

ImplantFailure

July 29, 2023

```
[1]: import pandas as pd
import seaborn as sns
import matplotlib.pyplot as plt
```

```
[2]: df = pd.read_csv("/content/drive/MyDrive/Dataset/stats/ImplantFailure - dental_
    ↪implant_failure_upload.csv")
df.head()
```

```
[2]:
```

	Age	Gender	Systemic disease	Factors of missing	Tobacco smoking	\
0	69	0	0	2	0	
1	42	0	0	1	0	
2	43	0	0	1	0	
3	43	0	0	1	0	
4	43	0	0	1	0	

	Betel nut Chewing	Alcohol consumption	Departments	Surgeon experience	\
0	0	0	1	5	
1	0	0	1	6	
2	0	0	1	7	
3	0	0	1	7	
4	0	0	1	7	

	Location of implant	...	Timing of implant placement	Ridge augmentation	\
0	4	...	2	1	
1	1	...	1	1	
2	4	...	2	1	
3	5	...	2	1	
4	5	...	2	1	

	Maxillary sinus augmentation	Implant system	Fixture length	\
0	0	0	10.0	
1	0	0	12.0	
2	0	0	10.0	
3	0	0	8.0	
4	0	0	10.0	

	Fixture width	Types of prosthesis	Angle of abutment	Prosthesis fixation	\
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0	4.1	0	0	0
1	4.1	0	0	0
2	3.3	0	0	0
3	4.1	0	0	0
4	4.1	0	0	0

Dental implant failure	
0	1
1	1
2	1
3	1
4	1

[5 rows x 21 columns]

```
[3]: df.columns
```

```
[3]: Index(['Age', 'Gender', 'Systemic disease', 'Factors of missing',
          'Tobacco smoking', 'Betel nut Chewing', 'Alcohol consumption',
          'Departments', 'Surgeon experience', 'Location of implant',
          'Bone density', 'Timing of implant placement', 'Ridge augmentation',
          'Maxillary sinus augmentation', 'Implant system', 'Fixture length',
          'Fixture width', 'Types of prosthesis', 'Angle of abutment',
          'Prosthesis fixation', 'Dental implant failure'],
          dtype='object')
```

```
[4]: df.shape
```

```
[4]: (699, 21)
```

1 Group Independent Variables Definition and Code

Demographics

Age:

Ratio scale

Gender

0: Female 1: Male

Physical condition Systemic disease

0: Healthy 1: Cardiovascular disorder 2: Diabetes 3: Osteoporosis 4: Radiotherapy 5: Others

Factors of missing

0: Congenital missing 1: Caries 2: Periodontitis 3: Fracture 4: Root resorption 5: Failure of endodontic treatment

Lifestyle Tobacco smoking

0: Never 1: Smoking 2: Stopped smoking

Betel nut chewing

0: Never 1: Chewing betel nut 2: Stopped chewing betel nut

Alcohol consumption

0: Never 1: Drinking 2: Stopped drinking

Surgeon Background**Departments**

0: General practice 1: Periodontics 2: Oral-Maxillary surgery

Surgeon experience

Ratio scale

Anatomic Condition**Location of implant**

0: Maxillary anterior teeth 1: Maxillary premolars 2: Maxillary molars 3: Mandibular anterior teeth 4: Mandibular premolars 5: Mandibular molars

Bone density

1: Type I 2: Type II 3: Type III 4: Type IV

Surgical Information**Timing of implant placement**

1: Immediate implant placement 2: Early implant placement 3: Staged implant placement

Ridge augmentation

0: None 1: Guided bone regeneration 2: Ridge splitting

Maxillary sinus augmentation

0: None 1: Lateral window technique 2: Osteotome technique

Implant attributes**Implant system**

0: Straumann® 1: Ankylos® 2: XIVE® 3: Nobeactive® 4: Branemark® 5: Lifecore®

Fixture length

Ratio scale

Fixture width

Ratio scale

Prosthetics attributed

Types of prosthesis

0: Fixed denture 1: Overdenture

Angle of abutment

0: Without angle 1: With angle

Prosthesis fixation

0: Cement-retained 1: Screw-retained

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

```
[5]: Age                0
     Gender              0
     Systemic disease    0
     Factors of missing  0
     Tobacco smoking     0
     Betel nut Chewing   0
     Alcohol consumption 0
     Departments         0
     Surgeon experience  0
     Location of implant 0
     Bone density        0
     Timing of implant placement 0
     Ridge augmentation  0
     Maxillary sinus augmentation 0
     Implant system      0
     Fixture length      0
     Fixture width       0
     Types of prosthesis 0
     Angle of abutment   0
     Prosthesis fixation 0
     Dental implant failure 0
     dtype: int64
```

```
[6]: print(df.dtypes)
```

```
Age                int64
Gender             int64
Systemic disease   int64
Factors of missing int64
Tobacco smoking    int64
Betel nut Chewing  int64
Alcohol consumption int64
Departments        int64
Surgeon experience int64
Location of implant int64
Bone density       int64
Timing of implant placement int64
```

```

Ridge augmentation          int64
Maxillary sinus augmentation int64
Implant system              int64
Fixture length              float64
Fixture width               object
Types of prosthesis         int64
Angle of abutment           int64
Prosthesis fixation         int64
Dental implant failure      int64
dtype: object

```

2 Exploratory Data Analysis

```

[10]: import plotly.express as px
systemic_disease_counts = new_data.groupby(['Gender', 'Systemic disease']).
    ↪size().unstack(fill_value=0)
systemic_disease_fig = px.bar(systemic_disease_counts, barmode='group',
    ↪title='Systemic Disease by Gender')
systemic_disease_fig.update_layout(xaxis_title='Gender', yaxis_title='Count',
    ↪xaxis={'categoryorder': 'total descending'})
systemic_disease_fig.show()

```

```

[11]: age_fig = px.histogram(df, x='Age', nbins=20, title='Age Distribution')
age_fig.show()

```

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[12]: bone_density_counts = new_data['Bone density'].value_counts()
bone_density_fig = px.pie(names=bone_density_counts.index,
    ↪values=bone_density_counts.values, title='Distribution of Bone Density')
bone_density_fig.show()

```

```

[13]: gender_counts = new_data['Gender'].value_counts()
gender_fig = px.bar(x=['Female', 'Male'], y=gender_counts, labels={'x':
    ↪'Gender', 'y': 'Count'}, title='Distribution of Gender')
gender_fig.show()

```

```

[14]: box_fig = px.box(df, x='Implant system', y='Age', title='Age by Implant System')
box_fig.show()

```

3 Descriptive Statistics:

```

[15]: df.describe()

```

```

[15]:
count      Age      Gender  Systemic disease  Factors of missing \
count  699.000000  699.000000      699.000000      699.000000
mean    51.054363    0.462089      0.658083      2.021459

```

std	11.923943	0.501781	1.365394	0.829850
min	18.000000	0.000000	0.000000	1.000000
25%	43.500000	0.000000	0.000000	1.000000
50%	52.000000	0.000000	0.000000	2.000000
75%	59.000000	1.000000	1.000000	3.000000
max	79.000000	2.000000	5.000000	5.000000

	Tobacco smoking	Betel nut Chewing	Alcohol consumption	Departments \
count	699.000000	699.000000	699.000000	699.000000
mean	0.234621	0.054363	0.130186	1.228898
std	0.545261	0.293028	0.406172	0.616600
min	0.000000	0.000000	0.000000	0.000000
25%	0.000000	0.000000	0.000000	1.000000
50%	0.000000	0.000000	0.000000	1.000000
75%	0.000000	0.000000	0.000000	2.000000
max	2.000000	2.000000	2.000000	2.000000

	Surgeon experience	Location of implant	Bone density \
count	699.000000	699.000000	699.000000
mean	11.502146	2.994278	2.698140
std	5.223754	1.902335	0.602416
min	4.000000	0.000000	1.000000
25%	8.000000	1.000000	2.000000
50%	10.000000	3.000000	3.000000
75%	15.000000	5.000000	3.000000
max	30.000000	5.000000	4.000000

	Timing of implant placement	Ridge augmentation \
count	699.000000	699.000000
mean	2.061516	0.407725
std	0.330743	0.525562
min	1.000000	0.000000
25%	2.000000	0.000000
50%	2.000000	0.000000
75%	2.000000	1.000000
max	3.000000	2.000000

	Maxillary sinus augmentation	Implant system	Fixture length \
count	699.000000	699.000000	699.000000
mean	0.216023	0.743920	10.384120
std	0.576995	1.189232	1.123858
min	0.000000	0.000000	3.500000
25%	0.000000	0.000000	10.000000
50%	0.000000	0.000000	10.000000
75%	0.000000	1.000000	11.000000
max	2.000000	5.000000	15.000000

	Types of prosthesis	Angle of abutment	Prosthesis fixation \
count	699.000000	699.000000	699.000000
mean	0.064378	0.128755	0.167382
std	0.245600	0.335169	0.373584
min	0.000000	0.000000	0.000000
25%	0.000000	0.000000	0.000000
50%	0.000000	0.000000	0.000000
75%	0.000000	0.000000	0.000000
max	1.000000	1.000000	1.000000

	Dental implant failure
count	699.000000
mean	0.854077
std	0.353282
min	0.000000
25%	1.000000
50%	1.000000
75%	1.000000
max	1.000000

4 Test for Normality

```
[16]: import scipy.stats as stats
import seaborn as sns
import matplotlib.pyplot as plt

numerical_columns = ['Age', 'Gender', 'Systemic disease', 'Factors of missing',
↳ 'Tobacco smoking',
↳ 'Betel nut Chewing', 'Alcohol consumption', 'Departments',
↳ 'Surgeon experience',
↳ 'Location of implant', 'Bone density', 'Timing of implant',
↳ 'placement', 'Ridge augmentation',
↳ 'Maxillary sinus augmentation', 'Implant system', 'Types',
↳ 'of prosthesis',
↳ 'Angle of abutment', 'Prosthesis fixation', 'Dental',
↳ 'implant failure']

for column in numerical_columns:
    # Shapiro-Wilk Test
    stat, p = stats.shapiro(df[column])
    print(f"Shapiro-Wilk Test for {column}:")
    print(f"    Statistic: {stat}")
    print(f"    p-value: {p}")
    if p > 0.05:
```

```

    print(" Result: Data is normally distributed (fail to reject null_
↪hypothesis)")
    else:
        print(" Result: Data is not normally distributed (reject null_
↪hypothesis)")

# QQ plot
plt.figure(figsize=(8, 6))
stats.probplot(df[column], dist="norm", plot=plt)
plt.title(f'Q-Q Plot of {column}')
plt.show()

