lung-cancer-dataset

November 18, 2023

1 Project Name : Lung Cancer Data Analysis

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2 Interoduction :

This dataset contains information on patients with lung cancer, including their age, gender, air pollution exposure, alcohol use, dust allergy, occupational hazards, genetic risk, chronic lung disease, balanced diet, obesity, smoking, passive smoker, chest pain, coughing of blood, fatigue, weight loss ,shortness of breath ,wheezing ,swallowing difficulty ,clubbing of finger nails and snoring

Lung cancer is the leading cause of cancer death worldwide, accounting for 1.59 million deaths in 2018. The majority of lung cancer cases are attributed to smoking, but exposure to air pollution is also a risk factor. A new study has found that air pollution may be linked to an increased risk of lung cancer, even in nonsmokers.

The study, which was published in the journal Nature Medicine, looked at data from over 462,000 people in China who were followed for an average of six years. The participants were divided into two groups: those who lived in areas with high levels of air pollution and those who lived in areas with low levels of air pollution.

The researchers found that the people in the high-pollution group were more likely to develop lung cancer than those in the low-pollution group. They also found that the risk was higher in nonsmokers than smokers, and that the risk increased with age.

Columns Descriptions :

Age : The age of the patient. (Numeric).

Gender : The gender of the patient. (Categorical).

Air Pollution : The level of air pollution exposure of the patient. (Categorical).

Alcohol use : The level of alcohol use of the patient. (Categorical).

Dust Allergy : The level of dust allergy of the patient. (Categorical).

OccuPational Hazards : The level of occupational hazards of the patient. (Categorical).

Genetic Risk : The level of genetic risk of the patient. (Categorical).

chronic Lung Disease : The level of chronic lung disease of the patient. (Categorical).

Balanced Diet : The level of balanced diet of the patient. (Categorical).

Obesity : The level of obesity of the patient. (Categorical).

Smoking : The level of smoking of the patient. (Categorical).

Passive Smoker : The level of passive smoker of the patient. (Categorical).

Chest Pain : The level of chest pain of the patient. (Categorical).

Coughing of Blood : The level of coughing of blood of the patient. (Categorical).

Fatigue : The level of fatigue of the patient. (Categorical).

Weight Loss : The level of weight loss of the patient. (Categorical).

Shortness of Breath : The level of shortness of breath of the patient. (Categorical).

Wheezing : The level of wheezing of the patient. (Categorical).

Swallowing Difficulty : The level of swallowing difficulty of the patient. (Categorical).

Clubbing of Finger Nails : The level of clubbing of finger nails of the patient. (Categorical).

3 Import Libraries

[250]:
```
import numpy as np
import pandas as pd
import matplotlib.pyplot as plt
import seaborn as sns
import scipy.stats as stats
import pylab

from sklearn.model_selection import train_test_split, cross_val_score
from sklearn.preprocessing import LabelEncoder,StandardScaler

from sklearn.feature_selection import mutual_info_classif

from sklearn.decomposition import PCA

from sklearn.linear_model import LogisticRegression
from sklearn.tree import DecisionTreeClassifier
from sklearn.ensemble import RandomForestClassifier,GradientBoostingClassifier
from sklearn.neighbors import KNeighborsClassifier
from sklearn.svm import SVC
import xgboost

from sklearn.metrics import accuracy_score, classification_report,␣
 ↪confusion_matrix, roc_curve, auc
```

4 Load Dataset

[111]:
```
df = pd.read_csv("/content/drive/MyDrive/Datasets/Lung Cancer Dataset/cancer␣
↪patient data sets.csv")
df.head()
```

[111]:

	index	Patient Id	Age	Gender	Air Pollution	Alcohol use	Dust Allergy	\
0	0	P1	33	1	2	4	5	
1	1	P10	17	1	3	1	5	
2	2	P100	35	1	4	5	6	
3	3	P1000	37	1	7	7	7	
4	4	P101	46	1	6	8	7	

	OccuPational Hazards	Genetic Risk	chronic Lung Disease	…	Fatigue	\
0	4	3	2	…	3	
1	3	4	2	…	1	
2	5	5	4	…	8	
3	7	6	7	…	4	
4	7	7	6	…	3	

	Weight Loss	Shortness of Breath	Wheezing	Swallowing Difficulty	\
0	4	2	2	3	
1	3	7	8	6	
2	7	9	2	1	
3	2	3	1	4	
4	2	4	1	4	

	Clubbing of Finger Nails	Frequent Cold	Dry Cough	Snoring	Level
0	1	2	3	4	Low
1	2	1	7	2	Medium
2	4	6	7	2	High
3	5	6	7	5	High
4	2	4	2	3	High

[5 rows x 26 columns]

[112]:
```
df.shape
```

[112]: (1000, 26)

[113]:
```
df.columns
```

[113]:
```
Index(['index', 'Patient Id', 'Age', 'Gender', 'Air Pollution', 'Alcohol use',
       'Dust Allergy', 'OccuPational Hazards', 'Genetic Risk',
       'chronic Lung Disease', 'Balanced Diet', 'Obesity', 'Smoking',
       'Passive Smoker', 'Chest Pain', 'Coughing of Blood', 'Fatigue',
       'Weight Loss', 'Shortness of Breath', 'Wheezing',
```

```
       'Swallowing Difficulty', 'Clubbing of Finger Nails', 'Frequent Cold',
       'Dry Cough', 'Snoring', 'Level'],
      dtype='object')
```

[114]:
```
df.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 1000 entries, 0 to 999
Data columns (total 26 columns):
 #   Column                    Non-Null Count  Dtype
---  ------                    --------------  -----
 0   index                     1000 non-null   int64
 1   Patient Id                1000 non-null   object
 2   Age                       1000 non-null   int64
 3   Gender                    1000 non-null   int64
 4   Air Pollution             1000 non-null   int64
 5   Alcohol use               1000 non-null   int64
 6   Dust Allergy              1000 non-null   int64
 7   OccuPational Hazards      1000 non-null   int64
 8   Genetic Risk              1000 non-null   int64
 9   chronic Lung Disease      1000 non-null   int64
 10  Balanced Diet             1000 non-null   int64
 11  Obesity                   1000 non-null   int64
 12  Smoking                   1000 non-null   int64
 13  Passive Smoker            1000 non-null   int64
 14  Chest Pain                1000 non-null   int64
 15  Coughing of Blood         1000 non-null   int64
 16  Fatigue                   1000 non-null   int64
 17  Weight Loss               1000 non-null   int64
 18  Shortness of Breath       1000 non-null   int64
 19  Wheezing                  1000 non-null   int64
 20  Swallowing Difficulty     1000 non-null   int64
 21  Clubbing of Finger Nails  1000 non-null   int64
 22  Frequent Cold             1000 non-null   int64
 23  Dry Cough                 1000 non-null   int64
 24  Snoring                   1000 non-null   int64
 25  Level                     1000 non-null   object
dtypes: int64(24), object(2)
memory usage: 203.2+ KB
```

[115]:
```
df.describe()
```

[115]:

	index	Age	Gender	Air Pollution	Alcohol use	\
count	1000.000000	1000.000000	1000.000000	1000.0000	1000.000000	
mean	499.500000	37.174000	1.402000	3.8400	4.563000	
std	288.819436	12.005493	0.490547	2.0304	2.620477	
min	0.000000	14.000000	1.000000	1.0000	1.000000	

25%	249.750000	27.750000	1.000000	2.0000	2.000000
50%	499.500000	36.000000	1.000000	3.0000	5.000000
75%	749.250000	45.000000	2.000000	6.0000	7.000000
max	999.000000	73.000000	2.000000	8.0000	8.000000

	Dust Allergy	OccuPational Hazards	Genetic Risk	chronic Lung Disease	\
count	1000.000000	1000.000000	1000.000000	1000.000000	
mean	5.165000	4.840000	4.580000	4.380000	
std	1.980833	2.107805	2.126999	1.848518	
min	1.000000	1.000000	1.000000	1.000000	
25%	4.000000	3.000000	2.000000	3.000000	
50%	6.000000	5.000000	5.000000	4.000000	
75%	7.000000	7.000000	7.000000	6.000000	
max	8.000000	8.000000	7.000000	7.000000	

	Balanced Diet	…	Coughing of Blood	Fatigue	Weight Loss	\
count	1000.000000	…	1000.000000	1000.000000	1000.000000	
mean	4.491000	…	4.859000	3.856000	3.855000	
std	2.135528	…	2.427965	2.244616	2.206546	
min	1.000000	…	1.000000	1.000000	1.000000	
25%	2.000000	…	3.000000	2.000000	2.000000	
50%	4.000000	…	4.000000	3.000000	3.000000	
75%	7.000000	…	7.000000	5.000000	6.000000	
max	7.000000	…	9.000000	9.000000	8.000000	

	Shortness of Breath	Wheezing	Swallowing Difficulty	\
count	1000.000000	1000.000000	1000.000000	
mean	4.240000	3.777000	3.746000	
std	2.285087	2.041921	2.270383	
min	1.000000	1.000000	1.000000	
25%	2.000000	2.000000	2.000000	
50%	4.000000	4.000000	4.000000	
75%	6.000000	5.000000	5.000000	
max	9.000000	8.000000	8.000000	

	Clubbing of Finger Nails	Frequent Cold	Dry Cough	Snoring
count	1000.000000	1000.000000	1000.000000	1000.000000
mean	3.923000	3.536000	3.853000	2.926000
std	2.388048	1.832502	2.039007	1.474686
min	1.000000	1.000000	1.000000	1.000000
25%	2.000000	2.000000	2.000000	2.000000
50%	4.000000	3.000000	4.000000	3.000000
75%	5.000000	5.000000	6.000000	4.000000
max	9.000000	7.000000	7.000000	7.000000

[8 rows x 24 columns]

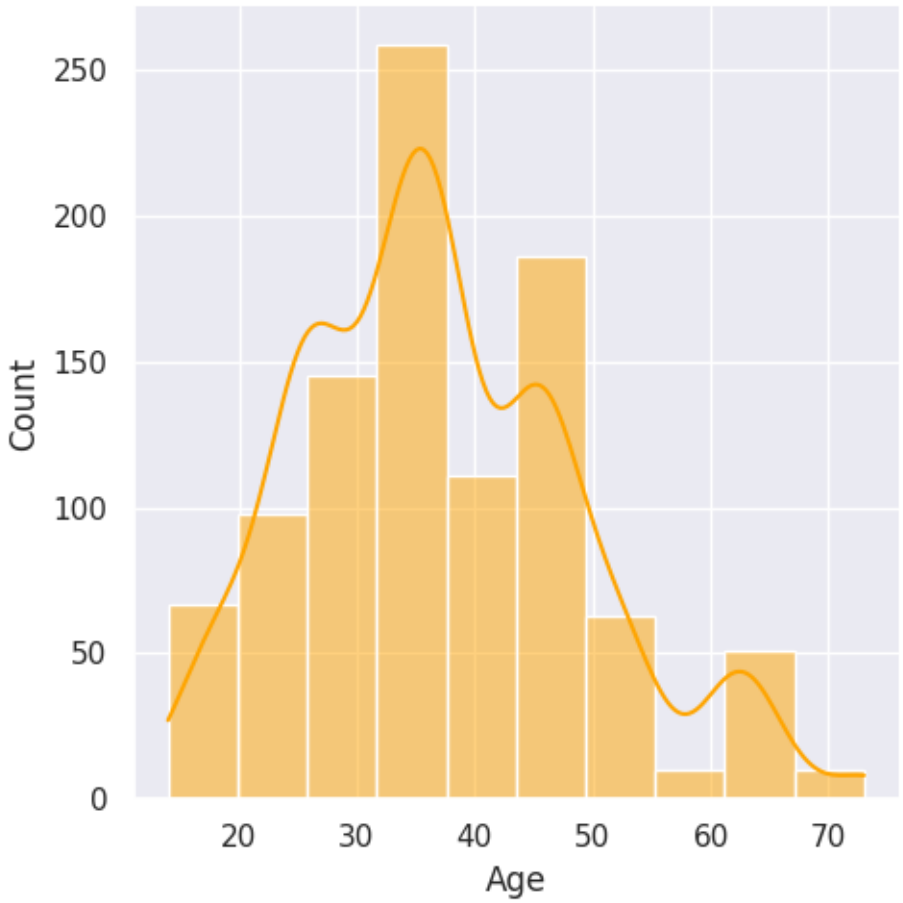
5 Univeriate Analysis

[116]:
```
df.info()
```

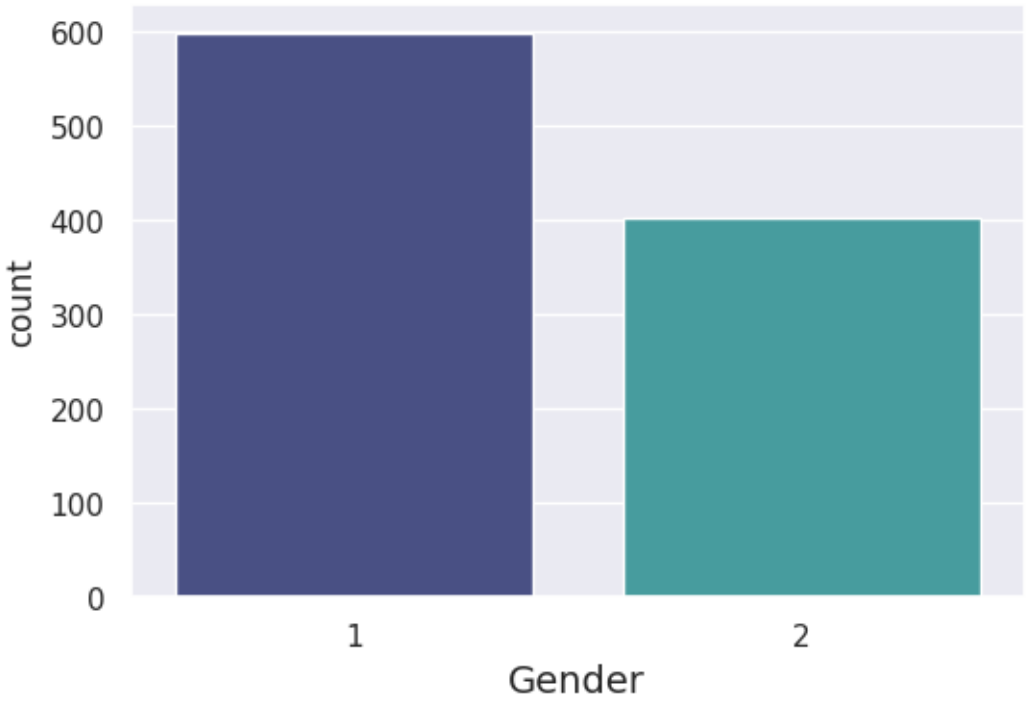
```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 1000 entries, 0 to 999
Data columns (total 26 columns):
 #   Column                    Non-Null Count  Dtype
---  ------                    --------------  -----
 0   index                     1000 non-null   int64
 1   Patient Id                1000 non-null   object
 2   Age                       1000 non-null   int64
 3   Gender                    1000 non-null   int64
 4   Air Pollution             1000 non-null   int64
 5   Alcohol use               1000 non-null   int64
 6   Dust Allergy              1000 non-null   int64
 7   OccuPational Hazards      1000 non-null   int64
 8   Genetic Risk              1000 non-null   int64
 9   chronic Lung Disease      1000 non-null   int64
 10  Balanced Diet             1000 non-null   int64
 11  Obesity                   1000 non-null   int64
 12  Smoking                   1000 non-null   int64
 13  Passive Smoker            1000 non-null   int64
 14  Chest Pain                1000 non-null   int64
 15  Coughing of Blood         1000 non-null   int64
 16  Fatigue                   1000 non-null   int64
 17  Weight Loss               1000 non-null   int64
 18  Shortness of Breath       1000 non-null   int64
 19  Wheezing                  1000 non-null   int64
 20  Swallowing Difficulty     1000 non-null   int64
 21  Clubbing of Finger Nails  1000 non-null   int64
 22  Frequent Cold             1000 non-null   int64
 23  Dry Cough                 1000 non-null   int64
 24  Snoring                   1000 non-null   int64
 25  Level                     1000 non-null   object
dtypes: int64(24), object(2)
memory usage: 203.2+ KB
```

[117]:
```
sns.set(rc={"figure.figsize":(6,4)})
sns.displot(df["Age"], kde=True, color="orange", bins=10)
```

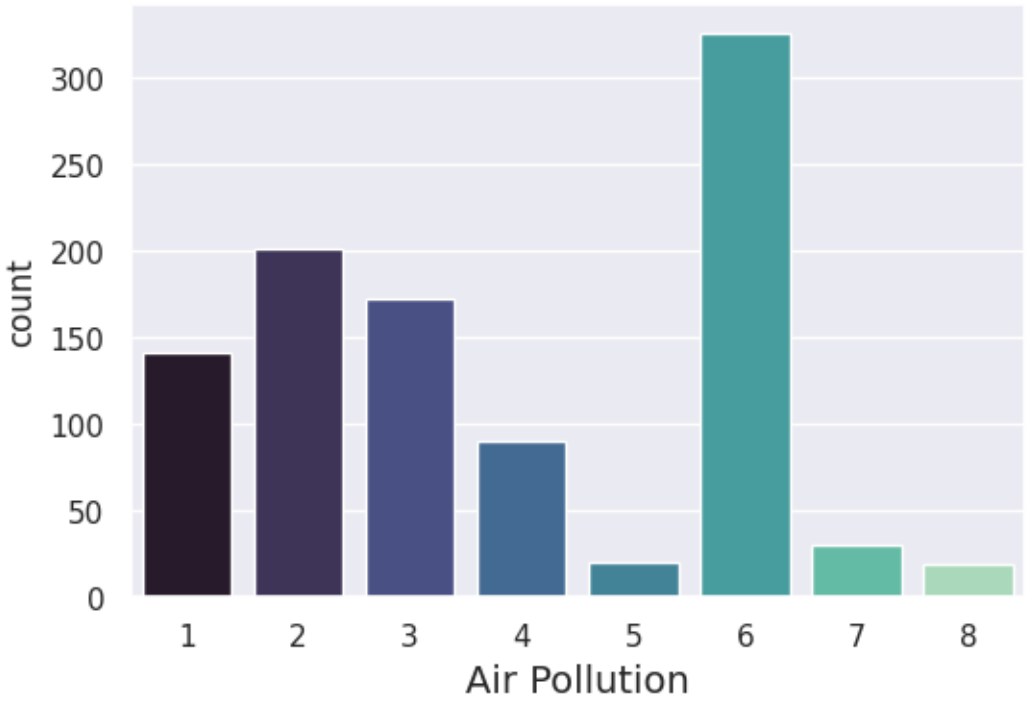
[117]:
```
<seaborn.axisgrid.FacetGrid at 0x7dcc2cc8d660>
```



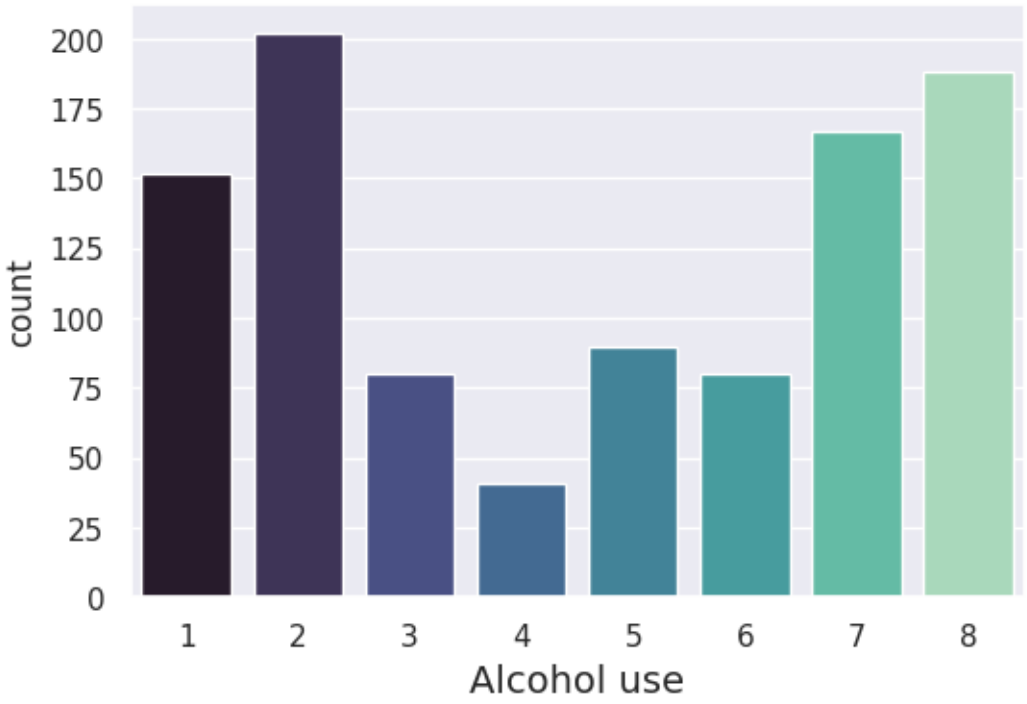
[118]:
```
plt.figure(figsize=(6,4))
sns.countplot(x = "Gender", data=df, palette="mako")
plt.xlabel("Gender", fontsize=14)
plt.show()
```



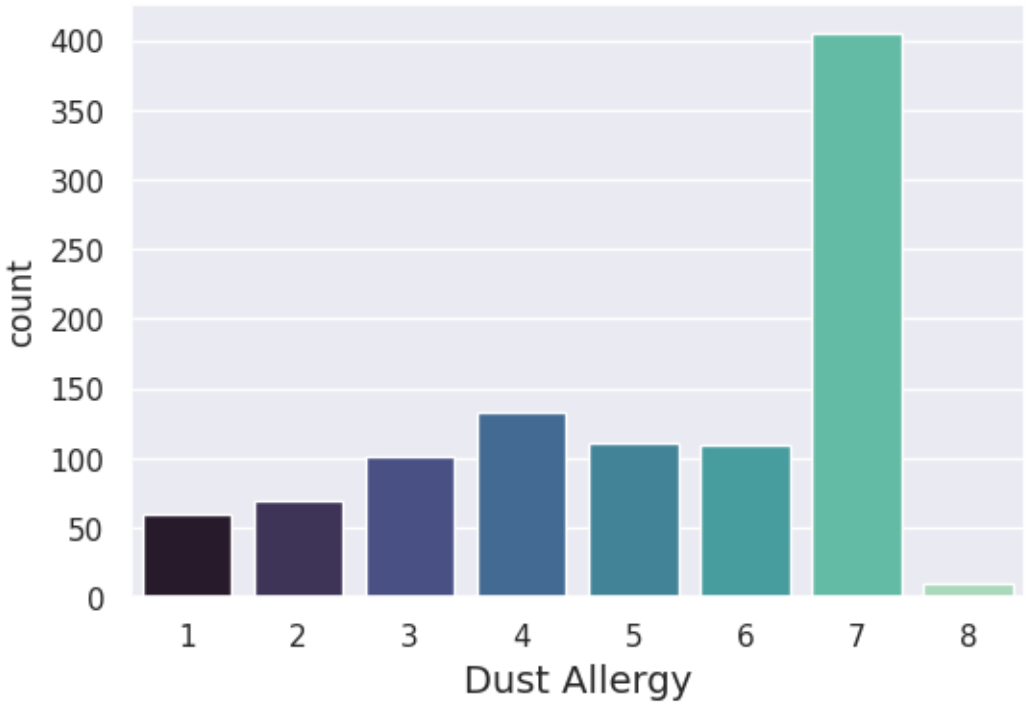
[119]:
```
plt.figure(figsize=(6,4))
sns.countplot(x="Air Pollution", data=df, palette="mako")
plt.xlabel("Air Pollution", fontsize=14)
plt.show()
```



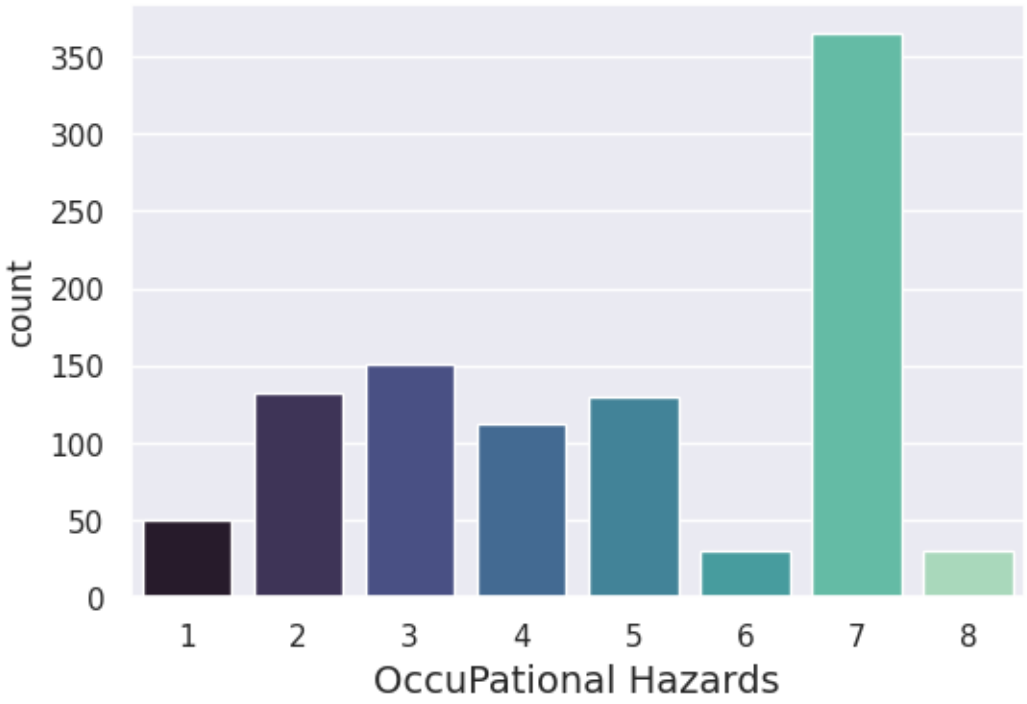
[120]:
```
plt.figure(figsize=(6,4))
sns.countplot(x="Alcohol use", data=df, palette="mako")
plt.xlabel("Alcohol use", fontsize=14)
plt.show()
```



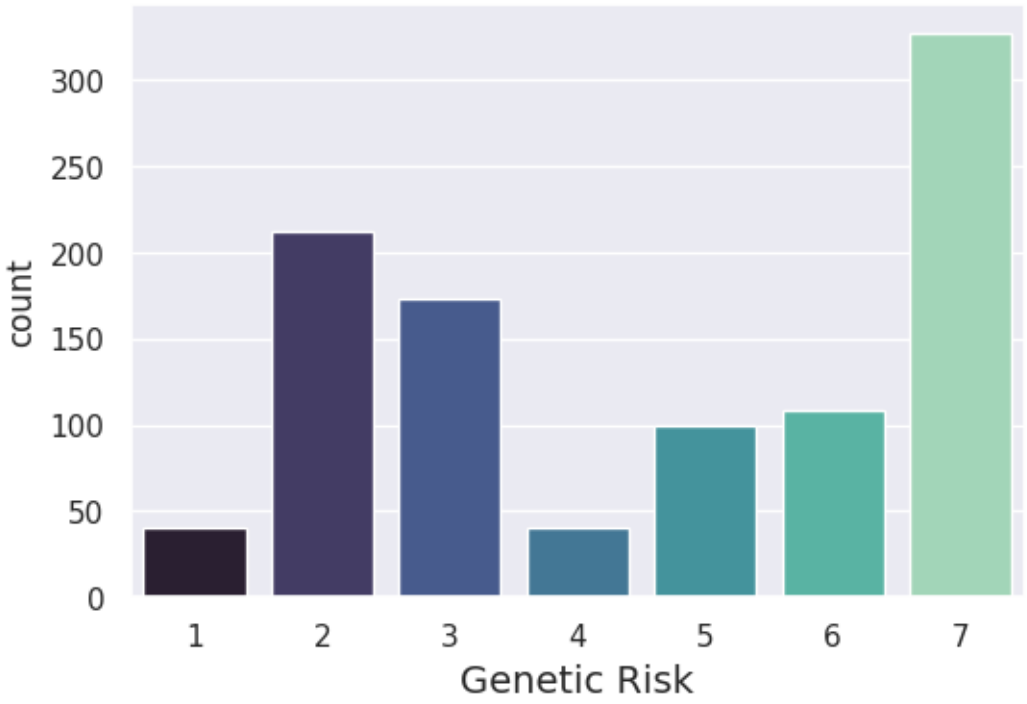
[121]:
```
plt.figure(figsize=(6,4))
sns.countplot(x="Dust Allergy", data=df, palette="mako")
plt.xlabel("Dust Allergy", fontsize=14)
plt.show()
```



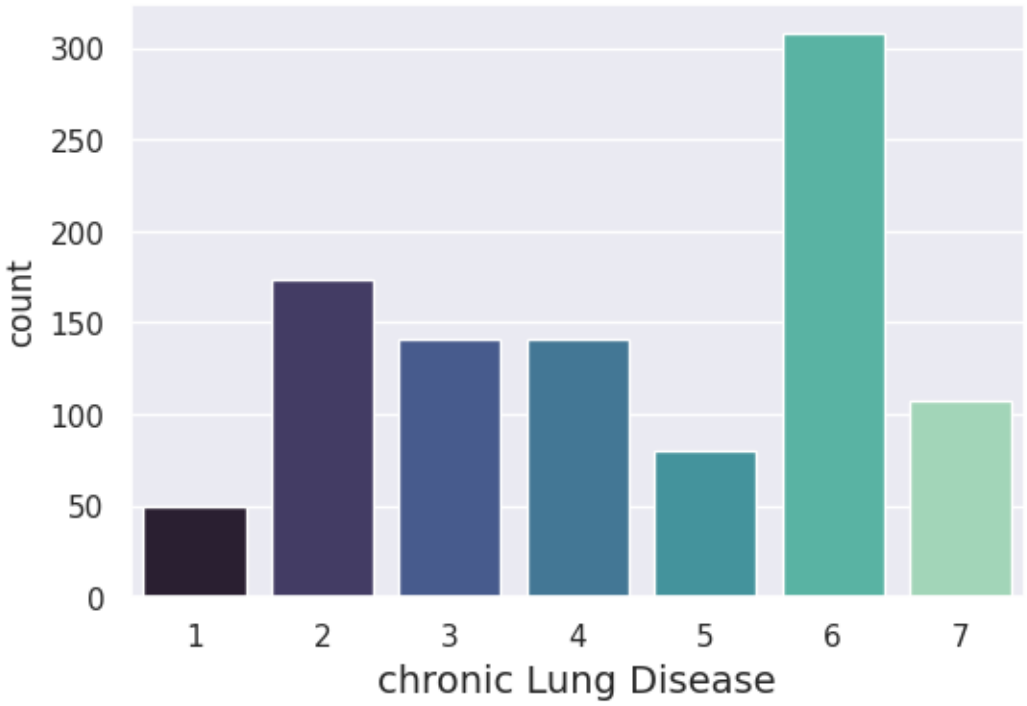
[122]:
```
plt.figure(figsize=(6,4))
sns.countplot(x="OccuPational Hazards", data=df, palette="mako")
plt.xlabel("OccuPational Hazards", fontsize=14)
plt.show()
```



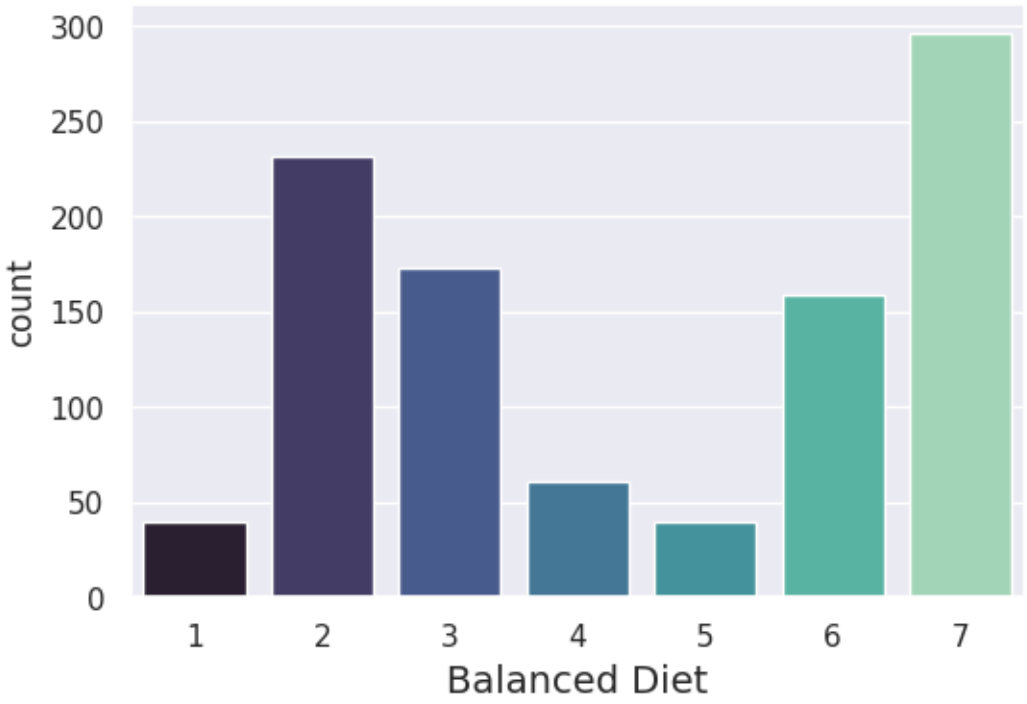
[123]:
```
plt.figure(figsize=(6,4))
sns.countplot(x="Genetic Risk", data=df, palette="mako")
plt.xlabel("Genetic Risk", fontsize=14)
plt.show()
```



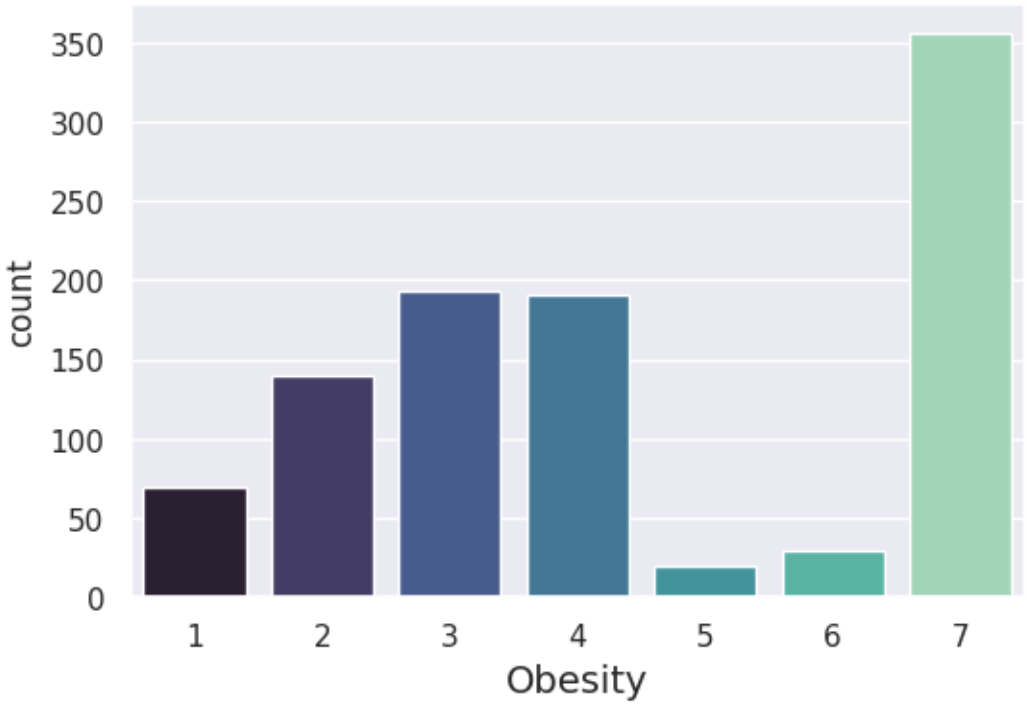
[124]:
```
plt.figure(figsize=(6,4))
sns.countplot(x="chronic Lung Disease", data=df, palette="mako")
plt.xlabel("chronic Lung Disease", fontsize=14)
plt.show()
```



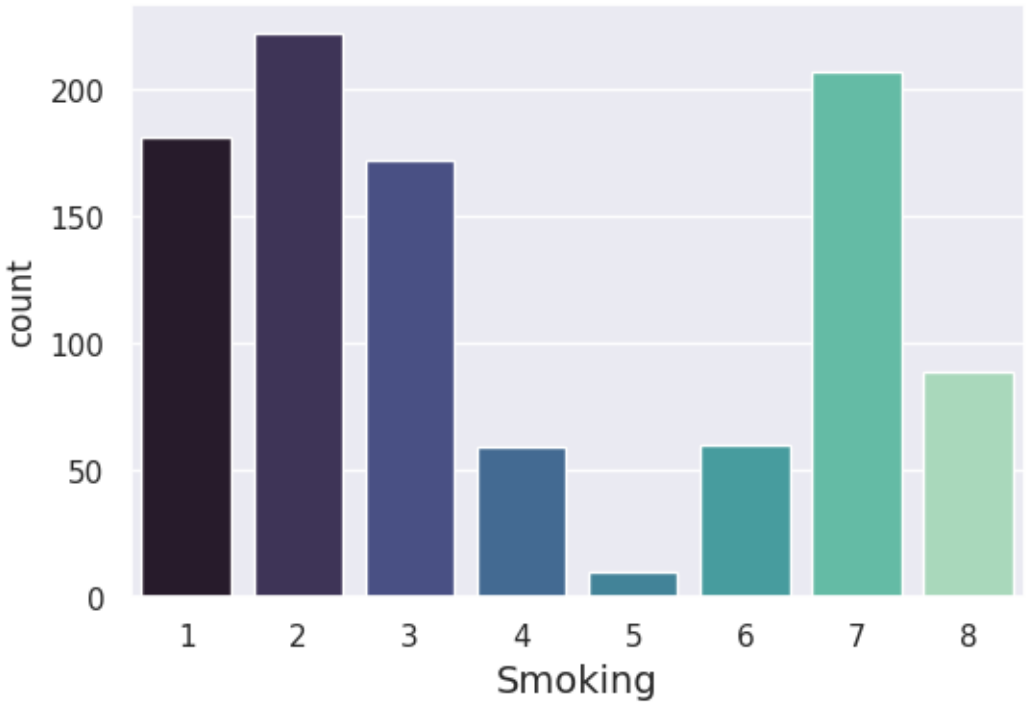
[125]:
```
plt.figure(figsize=(6,4))
sns.countplot(x="Balanced Diet", data=df, palette="mako")
plt.xlabel("Balanced Diet", fontsize=14)
plt.show()
```



