Classification of using Logistic Regression

In [1]:
```
pip install ucimlrepo
```

```
Collecting ucimlrepo
  Downloading ucimlrepo-0.0.6-py3-none-any.whl (8.0 kB)
Installing collected packages: ucimlrepo
Successfully installed ucimlrepo-0.0.6
```

In [4]:
```
#importing libraries
import pandas as pd
from sklearn.model_selection import train_test_split
from sklearn.linear_model import LogisticRegression
from sklearn.preprocessing import StandardScaler
from sklearn.metrics import classification_report, confusion_matrix
```

In [5]:
```
from ucimlrepo import fetch_ucirepo

# fetch dataset
cervical_cancer_risk_factors = fetch_ucirepo(id=383)

# data (as pandas dataframes)
X = cervical_cancer_risk_factors.data.features
y = cervical_cancer_risk_factors.data.targets

# metadata
print(cervical_cancer_risk_factors.metadata)

# variable information
print(cervical_cancer_risk_factors.variables)
```

```
{'uci_id': 383, 'name': 'Cervical Cancer (Risk Factors)', 'repository_url': 'http
s://archive.ics.uci.edu/dataset/383/cervical+cancer+risk+factors', 'data_url': 'http
s://archive.ics.uci.edu/static/public/383/data.csv', 'abstract': 'This dataset focus
es on the prediction of indicators/diagnosis of cervical cancer. The features cover
demographic information, habits, and historic medical records.', 'area': 'Health and
Medicine', 'tasks': ['Classification'], 'characteristics': ['Multivariate'], 'num_in
stances': 858, 'num_features': 36, 'feature_types': ['Integer', 'Real'], 'demographi
cs': ['Age', 'Other'], 'target_col': None, 'index_col': None, 'has_missing_values':
'yes', 'missing_values_symbol': 'NaN', 'year_of_dataset_creation': 2017, 'last_updat
ed': 'Sun Mar 10 2024', 'dataset_doi': '10.24432/C5Z310', 'creators': ['Kelwin Ferna
ndes', 'Jaime Cardoso', 'Jessica Fernandes'], 'intro_paper': {'title': 'Transfer Lea
rning with Partial Observability Applied to Cervical Cancer Screening', 'authors':
'Kelwin Fernandes, Jaime S. Cardoso, Jessica C. Fernandes', 'published_in': 'Iberian
Conference on Pattern Recognition and Image Analysis', 'year': 2017, 'url': 'http
s://www.semanticscholar.org/paper/Transfer-Learning-with-Partial-Observability-to-Fe
rnandes-Cardoso/1c02438ba4dfa775399ba414508e9cd335b69012', 'doi': None}, 'additional
_info': {'summary': "The dataset was collected at 'Hospital Universitario de Caraca
s' in Caracas, Venezuela. The dataset comprises demographic information, habits, and
historic medical records of 858 patients. Several patients decided not to answer som
e of the questions because of privacy concerns (missing values).", 'purpose': None,
'funded_by': None, 'instances_represent': None, 'recommended_data_splits': None, 'se
nsitive_data': None, 'preprocessing_description': None, 'variable_info': '(int) Age
\r\n(int) Number of sexual partners\r\n(int) First sexual intercourse (age)\r\n(int)
Num of pregnancies\r\n(bool) Smokes\r\n(bool) Smokes (years)\r\n(bool) Smokes (pack
s/year)\r\n(bool) Hormonal Contraceptives\r\n(int) Hormonal Contraceptives (years)\r
\n(bool) IUD\r\n(int) IUD (years)\r\n(bool) STDs\r\n(int) STDs (number)\r\n(bool) ST
Ds:condylomatosis\r\n(bool) STDs:cervical condylomatosis\r\n(bool) STDs:vaginal cond
ylomatosis\r\n(bool) STDs:vulvo-perineal condylomatosis\r\n(bool) STDs:syphilis\r\n
(bool) STDs:pelvic inflammatory disease\r\n(bool) STDs:genital herpes\r\n(bool) STD
s:molluscum contagiosum\r\n(bool) STDs:AIDS\r\n(bool) STDs:HIV\r\n(bool) STDs:Hepati
tis B\r\n(bool) STDs:HPV\r\n(int) STDs: Number of diagnosis\r\n(int) STDs: Time sinc
e first diagnosis\r\n(int) STDs: Time since last diagnosis\r\n(bool) Dx:Cancer\r\n(b
ool) Dx:CIN\r\n(bool) Dx:HPV\r\n(bool) Dx\r\n(bool) Hinselmann: target variable\r\n
(bool) Schiller: target variable\r\n(bool) Cytology: target variable\r\n(bool) Biops
y: target variable', 'citation': None}}
```

```
                                  name     role        type demographic  \
0                                  Age  Feature     Integer         Age   
1            Number of sexual partners  Feature  Continuous       Other   
2             First sexual intercourse  Feature  Continuous        None   
3                   Num of pregnancies  Feature  Continuous        None   
4                               Smokes  Feature  Continuous        None   
5                       Smokes (years)  Feature  Continuous        None   
6                  Smokes (packs/year)  Feature  Continuous        None   
7              Hormonal Contraceptives  Feature  Continuous        None   
8      Hormonal Contraceptives (years)  Feature  Continuous        None   
9                                  IUD  Feature  Continuous        None   
10                         IUD (years)  Feature  Continuous        None   
11                                STDs  Feature  Continuous        None   
12                       STDs (number)  Feature  Continuous        None   
13                 STDs:condylomatosis  Feature  Continuous        None   
14        STDs:cervical condylomatosis  Feature  Continuous        None   
15         STDs:vaginal condylomatosis  Feature  Continuous        None   
16  STDs:vulvo-perineal condylomatosis  Feature  Continuous        None   
17                       STDs:syphilis  Feature  Continuous        None   
18    STDs:pelvic inflammatory disease  Feature  Continuous        None   
19                STDs:genital herpes  Feature  Continuous        None   
```

```
20          STDs:molluscum contagiosum  Feature  Continuous        None
21                           STDs:AIDS  Feature  Continuous        None
22                            STDs:HIV  Feature  Continuous        None
23                    STDs:Hepatitis B  Feature  Continuous        None
24                            STDs:HPV  Feature  Continuous        None
25           STDs: Number of diagnosis  Feature     Integer        None
26     STDs: Time since first diagnosis  Feature  Continuous        None
27      STDs: Time since last diagnosis  Feature  Continuous        None
28                           Dx:Cancer  Feature     Integer        None
29                              Dx:CIN  Feature     Integer        None
30                              Dx:HPV  Feature     Integer        None
31                                  Dx  Feature     Integer        None
32                          Hinselmann  Feature     Integer        None
33                            Schiller  Feature     Integer        None
34                            Citology  Feature     Integer        None
35                              Biopsy  Feature     Integer        None

   description units missing_values
0         None  None             no
1         None  None            yes
2         None  None            yes
3         None  None            yes
4         None  None            yes
5         None  None            yes
6         None  None            yes
7         None  None            yes
8         None  None            yes
9         None  None            yes
10        None  None            yes
11        None  None            yes
12        None  None            yes
13        None  None            yes
14        None  None            yes
15        None  None            yes
16        None  None            yes
17        None  None            yes
18        None  None            yes
19        None  None            yes
20        None  None            yes
21        None  None            yes
22        None  None            yes
23        None  None            yes
24        None  None            yes
25        None  None             no
26        None  None            yes
27        None  None            yes
28        None  None             no
29        None  None             no
30        None  None             no
31        None  None             no
32        None  None             no
33        None  None             no
34        None  None             no
35        None  None             no
```

Data Exploration

In [7]:
```
X.shape
```

Out[7]:
```
(858, 36)
```

In [8]:
```
X.head()
```

Out[8]:

