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Ovarian Cancer Substantial Risk Factor Analysis by Machine Learning: a Low Incoming Country Perspective

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Abstract: In this paper, ovarian cancer data were inspected to figure out the significant risk factors. According to the American Cancer Society, it is the fifth leading cause of death of women. It characterizes that in 2019, 22,530 women will be diagnosed, whereas 22,240 women were diagnosed in 2018, and 13,980 will face death in 2019, but 14,070 women were died because of ovarian cancer. For this research, 521 woman's data were collected from Hospitals of Dhaka with case group 267 and control group 254. A set of a questionnaire of 47 factors that were elicited from various researches used for data collection. Data were examined with different machine learning algorithms like using SVM, logistics regression, random forest, naïve bayes, neural network, kNN, ada boost, CN2 rule, Decision tree, Quadratic Classifier. These algorithms were compared with each other with different tools and found that Logistics Regression provides the highest accuracy of 0.933 along with the highest CA of 0.848. Data were investigated with ranker algorithms to found out the rankings between factors with the help of feature selection. Significant factors like problems during pregnancy, abortion, cervical cancer history, menopause problems, etc., were found out as significant risk factors of ovarian cancer.

Keywords: overian cancer; data mining; statistics; low incoming country; risk factors.

1. Introduction

In female reproductive organs, ovaries or the fallopian tubes were disturbed, and cells appeared beyond necessity is ovarian cancer. Ovarian cancer consists of the top stage of tumor heterogeneity along with complexity. Epithelial ovarian cancer forms mostly of ovarian cancers and is the common cause of death of women by cancer [1,2]. BRAC1 and BRAC 2 are two common genes that cause ovarian cancer, whereas family history impacts on cancer [3]. In [4], research on ovarian cancer takes place where the analysis shows the significance of the long-term raised chance for mucinous ovarian cancer and benign ovarian tumors. Inflammatory damage to the fallopian tube induced by *C. trachomatis* salpingitis and could potentially create ovarian cancer *C. trachomatis*, a sexually transmitted infection may cause ovarian cancer [5, 6].

A number of research has been taken place to preclude ovarian cancer. Plant oil β-Caryophyllene (BCP) perform cell cycle arrest and apoptosis in ovarian cancer. So it can be an anti-cancer agent [7]. Clinical trials have been implemented to cure ovarian cancer [8].

Infertility and Ovarian cancer can be interrelated with breast cancer. Early-stage of breast cancer shows few symptoms that tend to serious causes of ovarian cancer [9]. In [10] shows, The late diagnosis of ovarian cancer and related problem cause a huge impact on women. The human immune system by blockade of the PD-1/PD-L1 axis has evidenced a positively clinical trial on ovarian cancer. A cross-resistance based model which has been proposed in [11] shows that cancer cells may be bounded by HLA chemotherapy- resistance. The risk of Ovarian cancer can be decreased if it can be screened at an early stage [12]. Ovarian tumors result in ovarian cancer illustrated in [13], which shows population-based survey research. Advanced age, menopause, weight loss, large cyst diameter are some of the important factors of ovarian cancer illustrate from case-control research [14]. Hormonal facts cause ovarian cancer. A combination of 2D light scattering anisotropy cytometry with machine learning-based, a label-free cytometric technique has been developed to classify single cells from ovarian cancer [15]. Machine learning algorithm Support Vector Machine (SVM) results of both breast cancer and ovarian cancer depict the model of performance for classification tasks [16]. Different machine learning approaches have been demonstrated to predict the risk factors of ovarian cancer. Gene expression patterns of ovarian cancer can be detected by machine learning and statistical approaches [17,18]. The merge of Convolution Neural Network and Relif that are two models of machine learning has been used to classify and predict the risk factors of ovarian cancer [19].

Hormonal imbalance can cause ovarian cancer [20]. Our research on the ovarian cancer dataset takes place by machine learning approach as well as statistical approaches. The research shows that significant risk factors with their level of significance have been observed and depicted. The methodology part illustrates the initial data collection and data cleaning process, whereas the results and discussion section shows the detailed output by which we extract the risk factors of ovarian cancer.