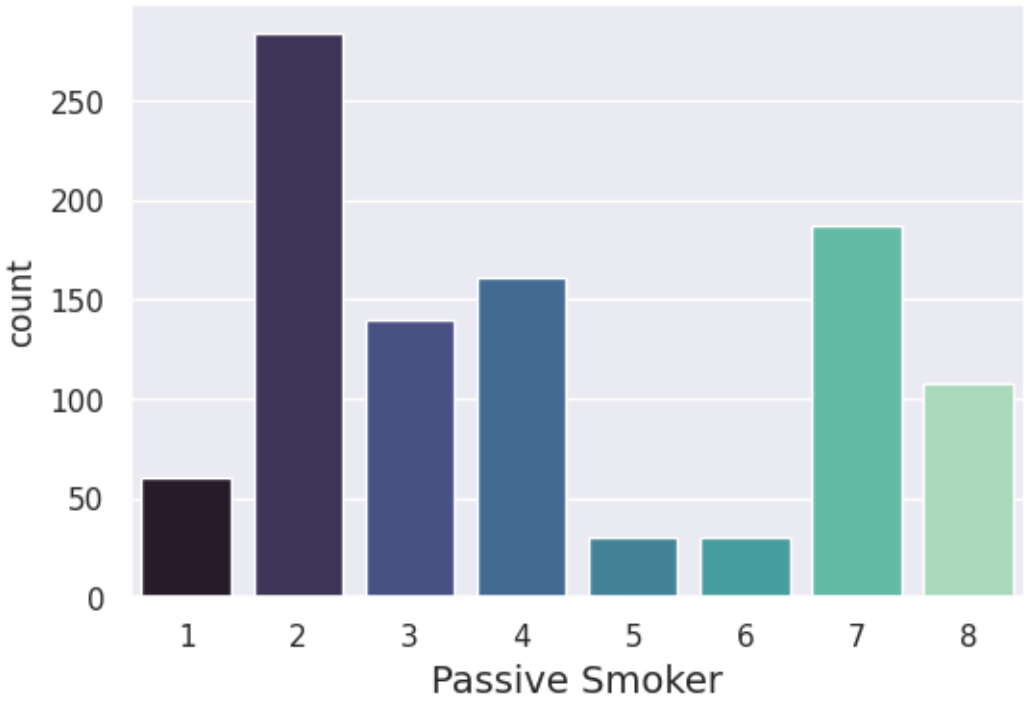
[126]:
```
plt.figure(figsize=(6,4))
sns.countplot(x="Obesity", data=df, palette="mako")
plt.xlabel("Obesity", fontsize=14)
plt.show()
```



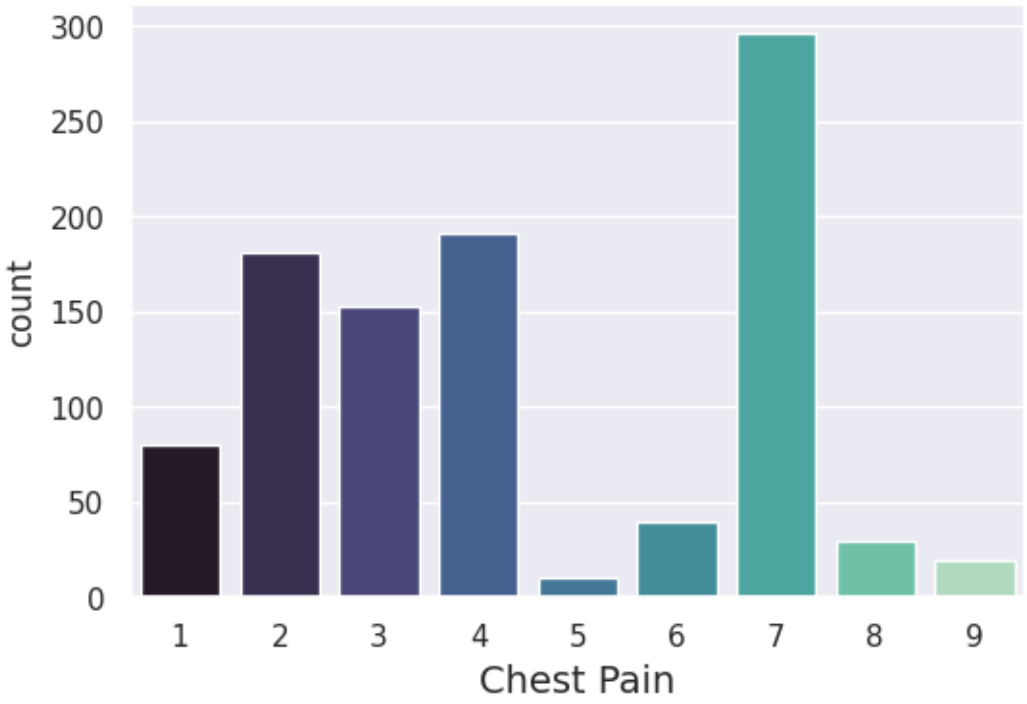
[127]:
```
plt.figure(figsize=(6,4))
sns.countplot(x="Smoking", data=df, palette="mako")
plt.xlabel("Smoking", fontsize=14)
plt.show()
```



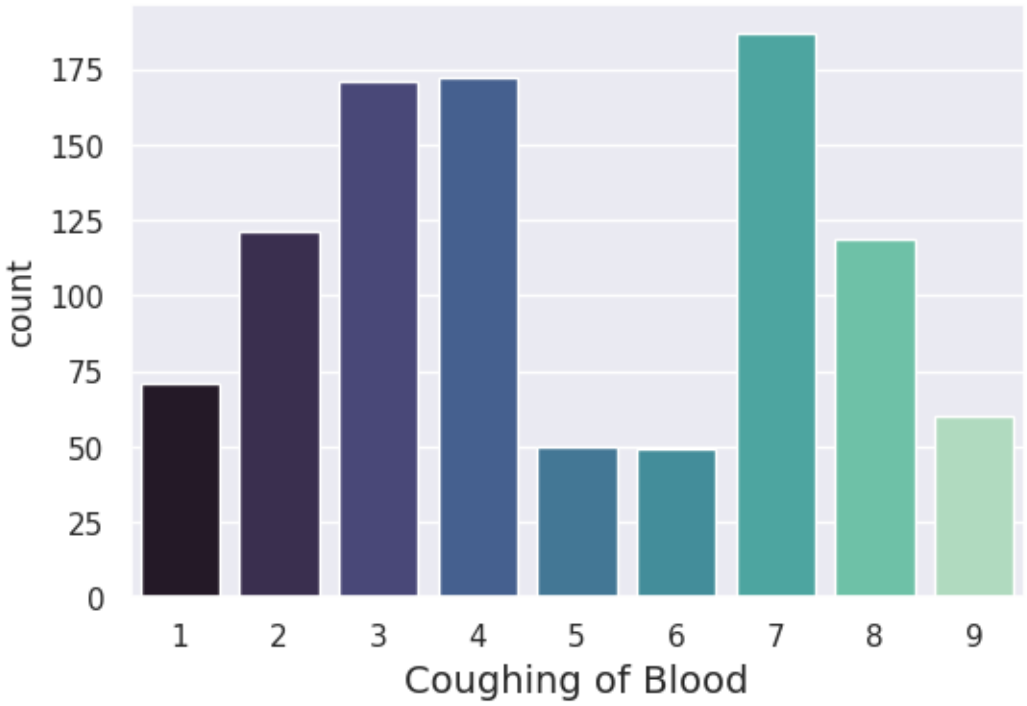
[128]:
```
plt.figure(figsize=(6,4))
sns.countplot(x="Passive Smoker", data=df, palette="mako")
plt.xlabel("Passive Smoker", fontsize=14)
plt.show()
```



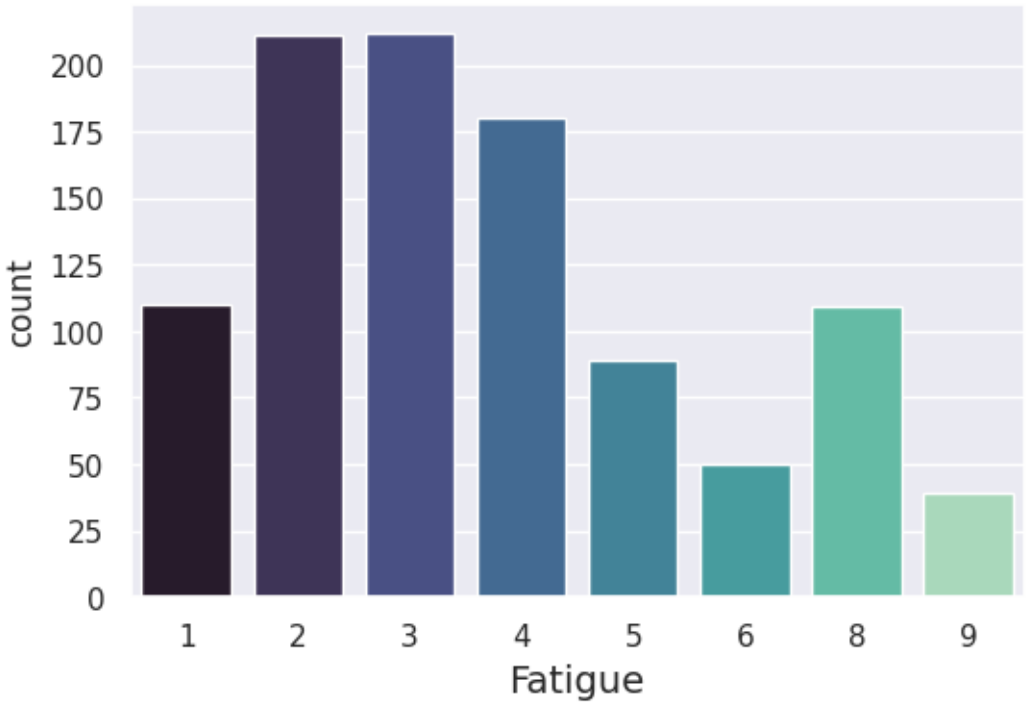
[129]:
```
plt.figure(figsize=(6,4))
sns.countplot(x="Chest Pain", data=df, palette="mako")
plt.xlabel("Chest Pain", fontsize=14)
plt.show()
```



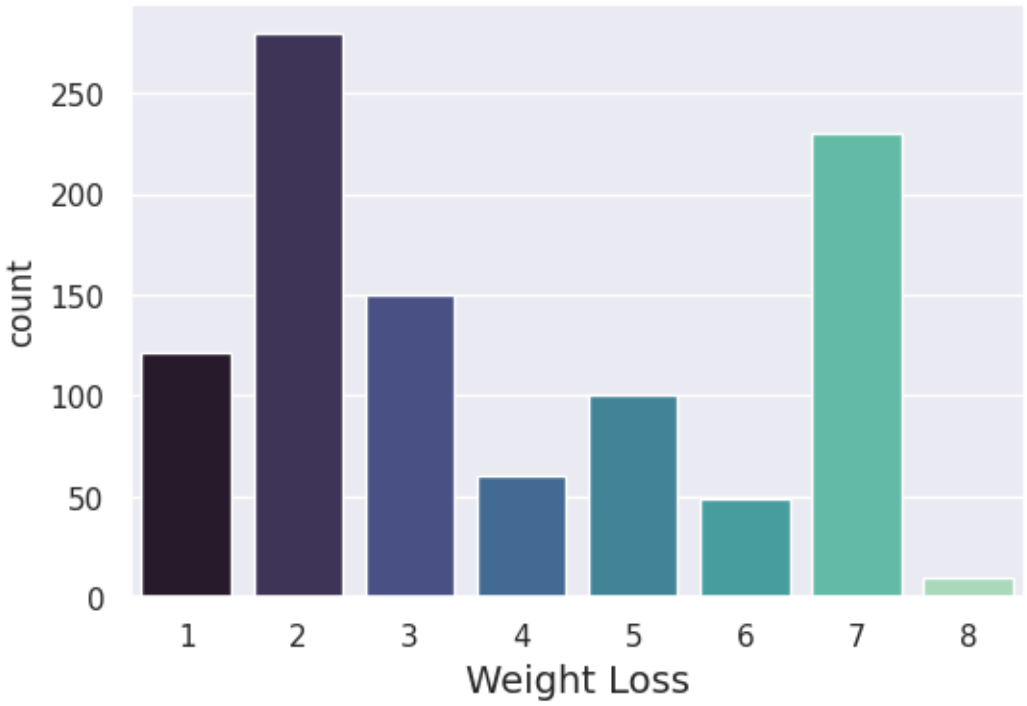
[130]:
```
plt.figure(figsize=(6,4))
sns.countplot(x="Coughing of Blood", data=df, palette="mako")
plt.xlabel("Coughing of Blood", fontsize=14)
plt.show()
```



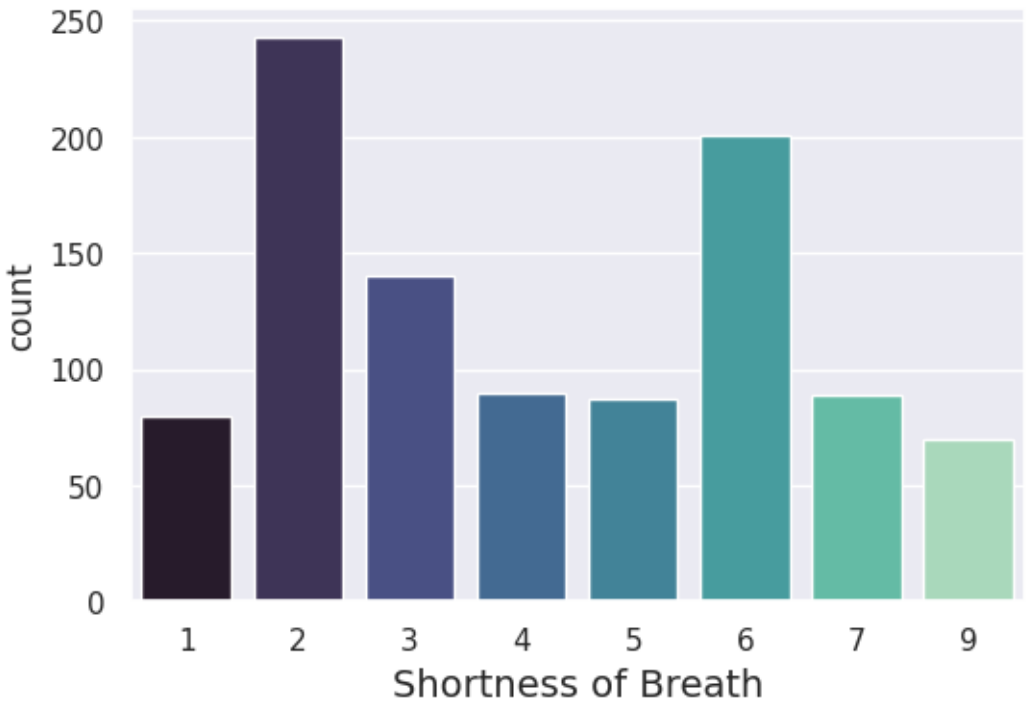
[131]:
```
plt.figure(figsize=(6,4))
sns.countplot(x="Fatigue", data=df, palette="mako")
plt.xlabel("Fatigue", fontsize=14)
plt.show()
```



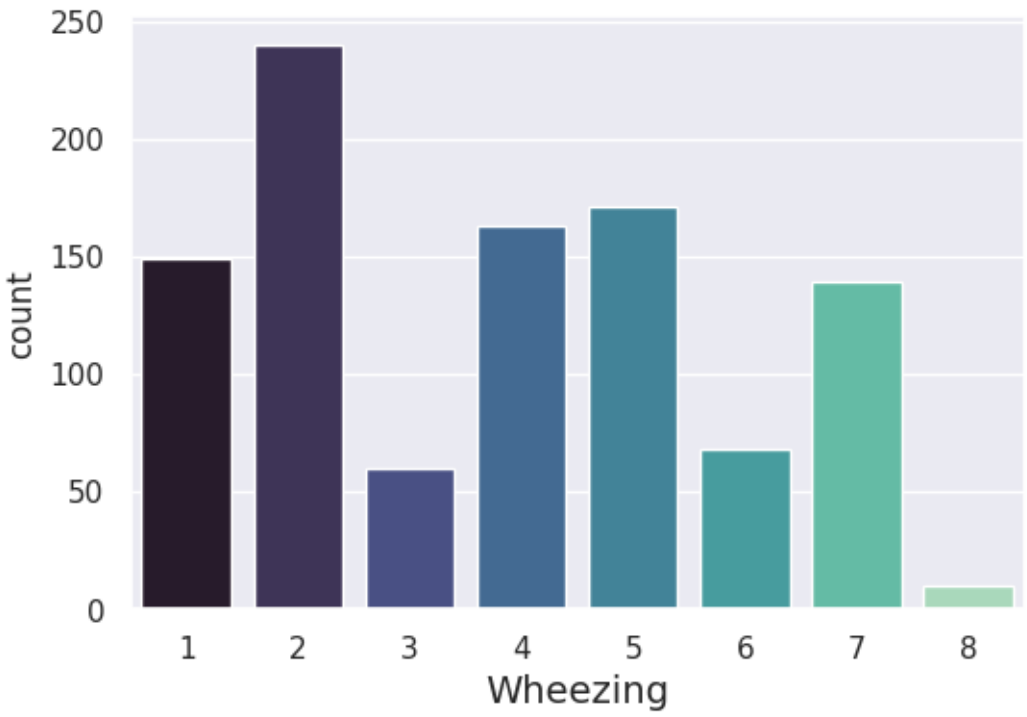
[132]:
```
plt.figure(figsize=(6,4))
sns.countplot(x="Weight Loss", data=df, palette="mako")
plt.xlabel("Weight Loss", fontsize=14)
plt.show()
```



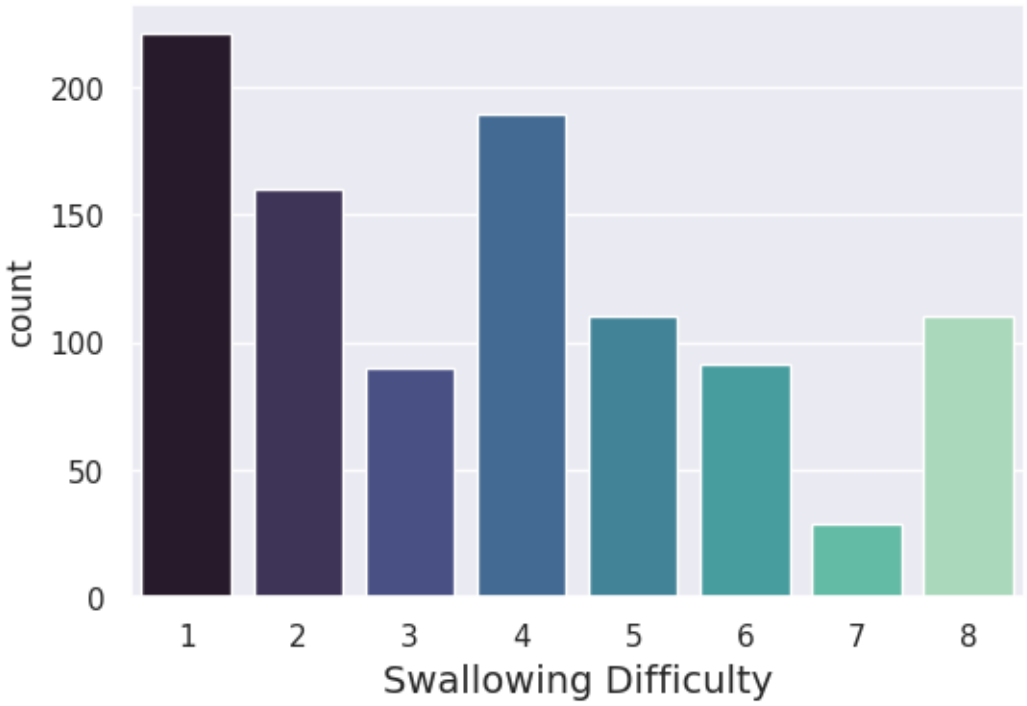
[133]:
```
plt.figure(figsize=(6,4))
sns.countplot(x="Shortness of Breath", data=df, palette="mako")
plt.xlabel("Shortness of Breath", fontsize=14)
plt.show()
```



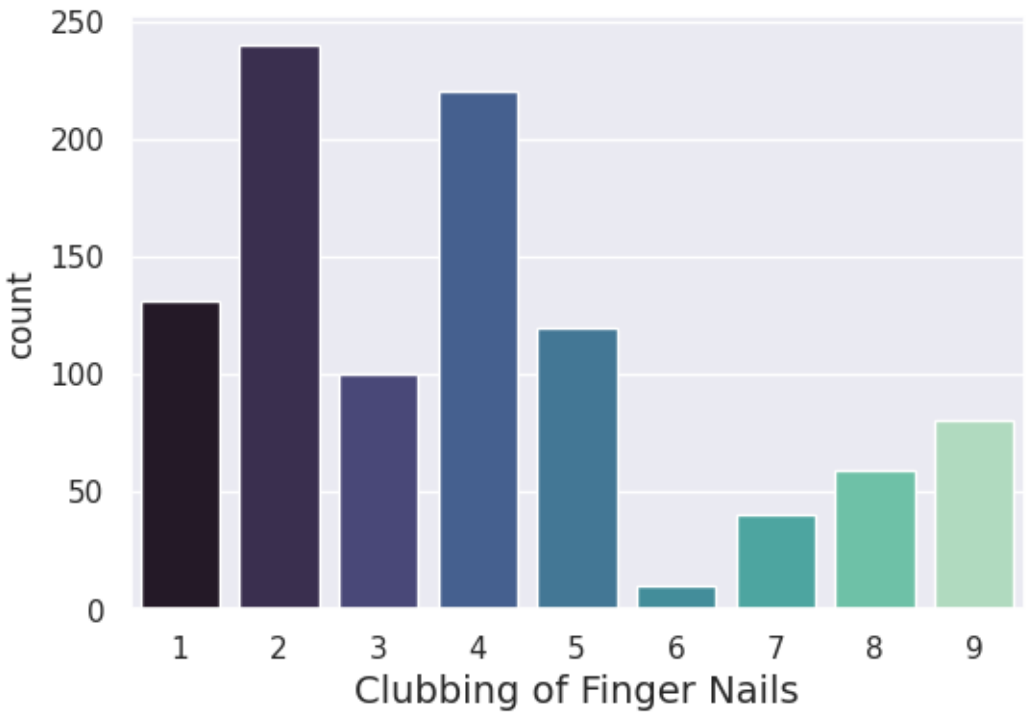
[134]:
```
plt.figure(figsize=(6,4))
sns.countplot(x="Wheezing", data=df, palette="mako")
plt.xlabel("Wheezing", fontsize=14)
plt.show()
```



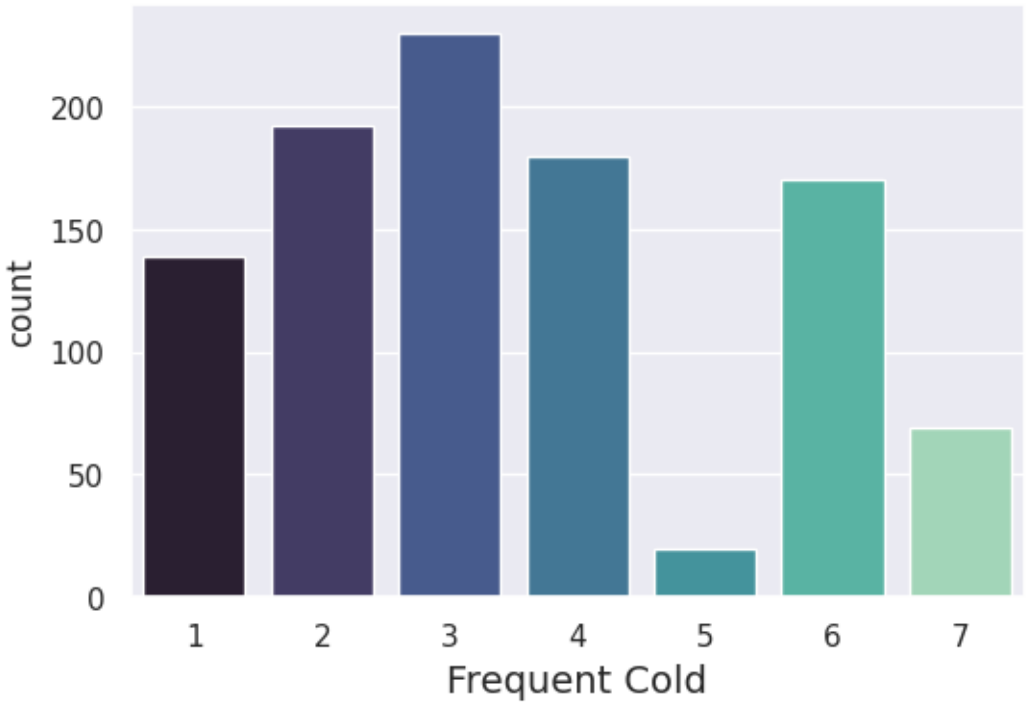
[135]:
```
plt.figure(figsize=(6,4))
sns.countplot(x="Swallowing Difficulty", data=df, palette="mako")
plt.xlabel("Swallowing Difficulty", fontsize=14)
plt.show()
```



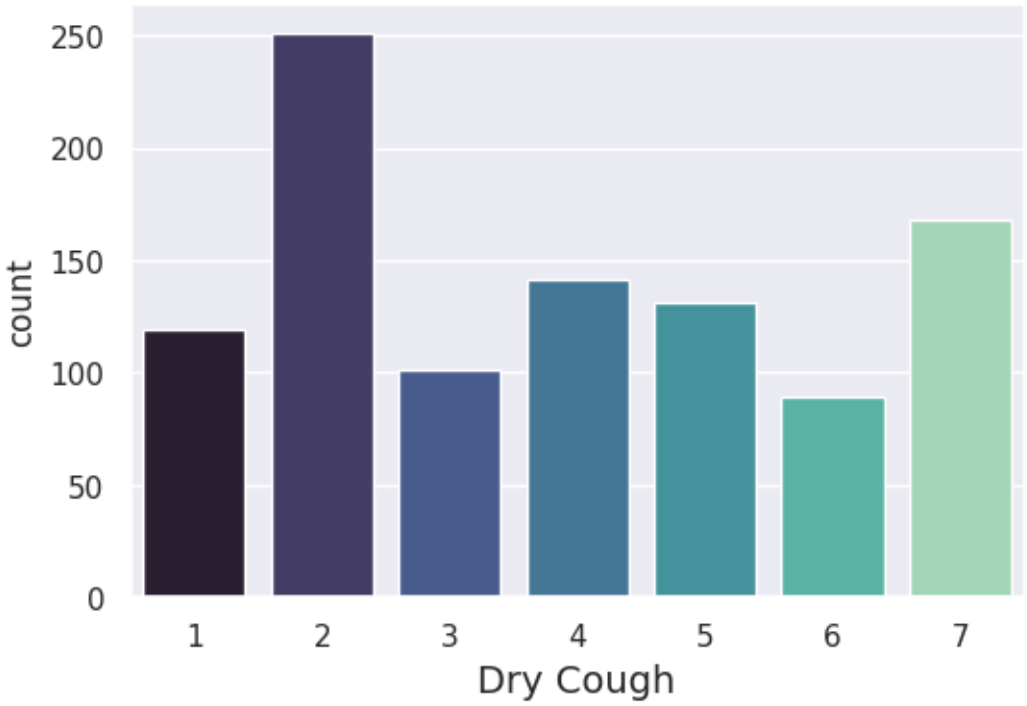
[136]:
```
plt.figure(figsize=(6,4))
sns.countplot(x="Clubbing of Finger Nails", data=df, palette="mako")
plt.xlabel("Clubbing of Finger Nails", fontsize=14)
plt.show()
```



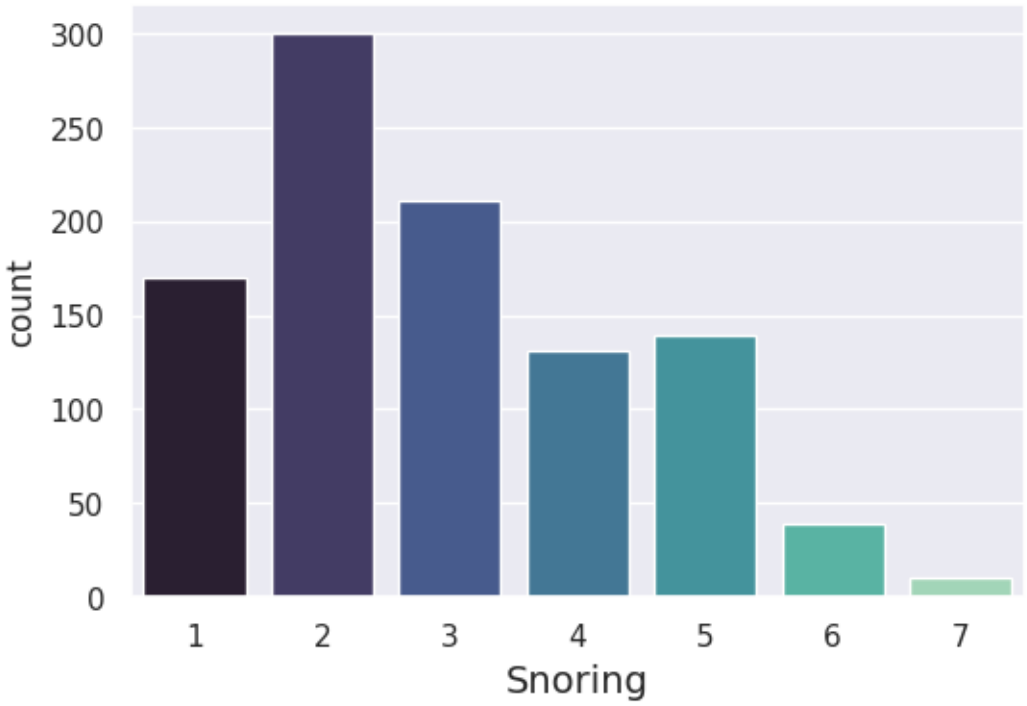
[137]:
```
plt.figure(figsize=(6,4))
sns.countplot(x="Frequent Cold", data=df, palette="mako")
plt.xlabel("Frequent Cold", fontsize=14)
plt.show()
```



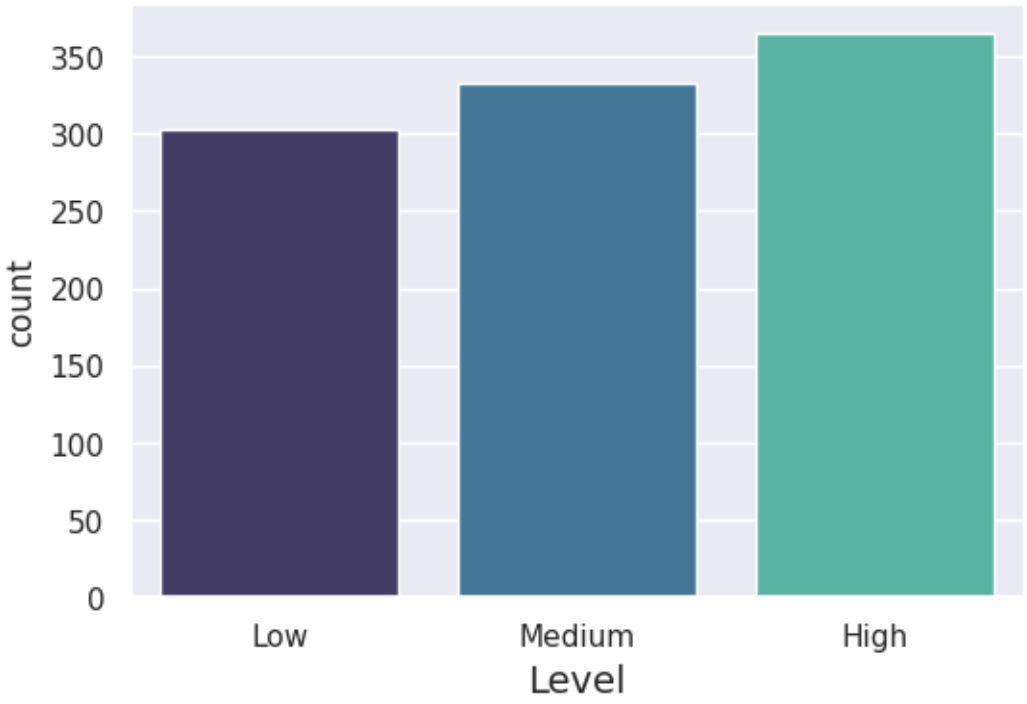
[138]:
```
plt.figure(figsize=(6,4))
sns.countplot(x="Dry Cough", data=df, palette="mako")
plt.xlabel("Dry Cough", fontsize=14)
plt.show()
```



[139]:
```
plt.figure(figsize=(6,4))
sns.countplot(x="Snoring", data=df, palette="mako")
plt.xlabel("Snoring", fontsize=14)
plt.show()
```



[140]:
```
plt.figure(figsize=(6,4))
sns.countplot(x="Level", data=df, palette="mako")
plt.xlabel("Level", fontsize=14)
plt.show()
```



6 EDA (Exploratory Data Analysis)

Check and Remove Duplicate

[141]:
```
duplicate = df.duplicated()
print(duplicate.sum())
```

```
0
```

Check and Remove NaN Values

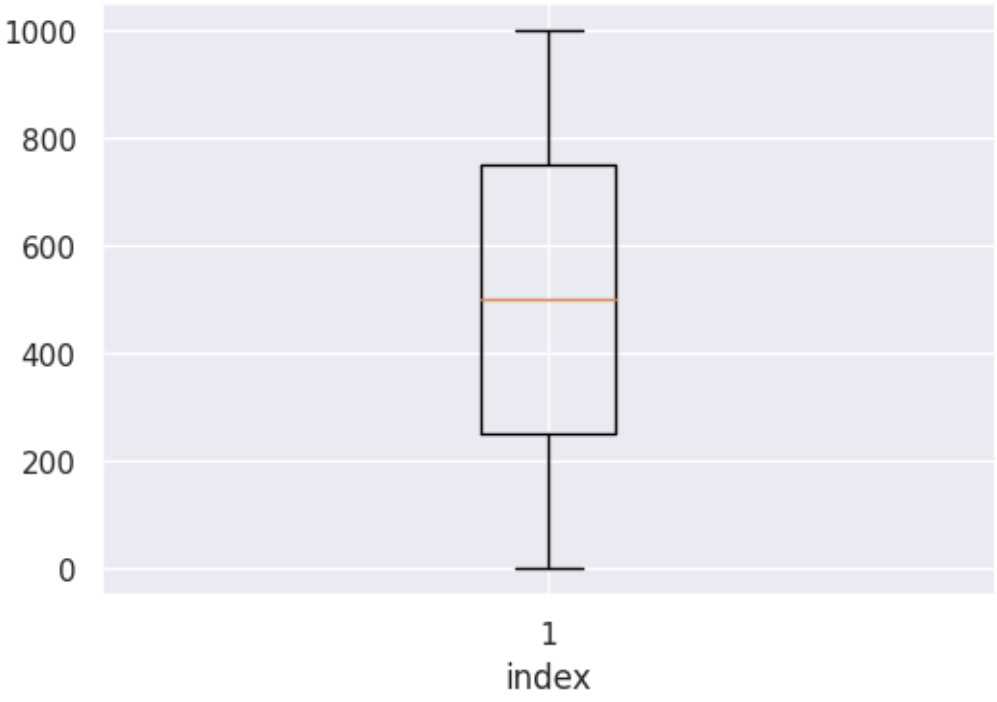
[142]:
```
df.isnull().sum()
```

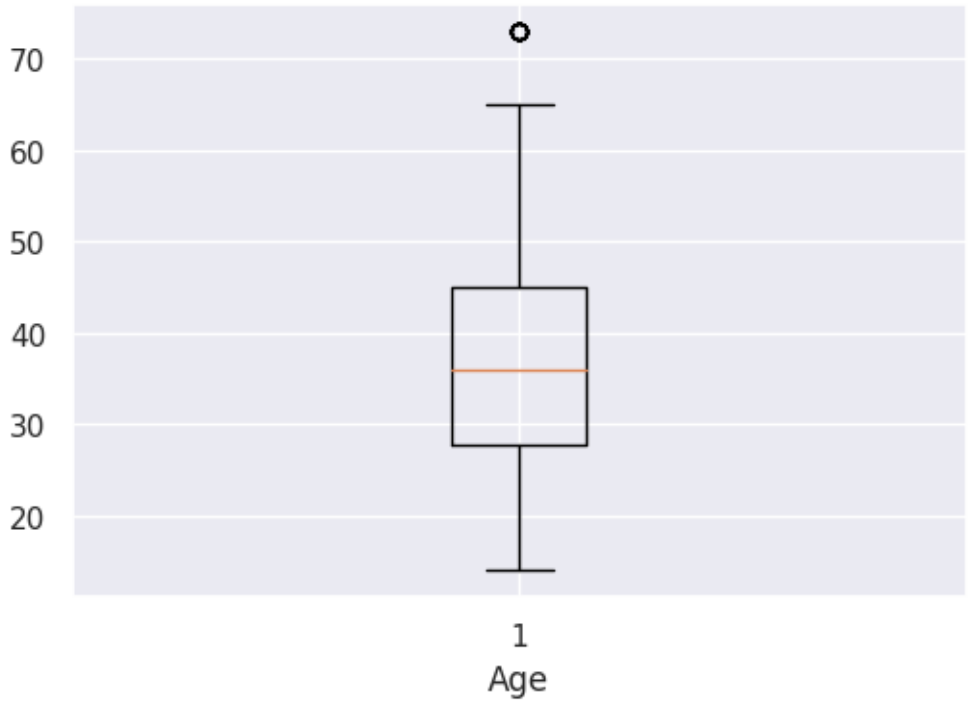
[142]:
```
index                     0
Patient Id                0
Age                       0
Gender                    0
Air Pollution             0
Alcohol use               0
Dust Allergy              0
OccuPational Hazards      0
Genetic Risk              0
chronic Lung Disease      0
Balanced Diet             0
Obesity                   0
```

