lung cancer mortality

July 2, 2024

[1]:
```python
import pandas as pd
import matplotlib.pyplot as plt
df=pd.read_csv('lung_cancer_mortality_data_small.csv')
df
```

[1]:
```
          id   age  gender     country diagnosis_date cancer_stage  \
0          1  64.0    Male     Croatia     2016-04-05      Stage I
1          2  50.0  Female       Italy     2023-04-20    Stage III
2          3  65.0    Male    Slovakia     2023-04-05     Stage IV
3          4  51.0  Female      Greece     2016-02-05    Stage III
4          5  37.0  Female    Slovakia     2023-11-29    Stage III
…          …     …     …           …              …            …
55995  55996  49.0  Female     Germany     2014-11-15    Stage III
55996  55997  65.0    Male  Luxembourg     2016-03-13     Stage IV
55997  55998  60.0  Female      Latvia     2023-05-21     Stage II
55998  55999  63.0  Female    Bulgaria     2015-12-09    Stage III
55999  56000  55.0  Female      Latvia     2015-08-09      Stage I

      family_history  smoking_status   bmi  cholesterol_level  hypertension  \
0                Yes  Current Smoker  27.3                196             0
1                 No  Passive Smoker  22.4                234             1
2                 No   Former Smoker  20.2                210             0
3                Yes    Never Smoked  41.8                262             1
4                Yes  Passive Smoker  33.5                262             0
…                  …               …    …                  …             …
55995            Yes    Never Smoked  23.6                155             0
55996            Yes  Current Smoker  19.6                185             0
55997            Yes  Passive Smoker  33.5                261             0
55998             No   Former Smoker  24.0                221             0
55999            Yes  Passive Smoker  24.3                189             1

       asthma  cirrhosis  other_cancer treatment_type end_treatment_date  \
0           1          0             0      Radiation         2018-01-09
1           1          1             0   Chemotherapy         2023-11-28
2           0          0             0   Chemotherapy         2025-01-12
3           0          1             0        Surgery         2016-11-14
4           0          0             0   Chemotherapy         2025-03-10
…           …          …             …              …                  …
```