2. Materials and Methods

The detailed materials and methods have been described as follows

2.1. Data Collection and pre-processing.

The dataset was collected from different hospitals in Dhaka, Bangladesh. A questionnaire was prepared from previous studies, and it was used for data collection. There were 47 factors in the questionnaire, and each and every individual was asked for data, and the meeting was coordinated by standard personnel in the hospital. The dataset contains case and control groups for a detailed analysis of the disease. In the dataset complete 47 factors like a problem during pregnancy, a number of children, age, age of husband, affected by Breast cancer, having an infection in the genital area, affected by cervical cancer, consume of a tentative drug as well as estrogen pill after menopause, abortion and other relevant factors were taken into account for the investigation of deadly cancer.

After data collection, the incompatible, lost, and unsorted data were filtered and cleaned before processing. This phase is easily done by WEKA(a data mining tool) and Orange(a machine learning tool), but sci-kit learn a function for cleaning and training dataset.

2.2. Data mining approach.

Important factors were elicited with the help of WEKA and Orange at the same time sci-kit learn was used for comparing the accuracy of machine learning models. Info gain, gain ratio, gini index, and chi-square test were analyzed with the help of Orange. The ranker algorithm of WEKA was used for feature selection. By these methods, the significance level among the factors is explored on the Dataset. For determining the most significant factors, chi-square, info-gain, gain-ratio, and attributes derived from evaluators and the ranking of Orange were taken into account.

2.3. Significance formulation.

Due to the increase in unnecessary epithelial cells in a carcinoma are the main reason for the development of ovarian cancer. From the analysis, a probability range and useful box plot for different factors influencing ovarian cancer can be derived. To determine an individual s affected or not, the probability range and the box plot can be used. Previously disease risk prediction and detailed analysis were made for developing a model that can accurately predict the risk of Diabetes by S. Asaduzzaman et al. [21].

3. Results and Discussion

SVM, Random Forest, Logistic regression, Adaboost, Neive Bias are some models of machine learning. These models or algorithms can predict the accuracy of the dataset on data models. Here to predict the accuracy along with precision, support, CA has been analyzed. The highest accuracy of 0.933 with an orange tool for the logistic regression model has been discovered and shown in Table 1.

Table 1. Comparison among the classifiers using machine learning algorithms.

Model	Tool	AUC	CA	F1	Precision	Recall	Specificity	Support
SVM	Orange	0.921	0.835	0.835	0.841	0.835	0.838	-
	Sklearn	0.761	-	0.76	0.77	0.76	-	126
Random Forest	Orange	0.926	0.843	0.843	0.843	0.843	0.843	-
	Sklearn	0.778	-	0.78	0.79	0.78	-	126
Logistic Regression	Orange	0.933	0.848	0.848	0.848	0.848	0.848	-
	Sklearn	0.793	-	0.79	0.79	0.79	-	126
AdaBoost	Orange	0.900	0.827	0.827	0.827	0.827	0.827	-
	Sklearn	0.762	-	0.76	0.76	0.76	-	126
Naïve Bayes	Orange	0.921	0.750	0.740	0.790	0.750	0.741	-
	Sklearn	0.785	-	0.78	0.79	0.78	-	126
Neural Network	Orange	0.912	0.814	0.814	0.814	0.814	0.813	-
	Sklearn	0.770	-	0.77	0.77	0.77	-	126
kNN	Orange	0.917	0.839	0.839	0.839	0.839	0.839	-
	Sklearn	0.761	-	0.76	0.77	0.76	-	126
CN2 rule Inducer	Orange	0.912	0.816	0.816	0.816	0.816	0.815	-
	Sklearn	-	-	-	-	-	-	-
Decision Tree	Orange	0.773	0.835	0.835	0.835	0.835	0.835	-
	Sklearn	0.754	-	0.75	0.76	0.75	-	126
Quadratic Classifier	Orange	-	-	-	-	-	-	-
	Sklearn	0.762	-	0.76	0.77	0.76	-	126

Table 2 shows the significant risk factors with their chi-square value. Here problem during pregnancy (χ^2 = 148.536) and abortion (χ^2 =118.676) shows the highest chi-square means they are the highest significance. Other factors like Have an infection in Genital Area> Menopose>afffected by cervical cancer are organized in a decreased manner in the Table. The factors with low chi-square value (χ^2) have been removed for future assessment. Take tentative

drug and knowledge about ovarian cancer, although it shows high chi-square value it is the overall feedback that we have not fully considered.

Table 2. Significant factors with the help of info gain, gain ratio, gini index and chi-square test.