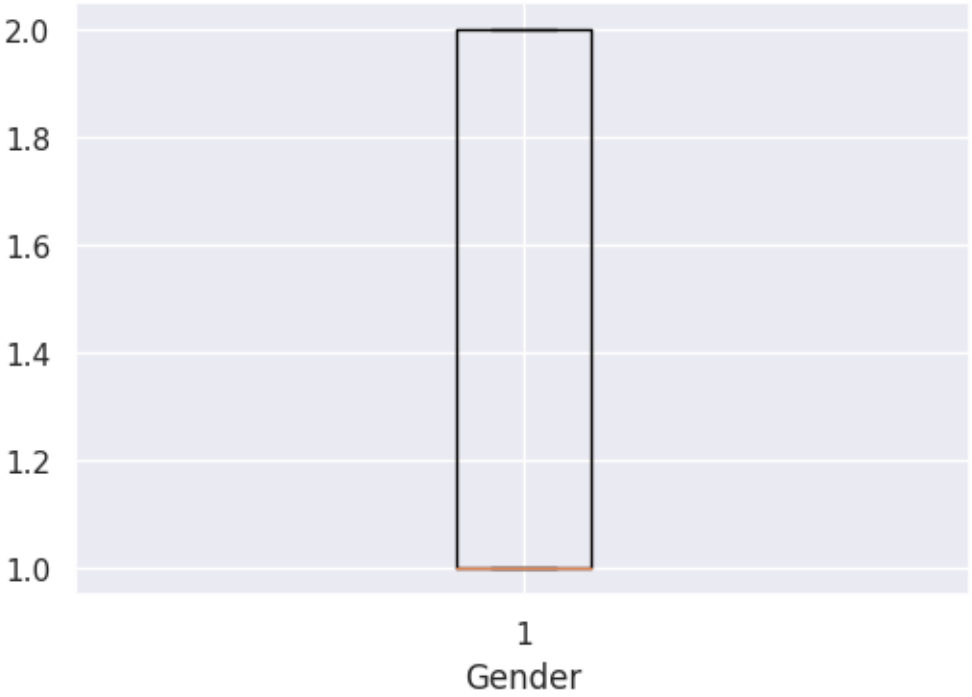
```
Smoking                    0
Passive Smoker             0
Chest Pain                 0
Coughing of Blood          0
Fatigue                    0
Weight Loss                0
Shortness of Breath        0
Wheezing                   0
Swallowing Difficulty      0
Clubbing of Finger Nails   0
Frequent Cold              0
Dry Cough                  0
Snoring                    0
Level                      0
dtype: int64
```

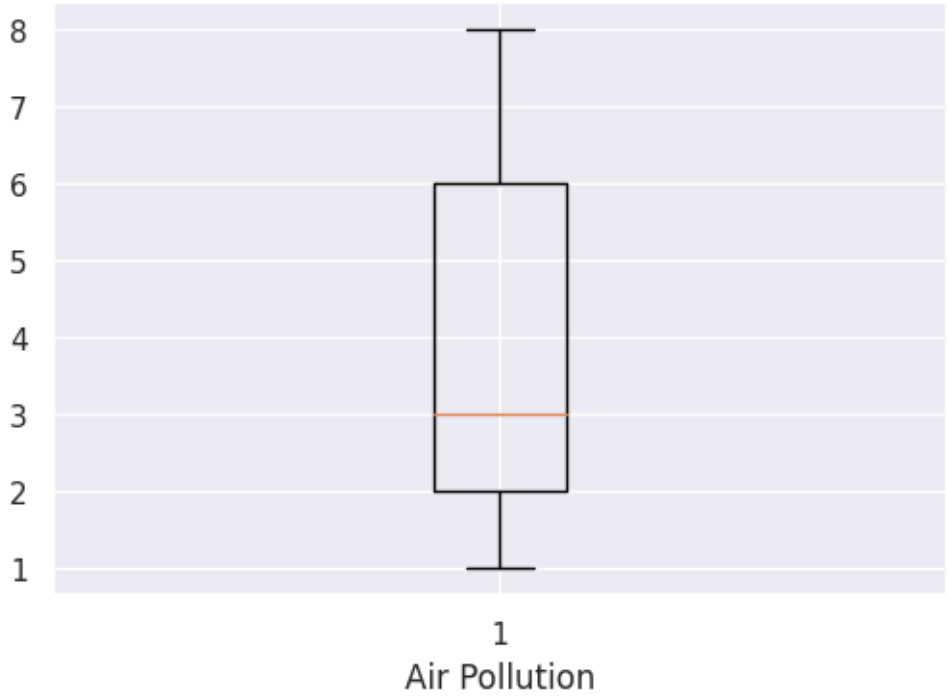
Remove Outlier

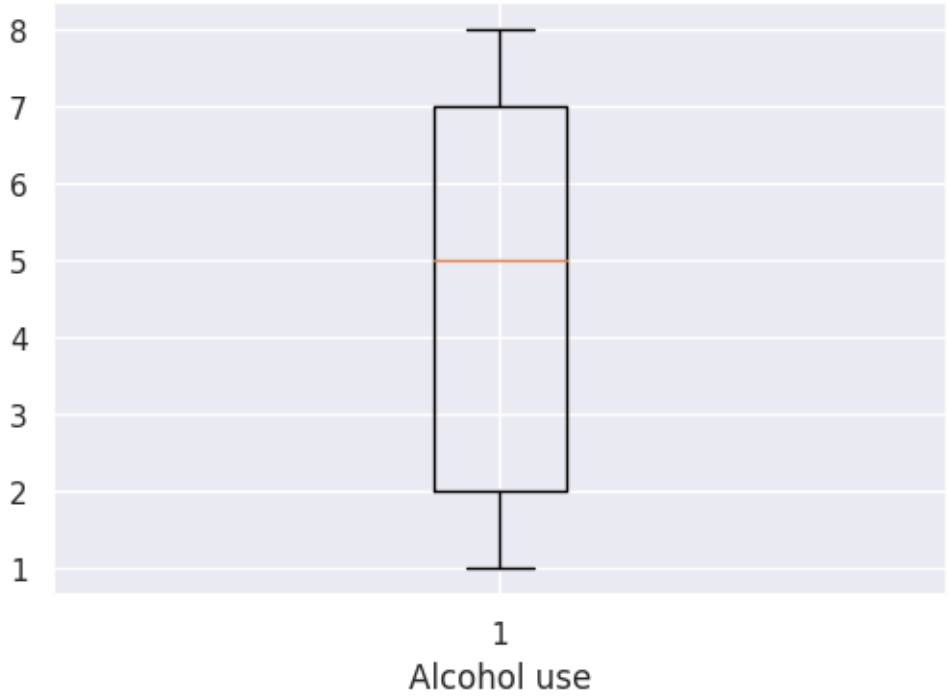
[143]:
```
num_cols =df.select_dtypes(["float64","int64"])
for i in num_cols.columns:
  plt.boxplot(df[i])
  plt.xlabel(i)
  plt.show()
```