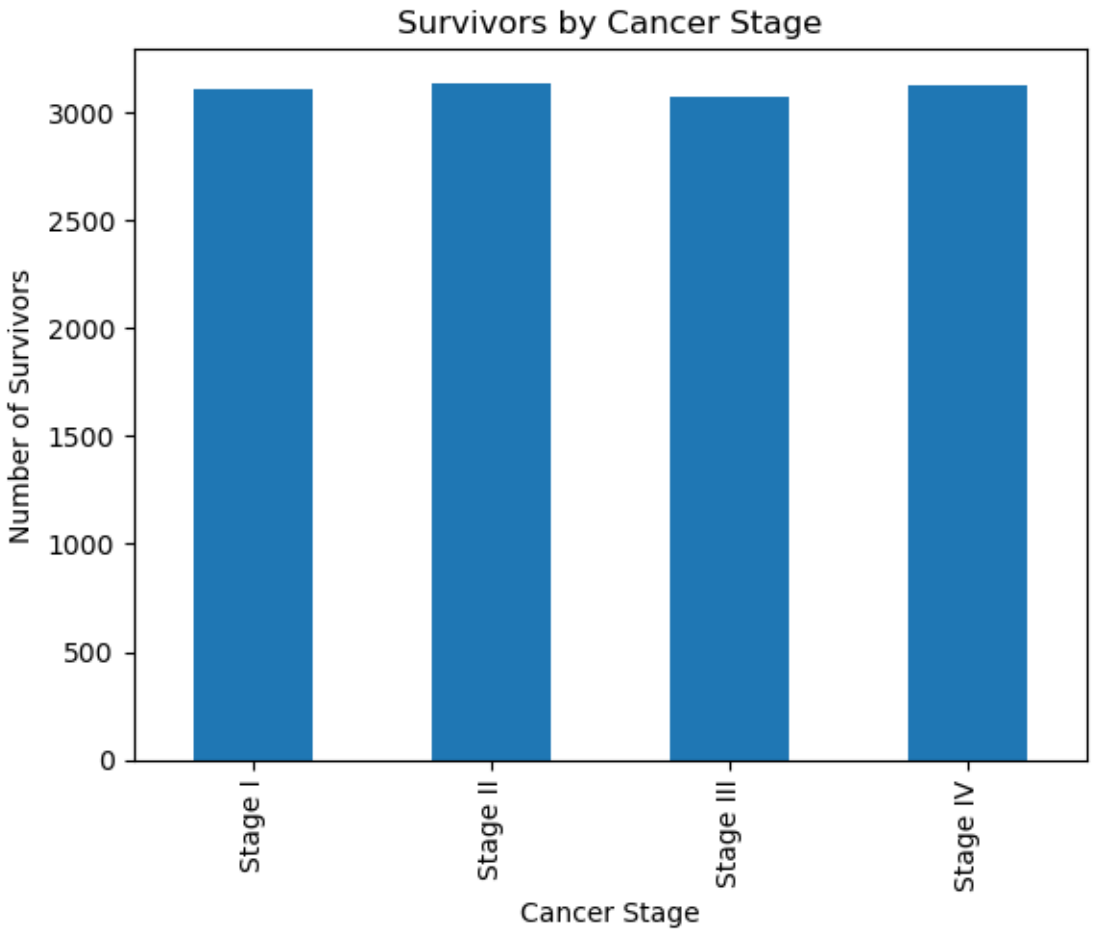
```
55995       0          0             0        Surgery         2016-02-13
55996       0          0             0       Combined         2017-11-11
55997       0          0             0      Radiation         2024-12-04
55998       0          0             0      Radiation         2017-05-10
55999       0          0             0      Radiation         2017-04-29

       survived
0             0
1             0
2             0
3             0
4             0
…           …
55995         0
55996         0
55997         1
55998         0
55999         0

[56000 rows x 17 columns]
```

[2]:
```
df[['age','bmi','cholesterol_level']].describe()
```

[2]:
```
                age           bmi  cholesterol_level
count  56000.000000  56000.000000       56000.000000
mean      54.924929     30.576352         233.891286
std        9.995458      8.387948          43.470036
min       15.000000     16.000000         150.000000
25%       48.000000     23.300000         197.000000
50%       55.000000     30.600000         242.000000
75%       62.000000     37.900000         271.000000
max      101.000000     45.000000         300.000000
```