	Age	Number of sexual partners	First sexual intercourse	Num of pregnancies	Smokes	Smokes (years)	Smokes (packs/year)	Hormonal Contraceptives
0	18	4.0	15.0	1.0	0.0	0.0	0.0	0.0
1	15	1.0	14.0	1.0	0.0	0.0	0.0	0.0
2	34	1.0	NaN	1.0	0.0	0.0	0.0	0.0
3	52	5.0	16.0	4.0	1.0	37.0	37.0	1.0
4	46	3.0	21.0	4.0	0.0	0.0	0.0	1.0

5 rows × 36 columns

In [9]:
```
X.describe()
```

Out[9]:

	Age	Number of sexual partners	First sexual intercourse	Num of pregnancies	Smokes	Smokes (years)	Smok (packs/ye
count	858.000000	832.000000	851.000000	802.000000	845.000000	845.000000	845.0000
mean	26.820513	2.527644	16.995300	2.275561	0.145562	1.219721	0.4531
std	8.497948	1.667760	2.803355	1.447414	0.352876	4.089017	2.2266
min	13.000000	1.000000	10.000000	0.000000	0.000000	0.000000	0.0000
25%	20.000000	2.000000	15.000000	1.000000	0.000000	0.000000	0.0000
50%	25.000000	2.000000	17.000000	2.000000	0.000000	0.000000	0.0000
75%	32.000000	3.000000	18.000000	3.000000	0.000000	0.000000	0.0000
max	84.000000	28.000000	32.000000	11.000000	1.000000	37.000000	37.0000

8 rows × 36 columns

```
In [10]: #checks missing values
         X.isnull().sum().sum()

Out[10]: 3622

In [11]: #checking categorical values
         col_names = X.columns

In [12]: col_names

Out[12]: Index(['Age', 'Number of sexual partners', 'First sexual intercourse',
                'Num of pregnancies', 'Smokes', 'Smokes (years)', 'Smokes (packs/year)',
                'Hormonal Contraceptives', 'Hormonal Contraceptives (years)', 'IUD',
                'IUD (years)', 'STDs', 'STDs (number)', 'STDs:condylomatosis',
                'STDs:cervical condylomatosis', 'STDs:vaginal condylomatosis',
                'STDs:vulvo-perineal condylomatosis', 'STDs:syphilis',
                'STDs:pelvic inflammatory disease', 'STDs:genital herpes',
                'STDs:molluscum contagiosum', 'STDs:AIDS', 'STDs:HIV',
                'STDs:Hepatitis B', 'STDs:HPV', 'STDs: Number of diagnosis',
                'STDs: Time since first diagnosis', 'STDs: Time since last diagnosis',
                'Dx:Cancer', 'Dx:CIN', 'Dx:HPV', 'Dx', 'Hinselmann', 'Schiller',
                'Citology', 'Biopsy'],
               dtype='object')

In [13]: X.dtypes
```

Out[13]:
```
Age                                     int64
Number of sexual partners             float64
First sexual intercourse              float64
Num of pregnancies                    float64
Smokes                                float64
Smokes (years)                        float64
Smokes (packs/year)                   float64
Hormonal Contraceptives               float64
Hormonal Contraceptives (years)       float64
IUD                                   float64
IUD (years)                           float64
STDs                                  float64
STDs (number)                         float64
STDs:condylomatosis                   float64
STDs:cervical condylomatosis          float64
STDs:vaginal condylomatosis           float64
STDs:vulvo-perineal condylomatosis    float64
STDs:syphilis                         float64
STDs:pelvic inflammatory disease      float64
STDs:genital herpes                   float64
STDs:molluscum contagiosum            float64
STDs:AIDS                             float64
STDs:HIV                              float64
STDs:Hepatitis B                      float64
STDs:HPV                              float64
STDs: Number of diagnosis               int64
STDs: Time since first diagnosis      float64
STDs: Time since last diagnosis       float64
Dx:Cancer                               int64
Dx:CIN                                  int64
Dx:HPV                                  int64
Dx                                      int64
Hinselmann                              int64
Schiller                                int64
Citology                                int64
Biopsy                                  int64
dtype: object
```

In [15]:
```python
categorical_checker = X.select_dtypes(include=['object']).columns.tolist()
```

In [16]:
```python
if len(categorical_checker) > 0:
    print("Categorical columns:")
    print(categorical_checker)
else:
    print("No categorical columns found in X.")
```

```
No categorical columns found in X.
```

No Categorical Values so Move on to Numerical Variables

Explore Numerical values

In [17]:
```python
df_X = pd.DataFrame(X)
```

In [18]:
```python
numerical = [var for var in df_X.columns if df_X[var].dtype != 'object']
```

In [19]:
```python
print('There are {} numerical variables\n'.format(len(numerical)))
print('Numerical variables are: ', numerical)
```

```
There are 36 numerical variables

Numerical variables are:  ['Age', 'Number of sexual partners', 'First sexual interco
urse', 'Num of pregnancies', 'Smokes', 'Smokes (years)', 'Smokes (packs/year)', 'Hor
monal Contraceptives', 'Hormonal Contraceptives (years)', 'IUD', 'IUD (years)', 'STD
s', 'STDs (number)', 'STDs:condylomatosis', 'STDs:cervical condylomatosis', 'STDs:va
ginal condylomatosis', 'STDs:vulvo-perineal condylomatosis', 'STDs:syphilis', 'STDs:
pelvic inflammatory disease', 'STDs:genital herpes', 'STDs:molluscum contagiosum',
'STDs:AIDS', 'STDs:HIV', 'STDs:Hepatitis B', 'STDs:HPV', 'STDs: Number of diagnosi
s', 'STDs: Time since first diagnosis', 'STDs: Time since last diagnosis', 'Dx:Cance
r', 'Dx:CIN', 'Dx:HPV', 'Dx', 'Hinselmann', 'Schiller', 'Citology', 'Biopsy']
```

Explore Numerical values Problems

Recheck missing values

In [20]:
```python
df_X[numerical].isnull().sum()
```

Out[20]:
```
Age                                    0
Number of sexual partners             26
First sexual intercourse               7
Num of pregnancies                    56
Smokes                                13
Smokes (years)                        13
Smokes (packs/year)                   13
Hormonal Contraceptives              108
Hormonal Contraceptives (years)      108
IUD                                  117
IUD (years)                          117
STDs                                 105
STDs (number)                        105
STDs:condylomatosis                  105
STDs:cervical condylomatosis         105
STDs:vaginal condylomatosis          105
STDs:vulvo-perineal condylomatosis   105
STDs:syphilis                        105
STDs:pelvic inflammatory disease     105
STDs:genital herpes                  105
STDs:molluscum contagiosum           105
STDs:AIDS                            105
STDs:HIV                             105
STDs:Hepatitis B                     105
STDs:HPV                             105
STDs: Number of diagnosis              0
STDs: Time since first diagnosis     787
STDs: Time since last diagnosis      787
Dx:Cancer                              0
Dx:CIN                                 0
Dx:HPV                                 0
Dx                                     0
Hinselmann                             0
Schiller                               0
Citology                               0
Biopsy                                 0
dtype: int64
```