# Normal distribution graph
plt.figure(figsize=(8, 6))
sns.histplot(df[column], kde=True, color='blue')
plt.title(f'Normal Distribution of {column}')
plt.xlabel(column)
plt.ylabel('Density')
plt.show()

```

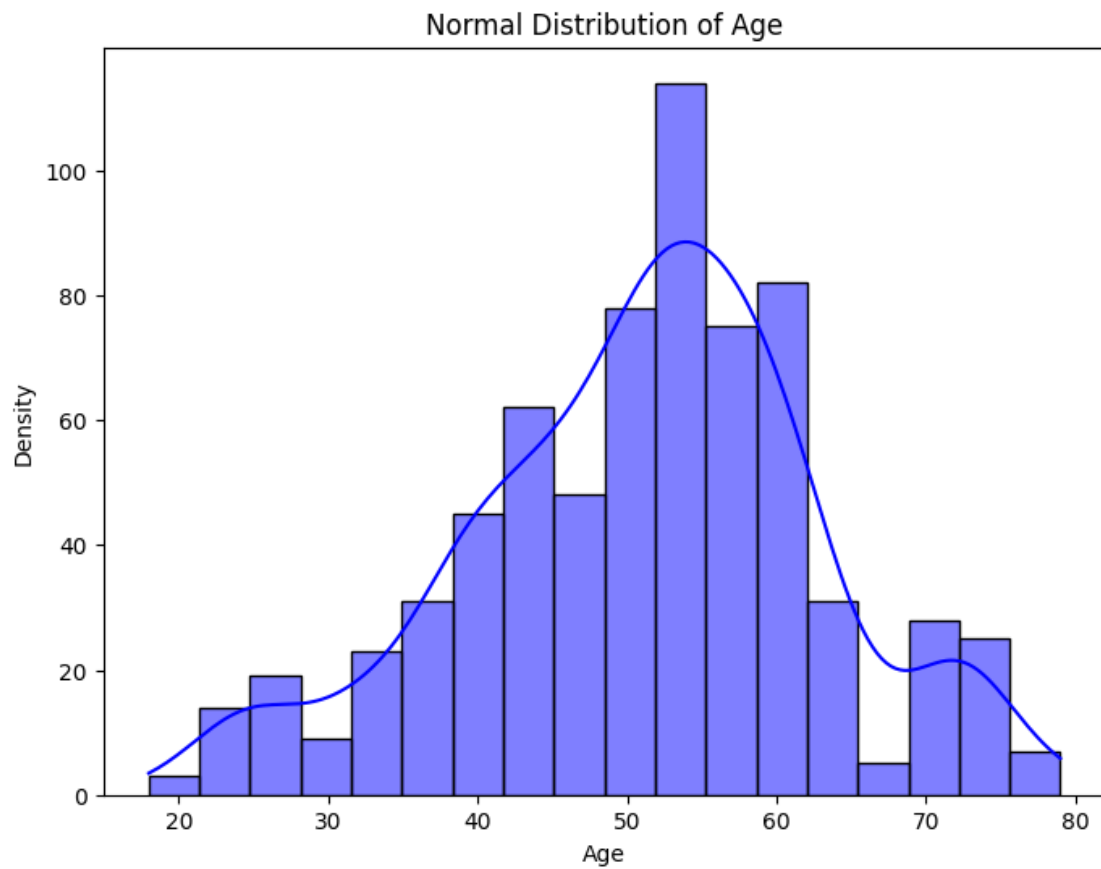
Shapiro-Wilk Test for Age:

Statistic: 0.9853785634040833

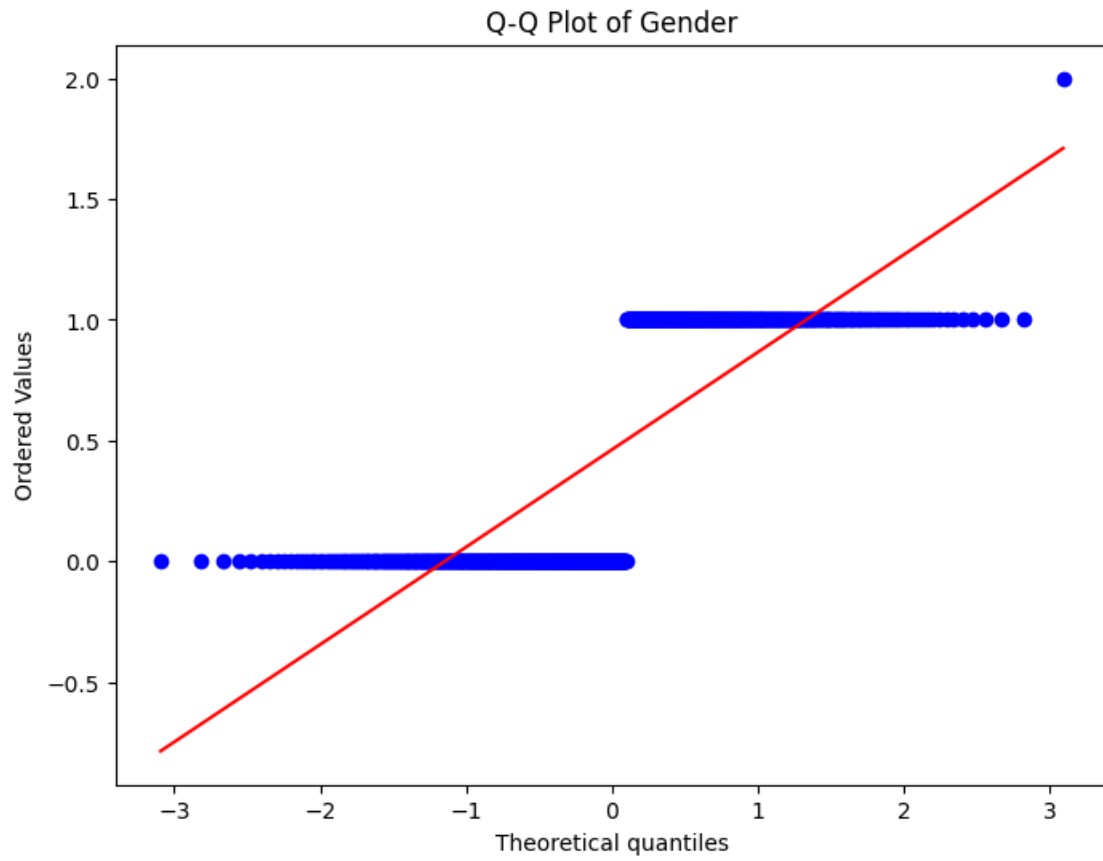
p-value: 1.8705891307035927e-06

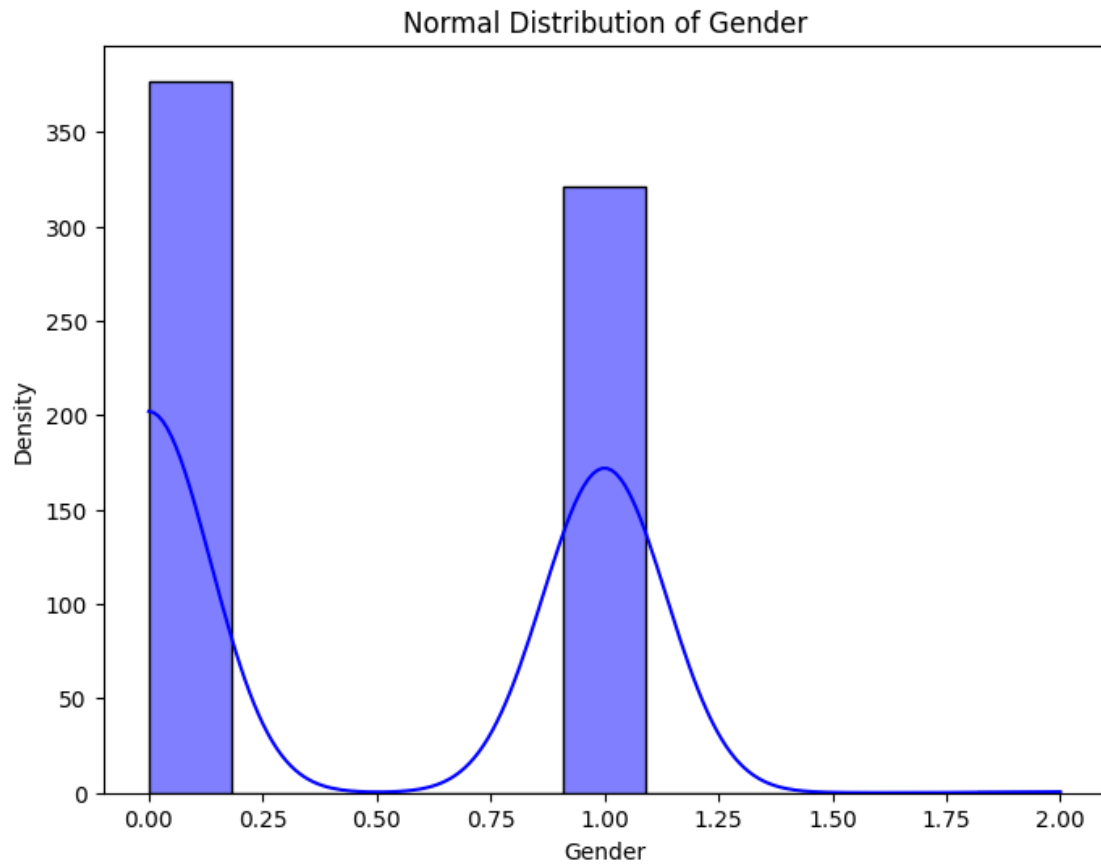
Result: Data is not normally distributed (reject null hypothesis)





Shapiro-Wilk Test for Gender:
Statistic: 0.6420215368270874
p-value: 9.338946037270648e-36
Result: Data is not normally distributed (reject null hypothesis)



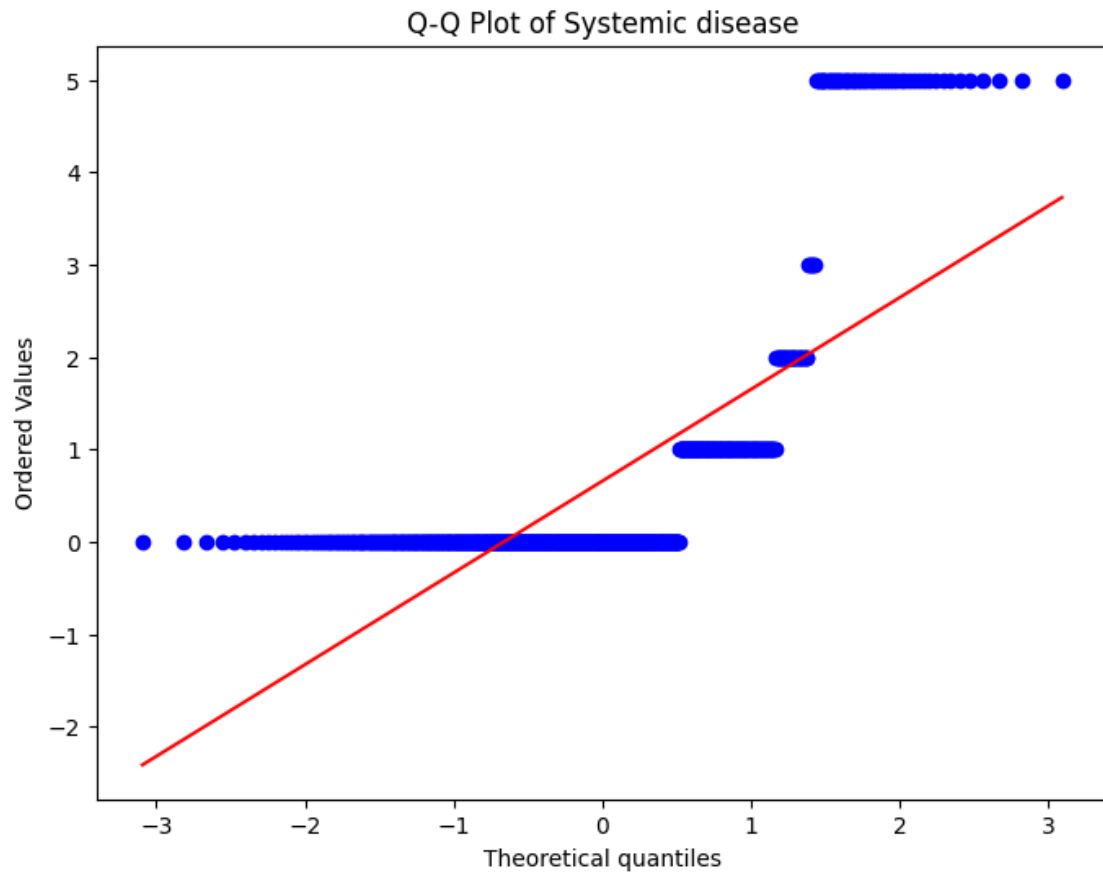


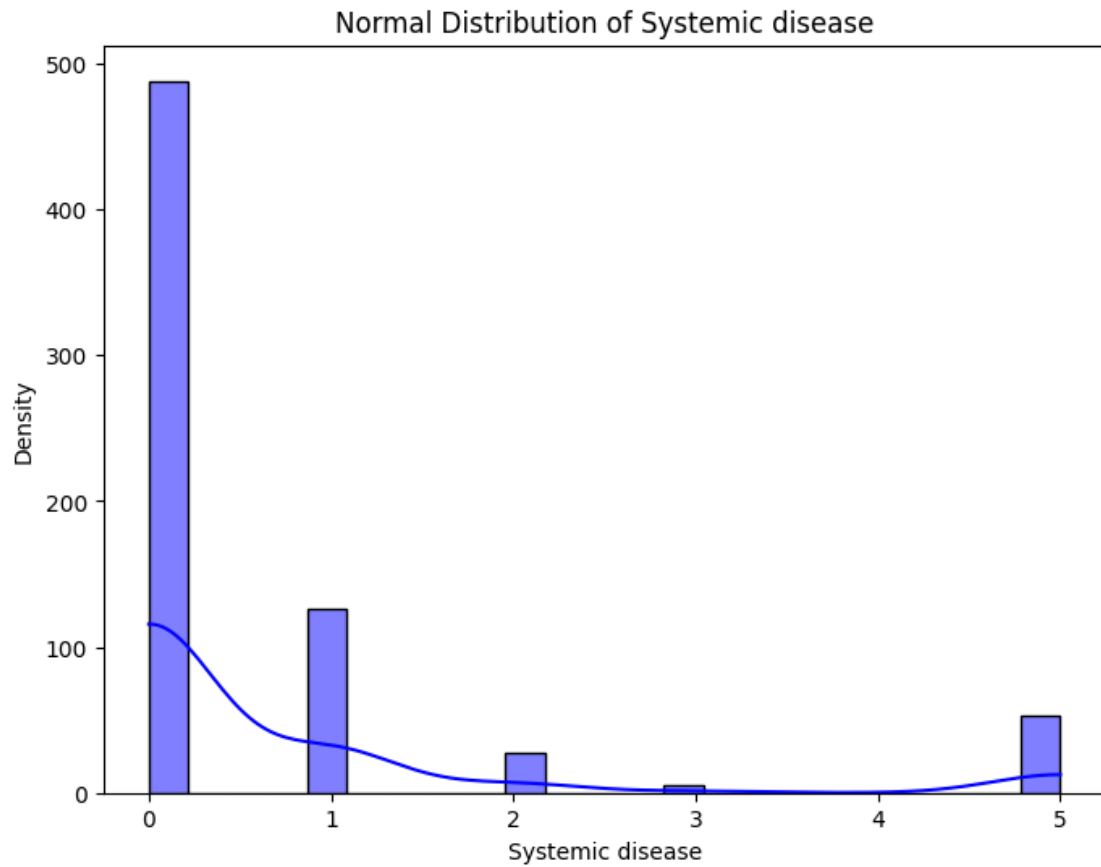
Shapiro-Wilk Test for Systemic disease:

Statistic: 0.5250942707061768

p-value: 1.3261790575477566e-39

Result: Data is not normally distributed (reject null hypothesis)



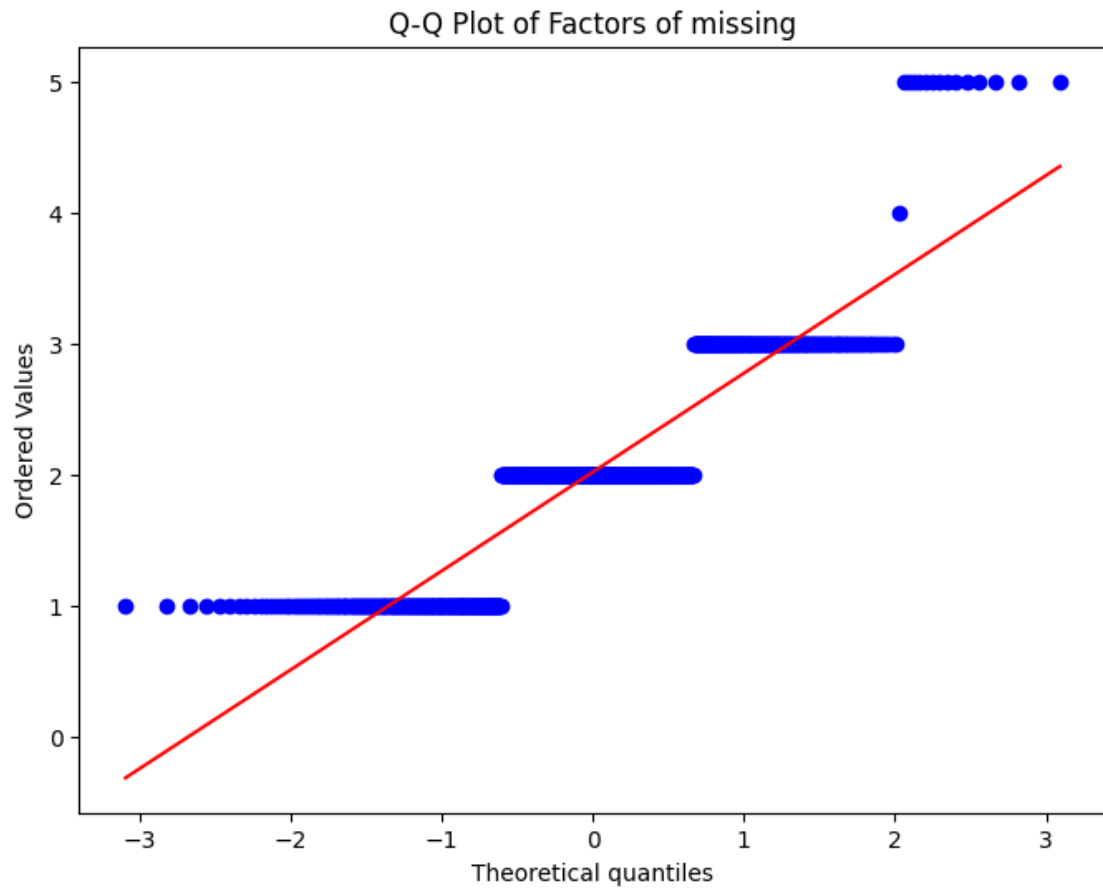


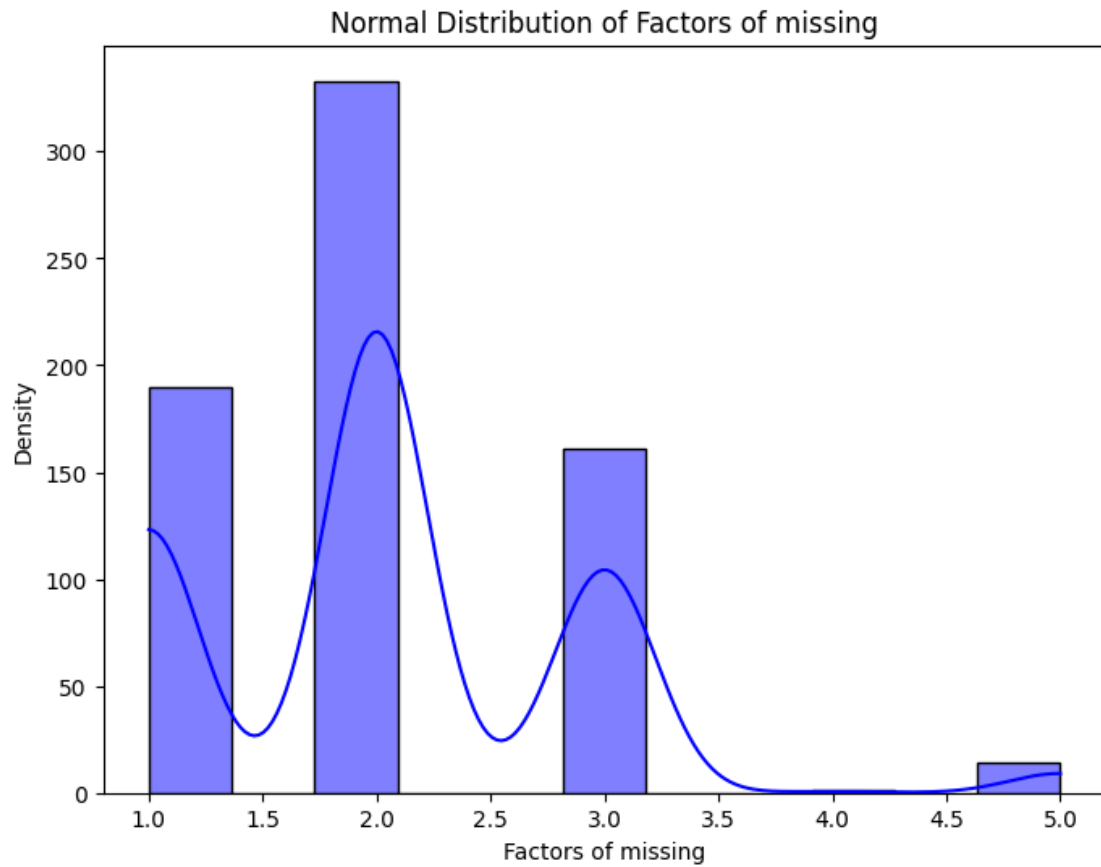
Shapiro-Wilk Test for Factors of missing:

Statistic: 0.81922847032547

p-value: 2.6558618229488703e-27

Result: Data is not normally distributed (reject null hypothesis)



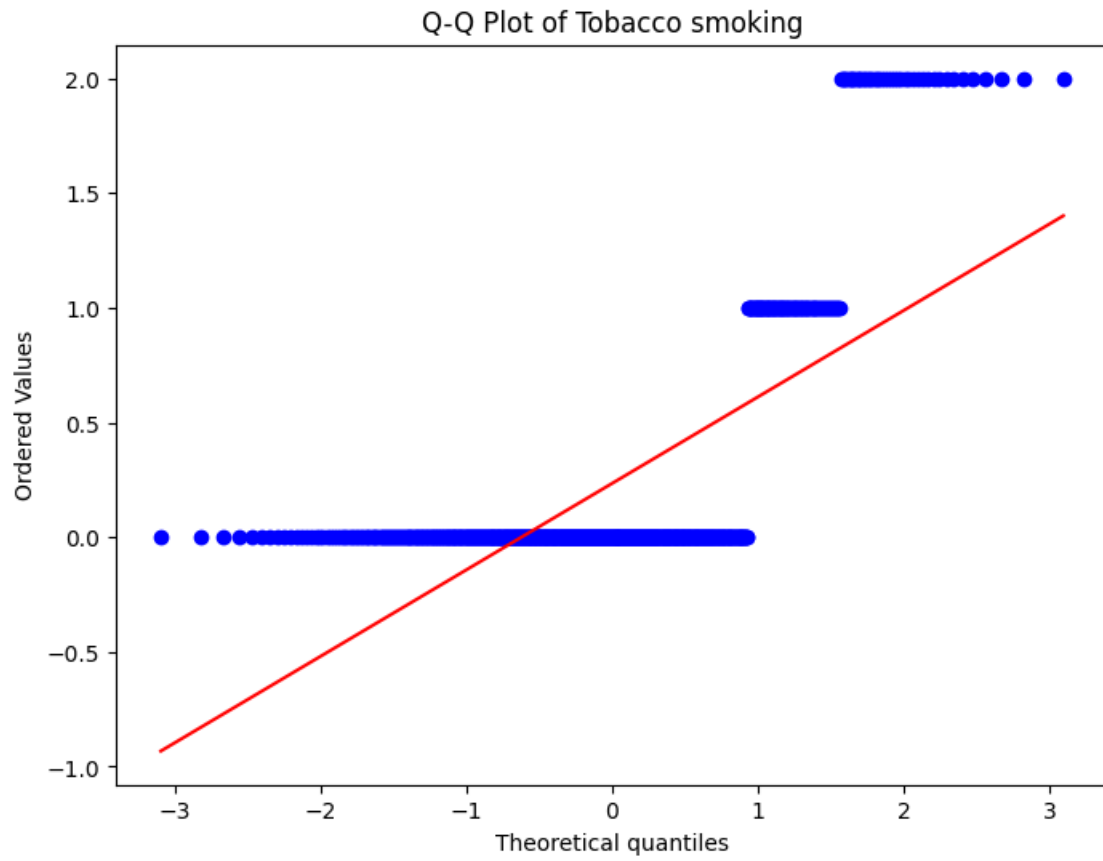


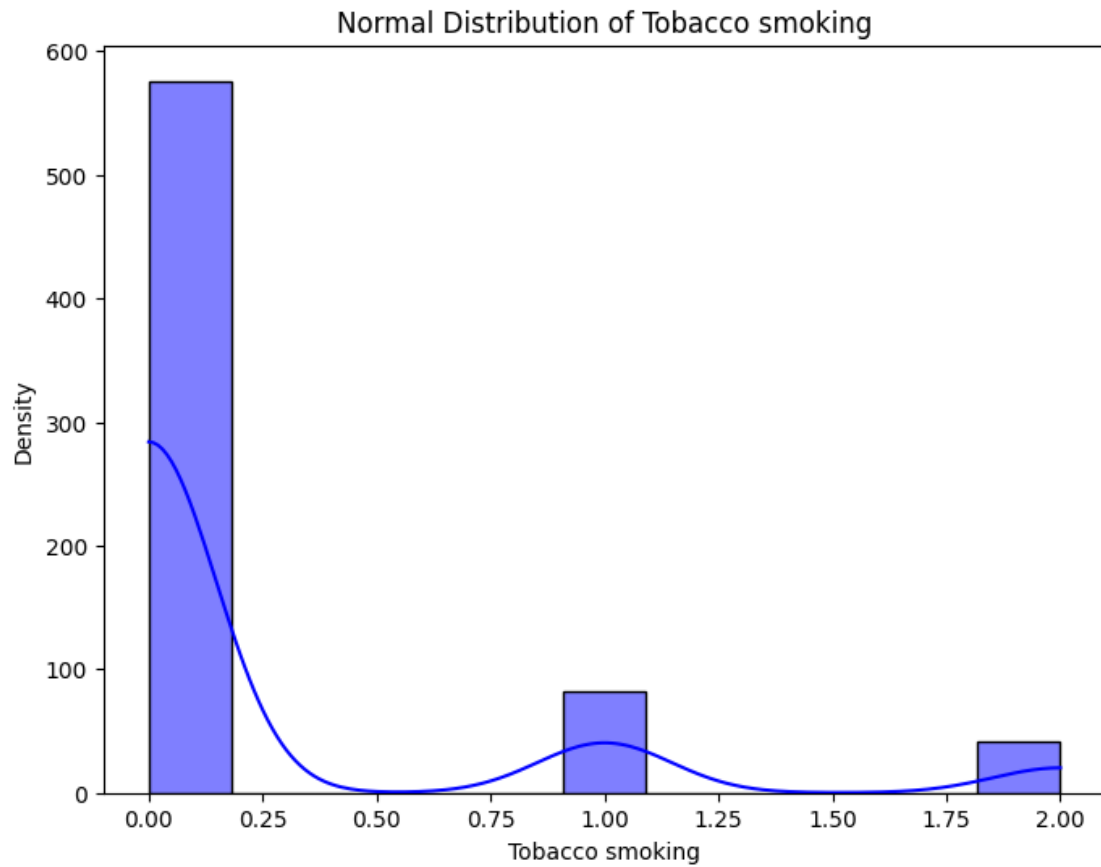
Shapiro-Wilk Test for Tobacco smoking:

Statistic: 0.475275456905365

p-value: 5.194753537098529e-41

Result: Data is not normally distributed (reject null hypothesis)



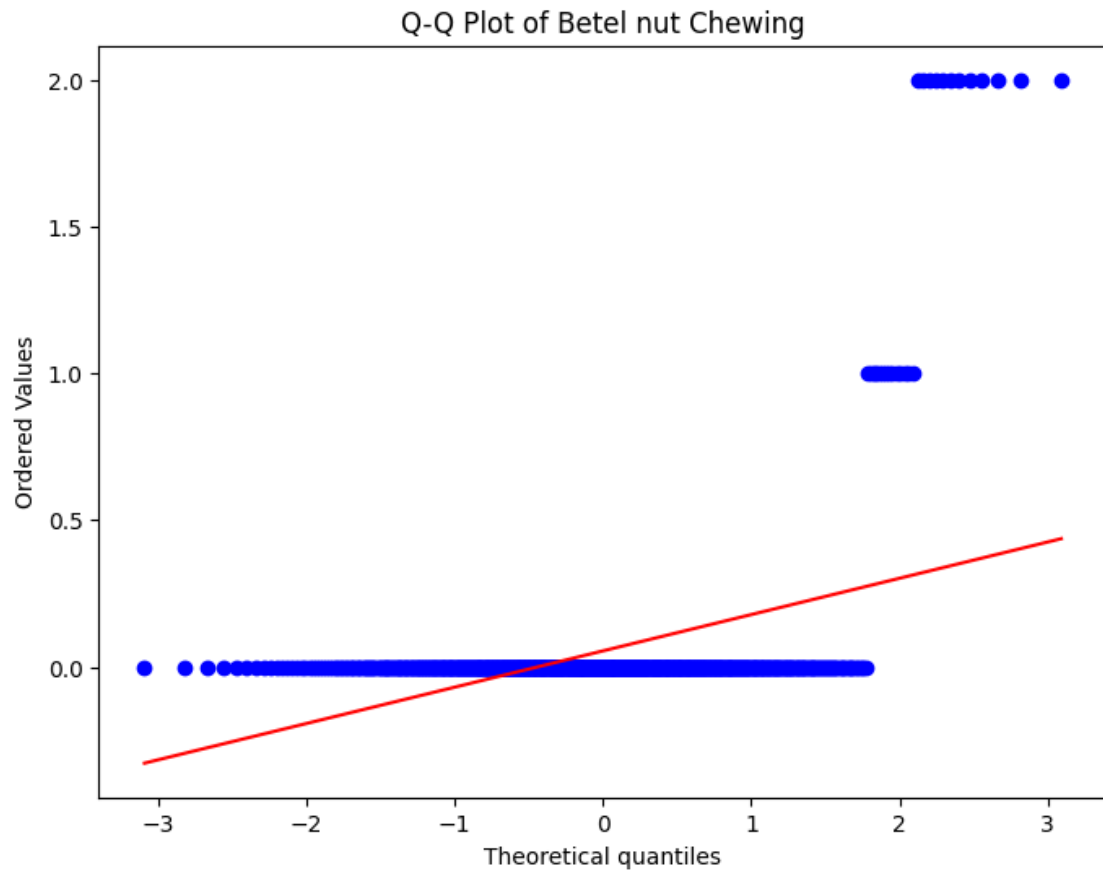


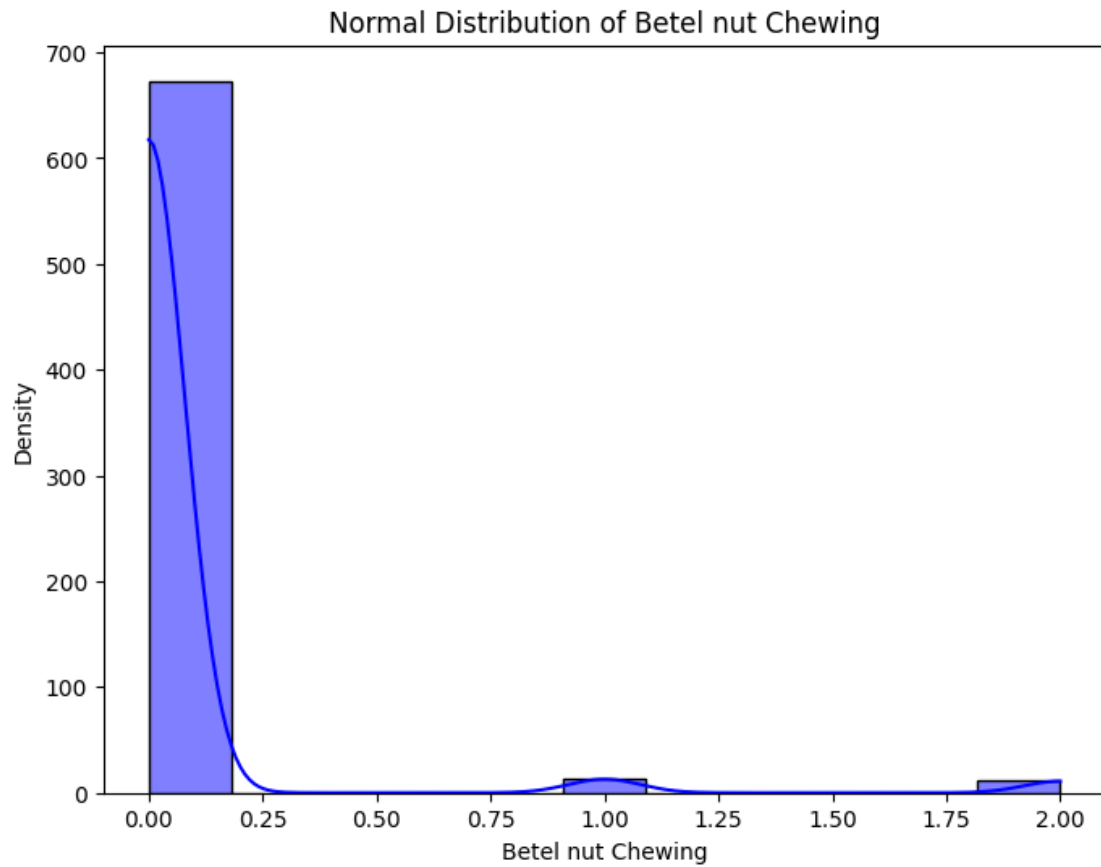
Shapiro-Wilk Test for Betel nut Chewing:

Statistic: 0.17858076095581055

p-value: 0.0

Result: Data is not normally distributed (reject null hypothesis)



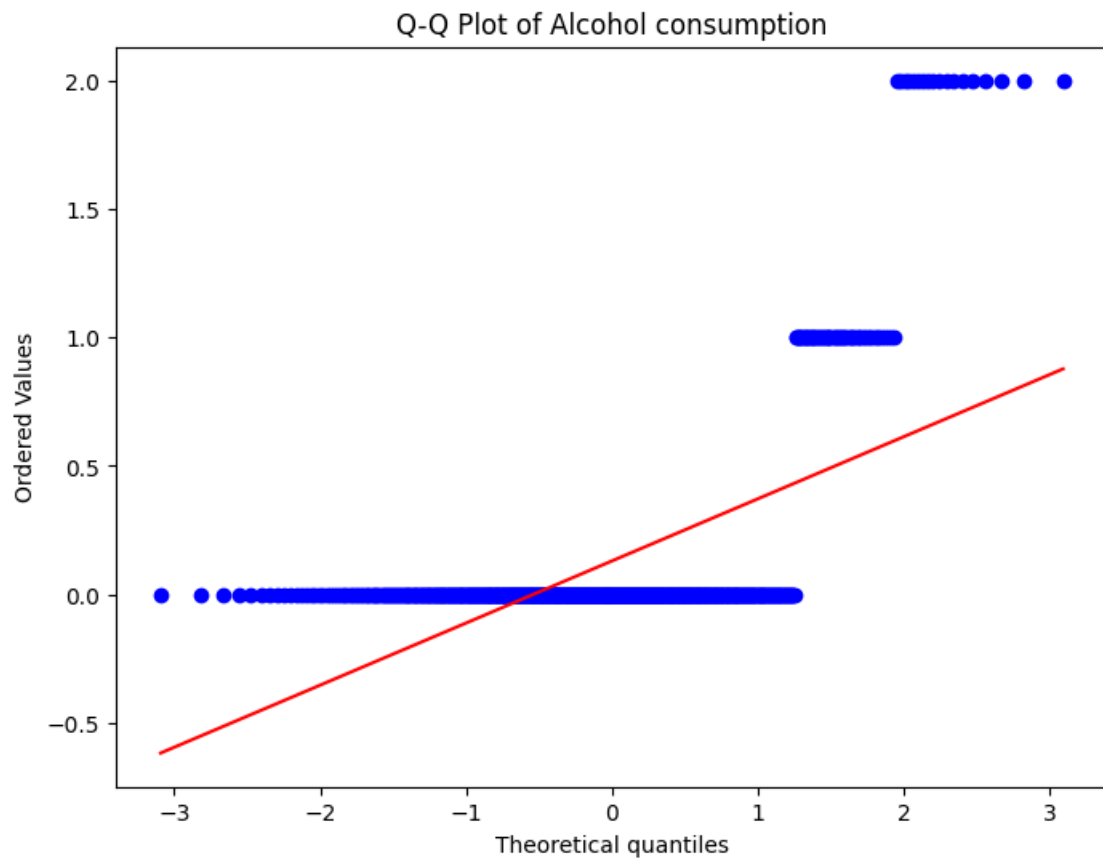


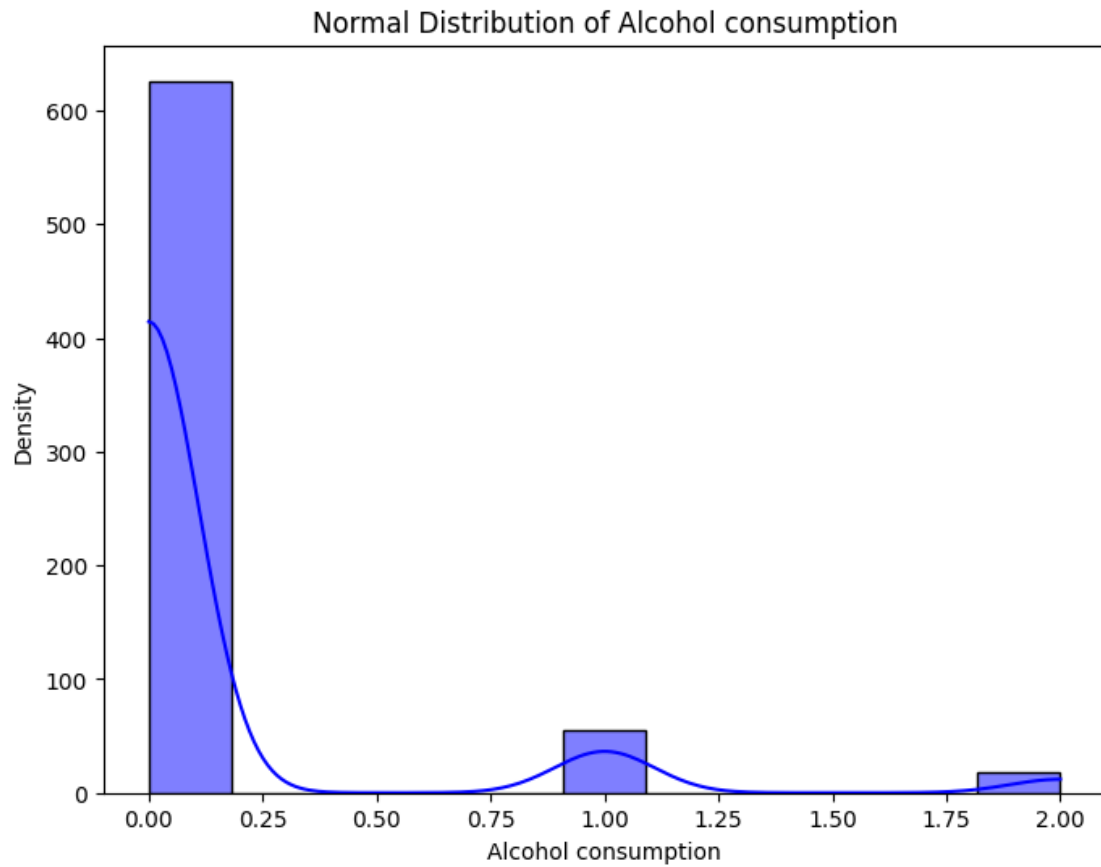
Shapiro-Wilk Test for Alcohol consumption:

Statistic: 0.3525697588920593

p-value: 4.624284932271896e-44

Result: Data is not normally distributed (reject null hypothesis)



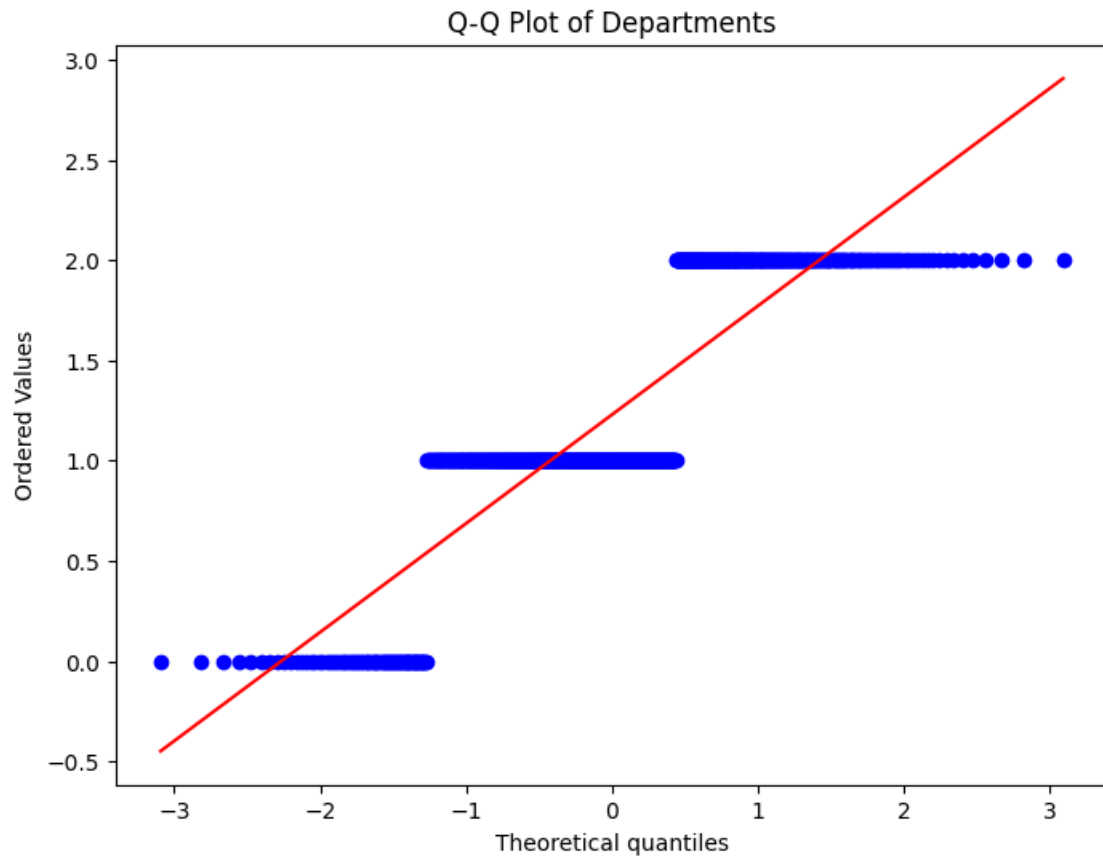


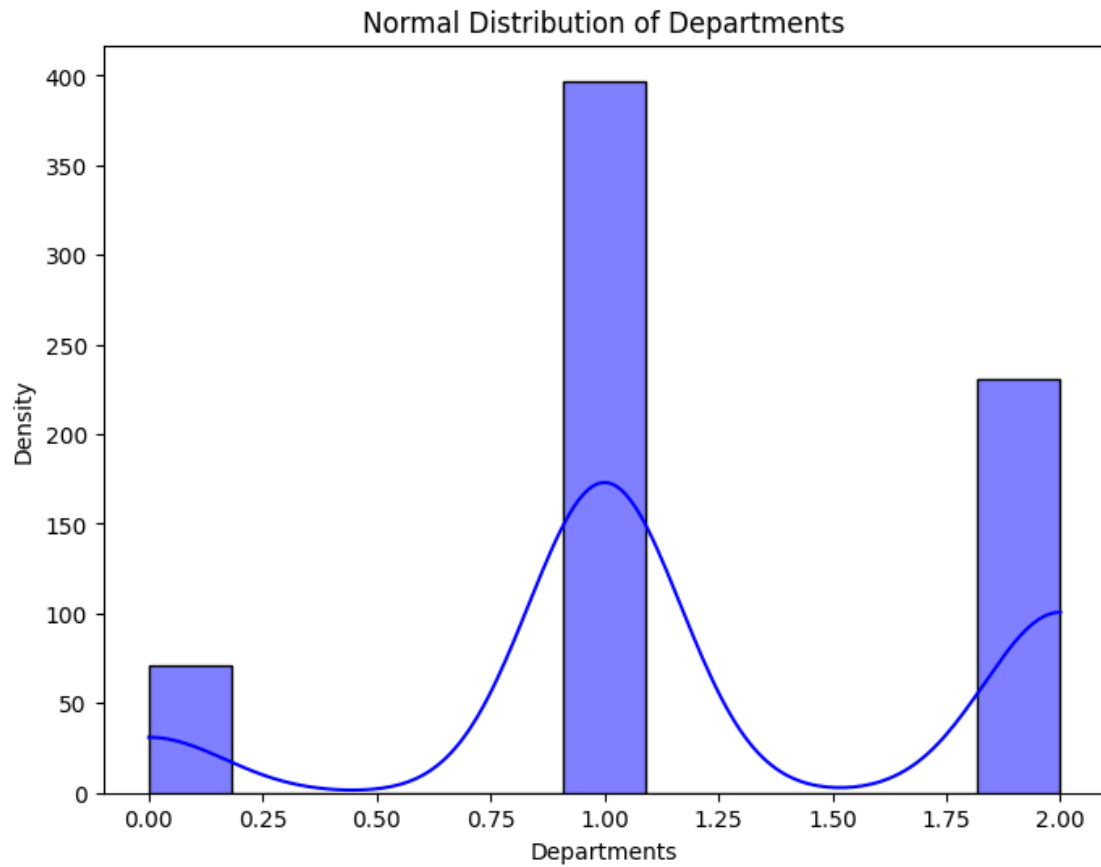
Shapiro-Wilk Test for Departments:

Statistic: 0.7675116062164307

p-value: 2.8206186311822688e-30

Result: Data is not normally distributed (reject null hypothesis)



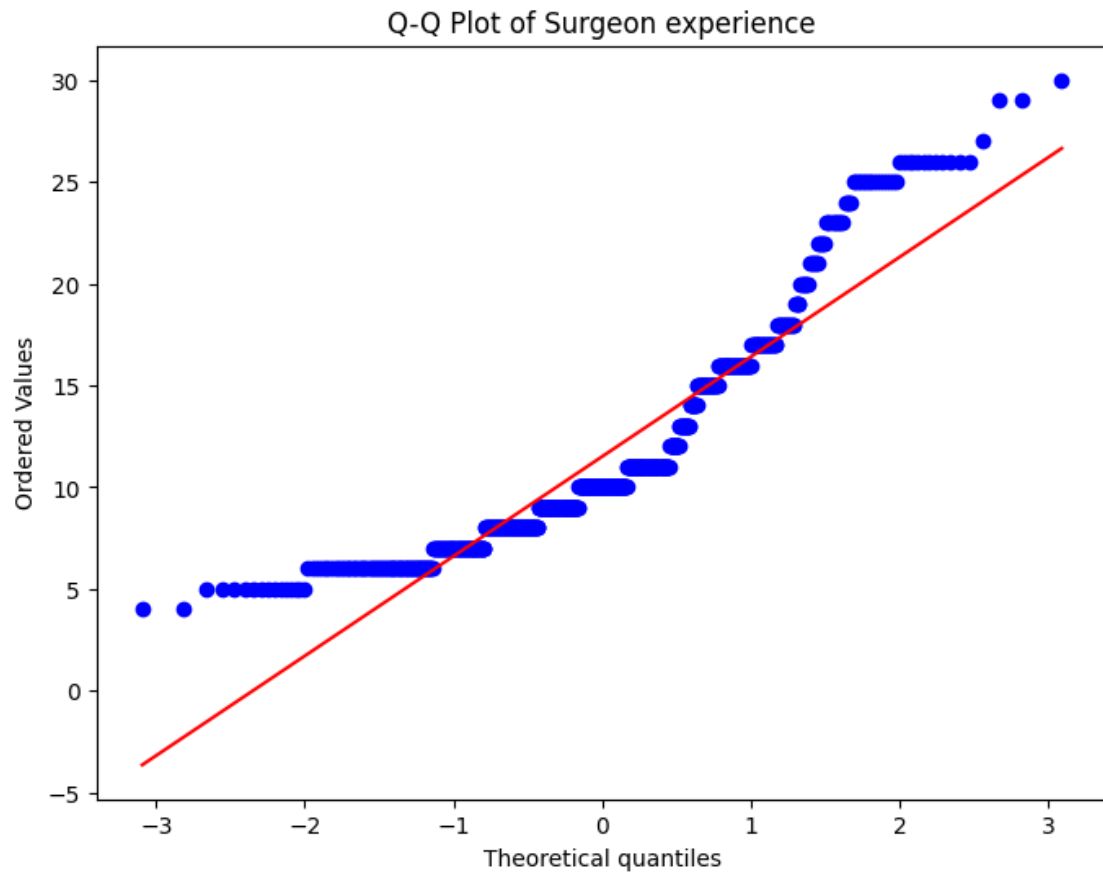


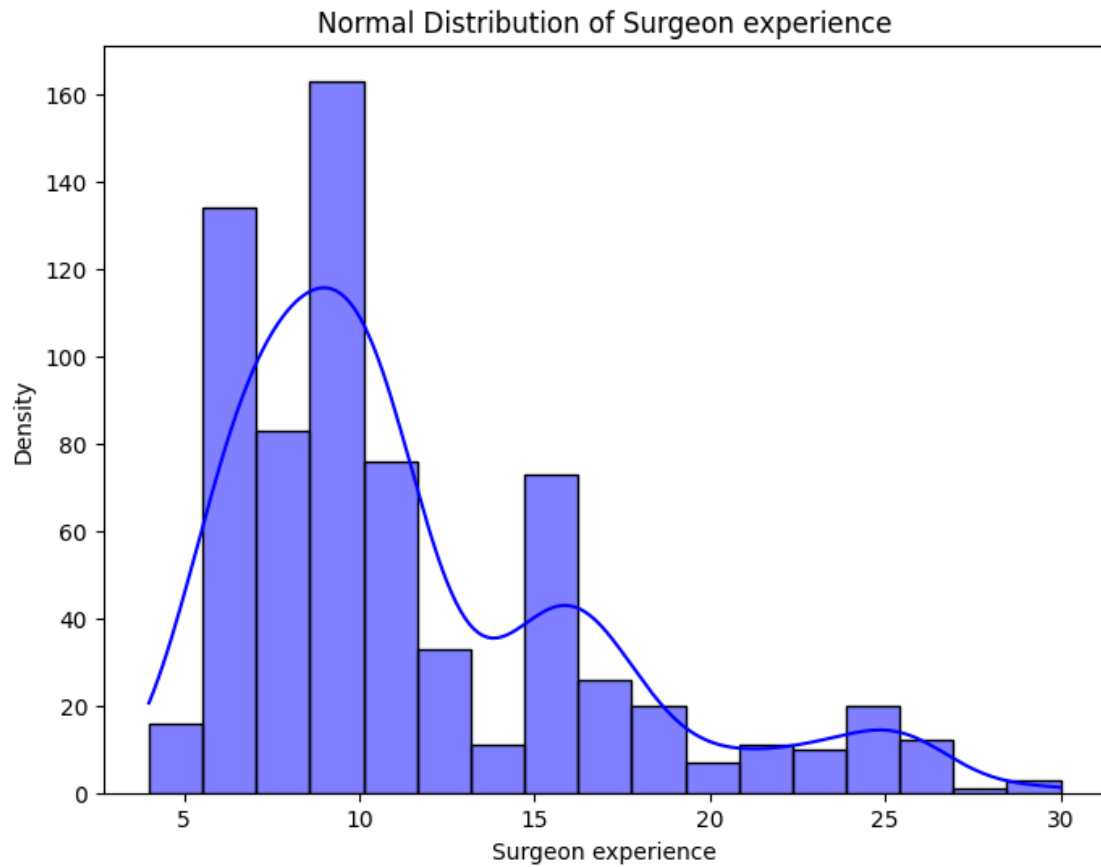
Shapiro-Wilk Test for Surgeon experience:

Statistic: 0.8720096349716187

p-value: 1.7422641535470137e-23

Result: Data is not normally distributed (reject null hypothesis)



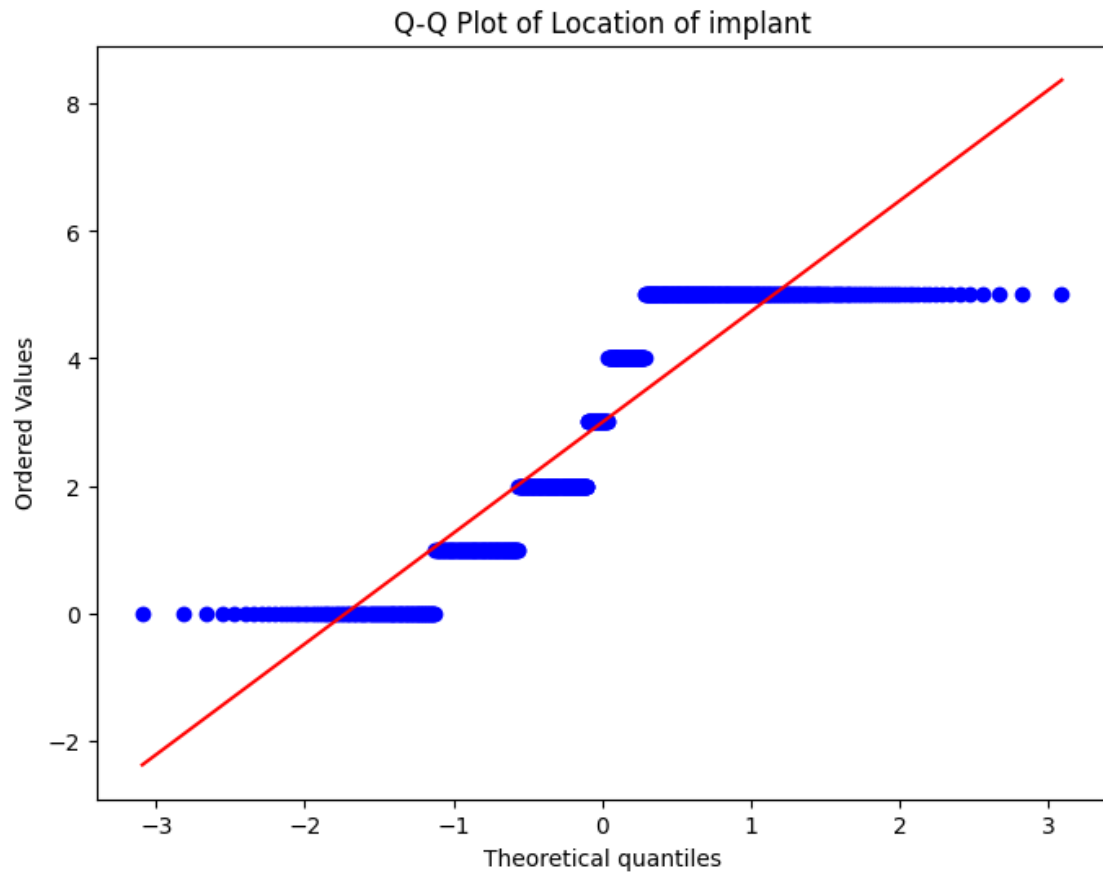


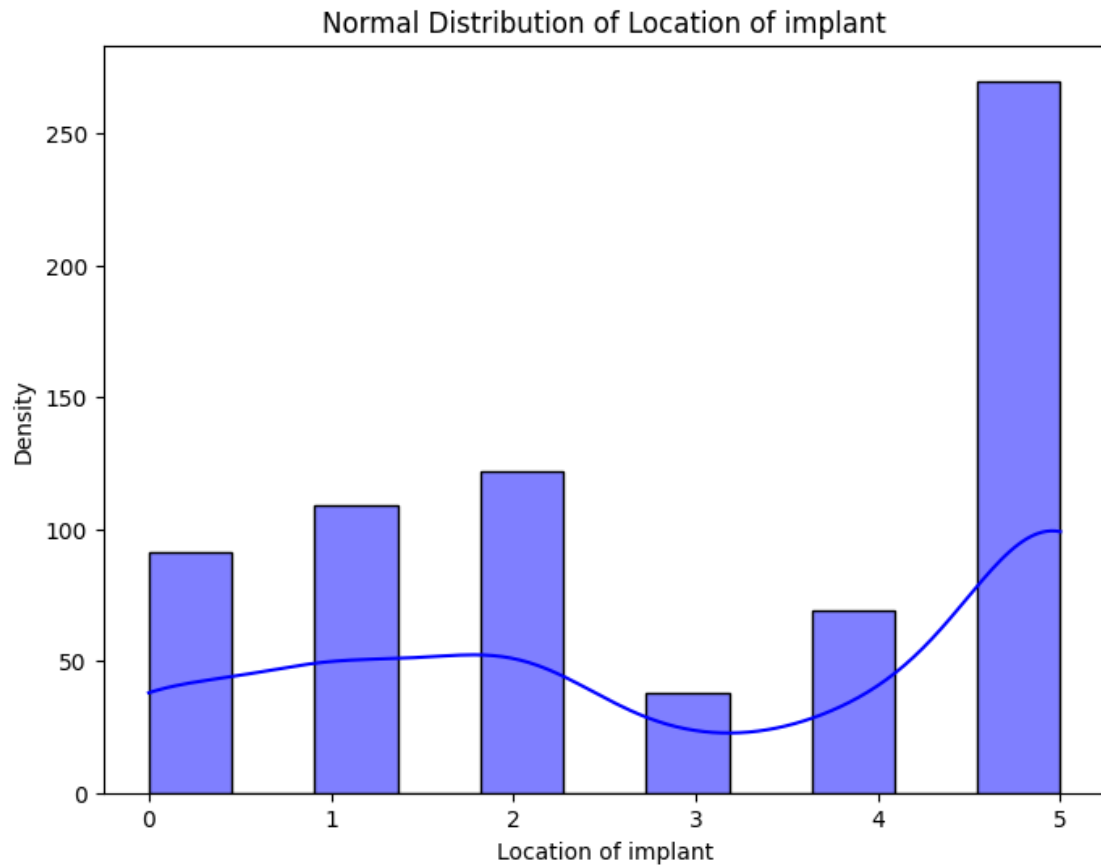
Shapiro-Wilk Test for Location of implant:

Statistic: 0.8282572031021118

p-value: 1.0230521375657531e-26

Result: Data is not normally distributed (reject null hypothesis)



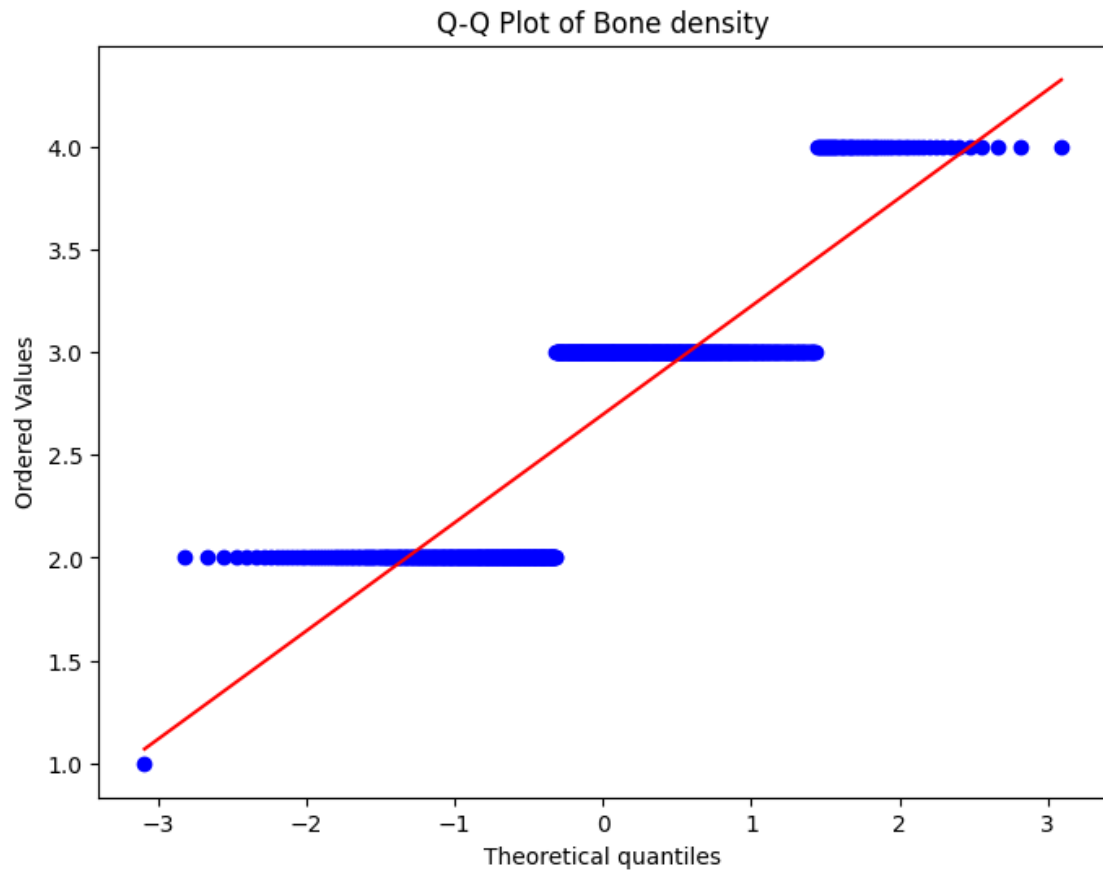


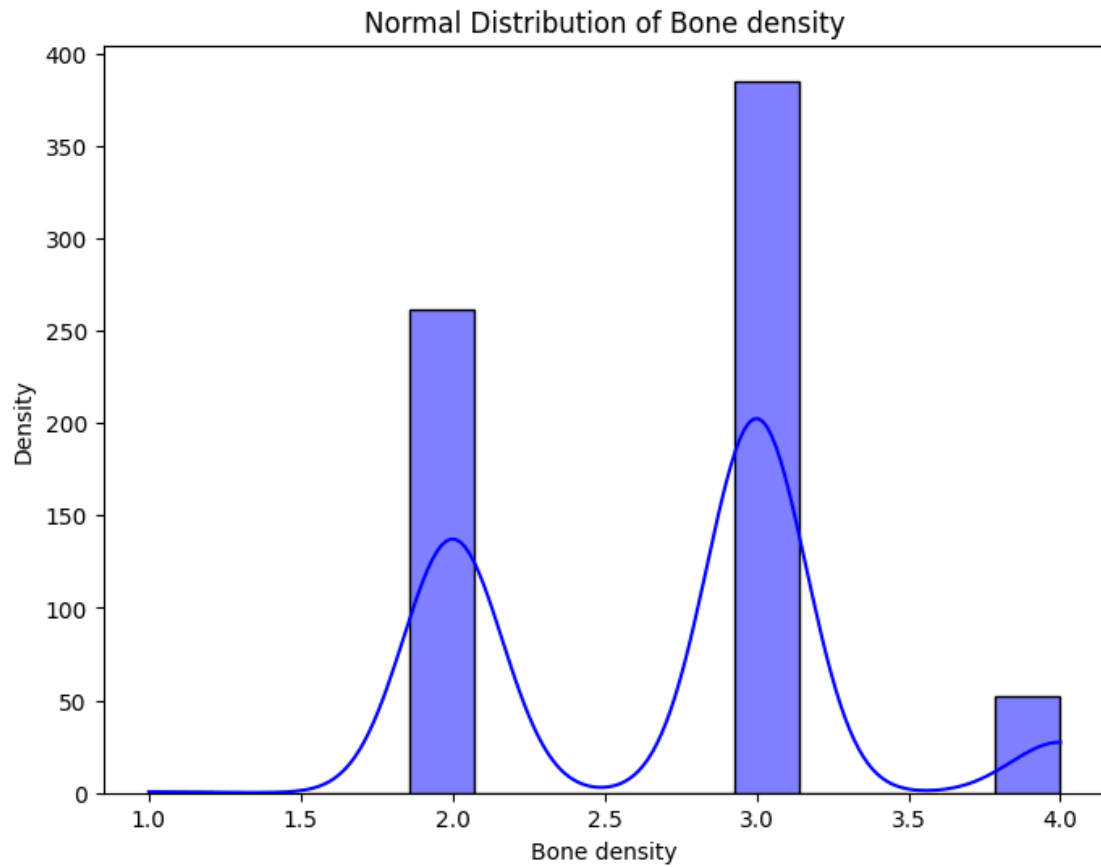
Shapiro-Wilk Test for Bone density:

Statistic: 0.7592836618423462

p-value: 1.0629216767027961e-30

Result: Data is not normally distributed (reject null hypothesis)



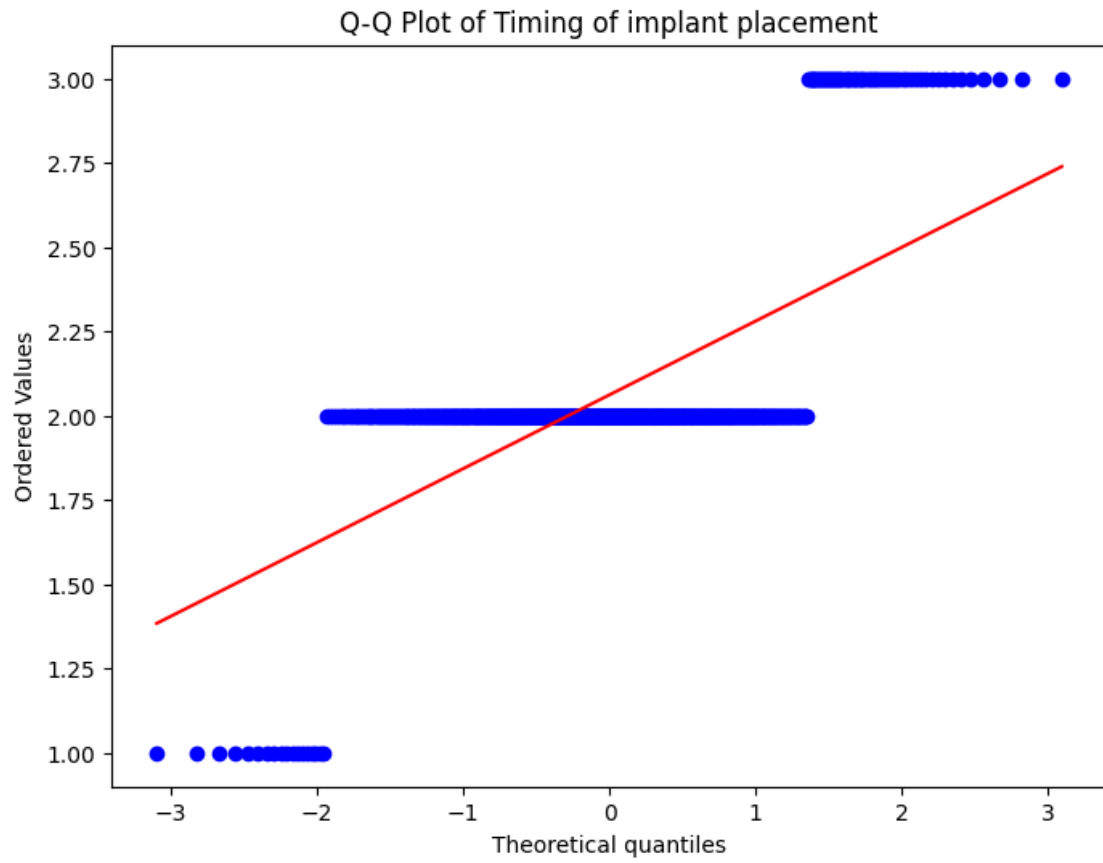


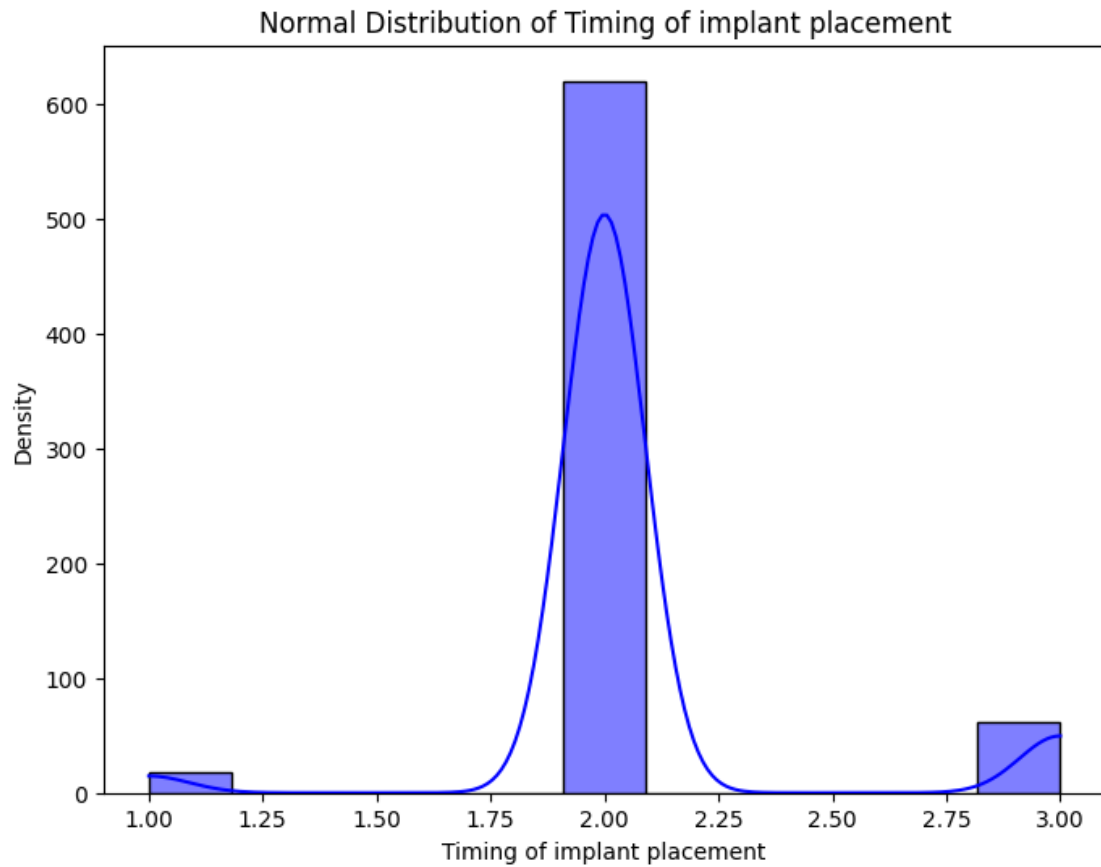