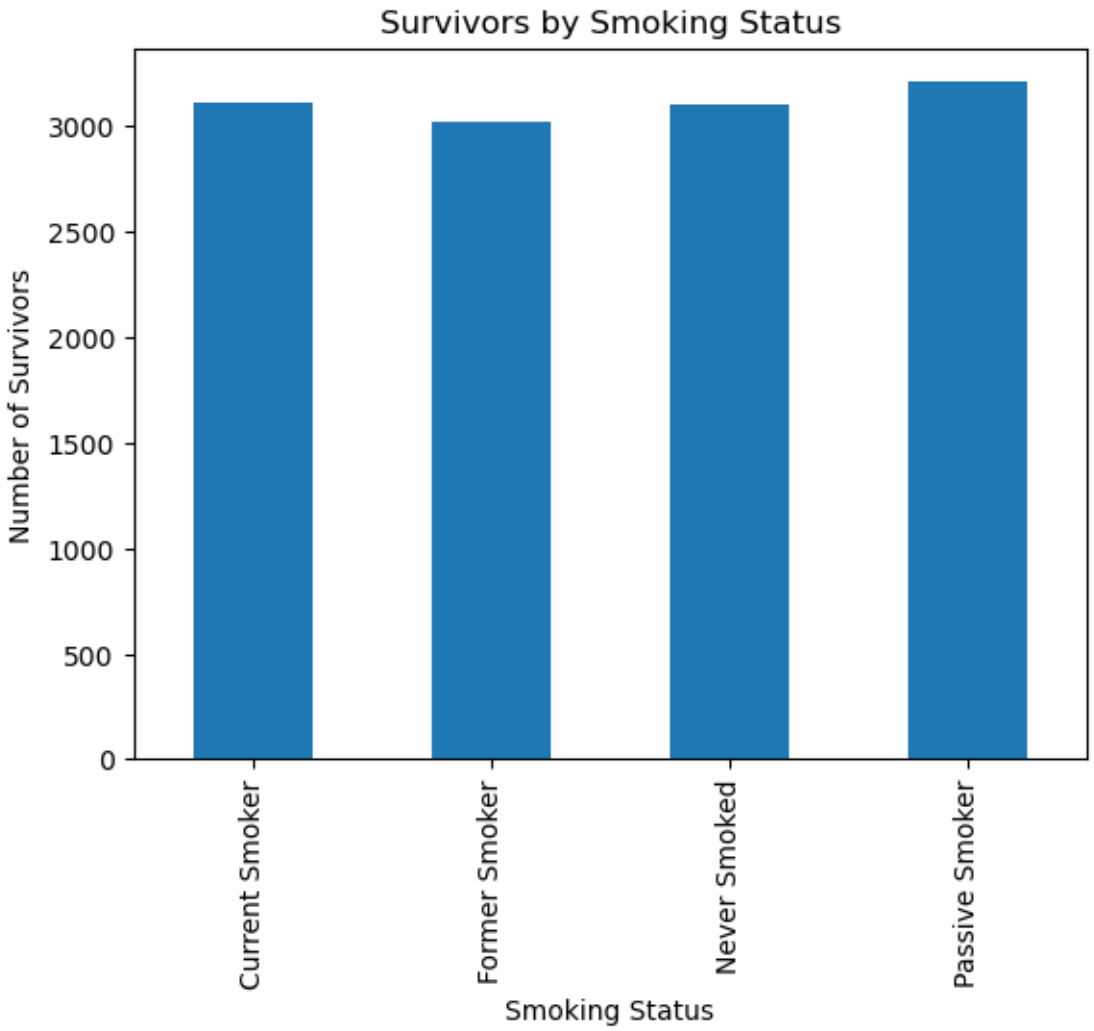
[3]:
```
df.groupby('cancer_stage')['survived'].sum().plot(kind='bar',xlabel='Cancer␣
↪Stage',ylabel='Number of Survivors',title='Survivors by Cancer Stage')
```

[3]:
```
<Axes: title={'center': 'Survivors by Cancer Stage'}, xlabel='Cancer Stage',
ylabel='Number of Survivors'>
```



