers various machine learning tools and tasks for solving any machine learning problems.

The remaining parts of the papers are as follows: Section 2 outlines various machine learning techniques and their tasks. Section 3 covers the steps involved in finding review articles and their results and discussions. Section 4 concludes the summary of the findings of this research article.

2. Machine Learning Techniques

2.1. Supervised Learning Technique

Supervised learning is one of the machine-learning techniques. It predicts a known output by marking such information with the correct answer. The trained data is a set of input variables (training data) and a target variable [6]. This technique has an implicit function for class label extraction from labeled trained data. Two types of supervised learning approaches are regression and classification. A regression technique finds a mathematical relationship between two variables measurements. A method for classifying data into a set of classes is classification.

2.2. Unsupervised Learning Technique

In the unsupervised machine learning algorithm, the unlabeled data is the input to find known patterns or clusters in the input dataset. This method identifies naturally occurring patterns or groupings within the data by inferring a mapping function from the unlabeled input data. These techniques utilizing unlabeled data are known as "unsupervised learning." Widely used examples of unsupervised learning techniques are clustering of data objects. It uses similarity metrics and dimensionality reduction to project high-dimensional data to lower-dimensional subsets.

2.3. Reinforcement Learning Technique

In the reinforcement learning method, the programmed computer is to map behavior to a particular decision, and thus the reward or feedback information is given. It does so by rewarding itself. With this experience, the computer itself seeks out the most rewarding activities.

There are several machine learning algorithms available. The majority of the algorithms are the categories of the above mentioned three types of machine learning techniques.

2.4. Major Tasks in Machine Learning

While solving any advanced analytical problem, the following are the most prime machine learning tasks:

2.4.1 Exploratory Data Analysis (EDA)

Exploratory data analysis is a technique to understand the data distribution and relationships between and within the data. It starts to analyze after preprocessing. Correlation analysis and Data distribution analysis are the activities of EDA.

2.4.2. Feature Engineering

Feature engineering is one of the prime activities because selecting the right features produces more realistic models and accomplishes objectives like creating simpler models, eliminating over-fitting, etc. Feature Extraction and Feature Selection plays major role in producing right features. Filter methods use their correlation with the dependent variable to evaluate the usefulness of features. Wrapper methods find the significance of feature subsets by using them to train a model. Filter and wrapper methods are combined to define the embedded method [7].

2.4.3. Training Machine Learning Models

Machine learning models are popular one to find solutions with good accuracy. A good model should always focus on building the model with desired output. The following models are mainly used to construct different models in machine learning techniques.

Regression: Most regression tasks estimate numerical values (continuous variables) [8]. In the statistical literature, the process of predicting the values of quantitative or continuous variables is called regression, and it is a research topic for many statisticians. Machine learning is often concerned with predicting real-world values using regression techniques [9]. Consider, for example, regression techniques to calculate house rental prices, product prices, stock prices, etc.

Classification: Classification tasks are all about predicting correct data labels accurately (discrete variables). Identifying whether an email is spam or harm is an accepted example. In the healthcare industry, determining whether a person is suffering from a severe disease or not is done by using classification techniques. These techniques are also applied in financial applications to determine whether a business is profitable or not.

Clustering: Clustering means grouping the data based on similarity metrics. The clustering task is to find natural groupings of data and a label for each of these groupings (clusters)[8]. Several clustering algorithms are available. Customer segmentation and product feature recognition, Document Analysis, Spam filter, Identifying Fake News are typical examples of clustering techniques.

3. Literature Review

3.1.Review Method

In NCBI, PubMed, Google Scholar, and Scopus Elsevier databases, the search of research papers with the inclusion criteria “health risk prediction using machine learning techniques during menopause" was conducted. The search goal is to find research papers published in indexed journals that address the research questions and survey the literature to examine how authors used machine learning techniques to predict menopause stage symptoms and health risks. Health threats and symptoms like hot flashes, depression, age factors, cancer, osteoporosis, and cardiovascular disease are the major threats and symptoms during menopause. The keywords are chosen based

on the inclusion criterion, which must be in the title or abstract of any paper focusing on the mentioned symptoms and health risks.

3.2.Review Results

This section outlines the research articles gathered through an online search focused on machine learning techniques using the review method. We considered only the machine learning-based papers and selected them for review. These articles follow the below order. First, we arrange traditional technique-based research articles and then advanced machine learning technique-based papers such as Support Vector Machines and neural networks papers.