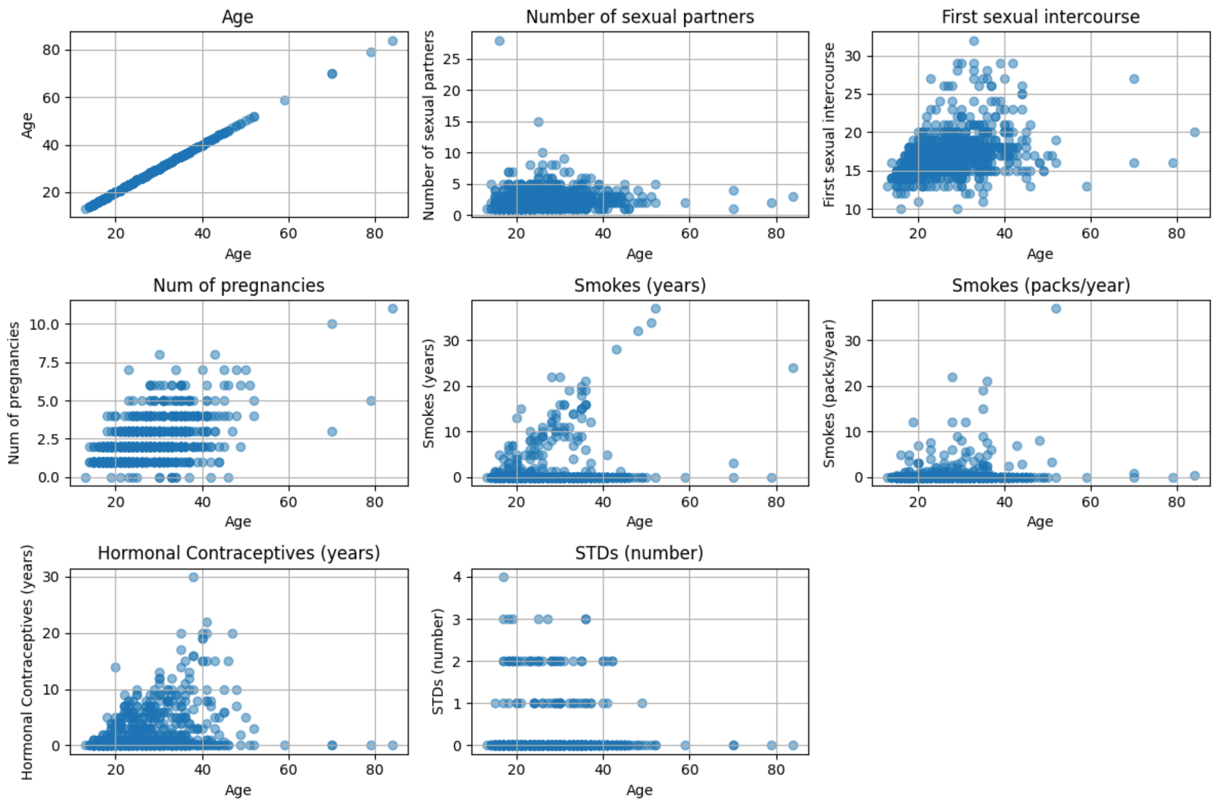
In [21]:
```
#checking for outliers
print(round(df_X[numerical].describe()),2)
```

```
        Age  Number of sexual partners  First sexual intercourse  \
count  858.0                      832.0                     851.0   
mean    27.0                        3.0                      17.0   
std      8.0                        2.0                       3.0   
min     13.0                        1.0                      10.0   
25%     20.0                        2.0                      15.0   
50%     25.0                        2.0                      17.0   
75%     32.0                        3.0                      18.0   
max     84.0                       28.0                      32.0   

       Num of pregnancies  Smokes  Smokes (years)  Smokes (packs/year)  \
count               802.0   845.0           845.0                845.0   
mean                  2.0     0.0             1.0                  0.0   
std                   1.0     0.0             4.0                  2.0   
min                   0.0     0.0             0.0                  0.0   
25%                   1.0     0.0             0.0                  0.0   
50%                   2.0     0.0             0.0                  0.0   
75%                   3.0     0.0             0.0                  0.0   
max                  11.0     1.0            37.0                 37.0   

       Hormonal Contraceptives  Hormonal Contraceptives (years)    IUD  ...  \
count                    750.0                            750.0  741.0  ...   
mean                       1.0                              2.0    0.0  ...   
std                        0.0                              4.0    0.0  ...   
min                        0.0                              0.0    0.0  ...   
25%                        0.0                              0.0    0.0  ...   
50%                        1.0                              0.0    0.0  ...   
75%                        1.0                              3.0    0.0  ...   
max                        1.0                             30.0    1.0  ...   

       STDs: Time since first diagnosis  STDs: Time since last diagnosis  \
count                              71.0                             71.0   
mean                                6.0                              6.0   
std                                 6.0                              6.0   
min                                 1.0                              1.0   
25%                                 2.0                              2.0   
50%                                 4.0                              3.0   
75%                                 8.0                              8.0   
max                                22.0                             22.0   

       Dx:Cancer  Dx:CIN  Dx:HPV     Dx  Hinselmann  Schiller  Citology  \
count      858.0   858.0   858.0  858.0       858.0     858.0     858.0   
mean         0.0     0.0     0.0    0.0         0.0       0.0       0.0   
std          0.0     0.0     0.0    0.0         0.0       0.0       0.0   
min          0.0     0.0     0.0    0.0         0.0       0.0       0.0   
25%          0.0     0.0     0.0    0.0         0.0       0.0       0.0   
50%          0.0     0.0     0.0    0.0         0.0       0.0       0.0   
75%          0.0     0.0     0.0    0.0         0.0       0.0       0.0   
max          1.0     1.0     1.0    1.0         1.0       1.0       1.0   

       Biopsy  
count   858.0  
mean      0.0  
std       0.0  
min       0.0  
25%       0.0  
```

```
50%        0.0
75%        0.0
max        1.0

[8 rows x 36 columns] 2
```

Check for distribution of variables

In [23]:
```
import pandas as pd
import matplotlib.pyplot as plt

numerical_vars = [
    'Age', 'Number of sexual partners', 'First sexual intercourse',
    'Num of pregnancies', 'Smokes (years)', 'Smokes (packs/year)',
    'Hormonal Contraceptives (years)', 'STDs (number)'
]

X_G = pd.DataFrame(X, columns=numerical_vars)

plt.figure(figsize=(12, 8))
for i, var in enumerate(numerical_vars, start=1):
    plt.subplot(3, 3, i)

    plt.scatter(df_X['Age'], df_X[var], alpha=0.5)

    plt.title(var)
    plt.xlabel('Age')
    plt.ylabel(var)
    plt.grid(True)

plt.tight_layout()
plt.show()
```



Declare feature vector and target variable

In [24]:
```
X = df_X.drop(['Age'], axis = 1)

y = df_X['Age']
```

Split data into separate training and test set

In [25]:
```
from sklearn.model_selection import train_test_split

X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.3, random_sta
```

In [26]:
```
X_train.shape, X_test.shape
```

Out[26]:
```
((600, 35), (258, 35))
```

Feature Engineering

In [27]:
```
X_train.dtypes
```

Out[27]:
```
Number of sexual partners              float64
First sexual intercourse               float64
Num of pregnancies                     float64
Smokes                                 float64
Smokes (years)                         float64
Smokes (packs/year)                    float64
Hormonal Contraceptives                float64
Hormonal Contraceptives (years)        float64
IUD                                    float64
IUD (years)                            float64
STDs                                   float64
STDs (number)                          float64
STDs:condylomatosis                    float64
STDs:cervical condylomatosis           float64
STDs:vaginal condylomatosis            float64
STDs:vulvo-perineal condylomatosis     float64
STDs:syphilis                          float64
STDs:pelvic inflammatory disease       float64
STDs:genital herpes                    float64
STDs:molluscum contagiosum             float64
STDs:AIDS                              float64
STDs:HIV                               float64
STDs:Hepatitis B                       float64
STDs:HPV                               float64
STDs: Number of diagnosis                int64
STDs: Time since first diagnosis       float64
STDs: Time since last diagnosis        float64
Dx:Cancer                                int64
Dx:CIN                                   int64
Dx:HPV                                   int64
Dx                                       int64
Hinselmann                               int64
Schiller                                 int64
Citology                                 int64
Biopsy                                   int64
dtype: object
```