Shapiro-Wilk Test for Timing of implant placement:

Statistic: 0.43739134073257446

p-value: 5.2142315857526443e-42

Result: Data is not normally distributed (reject null hypothesis)



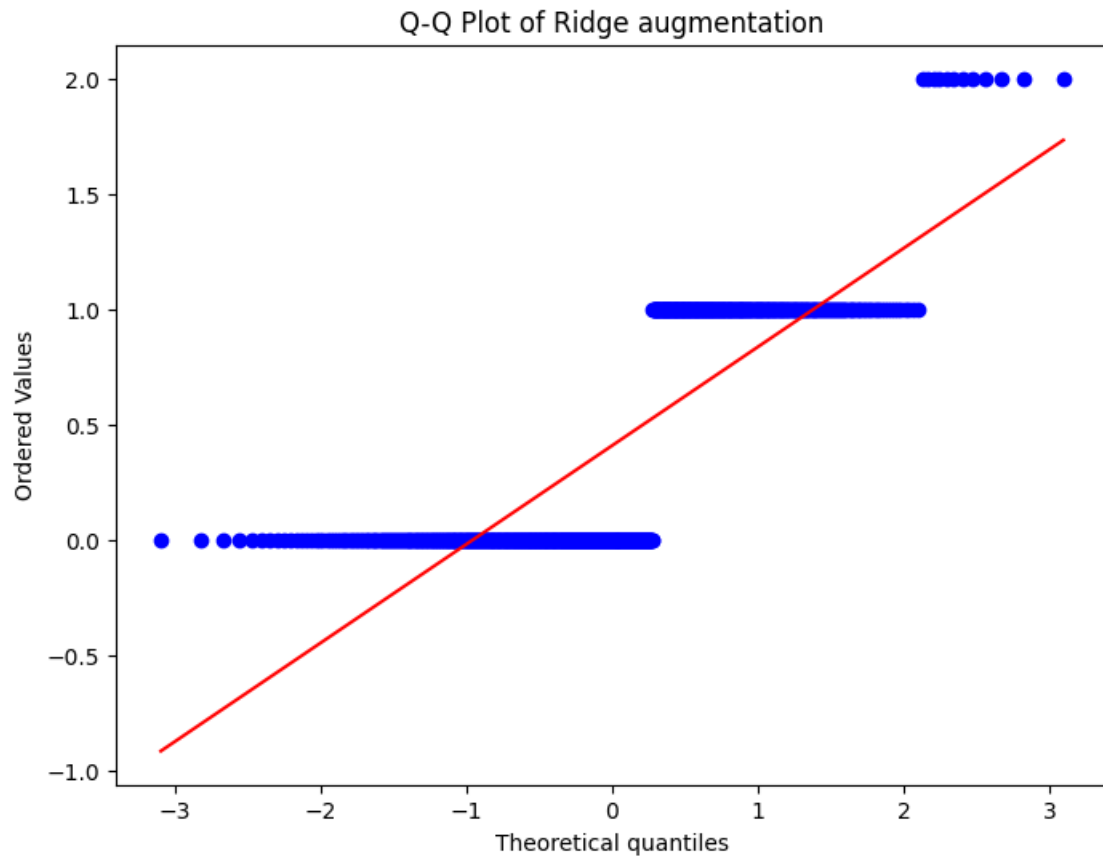


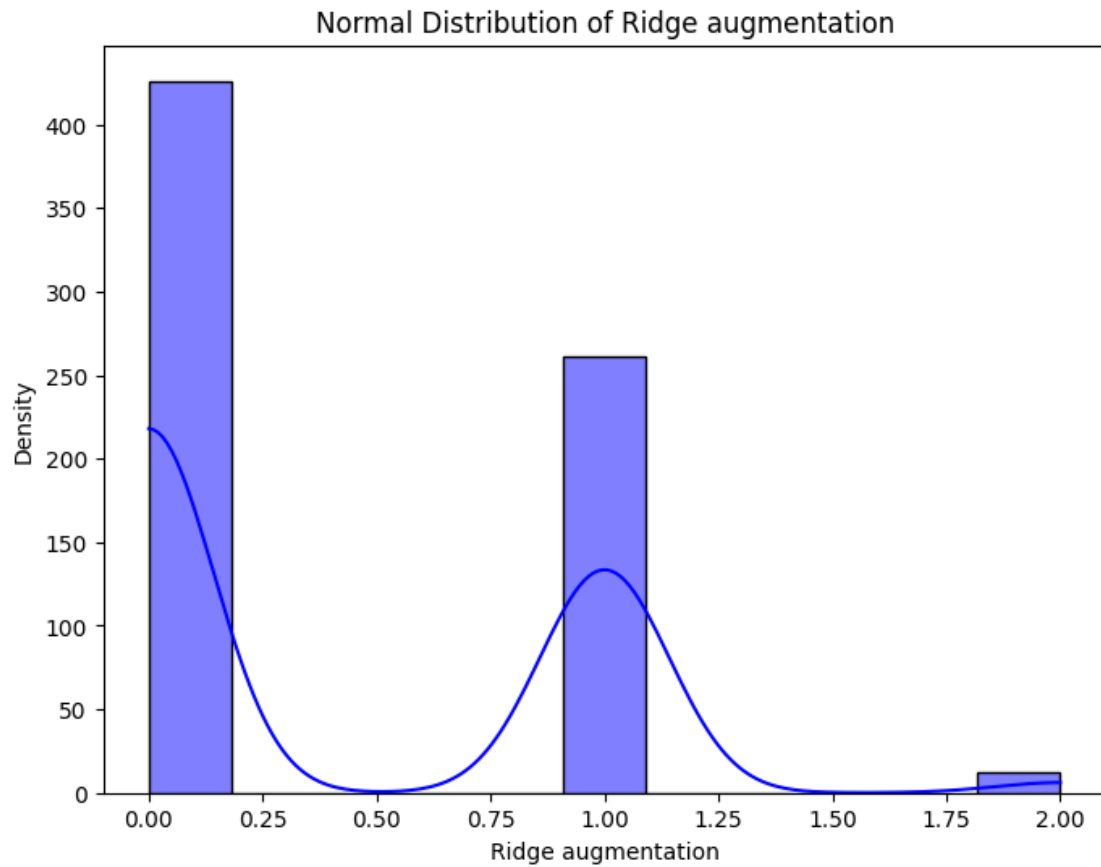
Shapiro-Wilk Test for Ridge augmentation:

Statistic: 0.6590396165847778

p-value: 4.0985082779216837e-35

Result: Data is not normally distributed (reject null hypothesis)



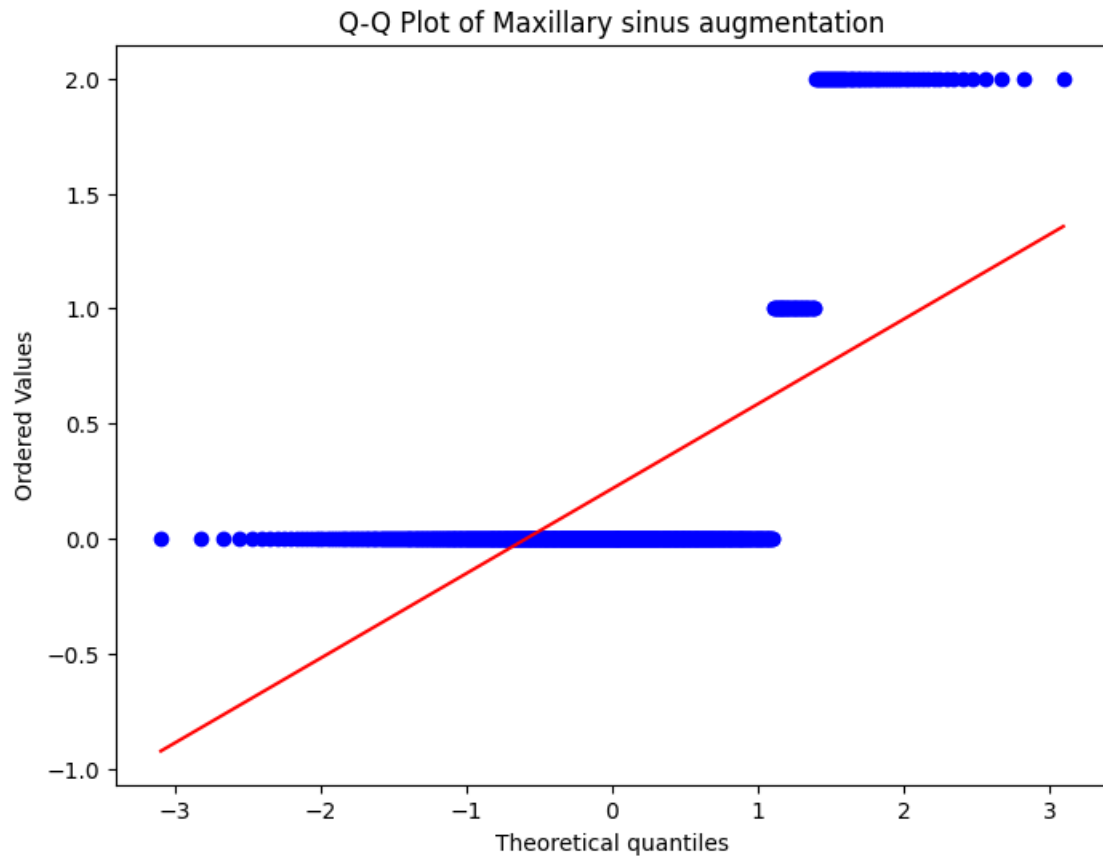


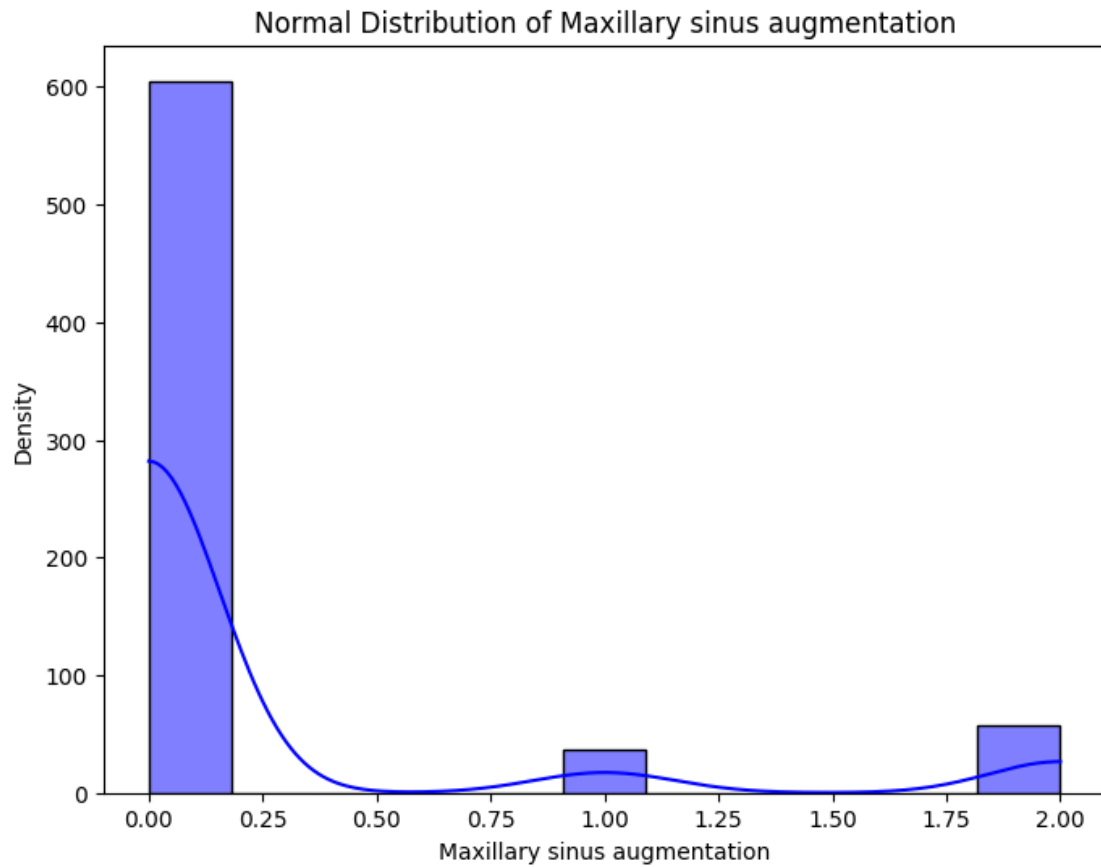
Shapiro-Wilk Test for Maxillary sinus augmentation:

Statistic: 0.40579837560653687

p-value: 8.435816755235399e-43

Result: Data is not normally distributed (reject null hypothesis)



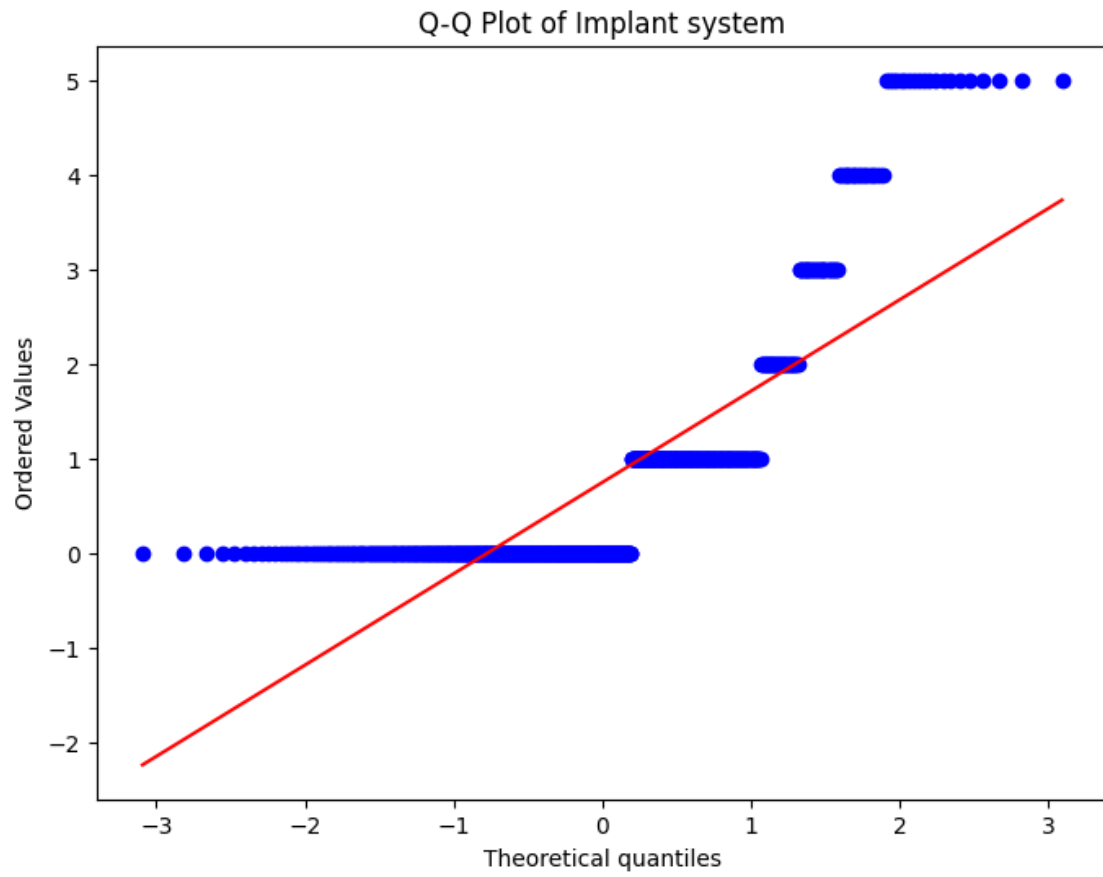


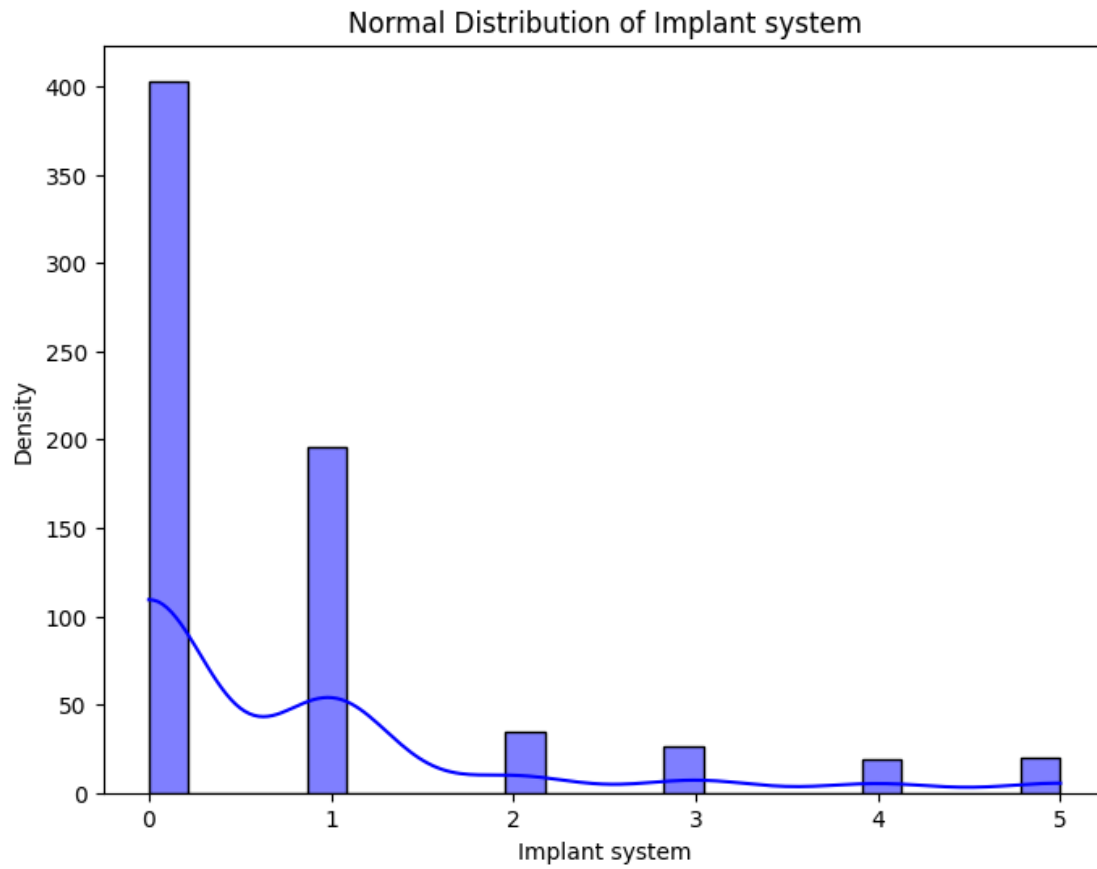
Shapiro-Wilk Test for Implant system:

Statistic: 0.6547759175300598

p-value: 2.8139452131014324e-35

Result: Data is not normally distributed (reject null hypothesis)



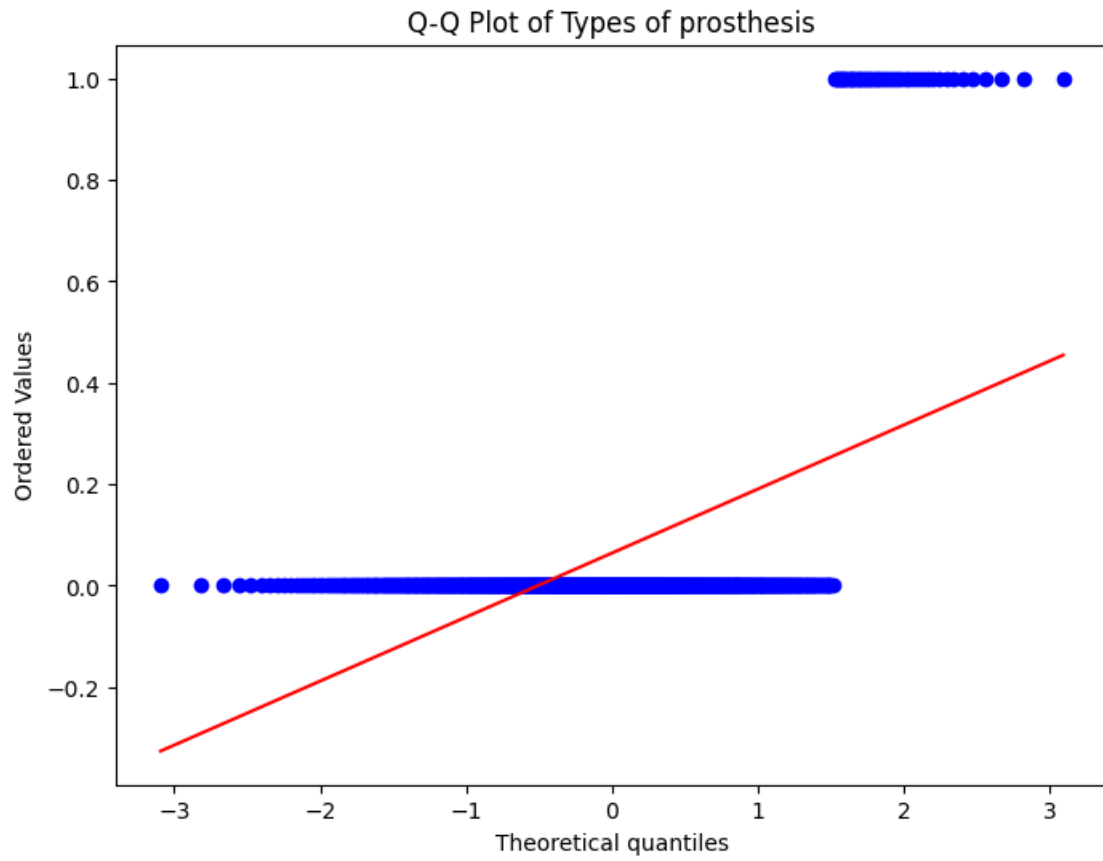


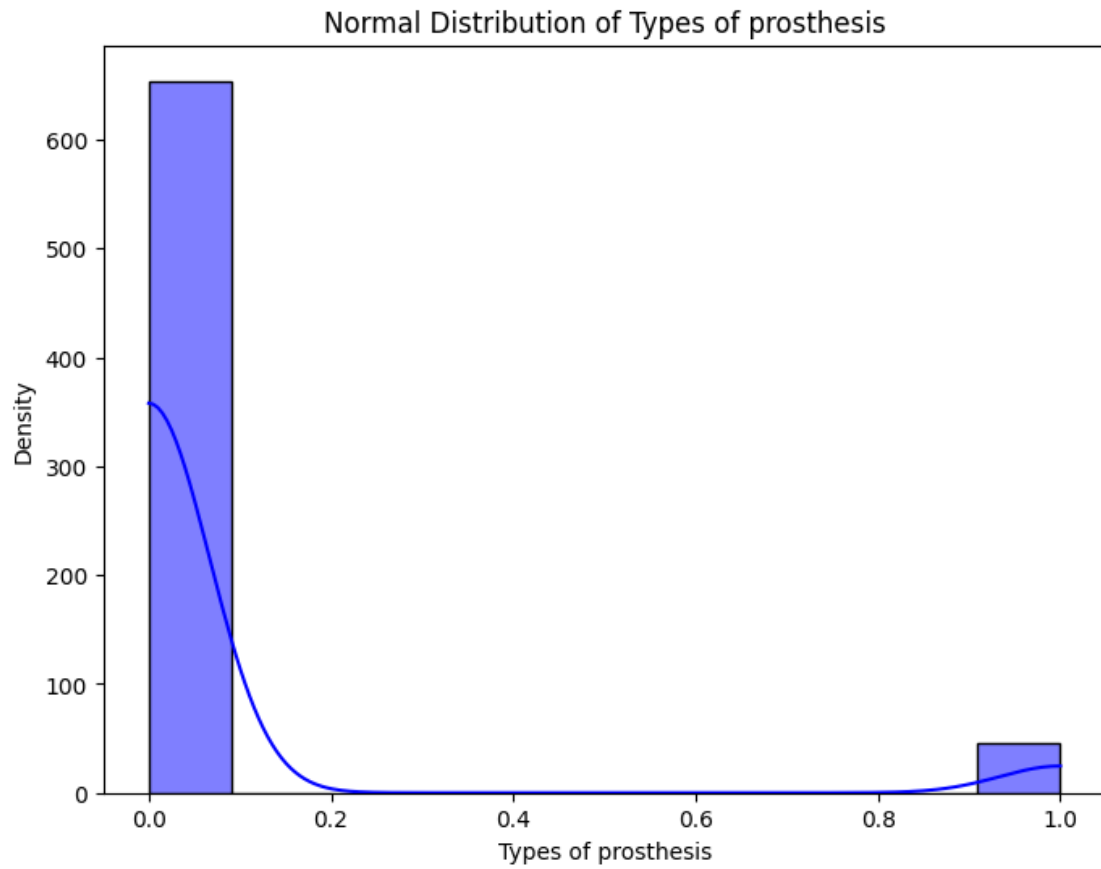