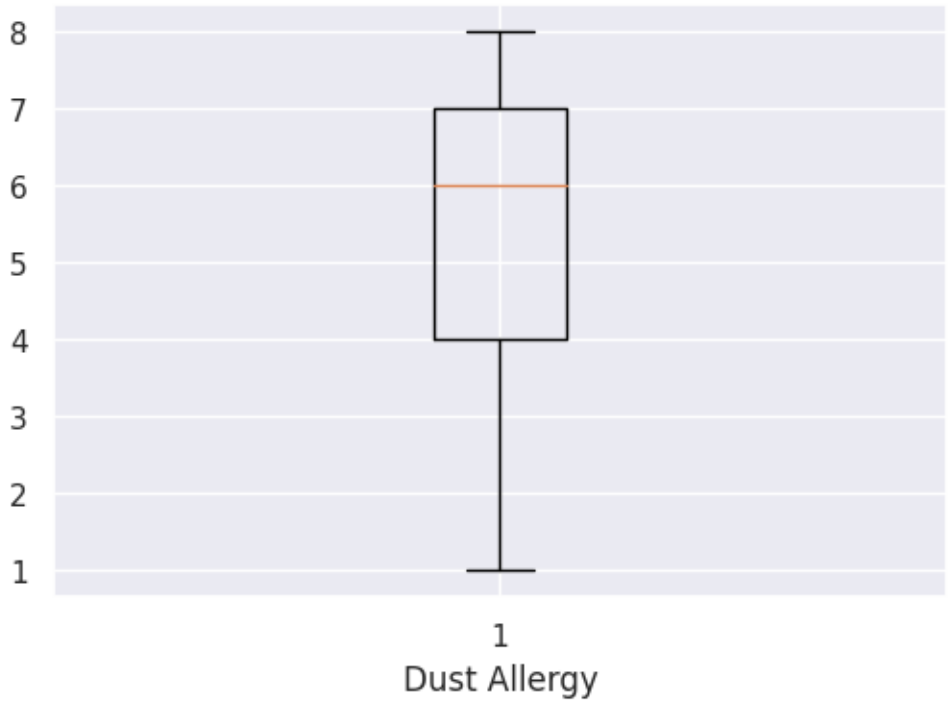


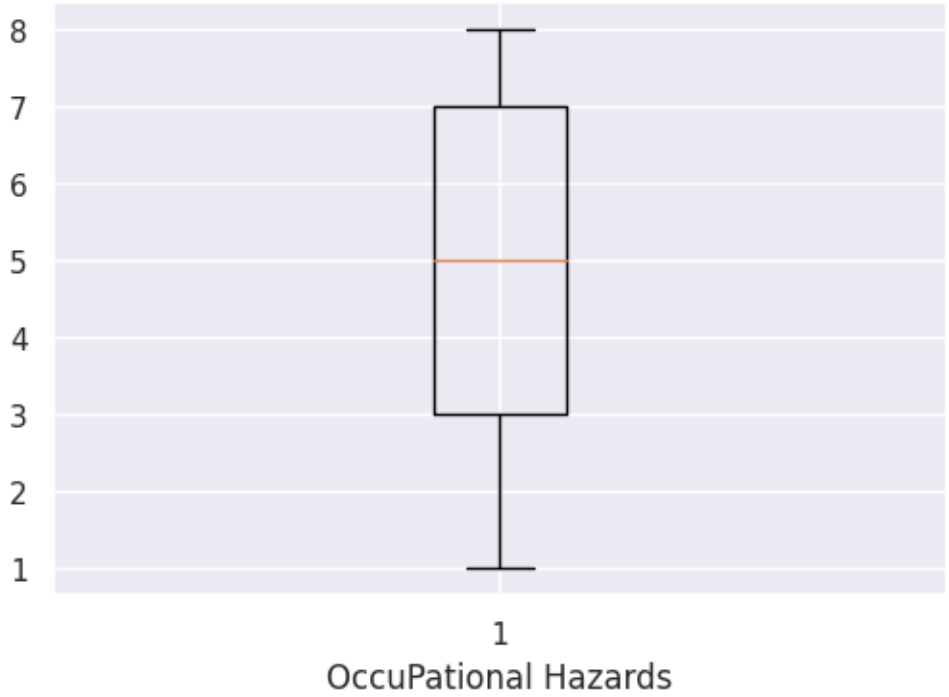

70
60
50
40
30
20
1
Age

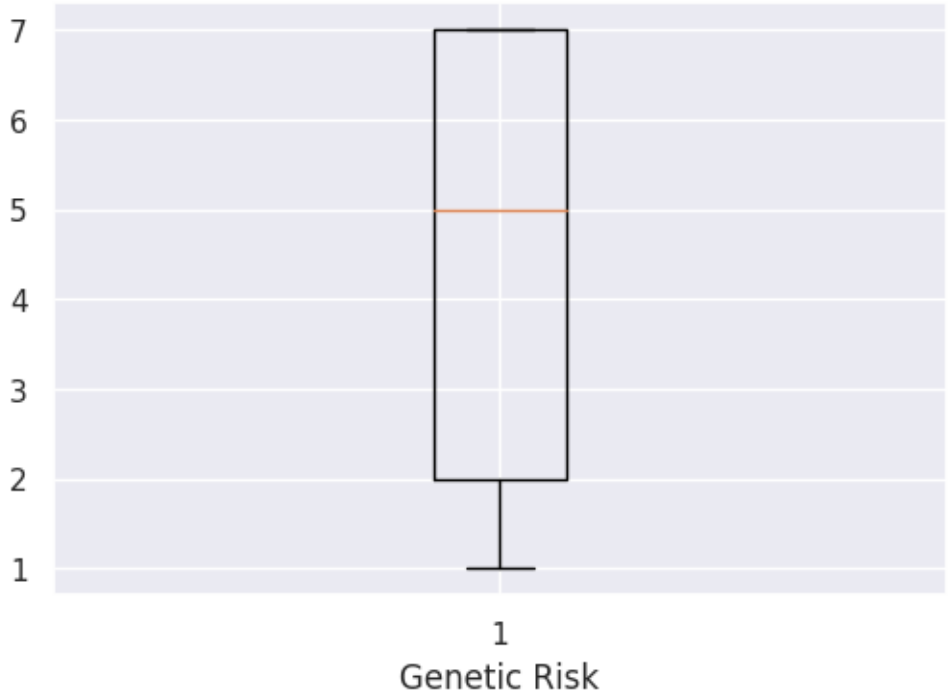

2.0
1.8
1.6
1.4
1.2
1.0
1
Gender

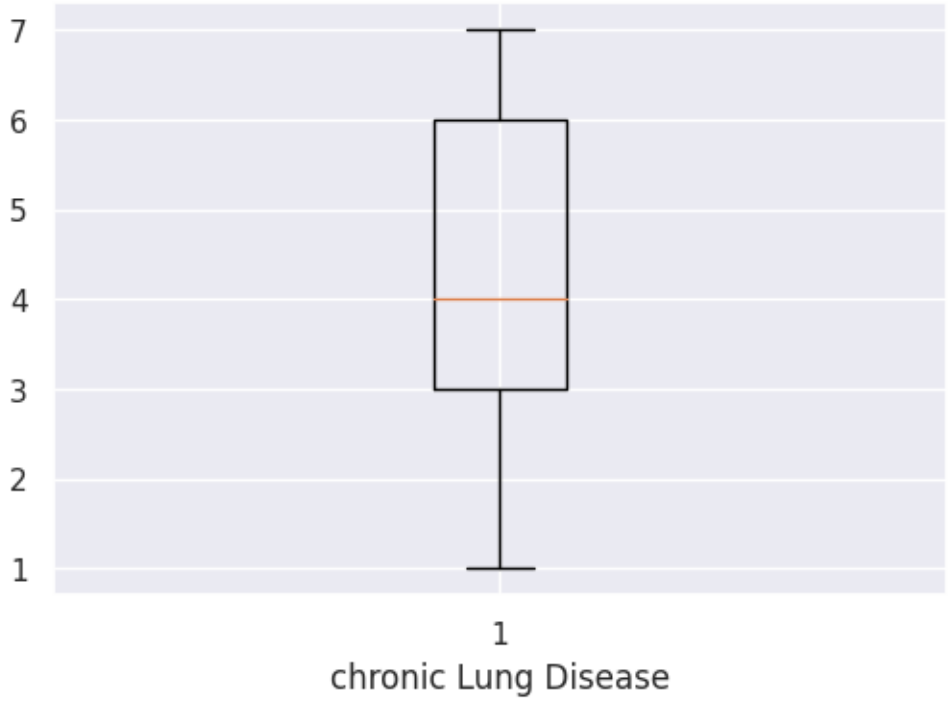

8
7
6
5
4
3
2
1
1
Air Pollution

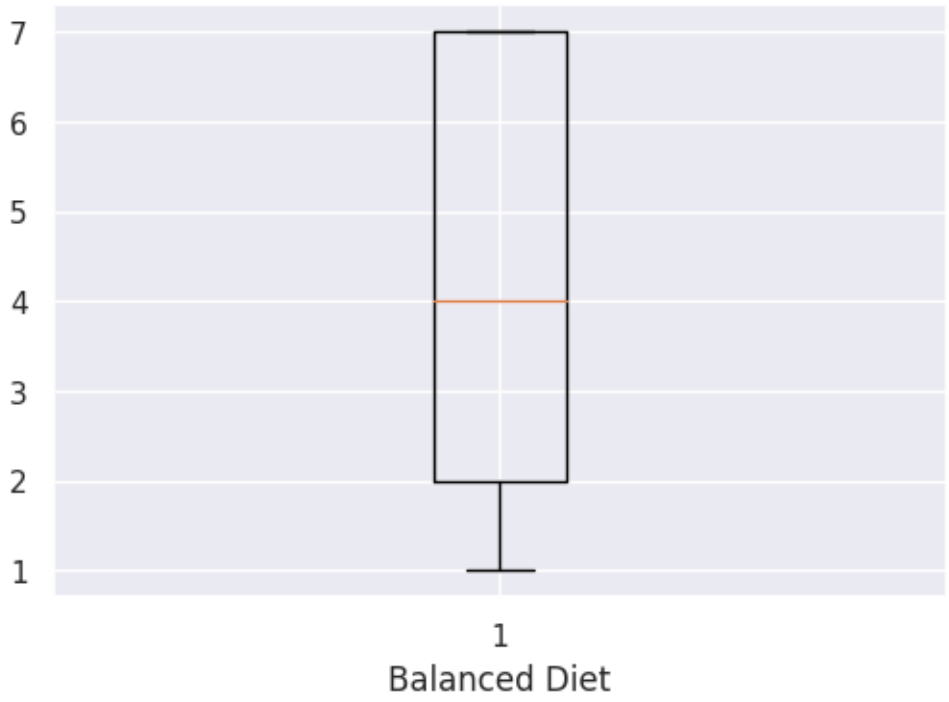

8
7
6
5
4
3
2
1
1
Alcohol use

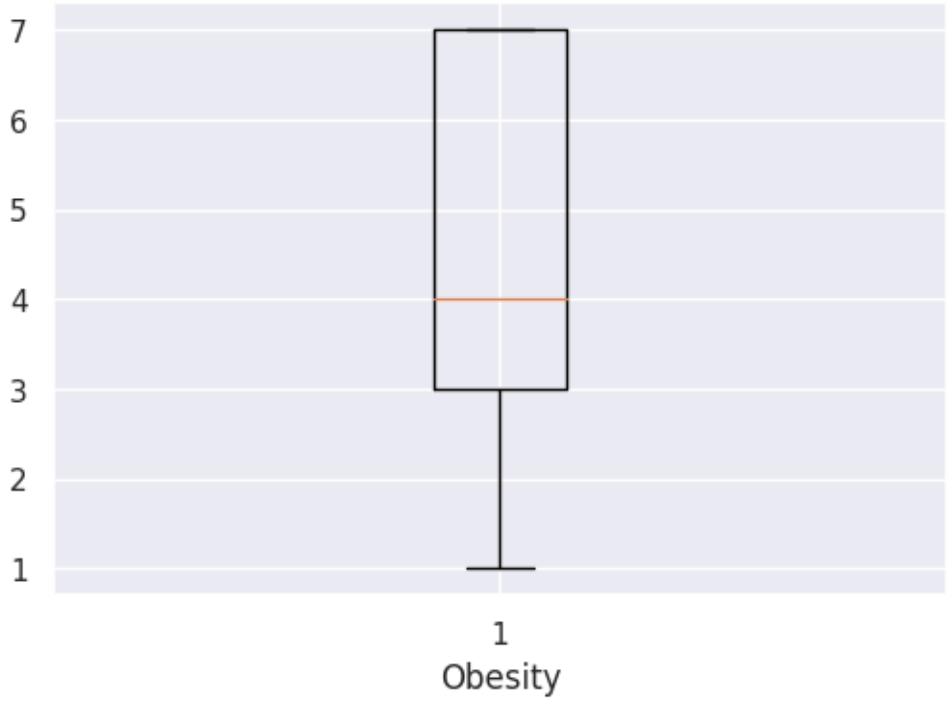

8
7
6
5
4
3
2
1
1
Dust Allergy

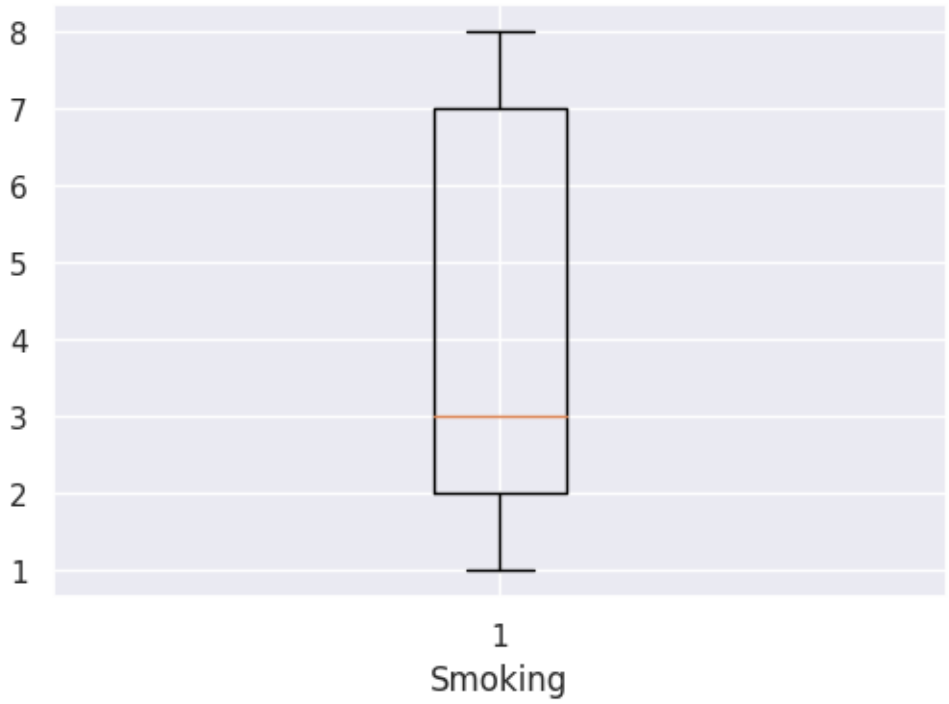

8
7
6
5
4
3
2
1
1
OccuPational Hazards

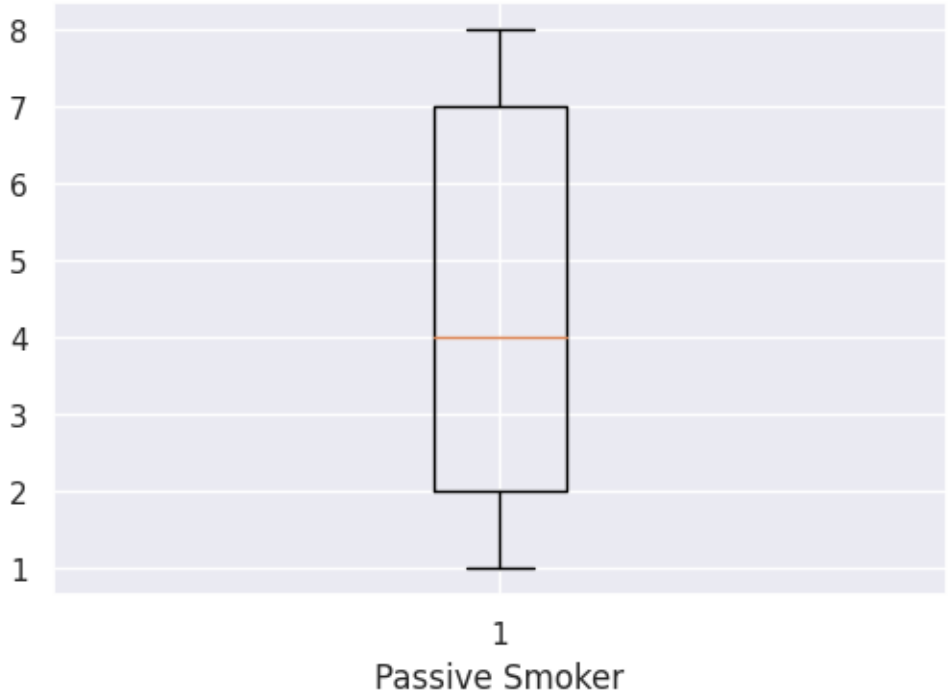

7
6
5
4
3
2
1
1
Genetic Risk

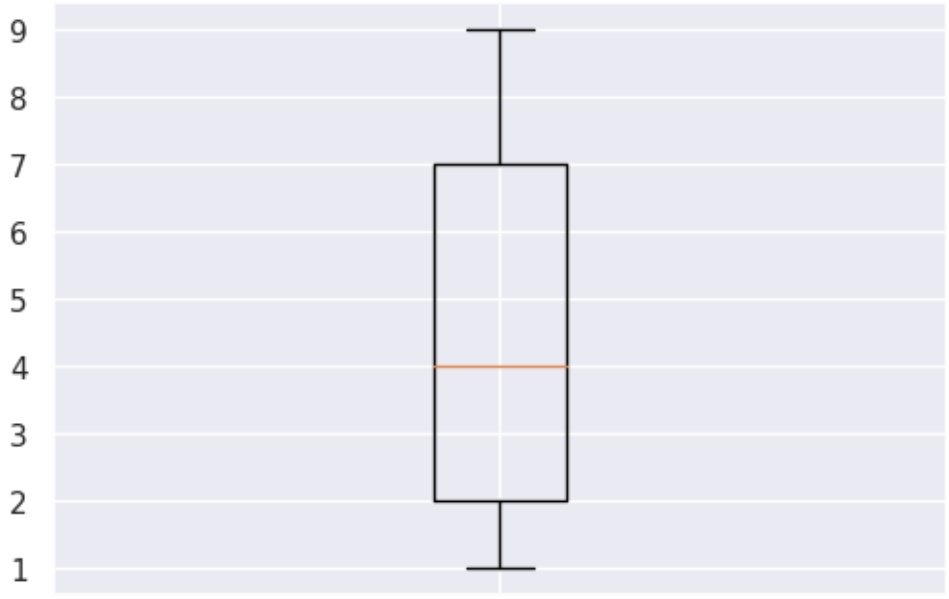

7
6
5
4
3
2
1
1
chronic Lung Disease

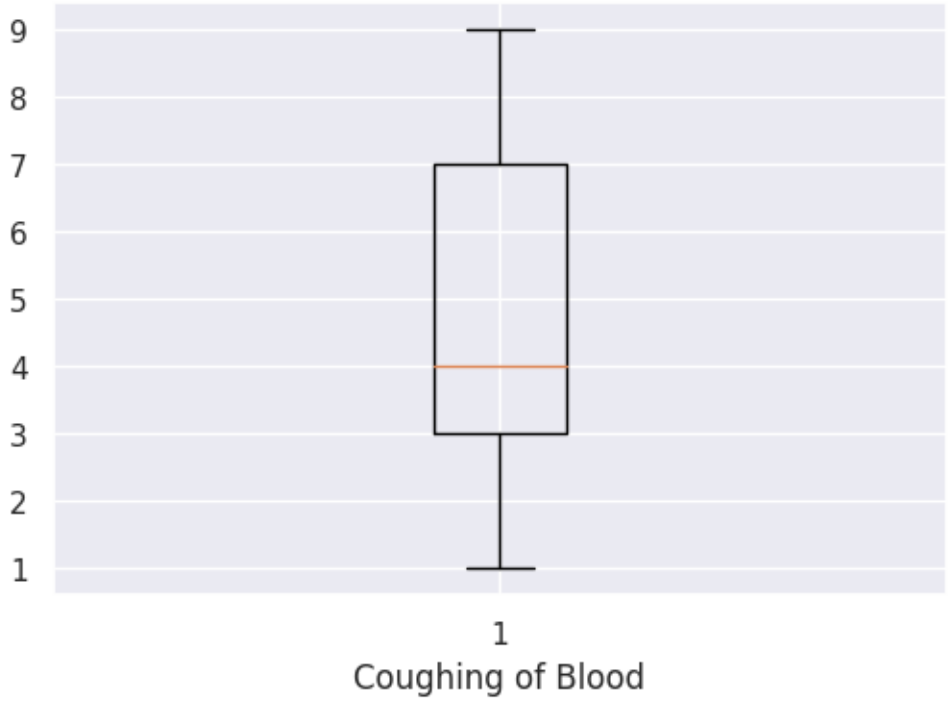

7
6
5
4
3
2
1
1
Balanced Diet

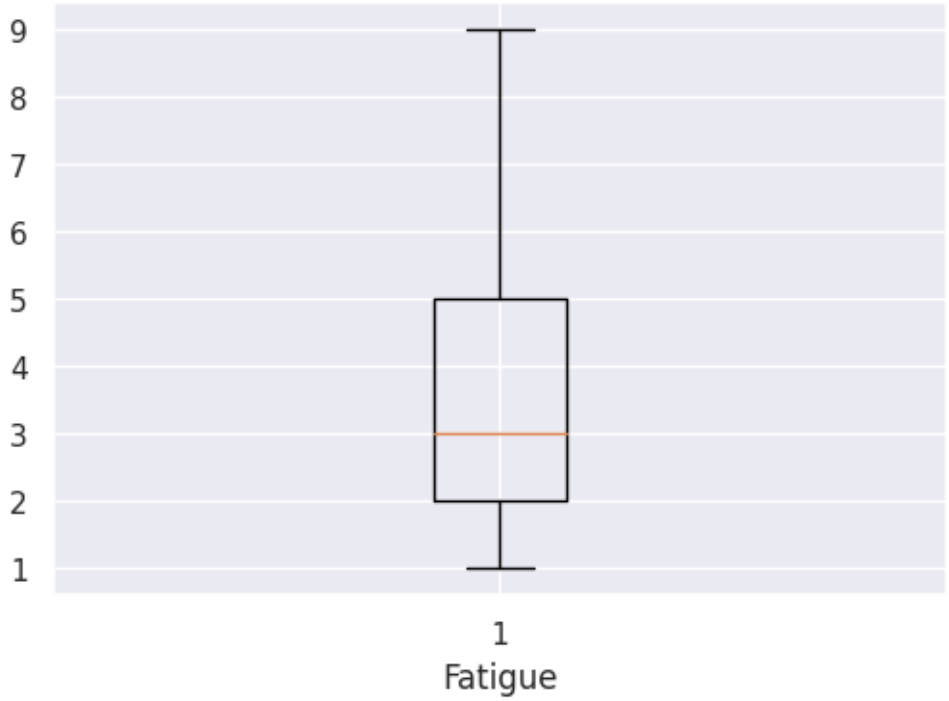

7
6
5
4
3
2
1
1
Obesity

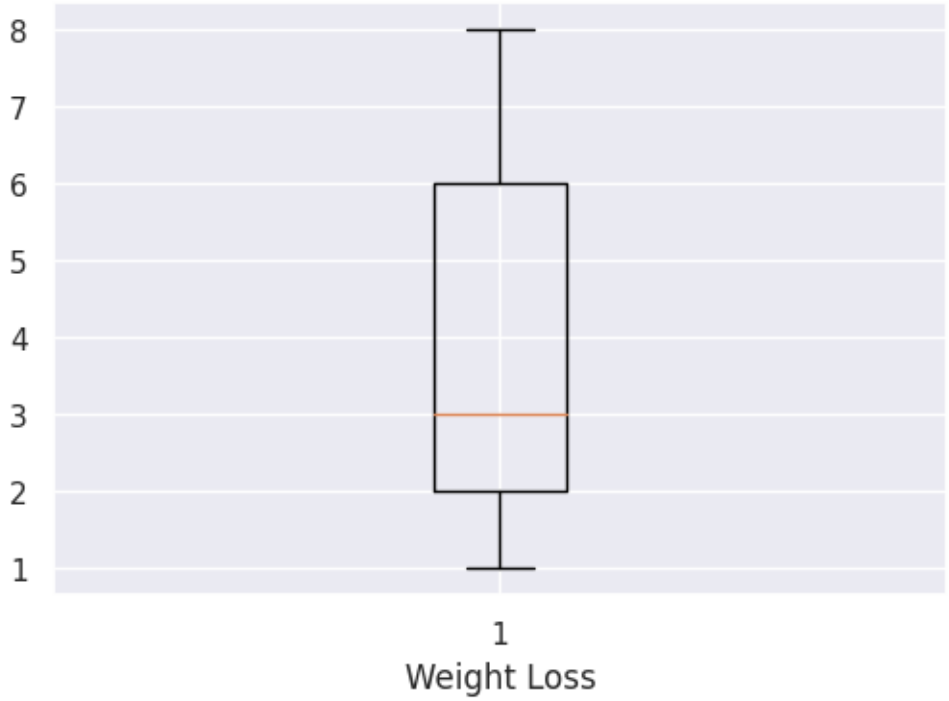

8
7
6
5
4
3
2
1
1
Smoking

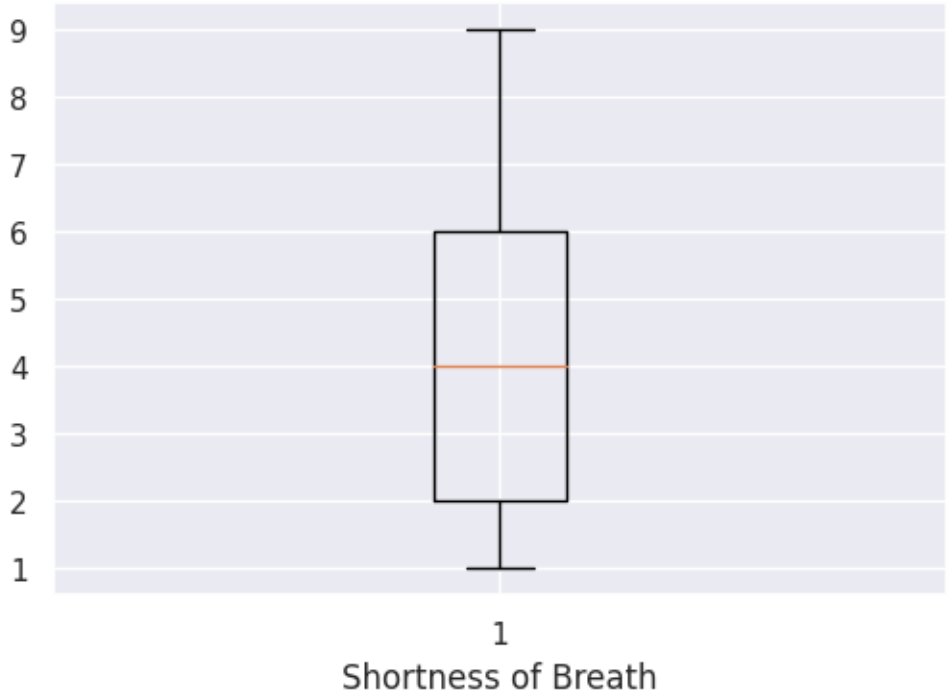

8
7
6
5
4
3
2
1
1
Passive Smoker


9
8
7
6
5
4
3
2
1
1
Chest Pain


9
8
7
6
5
4
3
2
1
1
Coughing of Blood

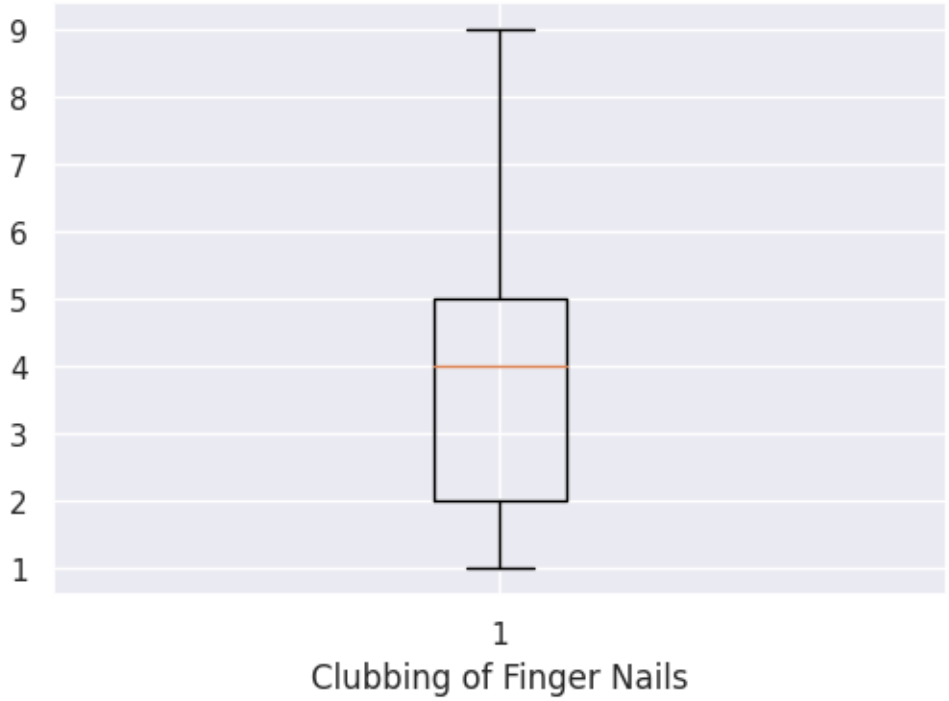

9
8
7
6
5
4
3
2
1
1
Fatigue

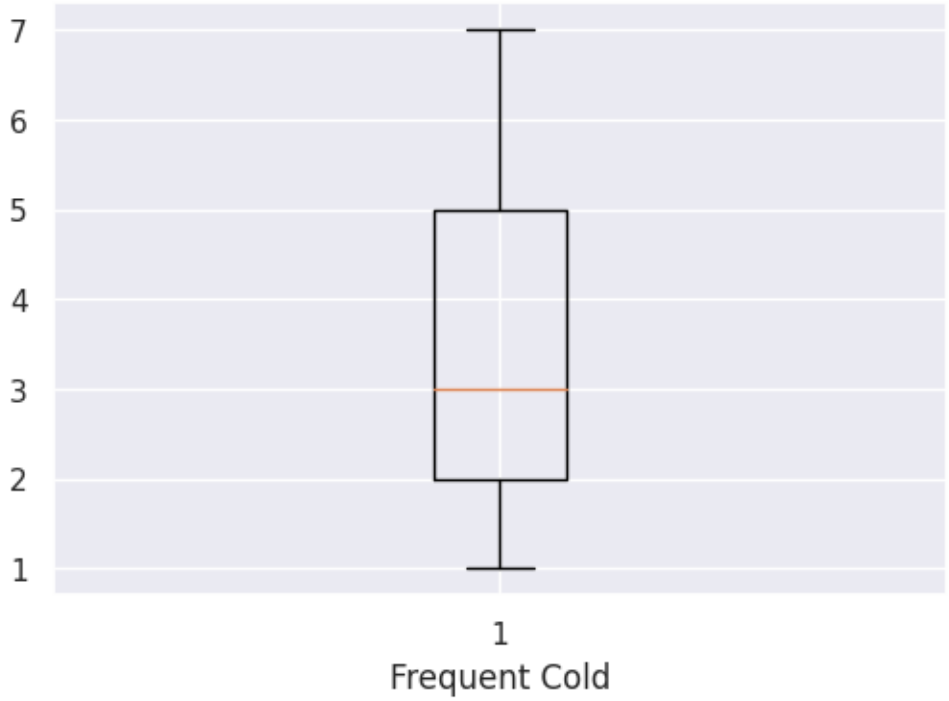

8
7
6
5
4
3
2
1
1
Weight Loss

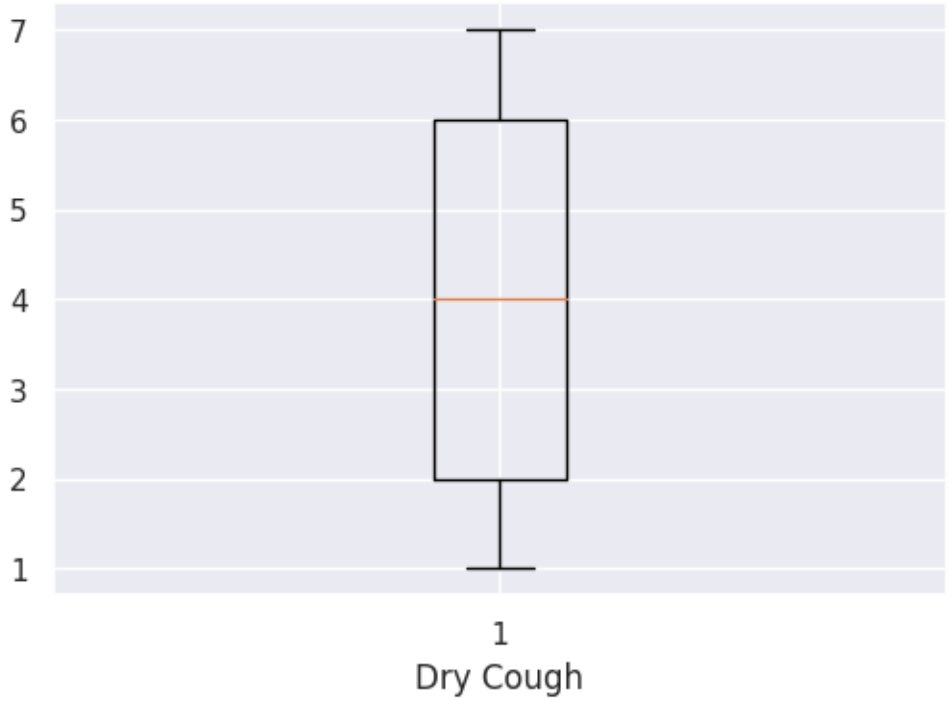

9
8
7
6
5
4
3
2
1
1
Shortness of Breath

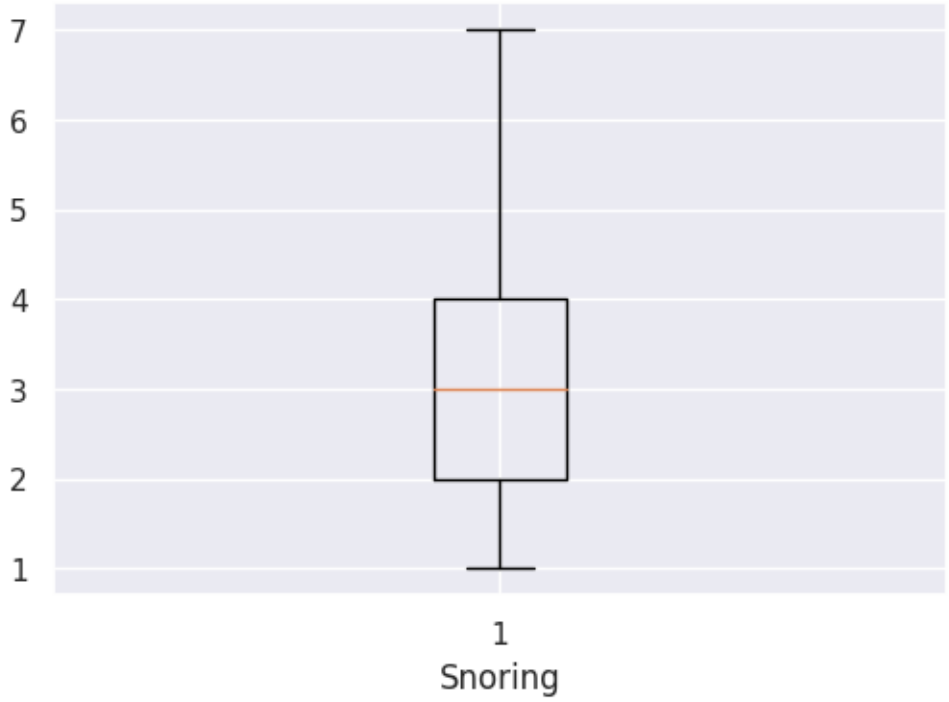

8
7
6
5
4
3
2
1
1
Wheezing


8
7
6
5
4
3
2
1
1
Swallowing Difficulty


9
8
7
6
5
4
3
2
1
1
Clubbing of Finger Nails


7
6
5
4
3
2
1
1
Frequent Cold

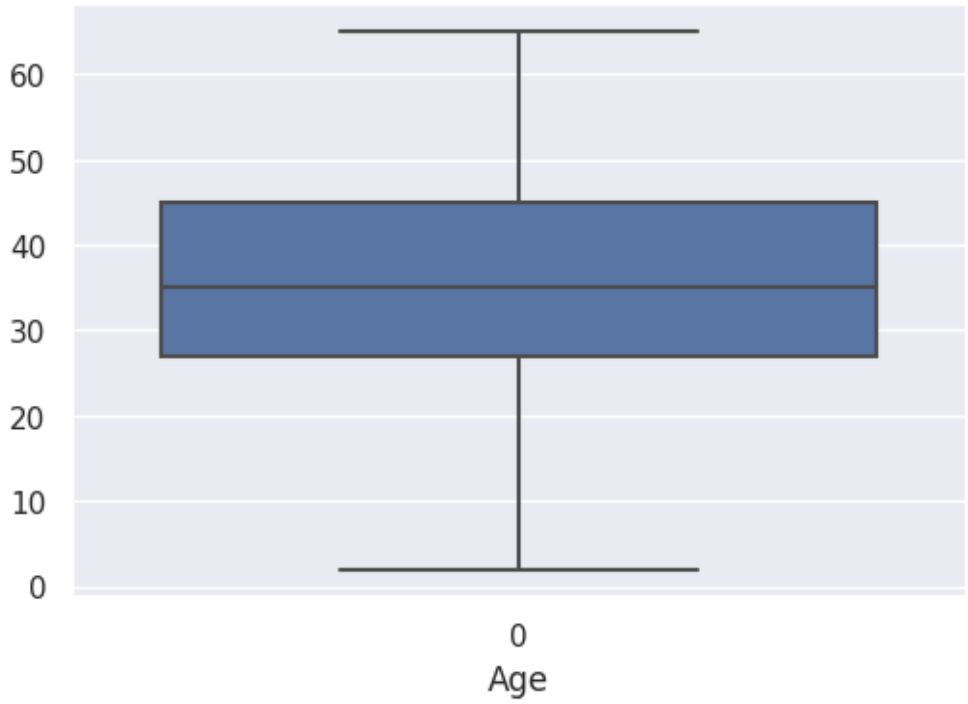

7
6
5
4
3
2
1
1
Dry Cough



[144]:
```
def remove_outlier(col):
  sorted(col)
  Q1,Q3 = col.quantile([0.25,0.75])
  IQR = Q3 - Q1
  lower_range = Q1 - (1.5 * IQR)
  upper_range = Q3 + (1.5 * IQR)
  return lower_range,upper_range
```

[145]:
```
lower_range, upper_range = remove_outlier(df["Age"])
df["Age"] = np.where(df["Age"] > upper_range, lower_range, df["Age"])
df["Age"] = np.where(df["Age"] < lower_range, upper_range, df['Age'])
```

[146]:
```
sns.boxplot(df["Age"])
plt.xlabel("Age")
plt.show()
```



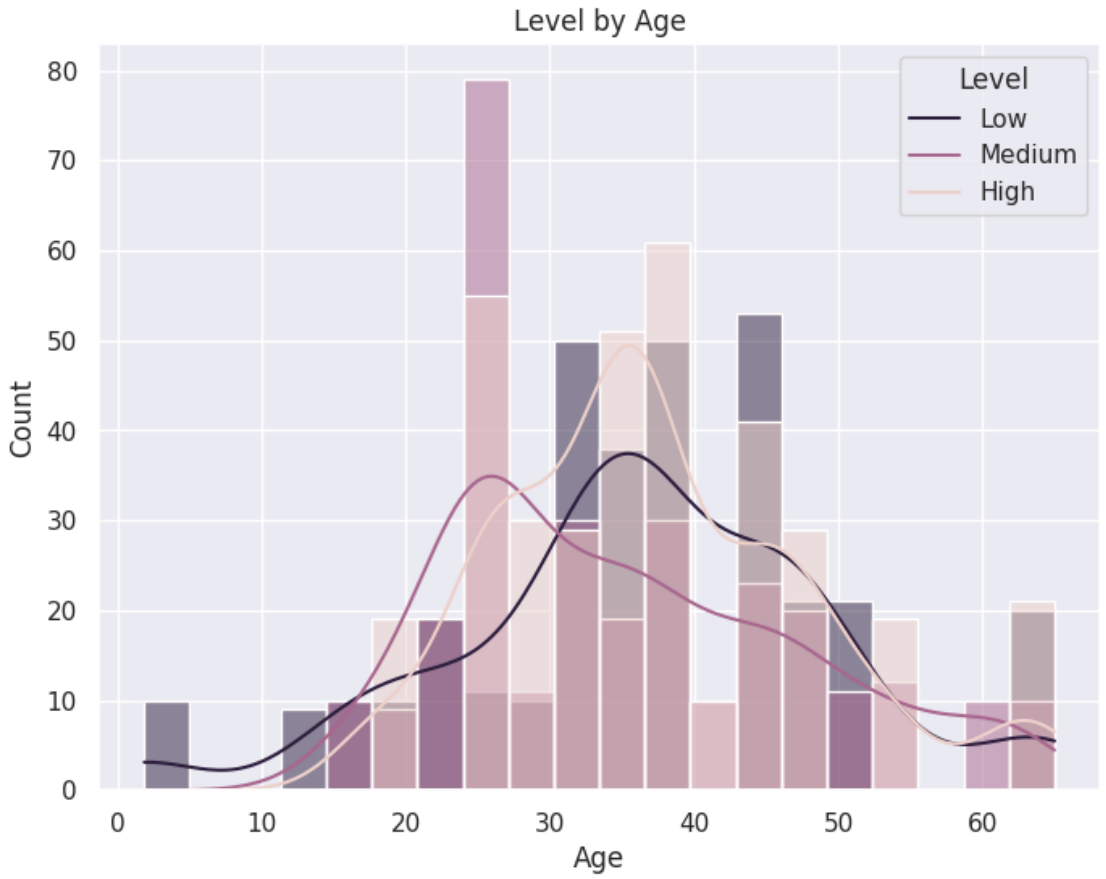
Bivariate Analysis

[147]:
```
df.info()
```

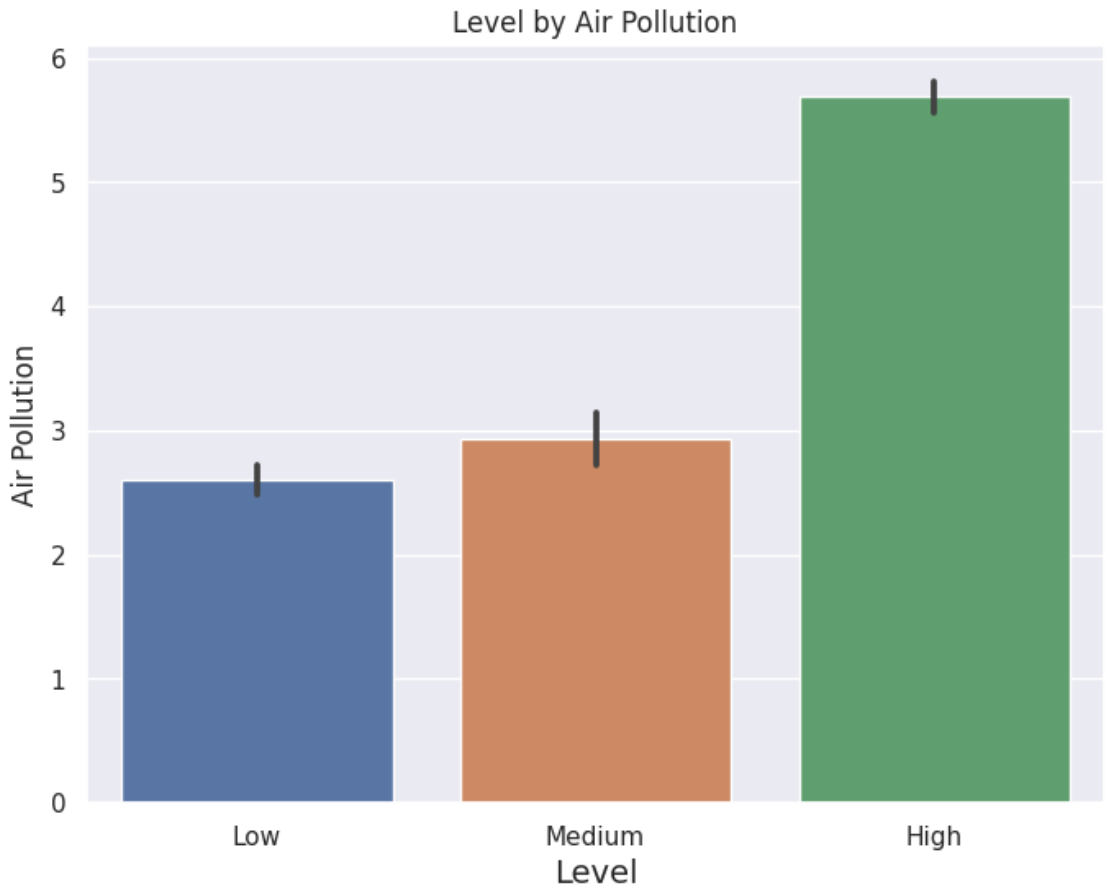
```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 1000 entries, 0 to 999
Data columns (total 26 columns):
 #   Column                    Non-Null Count  Dtype
---  ------                    --------------  -----
 0   index                     1000 non-null   int64
 1   Patient Id                1000 non-null   object
 2   Age                       1000 non-null   float64
 3   Gender                    1000 non-null   int64
 4   Air Pollution             1000 non-null   int64
 5   Alcohol use               1000 non-null   int64
 6   Dust Allergy              1000 non-null   int64
 7   OccuPational Hazards      1000 non-null   int64
 8   Genetic Risk              1000 non-null   int64
 9   chronic Lung Disease      1000 non-null   int64
 10  Balanced Diet             1000 non-null   int64
 11  Obesity                   1000 non-null   int64
 12  Smoking                   1000 non-null   int64
 13  Passive Smoker            1000 non-null   int64
 14  Chest Pain                1000 non-null   int64
```

```
 15  Coughing of Blood          1000 non-null   int64
 16  Fatigue                    1000 non-null   int64
 17  Weight Loss                1000 non-null   int64
 18  Shortness of Breath        1000 non-null   int64
 19  Wheezing                   1000 non-null   int64
 20  Swallowing Difficulty      1000 non-null   int64
 21  Clubbing of Finger Nails   1000 non-null   int64
 22  Frequent Cold              1000 non-null   int64
 23  Dry Cough                  1000 non-null   int64
 24  Snoring                    1000 non-null   int64
 25  Level                      1000 non-null   object
dtypes: float64(1), int64(23), object(2)
memory usage: 203.2+ KB
```

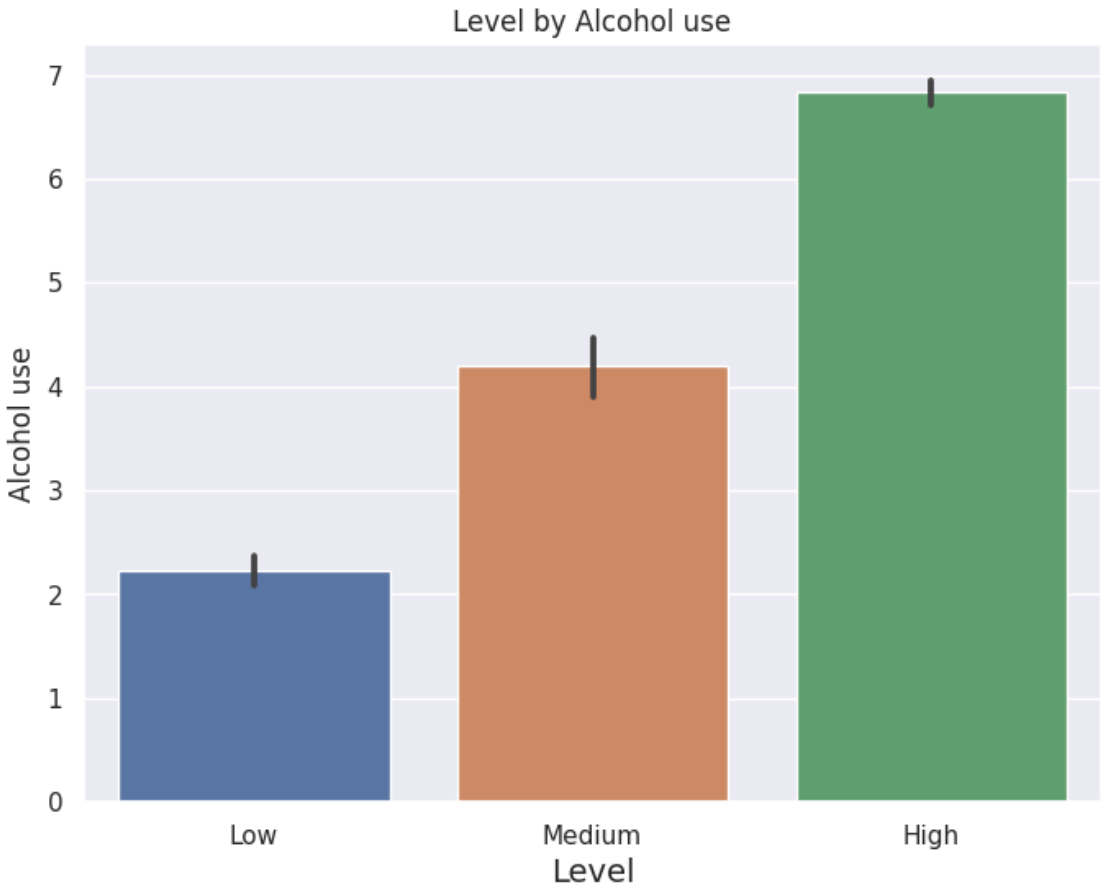
[277]:
```
plt.figure(figsize=(8, 6))
sns.histplot(data=df, x='Age', hue='Level', kde=True, bins=20)
plt.title('Level by Age')
plt.xlabel('Age')
plt.ylabel('Count')
plt.legend(title='Level', loc='upper right', labels=['Low', 'Medium',"High"])
plt.show()
```



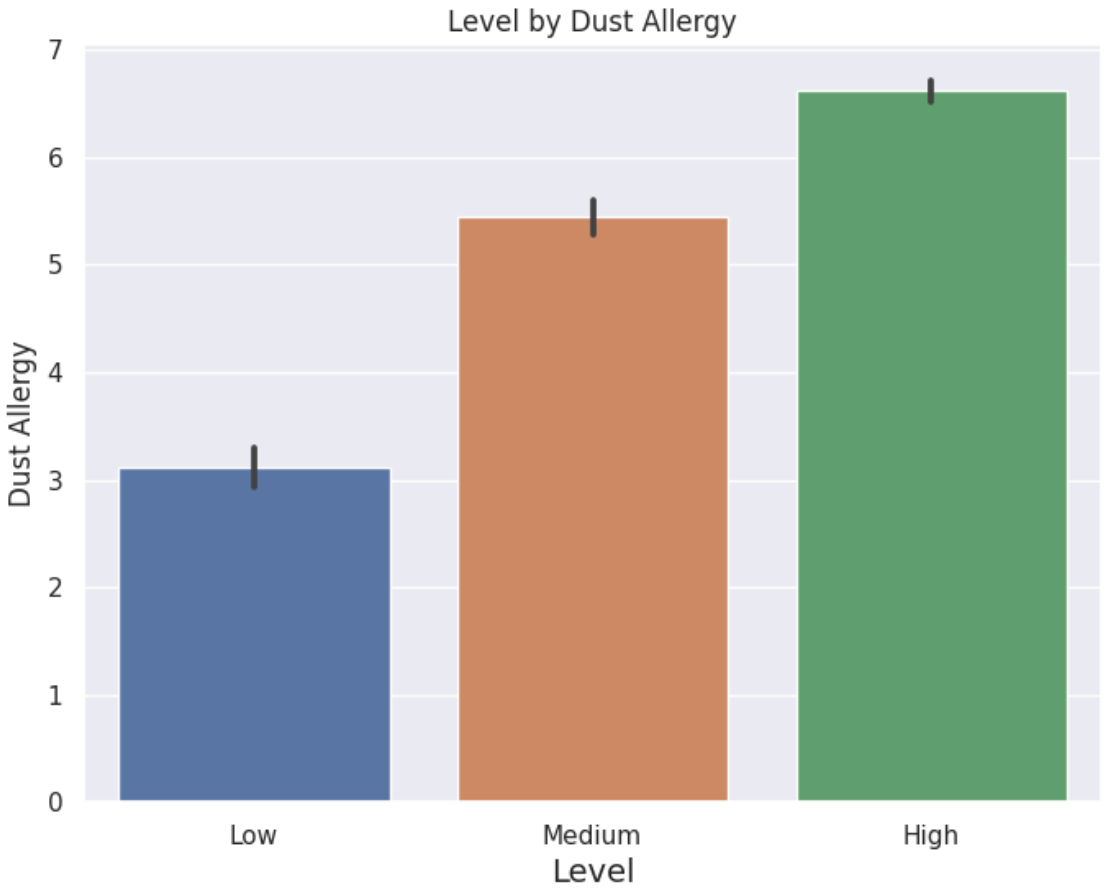
[149]:
```
plt.figure(figsize=(8, 6))
sns.barplot(x='Level', y='Air Pollution', data=df)
plt.title('Level by Air Pollution')
plt.xlabel('Level', fontsize=14)
plt.ylabel('Air Pollution')
plt.show()
```



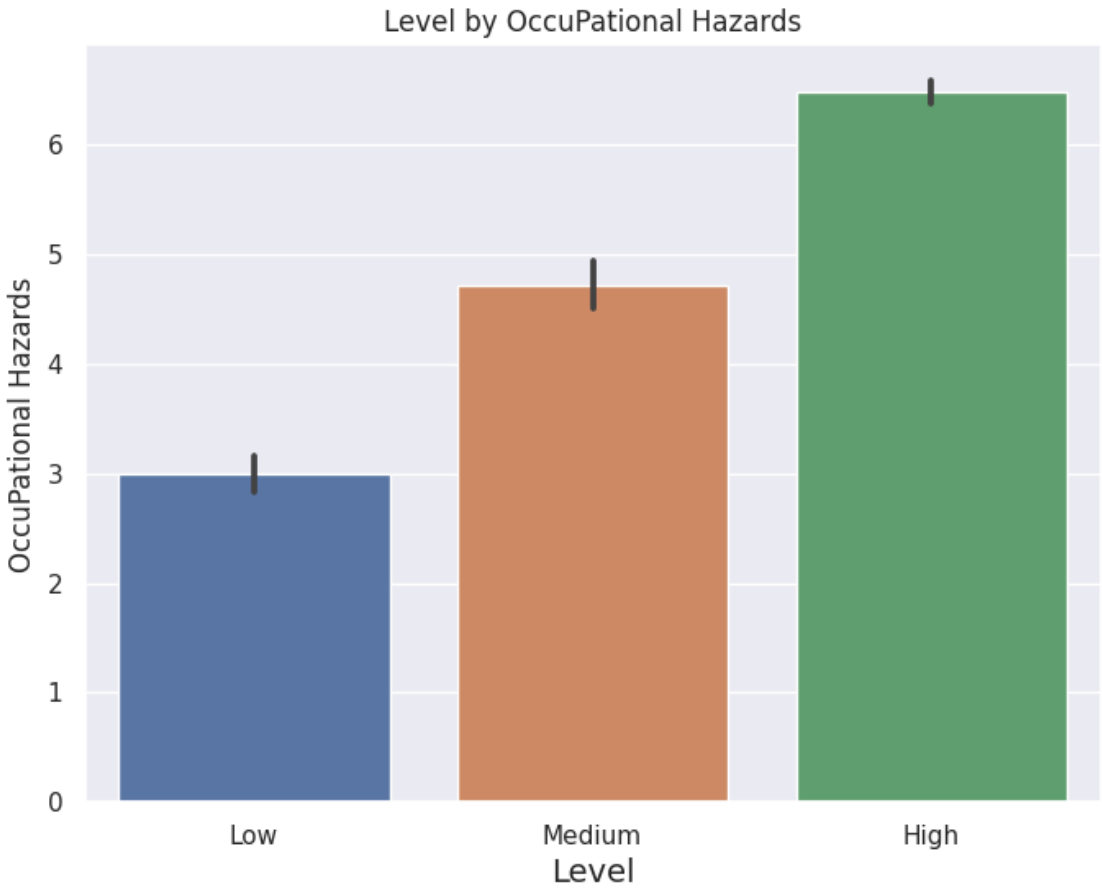
[150]:
```
plt.figure(figsize=(8, 6))
sns.barplot(x='Level', y='Alcohol use', data=df)
plt.title('Level by Alcohol use')
plt.xlabel('Level', fontsize=14)
plt.ylabel('Alcohol use')
plt.show()
```



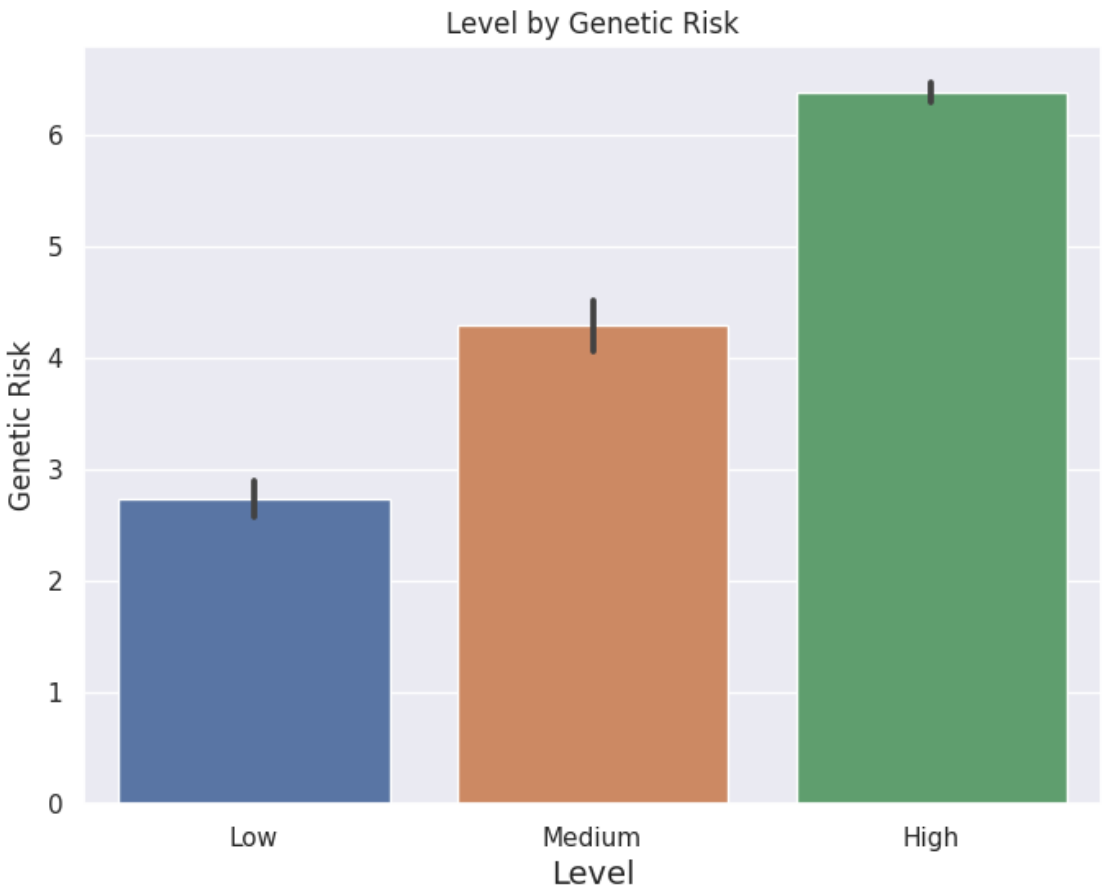
[151]:
```
plt.figure(figsize=(8, 6))
sns.barplot(x='Level', y='Dust Allergy', data=df)
plt.title('Level by Dust Allergy')
plt.xlabel('Level', fontsize=14)
plt.ylabel('Dust Allergy')
plt.show()
```



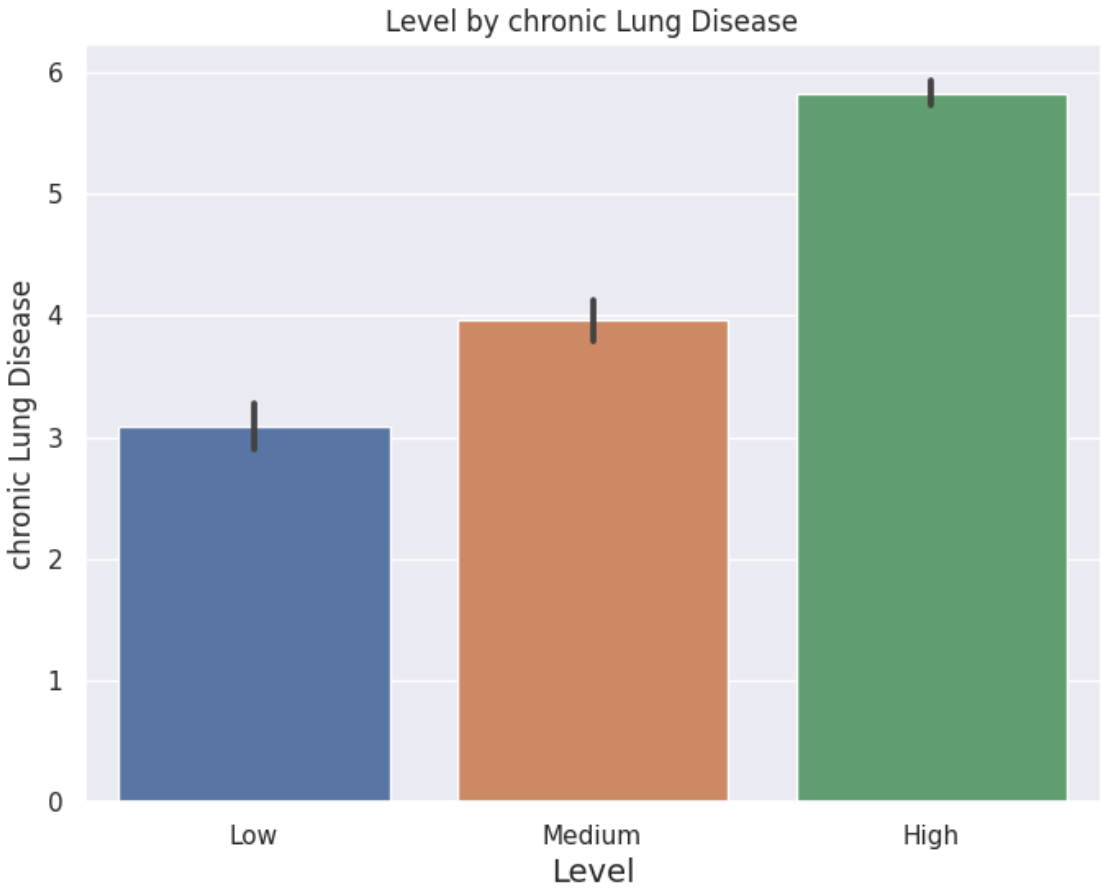
[152]:
```
plt.figure(figsize=(8, 6))
sns.barplot(x='Level', y='OccuPational Hazards', data=df)
plt.title('Level by OccuPational Hazards')
plt.xlabel('Level', fontsize=14)
plt.ylabel('OccuPational Hazards')
plt.show()
```



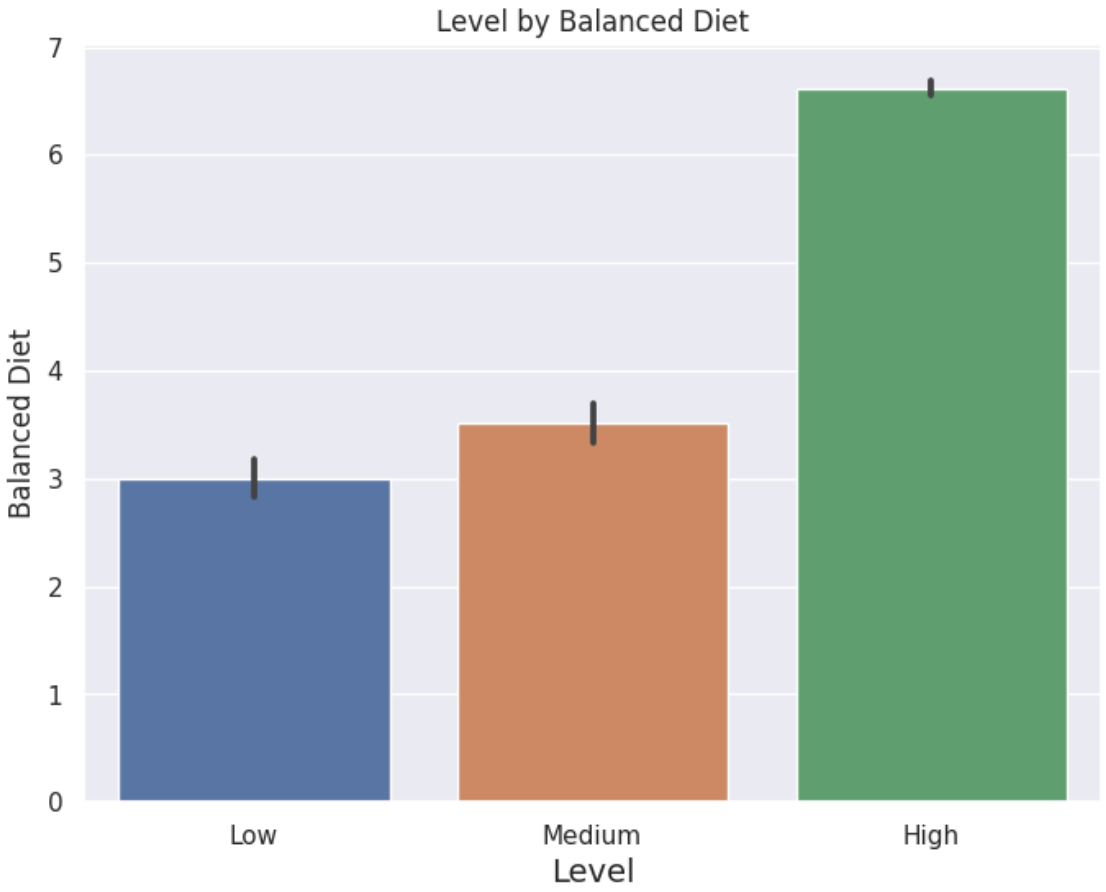
[153]:
```
plt.figure(figsize=(8, 6))
sns.barplot(x='Level', y='Genetic Risk', data=df)
plt.title('Level by Genetic Risk')
plt.xlabel('Level', fontsize=14)
plt.ylabel('Genetic Risk')
plt.show()
```



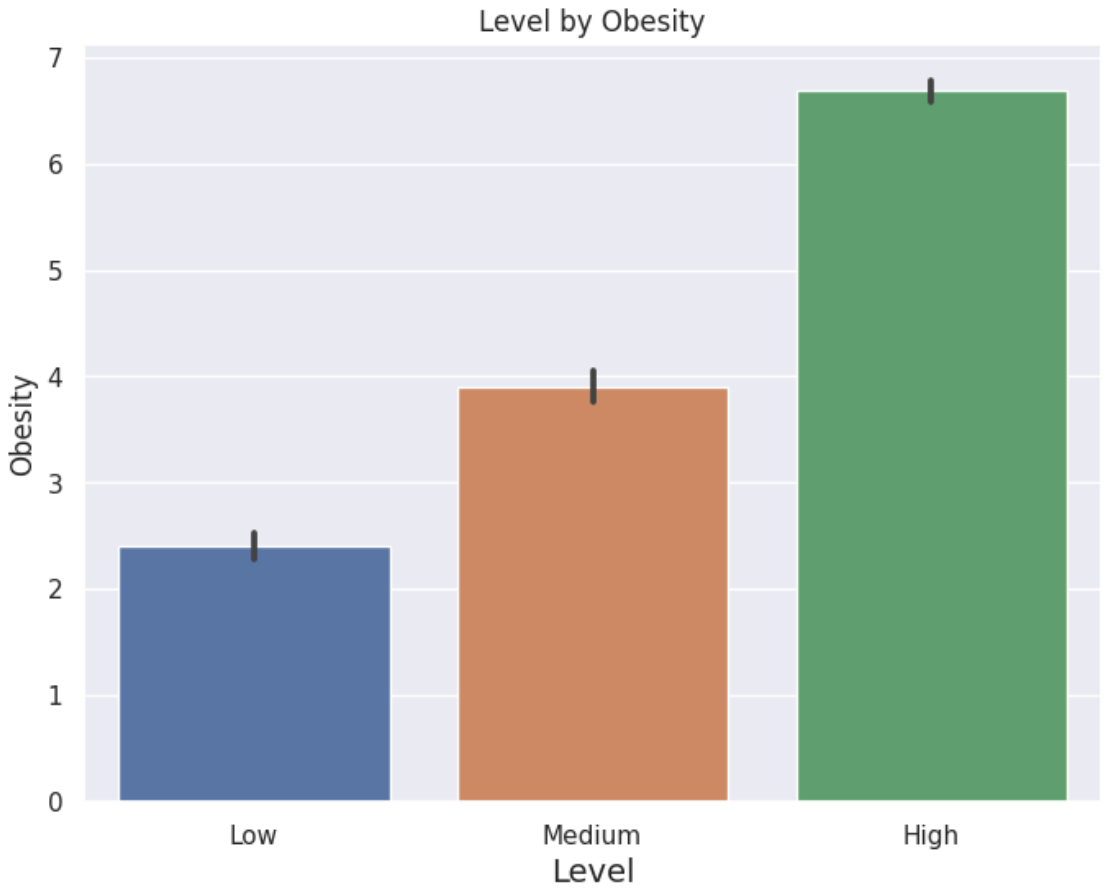
[154]:
```
plt.figure(figsize=(8, 6))
sns.barplot(x='Level', y='chronic Lung Disease', data=df)
plt.title('Level by chronic Lung Disease')
plt.xlabel('Level', fontsize=14)
plt.ylabel('chronic Lung Disease')
plt.show()
```