In [28]:
```
categorical = [col for col in X_train.columns if X_train[col].dtypes == '0']

categorical
```

Out[28]:
```
[]
```

In [29]:
```
numerical = [col for col in X_train.columns if X_train[col].dtypes != '0']

numerical
```

Out[29]:
```
['Number of sexual partners',
 'First sexual intercourse',
 'Num of pregnancies',
 'Smokes',
 'Smokes (years)',
 'Smokes (packs/year)',
 'Hormonal Contraceptives',
 'Hormonal Contraceptives (years)',
 'IUD',
 'IUD (years)',
 'STDs',
 'STDs (number)',
 'STDs:condylomatosis',
 'STDs:cervical condylomatosis',
 'STDs:vaginal condylomatosis',
 'STDs:vulvo-perineal condylomatosis',
 'STDs:syphilis',
 'STDs:pelvic inflammatory disease',
 'STDs:genital herpes',
 'STDs:molluscum contagiosum',
 'STDs:AIDS',
 'STDs:HIV',
 'STDs:Hepatitis B',
 'STDs:HPV',
 'STDs: Number of diagnosis',
 'STDs: Time since first diagnosis',
 'STDs: Time since last diagnosis',
 'Dx:Cancer',
 'Dx:CIN',
 'Dx:HPV',
 'Dx',
 'Hinselmann',
 'Schiller',
 'Citology',
 'Biopsy']
```

In [33]:
```python
for col in numerical:

    if X_train[col].isnull().mean() > 0:

        missing_percentage = round(X_train[col].isnull().mean() * 100, 2)

        print(f"{col:<30} {missing_percentage:>10}% missing values")
```

```
Number of sexual partners            3.0% missing values
First sexual intercourse            0.67% missing values
Num of pregnancies                   6.0% missing values
Smokes                               1.5% missing values
Smokes (years)                       1.5% missing values
Smokes (packs/year)                  1.5% missing values
Hormonal Contraceptives            11.67% missing values
Hormonal Contraceptives (years)     11.67% missing values
IUD                                12.67% missing values
IUD (years)                        12.67% missing values
STDs                               11.33% missing values
STDs (number)                      11.33% missing values
STDs:condylomatosis                11.33% missing values
STDs:cervical condylomatosis       11.33% missing values
STDs:vaginal condylomatosis        11.33% missing values
STDs:vulvo-perineal condylomatosis     11.33% missing values
STDs:syphilis                      11.33% missing values
STDs:pelvic inflammatory disease     11.33% missing values
STDs:genital herpes                11.33% missing values
STDs:molluscum contagiosum         11.33% missing values
STDs:AIDS                          11.33% missing values
STDs:HIV                           11.33% missing values
STDs:Hepatitis B                   11.33% missing values
STDs:HPV                           11.33% missing values
STDs: Time since first diagnosis      91.5% missing values
STDs: Time since last diagnosis      91.5% missing values
```

In [34]:
```
for df1 in [X_train, X_test]:
  for col in numerical:
    col_median=X_train[col].median()
    df1[col].fillna(col_median, inplace=True)
```

In [35]:
```
X_train[numerical].isnull().sum()
```

Out[35]:
```
Number of sexual partners             0
First sexual intercourse              0
Num of pregnancies                    0
Smokes                                0
Smokes (years)                        0
Smokes (packs/year)                   0
Hormonal Contraceptives               0
Hormonal Contraceptives (years)       0
IUD                                   0
IUD (years)                           0
STDs                                  0
STDs (number)                         0
STDs:condylomatosis                   0
STDs:cervical condylomatosis          0
STDs:vaginal condylomatosis           0
STDs:vulvo-perineal condylomatosis    0
STDs:syphilis                         0
STDs:pelvic inflammatory disease      0
STDs:genital herpes                   0
STDs:molluscum contagiosum            0
STDs:AIDS                             0
STDs:HIV                              0
STDs:Hepatitis B                      0
STDs:HPV                              0
STDs: Number of diagnosis             0
STDs: Time since first diagnosis      0
STDs: Time since last diagnosis       0
Dx:Cancer                             0
Dx:CIN                                0
Dx:HPV                                0
Dx                                    0
Hinselmann                            0
Schiller                              0
Citology                              0
Biopsy                                0
dtype: int64
```

In [36]:
```
X_test[numerical].isnull().sum()
```

Out[36]:
```
Number of sexual partners             0
First sexual intercourse              0
Num of pregnancies                    0
Smokes                                0
Smokes (years)                        0
Smokes (packs/year)                   0
Hormonal Contraceptives               0
Hormonal Contraceptives (years)       0
IUD                                   0
IUD (years)                           0
STDs                                  0
STDs (number)                         0
STDs:condylomatosis                   0
STDs:cervical condylomatosis          0
STDs:vaginal condylomatosis           0
STDs:vulvo-perineal condylomatosis    0
STDs:syphilis                         0
STDs:pelvic inflammatory disease      0
STDs:genital herpes                   0
STDs:molluscum contagiosum            0
STDs:AIDS                             0
STDs:HIV                              0
STDs:Hepatitis B                      0
STDs:HPV                              0
STDs: Number of diagnosis             0
STDs: Time since first diagnosis      0
STDs: Time since last diagnosis       0
Dx:Cancer                             0
Dx:CIN                                0
Dx:HPV                                0
Dx                                    0
Hinselmann                            0
Schiller                              0
Citology                              0
Biopsy                                0
dtype: int64
```

Feature Scaling

In [37]:
```
X_train.describe()
```

Out[37]:

	Number of sexual partners	First sexual intercourse	Num of pregnancies	Smokes	Smokes (years)	Smokes (packs/year)	Hor Contrac
count	600.000000	600.000000	600.000000	600.000000	600.000000	600.000000	600.
mean	2.478333	16.893333	2.276667	0.143333	1.252103	0.484163	0.
std	1.362335	2.567023	1.436510	0.350705	4.161544	2.351749	0.
min	1.000000	11.000000	0.000000	0.000000	0.000000	0.000000	0.
25%	2.000000	15.000000	1.000000	0.000000	0.000000	0.000000	0.
50%	2.000000	17.000000	2.000000	0.000000	0.000000	0.000000	1.
75%	3.000000	18.000000	3.000000	0.000000	0.000000	0.000000	1.
max	10.000000	29.000000	11.000000	1.000000	37.000000	37.000000	1.

8 rows × 35 columns

In [38]:
```
cols = X_train.columns
```

In [39]:
```
from sklearn.preprocessing import MinMaxScaler

scaler = MinMaxScaler()

X_train = scaler.fit_transform(X_train)

X_test = scaler.transform(X_test)
```

In [41]:
```
X_train = pd.DataFrame(X_train, columns=[cols])
X_test = pd.DataFrame(X_test, columns=[cols])
```

In [42]:
```
X_train.describe()
```

Out[42]:

	Number of sexual partners	First sexual intercourse	Num of pregnancies	Smokes	Smokes (years)	Smokes (packs/year)	Hor Contrac
count	600.000000	600.000000	600.000000	600.000000	600.000000	600.000000	600.
mean	0.164259	0.327407	0.206970	0.143333	0.033841	0.013085	0.
std	0.151371	0.142612	0.130592	0.350705	0.112474	0.063561	0.
min	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.
25%	0.111111	0.222222	0.090909	0.000000	0.000000	0.000000	0.
50%	0.111111	0.333333	0.181818	0.000000	0.000000	0.000000	1.
75%	0.222222	0.388889	0.272727	0.000000	0.000000	0.000000	1.
max	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000	1.