3.2.1. Conventional Machine Learning Techniques

This section describes the conventional machine learning techniques applied in the articles based on the models developed with clustering techniques, regression techniques, decision trees and random forest based classification techniques.

3.2.1.1.Decision Trees and Random forest

Decision trees are a type of tree in which attributes are grouped and sorted according to their values [8]. The decision tree is primarily for solving classification and prediction problems. The decision tree's main objective is to construct a prediction model out of basic decision rules inferred from a data set. The random forest is a classification algorithm based on the ensemble learning method. It consists of a collection of decision trees. It tries to establish an uncorrelated forest of trees by bagging and boosting randomness while constructing each tree [8].

Endometrial carcinoma (EC) is common cancer among women in post menopause stage. In Wang, W et al. (2022) [10], the authors have developed a machine learning model-based diagnostic prediction model for it. This model integrates with three top machine learning methods logistic regression, gradient-boosted decision tree, and random forest using the ensemble technique. The performance of this new model is quite good. This new model produces the most accurate results for predicting EC, especially in the early stages among women.

Predicting health risk at an early stage is a prime work of each and every individual in their life. G. R. Hart et al. (2020) have performed a study with seven different machine learning algorithms on personal health data and tested them without applying invasive techniques [11]. This study has discovered that a random forest model and a neural network model have good AUCs of 0.96 and 0.91, respectively. The random forest model is 2.5 times better at identifying above-average risk women during risk analysis. The neural network model is also twice as good at identifying higher-than-average risk women. This study has proved that the models are equivalent to fifteen physicians in performance. They have considered only specific risks in their research.

Risk factor identification is another novel work for early prediction. Finding the association between the disease and risk factors is a good job. In YanjunWu et al. (2019) [12], the authors have explored and examined the correlation between endometrial cancer and menopausal age. For evaluation and data processing, they used the model of random effects and the cubic spline model.

They used the I2 algorithm to determine the heterogeneity between studies. They observed a nonlinear relationship between menopause age and endometrial cancer. Then they predicted that the positive correlation would become scientifically important when the menopause age was higher than forty-six years of age. This systematic review has recommended that the correlation be high between endometrial cancer and menopausal age. They suggested that the risk of endometrial cancer in women over forty-six years of age increased with menopausal age. They did not correlate other risk factors with endometrial cancer in their study.

Hypertension is a root cause of most diseases like cardiovascular disease, Diabetic and depression. In Sabanovic S et al. (2018) [13], the authors have used regression and decision trees are classifiers for classification with the available data from GP eHR. They gathered information on hypertensive women aged 47 to 59 years old. Their model with the regression and decision tree methods predicted that the identification of metabolic syndrome emergencies would be in the range of age 51-55 years. For menopausal women with hypertension with metabolic syndrome, the BMI threshold value would be 25.5. Finally, they proposed and discovered that cardiovascular disease prevention should focus on diabetic women and women who have many medical disorders caused by prolonged hypertension combined with anxiety and depression. They have concentrated only on hypertensive women's information in their study.

3.2.1.2.Regression Techniques

In the statistical literature, the process of predicting the values of quantitative or continuous variables is called regression, and it is a research topic for many statisticians. Machine learning is often concerned with predicting real-world values using regression techniques [14]. Different types of regression techniques are available for building models. They are linear regression, logistic regression, lasso regression, etc.

Menarche age is one of the risk factors among women. Health risk severity depends on menarche age and menopause age. In the study of Yi Zheng et al. (2020) [15], the authors focused on the associations between menarche age and cardiovascular health. The survey data comes from the National Health and Nutrition Examinations from 1999-to 2016 for their study. They have examined the associations between menarche age and cardiovascular health using weighted linear and logistic regression models. Finally, the authors concluded that women with early menarche had poor cardiovascular health, and late menarche was associated with a higher probability of achieving ideal cardiovascular health. They did not include other risk factors such as hypertension and blood pressure.

Osteoporosis disease affects men and women of all races. But white and Asian women, especially older women at post menopause, are at the highest risk. JG., Kim, D.W., Ryu, KH. et al. (2020) perform research work using the survey data of Korean women's postmenopausal data from the Korea National Health and Nutrition Review [16]. This research has constructed prediction models using various machine learning techniques such as kNN, decision tree, random forest, gradient boosting algorithm, SVM, ANN, and logistic regression. The study aims to

identify osteoporosis risks and has predicted that 613 out of 1792 patients had osteoporosis using their model. They have used multiple machine learning algorithms to predict the risk. Comparisons among algorithms are missing in their study.