Shapiro-Wilk Test for Types of prosthesis:

Statistic: 0.2628212571144104

p-value: 0.0

Result: Data is not normally distributed (reject null hypothesis)



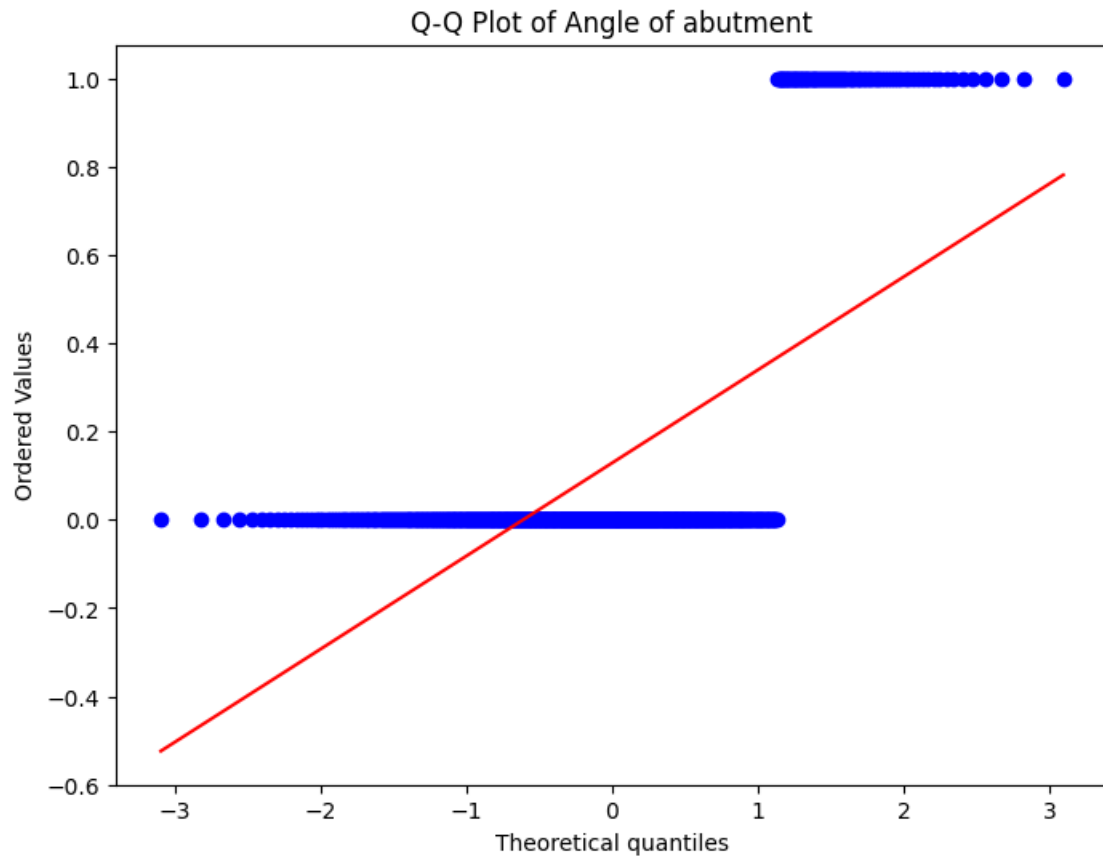


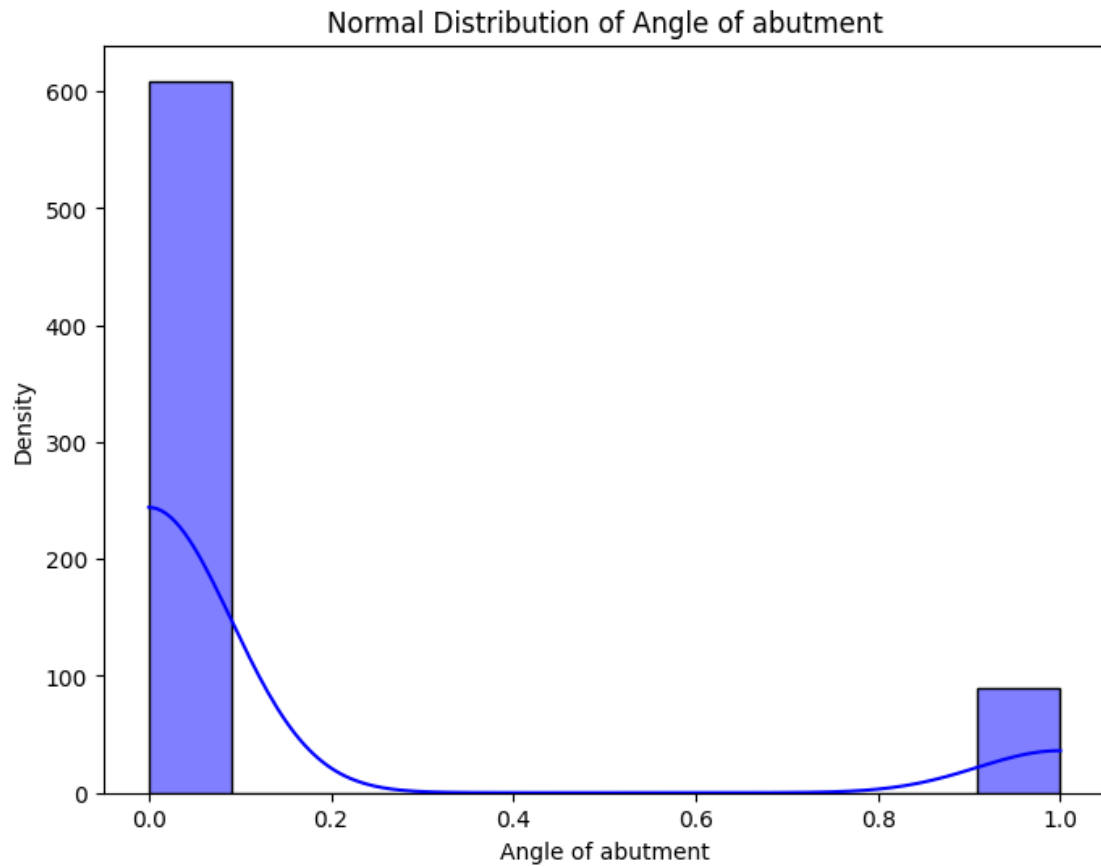
Shapiro-Wilk Test for Angle of abutment:

Statistic: 0.39350223541259766

p-value: 4.245934346904196e-43

Result: Data is not normally distributed (reject null hypothesis)



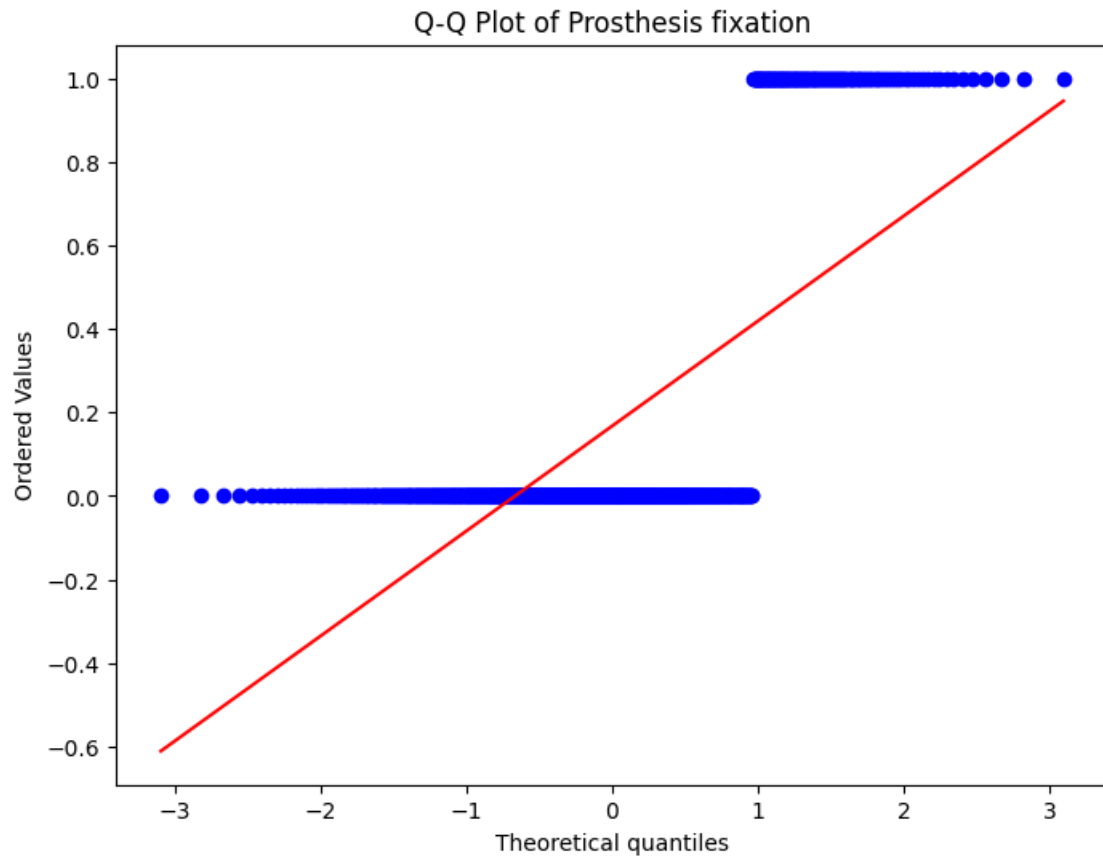


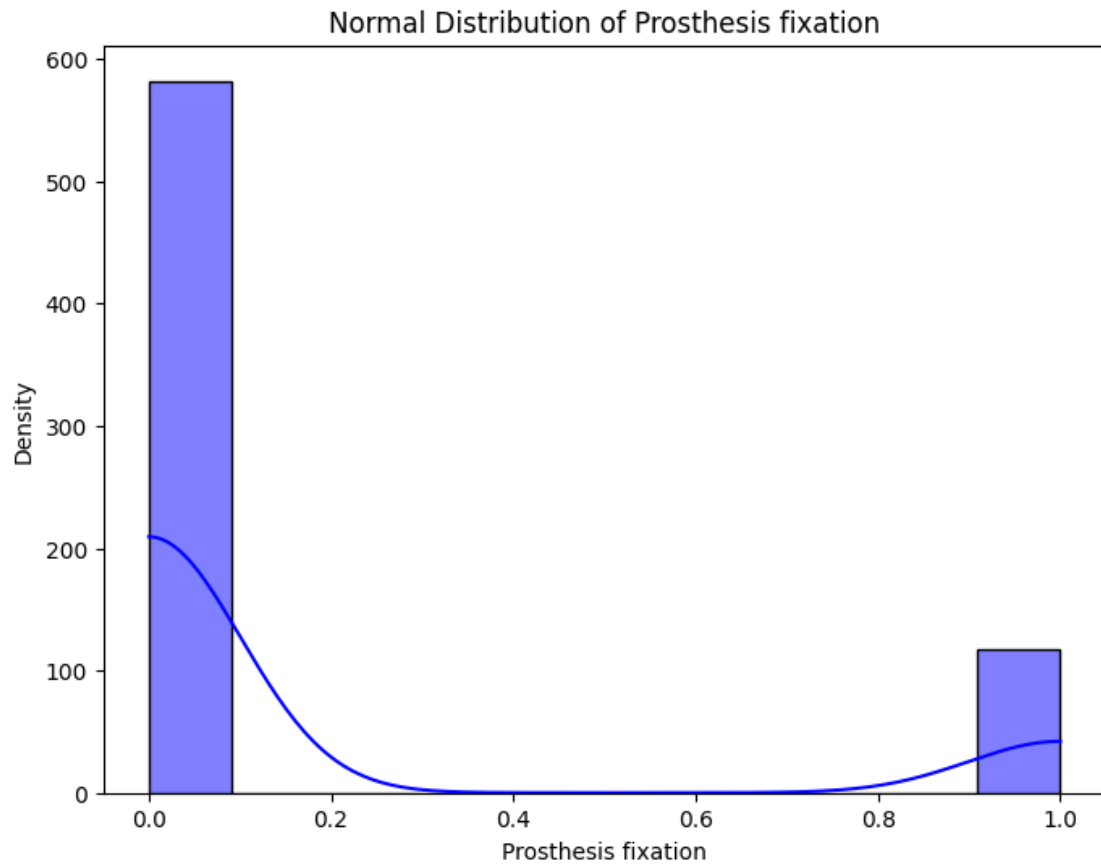
Shapiro-Wilk Test for Prosthesis fixation:

Statistic: 0.45027226209640503

p-value: 1.122580199770611e-41

Result: Data is not normally distributed (reject null hypothesis)



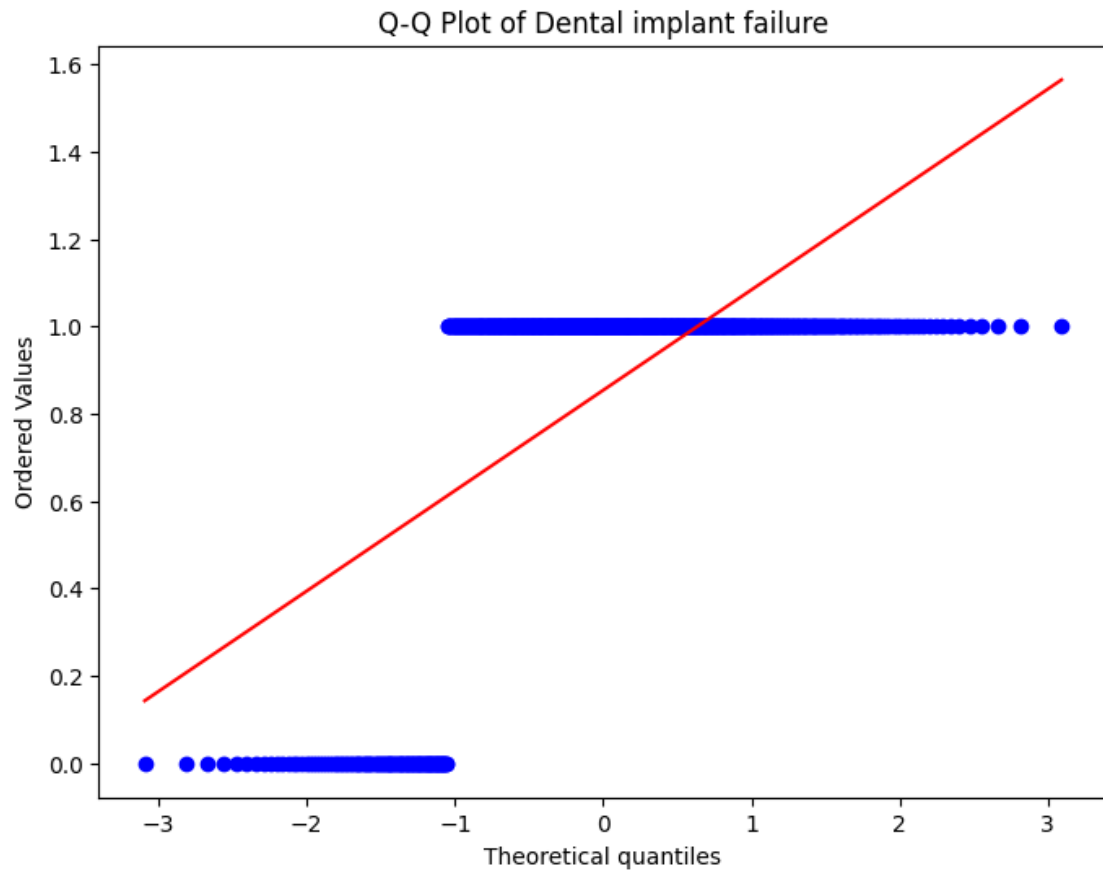


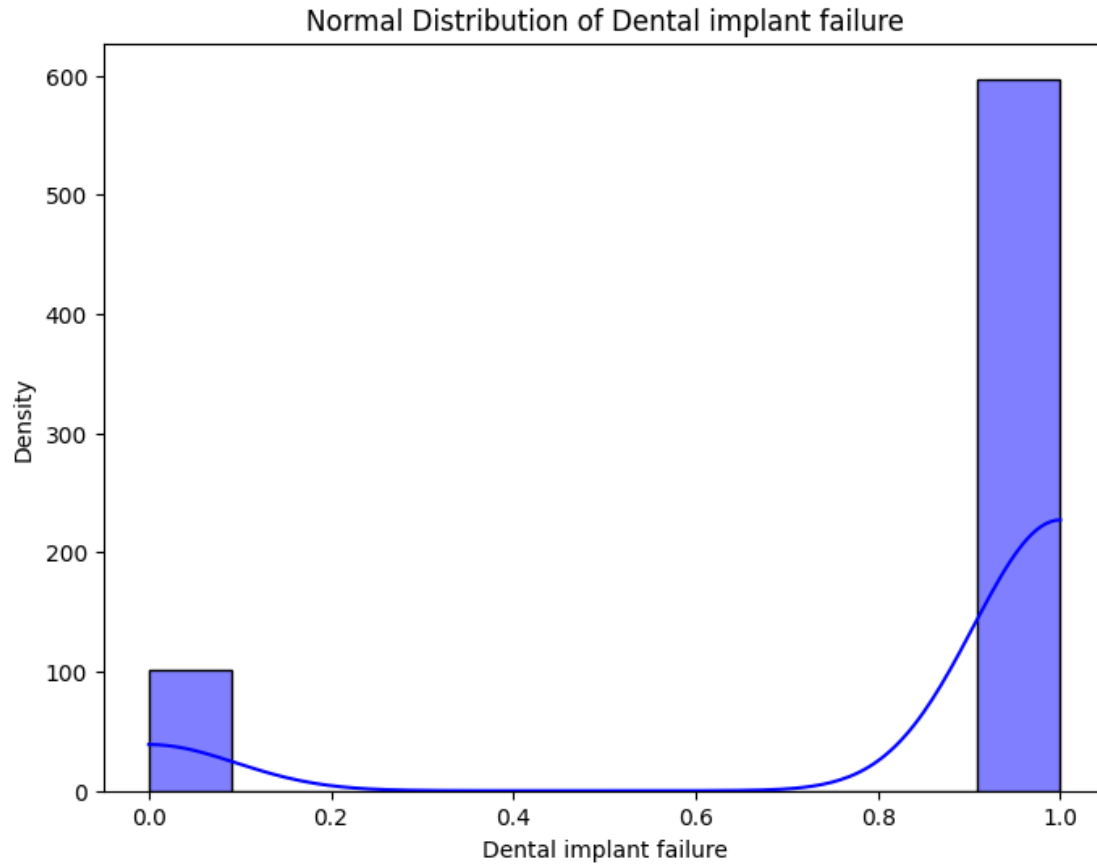
Shapiro-Wilk Test for Dental implant failure:

Statistic: 0.42025476694107056

p-value: 1.9211801945893242e-42

Result: Data is not normally distributed (reject null hypothesis)





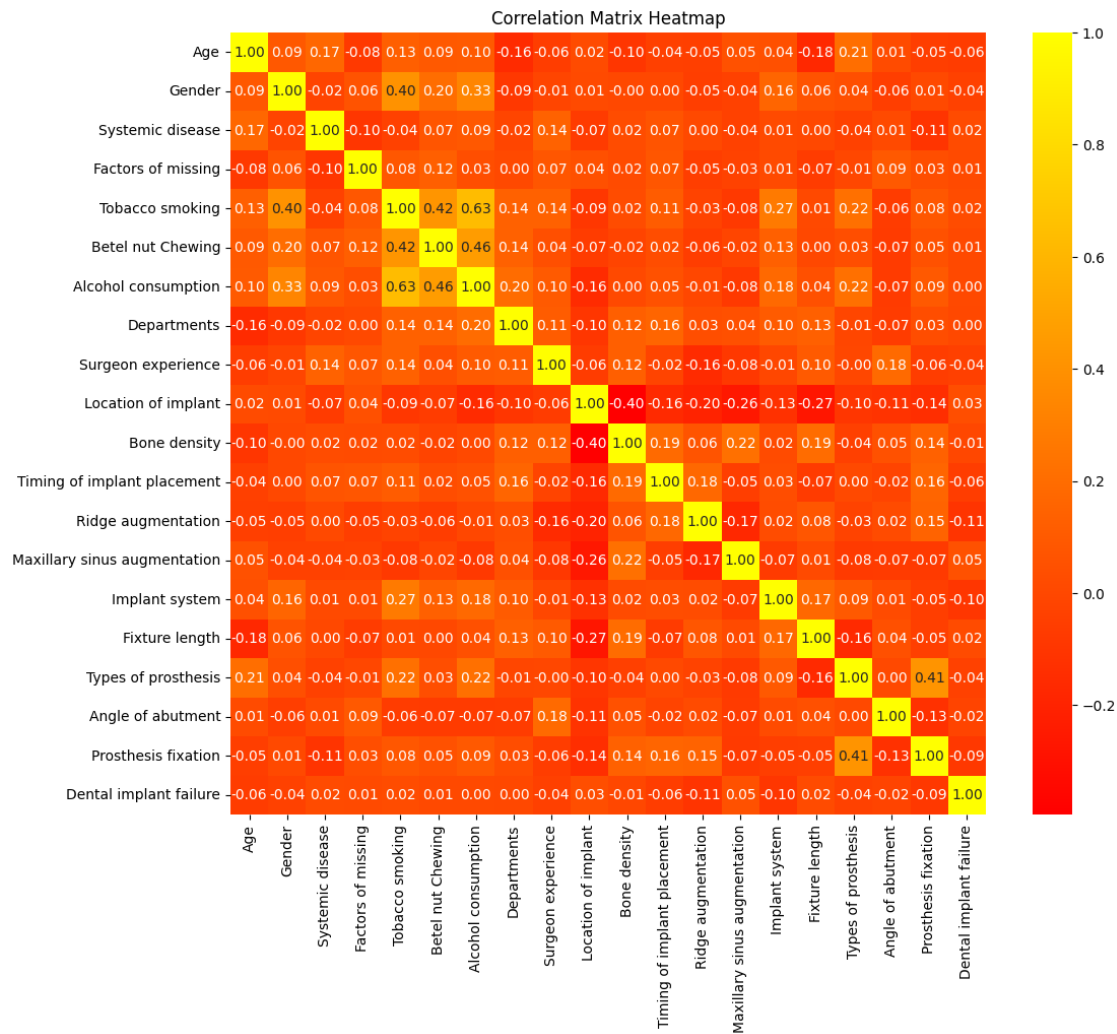
5 Correlation Analysis:

```
[17]: numerical_columns = ['Age', 'Gender', 'Systemic disease', 'Factors of missing',
    ↪ 'Tobacco smoking', 'Betel nut Chewing', 'Alcohol_
    ↪ consumption',
    ↪ 'Departments', 'Surgeon experience', 'Location of implant',
    ↪ 'Bone density', 'Timing of implant placement', 'Ridge_
    ↪ augmentation',
    ↪ 'Maxillary sinus augmentation', 'Implant system', 'Fixture_
    ↪ length',
    ↪ 'Types of prosthesis', 'Angle of abutment', 'Prosthesis_
    ↪ fixation',
    ↪ 'Dental implant failure']

correlation_matrix = df[numerical_columns].corr()
```

```
[18]: plt.figure(figsize=(12, 10))
```

```
sns.heatmap(correlation_matrix, annot=True, cmap='autumn', fmt='.2f')
plt.title("Correlation Matrix Heatmap")
plt.show()
```



```
[19]: df
```

```
[19]:
```

	Age	Gender	Systemic disease	Factors of missing	Tobacco smoking	\
0	69	0			2	0
1	42	0			1	0
2	43	0			1	0
3	43	0			1	0
4	43	0			1	0
..
694	51	0			2	0
695	52	0			2	0

696	52	0	0	2	0
697	55	0	0	3	0
698	41	0	0	2	0

	Betel nut Chewing	Alcohol consumption	Departments	Surgeon experience \
0	0	0	1	5
1	0	0	1	6
2	0	0	1	7
3	0	0	1	7
4	0	0	1	7
..
694	0	0	2	15
695	0	0	2	16
696	0	0	2	16
697	0	0	2	19
698	0	0	0	16

	Location of implant	...	Timing of implant placement \
0	4	...	2
1	1	...	1
2	4	...	2
3	5	...	2
4	5	...	2
..
694	5	...	2
695	5	...	2
696	5	...	2
697	4	...	2
698	2	...	2

	Ridge augmentation	Maxillary sinus augmentation	Implant system \
0	1	0	0
1	1	0	0
2	1	0	0
3	1	0	0
4	1	0	0
..
694	1	0	0
695	0	0	0
696	0	0	0
697	0	0	0
698	0	0	0

	Fixture length	Fixture width	Types of prosthesis	Angle of abutment \
0	10.0	4.1	0	0
1	12.0	4.1	0	0
2	10.0	3.3	0	0

3	8.0	4.1	0	0
4	10.0	4.1	0	0
..
694	10.0	4.8	0	0
695	10.0	4.8	0	0
696	10.0	4.8	0	0
697	10.0	4.1	0	0
698	12.0	4.8	0	0

	Prosthesis fixation	Dental implant failure
0	0	1
1	0	1
2	0	1
3	0	1
4	0	1
..
694	0	1
695	0	1
696	0	1
697	0	1
698	0	1

[699 rows x 21 columns]

```
[20]: new_data = pd.DataFrame()

gender_mapping = {0: 'Female', 1: 'Male'}
new_data['Gender'] = df['Gender'].map(gender_mapping)

systemic_disease_mapping = {
    0: 'Healthy',
    1: 'Cardiovascular disorder',
    2: 'Diabetes',
    3: 'Osteoporosis',
    4: 'Radiotherapy',
    5: 'Others'
}
new_data['Systemic disease'] = df['Systemic disease'].
    ↪map(systemic_disease_mapping)

factors_of_missing_mapping = {
    0: 'Congenital missing',
    1: 'Caries',
    2: 'Periodontitis',
    3: 'Fracture',
    4: 'Root resorption',
    5: 'Failure of endodontic treatment'
}
```

```

}
new_data['Factors of missing'] = df['Factors of missing'].
    ↪map(factors_of_missing_mapping)

tobacco_smoking_mapping = {
    0: 'Never',
    1: 'Smoking',
    2: 'Stopped smoking'
}
new_data['Tobacco smoking'] = df['Tobacco smoking'].map(tobacco_smoking_mapping)

betel_nut_chewing_mapping = {
    0: 'Never',
    1: 'Chewing betel nut',
    2: 'Stopped chewing betel nut'
}
new_data['Betel nut chewing'] = df['Betel nut Chewing'].
    ↪map(betel_nut_chewing_mapping)

alcohol_consumption_mapping = {
    0: 'Never',
    1: 'Drinking',
    2: 'Stopped drinking'
}
new_data['Alcohol consumption'] = df['Alcohol consumption'].
    ↪map(alcohol_consumption_mapping)

departments_mapping = {
    0: 'General practice',
    1: 'Periodontics',
    2: 'Oral-Maxillary surgery'
}
new_data['Departments'] = df['Departments'].map(departments_mapping)

location_of_implant_mapping = {
    0: 'Maxillary anterior teeth',
    1: 'Maxillary premolars',
    2: 'Maxillary molars',
    3: 'Mandibular anterior teeth',
    4: 'Mandibular premolars',
    5: 'Mandibular molars'
}
new_data['Location of implant'] = df['Location of implant'].
    ↪map(location_of_implant_mapping)

bone_density_mapping = {
    1: 'Type I',

```

```

    2: 'Type II',
    3: 'Type III',
    4: 'Type IV'
}
new_data['Bone density'] = df['Bone density'].map(bone_density_mapping)

new_data

```

```

[20]:      Gender Systemic disease Factors of missing Tobacco smoking \
0      Female          Healthy      Periodontitis          Never
1      Female          Healthy          Caries          Never
2      Female          Healthy          Caries          Never
3      Female          Healthy          Caries          Never
4      Female          Healthy          Caries          Never
..      ...
694    Female          Healthy      Periodontitis          Never
695    Female          Healthy      Periodontitis          Never
696    Female          Healthy      Periodontitis          Never
697    Female          Healthy          Fracture          Never
698    Female          Healthy      Periodontitis          Never

      Betel nut chewing Alcohol consumption      Departments \
0              Never          Never      Periodontics
1              Never          Never      Periodontics
2              Never          Never      Periodontics
3              Never          Never      Periodontics
4              Never          Never      Periodontics
..              ...
694            Never          Never      Oral-Maxillary surgery
695            Never          Never      Oral-Maxillary surgery
696            Never          Never      Oral-Maxillary surgery
697            Never          Never      Oral-Maxillary surgery
698            Never          Never      General practice

      Location of implant Bone density
0      Mandibular premolars      Type II
1      Maxillary premolars      Type III
2      Mandibular premolars      Type II
3      Mandibular molars      Type II
4      Mandibular molars      Type II
..      ...
694      Mandibular molars      Type III
695      Mandibular molars      Type II
696      Mandibular molars      Type II
697      Mandibular premolars      Type II
698      Maxillary molars      Type II

```

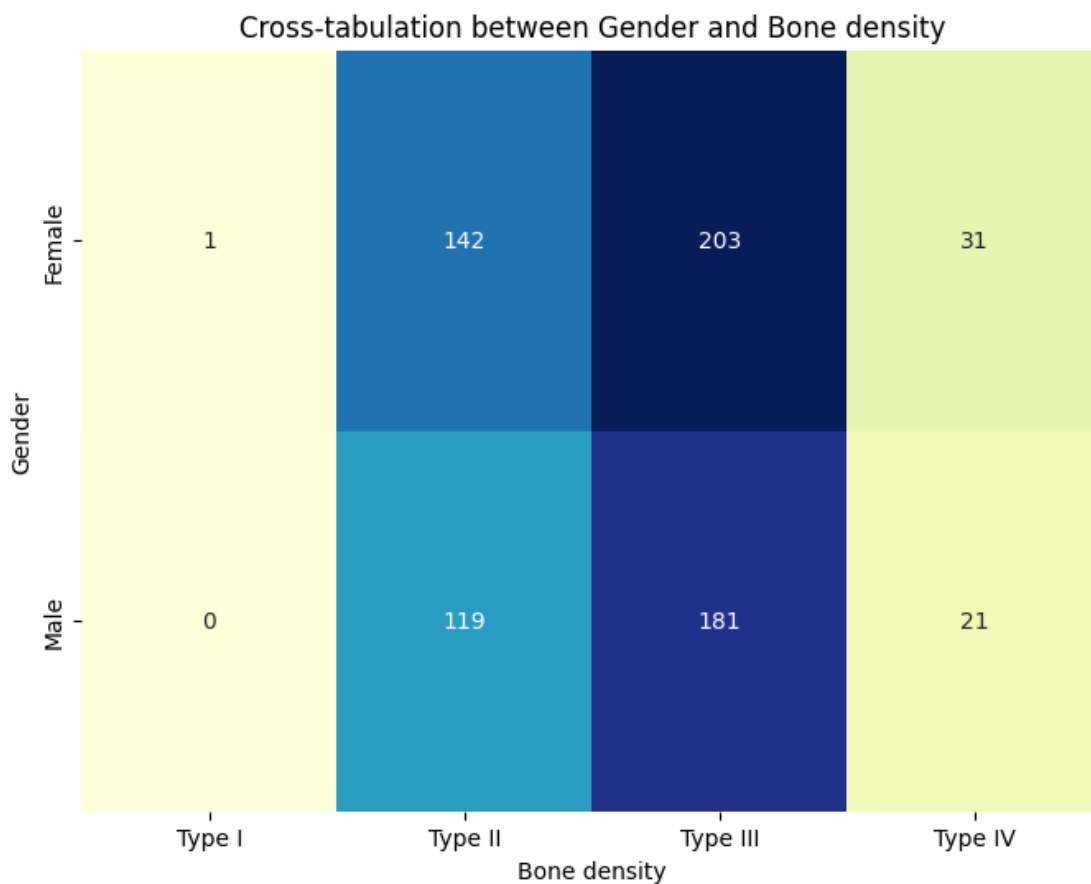
[699 rows x 9 columns]

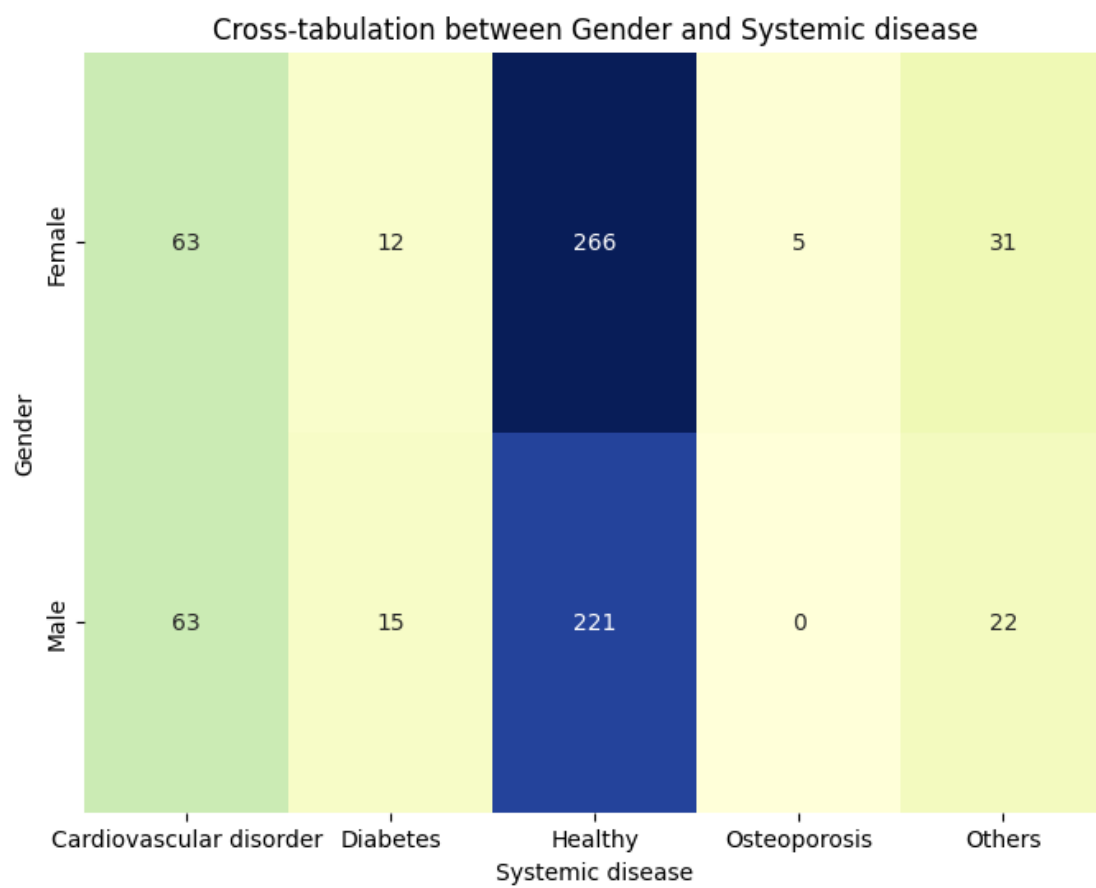
6 Chi-square Test:

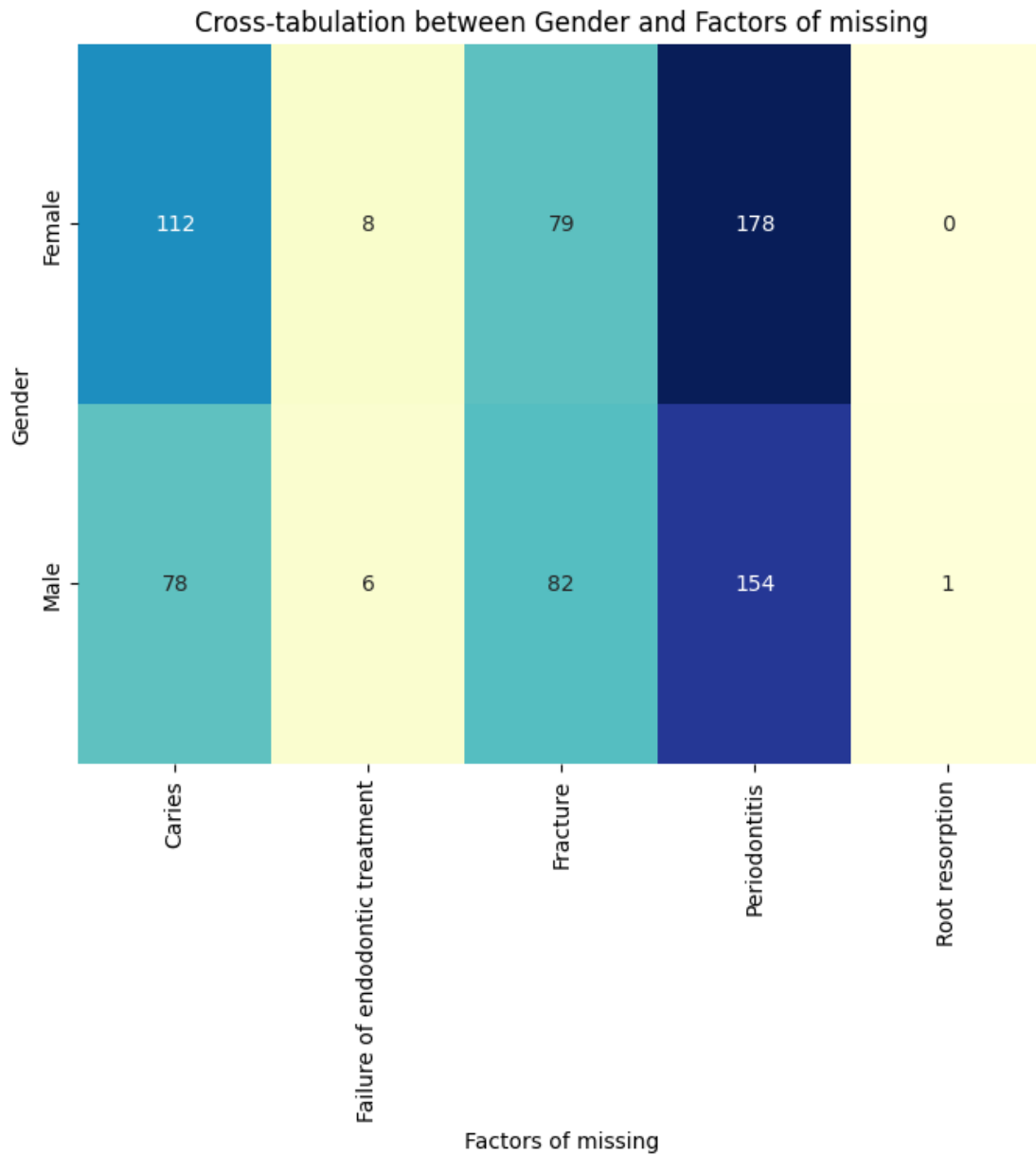
```
[21]: import pandas as pd
import seaborn as sns
import matplotlib.pyplot as plt

attributes = ['Bone density', 'Systemic disease', 'Factors of missing']

for attribute in attributes:
    dataset_table = pd.crosstab(new_data['Gender'], new_data[attribute])
    plt.figure(figsize=(8, 6))
    sns.heatmap(dataset_table, annot=True, fmt='d', cmap='YlGnBu', cbar=False)
    plt.xlabel(attribute)
    plt.ylabel('Gender')
    plt.title(f'Cross-tabulation between Gender and {attribute}')
    plt.show()
```







```
[22]: Observed_Values = dataset_table.values
print("Observed Values :-\n",Observed_Values)    #gender and factor of missing
```

```
Observed Values :-
[[112  8  79 178  0]
 [ 78  6  82 154  1]]
```

```
[23]: import pandas as pd
from scipy.stats import chi2_contingency
```

```

#Chi-square to check upon the association between Gender and Bone Density

#H0: There is no association between 'Gender' and 'Bone density' concerning
↳dental implant failure.
#H1: There is association between 'Gender' and 'Bone density' concerning dental
↳implant failure.

#H0: There is no association between 'Gender' and 'Systemic disease' concerning
↳dental implant failure.
#H1: There is association between 'Gender' and 'Systemic disease' concerning
↳dental implant failure.

#H0: There is no association between 'Gender' and 'Factors of missing'
↳concerning dental implant failure.
#H1: There is association between 'Gender' and 'Factors of missing' concerning
↳dental implant failure.