8 rows × 35 columns

Model training

In [43]:
```
from sklearn.linear_model import LogisticRegression

logreg = LogisticRegression(solver='liblinear', random_state = 0)

logreg.fit(X_train, y_train)
```

Out[43]:
```
▾ LogisticRegression
LogisticRegression(random_state=0, solver='liblinear')
```

Predict Results

In [44]:
```
y_pred_test = logreg.predict(X_test)

y_pred_test
```

Out[44]:
```
array([26, 19, 18, 24, 18, 26, 18, 20, 21, 41, 19, 19, 23, 23, 19, 18, 19,
       18, 31, 23, 18, 23, 35, 30, 19, 23, 34, 18, 23, 19, 23, 19, 35, 19,
       19, 28, 19, 36, 19, 19, 18, 21, 21, 19, 26, 18, 19, 23, 26, 34, 26,
       19, 23, 19, 18, 24, 19, 18, 19, 34, 35, 19, 19, 17, 19, 18, 19, 25,
       19, 21, 28, 18, 23, 18, 18, 27, 27, 35, 25, 19, 18, 19, 19, 31, 19,
       24, 21, 18, 24, 19, 24, 18, 19, 19, 19, 19, 19, 18, 27, 19, 19, 24,
       28, 26, 19, 19, 28, 19, 40, 24, 18, 17, 19, 33, 19, 34, 18, 18, 18,
       24, 18, 21, 23, 23, 26, 19, 21, 21, 26, 19, 23, 30, 24, 19, 25, 25,
       34, 19, 25, 19, 18, 18, 19, 25, 18, 18, 34, 19, 19, 18, 19, 18, 18,
       19, 23, 18, 26, 19, 24, 25, 19, 18, 24, 25, 18, 19, 19, 23, 19, 25,
       24, 18, 23, 34, 19, 23, 21, 17, 19, 19, 35, 34, 18, 26, 21, 23, 20,
       30, 19, 18, 18, 19, 30, 19, 24, 20, 18, 21, 19, 20, 30, 19, 19, 18,
       19, 24, 19, 19, 27, 19, 23, 18, 26, 24, 19, 30, 34, 19, 20, 26, 19,
       19, 18, 40, 18, 34, 19, 18, 18, 18, 18, 18, 19, 18, 19, 19, 23, 19,
       19, 18, 27, 18, 18, 34, 35, 23, 19, 19, 25, 30, 27, 26, 23, 35, 21,
       18, 19, 31])
```

In [45]:
```python
logreg.predict_proba(X_test)[:,0]
```

```
Out[45]:  array([0.00257353, 0.00399272, 0.0100894 , 0.00281407, 0.01054731,
                0.00301097, 0.0108993 , 0.00401071, 0.00698407, 0.00197939,
                0.0039962 , 0.00376588, 0.00268822, 0.00267909, 0.00377783,
                0.01188848, 0.00367413, 0.01062505, 0.00177621, 0.0028448 ,
                0.01205777, 0.00314333, 0.00324846, 0.00817091, 0.00369901,
                0.0024679 , 0.00931322, 0.01211857, 0.00331648, 0.00371361,
                0.00361802, 0.00389594, 0.0022301 , 0.00377806, 0.00389483,
                0.00318388, 0.00354974, 0.00183991, 0.00362241, 0.00409199,
                0.01109818, 0.00245209, 0.00244971, 0.00423392, 0.00964493,
                0.00716898, 0.00379468, 0.00236979, 0.00299913, 0.00338255,
                0.00262294, 0.00389388, 0.00312507, 0.00370023, 0.01002922,
                0.00371741, 0.00362241, 0.01253573, 0.00198429, 0.00831954,
                0.00295478, 0.00375978, 0.00341799, 0.00432336, 0.00379353,
                0.00279343, 0.0036232 , 0.00274162, 0.00376753, 0.00160651,
                0.00281734, 0.00323203, 0.00193474, 0.01192904, 0.00818507,
                0.00668169, 0.00811841, 0.00192768, 0.00302717, 0.00367362,
                0.00819972, 0.0039632 , 0.00389597, 0.00193123, 0.00381839,
                0.00311583, 0.00375742, 0.01163531, 0.00329315, 0.00386511,
                0.00363324, 0.01143476, 0.00375644, 0.00406183, 0.00395334,
                0.00390253, 0.00409195, 0.00748637, 0.00843297, 0.00426326,
                0.00409819, 0.00375328, 0.00337207, 0.00234114, 0.00356334,
                0.00386127, 0.00307698, 0.00368968, 0.00160235, 0.00297859,
                0.01211857, 0.00709824, 0.0039921 , 0.00261502, 0.00393049,
                0.0032861 , 0.01114771, 0.01020928, 0.01063606, 0.0027868 ,
                0.01045774, 0.00260124, 0.00154839, 0.00251186, 0.00281193,
                0.00399535, 0.00202947, 0.00297378, 0.0031609 , 0.00374543,
                0.00256887, 0.00262858, 0.00367052, 0.00371996, 0.00330418,
                0.00326767, 0.00347829, 0.00412538, 0.004063  , 0.00347878,
                0.01253573, 0.00442786, 0.00386127, 0.00313026, 0.01119107,
                0.01192904, 0.00622656, 0.00358372, 0.00382706, 0.01138947,
                0.00347308, 0.00181484, 0.01086708, 0.00352611, 0.00271463,
                0.00589394, 0.00303631, 0.00400982, 0.00377865, 0.00272063,
                0.00397087, 0.01063495, 0.00172006, 0.00139274, 0.01211857,
                0.00385998, 0.00382622, 0.00276962, 0.0036893 , 0.00287509,
                0.00331733, 0.01119107, 0.00247816, 0.00901803, 0.00355445,
                0.00284556, 0.00247073, 0.00739079, 0.00385014, 0.00405102,
                0.00231681, 0.00346085, 0.01061802, 0.00325816, 0.00535199,
                0.0032561 , 0.0028696 , 0.00889089, 0.0037197 , 0.01167532,
                0.00872058, 0.00421804, 0.00165302, 0.00422237, 0.00341956,
                0.00260314, 0.01088185, 0.00252159, 0.00380342, 0.00287363,
                0.00905023, 0.00377161, 0.00409195, 0.01129274, 0.00354895,
                0.00345177, 0.00340351, 0.00385781, 0.0069115 , 0.0040011 ,
                0.00231112, 0.01032239, 0.00325576, 0.00347078, 0.00358387,
                0.00215412, 0.00867153, 0.00201578, 0.00284118, 0.00246355,
                0.0041833 , 0.00368229, 0.01215939, 0.00494756, 0.00872203,
                0.00242668, 0.00394467, 0.01238621, 0.01113286, 0.01167532,
                0.00794232, 0.00368802, 0.00405972, 0.01033033, 0.00400732,
                0.00340279, 0.00337131, 0.00368989, 0.00371361, 0.01139514,
                0.00314854, 0.01113317, 0.00769975, 0.00944234, 0.00343343,
                0.00387602, 0.00332257, 0.00363648, 0.00219793, 0.00302444,
                0.00816752, 0.00253343, 0.00353349, 0.00291908, 0.00229916,
                0.00998748, 0.00366023, 0.00197514])
```

```
In [46]:  logreg.predict_proba(X_test)[:,1]
```

```
Out[46]:  array([0.00506526, 0.00831363, 0.01133216, 0.00511732, 0.01312885,
                 0.00628249, 0.01277106, 0.00327126, 0.00802251, 0.00329502,
                 0.00829591, 0.00825   , 0.00483418, 0.00475953, 0.00791952,
                 0.01395741, 0.00801414, 0.01201613, 0.00299856, 0.00505894,
                 0.01403951, 0.00614599, 0.00282286, 0.00986657, 0.00794252,
                 0.00459406, 0.01029969, 0.01427534, 0.00676839, 0.00774996,
                 0.00758795, 0.00774025, 0.0037773 , 0.00760526, 0.00774599,
                 0.00668483, 0.00712003, 0.0029705 , 0.00762487, 0.00852288,
                 0.01331499, 0.00428484, 0.00453113, 0.00854162, 0.01016459,
                 0.00796022, 0.00782504, 0.0042218 , 0.00654752, 0.00648468,
                 0.00572759, 0.00791082, 0.00541788, 0.00760288, 0.01126262,
                 0.00730486, 0.00762487, 0.0142366 , 0.00383479, 0.00951155,
                 0.00610509, 0.00770442, 0.00750834, 0.00407335, 0.00785004,
                 0.00536282, 0.00761552, 0.00537021, 0.0082452 , 0.00264583,
                 0.00588868, 0.00588641, 0.00371077, 0.01416907, 0.00874983,
                 0.00732669, 0.00881835, 0.00324628, 0.00665879, 0.00789032,
                 0.00875446, 0.00813072, 0.00807307, 0.00363125, 0.00799555,
                 0.00625326, 0.00712481, 0.01421858, 0.00654085, 0.00790305,
                 0.00715968, 0.0134906 , 0.00747273, 0.00826188, 0.00791843,
                 0.00767994, 0.00818425, 0.00812101, 0.00919319, 0.00896873,
                 0.00816824, 0.00746484, 0.0075591 , 0.00489178, 0.00762601,
                 0.00792279, 0.00711529, 0.00758282, 0.00251099, 0.00560808,
                 0.01427534, 0.00730102, 0.00831633, 0.00502763, 0.00790184,
                 0.00612761, 0.01254777, 0.01338658, 0.01256611, 0.00509296,
                 0.01328321, 0.00457991, 0.00229808, 0.00464869, 0.00547328,
                 0.0084214 , 0.00319268, 0.00542808, 0.00620055, 0.00757583,
                 0.00516929, 0.00498859, 0.00712622, 0.00742809, 0.00681879,
                 0.0070041 , 0.00649831, 0.00836625, 0.00613904, 0.00754386,
                 0.0142366 , 0.00407309, 0.00792279, 0.00690929, 0.01274492,
                 0.01416907, 0.00604704, 0.00736218, 0.00764123, 0.01387179,
                 0.00749749, 0.0028124 , 0.0131464 , 0.00791689, 0.00492715,
                 0.00604165, 0.0061462 , 0.007823  , 0.00727651, 0.00595695,
                 0.00790514, 0.012713  , 0.00285238, 0.00206033, 0.01427534,
                 0.00792824, 0.00773152, 0.00494495, 0.00803479, 0.00705039,
                 0.00611255, 0.01274492, 0.00456316, 0.00971078, 0.00721604,
                 0.00504609, 0.00402121, 0.00742429, 0.00825582, 0.00836756,
                 0.00436999, 0.006563  , 0.01239852, 0.00664143, 0.00524587,
                 0.00706436, 0.00521485, 0.01049036, 0.00741639, 0.01323309,
                 0.00874256, 0.00828443, 0.00275227, 0.00857369, 0.00720588,
                 0.00529287, 0.01331928, 0.00481397, 0.00774532, 0.00521352,
                 0.00985906, 0.00803079, 0.00818425, 0.01403381, 0.0075455 ,
                 0.00677569, 0.00742197, 0.00847059, 0.00748735, 0.00825633,
                 0.00444617, 0.01254855, 0.00662291, 0.00703836, 0.00736605,
                 0.00382976, 0.0100292 , 0.00383995, 0.00491749, 0.00503272,
                 0.00839919, 0.00747692, 0.01449089, 0.00472945, 0.00931414,
                 0.00480535, 0.00848652, 0.01418315, 0.01293739, 0.01323309,
                 0.0083658 , 0.00690966, 0.00828643, 0.01164182, 0.00777119,
                 0.00814893, 0.00689767, 0.00760981, 0.00774996, 0.0132877 ,
                 0.00619931, 0.01351407, 0.00831133, 0.01051104, 0.00700143,
                 0.00799463, 0.00783646, 0.00755754, 0.0039613 , 0.00585141,
                 0.00977211, 0.0047226 , 0.0028935 , 0.00644094, 0.00392189,
                 0.01181859, 0.00743373, 0.00394042])
```