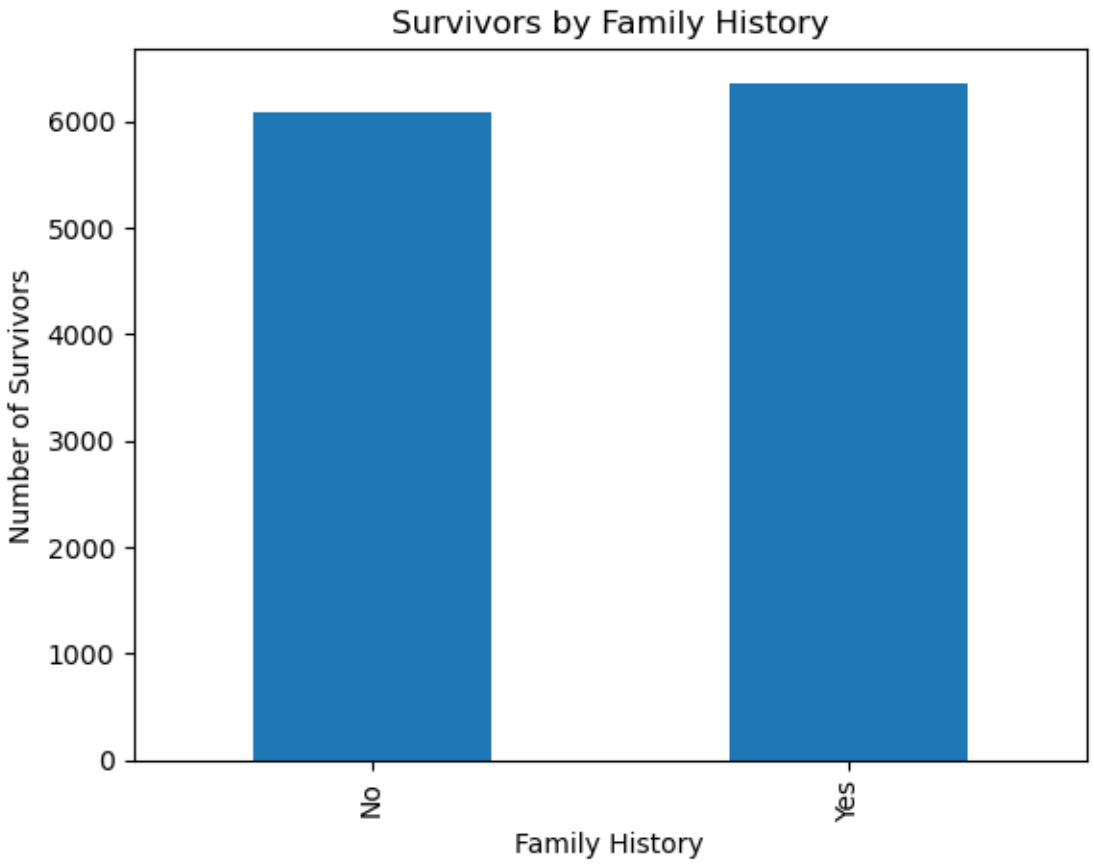
[4]:
```
df.groupby('smoking_status')['survived'].sum().plot(kind='bar',xlabel='Smoking␣
↪Status',ylabel='Number of Survivors',title='Survivors by Smoking Status')
```

[4]:
```
<Axes: title={'center': 'Survivors by Smoking Status'}, xlabel='Smoking Status',
ylabel='Number of Survivors'>
```