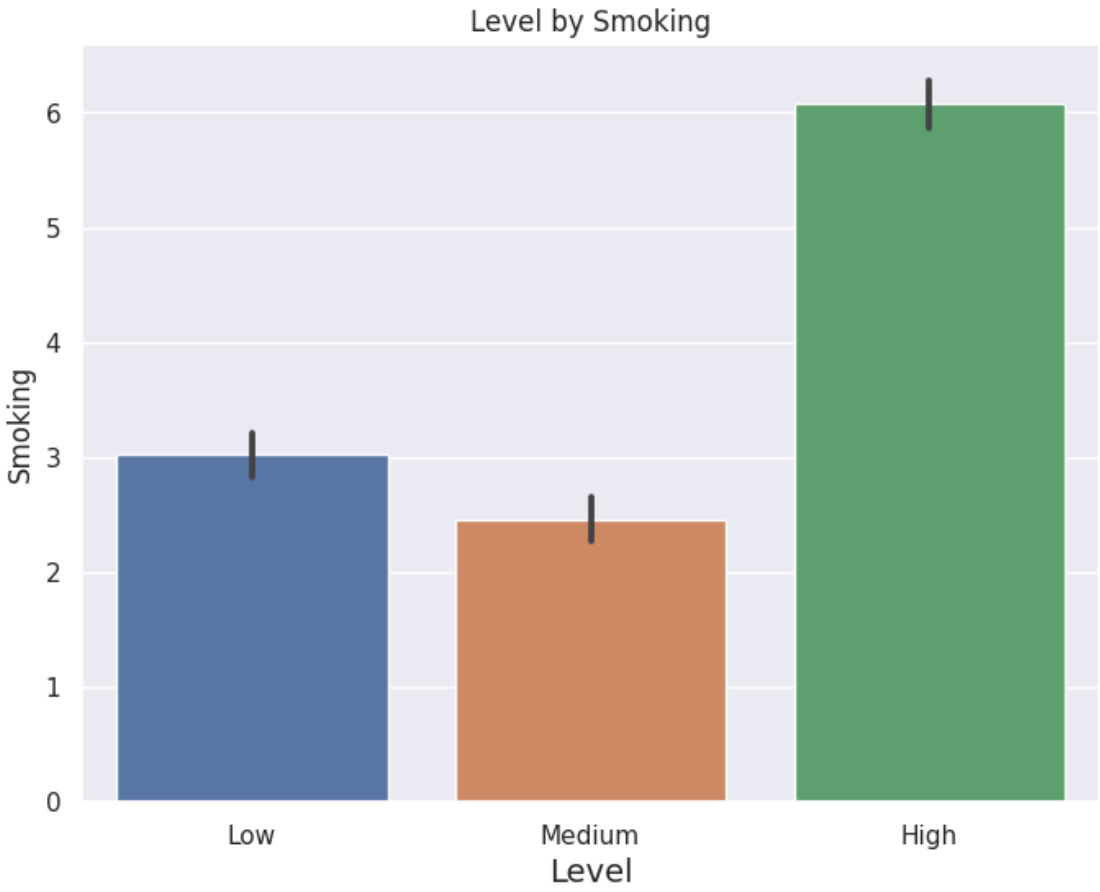
[155]:
```
plt.figure(figsize=(8, 6))
sns.barplot(x='Level', y='Balanced Diet', data=df)
plt.title('Level by Balanced Diet')
plt.xlabel('Level', fontsize=14)
plt.ylabel('Balanced Diet')
plt.show()
```



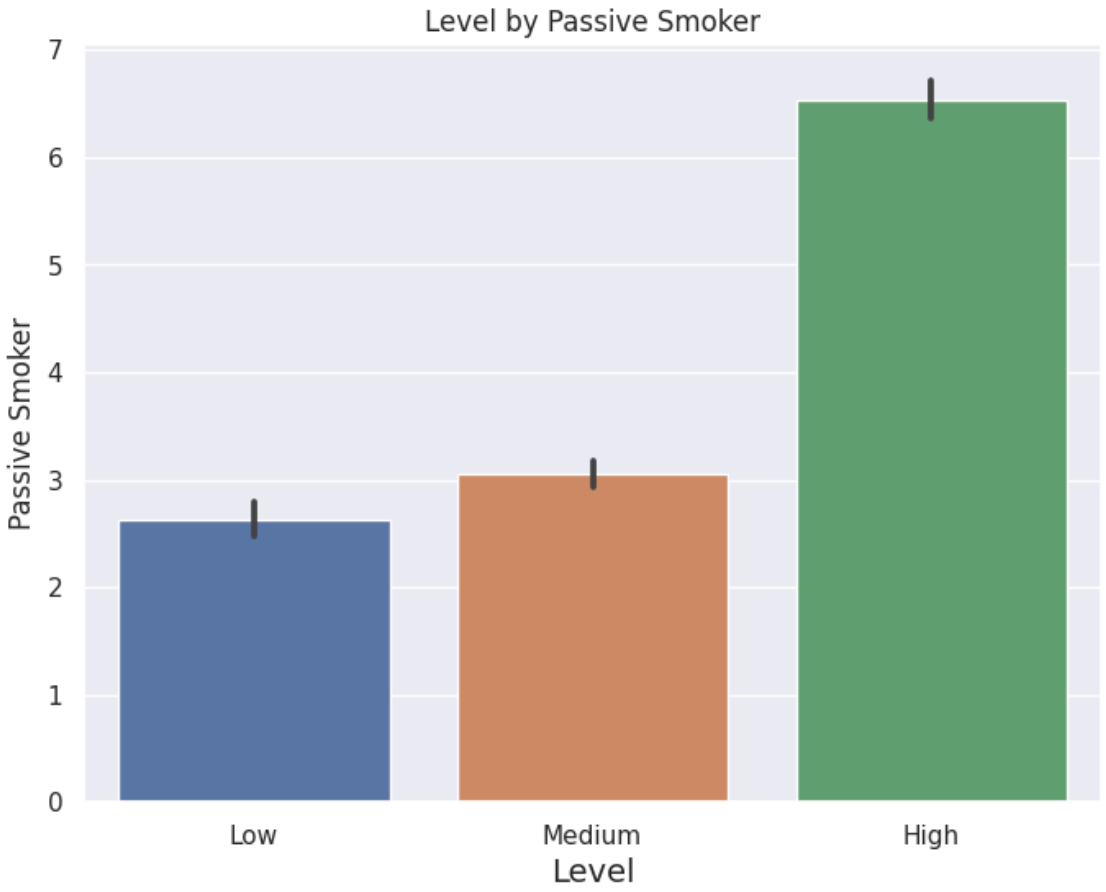
[156]:
```
plt.figure(figsize=(8, 6))
sns.barplot(x='Level', y='Obesity', data=df)
plt.title('Level by Obesity')
plt.xlabel('Level', fontsize=14)
plt.ylabel('Obesity')
plt.show()
```



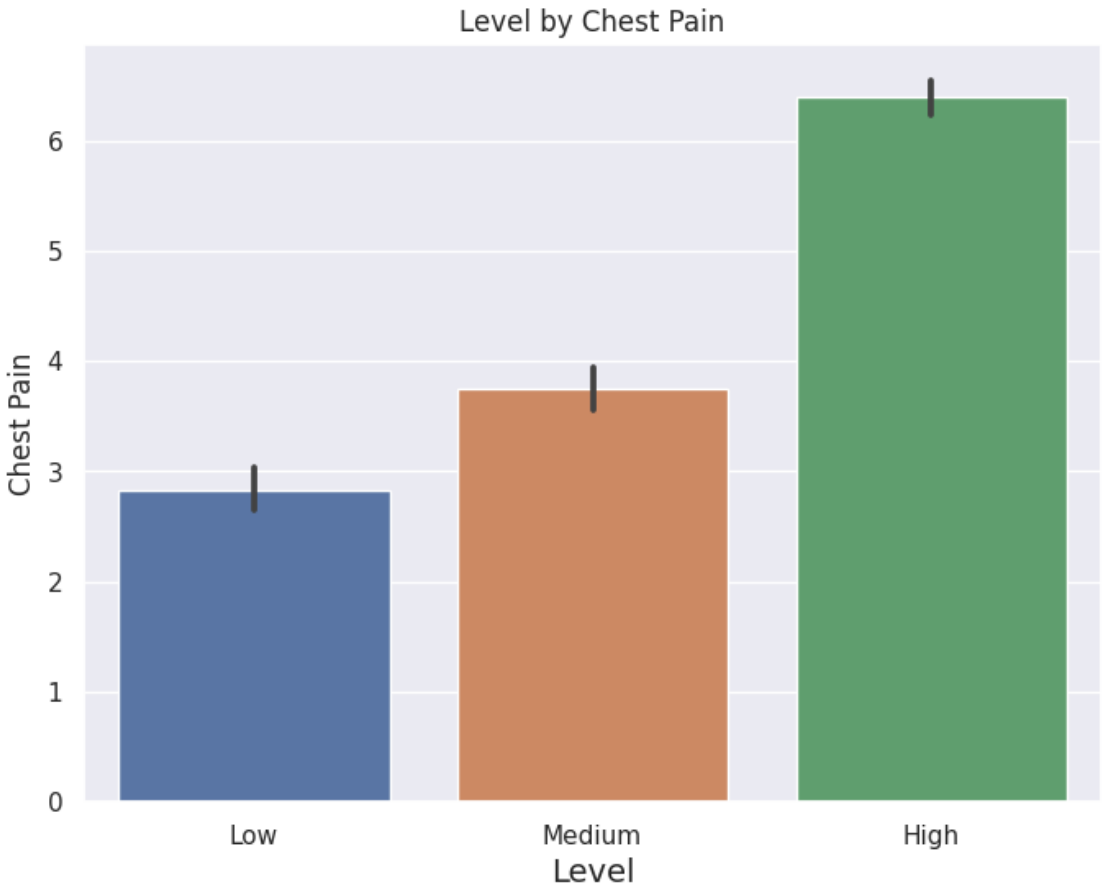
[157]:
```
plt.figure(figsize=(8, 6))
sns.barplot(x='Level', y='Smoking', data=df)
plt.title('Level by Smoking')
plt.xlabel('Level', fontsize=14)
plt.ylabel('Smoking')
plt.show()
```



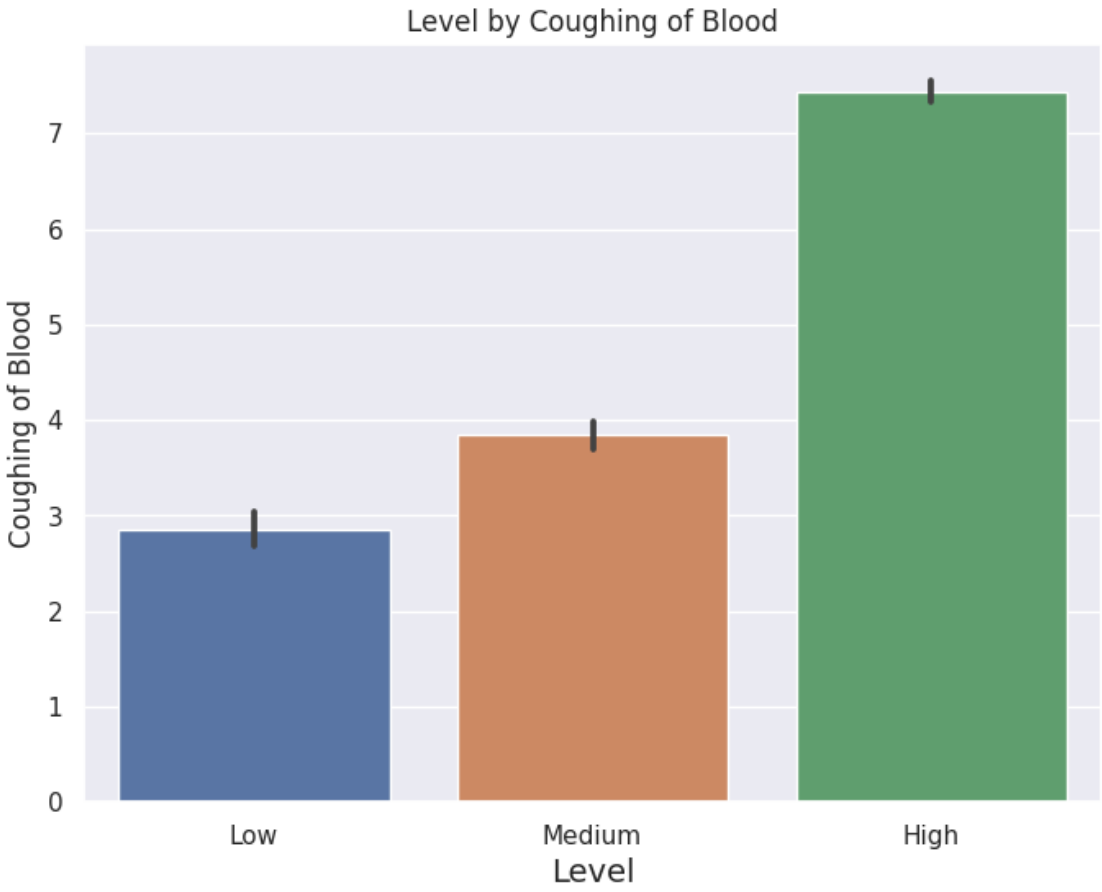
[158]:
```
plt.figure(figsize=(8, 6))
sns.barplot(x='Level', y='Passive Smoker', data=df)
plt.title('Level by Passive Smoker')
plt.xlabel('Level', fontsize=14)
plt.ylabel('Passive Smoker')
plt.show()
```



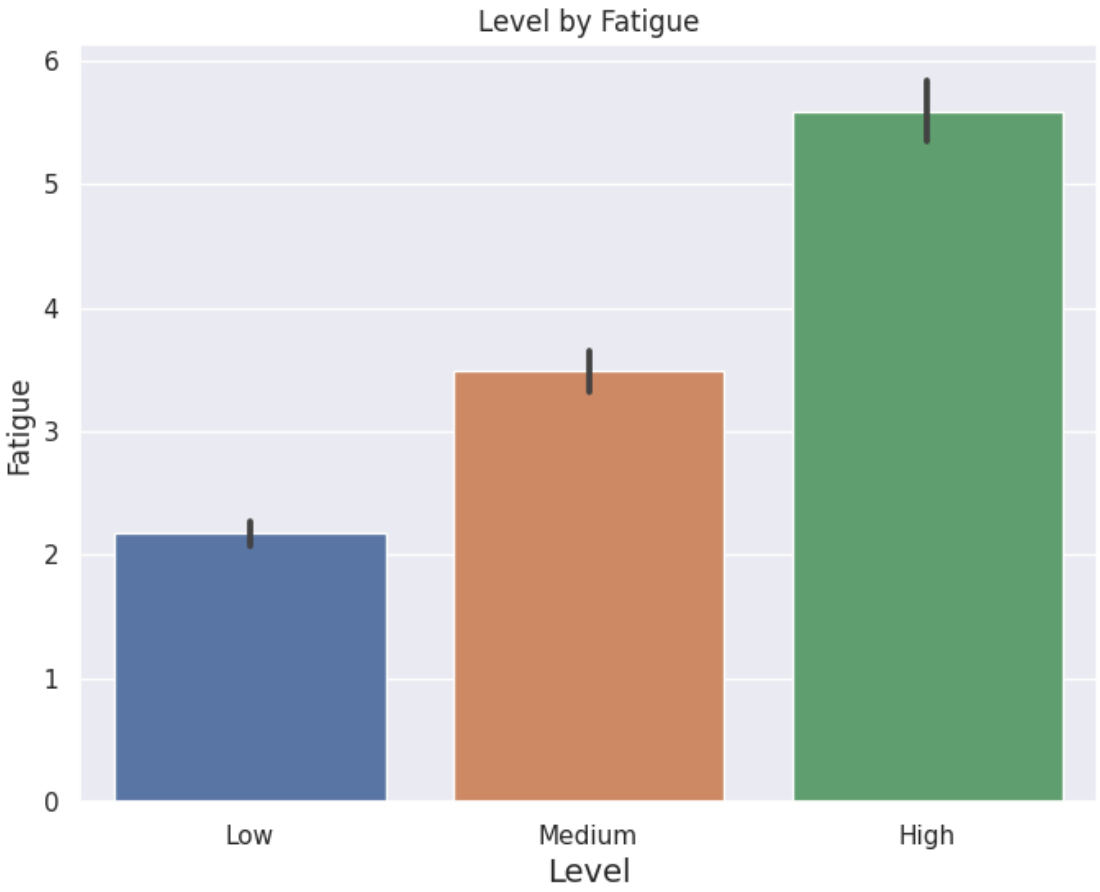
[159]:
```
plt.figure(figsize=(8, 6))
sns.barplot(x='Level', y='Chest Pain', data=df)
plt.title('Level by Chest Pain')
plt.xlabel('Level', fontsize=14)
plt.ylabel('Chest Pain')
plt.show()
```



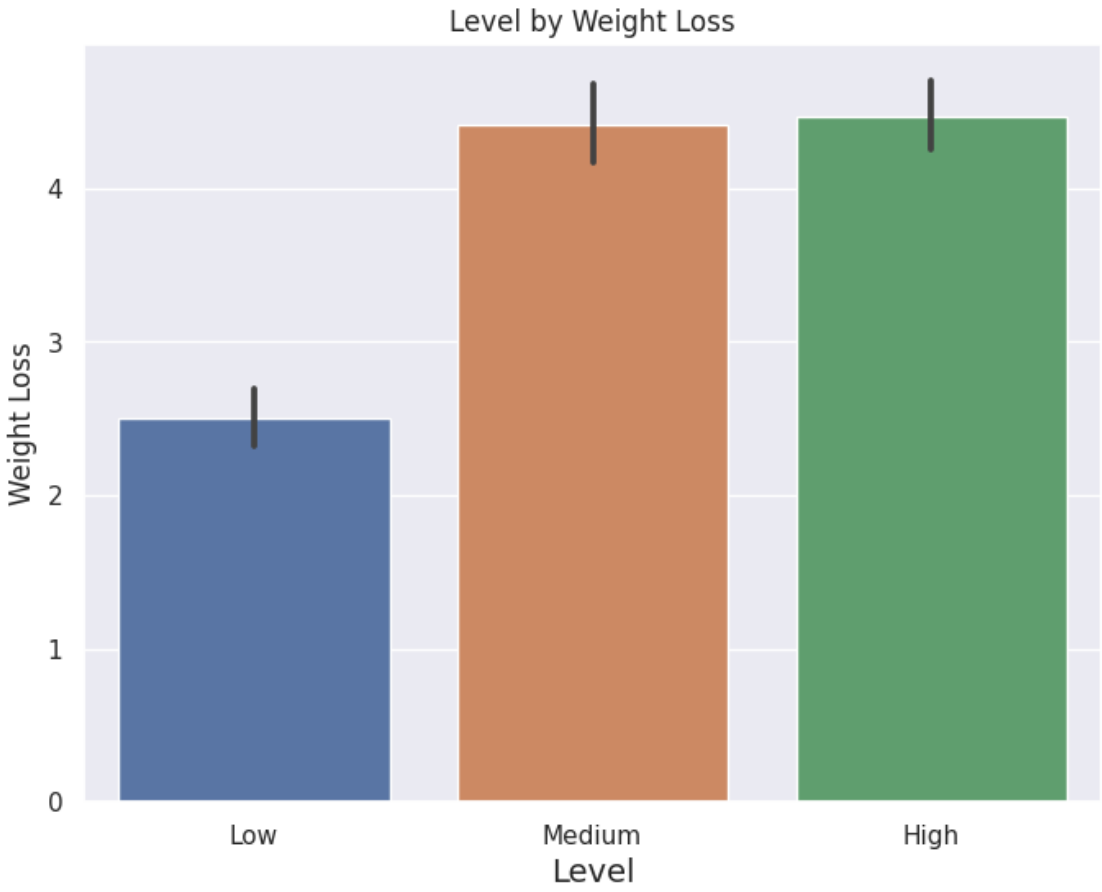
[160]:
```
plt.figure(figsize=(8, 6))
sns.barplot(x='Level', y='Coughing of Blood', data=df)
plt.title('Level by Coughing of Blood')
plt.xlabel('Level', fontsize=14)
plt.ylabel('Coughing of Blood')
plt.show()
```



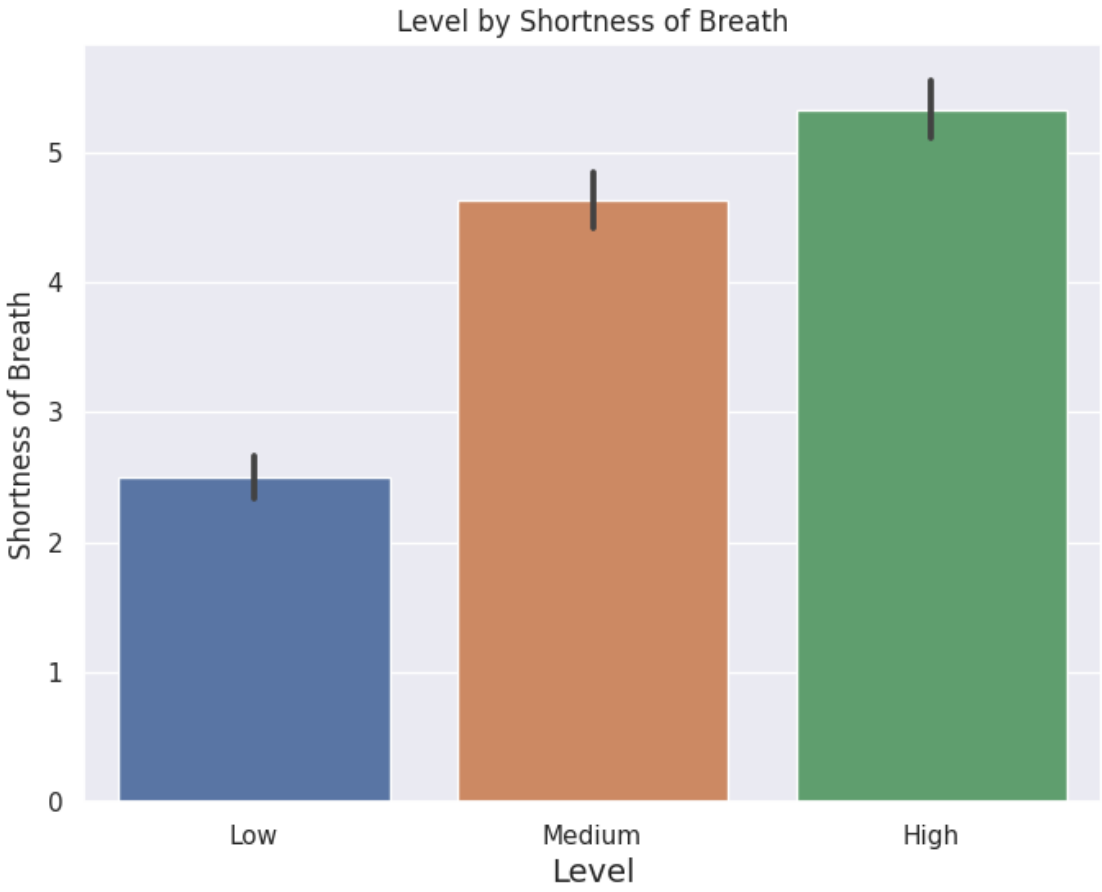
[161]:
```
plt.figure(figsize=(8, 6))
sns.barplot(x='Level', y='Fatigue', data=df)
plt.title('Level by Fatigue')
plt.xlabel('Level', fontsize=14)
plt.ylabel('Fatigue')
plt.show()
```



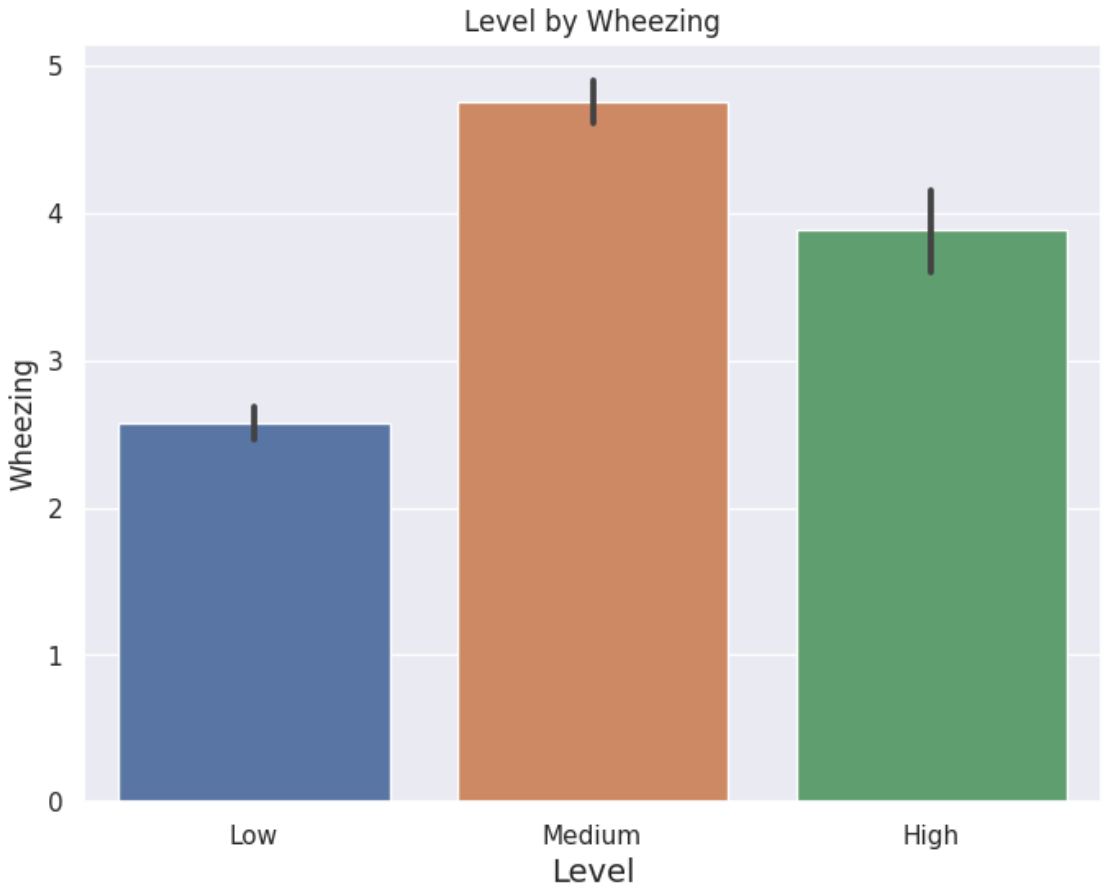
[162]:
```
plt.figure(figsize=(8, 6))
sns.barplot(x='Level', y='Weight Loss', data=df)
plt.title('Level by Weight Loss')
plt.xlabel('Level', fontsize=14)
plt.ylabel('Weight Loss')
plt.show()
```



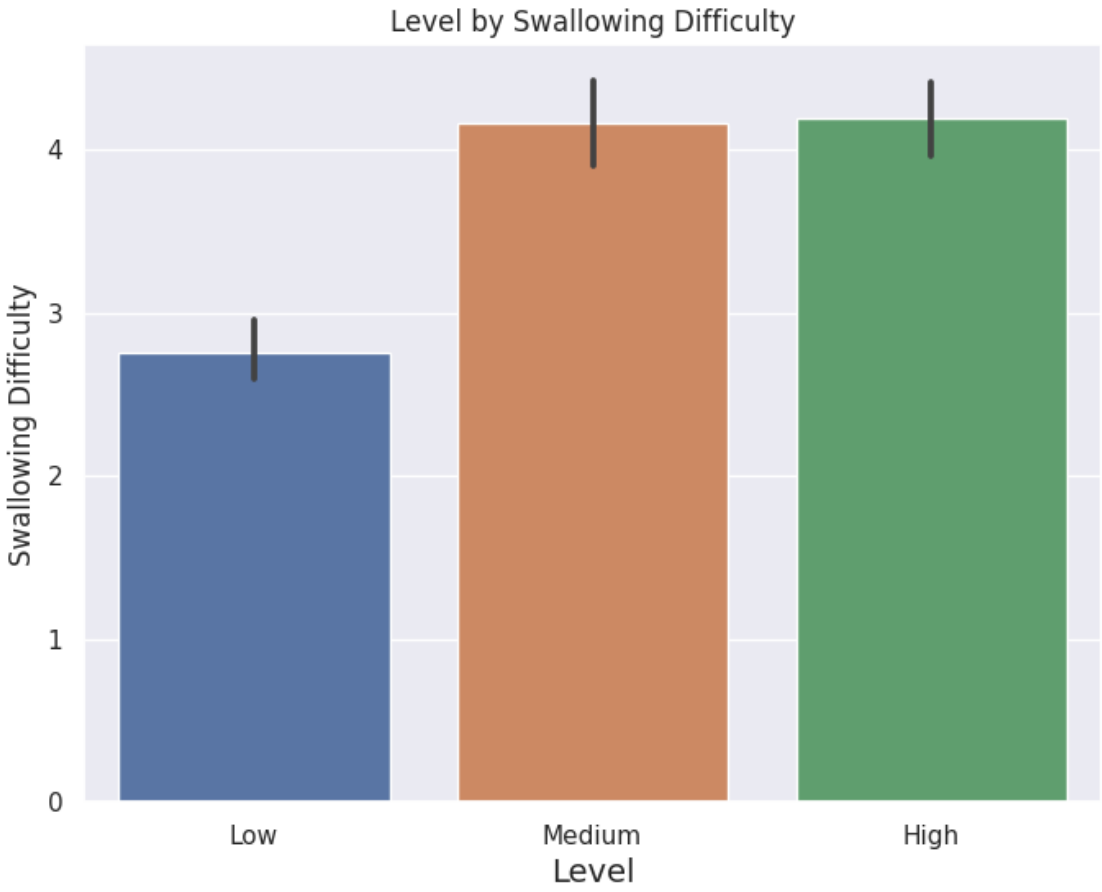
[163]:
```
plt.figure(figsize=(8, 6))
sns.barplot(x='Level', y='Shortness of Breath', data=df)
plt.title('Level by Shortness of Breath')
plt.xlabel('Level', fontsize=14)
plt.ylabel('Shortness of Breath')
plt.show()
```



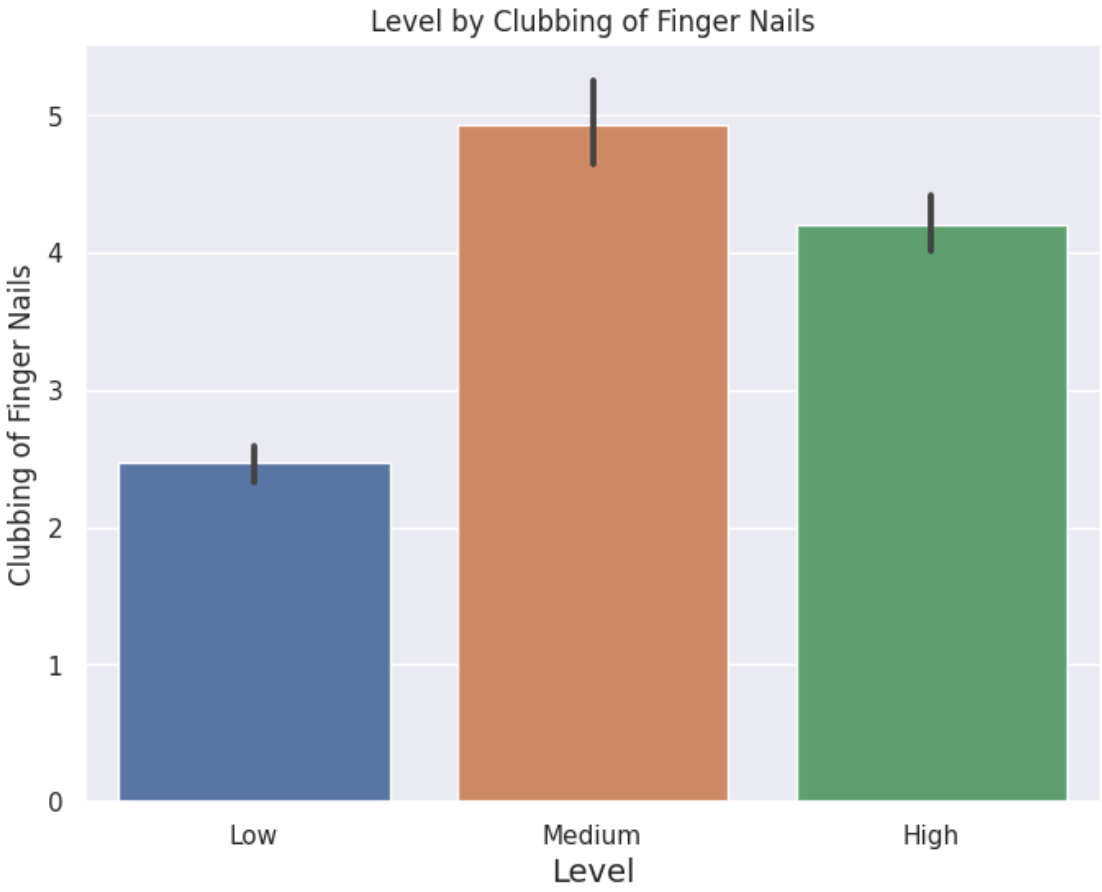
[164]:
```
plt.figure(figsize=(8, 6))
sns.barplot(x='Level', y='Wheezing', data=df)
plt.title('Level by Wheezing')
plt.xlabel('Level', fontsize=14)
plt.ylabel('Wheezing')
plt.show()
```



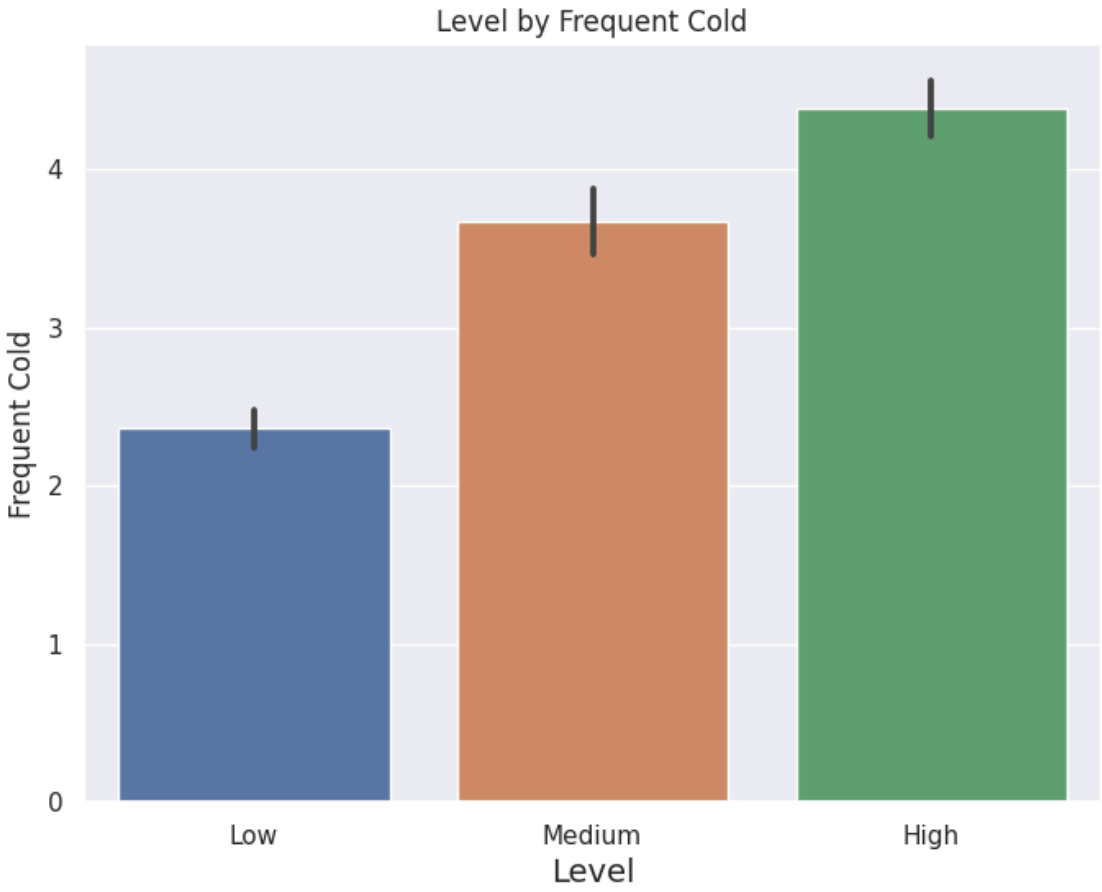
[165]:
```
plt.figure(figsize=(8, 6))
sns.barplot(x='Level', y='Swallowing Difficulty', data=df)
plt.title('Level by Swallowing Difficulty')
plt.xlabel('Level', fontsize=14)
plt.ylabel('Swallowing Difficulty')
plt.show()
```