Check accuracy score

In [47]:
```
from sklearn.metrics import accuracy_score

print ('Model accuracy score: {0:0.4f}'. format(accuracy_score(y_test, y_pred_test)
```

```
Model accuracy score: 0.0543
```

In [48]:
```
y_pred_train = logreg.predict(X_train)

y_pred_train
```

Out[48]:
```
array([25, 23, 21, 19, 18, 18, 24, 31, 40, 35, 19, 38, 19, 19, 24, 18, 19,
       28, 34, 18, 34, 18, 23, 18, 19, 18, 19, 23, 35, 35, 21, 19, 26, 19,
       24, 19, 30, 23, 36, 23, 19, 18, 19, 36, 30, 35, 34, 19, 19, 19, 23,
       18, 18, 19, 24, 18, 19, 18, 19, 23, 19, 35, 18, 19, 18, 21, 18, 27,
       19, 18, 35, 30, 18, 18, 40, 19, 30, 24, 24, 23, 18, 23, 23, 19, 19,
       27, 18, 18, 18, 19, 24, 18, 18, 23, 27, 23, 23, 18, 24, 20, 27, 24,
       19, 27, 41, 18, 19, 30, 30, 19, 23, 19, 35, 18, 24, 19, 20, 18, 18,
       24, 23, 18, 19, 30, 18, 19, 27, 19, 19, 17, 19, 21, 19, 25, 19, 37,
       35, 19, 26, 19, 35, 19, 36, 19, 31, 18, 24, 19, 24, 19, 18, 21, 18,
       34, 20, 19, 19, 23, 18, 18, 23, 17, 18, 23, 19, 30, 19, 19, 19, 19,
       27, 27, 23, 18, 18, 24, 23, 23, 19, 19, 24, 18, 23, 35, 19, 18, 18,
       28, 18, 34, 20, 31, 19, 19, 20, 19, 19, 19, 19, 18, 18, 18, 19, 19,
       18, 23, 23, 30, 35, 18, 19, 18, 18, 21, 24, 34, 21, 33, 18, 19, 19,
       19, 19, 30, 26, 18, 24, 18, 18, 18, 37, 35, 25, 35, 18, 24, 19, 18,
       19, 19, 18, 19, 18, 24, 19, 23, 23, 18, 19, 27, 19, 19, 30, 23, 34,
       23, 18, 35, 18, 23, 19, 19, 18, 18, 19, 19, 18, 26, 30, 19, 19, 19,
       26, 18, 18, 23, 20, 28, 24, 34, 23, 19, 27, 19, 19, 19, 33, 38, 18,
       18, 35, 19, 26, 24, 20, 18, 30, 19, 18, 19, 18, 35, 18, 23, 23, 19,
       19, 24, 18, 18, 34, 18, 23, 19, 19, 18, 21, 20, 18, 21, 19, 24, 19,
       19, 19, 19, 19, 35, 18, 35, 18, 19, 18, 35, 23, 35, 19, 19, 41, 24,
       19, 24, 18, 19, 19, 28, 23, 35, 19, 19, 19, 23, 21, 19, 23, 19, 23,
       18, 19, 19, 28, 19, 23, 18, 26, 24, 23, 34, 24, 18, 38, 19, 18, 19,
       35, 18, 30, 18, 34, 24, 18, 24, 19, 18, 28, 19, 19, 23, 24, 23, 23,
       19, 23, 19, 26, 19, 19, 19, 19, 20, 19, 19, 18, 23, 18, 19, 19, 24,
       23, 24, 18, 19, 21, 18, 37, 18, 27, 18, 26, 19, 19, 35, 25, 19, 19,
       30, 19, 18, 27, 35, 19, 19, 19, 35, 18, 19, 23, 28, 36, 19, 18, 18,
       19, 23, 23, 19, 18, 19, 23, 21, 19, 18, 18, 19, 18, 19, 19, 41, 26,
       20, 19, 19, 23, 24, 20, 19, 18, 23, 18, 19, 18, 18, 21, 18, 19, 18,
       18, 41, 23, 19, 25, 20, 18, 18, 24, 18, 18, 18, 19, 23, 18, 19, 19,
       19, 26, 38, 34, 19, 26, 19, 19, 19, 27, 18, 19, 31, 18, 17, 18, 18,
       20, 18, 34, 25, 19, 23, 18, 30, 19, 21, 19, 34, 21, 25, 18, 18, 19,
       18, 23, 26, 19, 19, 30, 18, 19, 19, 38, 18, 28, 19, 34, 30, 19, 35,
       20, 19, 19, 18, 18, 19, 19, 23, 18, 18, 35, 18, 18, 19, 19, 24, 23,
       19, 20, 23, 18, 34, 18, 20, 23, 20, 28, 18, 21, 19, 19, 17, 41, 23,
       19, 23, 24, 19, 27, 18, 27, 19, 18, 18, 19, 19, 24, 23, 19, 18, 26,
       20, 18, 24, 35, 19])
```