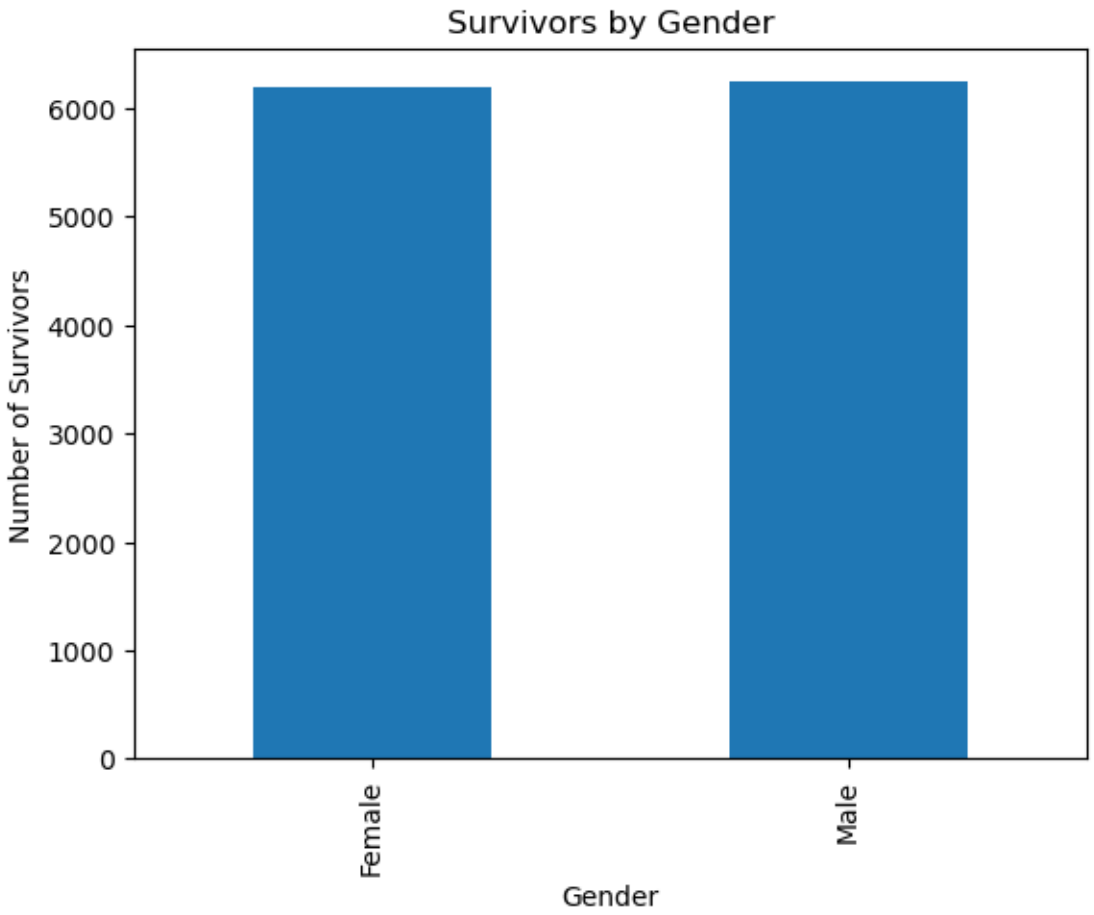
[5]:
```
df.groupby('family_history')['survived'].sum().plot(kind='bar',xlabel='Family␣
↪History',ylabel='Number of Survivors',title='Survivors by Family History')
```

[5]:
```
<Axes: title={'center': 'Survivors by Family History'}, xlabel='Family History',
ylabel='Number of Survivors'>
```



[6]:
```
df.groupby('gender')['survived'].sum().
  ↪plot(kind='bar',xlabel='Gender',ylabel='Number of␣
  ↪Survivors',title='Survivors by Gender')
```

[6]:
```
<Axes: title={'center': 'Survivors by Gender'}, xlabel='Gender', ylabel='Number
of Survivors'>
```



[7]:
```
#Descending Survival Rate by Treatment Type
SRbytreatment=df.groupby('treatment_type')['survived'].
  ↪agg(total='count',survivors=lambda x:(x==1).sum())
SRbytreatment['survival rate']=SRbytreatment['survivors']/SRbytreatment['total']
SRbytreatment.sort_values('survival rate',ascending=False)
```

[7]:

treatment_type	total	survivors	survival rate
Chemotherapy	14112	3189	0.225978
Combined	13899	3095	0.222678
Radiation	14074	3104	0.220549
Surgery	13915	3050	0.219188

[8]:
```
#Descending Survival Rate by Country
SRbycountry=df.groupby('country')['survived'].
  ↪agg(total='count',survivors=lambda x:(x==1).sum())
SRbycountry['survival rate']=SRbycountry['survivors']/SRbycountry['total']
SRbycountry.sort_values('survival rate',ascending=False)
```

[8]:

country	total	survivors	survival rate
Hungary	2113	506	0.239470
Netherlands	2047	484	0.236444
Sweden	1989	459	0.230769
Denmark	2115	488	0.230733
Portugal	2098	484	0.230696
Czech Republic	2115	487	0.230260
France	2023	463	0.228868
Belgium	2018	460	0.227948
Estonia	2015	458	0.227295
Slovenia	2031	458	0.225505
Latvia	2059	461	0.223895
Lithuania	2149	481	0.223825
Slovakia	2047	457	0.223254
Spain	2125	474	0.223059
Greece	2120	469	0.221226
Ireland	2083	457	0.219395
Croatia	2084	457	0.219290
Austria	2080	456	0.219231
Romania	2035	445	0.218673
Finland	2087	455	0.218016
Germany	2037	443	0.217477
Malta	2133	457	0.214252
Bulgaria	2115	452	0.213712
Luxembourg	2019	426	0.210996
Cyprus	2110	443	0.209953
Italy	2081	432	0.207593
Poland	2072	426	0.205598