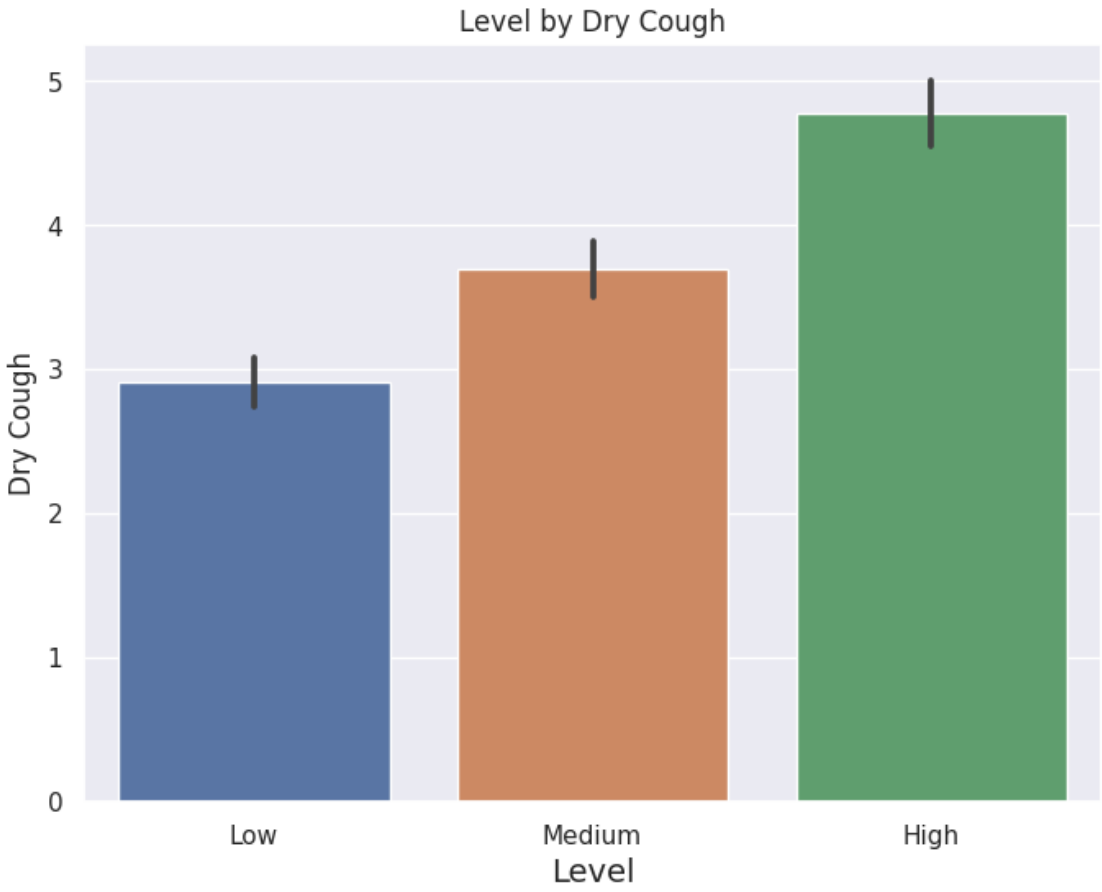
[166]:
```
plt.figure(figsize=(8, 6))
sns.barplot(x='Level', y='Clubbing of Finger Nails', data=df)
plt.title('Level by Clubbing of Finger Nails')
plt.xlabel('Level', fontsize=14)
plt.ylabel('Clubbing of Finger Nails')
plt.show()
```



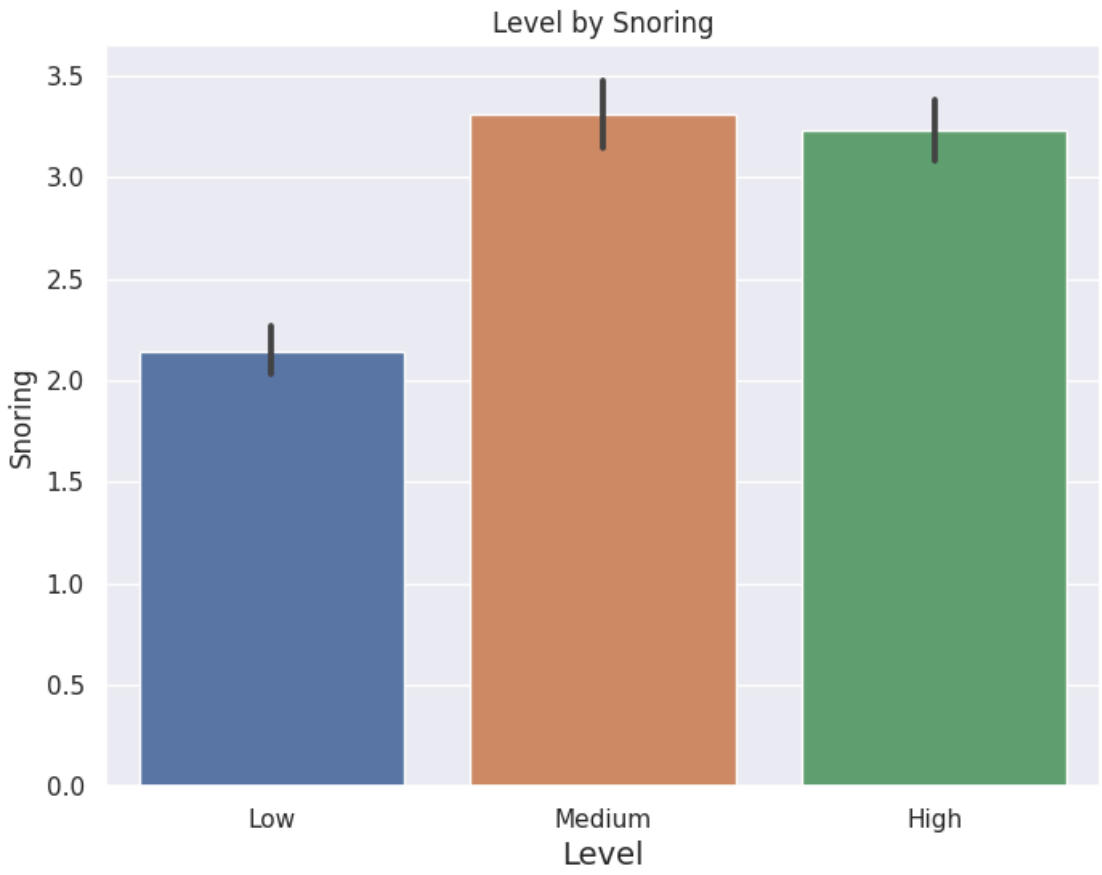
[167]:
```
plt.figure(figsize=(8, 6))
sns.barplot(x='Level', y='Frequent Cold', data=df)
plt.title('Level by Frequent Cold')
plt.xlabel('Level', fontsize=14)
plt.ylabel('Frequent Cold')
plt.show()
```



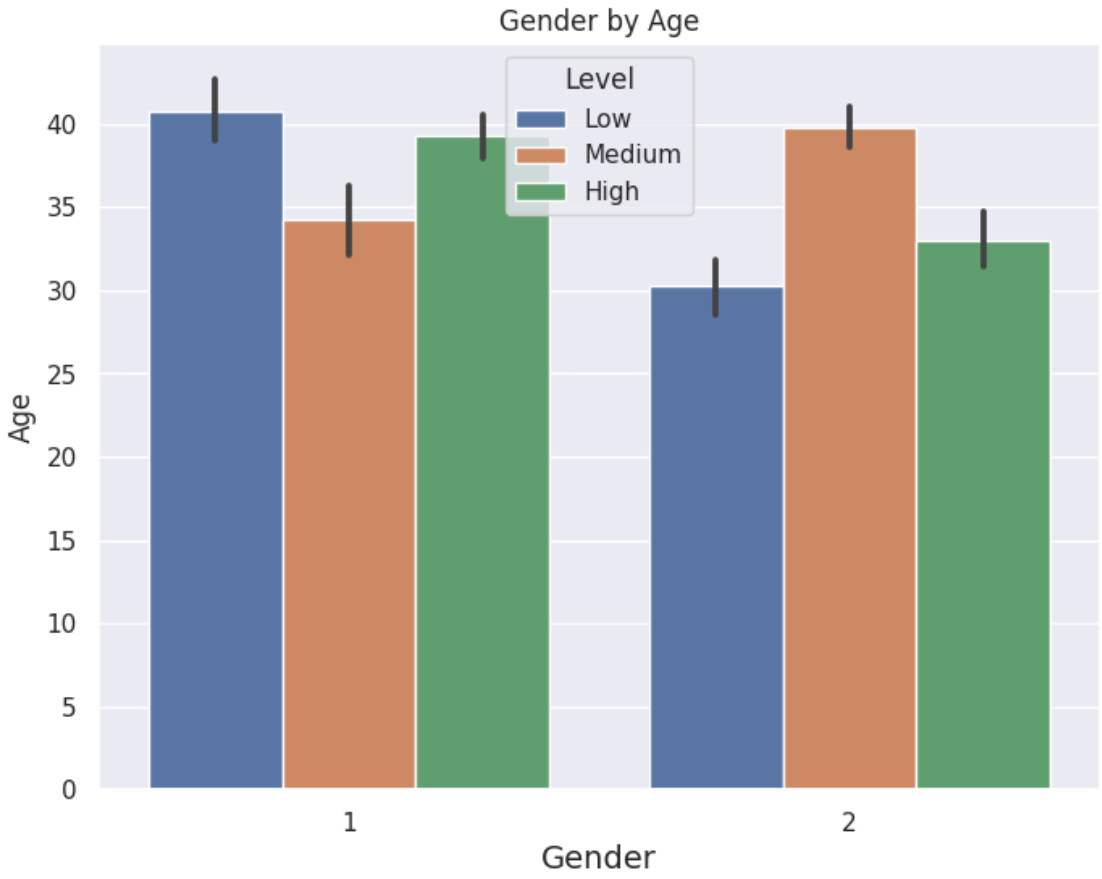
[168]:
```
plt.figure(figsize=(8, 6))
sns.barplot(x='Level', y='Dry Cough', data=df)
plt.title('Level by Dry Cough')
plt.xlabel('Level', fontsize=14)
plt.ylabel('Dry Cough')
plt.show()
```



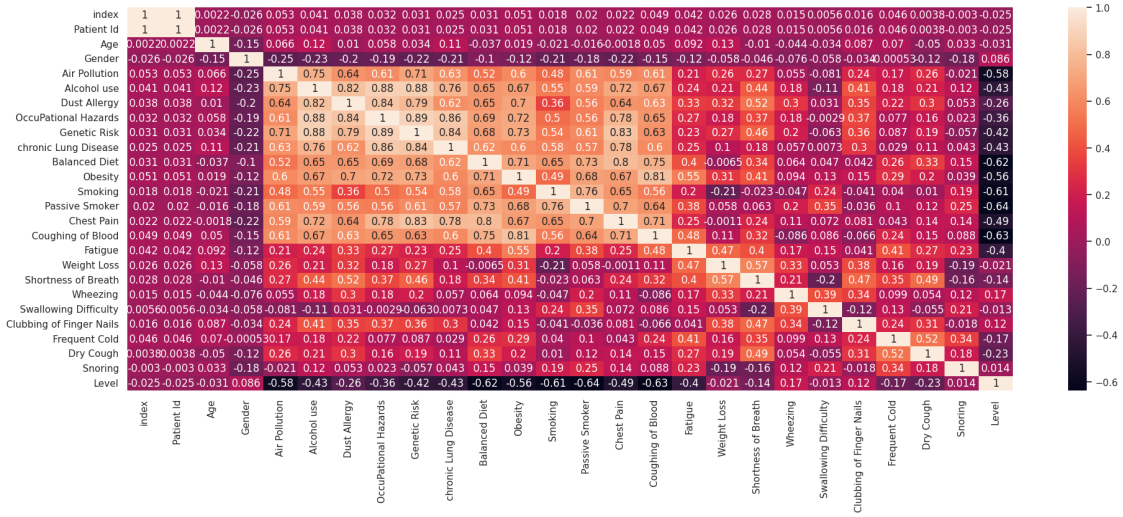
[169]:
```
plt.figure(figsize=(8, 6))
sns.barplot(x='Level', y='Snoring', data=df)
plt.title('Level by Snoring')
plt.xlabel('Level', fontsize=14)
plt.ylabel('Snoring')
plt.show()
```



[170]:
```
plt.figure(figsize=(8, 6))
sns.barplot(x='Gender', y='Age',hue="Level", data=df)
plt.title('Gender by Age')
plt.xlabel('Gender', fontsize=14)
plt.ylabel('Age')
plt.show()
```



[278]:
```
plt.figure(figsize=(23,8))
sns.heatmap(df.corr(), annot=True)
plt.show()
```



[171]:
```
num_cols = df.select_dtypes(["float64","int64"])
def plots(df, variable):
    plt.figure(figsize=(15,6))
    plt.subplot(1, 2, 1)
    #df[variable].hist()
    sns.distplot(df[variable], kde=True, bins=10)
    plt.title(variable)
    plt.subplot(1, 2, 2)
    stats.probplot(df[variable], dist="norm", plot=pylab)
    plt.title(variable)
    plt.show()
for i in num_cols.columns:
  plots(num_cols, i)
```

```
<ipython-input-171-a31d4fb8b7dc>:6: UserWarning:

`distplot` is a deprecated function and will be removed in seaborn v0.14.0.

Please adapt your code to use either `displot` (a figure-level function with
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For a guide to updating your code to use the new functions, please see
https://gist.github.com/mwaskom/de44147ed2974457ad6372750bbe5751

  sns.distplot(df[variable], kde=True, bins=10)
```

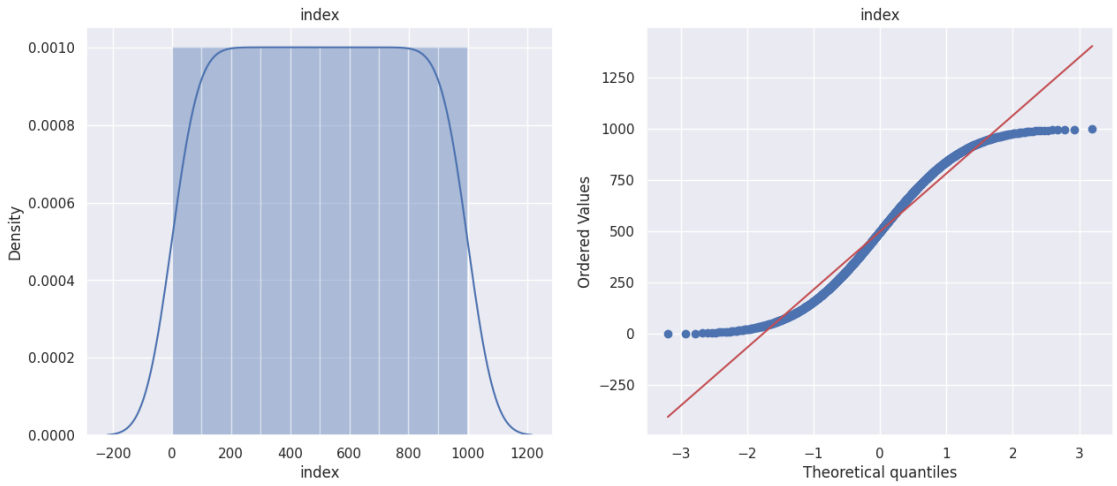


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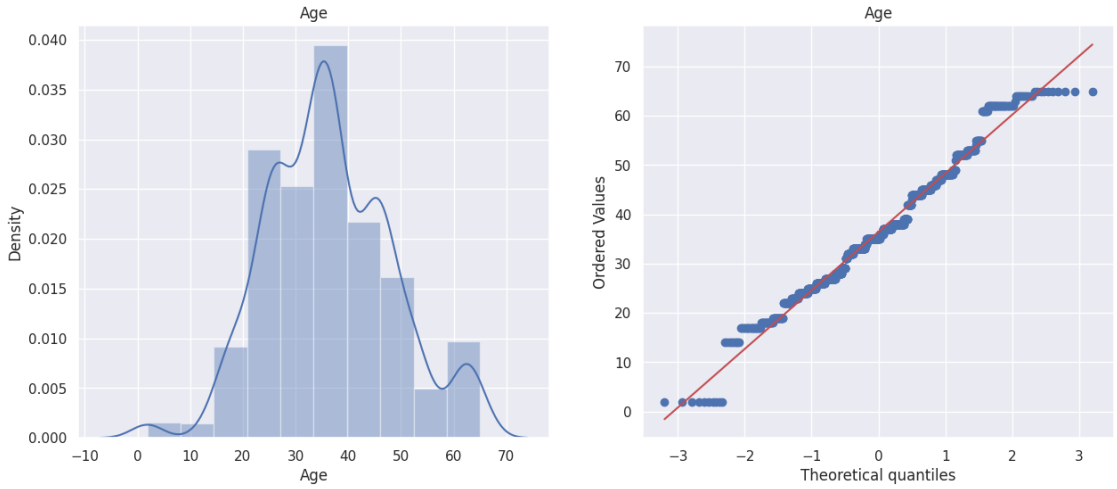


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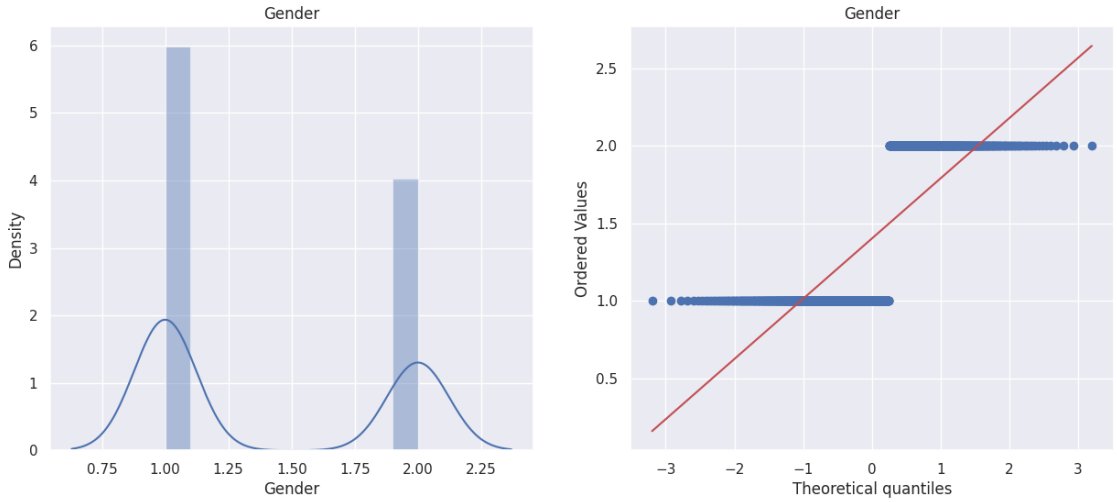
```

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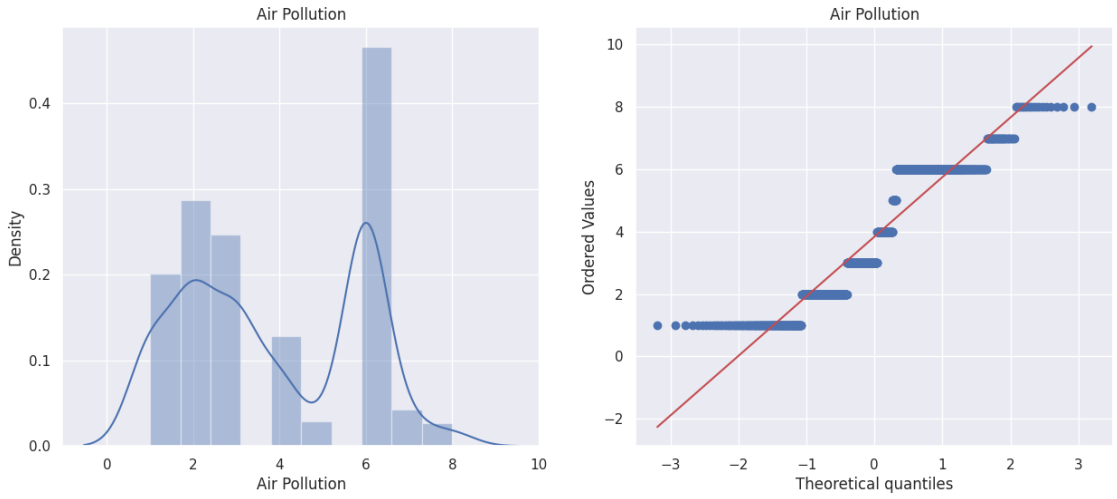


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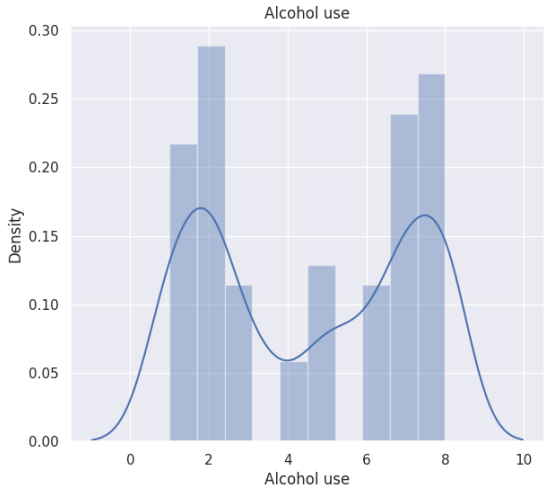

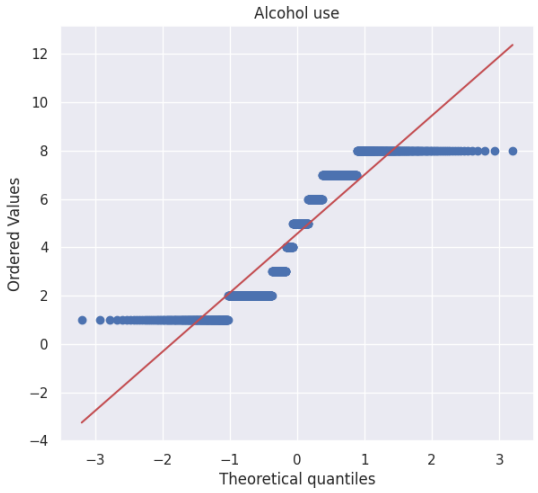


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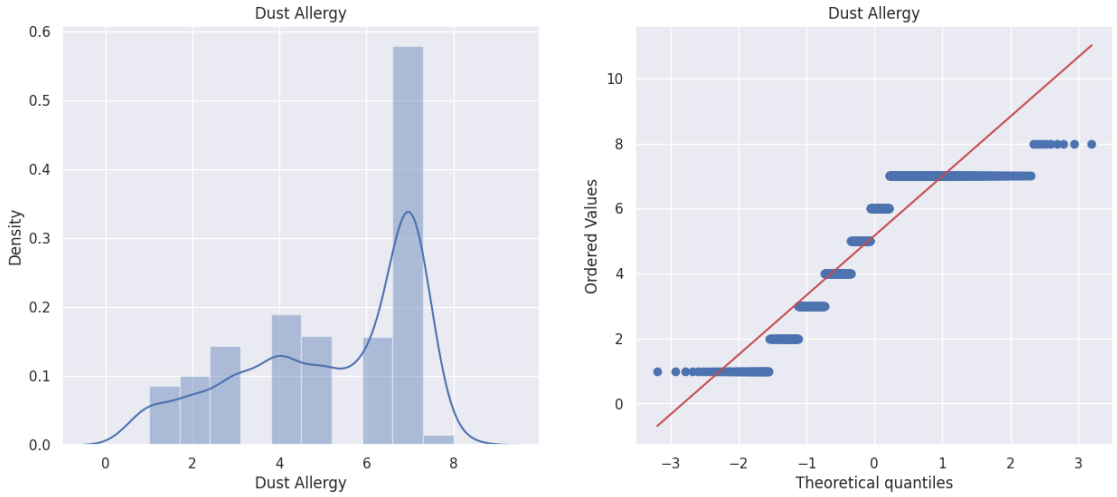


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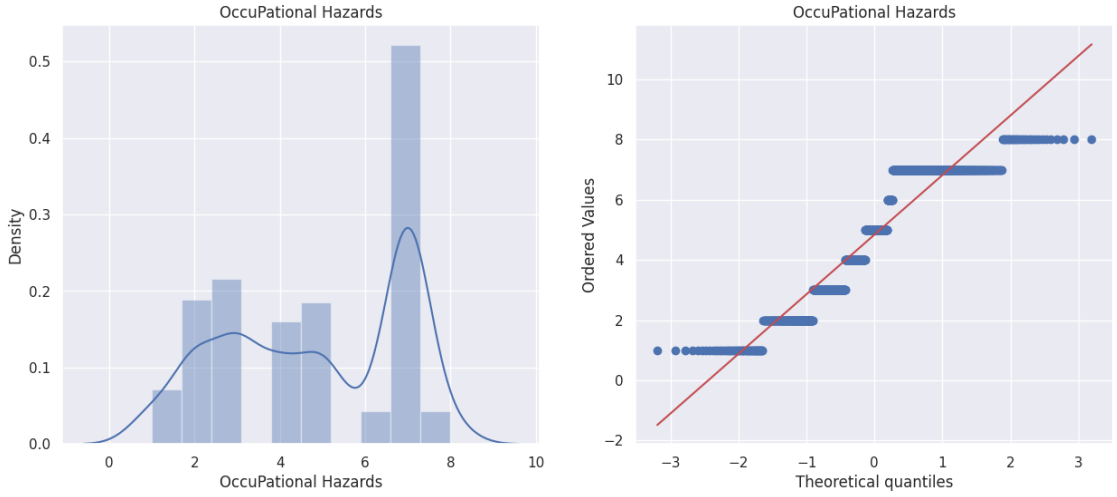


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```

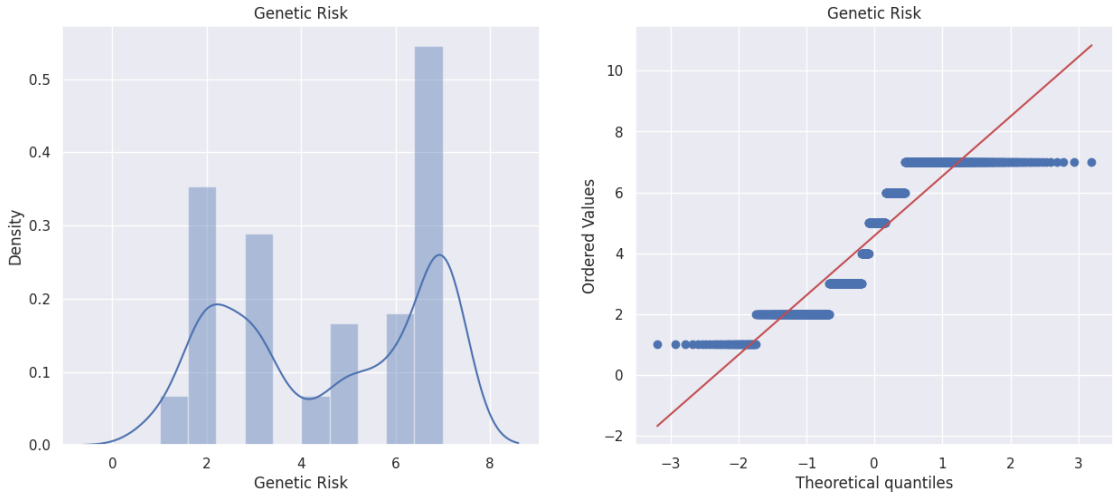


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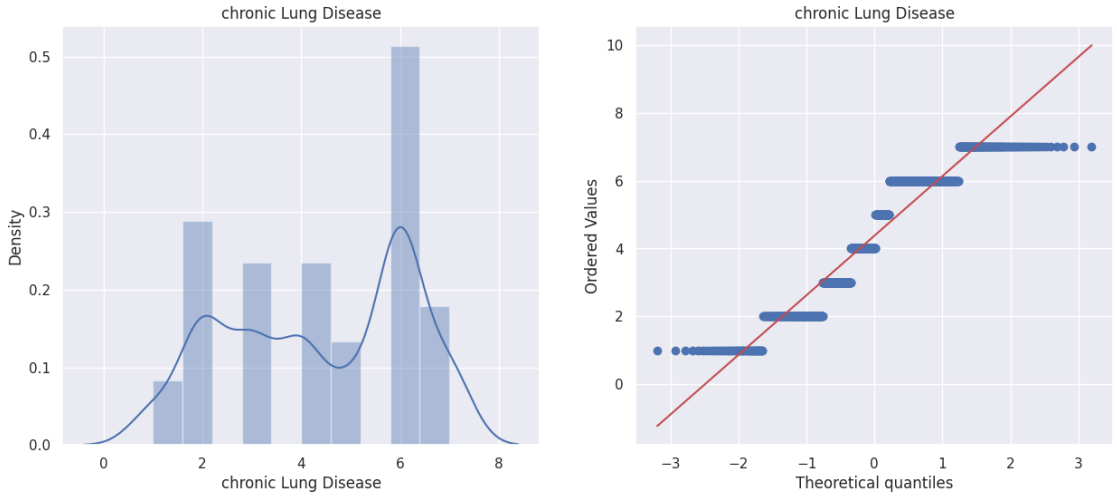


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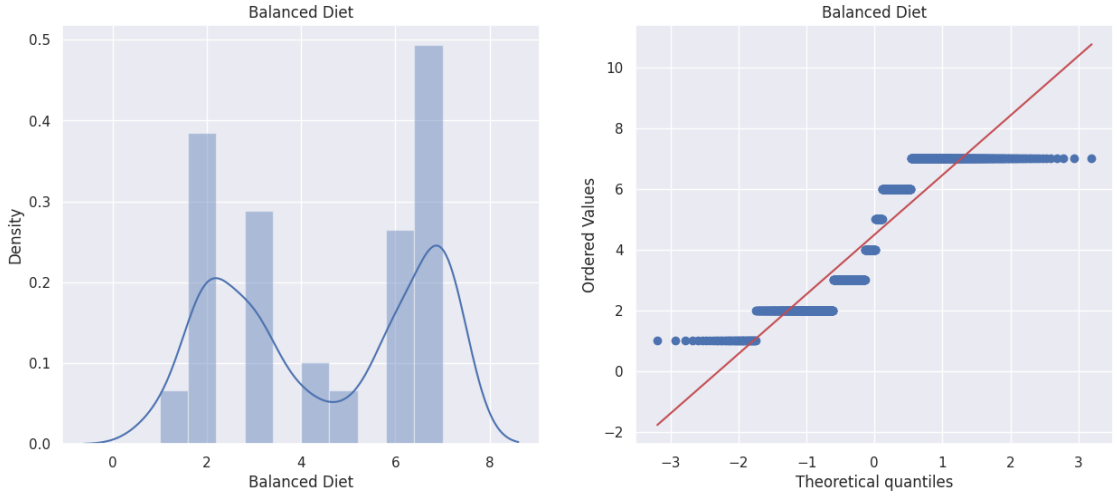


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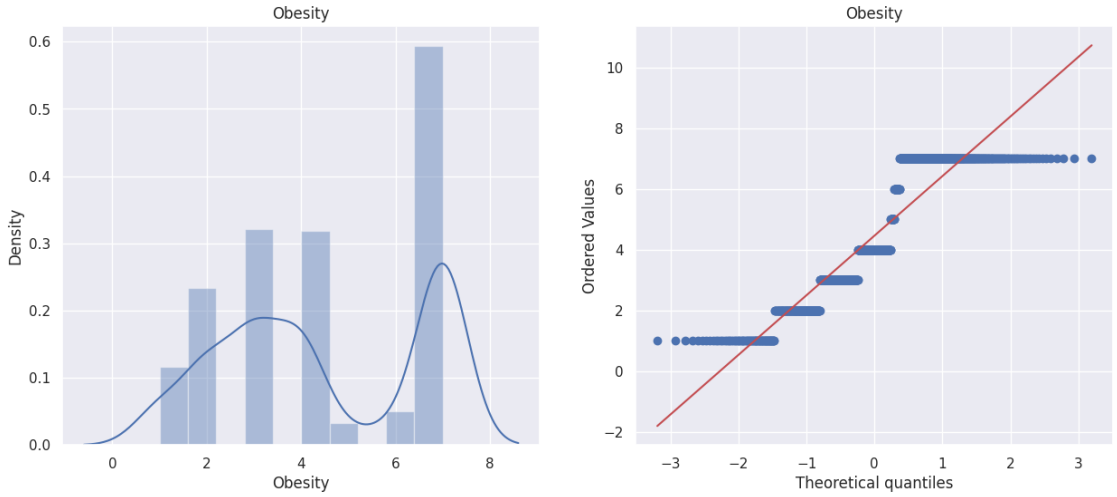


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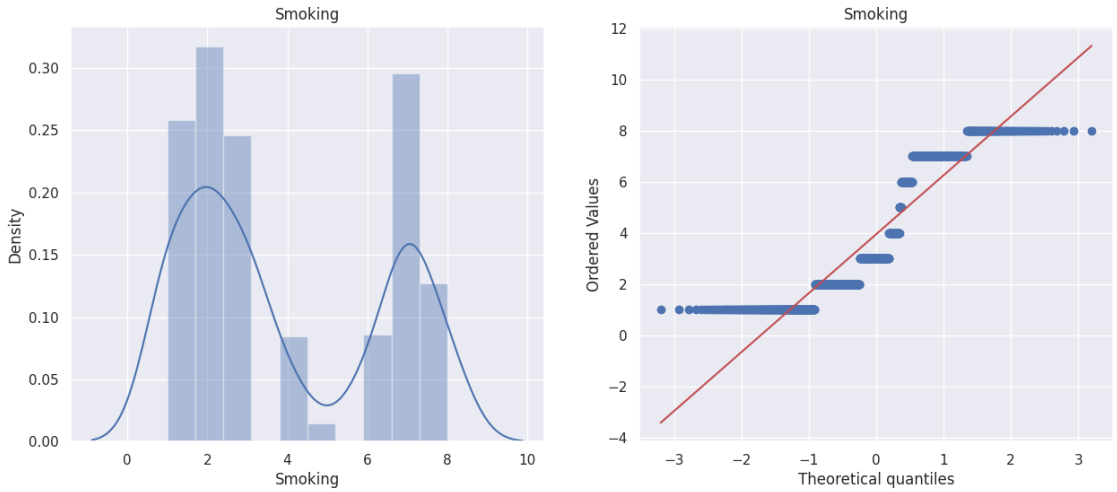


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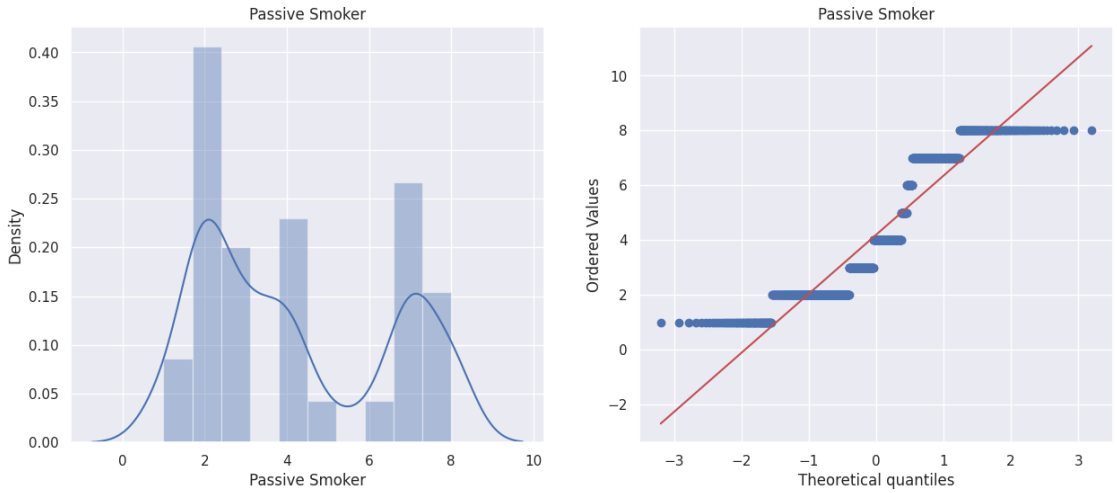
```

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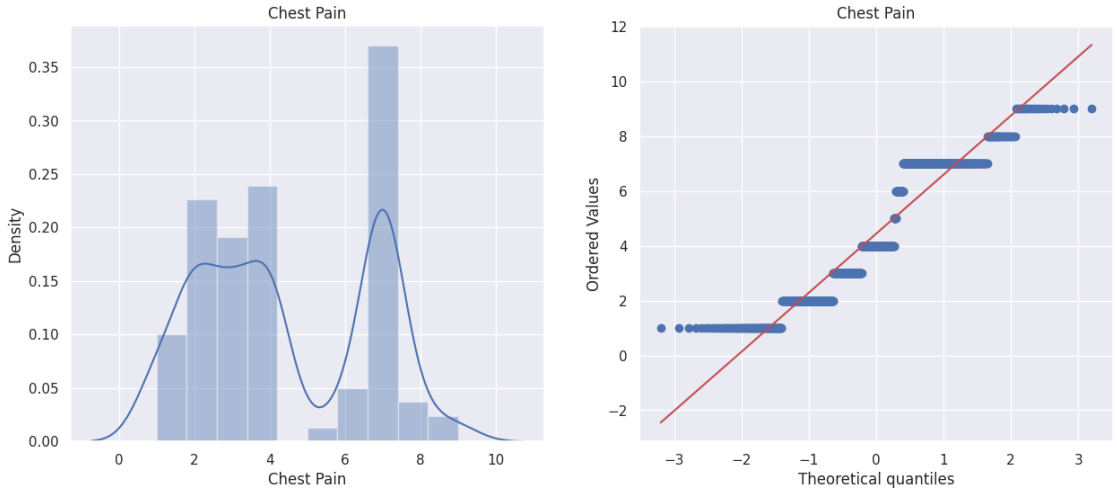