In [52]:
```
#confusion matrix
from sklearn.metrics import confusion_matrix

cm = confusion_matrix(y_test, y_pred_test)
```

```
print('Confusion matrix\n\n', cm)

print('\nTrue Positives(TP) =', cm[0,0])

print('\nTrue Negatives(TN) =', cm[1,1])

print('\nFalse Positives(FP) =', cm[0,1])

print('nFalse Negatives(FN) =', cm[1,0])
```

```
Confusion matrix

 [[0 0 0 ... 0 0 0]
 [0 0 0 ... 0 0 0]
 [0 0 0 ... 0 0 0]
 ...
 [0 0 0 ... 0 0 0]
 [0 0 0 ... 0 0 0]
 [0 0 0 ... 0 0 0]]

True Positives(TP) = 0

True Negatives(TN) = 0

False Positives(FP) = 0
nFalse Negatives(FN) = 0
```

In [51]:

```
#classification matrix
from sklearn.metrics import classification_report

print(classification_report(y_test, y_pred_test))
```

```
              precision    recall  f1-score   support

          14       0.00      0.00      0.00         2
          15       0.00      0.00      0.00         3
          16       0.00      0.00      0.00         9
          17       0.33      0.08      0.13        12
          18       0.04      0.18      0.06        11
          19       0.06      0.42      0.11        12
          20       0.00      0.00      0.00        12
          21       0.17      0.13      0.15        15
          22       0.00      0.00      0.00        10
          23       0.05      0.06      0.05        17
          24       0.07      0.11      0.08         9
          25       0.10      0.07      0.08        15
          26       0.00      0.00      0.00        12
          27       0.00      0.00      0.00        10
          28       0.00      0.00      0.00        15
          29       0.00      0.00      0.00        17
          30       0.00      0.00      0.00        10
          31       0.00      0.00      0.00         8
          32       0.00      0.00      0.00         4
          33       0.00      0.00      0.00        10
          34       0.00      0.00      0.00         4
          35       0.14      0.14      0.14         7
          36       0.00      0.00      0.00         6
          37       0.00      0.00      0.00         5
          38       0.00      0.00      0.00         4
          39       0.00      0.00      0.00         4
          40       0.00      0.00      0.00         3
          41       0.00      0.00      0.00         3
          42       0.00      0.00      0.00         1
          44       0.00      0.00      0.00         2
          45       0.00      0.00      0.00         3
          50       0.00      0.00      0.00         1
          51       0.00      0.00      0.00         1
          59       0.00      0.00      0.00         1

    accuracy                           0.05       258
   macro avg       0.03      0.04      0.02       258
weighted avg       0.04      0.05      0.04       258
```

```
/usr/local/lib/python3.10/dist-packages/sklearn/metrics/_classification.py:1344: Und
efinedMetricWarning: Precision and F-score are ill-defined and being set to 0.0 in l
abels with no predicted samples. Use `zero_division` parameter to control this behav
ior.
  _warn_prf(average, modifier, msg_start, len(result))
/usr/local/lib/python3.10/dist-packages/sklearn/metrics/_classification.py:1344: Und
efinedMetricWarning: Precision and F-score are ill-defined and being set to 0.0 in l
abels with no predicted samples. Use `zero_division` parameter to control this behav
ior.
  _warn_prf(average, modifier, msg_start, len(result))
/usr/local/lib/python3.10/dist-packages/sklearn/metrics/_classification.py:1344: Und
efinedMetricWarning: Precision and F-score are ill-defined and being set to 0.0 in l
abels with no predicted samples. Use `zero_division` parameter to control this behav
ior.
  _warn_prf(average, modifier, msg_start, len(result))
```

In [53]:
```python
TP = cm[0, 0]
TN = cm[1, 1]
FP = cm[0, 1]
FN = cm[1, 0]

classification_accuracy = (TP + TN) / float(TP + TN + FP + FN)

print('Classification accuracy: {:.4f}'.format(classification_accuracy))
```

```
Classification accuracy: nan
```

```
<ipython-input-53-b5213b263dc3>:6: RuntimeWarning: invalid value encountered in divi
de
  classification_accuracy = (TP + TN) / float(TP + TN + FP + FN)
```

In [54]:
```python
precision = TP / float(TP + FP)

print('Precision : {0:0.4f}'.format(precision))
```

```
Precision : nan
```

```
<ipython-input-54-de8ba741fd3c>:1: RuntimeWarning: invalid value encountered in divi
de
  precision = TP / float(TP + FP)
```

In [55]:
```python
recall = TP / float(TP + FN)

print('Recall or Sensitivity : {0:0.4f}'.format(recall))
```

```
Recall or Sensitivity : nan
```

```
<ipython-input-55-4541e477f8ab>:1: RuntimeWarning: invalid value encountered in divi
de
  recall = TP / float(TP + FN)
```

In [56]:
```python
true_positive_rate = TP / float(TP + FN)

print('True Positive Rate : {0:0.4f}'.format(true_positive_rate))
```

```
True Positive Rate : nan
```

```
<ipython-input-56-934b41082672>:1: RuntimeWarning: invalid value encountered in divi
de
  true_positive_rate = TP / float(TP + FN)
```

In [57]:
```
false_positive_rate = FP / float(FP + TN)

print('False Positive Rate : {0:0.4f}'.format(false_positive_rate))
```

```
False Positive Rate : nan
<ipython-input-57-d365adb81363>:1: RuntimeWarning: invalid value encountered in divi
de
  false_positive_rate = FP / float(FP + TN)
```

In [58]:
```
specifity = TN / (TN + FP)

print('Specifity : {0:0.4f}'.format(specifity))
```

```
Specifity : nan
<ipython-input-58-9df300ba775b>:1: RuntimeWarning: invalid value encountered in scal
ar divide
  specifity = TN / (TN + FP)
```