[9]:
```
#Logistic Regression
from sklearn.linear_model import LogisticRegression
from sklearn.model_selection import train_test_split
from sklearn.preprocessing import LabelEncoder
from sklearn.metrics import␣
 ↪accuracy_score,precision_score,recall_score,confusion_matrix,classification_report
labelencoder=LabelEncoder()
df['gender encoded']=labelencoder.fit_transform(df['gender'])
df['cancer stage encoded']=labelencoder.fit_transform(df['cancer_stage'])
df['family history encoded']=labelencoder.fit_transform(df['family_history'])
df['smoking status encoded']=labelencoder.fit_transform(df['smoking_status'])
df['treatment type encoded']=labelencoder.fit_transform(df['treatment_type'])
#x=df[['age','bmi','cholesterol_level','hypertension','asthma','cirrhosis','other_cancer']]
x=df[['age','gender encoded','cancer stage encoded','family history␣
 ↪encoded','smoking status␣
 ↪encoded','bmi','cholesterol_level','hypertension','asthma','cirrhosis','other_cancer']]
y=df['survived']
```

```
x_train,x_test,y_train,y_test=train_test_split(x,y,test_size=.3,random_state=42)
logreg=LogisticRegression()
logreg.fit(x_train,y_train)
y_pred=logreg.predict(x_test)
#accuracy=overall correctness
accuracy=accuracy_score(y_test,y_pred)
#precision=ability to correctly predict positive class
precision=precision_score(y_test,y_pred)
#recall=quantifies ability to correctly predict positive class
recall=recall_score(y_test,y_pred)
#confmatrix=[TP FP][FN TN]
confmatrix=confusion_matrix(y_test,y_pred)
classreport=classification_report(y_test,y_pred)
print('Accuracy: ',accuracy)
print('Precision: ',precision)
print('Recall: ',recall)
print('Confusion Matrix: ',confmatrix)
print('Classification Report: ',classreport)
```

```
Accuracy:  0.7757738095238095
Precision:  0.0
Recall:  0.0
Confusion Matrix:  [[13033     0]
 [ 3767     0]]
Classification Report:                precision    recall  f1-score   support

           0       0.78      1.00      0.87     13033
           1       0.00      0.00      0.00      3767

    accuracy                           0.78     16800
   macro avg       0.39      0.50      0.44     16800
weighted avg       0.60      0.78      0.68     16800


C:\Users\639517\AppData\Local\anaconda3\Lib\site-
packages\sklearn\linear_model\_logistic.py:458: ConvergenceWarning: lbfgs failed
to converge (status=1):
STOP: TOTAL NO. of ITERATIONS REACHED LIMIT.

Increase the number of iterations (max_iter) or scale the data as shown in:
    https://scikit-learn.org/stable/modules/preprocessing.html
Please also refer to the documentation for alternative solver options:
    https://scikit-learn.org/stable/modules/linear_model.html#logistic-
regression
  n_iter_i = _check_optimize_result(
C:\Users\639517\AppData\Local\anaconda3\Lib\site-
packages\sklearn\metrics\_classification.py:1344: UndefinedMetricWarning:
Precision is ill-defined and being set to 0.0 due to no predicted samples. Use
```

```
`zero_division` parameter to control this behavior.
  _warn_prf(average, modifier, msg_start, len(result))
C:\Users\639517\AppData\Local\anaconda3\Lib\site-
packages\sklearn\metrics\_classification.py:1344: UndefinedMetricWarning:
Precision and F-score are ill-defined and being set to 0.0 in labels with no
predicted samples. Use `zero_division` parameter to control this behavior.
  _warn_prf(average, modifier, msg_start, len(result))
C:\Users\639517\AppData\Local\anaconda3\Lib\site-
packages\sklearn\metrics\_classification.py:1344: UndefinedMetricWarning:
Precision and F-score are ill-defined and being set to 0.0 in labels with no
predicted samples. Use `zero_division` parameter to control this behavior.
  _warn_prf(average, modifier, msg_start, len(result))
C:\Users\639517\AppData\Local\anaconda3\Lib\site-
packages\sklearn\metrics\_classification.py:1344: UndefinedMetricWarning:
Precision and F-score are ill-defined and being set to 0.0 in labels with no
predicted samples. Use `zero_division` parameter to control this behavior.
  _warn_prf(average, modifier, msg_start, len(result))
```