Attributes	#	Info. gain	Gain ratio	Gini	χ^2
Problem during pregnancy?	2	0.408	0.414	0.250	148.636
Abortion?	2	0.355	0.355	0.225	118.676
Have infection in genital area	2	0.342	0.356	0.213	84.280
Menopose	3	0.270	0.181	0.153	47.347
Affected by cervical cancer?	2	0.264	0.308	0.160	47.090
Affected by breast cancer	2	0.251	0.278	0.157	52.243
Knowledge about ovarian cancer?	2	0.247	0.296	0.149	114.100
Take a tentative drug?	2	0.246	0.281	0.152	111.921
Cloase relative affeted by breast cancer	2	0.241	0.287	0.146	40.581
Berast cancer prior to age 40	2	0.240	0.284	0.146	41.612
Estrogen pill taking after menopose	2	0.237	0.291	0.142	110.485
Menopause after 50?	2	0.231	0.276	0.141	39.288
Ever had a hysterectomy	2	0.228	0.268	0.141	40.543
Condom/ Diaphram	2	0.221	0.274	0.134	104.769
Any birth control pill?	2	0.221	0.232	0.143	93.780
Use napkin	2	0.220	0.263	0.135	103.446
Any replacement therapy taken	2	0.214	0.249	0.134	100.124
Pregnency after 35	2	0.212	0.245	0.133	39.975
Pap test?	2	0.211	0.246	0.132	99.114
Childern after 35	2	0.208	0.237	0.131	40.476
Regular exercise?	2	0.206	0.213	0.135	85.197
Takes hormone after menopose	2	0.206	0.251	0.127	98.322
Diat maintain	2	0.200	0.238	0.125	95.336
Cancer history in the family?	2	0.197	0.215	0.127	43.440
Take adequate fruit	2	0.185	0.187	0.122	72.132
STI?	2	0.171	0.200	0.110	32.078
Food contains high fat?	2	0.113	0.151	0.071	58.026
Age	3	0.107	0.148	0.060	46.190
Menopause end age?	3	0.100	0.063	0.067	7.758
Oral contraception	2	0.099	0.163	0.059	52.634
Education	3	0.070	0.058	0.047	3.586
Age of husband	4	0.069	0.081	0.042	5.796
BMI?	3	0.061	0.085	0.039	6.488
Social class	3	0.055	0.045	0.037	1.028
Height?	3	0.013	0.016	0.009	13.957
Family members	3	0.012	0.010	0.008	0.293
Cancer vaccine taken?	2	0.007	0.031	0.005	4.727
First sex age?	2	0.005	0.005	0.003	1.736
Source of knowledge?	3	0.003	0.002	0.002	0.010
Marital status?	2	0.002	0.099	0.001	0.002
How many children?	3	0.002	0.002	0.001	0.101
Never pregnant?	2	0.001	0.005	0.001	0.701
Smoker?	2	0.001	0.004	0.000	0.441
Obese?	2	0.000	0.005	0.000	0.253
Take alcohol?	2	0.000	0.000	0.000	0.011

Table 3, Table 4, and Table 5 show the ranking output of different algorithms and attribute evaluators. In all cases problem during pregnancy, menopause problem, infection in the genital area, breast cancer history, abortion history shows the highest-ranking value. The values of ranking by the algorithm have been ordered as top-level factors show the highest significance. BMI also affects ovarian cancer; the box plot with age distribution has been shown in Figure 1. Women with BMI than 29 show the highest risk of ovarian cancer. Each factor has been crossmatched in this way.

Table 3. Data table on the significance of factors with the help of feature selection.

Classifier Attribute Eval	Correlation Attribute Eval	Gain Ratio Attribute Eval
A. Condom/ Diaphram	A. Problem during pregnancy?	A. Problem during pregnancy?