Alpha = 0.01

attribute_combinations = [('Gender', 'Bone density'),
                          ('Gender', 'Systemic disease'),
                          ('Gender', 'Factors of missing')]

for attribute1, attribute2 in attribute_combinations:
    contingency_table = pd.crosstab(new_data[attribute1], new_data[attribute2])
    chi2, p_value, _, _ = chi2_contingency(contingency_table)

    print(f"Chi-square test between {attribute1} and {attribute2}:")
    print(f"Chi-square statistic: {chi2}")
    print(f"P-value: {p_value}")
    print("Result: Significant" if p_value < 0.01 else "Result: Not
↳Significant")
    print()

```

Chi-square test between Gender and Bone density:
Chi-square statistic: 1.7286033880442324
P-value: 0.6305934430381048
Result: Not Significant

Chi-square test between Gender and Systemic disease:
Chi-square statistic: 6.569193543895252
P-value: 0.16048250803529687
Result: Not Significant

Chi-square test between Gender and Factors of missing:
 Chi-square statistic: 4.698169357802886
 P-value: 0.3196918868647357
 Result: Not Significant

The p-value (0.6306) is greater than the significance level ($\alpha = 0.01$), indicating that there is no significant association between 'Gender' and 'Bone density' at the 0.01 significance level.

The p-value (0.1605) is greater than the significance level ($\alpha = 0.01$), indicating that there is no significant association between 'Gender' and 'Systemic disease' at the 0.01 significance level.

The p-value (0.3197) is greater than the significance level ($\alpha = 0.01$), indicating that there is no significant association between 'Gender' and 'Factors of missing' at the 0.01 significance level.

7 Logistic Regression:

```
[24]: from sklearn.model_selection import train_test_split
      from sklearn.linear_model import LogisticRegression
      from sklearn.decomposition import PCA

      from sklearn.discriminant_analysis import LinearDiscriminantAnalysis

      from sklearn.metrics import confusion_matrix
      from sklearn.metrics import classification_report
```

```
[28]: df1 = df.drop('Fixture length', axis =1)
```

```
[33]: df1 = df.drop('Fixture width', axis =1)
```

```
[69]: y = df1['Dental implant failure'].copy()
      X = df1.drop('Dental implant failure', axis=1).copy()

      X_train, X_test, y_train, y_test = train_test_split(X, y, train_size=0.7,
      ↪shuffle=True, random_state=1)
```

```
[71]: X_train.head()
```

```
[71]:
```

	Age	Gender	Systemic disease	Factors of missing	Tobacco smoking	\
146	55	0	1	2	0	
347	53	1	0	2	0	
286	49	0	1	3	0	
165	55	0	0	2	0	
493	54	0	5	2	0	

	Betel nut Chewing	Alcohol consumption	Departments	Surgeon experience	\
146	0	0	0	16	
347	0	0	1	11	

286	0	0	1	9
165	0	0	1	8
493	0	0	0	25

	Location of implant	Bone density	Timing of implant placement	\
146	5	3	2	
347	2	4	3	
286	0	3	2	
165	5	3	2	
493	4	2	2	

	Ridge augmentation	Maxillary sinus augmentation	Implant system	\
146	0	0	1	
347	0	0	0	
286	1	0	2	
165	0	0	2	
493	0	0	1	

	Fixture length	Types of prosthesis	Angle of abutment	\
146	11.0	0	0	
347	10.0	0	1	
286	13.0	1	1	
165	11.0	0	0	
493	9.5	0	1	

	Prosthesis fixation
146	0
347	0
286	1
165	0
493	0

```
[72]: y_train.head()
```

```
[72]: 146    1
      347    1
      286    1
      165    1
      493    1
      Name: Dental implant failure, dtype: int64
```

```
[73]: model = LogisticRegression()
      model.fit(X_train, y_train)
```

```
/usr/local/lib/python3.10/dist-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

```
[73]: LogisticRegression()
```

```
[74]: y_pred1 = model.predict(X_test)
```

```
[75]: # Accuracy
accuracy = accuracy_score(y_test, y_pred1)
print("Accuracy: {:.2f}%".format(accuracy * 100))

print("\nClassification Report:")
print(classification_report(y_test, y_pred1))

# Confusion Matrix
confusion_mat = confusion_matrix(y_test, y_pred1)
print("\nConfusion Matrix:")
print(confusion_mat)
```

Accuracy: 84.29%

Classification Report:

	precision	recall	f1-score	support
0	0.00	0.00	0.00	31
1	0.85	0.99	0.91	179
accuracy			0.84	210
macro avg	0.43	0.49	0.46	210
weighted avg	0.73	0.84	0.78	210

Confusion Matrix:

```
[[ 0 31]
 [ 2 177]]
```

#Decision Tree:

```
[76]: from sklearn.tree import DecisionTreeClassifier
from sklearn.metrics import accuracy_score, classification_report, \
confusion_matrix
```

```
X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.2,
↳random_state=42)

dt = DecisionTreeClassifier(random_state=42)
dt.fit(X_train, y_train)
```

```
[76]: DecisionTreeClassifier(random_state=42)
```

```
[77]: y_pred = dt.predict(X_test)
```

```
[78]: accuracy = accuracy_score(y_test, y_pred)
print("Accuracy:", accuracy)

print("\nClassification Report:")
print(classification_report(y_test, y_pred))

print("\nConfusion Matrix:")
print(confusion_matrix(y_test, y_pred))
print()
```

Accuracy: 0.8285714285714286

Classification Report:

	precision	recall	f1-score	support
0	0.56	0.35	0.43	26
1	0.86	0.94	0.90	114
accuracy			0.83	140
macro avg	0.71	0.64	0.66	140
weighted avg	0.81	0.83	0.81	140

Confusion Matrix:

```
[[ 9 17]
 [ 7 107]]
```

8 SVM:

```
[79]: from sklearn.svm import SVC
from sklearn.preprocessing import StandardScaler

X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.3,
↳random_state=1)
```

```

scaler = StandardScaler()
X_train_scaled = scaler.fit_transform(X_train)
X_test_scaled = scaler.transform(X_test)

```

```
[80]: svm_model = SVC(kernel='linear', random_state=1)
```

```
[81]: svm_model.fit(X_train_scaled, y_train)
```

```
[81]: SVC(kernel='linear', random_state=1)
```

```
[82]: y_pred_svm = svm_model.predict(X_test_scaled)
```

```

[84]: accuracy_svm = accuracy_score(y_test, y_pred_svm)
print("SVM Accuracy: {:.2f}%".format(accuracy_svm * 100))

print("\nSVM Classification Report:")
print(classification_report(y_test, y_pred_svm))

print("\nSVM Confusion Matrix:")
confusion_mat_svm = confusion_matrix(y_test, y_pred_svm)
print(confusion_mat_svm)

print()
print('='*150)

```

SVM Accuracy: 85.24%

SVM Classification Report:

	precision	recall	f1-score	support
0	0.00	0.00	0.00	31
1	0.85	1.00	0.92	179
accuracy			0.85	210
macro avg	0.43	0.50	0.46	210
weighted avg	0.73	0.85	0.78	210

SVM Confusion Matrix:

```

[[ 0 31]
 [ 0 179]]

```

```

=====
=====

```

```

/usr/local/lib/python3.10/dist-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.

/usr/local/lib/python3.10/dist-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.

/usr/local/lib/python3.10/dist-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.

```
[85]: !apt-get install -qq -y texlive-xetex
```

```
Extracting templates from packages: 100%
Preconfiguring packages ...
Selecting previously unselected package fonts-droid-fallback.
(Reading database ... 120493 files and directories currently installed.)
Preparing to unpack .../00-fonts-droid-fallback_1%3a6.0.1r16-1.1build1_all.deb
...
Unpacking fonts-droid-fallback (1:6.0.1r16-1.1build1) ...
Selecting previously unselected package fonts-lato.
Preparing to unpack .../01-fonts-lato_2.0-2.1_all.deb ...
Unpacking fonts-lato (2.0-2.1) ...
Selecting previously unselected package poppler-data.
Preparing to unpack .../02-poppler-data_0.4.11-1_all.deb ...
Unpacking poppler-data (0.4.11-1) ...
Selecting previously unselected package tex-common.
Preparing to unpack .../03-tex-common_6.17_all.deb ...
Unpacking tex-common (6.17) ...
Selecting previously unselected package fonts-urw-base35.
Preparing to unpack .../04-fonts-urw-base35_20200910-1_all.deb ...
Unpacking fonts-urw-base35 (20200910-1) ...
Selecting previously unselected package libgs9-common.
Preparing to unpack .../05-libgs9-common_9.55.0~dfsg1-0ubuntu5.3_all.deb ...
Unpacking libgs9-common (9.55.0~dfsg1-0ubuntu5.3) ...
Selecting previously unselected package libidn12:amd64.
Preparing to unpack .../06-libidn12_1.38-4ubuntu1_amd64.deb ...
Unpacking libidn12:amd64 (1.38-4ubuntu1) ...
Selecting previously unselected package libijs-0.35:amd64.
Preparing to unpack .../07-libijs-0.35_0.35-15build2_amd64.deb ...
Unpacking libijs-0.35:amd64 (0.35-15build2) ...
Selecting previously unselected package libjbig2dec0:amd64.
```

```

Preparing to unpack .../08-libjbig2dec0_0.19-3build2_amd64.deb ...
Unpacking libjbig2dec0:amd64 (0.19-3build2) ...
Selecting previously unselected package libgs9:amd64.
Preparing to unpack .../09-libgs9_9.55.0~dfsg1-0ubuntu5.3_amd64.deb ...
Unpacking libgs9:amd64 (9.55.0~dfsg1-0ubuntu5.3) ...
Selecting previously unselected package libkpathsea6:amd64.
Preparing to unpack .../10-libkpathsea6_2021.20210626.59705-1ubuntu0.1_amd64.deb
...
Unpacking libkpathsea6:amd64 (2021.20210626.59705-1ubuntu0.1) ...
Selecting previously unselected package libwoff1:amd64.
Preparing to unpack .../11-libwoff1_1.0.2-1build4_amd64.deb ...
Unpacking libwoff1:amd64 (1.0.2-1build4) ...
Selecting previously unselected package dvisvgm.
Preparing to unpack .../12-dvisvgm_2.13.1-1_amd64.deb ...
Unpacking dvisvgm (2.13.1-1) ...
Selecting previously unselected package fonts-lmodern.
Preparing to unpack .../13-fonts-lmodern_2.004.5-6.1_all.deb ...
Unpacking fonts-lmodern (2.004.5-6.1) ...
Selecting previously unselected package fonts-noto-mono.
Preparing to unpack .../14-fonts-noto-mono_20201225-1build1_all.deb ...
Unpacking fonts-noto-mono (20201225-1build1) ...
Selecting previously unselected package fonts-texgyre.
Preparing to unpack .../15-fonts-texgyre_20180621-3.1_all.deb ...
Unpacking fonts-texgyre (20180621-3.1) ...
Selecting previously unselected package libapache-pom-java.
Preparing to unpack .../16-libapache-pom-java_18-1_all.deb ...
Unpacking libapache-pom-java (18-1) ...
Selecting previously unselected package libcommons-parent-java.
Preparing to unpack .../17-libcommons-parent-java_43-1_all.deb ...
Unpacking libcommons-parent-java (43-1) ...
Selecting previously unselected package libcommons-logging-java.
Preparing to unpack .../18-libcommons-logging-java_1.2-2_all.deb ...
Unpacking libcommons-logging-java (1.2-2) ...
Selecting previously unselected package libfontenc1:amd64.
Preparing to unpack .../19-libfontenc1_1%3a1.1.4-1build3_amd64.deb ...
Unpacking libfontenc1:amd64 (1:1.1.4-1build3) ...
Selecting previously unselected package libptexenc1:amd64.
Preparing to unpack .../20-libptexenc1_2021.20210626.59705-1ubuntu0.1_amd64.deb
...
Unpacking libptexenc1:amd64 (2021.20210626.59705-1ubuntu0.1) ...
Selecting previously unselected package rubygems-integration.
Preparing to unpack .../21-rubygems-integration_1.18_all.deb ...
Unpacking rubygems-integration (1.18) ...
Selecting previously unselected package ruby3.0.
Preparing to unpack .../22-ruby3.0_3.0.2-7ubuntu2.4_amd64.deb ...
Unpacking ruby3.0 (3.0.2-7ubuntu2.4) ...
Selecting previously unselected package ruby-rubygems.
Preparing to unpack .../23-ruby-rubygems_3.3.5-2_all.deb ...

```

```

Unpacking ruby-rubygems (3.3.5-2) ...
Selecting previously unselected package ruby.
Preparing to unpack .../24-ruby_1%3a3.0~exp1_amd64.deb ...
Unpacking ruby (1:3.0~exp1) ...
Selecting previously unselected package rake.
Preparing to unpack .../25-rake_13.0.6-2_all.deb ...
Unpacking rake (13.0.6-2) ...
Selecting previously unselected package ruby-net-telnet.
Preparing to unpack .../26-ruby-net-telnet_0.1.1-2_all.deb ...
Unpacking ruby-net-telnet (0.1.1-2) ...
Selecting previously unselected package ruby-webrick.
Preparing to unpack .../27-ruby-webrick_1.7.0-3_all.deb ...
Unpacking ruby-webrick (1.7.0-3) ...
Selecting previously unselected package ruby-xmlrpc.
Preparing to unpack .../28-ruby-xmlrpc_0.3.2-1ubuntu0.1_all.deb ...
Unpacking ruby-xmlrpc (0.3.2-1ubuntu0.1) ...
Selecting previously unselected package libruby3.0:amd64.
Preparing to unpack .../29-libruby3.0_3.0.2-7ubuntu2.4_amd64.deb ...
Unpacking libruby3.0:amd64 (3.0.2-7ubuntu2.4) ...
Selecting previously unselected package libsyntax2:amd64.
Preparing to unpack .../30-libsyntax2_2021.20210626.59705-1ubuntu0.1_amd64.deb
...
Unpacking libsyntax2:amd64 (2021.20210626.59705-1ubuntu0.1) ...
Selecting previously unselected package libteckit0:amd64.
Preparing to unpack .../31-libteckit0_2.5.11+ds1-1_amd64.deb ...
Unpacking libteckit0:amd64 (2.5.11+ds1-1) ...
Selecting previously unselected package libtexlua53:amd64.
Preparing to unpack .../32-libtexlua53_2021.20210626.59705-1ubuntu0.1_amd64.deb
...
Unpacking libtexlua53:amd64 (2021.20210626.59705-1ubuntu0.1) ...
Selecting previously unselected package libtexluajit2:amd64.
Preparing to unpack
.../33-libtexluajit2_2021.20210626.59705-1ubuntu0.1_amd64.deb ...
Unpacking libtexluajit2:amd64 (2021.20210626.59705-1ubuntu0.1) ...
Selecting previously unselected package libzip-0-13:amd64.
Preparing to unpack .../34-libzip-0-13_0.13.72+dfsg.1-1.1_amd64.deb ...
Unpacking libzip-0-13:amd64 (0.13.72+dfsg.1-1.1) ...
Selecting previously unselected package xfonts-encodings.
Preparing to unpack .../35-xfonts-encodings_1%3a1.0.5-0ubuntu2_all.deb ...
Unpacking xfonts-encodings (1:1.0.5-0ubuntu2) ...
Selecting previously unselected package xfonts-utils.
Preparing to unpack .../36-xfonts-utils_1%3a7.7+6build2_amd64.deb ...
Unpacking xfonts-utils (1:7.7+6build2) ...
Selecting previously unselected package lmodern.
Preparing to unpack .../37-lmodern_2.004.5-6.1_all.deb ...
Unpacking lmodern (2.004.5-6.1) ...
Selecting previously unselected package preview-latex-style.
Preparing to unpack .../38-preview-latex-style_12.2-1ubuntu1_all.deb ...

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Unpacking preview-latex-style (12.2-1ubuntu1) ...
Selecting previously unselected package t1utils.
Preparing to unpack .../39-t1utils_1.41-4build2_amd64.deb ...
Unpacking t1utils (1.41-4build2) ...
Selecting previously unselected package teckit.
Preparing to unpack .../40-teckit_2.5.11+ds1-1_amd64.deb ...
Unpacking teckit (2.5.11+ds1-1) ...
Selecting previously unselected package tex-gyre.
Preparing to unpack .../41-tex-gyre_20180621-3.1_all.deb ...
Unpacking tex-gyre (20180621-3.1) ...
Selecting previously unselected package texlive-binaries.
Preparing to unpack .../42-texlive-
binaries_2021.20210626.59705-1ubuntu0.1_amd64.deb ...
Unpacking texlive-binaries (2021.20210626.59705-1ubuntu0.1) ...
Selecting previously unselected package texlive-base.
Preparing to unpack .../43-texlive-base_2021.20220204-1_all.deb ...
Unpacking texlive-base (2021.20220204-1) ...
Selecting previously unselected package texlive-fonts-recommended.
Preparing to unpack .../44-texlive-fonts-recommended_2021.20220204-1_all.deb ...
Unpacking texlive-fonts-recommended (2021.20220204-1) ...
Selecting previously unselected package texlive-latex-base.
Preparing to unpack .../45-texlive-latex-base_2021.20220204-1_all.deb ...
Unpacking texlive-latex-base (2021.20220204-1) ...
Selecting previously unselected package libfontbox-java.
Preparing to unpack .../46-libfontbox-java_1%3a1.8.16-2_all.deb ...
Unpacking libfontbox-java (1:1.8.16-2) ...
Selecting previously unselected package libpdfbox-java.
Preparing to unpack .../47-libpdfbox-java_1%3a1.8.16-2_all.deb ...
Unpacking libpdfbox-java (1:1.8.16-2) ...
Selecting previously unselected package texlive-latex-recommended.
Preparing to unpack .../48-texlive-latex-recommended_2021.20220204-1_all.deb ...
Unpacking texlive-latex-recommended (2021.20220204-1) ...
Selecting previously unselected package texlive-pictures.
Preparing to unpack .../49-texlive-pictures_2021.20220204-1_all.deb ...
Unpacking texlive-pictures (2021.20220204-1) ...
Selecting previously unselected package texlive-latex-extra.
Preparing to unpack .../50-texlive-latex-extra_2021.20220204-1_all.deb ...
Unpacking texlive-latex-extra (2021.20220204-1) ...
Selecting previously unselected package texlive-plain-generic.
Preparing to unpack .../51-texlive-plain-generic_2021.20220204-1_all.deb ...
Unpacking texlive-plain-generic (2021.20220204-1) ...
Selecting previously unselected package tipa.
Preparing to unpack .../52-tipa_2%3a1.3-21_all.deb ...
Unpacking tipa (2:1.3-21) ...
Selecting previously unselected package texlive-xetex.
Preparing to unpack .../53-texlive-xetex_2021.20220204-1_all.deb ...
Unpacking texlive-xetex (2021.20220204-1) ...
Setting up fonts-lato (2.0-2.1) ...

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Setting up fonts-noto-mono (20201225-1build1) ...
Setting up libwoff1:amd64 (1.0.2-1build4) ...
Setting up libtexlua53:amd64 (2021.20210626.59705-1ubuntu0.1) ...
Setting up libijs-0.35:amd64 (0.35-15build2) ...
Setting up libtexluajit2:amd64 (2021.20210626.59705-1ubuntu0.1) ...
Setting up libfontbox-java (1:1.8.16-2) ...
Setting up rubygems-integration (1.18) ...
Setting up libzip-0-13:amd64 (0.13.72+dfsg.1-1.1) ...
Setting up fonts-urw-base35 (20200910-1) ...
Setting up poppler-data (0.4.11-1) ...
Setting up tex-common (6.17) ...
update-language: texlive-base not installed and configured, doing nothing!
Setting up libfontenc1:amd64 (1:1.1.4-1build3) ...
Setting up libjbig2dec0:amd64 (0.19-3build2) ...
Setting up libteckit0:amd64 (2.5.11+ds1-1) ...
Setting up libapache-pom-java (18-1) ...
Setting up ruby-net-telnet (0.1.1-2) ...
Setting up xfonts-encodings (1:1.0.5-0ubuntu2) ...
Setting up t1utils (1.41-4build2) ...
Setting up libidn12:amd64 (1.38-4ubuntu1) ...
Setting up fonts-texgyre (20180621-3.1) ...
Setting up libkpathsea6:amd64 (2021.20210626.59705-1ubuntu0.1) ...
Setting up ruby-webrick (1.7.0-3) ...
Setting up fonts-lmodern (2.004.5-6.1) ...
Setting up fonts-droid-fallback (1:6.0.1r16-1.1build1) ...
Setting up ruby-xmlrpc (0.3.2-1ubuntu0.1) ...
Setting up libsyntax2:amd64 (2021.20210626.59705-1ubuntu0.1) ...
Setting up libgs9-common (9.55.0~dfsg1-0ubuntu5.3) ...
Setting up teckit (2.5.11+ds1-1) ...
Setting up libpdfbox-java (1:1.8.16-2) ...
Setting up libgs9:amd64 (9.55.0~dfsg1-0ubuntu5.3) ...
Setting up preview-latex-style (12.2-1ubuntu1) ...
Setting up libcommons-parent-java (43-1) ...
Setting up dvisvgm (2.13.1-1) ...
Setting up libcommons-logging-java (1.2-2) ...
Setting up xfonts-utils (1:7.7+6build2) ...
Setting up libptexenc1:amd64 (2021.20210626.59705-1ubuntu0.1) ...
Setting up texlive-binaries (2021.20210626.59705-1ubuntu0.1) ...
update-alternatives: using /usr/bin/xdvi-xaw to provide /usr/bin/xdvi.bin
(xdvi.bin) in auto mode
update-alternatives: using /usr/bin/bibtex.original to provide /usr/bin/bibtex
(bibtex) in auto mode
Setting up lmodern (2.004.5-6.1) ...
Setting up texlive-base (2021.20220204-1) ...
/usr/bin/ucfr
/usr/bin/ucfr
/usr/bin/ucfr
/usr/bin/ucfr

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mktexlsr: Updating /var/lib/texmf/ls-R-TEXLIVEDIST...
mktexlsr: Updating /var/lib/texmf/ls-R-TEXMFMAIN...
mktexlsr: Updating /var/lib/texmf/ls-R...
mktexlsr: Done.
tl-paper: setting paper size for dvips to a4:
/var/lib/texmf/dvips/config/config-paper.ps
tl-paper: setting paper size for dvipdfmx to a4:
/var/lib/texmf/dvipdfmx/dvipdfmx-paper.cfg
tl-paper: setting paper size for xdvi to a4: /var/lib/texmf/xdvi/XDvi-paper
tl-paper: setting paper size for pdftex to a4: /var/lib/texmf/tex/generic/tex-
ini-files/pdftexconfig.tex
Setting up tex-gyre (20180621-3.1) ...
Setting up texlive-plain-generic (2021.20220204-1) ...
Setting up texlive-latex-base (2021.20220204-1) ...
Setting up texlive-latex-recommended (2021.20220204-1) ...
Setting up texlive-pictures (2021.20220204-1) ...
Setting up texlive-fonts-recommended (2021.20220204-1) ...
Setting up tipa (2:1.3-21) ...
Setting up texlive-latex-extra (2021.20220204-1) ...
Setting up texlive-xetex (2021.20220204-1) ...
Setting up rake (13.0.6-2) ...
Setting up libruby3.0:amd64 (3.0.2-7ubuntu2.4) ...
Setting up ruby3.0 (3.0.2-7ubuntu2.4) ...
Setting up ruby (1:3.0~exp1) ...
Setting up ruby-rubygems (3.3.5-2) ...
Processing triggers for man-db (2.10.2-1) ...
Processing triggers for fontconfig (2.13.1-4.2ubuntu5) ...
Processing triggers for libc-bin (2.35-0ubuntu3.1) ...
Processing triggers for tex-common (6.17) ...
Running updmmap-sys. This may take some time... done.
Running mktexlsr /var/lib/texmf ... done.
Building format(s) --all.
    This may take some time... done.

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[ ]: !jupyter nbconvert --to latex YOUR_NOTEBOOK_NAME.ipynb
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