[10]:
```
#Random Forest Classifier: builds trees independently using random subset
from sklearn.ensemble import RandomForestClassifier
from sklearn.metrics import␣
 ↪accuracy_score,confusion_matrix,classification_report,precision_score,r2_score
labelencoder=LabelEncoder()
df['gender encoded']=labelencoder.fit_transform(df['gender'])
df['cancer stage encoded']=labelencoder.fit_transform(df['cancer_stage'])
df['family history encoded']=labelencoder.fit_transform(df['family_history'])
df['smoking status encoded']=labelencoder.fit_transform(df['smoking_status'])
df['treatment type encoded']=labelencoder.fit_transform(df['treatment_type'])
#x=df[['age','bmi','cholesterol_level','hypertension','asthma','cirrhosis','other_cancer']]
x=df[['age','gender encoded','cancer stage encoded','family history␣
 ↪encoded','smoking status␣
 ↪encoded','bmi','cholesterol_level','hypertension','asthma','cirrhosis','other_cancer']]
y=df['survived']
x_train,x_test,y_train,y_test=train_test_split(x,y,test_size=.3,random_state=42)
rf=RandomForestClassifier(n_estimators=100,random_state=42)
rf.fit(x_train,y_train)
y_pred=rf.predict(x_test)
#accuracy=overall correctness
accuracy=accuracy_score(y_test,y_pred)
#precision=ability to correctly predict positive class
precision=precision_score(y_test,y_pred)
#recall=quantifies ability to correctly predict positive class
recall=recall_score(y_test,y_pred)
#confmatrix=[TP FP][FN TN]
confmatrix=confusion_matrix(y_test,y_pred)
classreport=classification_report(y_test,y_pred)
print('Accuracy: ',accuracy)
```

```
print('Precision: ',precision)
print('Recall: ',recall)
print('Confusion Matrix: ',confmatrix)
print('Classification Report: ',classreport)
```

```
Accuracy:  0.7695238095238095
Precision:  0.21311475409836064
Recall:  0.010353066100345103
Confusion Matrix:  [[12889   144]
 [ 3728    39]]
Classification Report:                precision    recall  f1-score   support

           0       0.78      0.99      0.87     13033
           1       0.21      0.01      0.02      3767

    accuracy                           0.77     16800
   macro avg       0.49      0.50      0.44     16800
weighted avg       0.65      0.77      0.68     16800
```

[11]:
```
#Random Forest Factors' Importance
rfimportance=pd.DataFrame()
rfimportance['variables']=x.columns
rfimportance['importance']=rf.feature_importances_
rfimportance.sort_values(by='importance',ascending=False)
```

[11]:

	variables	importance
5	bmi	0.287138
6	cholesterol_level	0.261529
0	age	0.229232
2	cancer stage encoded	0.056331
4	smoking status encoded	0.054125
1	gender encoded	0.023882
8	asthma	0.022923
9	cirrhosis	0.021598
7	hypertension	0.017211
3	family history encoded	0.013203
10	other_cancer	0.012828