Menopause age, BMI, and other risk factors affect women's physical activities. Maria P. Velez et al. (2019)[17] have developed a research work using linear regression to assess the relationship between natural menopause age and gait speed (slowness) and grip strength (weakness). They used data from the Canadian Longitudinal Study on Aging, which took place in 2012 and included people from seven different cities across Canada. They have divided natural menopause into five categories: less than 40 (premature), 40 to 44 (early), 45 to 49, 50 to 54, and more than 54 years old. They have concluded that premature menopause (40 years old) is related to slower gait speed (slowness) in Canadian women. They mentioned no association between grip strength (weakness) and age during natural menopause. They did not consider other risk factors in their study.

Health risks such as cardiac infarction, stroke, fracture, and cancer are primary risks in the post-menopause stage among women. Authors Hedlin et al. (2019) [18] have modelled and created a web-based calculator that predicts during menopause stage causes of death, health risks such as cardiac infarction, stroke, fracture at the hip, and cancer diseases. With the help of the proportional sub-distribution hazards regression model, they have modelled and developed this web-based calculator using a training dataset from three zones. They have used the C-statistic technique with the test dataset of the fourth zone to test the calculator performance and its accurate prediction.

Cardiovascular disease severity depends on menarche age and menopause age. Dongshan Zhu et al. (2019) [19] used Cox proportional hazards regression models to analyze the correlations between menopause age and cardiovascular disease event incidence among women. They collected information from women who had registered their data, such as menopause status, cardiovascular disease status, and normal menopause occurred age. After that, natural menopause age by their model is below 40 years for premature menopause, forty-forty years for early menopause, forty-five to forty-nine years for fairly early, fifty to fifty-one years for the reference category, fifty-two to fifty-four years for relatively late, and fifty-five years or older for late menopause. They have analyzed only the menopause age factor with cardiovascular disease.

3.2.1.3.Clustering Techniques

The clustering task is to find natural groupings of data and a label for each of these groupings (clusters) is the aim of clustering tasks. The existing clustering algorithms are hierarchical and partition clustering techniques [8].

The study has developed the multiple-cantered fuzzy clustering (MCFC) algorithm (2019) [20]. The medical dataset is from multiple patient groups, including peri-menopausal and postmenopausal patients with various menopausal issues. Finally, they have created a hybrid intelligent system by incorporating different algorithms. They have used Fuzzy C-means, Hard C-means, similarity-

based clustering, and the MCFC algorithm in their model. They concluded that the MCFC algorithm is the best fit.

3.2.2. Advanced Machine Learning Techniques

3.2.2.1.Support Vector Machines

In the early 1990s, Vapnik and his colleagues created the powerful algorithm Support Vector Machines (SVMs). They have proven that SVM is a powerful and efficient technique for data mining and machine learning. SVMs are efficient techniques due to the maximal margin, dual theory, and the kernel trick. Statistical learning theory and optimization techniques are the foundations of SVMs. SVMs are excellent tools for resolving issues like the "curse of dimensionality," "over-fitting," and other challenges in machine learning [21].

Osteoporosis is one of the health risks among women in post-menopause. In Ou-Yang et al. (2021) [22], the authors constructed prediction models for men and women separately with different machine learning algorithms such as an artificial neural network (ANN), support vector machine (SVM), random forest (RF), k-nearest neighbor (KNN), and logistic regression (LoR) to predict the presence of osteoporosis. These algorithms performed significantly better than the traditional Osteoporosis Self-Assessment Tool for Asians (OSTA). They have demonstrated that machine learning algorithms improve the performance of the prediction of osteoporosis.

Tae Keun Yoo et al. (2013) have done research work with the Korean postmenopausal women's survey dataset as a training dataset from the Korea National Health and Nutrition Examination (2013) [23]. The research has developed models using well-known machine learning algorithms like SVMs, Random Forests, ANN, and Logistic Regression to predict osteoporosis risk. They tested their models with the osteoporosis self-assessment tool (OST), the osteoporosis risk assessment instrument (ORAI), the simple calculated osteoporosis risk estimate (SCORE), and the osteoporosis index of risk (OSIRIS). Ultimately, they discovered that the SVM outperformed the ANN, LR, OST, ORAI, SCORE, and OSIRIS algorithms. They have concluded that SVM correctly predicted osteoporosis risk among postmenopausal women with a 76.7 per cent accuracy rate. They have not considered other risk analyses in their study.

Hot Flashes are one of the symptoms of menopause. Severe hot flashes will affect the day to day life of a woman. Thurston et al. (2011) [24] have developed a model using the SVM algorithm to improve Physiologic Hot Flash Measures. They collected information from thirty-four women between the ages of 40 and 60. The input criteria for data collection are late peri-menopausal or postmenopausal status, more than four hot flashes appearing per day, and having a uterus with both ovaries. They have analyzed both expert-labelled hot flashes and self-reported hot flashes. The application of SVMs enhanced the efficiency of hot flashes as assessed by sternal skin conductance. They concluded that these changes were statistically best compared to the standard criteria. They have considered only hot flashes as risk factors.

3.2.2.2.Artificial Neural networks

An optimization technique to find the best solution to the problem is the ANN algorithm [25]. Artificial neural networks are not simple processes; they require additional steps and deal with complex structures in large amounts of data. This technique necessitates a thorough understanding of methods and also a well-structured algorithm. ANN uses all the learning methods in its implementation process.

A metabolic syndrome is a group of symptoms that occur regularly and increase the risk of heart disease, stroke, and type 2 diabetes. Increased blood pressure, excessive blood sugar, excess body fat around the waist, and abnormal cholesterol or triglyceride levels are health risks of these disorders. Feng-Hsu Wang et al. (2020) [26] have developed a model using an artificial neural network for metabolic syndrome prediction based on socioeconomic status and lifestyle factors. The study collected data from the Taiwanese health institute from 2006 to 2014. The information is from more than 27,415 women. An over-sampling technique with ANN analysis performed well, with a good AUC value of 0.93. The prediction accuracy is improved based on sensitivity and F2 metrics. The findings help doctors make primary care decisions during metabolic syndrome disease. They have also suggested that healthcare professionals may create prevention measures in advance by forecasting the occurrence of metabolic syndrome, improving the efficiency of health promotion. They did not consider other risk factors such as chronic diseases.

Carcinoma is a type of cancer that begins in the cells that make up the skin or the tissue that lines organs like the liver and kidneys. Pergialiotis et al. (2018) [27] analyzed data from the medical records of postmenopausal women's operation specimens using traditional regression analysis, ANN, and CART analysis. In total, one hundred and seventy-two women were for analysis. They analyzed the diagnosis of carcinoma in one hundred and six women. The remaining seventy-two women had normal histology in the final study. They found that CART analysis and regression analysis have lower sensitivity and predictive accuracy, while ANN analysis tends to do better, with an overall accuracy of 85.4 per cent. They have not included other risk analyses in their study.

Severe menopausal symptoms and risk factors are the major causes of all health risks among women in menopause. Xian Li et al. (2015) [28] have focused on and proposed an artificial neural network model to predict menopausal symptoms and risk factors. Menopausal samples are from some hospitals for their studies. They listed nine possible risk factors. It includes age, educational history, work status, monthly salary, body mass index, menarche age, parity, contraceptive use, and chronic disease. The output of this model was the KMI score. They additionally compared their prediction model with statistical analysis. Finally, they have used a sensitivity study to explain the impact factors on the KMI score. This model facilitates helpful information for clinical practice. There is no specific risk analysis such as cardiovascular disease and cancer in their study.

3.3. Discussion of Review Results

We have reviewed the selected research articles using machine learning techniques to examine the best model or framework for analyzing menopause symptoms and health risks among women.

The findings support the idea that computers can exceed human doctors in several medical tasks, including women's health analysis. But still, there is a gap in building a perfect model to predict health risk and some integration techniques are needed to improve and create the best model in this area of research. Integration can have the ability to predict the level and type of risk. It depends on the volume and heterogeneity of the dataset. Machine learning techniques with soft computing integration will be most useful in the future. Soft computing is an advanced approach to building hybrid intelligent systems capable of reasoning and learning in an unpredictable and imprecise world that combines fuzzy logic, neural networks, and evolutionary computation. In the future, we have a plan to create a hybrid intelligent system for predicting menopause stage symptoms and various health risks among women.

CONCLUSION

We reviewed the articles on the symptoms and various health risks among women during menopause. We have identified regression, classification, and clustering as the most common and powerful tools in machine learning techniques. The literature review section showed that the role of machine learning techniques outperforms well in predicting health risks among women during menopause. We concluded that these techniques and tools help physicians and healthcare providers in their prime tasks. The combination of machine learning and soft computing techniques in future research is a proposal. The new model will be successful in the classification accuracy of positive factors causing various menopause stage health risks among women.

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