Classifier Attribute Eval	Correlation Attribute Eval	Gain Ratio Attribute Eval
B. Affected by breast cancer	B. Abortion?	B. Have an infection in the genital area
C. Family members	C. Have an infection in the genital area	C. Abortion?
D. smoker?	D. Affected By cervical cancer?	D. Affected by cervical cancer?
E. Affected by cervical cancer?	E. Affected by breast cancer	E. Knowledge about ovarian cancer?
F. Height?	F. Take a tentative drug?	F. Estrogen pill-taking after menopause
G. How many children?	G. Knowledge about ovarian cancer?	G. Close Relative affected by Breast Cancer
H. Ever had a hysterectomy	H. Breast cancer prior to age 40	H. Breast cancer prior to age 40
I. Close relative affected by breast cancer	I. Close relative affected by breast cancer	I. Take a tentative drug?
J. Breast cancer prior to age 40	J.Any birth control pill?	J. Affected by breast cancer
K. Menopause after 50?	K. Estrogen pill-taking after menopause	K. Menopause after 50?
L. Any replacement therapy taken	L. Menopause after 50?	L. Condom/ Diaphram
M. pap test?	M. Ever had a hysterectomy	M. Ever had a hysterectomy
N. Estrogen pill taking after menopause	N. Use napkin	N. Use napkin
O. Menopause	O. Regular exercise?	O. Takes hormone after menopause
P. Pregnancy after 35	P. Any replacement therapy has taken	P. Any replacement therapy has taken
Q. Children after 35	Q. Condom/ Diaphram	Q. pap test?
R. Oral Contraception	R. Pregnency after 35	R. Pregnency after 35
S. Takes hormone after menopause	S. Pap test?	S. Diet maintain
T. Social class	T. Childern after 35	T. Childern after 35
U. Use napkin	U. Cancer history in the family?	U. Any birth control pill?
V. Diet maintain	V. Takes hormone after menopause	V. Cancer history in the family?
W. STI?	W. Diat maintain	W. Regular exercise?
X. Cancer history in the family?	X. Take adequate fruit	X. STI?
Y. Education	Y. STI?	Y. Take adequate fruit
Z. Obese?	Z. Food contains high fat?	Z. Menopause
AA. BMI?	AA. Oral contraception	AA. Oral contraception
AB. Take a tentative drug?	AB. Menopause	AB. Food contains high fat?
AC. Take alcohol?	AC. BMI?	AC. Age
AD. Knowledge about ovarian cancer?	AD. Education	AD. Marital status?
AE. Age of husband	AE. Menopause end age?	AE. BMI?
AF. Source of knowledge?	AF. Age of husband	AF. Age of husband
AG. Have an infection in the genital area	AG. Social class	AG. Menopause End age?
AH. Marital status?	AH. Age	AH. Education
AI. Take adequate fruit	AI. Height?	AI. Social class
AJ. First sex age?	AJ. Cancer vaccine taken?	AJ. Cancer vaccine taken?
AK. Number of sex partners?	AK. Family members	AK. Height?
AL. Menopause end age?	AL. First sex age?	AL. Family members
AM. Never pregnant?	AM. Marital status?	AM. Never pregnant?
AN. Cancer vaccine taken?	AN. Never pregnant?	AN. First sex age?
AO. Problem during pregnancy?	AO. Smoker?	AO. Obese?
AP. Food contains high fat?	AP. Obese?	AP. Smoker?
AQ. Any birth control pill?	AQ. Source of knowledge?	AQ. Source of knowledge?
AR. Regular exercise?	AR. How many children?	AR. How many children?
AS. Abortion?	AS. Take alcohol?	AS. Take alcohol?
AT. Age	AT. Number of sex partners?	AT. Number of sex partners?

Table 4. Data table on the significance of factors with the help of feature selection.

Info Gain Attribute Eval	OneR Attribute Eval
A. Problem during pregnancy?	A. Problem during pregnancy?
B. Abortion?	B. Abortion?
C. Have infection in genital area	C. Have infection in genital area
D. Menopause	D. Affected by breast cancer
E. Affected by cervical cancer?	E. Any birth control pill?
F. Affected by breast cancer	F. Affected by cervical cancer?
G. Knowledge about ovarian cancer?	G. Regular Exercise?
H. Take a tentative drug?	H. Take a tentative drug?
I. Close relative affected by breast cancer	I. Knowledge about ovarian cancer?