[12]:
```
#Gradient Boost: builds trees sequentially, correcting errors of previous one
from xgboost import XGBClassifier
labelencoder=LabelEncoder()
df['gender encoded']=labelencoder.fit_transform(df['gender'])
df['cancer stage encoded']=labelencoder.fit_transform(df['cancer_stage'])
df['family history encoded']=labelencoder.fit_transform(df['family_history'])
df['smoking status encoded']=labelencoder.fit_transform(df['smoking_status'])
df['treatment type encoded']=labelencoder.fit_transform(df['treatment_type'])
#x=df[['age','bmi','cholesterol_level','hypertension','asthma','cirrhosis','other_cancer']]
```

```
x=df[['age','gender encoded','cancer stage encoded','family history␣
 ↪encoded','smoking status␣
 ↪encoded','bmi','cholesterol_level','hypertension','asthma','cirrhosis','other_cancer']]
y=df['survived']
x_train,x_test,y_train,y_test=train_test_split(x,y,test_size=.3,random_state=42)
xgb=XGBClassifier()
xgb.fit(x_train,y_train)
y_pred=xgb.predict(x_test)
#accuracy=overall correctness
accuracy=accuracy_score(y_test,y_pred)
#precision=ability to correctly predict positive class
precision=precision_score(y_test,y_pred)
#recall=quantifies ability to correctly predict positive class
recall=recall_score(y_test,y_pred)
#confmatrix=[TP FP][FN TN]
confmatrix=confusion_matrix(y_test,y_pred)
classreport=classification_report(y_test,y_pred)
print('Accuracy: ',accuracy)
print('Precision: ',precision)
print('Recall: ',recall)
print('Confusion Matrix: ',confmatrix)
print('Classification Report: ',classreport)
```

```
Accuracy:  0.7723809523809524
Precision:  0.23853211009174313
Recall:  0.006902044066896735
Confusion Matrix:  [[12950    83]
 [ 3741    26]]
Classification Report:                precision    recall  f1-score   support

           0       0.78      0.99      0.87     13033
           1       0.24      0.01      0.01      3767

    accuracy                           0.77     16800
   macro avg       0.51      0.50      0.44     16800
weighted avg       0.66      0.77      0.68     16800
```

[13]:
```
#Gradient Boost Factors' Importance
xgbimportance=pd.DataFrame()
xgbimportance['variables']=x.columns
xgbimportance['importance']=xgb.feature_importances_
xgbimportance.sort_values(by='importance',ascending=False)
```

[13]:

	variables	importance
10	other_cancer	0.108651
9	cirrhosis	0.095026

```
2     cancer stage encoded    0.092776
1           gender encoded    0.092687
5                       bmi    0.091114
6        cholesterol_level    0.088945
4   smoking status encoded    0.088729
3   family history encoded    0.087482
0                       age    0.086039
8                    asthma    0.084667
7              hypertension    0.083882
```

[14]:
```
df['predicted']=xgb.predict(x)
#accuracy=overall correctness
accuracy=accuracy_score(df['survived'],df['predicted'])
#precision=ability to correctly predict positive class
precision=precision_score(df['survived'],df['predicted'])
#recall=quantifies ability to correctly predict positive class
recall=recall_score(df['survived'],df['predicted'])
#confmatrix=[TP FP][FN TN]
confmatrix=confusion_matrix(df['survived'],df['predicted'])
classreport=classification_report(df['survived'],df['predicted'])
print('Accuracy: ',accuracy)
print('Precision: ',precision)
print('Recall: ',recall)
print('Confusion Matrix: ',confmatrix)
print('Classification Report: ',classreport)
```

```
Accuracy:  0.786875
Precision:  0.862914862914863
Recall:  0.04807846920726805
Confusion Matrix:  [[43467    95]
 [11840   598]]
Classification Report:                precision    recall  f1-score   support

           0       0.79      1.00      0.88     43562
           1       0.86      0.05      0.09     12438

    accuracy                           0.79     56000
   macro avg       0.82      0.52      0.49     56000
weighted avg       0.80      0.79      0.70     56000
```