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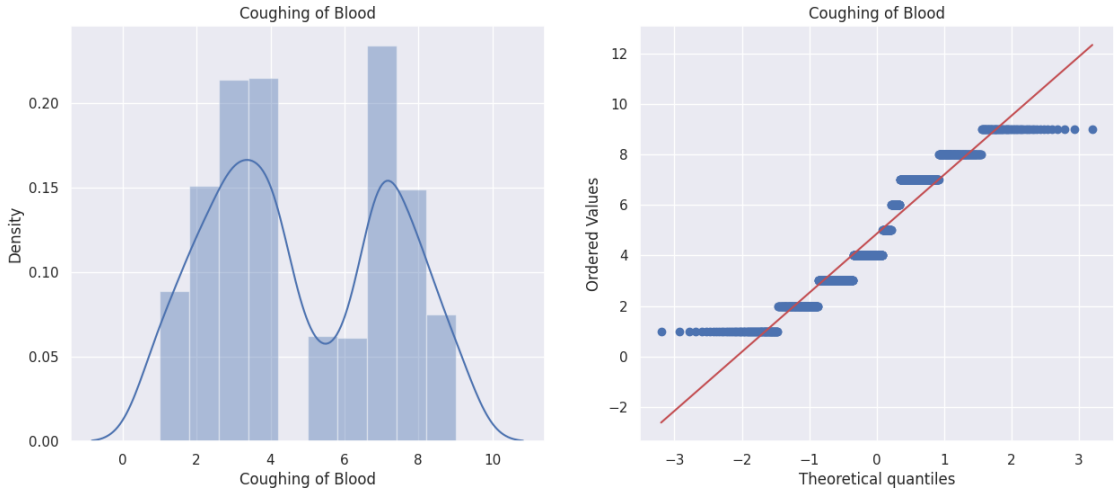


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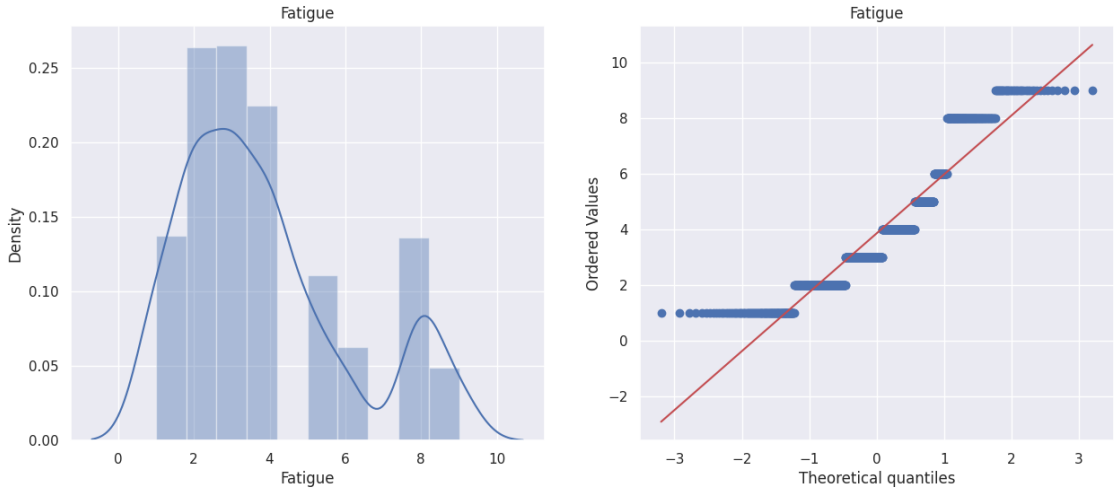


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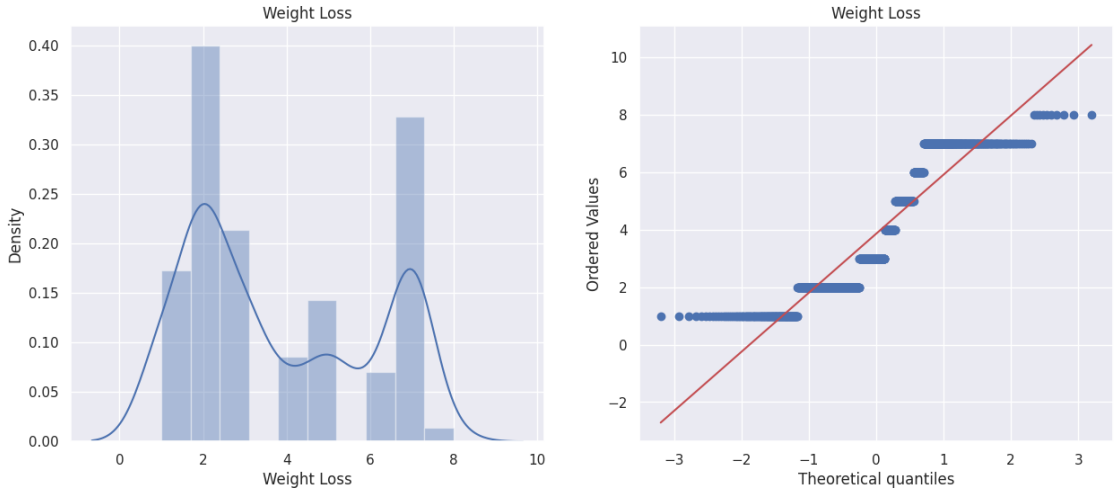


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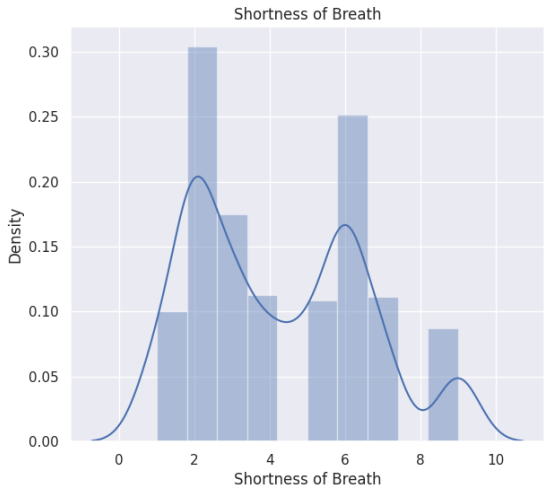

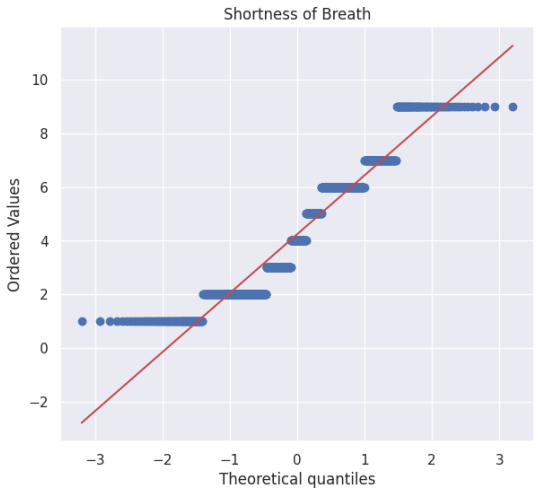


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  sns.distplot(df[variable], kde=True, bins=10)
```

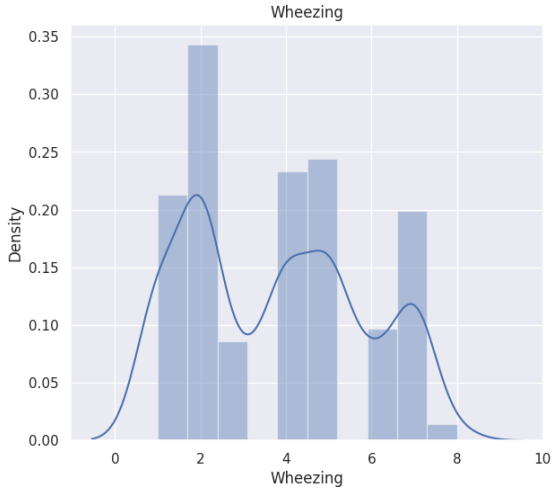

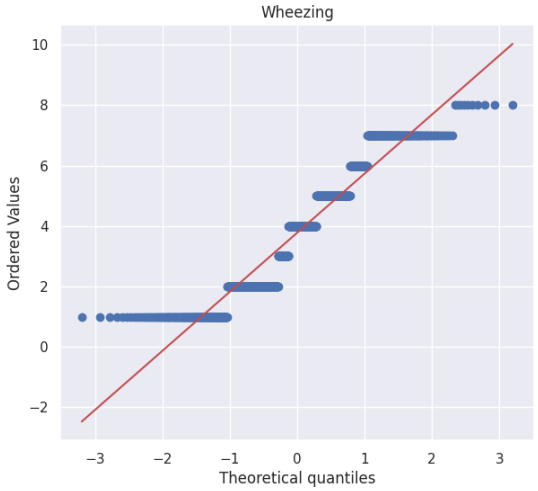


```
<ipython-input-171-a31d4fb8b7dc>:6: UserWarning:
```

```
`distplot` is a deprecated function and will be removed in seaborn v0.14.0.

Please adapt your code to use either `displot` (a figure-level function with
similar flexibility) or `histplot` (an axes-level function for histograms).

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https://gist.github.com/mwaskom/de44147ed2974457ad6372750bbe5751

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```

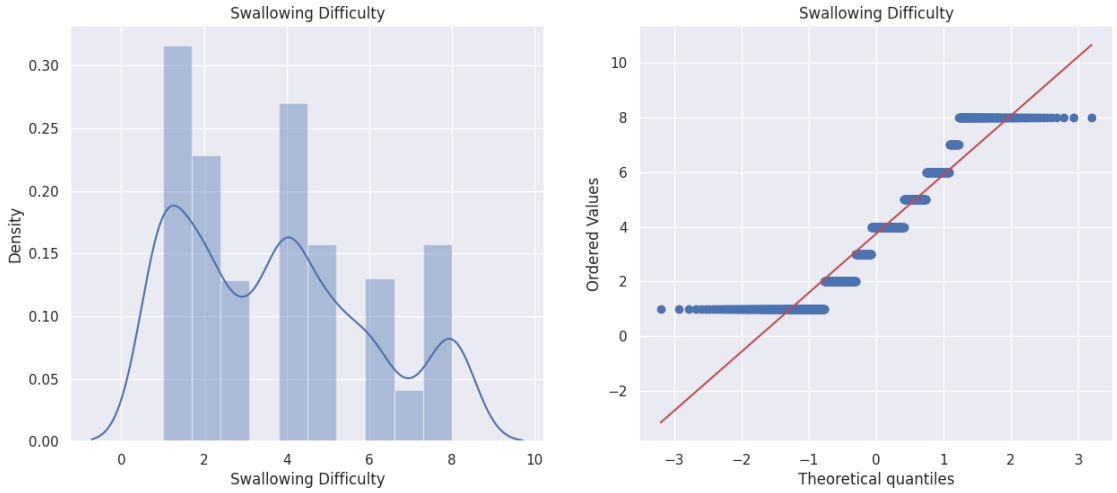


```
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```

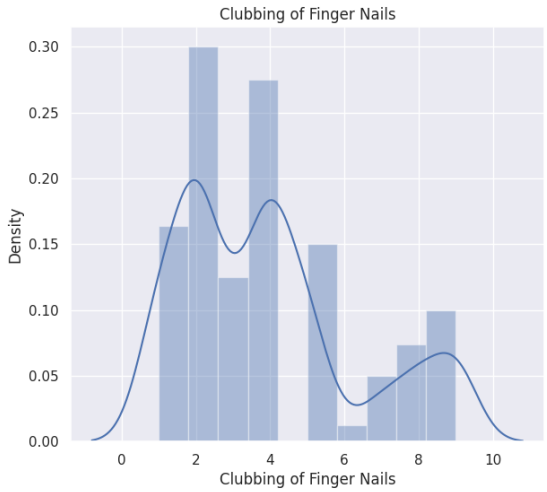

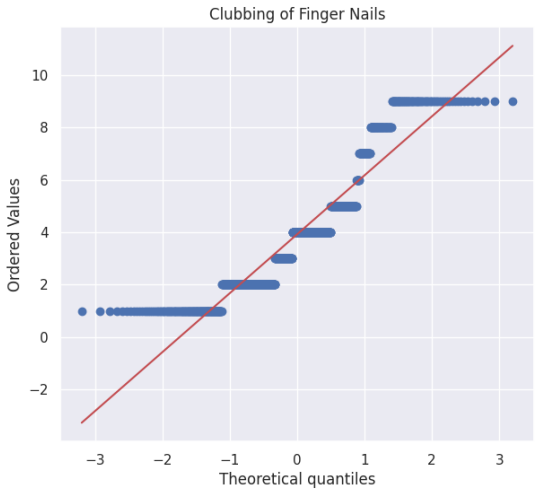


```
<ipython-input-171-a31d4fb8b7dc>:6: UserWarning:

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```

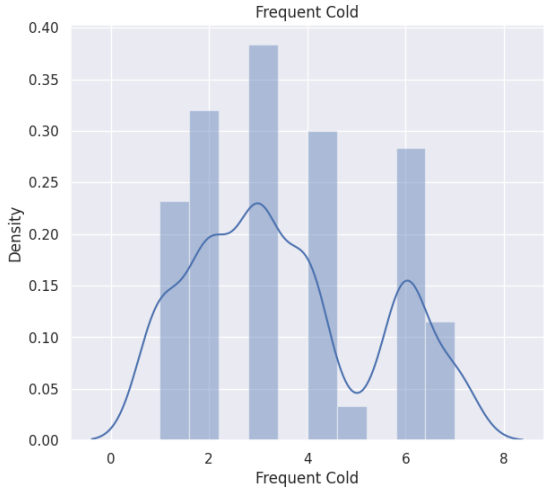

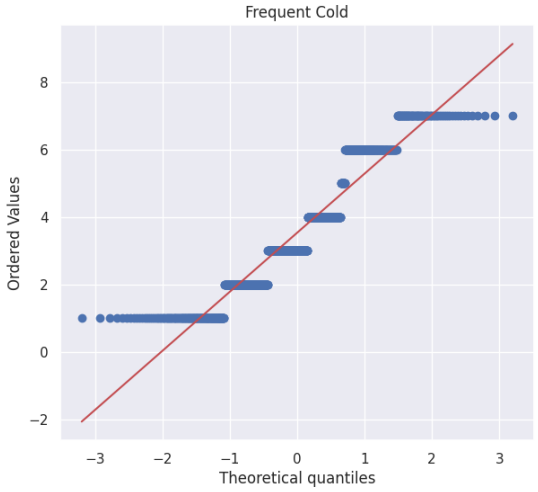


```
<ipython-input-171-a31d4fb8b7dc>:6: UserWarning:
```

```
`distplot` is a deprecated function and will be removed in seaborn v0.14.0.

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  sns.distplot(df[variable], kde=True, bins=10)
```

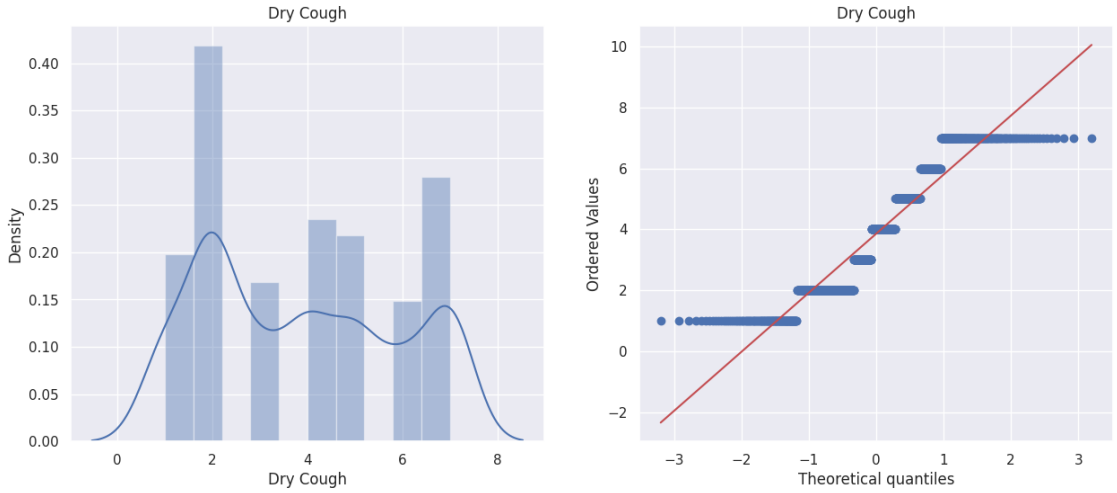


```
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https://gist.github.com/mwaskom/de44147ed2974457ad6372750bbe5751

  sns.distplot(df[variable], kde=True, bins=10)
```
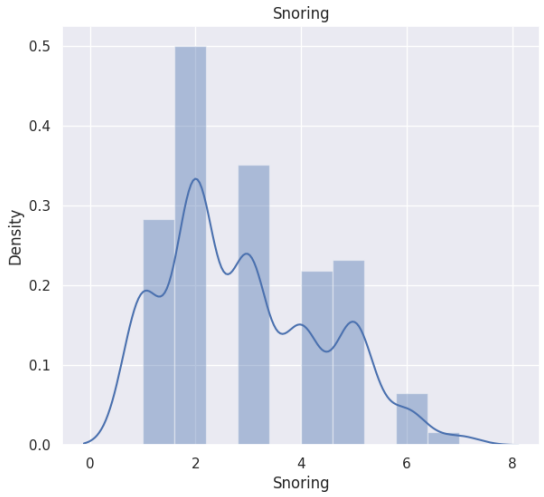
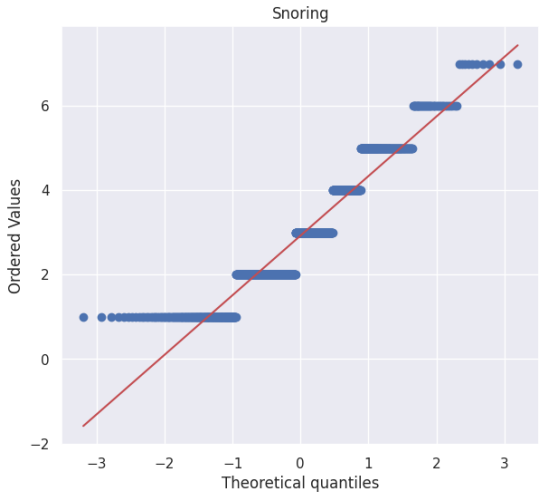





Convert Categorical Data To Numerical

[172]:
```
le = LabelEncoder()
Label = df.select_dtypes(include=["object"])
df = df.copy()

for i in Label:
  df[i] = le.fit_transform(df[i])

df.shape
```

[172]: (1000, 26)

[173]:
```
df.head()
```

[173]:

	index	Patient Id	Age	Gender	Air Pollution	Alcohol use	Dust Allergy	\
0	0	0	33.0	1	2	4	5	
1	1	1	17.0	1	3	1	5	
2	2	2	35.0	1	4	5	6	
3	3	3	37.0	1	7	7	7	
4	4	4	46.0	1	6	8	7	

	OccuPational Hazards	Genetic Risk	chronic Lung Disease	…	Fatigue	\
0	4	3	2	…	3	
1	3	4	2	…	1	
2	5	5	4	…	8	
3	7	6	7	…	4	
4	7	7	6	…	3	

	Weight Loss	Shortness of Breath	Wheezing	Swallowing Difficulty	\

```
0            4                    2         2                    3
1            3                    7         8                    6
2            7                    9         2                    1
3            2                    3         1                    4
4            2                    4         1                    4

   Clubbing of Finger Nails  Frequent Cold  Dry Cough  Snoring  Level
0                         1              2          3        4      1
1                         2              1          7        2      2
2                         4              6          7        2      0
3                         5              6          7        5      0
4                         2              4          2        3      0

[5 rows x 26 columns]
```

[257]:
```
df.iloc[:,-1]
```

[257]:
```
0      1
1      2
2      0
3      0
4      0
      ..
995    0
996    0
997    0
998    0
999    0
Name: Level, Length: 1000, dtype: int64
```

[174]:
```
X = df.iloc[:,2:25]
Y = df.iloc[:,-1]
```

[175]:
```
X.head()
```

[175]:
```
    Age  Gender  Air Pollution  Alcohol use  Dust Allergy  \
0  33.0       1              2            4             5
1  17.0       1              3            1             5
2  35.0       1              4            5             6
3  37.0       1              7            7             7
4  46.0       1              6            8             7

   OccuPational Hazards  Genetic Risk  chronic Lung Disease  Balanced Diet  \
0                     4             3                     2              2
1                     3             4                     2              2
2                     5             5                     4              6
3                     7             6                     7              7
```

```
4                    7             7                    6              7

   Obesity  …  Coughing of Blood  Fatigue  Weight Loss  Shortness of Breath  \
0        4  …                  4        3            4                    2
1        2  …                  3        1            3                    7
2        7  …                  8        8            7                    9
3        7  …                  8        4            2                    3
4        7  …                  9        3            2                    4

   Wheezing  Swallowing Difficulty  Clubbing of Finger Nails  Frequent Cold  \
0         2                      3                         1              2
1         8                      6                         2              1
2         2                      1                         4              6
3         1                      4                         5              6
4         1                      4                         2              4

   Dry Cough  Snoring
0          3        4
1          7        2
2          7        2
3          7        5
4          2        3

[5 rows x 23 columns]
```

[256]:
```
Y
```

[256]:
```
0      1
1      2
2      0
3      0
4      0
      ..
995    0
996    0
997    0
998    0
999    0
Name: Level, Length: 1000, dtype: int64
```

7 Feature Engineering

Mutual Information

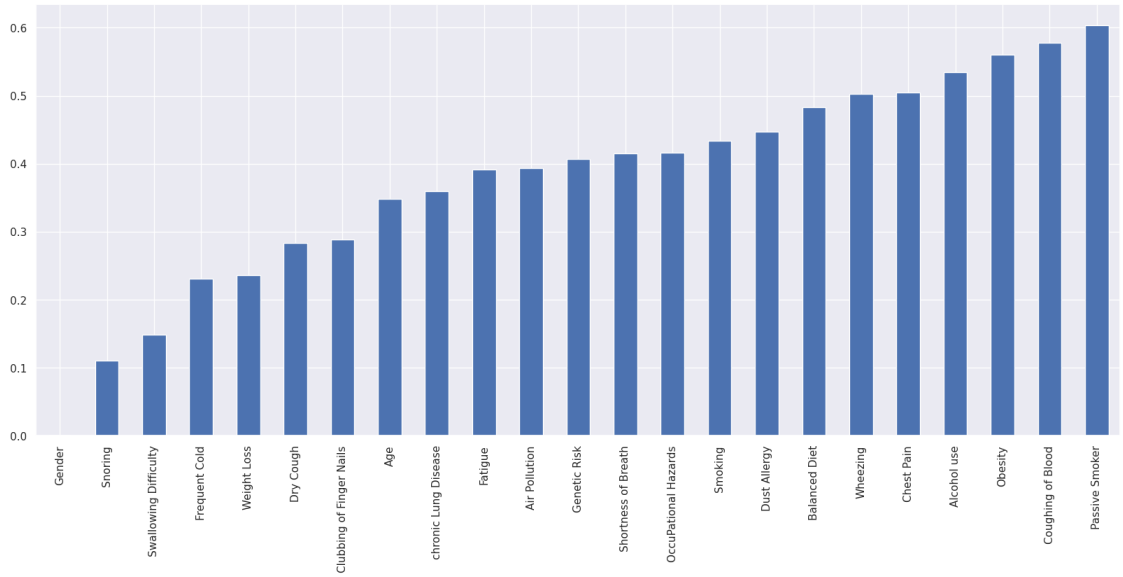
[176]:
```
mi_score = mutual_info_classif(X,Y)
mi_score = pd.Series(mi_score)
mi_score.index = X.columns
```

```
mi_score.sort_values(ascending=True)
```

[176]:
```
Gender                          0.000000
Snoring                         0.110750
Swallowing Difficulty           0.148515
Frequent Cold                   0.231064
Weight Loss                     0.236030
Dry Cough                       0.283007
Clubbing of Finger Nails        0.288701
Age                             0.347935
chronic Lung Disease            0.359142
Fatigue                         0.391270
Air Pollution                   0.393316
Genetic Risk                    0.406658
Shortness of Breath             0.415129
OccuPational Hazards            0.415708
Smoking                         0.433691
Dust Allergy                    0.447152
Balanced Diet                   0.483101
Wheezing                        0.502561
Chest Pain                      0.505141
Alcohol use                     0.534074
Obesity                         0.559983
Coughing of Blood               0.577779
Passive Smoker                  0.603741
dtype: float64
```

[177]:
```
mi_score.sort_values(ascending=True).plot.bar(figsize=(20, 8))
```

[177]: <Axes: >



Splitting Data into Train And Test

[178]:
```
train_data,test_data,train_label,test_label = train_test_split(X,Y,test_size=0.
↪3, random_state=0)
```

[179]:
```
print("train_data : ",train_data.shape)
print("train_label : ",train_label.shape)
print("test_data : ",test_data.shape)
print("test_label : ",test_label.shape)
```

```
train_data :  (700, 23)
train_label :  (700,)
test_data :  (300, 23)
test_label :  (300,)
```

Normalize The Data

[180]:
```
sc = StandardScaler()
train_data_sc = sc.fit_transform(train_data)
test_data_sc = sc.fit_transform(test_data)
```

[181]:
```
train_data_sc
```

[181]:
```
array([[ 0.03413479,  1.21387736,  1.50954409, …,  1.32578794,
         1.49563496,  1.40644191],
       [ 2.06424152, -0.82380645,  1.01737788, …,  0.24603046,
        -0.9425217 ,  0.048498  ],
       [ 0.68376895,  1.21387736, -1.4434532 , …,  0.24603046,
        -0.9425217 ,  1.40644191],
       …,
       [-1.18392924, -0.82380645,  1.01737788, …, -0.29384829,
         0.03274096, -0.63047396],
       [ 0.03413479, -0.82380645,  1.50954409, …,  1.32578794,
         1.49563496,  1.40644191],
       [-0.04706947, -0.82380645,  1.01737788, …,  1.86566669,
         1.00800363, -0.63047396]])
```

PCA

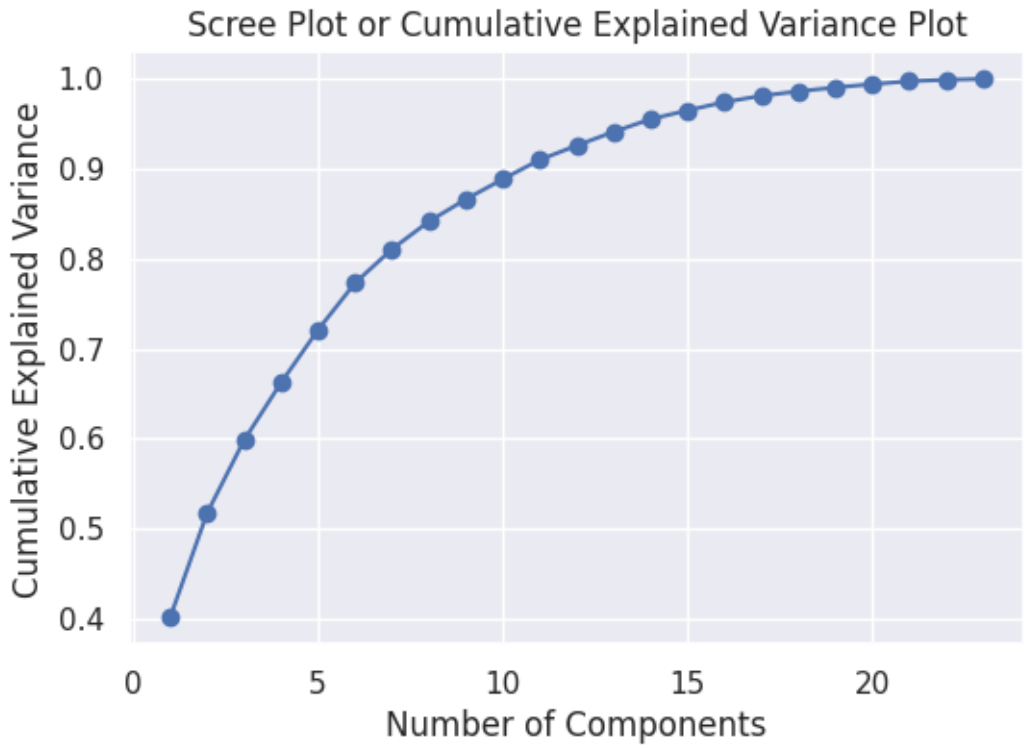
[182]:
```
pc = PCA()
train_data_sc_pc = pc.fit_transform(train_data_sc)
test_data_sc_pc = pc.fit_transform(test_data_sc)
```

[183]:
```
explained_variance = pc.explained_variance_ratio_
```

[184]:
```
print("Explained Variance Ratios:", explained_variance)
```

```
Explained Variance Ratios: [0.40143189 0.11595519 0.0809727  0.063913
0.05872856 0.05202227
 0.03768021 0.03081583 0.02463855 0.02241642 0.02146209 0.0159059
 0.01525445 0.01406892 0.00975376 0.00926771 0.00692823 0.00502174
 0.00426276 0.00370965 0.00322876 0.00158369 0.00097771]
```

[185]:
```
# calculate cumulative sum of explained variance ratio
cumulative_variance = np.cumsum(explained_variance)


# plot the scree plot or cumulative explained variance plot
plt.plot(range(1, len(explained_variance) + 1), cumulative_variance,␣
 ↪marker='o', linestyle='-')
plt.xlabel('Number of Components')
plt.ylabel('Cumulative Explained Variance')
plt.title('Scree Plot or Cumulative Explained Variance Plot')
plt.grid(True)
plt.show()
```



[186]:
```
# Cumulative explained variance nikalen
cumulative_variance = np.cumsum(explained_variance)

# Kitne components select karna hai, yeh decide karen
```

```
desired_variance = 0.95  # Example: 95% variance ko capture karna hai

# Kitne components select kiye ja sakte hain
num_components = np.argmax(cumulative_variance >= desired_variance) + 1

print(f"\nNumber of components selected: {num_components}")
```

```
Number of components selected: 14
```

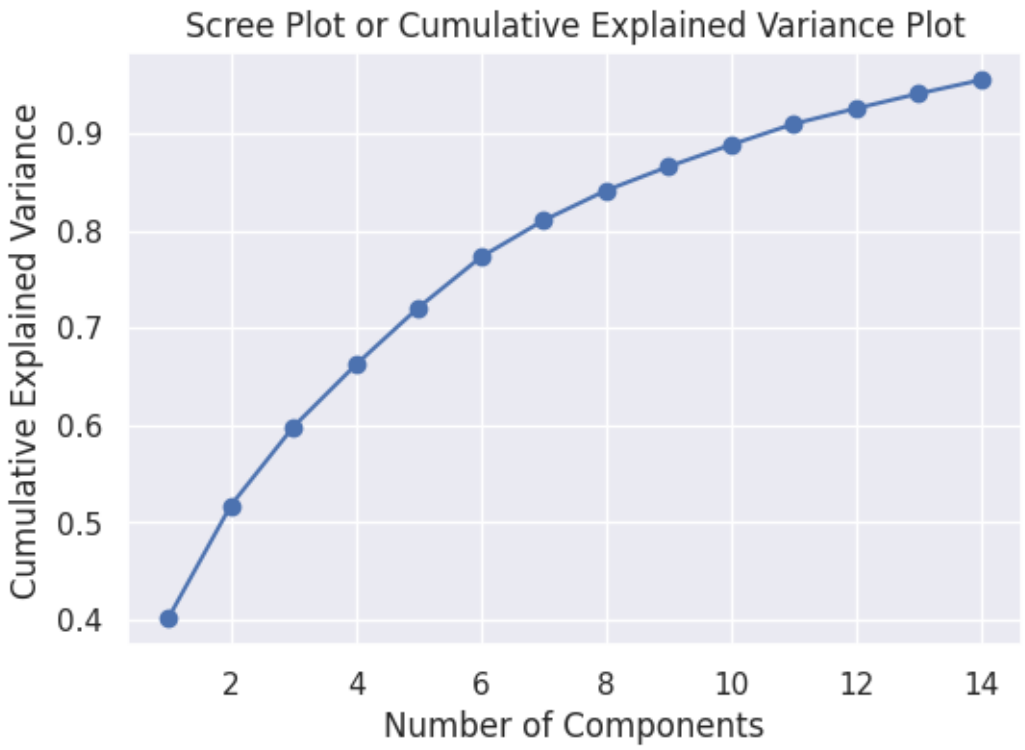
[187]:
```
pc = PCA(n_components=14)
train_data_sc_pc_select = pc.fit_transform(train_data_sc)
test_data_sc_pc_select = pc.fit_transform(test_data_sc)
```

[188]:
```
explained_variance = pc.explained_variance_ratio_
```

[189]:
```
print("Explained Variance Ratios:", explained_variance)
```

```
Explained Variance Ratios: [0.40143189 0.11595519 0.0809727  0.063913
0.05872856 0.05202227
 0.03768021 0.03081583 0.02463855 0.02241642 0.02146209 0.0159059
 0.01525445 0.01406892]
```

[190]:
```
# calculate cumulative sum of explained variance ratio
cumulative_variance = np.cumsum(explained_variance)


# plot the scree plot or cumulative explained variance plot
plt.plot(range(1, len(explained_variance) + 1), cumulative_variance,␣
 ↪marker='o', linestyle='-')
plt.xlabel('Number of Components')
plt.ylabel('Cumulative Explained Variance')
plt.title('Scree Plot or Cumulative Explained Variance Plot')
plt.grid(True)
plt.show()
```



8 Models

[191]:
```
accuracy_results = {}
```

Logistic Regression Model

[192]:
```
model_lr = LogisticRegression().fit(train_data_sc_pc_select,train_label)
```

[193]:
```
y_pred = model_lr.predict(test_data_sc_pc_select)
y_pred
```

[193]:
```
array([1, 2, 2, 2, 0, 0, 2, 2, 0, 0, 0, 1, 0, 1, 1, 0, 1, 2, 0, 2, 1, 2,
       1, 1, 1, 1, 0, 1, 1, 0, 1, 0, 0, 1, 0, 2, 2, 0, 1, 0, 2, 1, 2, 1,
       2, 0, 0, 1, 1, 1, 2, 2, 0, 2, 2, 2, 0, 0, 2, 1, 0, 1, 1, 2, 2, 2,
       0, 1, 1, 2, 0, 1, 2, 2, 2, 0, 0, 2, 0, 2, 2, 2, 0, 1, 2, 2, 0, 2,
       0, 1, 1, 0, 1, 0, 0, 0, 0, 1, 0, 1, 2, 1, 2, 0, 1, 2, 2, 2, 2, 1,
       1, 1, 1, 1, 0, 0, 2, 0, 0, 2, 1, 0, 1, 0, 0, 1, 2, 0, 0, 0, 0, 0,
       0, 0, 1, 2, 0, 1, 2, 2, 0, 0, 2, 2, 0, 2, 0, 0, 0, 0, 0, 1, 2, 2,
       1, 2, 0, 2, 0, 2, 2, 1, 1, 1, 2, 0, 1, 0, 1, 2, 2, 1, 0, 0, 0, 2,
       1, 1, 2, 0, 2, 2, 1, 1, 1, 0, 0, 0, 1, 1, 1, 0, 2, 2, 1, 0, 0, 1,
       1, 2, 2, 0, 1, 0, 0, 2, 2, 0, 2, 0, 2, 2, 2, 0, 0, 1, 0, 0, 0, 1,
       1, 2, 2, 0, 2, 0, 0, 2, 1, 2, 0, 2, 1, 1, 0, 1, 0, 2, 0, 2, 2, 0,
```

```
       1, 1, 1, 1, 1, 2, 0, 2, 1, 2, 2, 2, 0, 2, 1, 2, 1, 2, 0, 0, 1, 2,
       0, 0, 1, 2, 2, 0, 0, 2, 0, 0, 2, 1, 2, 2, 1, 0, 1, 1, 2, 2, 1, 2,
       0, 1, 0, 2, 2, 2, 2, 0, 0, 0, 1, 2, 0, 1])
```

[194]:
```
print("Accuracy Score : ", accuracy_score(y_pred, test_label))
```

```
Accuracy Score :  0.21
```

[195]:
```
confusion_matrix(y_pred, test_label)
```

[195]:
```
array([[ 0, 87, 21],
       [80,  0,  9],
       [28, 12, 63]])
```

[196]:
```
print(classification_report(y_pred, test_label))
```

```
              precision    recall  f1-score   support

           0       0.00      0.00      0.00       108
           1       0.00      0.00      0.00        89
           2       0.68      0.61      0.64       103

    accuracy                           0.21       300
   macro avg       0.23      0.20      0.21       300
weighted avg       0.23      0.21      0.22       300
```

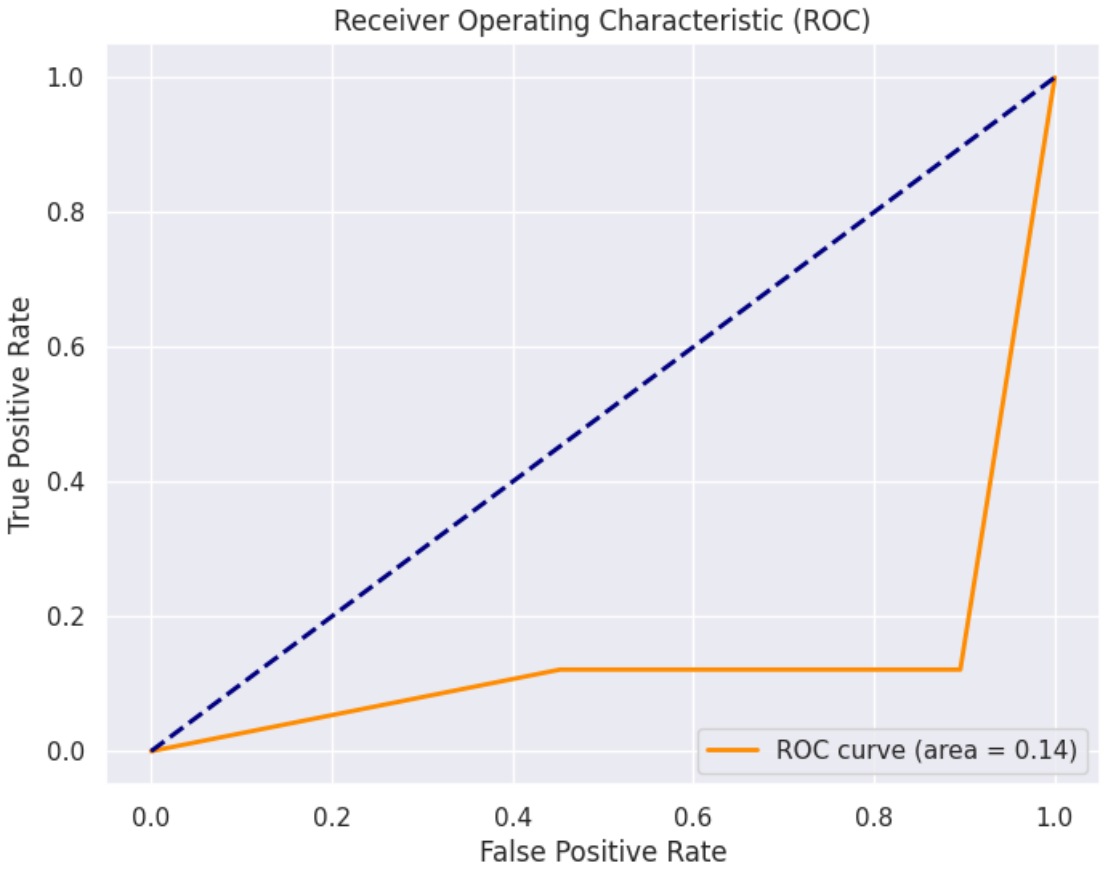
[197]:
```
train_accuracy_lr =␣
 ↪cross_val_score(model_lr,train_data_sc_pc_select,train_label,cv=5).mean()
test_accuracy_lr =␣
 ↪cross_val_score(model_lr,test_data_sc_pc_select,test_label,cv=5).mean()
print(" Train Data Cross_val_score : ",train_accuracy_lr)
print("Test Data Cross_val_score : ",test_accuracy_lr)
```

```
 Train Data Cross_val_score :  1.0
Test Data Cross_val_score :  0.9833333333333334
```