Adjusting the threshold level

In [59]:
```
y_pred_prob = logreg.predict_proba(X_test)[0:10]

y_pred_prob
```

```
Out[59]: array([[0.00257353, 0.00506526, 0.00894116, 0.00929437, 0.01100428,
         0.02189776, 0.03231865, 0.05074597, 0.0318772 , 0.03835678,
         0.05979673, 0.05652839, 0.06254897, 0.07750053, 0.05260326,
         0.04367154, 0.02192095, 0.04202645, 0.03056631, 0.03577554,
         0.05040407, 0.02729505, 0.04597197, 0.0360051 , 0.03070043,
         0.00773785, 0.01179163, 0.01762867, 0.01311988, 0.00883457,
         0.00602795, 0.01587491, 0.00635549, 0.00436779, 0.00325353,
         0.00379094, 0.00353365, 0.00334671, 0.00362875, 0.00272612,
         0.00259128],
        [0.00399272, 0.00831363, 0.03609807, 0.02620335, 0.02704087,
         0.04777543, 0.08182183, 0.04987633, 0.04954438, 0.04200428,
         0.05677125, 0.05288797, 0.04746386, 0.04653228, 0.03662504,
         0.03719159, 0.02345649, 0.03311216, 0.03239921, 0.02964388,
         0.02460153, 0.02989584, 0.02654978, 0.02319232, 0.01613866,
         0.00769372, 0.00876181, 0.00878386, 0.01448556, 0.00780414,
         0.00860648, 0.00759226, 0.00889237, 0.00615283, 0.0046633 ,
         0.0060235 , 0.00560274, 0.00460054, 0.00374098, 0.00397538,
         0.0034878 ],
        [0.0100894 , 0.01133216, 0.06917836, 0.04244925, 0.04846814,
         0.15780828, 0.02361809, 0.0406979 , 0.04458707, 0.01598541,
         0.03470736, 0.02791428, 0.05325171, 0.02496876, 0.01948394,
         0.01574266, 0.01164744, 0.03532278, 0.01903598, 0.02130706,
         0.02795675, 0.01654505, 0.02337171, 0.01317024, 0.01021362,
         0.01913197, 0.01075923, 0.0173256 , 0.01043394, 0.01050614,
         0.01100065, 0.01235151, 0.0088414 , 0.01243563, 0.01485078,
         0.00695096, 0.01003884, 0.00786467, 0.01037726, 0.00991249,
         0.00836553],
        [0.00281407, 0.00511732, 0.0107005 , 0.00977665, 0.00772834,
         0.00906614, 0.01404168, 0.01049944, 0.0187219 , 0.02946667,
         0.0519206 , 0.06672986, 0.01548925, 0.02245009, 0.01449478,
         0.06488373, 0.02435788, 0.05895656, 0.02901299, 0.03750333,
         0.04387679, 0.06610817, 0.0468129 , 0.05456425, 0.03458407,
         0.02694158, 0.02047828, 0.03882848, 0.06301454, 0.0140146 ,
         0.02559373, 0.00505839, 0.01332178, 0.00573607, 0.0047805 ,
         0.01116771, 0.00405674, 0.00596048, 0.00567754, 0.00296886,
         0.00272275],
        [0.01054731, 0.01312885, 0.02558225, 0.02584192, 0.04901366,
         0.06339481, 0.0287722 , 0.04060529, 0.04861127, 0.02531803,
         0.0470696 , 0.03358698, 0.03607685, 0.03287692, 0.05027265,
         0.02572361, 0.02362664, 0.03158231, 0.02311375, 0.01813953,
         0.02466383, 0.03207744, 0.03229352, 0.02612535, 0.02346675,
         0.01007846, 0.01659781, 0.0179266 , 0.01700269, 0.01485147,
         0.01527205, 0.01748044, 0.01071097, 0.01450441, 0.00835209,
         0.00892269, 0.01162729, 0.01034523, 0.01326837, 0.01113003,
         0.01041808],
        [0.00301097, 0.00628249, 0.01467561, 0.0128878 , 0.01521758,
         0.02886378, 0.04804109, 0.04420596, 0.03764325, 0.03666953,
         0.05876453, 0.05601355, 0.06101961, 0.06727193, 0.04954531,
         0.04632431, 0.02445255, 0.03923192, 0.03494606, 0.03392672,
         0.03827367, 0.02986914, 0.0435277 , 0.03178577, 0.02537132,
         0.0076255 , 0.01075573, 0.01301053, 0.01420212, 0.00842915,
         0.00743243, 0.01158656, 0.00744534, 0.0050201 , 0.00371695,
         0.00469437, 0.00435505, 0.00390935, 0.00377208, 0.00320467,
         0.0030179 ],
        [0.0108993 , 0.01277106, 0.02649481, 0.02995219, 0.04992006,
         0.06329829, 0.0253621 , 0.04745813, 0.04782545, 0.02936823,
         0.04891048, 0.0341762 , 0.02960972, 0.02994064, 0.04719404,
         0.02321735, 0.02139433, 0.03203769, 0.02066678, 0.01758341,
         0.02728984, 0.03226241, 0.02782497, 0.0265793 , 0.02301641,
         0.010665  , 0.01676969, 0.02027387, 0.01714669, 0.01504276,
         0.01499303, 0.01869575, 0.01074177, 0.01523498, 0.00865332,
         0.00895877, 0.0116124 , 0.01026935, 0.01385533, 0.01135745,
         0.01067668],
        [0.00401071, 0.00327126, 0.00528848, 0.00614952, 0.05378486,
         0.14014187, 0.02565009, 0.15199161, 0.06373131, 0.01210715,
         0.05115941, 0.01002655, 0.01397046, 0.00669747, 0.00356197,
         0.05350392, 0.01951351, 0.01995641, 0.01159611, 0.00232678,
         0.04931752, 0.01271681, 0.03766907, 0.01686448, 0.02662826,
         0.00943711, 0.00537729, 0.06478945, 0.01140073, 0.02396362,
         0.00420892, 0.00449774, 0.00248091, 0.00401404, 0.0090517 ,
         0.01364493, 0.00579792, 0.01539647, 0.00770197, 0.00410186,
         0.0124997 ],
        [0.00698407, 0.00802251, 0.0067231 , 0.02747781, 0.0329448 ,
         0.03378263, 0.01925299, 0.02757315, 0.11100597, 0.05219863,
         0.017278  , 0.01827968, 0.03317279, 0.01229916, 0.04051347,
         0.05073459, 0.01921546, 0.0236776 , 0.00834538, 0.00694485,
         0.04629445, 0.03121206, 0.05761897, 0.01050183, 0.05823635,
         0.03258692, 0.01788441, 0.03045571, 0.01289743, 0.00779571,
         0.00946373, 0.01121243, 0.00654281, 0.00963927, 0.0182577 ,
         0.02026957, 0.00770775, 0.02232498, 0.00960439, 0.00792822,
         0.01513867],
        [0.00197939, 0.00329502, 0.00431781, 0.00446281, 0.00371306,
         0.0041456 , 0.00595496, 0.00769956, 0.01118166, 0.02451003,
         0.04094198, 0.05554524, 0.0140117 , 0.0180278 , 0.01179027,
         0.05600174, 0.02184583, 0.0770507 , 0.02227597, 0.0424647 ,
         0.04502056, 0.06415137, 0.06103282, 0.06529298, 0.03424272,
         0.03691899, 0.01936133, 0.05971053, 0.09917713, 0.01321761,
         0.02144522, 0.00590487, 0.0105633 , 0.00458077, 0.00430564,
         0.00823803, 0.00263396, 0.00495322, 0.0042387 , 0.00201476,
         0.00177965]])
```

In this exercise, we used a confusion matrix to evaluate the performance of a classification model. Even though we faced difficulties and had limited time, we learned important lessons. True positives (TP), true negatives (TN), false positives (FP), and false negatives (FN) were all counted in the confusion matrix. To evaluate the efficacy of the model, we computed important metrics such as recall (sensitivity) and classification accuracy. But due to time constraints, certain scheduled tasks—like visualizing the confusion matrix—were not finished. In order to improve predicted accuracy and reliability going forward, more model improvement and modification are advised. The significance of iterative model evaluation and improvement in machine learning is emphasized by this work.