Info Gain Attribute Eval	OneR Attribute Eval
J. Breast cancer prior to Age 40	J. Breast cancer prior to age 40
K. Estrogen pill taking after menopause	K. Take adequate fruit
L. Menopause after 50?	L. Close relative affected by breast cancer
M. Ever had a hysterectomy	M. Ever had a hysterectomy
N. Condom/ Diaphram	N. Cancer history in the family?
O. Any birth control pill?	O. Menopose after 50?
P. Use napkin	P. Menopause
Q. Any replacement therapy taken	Q. Pregnancy after 35
R. Pregnancy after 35	R. Children after 35
S. pap test?	S. Any replacement therapy taken
T. Children after 35	T. Estrogen pill taking after menopause
U. Regular exercise?	U. pap test?
V. Takes hormone after menopose	V. Use napkin
W. Diet maintain	W. Condom/ Diaphram
X. Cancer history in the family?	X. Diet maintain
Y. Take adequate fruit	Y. Takes Hormone after menopause
Z. STI?	Z. STI?
AA. Food contains high fat?	AA. Menopause end age?
AB. Age	AB. Education
AC. Menopause end age?	AC. Food contains high fat?
AD. Oral contraception	AD. Oral contraception
AE. Education	AE. Social class
AF. Age of husband	AF. Age
AG. BMI?	AG. Age of husband
AH. Social class	AH. BMI?
AI. Height?	AI. Height?
AJ. Family members	AJ. Family members
AK. Cancer vaccine taken?	AK. First sex age?
AL. First sex age?	AL. Cancer vaccine taken?
AM. Source of knowledge?	AM. How many children?
AN. Marital status?	AN. Smoker?
AO. How many children?	AO. Marital status?
AP. Never pregnant?	AP. Obese?
AQ. Smoker?	AQ. Number of sex partners?
AR. Obese?	AR. Take alcohol?
AS. Take alcohol?	AS. Never pregnant?
AT. Number of sex partners?	AT. Source of knowledge?

Table 5. Data table on the significance of factors with the help of feature selection.

Relief Attribute Eval	Symmetrical Uncert Attribute Eval
A. Problem during pregnancy?	A.Problem during pregnancy?
B. Have an infection in the genital area	B. Abortion?
C. Menopause end age?	C. Have infection in genital area
D. Abortion?	D. Affected by cervical cancer?
E. Family members	E. Knowledge about ovarian cancer?
F. Take a tentative drug?	F. Affected by breast cancer
G. Menopause	G. Take a tentative drug?
H. Knowledge about ovarian cancer?	H. Close relative affected by breast cancer
I. Affected by breast cancer	I. Estrogen pill taking after menopause
J. Take adequate fruit	J. Breast cancer prior to age 40
K. Pap test?	K. Menopause after 50?
L. Affected By cervical cancer?	L. Ever had a hysterectomy
M. Condom/ Diaphram	M. Condom/ Diaphram
N. Food contains high fat?	N. Use napkin
O. Estrogen pill taking after menopause	O. Any replacement therapy taken
P. Any birth control pill?	P. Pap test?
Q. Menopose after 50?	Q. Pregnancy after 35
R. Takes hormone after menopause	R. Any birth control pill?
S. Education	S. Takes hormone after menopose
T. Use napkin	T. Children after 35
U. How many children?	U. Diet maintain
V. Diet maintain	V. Menopause
W. Age of husband	W. Regular exercise?
X. Close relative affected by breast cancer	X. Cancer History in the family?
Y. Oral contraception	Y. Take adequate fruit
Z. Breast cancer prior to age 40	Z. STI?

Relief Attribute Eval	Symmetrical Uncert Attribute Eval
AA. Regular exercise?	AA. Food contains high fat?
AB. Any replacement therapy taken	AB. Age
AC. Age	AC. Oral contraception
AD. Ever had a hysterectomy	AD. Menopause end age?
AE. Social class	AE. Age of husband
AF. First sex age?	AF. BMI?
AG. STI?	AG. Education
AH. Pregnancy after 35	AH. Social class
AI. Cancer history in the family?	AI. Height?
AJ. Source of knowledge?	AJ. Cancer vaccine taken?
AK. Take alcohol?	AK. Family members
AL. Children after 35	AL. First sex age?
AM. Height?	AM. Marital status?
AN. BMI?	AN. Source of knowledge?
AO. Cancer vaccine taken?	AO. Never pregnant?
AP. Never pregnant?	AP. How many children?
AQ. Smoker?	AQ. Smoker?
AR. Obese?	AR. Obese?
AS. Marital status?	AS. Take alcohol?
AT. Number of sex partners?	AT. Number of sex partners?

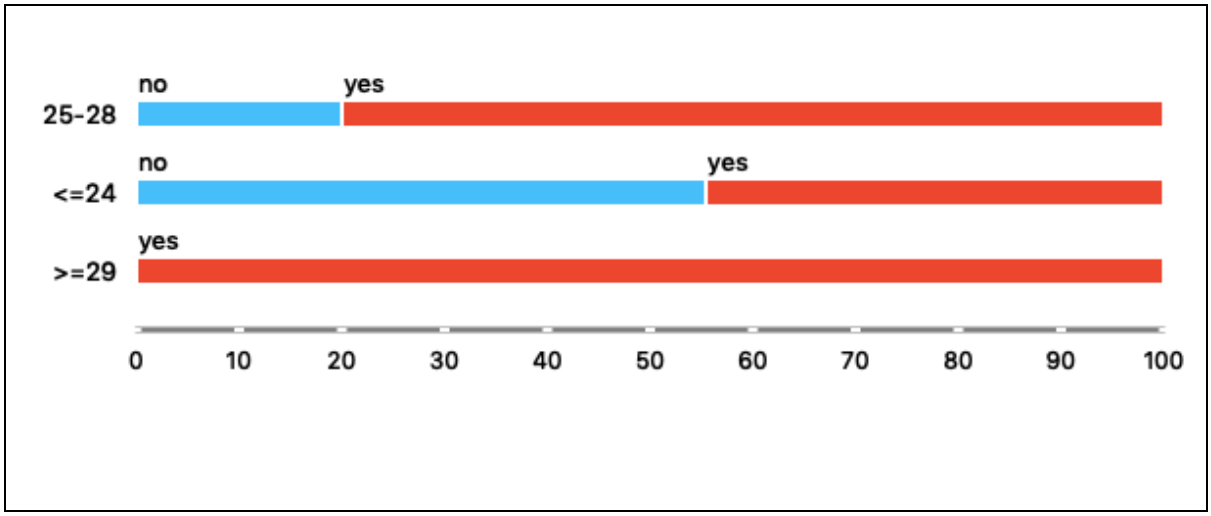

Figure 1. BMI box plot.

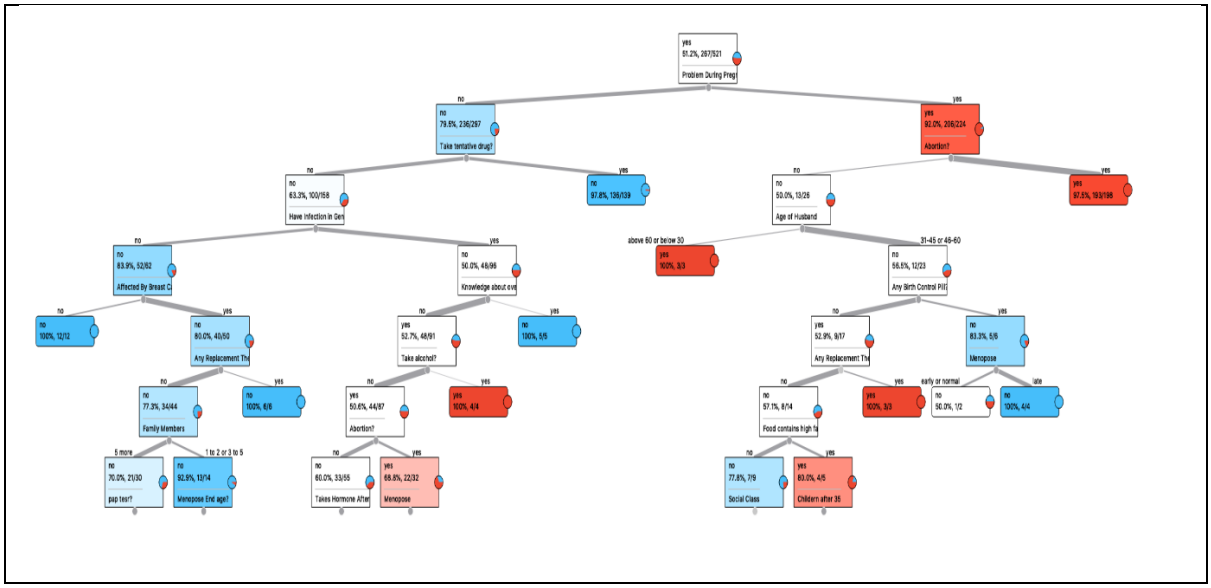

Figure 2. Decision tree among the risk factors of ovarian cancer.

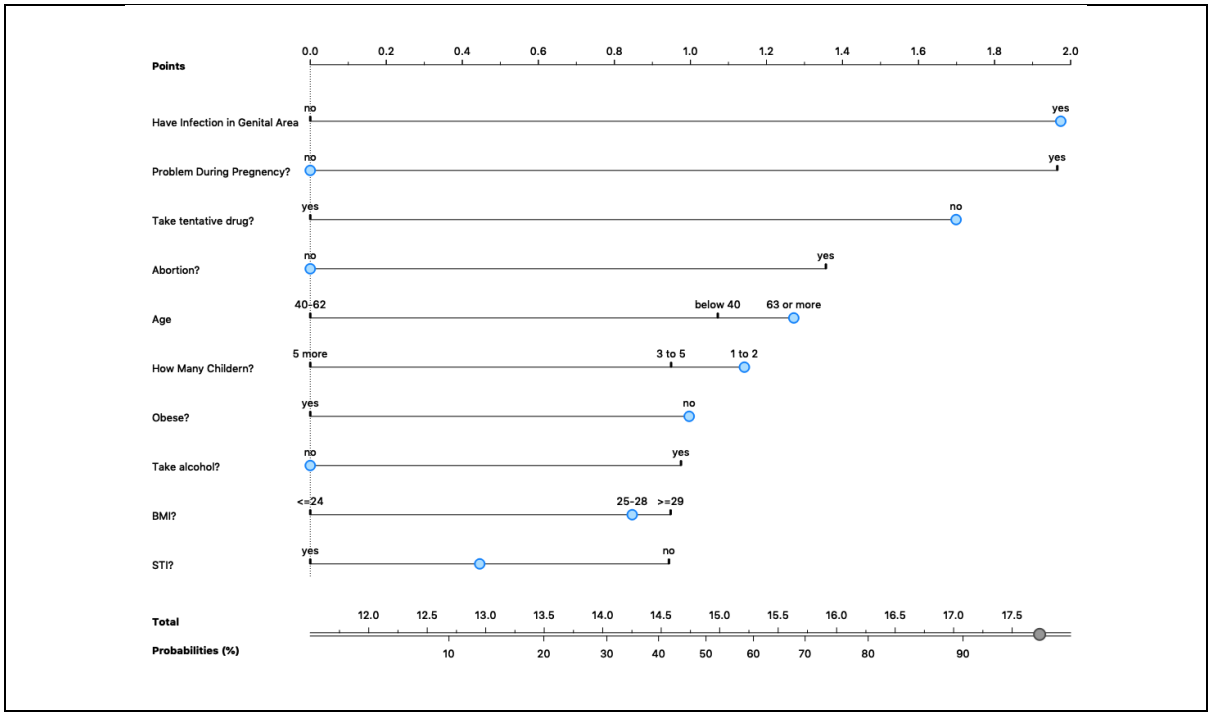

Figure 3. Probabilities distribution among the significant factors of ovarian cancer.

Figure 2 shows the decision tree of the significant risk factors of ovarian cancer where the high red portion shows the highest, light red is high, blue is medium, and white is very low risk. This tree also shows the association of the risk factors as those who have problems during pregnancy (Yes), and Abortion (Yes) has the chance of about 92% for ovarian cancer. The whole probability distribution of ovarian cancer, which shows the probability of happening ovarian cancer with the highest significant factors, has been shown in Figure 3.

4. Conclusions

Ovarian cancer is a woman's lifetime threat to die of 1 in 109. Total of 47 risk factors with 521 case and control group data of women were evoked by data mining and statistical and machine learning approach. About 30 are found to be linked with ovarian cancer, and 25 were considered as most significant factors by combining data mining and machine learning algorithms. The whole data set was analyzed by a machine learning model where 0.933 was the highest accuracy. The results show the significant factors along with their significance on ovarian cancer. Problem during pregnancy (**χ^2 = 148.686 pro=98.88%**), infection in genital area **(pro=99%)** , abortion (**χ^2 = 118 pro=74%**), children after 35, BMI, alcohol taken , replacement therapy are extensive high significant risk factors . Husband age, age level, pregnancy after 35 are also found as highly significant factors. More data with a large no of factors should be considered in the future for more appropriate research.

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Conflicts of Interest

The authors declare no conflict of interest.

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