[198]:
```
accuracy_results["Logistic_Regression_Accuracy"] = train_accuracy_lr
```

[199]:
```
fpr, tpr, thresholds = roc_curve(test_label, y_pred, pos_label=1)

# Calculate the Area Under the Curve (AUC)
roc_auc = auc(fpr, tpr)

# Plot ROC curve
plt.figure(figsize=(8, 6))
```

```
plt.plot(fpr, tpr, color='darkorange', lw=2, label='ROC curve (area = %0.2f)' %␣
 ↪roc_auc)
plt.plot([0, 1], [0, 1], color='navy', lw=2, linestyle='--')
plt.xlabel('False Positive Rate')
plt.ylabel('True Positive Rate')
plt.title('Receiver Operating Characteristic (ROC)')
plt.legend(loc='lower right')
plt.show()
```



Random Forest Model

[210]:
```
model_rf = RandomForestClassifier(max_depth=10, min_samples_leaf=1,␣
 ↪min_samples_split=2, n_estimators=100).
 ↪fit(train_data_sc_pc_select,train_label)
```

[211]:
```
y_pred_2 = model_rf.predict(test_data_sc_pc_select)
y_pred_2
```

[211]:
```
array([1, 2, 0, 2, 1, 0, 0, 2, 0, 0, 0, 1, 0, 1, 1, 0, 1, 2, 0, 2, 2, 2,
       1, 1, 1, 1, 0, 1, 1, 0, 1, 0, 0, 1, 0, 2, 2, 1, 1, 0, 1, 1, 0, 2,
       2, 1, 0, 1, 1, 2, 2, 0, 0, 2, 0, 0, 0, 0, 2, 1, 0, 1, 2, 1, 0, 0,
       0, 1, 1, 2, 0, 2, 2, 2, 2, 0, 0, 1, 0, 2, 1, 1, 0, 1, 2, 0, 0, 0,
       0, 1, 1, 0, 1, 0, 0, 0, 0, 1, 0, 1, 1, 1, 0, 0, 1, 2, 2, 1, 2, 1,
       1, 1, 1, 2, 1, 0, 2, 0, 0, 2, 1, 0, 1, 0, 0, 2, 1, 0, 0, 0, 0, 0,
       0, 0, 1, 2, 0, 1, 0, 2, 0, 0, 0, 0, 0, 1, 0, 0, 0, 0, 0, 1, 2, 1,
       1, 2, 0, 2, 0, 1, 2, 1, 1, 1, 1, 0, 1, 0, 1, 0, 2, 1, 0, 0, 0, 0,
       1, 1, 2, 1, 2, 2, 1, 1, 1, 0, 0, 0, 1, 1, 1, 0, 2, 2, 1, 0, 0, 1,
       1, 1, 2, 0, 1, 0, 0, 0, 2, 0, 2, 0, 0, 0, 2, 1, 0, 1, 0, 0, 0, 1,
       1, 2, 0, 0, 0, 0, 0, 2, 1, 2, 0, 2, 2, 1, 0, 1, 0, 2, 0, 2, 1, 0,
       1, 2, 1, 1, 1, 2, 0, 2, 2, 1, 0, 2, 0, 2, 1, 2, 2, 2, 0, 0, 1, 2,
       0, 0, 1, 0, 2, 0, 0, 2, 0, 0, 2, 1, 2, 0, 1, 0, 1, 1, 1, 0, 1, 1,
       0, 1, 0, 2, 2, 2, 0, 0, 0, 0, 1, 0, 0, 1])
```

[212]:
```
print("Accuracy Score : ",accuracy_score(y_pred_2,test_label))
```

```
Accuracy Score :  0.16
```

[213]:
```
confusion_matrix(y_pred_2, test_label)
```

[213]:
```
array([[ 0, 81, 48],
       [80, 12,  9],
       [28,  6, 36]])
```

[214]:
```
print(classification_report(y_pred_2,test_label))
```

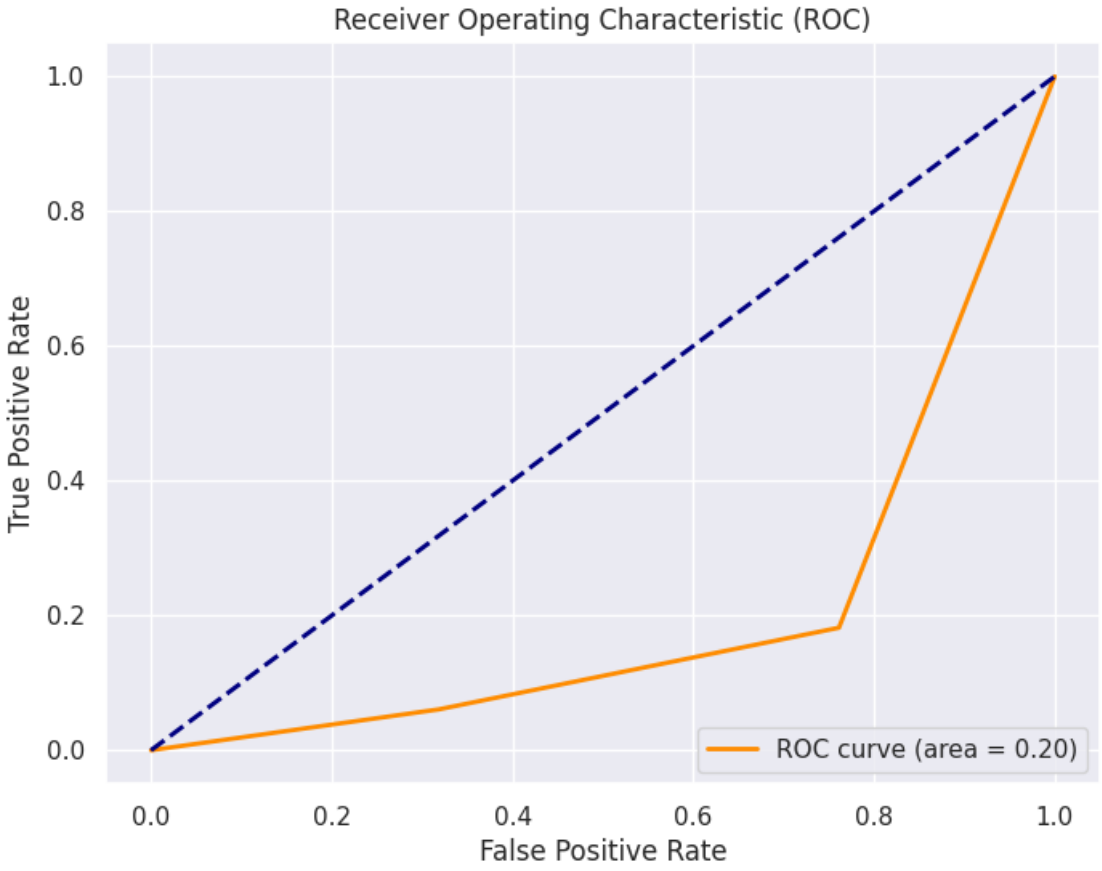
```
              precision    recall  f1-score   support

           0       0.00      0.00      0.00       129
           1       0.12      0.12      0.12       101
           2       0.39      0.51      0.44        70

    accuracy                           0.16       300
   macro avg       0.17      0.21      0.19       300
weighted avg       0.13      0.16      0.14       300
```

[215]:
```
train_accuracy_rf =␣
 ↪cross_val_score(model_rf,train_data_sc_pc_select,train_label,cv=5).mean()
test_accuracy_rf =␣
 ↪cross_val_score(model_rf,test_data_sc_pc_select,test_label,cv=5).mean()
print(" Train Data Cross_val_score : ",train_accuracy_rf)
print("Test Data Cross_val_score : ",test_accuracy_rf)
```

```
 Train Data Cross_val_score :  1.0
Test Data Cross_val_score :  1.0
```

[216]:
```
accuracy_results["Random_Forest_Accuracy"] = train_accuracy_rf
```

[217]:
```
fpr, tpr, thresholds = roc_curve(test_label, y_pred_2, pos_label=1)

# Calculate the Area Under the Curve (AUC)
roc_auc = auc(fpr, tpr)

# Plot ROC curve
plt.figure(figsize=(8, 6))
plt.plot(fpr, tpr, color='darkorange', lw=2, label='ROC curve (area = %0.2f)' %␣
 ↪roc_auc)
plt.plot([0, 1], [0, 1], color='navy', lw=2, linestyle='--')
plt.xlabel('False Positive Rate')
plt.ylabel('True Positive Rate')
plt.title('Receiver Operating Characteristic (ROC)')
plt.legend(loc='lower right')
plt.show()
```



[208]:
```
from sklearn.model_selection import GridSearchCV

# Define the hyperparameter grid
param_grid = {
    'n_estimators': [50, 100, 200],
    'max_depth': [5, 10, 15],
    'min_samples_split': [2, 5, 10],
    'min_samples_leaf': [1, 2, 4]
}

# Create a Random Forest Classifier
rf_model = RandomForestClassifier(random_state=42)

# Create Grid Search
grid_search = GridSearchCV(estimator=rf_model, param_grid=param_grid, cv=5,␣
 ↪scoring='accuracy', n_jobs=-1)

# Fit the Grid Search to the data
grid_search.fit(train_data_sc_pc_select, train_label)

# Print the best parameters
print("Best Parameters:", grid_search.best_params_)

# Print the best score
print("Best Score:", grid_search.best_score_)

# Get the best model
best_rf_model = grid_search.best_estimator_
```

```
Best Parameters: {'max_depth': 10, 'min_samples_leaf': 1, 'min_samples_split':
2, 'n_estimators': 100}
Best Score: 1.0
```

Decision Tree Model

[228]:
```
model_tree = DecisionTreeClassifier(max_depth=5, min_samples_leaf=1,␣
 ↪min_samples_split=2).fit(train_data_sc_pc_select,train_label)
```

[229]:
```
y_pred_3 = model_tree.predict(test_data_sc_pc_select)
y_pred_3
```

[229]:
```
array([1, 2, 0, 2, 0, 1, 0, 0, 0, 0, 0, 1, 0, 1, 1, 0, 1, 2, 0, 1, 0, 2,
       1, 1, 1, 1, 0, 1, 1, 0, 1, 0, 0, 1, 1, 0, 1, 0, 0, 0, 2, 1, 0, 1,
       1, 0, 0, 0, 1, 1, 2, 0, 0, 2, 0, 0, 0, 0, 2, 1, 0, 1, 0, 1, 0, 0,
       0, 1, 0, 2, 1, 1, 2, 1, 2, 0, 0, 0, 1, 2, 2, 2, 0, 1, 2, 0, 0, 1,
       0, 1, 2, 0, 1, 0, 1, 0, 1, 1, 0, 1, 2, 1, 1, 0, 1, 2, 2, 2, 0, 1,
       1, 1, 1, 1, 0, 0, 0, 0, 0, 1, 1, 0, 1, 0, 0, 1, 2, 0, 0, 0, 0, 1,
       0, 0, 1, 1, 0, 2, 0, 2, 1, 0, 0, 0, 0, 1, 0, 0, 0, 0, 0, 0, 0, 1,
```

```
       1, 2, 0, 1, 1, 2, 1, 1, 1, 1, 2, 0, 1, 0, 1, 0, 2, 1, 0, 0, 0, 0,
       1, 1, 2, 0, 2, 2, 1, 1, 1, 0, 0, 0, 1, 1, 1, 0, 2, 2, 1, 1, 0, 1,
       1, 2, 2, 0, 1, 0, 0, 1, 2, 1, 2, 0, 0, 0, 2, 0, 0, 1, 0, 0, 0, 0,
       1, 2, 0, 0, 0, 1, 0, 1, 1, 2, 1, 2, 1, 1, 0, 1, 0, 2, 0, 0, 1, 0,
       1, 0, 1, 1, 1, 2, 0, 1, 0, 2, 0, 2, 1, 0, 1, 2, 1, 2, 0, 0, 1, 1,
       0, 0, 1, 0, 0, 1, 0, 2, 0, 0, 2, 1, 2, 0, 1, 0, 1, 1, 0, 0, 1, 2,
       1, 1, 0, 2, 2, 2, 0, 1, 0, 0, 1, 0, 0, 1])
```

[230]:
```
print("Accuracy Score : ",accuracy_score(y_pred_3,test_label))
```

```
Accuracy Score :  0.08666666666666667
```

[231]:
```
confusion_matrix(y_pred_3,test_label)
```

[231]:
```
array([[ 9, 87, 38],
       [75,  0, 38],
       [24, 12, 17]])
```

[232]:
```
print(classification_report(y_pred_3,test_label))
```

```
              precision    recall  f1-score   support

           0       0.08      0.07      0.07       134
           1       0.00      0.00      0.00       113
           2       0.18      0.32      0.23        53

    accuracy                           0.09       300
   macro avg       0.09      0.13      0.10       300
weighted avg       0.07      0.09      0.07       300
```

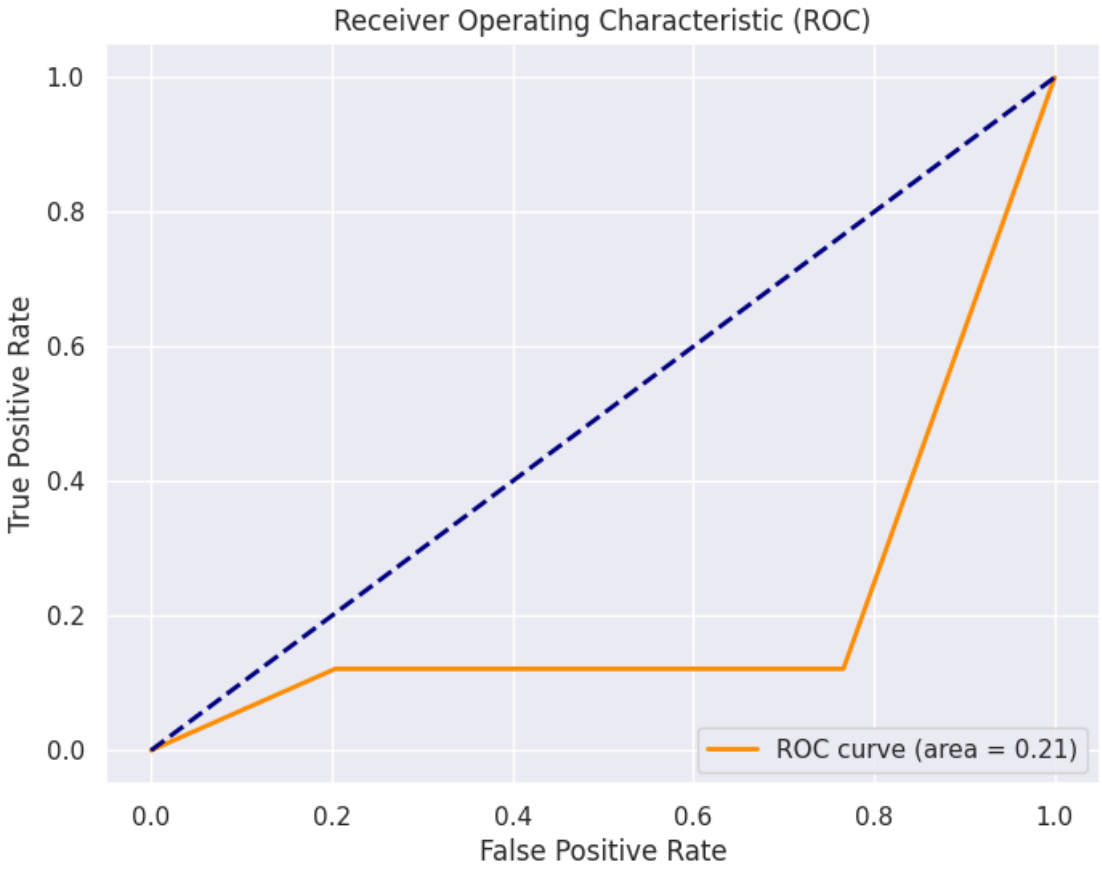
[233]:
```
train_accuracy_tree =␣
 ↪cross_val_score(model_tree,train_data_sc_pc_select,train_label,cv=5).mean()
test_accuracy_tree =␣
 ↪cross_val_score(model_tree,test_data_sc_pc_select,test_label,cv=5).mean()
print(" Train Data Cross_val_score : ",train_accuracy_tree)
print("Test Data Cross_val_score : ",test_accuracy_tree)
```

```
 Train Data Cross_val_score :  0.9971428571428571
Test Data Cross_val_score :  0.9966666666666667
```

[234]:
```
accuracy_results["Decision_Tree_Accuracy"] = train_accuracy_tree
```

[235]:
```
fpr, tpr, thresholds = roc_curve(test_label, y_pred_3, pos_label=1)

# Calculate the Area Under the Curve (AUC)
roc_auc = auc(fpr, tpr)
```

```
# Plot ROC curve
plt.figure(figsize=(8, 6))
plt.plot(fpr, tpr, color='darkorange', lw=2, label='ROC curve (area = %0.2f)' %␣
 ↪roc_auc)
plt.plot([0, 1], [0, 1], color='navy', lw=2, linestyle='--')
plt.xlabel('False Positive Rate')
plt.ylabel('True Positive Rate')
plt.title('Receiver Operating Characteristic (ROC)')
plt.legend(loc='lower right')
plt.show()
```



[227]:
```
from sklearn.model_selection import GridSearchCV

# Define the hyperparameter grid
param_grid = {
    'max_depth': [5, 10, 15],
    'min_samples_split': [2, 5, 10],
    'min_samples_leaf': [1, 2, 4]
```

```
}

# Create a Decision Tree Classifier
dt_model = DecisionTreeClassifier(random_state=42)

# Create Grid Search
grid_search = GridSearchCV(estimator=dt_model, param_grid=param_grid, cv=5,␣
 ↪scoring='accuracy', n_jobs=-1)

# Fit the Grid Search to the data
grid_search.fit(train_data_sc_pc_select, train_label)

# Print the best parameters
print("Best Parameters:", grid_search.best_params_)

# Print the best score
print("Best Score:", grid_search.best_score_)

# Get the best model
best_dt_model = grid_search.best_estimator_
```

```
Best Parameters: {'max_depth': 5, 'min_samples_leaf': 1, 'min_samples_split': 2}
Best Score: 0.9957142857142858
```

KNN Model

[237]:
```
model_knn = KNeighborsClassifier().fit(train_data_sc_pc_select,train_label)
```

[238]:
```
y_pred_4 = model_knn.predict(test_data_sc_pc_select)
y_pred_4
```

[238]:
```
array([1, 2, 2, 2, 0, 2, 2, 0, 2, 0, 0, 1, 0, 1, 1, 0, 1, 2, 0, 1, 1, 2,
       1, 1, 1, 1, 0, 1, 1, 0, 1, 0, 0, 1, 2, 1, 2, 0, 2, 0, 1, 1, 1, 1,
       2, 0, 0, 2, 1, 1, 2, 2, 0, 2, 1, 2, 0, 0, 2, 1, 0, 1, 1, 2, 1, 1,
       0, 1, 2, 2, 2, 1, 2, 2, 2, 0, 0, 1, 2, 2, 2, 2, 0, 1, 2, 2, 0, 2,
       0, 1, 1, 0, 1, 0, 2, 0, 2, 1, 0, 1, 1, 1, 2, 0, 1, 2, 2, 2, 1, 1,
       1, 1, 1, 2, 0, 0, 1, 0, 0, 2, 1, 0, 1, 0, 0, 2, 1, 0, 0, 0, 0, 2,
       0, 0, 1, 2, 0, 1, 1, 2, 2, 0, 2, 2, 0, 1, 0, 0, 0, 0, 0, 2, 1, 2,
       1, 2, 0, 2, 2, 2, 2, 1, 1, 1, 2, 0, 1, 0, 1, 1, 2, 1, 0, 0, 0, 1,
       1, 1, 2, 0, 2, 2, 1, 1, 1, 0, 0, 0, 1, 1, 1, 0, 2, 2, 1, 2, 0, 1,
       1, 2, 2, 0, 1, 0, 0, 2, 2, 2, 2, 0, 2, 2, 2, 0, 0, 1, 0, 0, 0, 2,
       1, 2, 2, 0, 2, 2, 0, 2, 1, 2, 2, 2, 2, 1, 0, 1, 0, 2, 2, 1, 2, 0,
       1, 1, 1, 1, 1, 2, 0, 2, 1, 2, 1, 2, 2, 0, 1, 2, 1, 2, 0, 0, 1, 2,
       0, 0, 1, 2, 0, 1, 0, 2, 0, 0, 2, 1, 2, 1, 1, 0, 1, 1, 1, 1, 1, 2,
       2, 1, 0, 2, 2, 2, 1, 2, 0, 0, 1, 1, 0, 1])
```

[239]:
```
print("Accuracy Score : ",accuracy_score(y_pred_4,test_label))
```

```
Accuracy Score :  0.2
```

[240]:
```
confusion_matrix(y_pred_4,test_label)
```

[240]:
```
array([[ 0, 87,  5],
       [76,  1, 29],
       [32, 11, 59]])
```

[241]:
```
print(classification_report(y_pred_4,test_label))
```

```
              precision    recall  f1-score   support

           0       0.00      0.00      0.00        92
           1       0.01      0.01      0.01       106
           2       0.63      0.58      0.61       102

    accuracy                           0.20       300
   macro avg       0.21      0.20      0.20       300
weighted avg       0.22      0.20      0.21       300
```

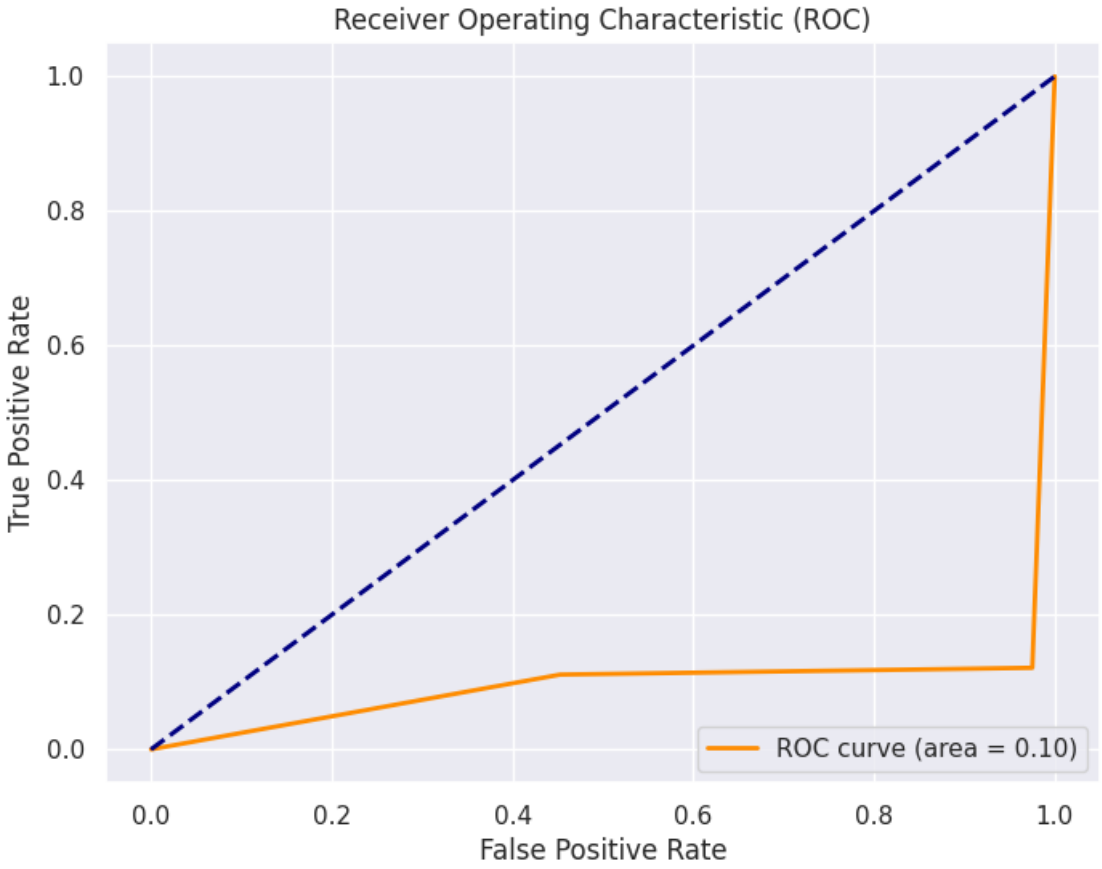
[242]:
```
train_accuracy_knn = cross_val_score(model_knn,train_data_sc,train_label,cv=5).
 ↪mean()
test_accuracy_knn = cross_val_score(model_knn,test_data_sc,test_label,cv=5).
 ↪mean()
print(" Train Data Cross_val_score : ",train_accuracy_knn)
print("Test Data Cross_val_score : ",test_accuracy_knn)
```

```
 Train Data Cross_val_score :  0.9928571428571429
Test Data Cross_val_score :  0.9733333333333333
```

[243]:
```
accuracy_results["KNeighborsClassifier_Accuracy"] = train_accuracy_knn
```

[245]:
```
fpr, tpr, thresholds = roc_curve(test_label, y_pred_4, pos_label=1)

# Calculate the Area Under the Curve (AUC)
roc_auc = auc(fpr, tpr)

# Plot ROC curve
plt.figure(figsize=(8, 6))
plt.plot(fpr, tpr, color='darkorange', lw=2, label='ROC curve (area = %0.2f)' %␣
 ↪roc_auc)
plt.plot([0, 1], [0, 1], color='navy', lw=2, linestyle='--')
plt.xlabel('False Positive Rate')
plt.ylabel('True Positive Rate')
plt.title('Receiver Operating Characteristic (ROC)')
plt.legend(loc='lower right')
```

```
plt.show()
```



XGBOOSt Model

[251]:
```
model_xgb = xgboost.XGBClassifier().fit(train_data_sc_pc_select,train_label)
```

[253]:
```
y_pred_5 = model_xgb.predict(test_data_sc_pc_select)
y_pred_5
```

[253]:
```
array([1, 2, 0, 2, 0, 0, 0, 0, 0, 0, 0, 1, 0, 1, 1, 0, 1, 2, 0, 1, 1, 2,
       1, 1, 1, 1, 0, 1, 1, 0, 1, 0, 0, 1, 0, 0, 1, 0, 2, 0, 2, 1, 0, 1,
       1, 0, 0, 2, 1, 1, 2, 0, 0, 2, 0, 0, 0, 0, 2, 1, 0, 1, 1, 1, 0, 0,
       0, 1, 2, 2, 0, 1, 2, 2, 1, 0, 0, 2, 0, 2, 1, 2, 0, 1, 2, 0, 0, 0,
       0, 1, 2, 0, 1, 0, 0, 0, 0, 1, 0, 1, 2, 1, 0, 0, 1, 2, 2, 2, 0, 1,
       1, 1, 1, 1, 0, 0, 0, 0, 0, 1, 1, 0, 1, 0, 0, 1, 1, 0, 0, 0, 0, 0,
       0, 0, 1, 1, 0, 2, 0, 2, 0, 0, 0, 0, 0, 1, 0, 0, 0, 0, 0, 2, 0, 1,
       1, 2, 0, 1, 0, 1, 2, 1, 1, 1, 1, 0, 1, 0, 1, 0, 2, 1, 0, 0, 0, 0,
       1, 1, 2, 0, 2, 2, 1, 1, 1, 0, 0, 0, 1, 1, 1, 0, 2, 2, 1, 0, 0, 1,
       1, 1, 2, 0, 1, 0, 0, 0, 2, 0, 2, 0, 0, 0, 2, 0, 0, 1, 0, 0, 0, 2,
       1, 2, 0, 0, 0, 0, 0, 1, 1, 2, 0, 2, 1, 1, 0, 1, 0, 2, 0, 0, 1, 0,
```

```
       1, 1, 1, 1, 1, 2, 0, 1, 1, 2, 0, 2, 0, 0, 1, 2, 1, 1, 0, 0, 1, 1,
       0, 0, 1, 0, 0, 0, 0, 2, 0, 0, 2, 1, 2, 0, 1, 0, 1, 1, 2, 0, 1, 1,
       0, 1, 0, 2, 2, 2, 0, 0, 0, 0, 1, 0, 0, 1])
```

[254]:
```
print("Accuracy Score : ",accuracy_score(y_pred_5,test_label))
```

```
Accuracy Score :  0.09666666666666666
```

[255]:
```
confusion_matrix(y_pred_5,test_label)
```

[255]:
```
array([[ 0, 87, 56],
       [79,  8, 16],
       [29,  4, 21]])
```

[258]:
```
print(classification_report(y_pred_5,test_label))
```

```
              precision    recall  f1-score   support

           0       0.00      0.00      0.00       143
           1       0.08      0.08      0.08       103
           2       0.23      0.39      0.29        54

    accuracy                           0.10       300
   macro avg       0.10      0.16      0.12       300
weighted avg       0.07      0.10      0.08       300
```

[259]:
```
train_accuracy_xgb = cross_val_score(model_xgb,train_data_sc,train_label,cv=5).
 ↪mean()
test_accuracy_xgb = cross_val_score(model_xgb,test_data_sc,test_label,cv=5).
 ↪mean()
print(" Train Data Cross_val_score : ",train_accuracy_xgb)
print("Test Data Cross_val_score : ",test_accuracy_xgb)
```

```
 Train Data Cross_val_score :  1.0
Test Data Cross_val_score :  1.0
```

[260]:
```
accuracy_results["XGBOOSt_Accuracy"] = train_accuracy_xgb
```

[262]:
```
fpr, tpr, thresholds = roc_curve(test_label, y_pred_5,pos_label=1)

# Calculate the Area Under the Curve (AUC)
roc_auc = auc(fpr, tpr)

# Plot ROC curve
plt.figure(figsize=(8, 6))
```

```
plt.plot(fpr, tpr, color='darkorange', lw=2, label='ROC curve (area = %0.2f)' %␣
↪roc_auc)
plt.plot([0, 1], [0, 1], color='navy', lw=2, linestyle='--')
plt.xlabel('False Positive Rate')
plt.ylabel('True Positive Rate')
plt.title('Receiver Operating Characteristic (ROC)')
plt.legend(loc='lower right')
plt.show()
```

SVC Model

[264]:
```
model_svc = SVC().fit(train_data_sc_pc_select,train_label)
```

[265]:
```
y_pred_6 = model_svc.predict(test_data_sc_pc_select)
y_pred_6
```

[265]:
```
array([1, 2, 2, 2, 0, 0, 2, 2, 2, 0, 0, 1, 0, 1, 1, 0, 1, 2, 0, 1, 2, 2,
       1, 1, 1, 1, 0, 1, 1, 0, 1, 0, 0, 1, 2, 2, 2, 0, 2, 0, 1, 1, 2, 1,
       2, 0, 0, 2, 1, 1, 2, 2, 0, 2, 2, 2, 0, 0, 2, 1, 0, 1, 2, 2, 2, 2,
       0, 1, 2, 2, 0, 1, 2, 2, 2, 0, 0, 2, 2, 2, 2, 2, 0, 1, 2, 2, 0, 2,
```

```
       0, 1, 1, 0, 1, 0, 0, 0, 0, 1, 0, 1, 1, 1, 2, 0, 1, 2, 2, 2, 2, 1,
       1, 1, 1, 1, 0, 0, 2, 0, 0, 2, 1, 0, 1, 0, 0, 1, 2, 0, 0, 0, 0, 2,
       0, 0, 1, 2, 0, 1, 2, 2, 0, 0, 2, 2, 0, 2, 0, 0, 0, 0, 0, 2, 2, 2,
       1, 2, 0, 2, 0, 2, 2, 1, 1, 1, 2, 0, 1, 0, 1, 2, 2, 1, 0, 0, 0, 2,
       1, 1, 2, 0, 2, 2, 1, 1, 1, 0, 0, 0, 1, 1, 1, 0, 2, 2, 1, 0, 0, 1,
       1, 2, 2, 0, 1, 0, 0, 2, 2, 0, 2, 0, 2, 2, 2, 0, 0, 1, 0, 0, 0, 2,
       1, 2, 2, 0, 2, 0, 0, 2, 1, 2, 0, 2, 1, 1, 0, 1, 0, 2, 2, 2, 2, 0,
       1, 2, 1, 1, 1, 2, 0, 2, 2, 2, 2, 2, 2, 2, 1, 2, 1, 2, 0, 0, 1, 2,
       0, 0, 1, 2, 2, 2, 0, 2, 0, 0, 2, 1, 2, 2, 1, 0, 1, 1, 2, 2, 1, 2,
       2, 1, 0, 2, 2, 2, 2, 0, 0, 0, 1, 2, 0, 1])
```

[266]:
```
print("Accuracy Score : ",accuracy_score(y_pred_6,test_label))
```

```
Accuracy Score :  0.22666666666666666
```

[267]:
```
confusion_matrix(y_pred_6,test_label)
```

[267]:
```
array([[ 0, 87, 13],
       [71,  0, 12],
       [37, 12, 68]])
```

[268]:
```
print(classification_report(y_pred_6,test_label))
```

```
              precision    recall  f1-score   support

           0       0.00      0.00      0.00       100
           1       0.00      0.00      0.00        83
           2       0.73      0.58      0.65       117

    accuracy                           0.23       300
   macro avg       0.24      0.19      0.22       300
weighted avg       0.29      0.23      0.25       300
```

[269]:
```
train_accuracy_svc = cross_val_score(model_svc,train_data_sc,train_label,cv=5).
 ↪mean()
test_accuracy_svc = cross_val_score(model_svc,test_data_sc,test_label,cv=5).
 ↪mean()
print(" Train Data Cross_val_score : ",train_accuracy_svc)
print("Test Data Cross_val_score : ",test_accuracy_svc)
```

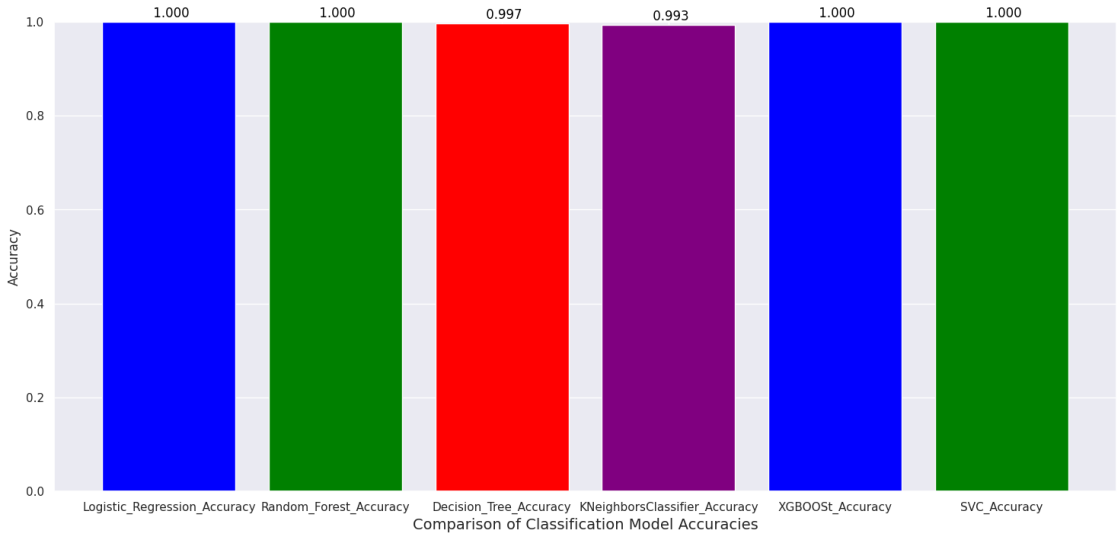
```
 Train Data Cross_val_score :  1.0
Test Data Cross_val_score :  1.0
```

[270]:
```
accuracy_results["SVC_Accuracy"] = train_accuracy_xgb
```

[272]:
```
fpr, tpr, thresholds = roc_curve(test_label, y_pred_6, pos_label=1)

# Calculate the Area Under the Curve (AUC)
roc_auc = auc(fpr, tpr)

# Plot ROC curve
plt.figure(figsize=(8, 6))
plt.plot(fpr, tpr, color='darkorange', lw=2, label='ROC curve (area = %0.2f)' %␣
 ↪roc_auc)
plt.plot([0, 1], [0, 1], color='navy', lw=2, linestyle='--')
plt.xlabel('False Positive Rate')
plt.ylabel('True Positive Rate')
plt.title('Receiver Operating Characteristic (ROC)')
plt.legend(loc='lower right')
plt.show()
```

9 Comparison of Classification Model Accuracies

[275]:
```
# Plotting the accuracy results
model_names = list(accuracy_results.keys())
accuracy_values = list(accuracy_results.values())

# Plotting the accuracy results using a different style
plt.figure(figsize=(18, 8))
plt.bar(model_names, accuracy_values, color=['blue', 'green', 'red', 'purple'])
plt.ylabel('Accuracy')
plt.xlabel('Comparison of Classification Model Accuracies', fontsize=14)
plt.ylim(0, 1)
for i, v in enumerate(accuracy_values):
    plt.text(i, v + 0.01, " {:.3f}".format(v), ha='center', color='black')

plt.show()
```



[ ]: