Assignment 5

November 1, 2022

[1]:

```
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
import seaborn as sns
import statsmodels.api as sm
import statsmodels.formula.api as smf
from scipy.stats import norm
from sklearn.preprocessing import PowerTransformer
from sklearn import metrics
from scipy.stats import skew, kurtosis
import pandas_profiling as pp
```

[2]:

```
df = pd.read_csv("HeartDisease.csv", index_col = "names")
```

[3]:

```
df.head()
```

[3]:

```
       sbp  tobacco   ldl  adiposity  famhist  typea  obesity  alcohol  age  \
names
1      160    12.00  5.73      23.11  Present     49    25.30    97.20   52
2      144     0.01  4.41      28.61   Absent     55    28.87     2.06   63
3      118     0.08  3.48      32.28  Present     52    29.14     3.81   46
4      170     7.50  6.41      38.03  Present     51    31.99    24.26   58
5      134    13.60  3.50      27.78  Present     60    25.99    57.34   49

       chd
names
1        1
2        1
3        0
4        1
5        1
```

[4]:

```
df.iloc[:,:8].describe()
```

[4]:

```
              sbp     tobacco         ldl   adiposity       typea     obesity  \
count  462.000000  462.000000  462.000000  462.000000  462.000000  462.000000
mean   138.326840    3.635649    4.740325   25.406732   53.103896   26.044113
```

```
std     20.496317   4.593024   2.070909   7.780699   9.817534   4.213680
min    101.000000   0.000000   0.980000   6.740000  13.000000  14.700000
25%    124.000000   0.052500   3.282500  19.775000  47.000000  22.985000
50%    134.000000   2.000000   4.340000  26.115000  53.000000  25.805000
75%    148.000000   5.500000   5.790000  31.227500  60.000000  28.497500
max    218.000000  31.200000  15.330000  42.490000  78.000000  46.580000

          alcohol
count  462.000000
mean    17.044394
std     24.481059
min      0.000000
25%      0.510000
50%      7.510000
75%     23.892500
max    147.190000
```

[5]:
```python
df.skew()
```

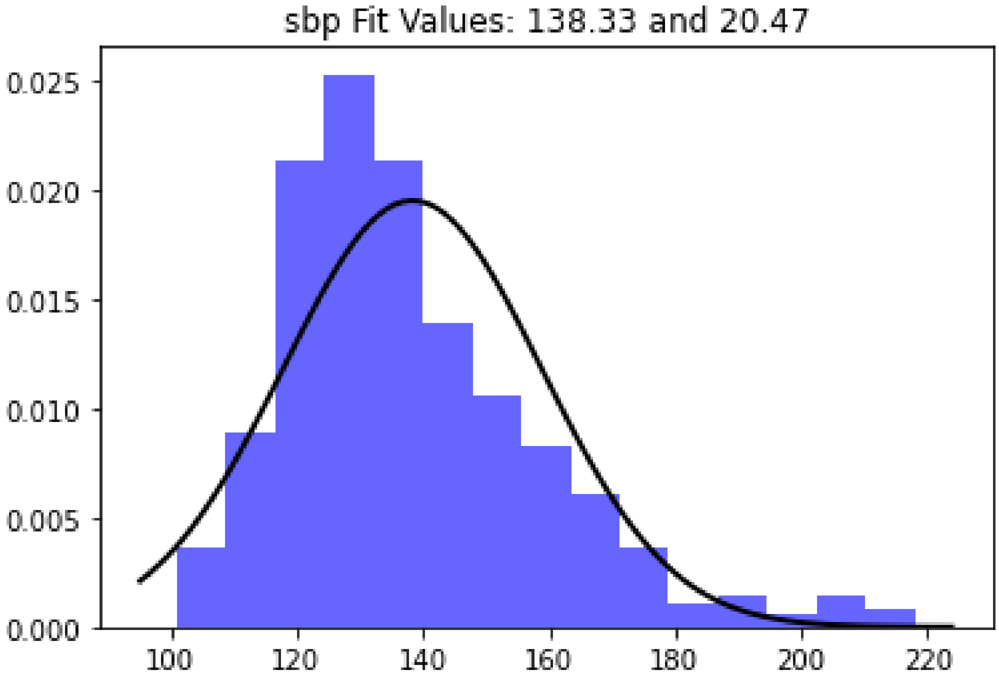
```
C:\Users\matth\AppData\Local\Temp/ipykernel_23600/1665899112.py:1:
FutureWarning: Dropping of nuisance columns in DataFrame reductions (with
'numeric_only=None') is deprecated; in a future version this will raise
TypeError.  Select only valid columns before calling the reduction.
  df.skew()
```

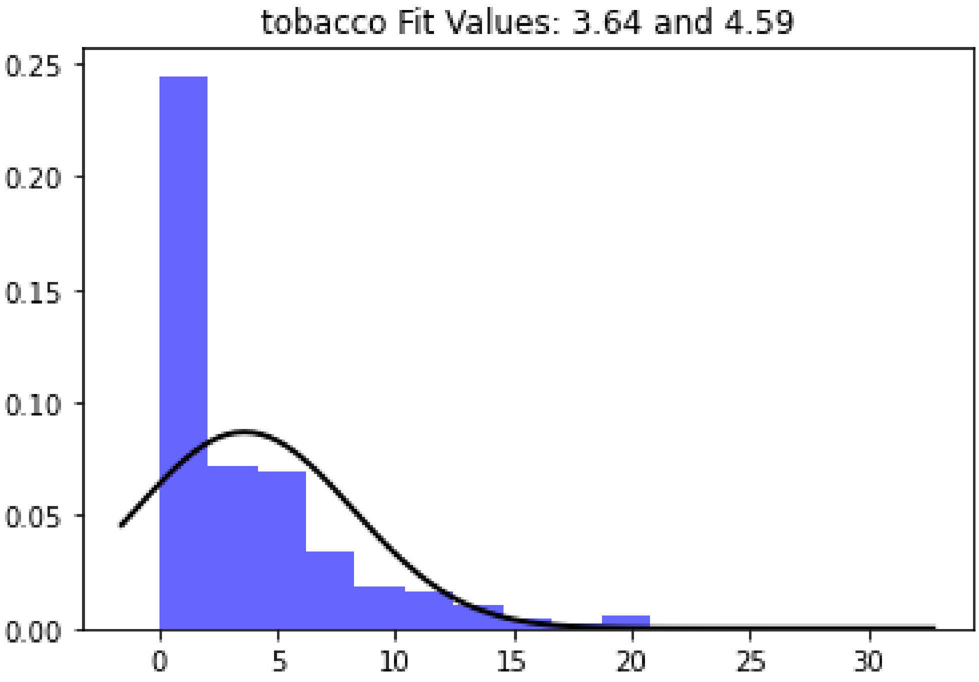
[5]:
```
sbp          1.180591
tobacco      2.079210
ldl          1.313104
adiposity   -0.214646
typea       -0.346438
obesity      0.905219
alcohol      2.312699
age         -0.381734
chd          0.648095
dtype: float64
```

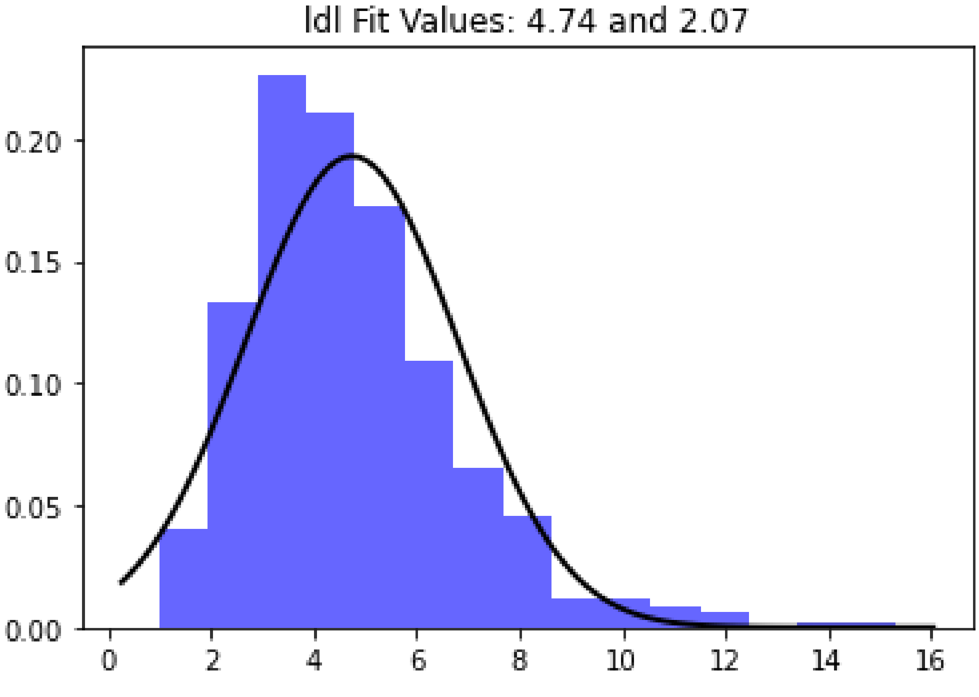
[6]:
```python
eda = pp.ProfileReport(df)
eda.to_file("HeartDisease_Report.html")
```

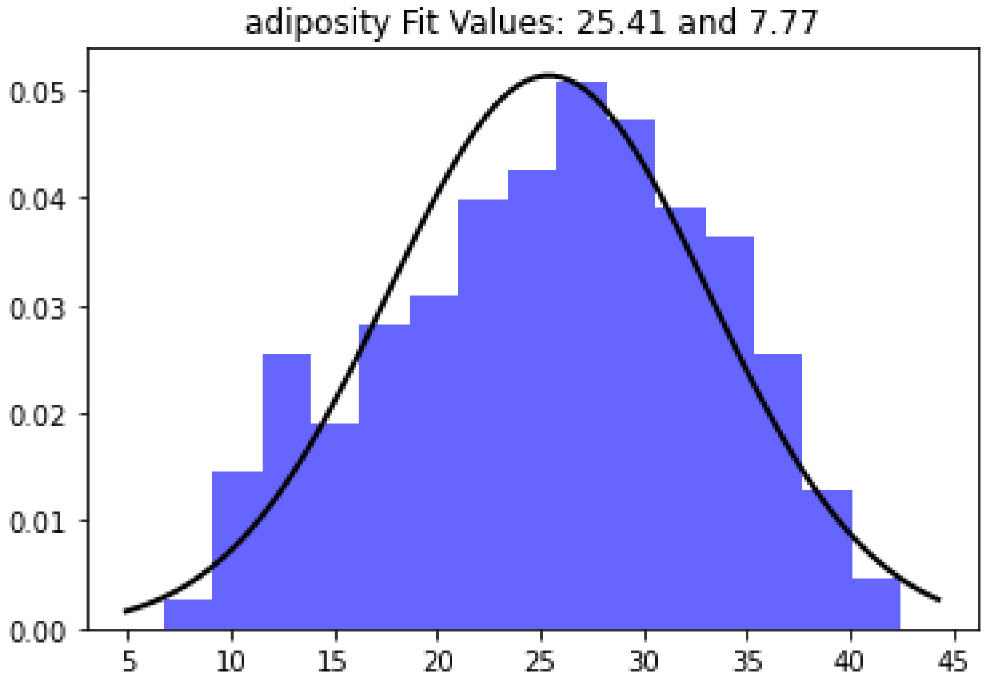
```
Summarize dataset:   0%|          | 0/5 [00:00<?, ?it/s]

Generate report structure:   0%|          | 0/1 [00:00<?, ?it/s]

Render HTML:   0%|          | 0/1 [00:00<?, ?it/s]

Export report to file:   0%|          | 0/1 [00:00<?, ?it/s]
```

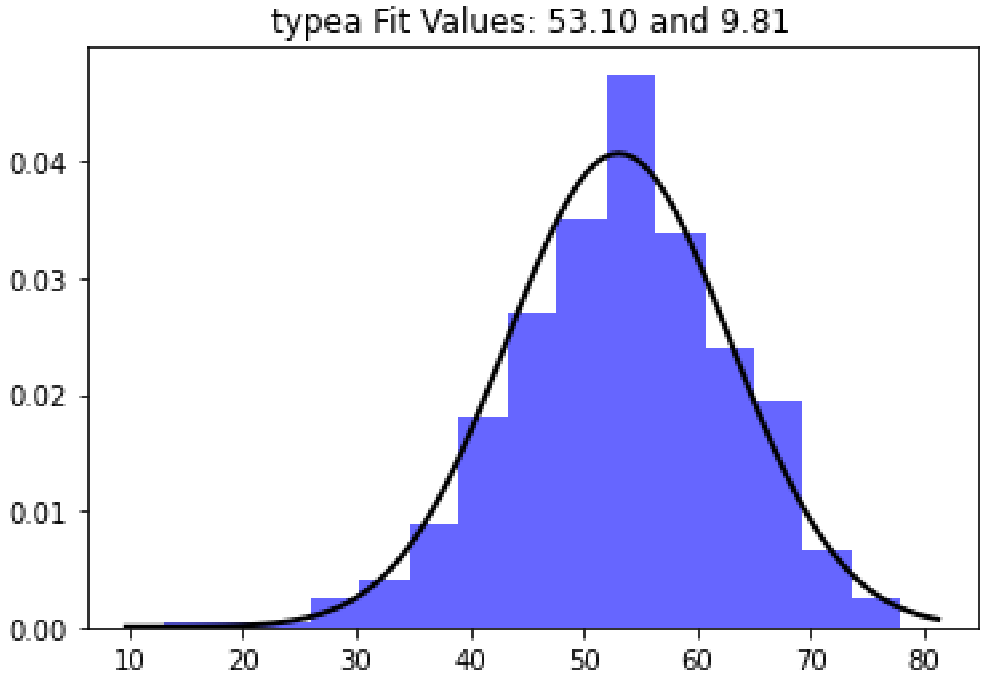
[7]:
```python
for feature in df.select_dtypes(include=np.number).iloc[:,:8]:
    mu, std = norm.fit(df[feature])
    plt.hist(df[feature], bins=15, density=True, alpha=0.6, color='b')

    xmin, xmax = plt.xlim()
    x = np.linspace(xmin, xmax, 100)
    p = norm.pdf(x, mu, std)

    plt.plot(x, p, 'k', linewidth=2)
    title = feature + " Fit Values: {:.2f} and {:.2f}".format(mu, std)
    plt.title(title)
    plt.savefig(feature +" histogram.jpg", dpi = 600)
    plt.show()
print("Saving complete!")
```

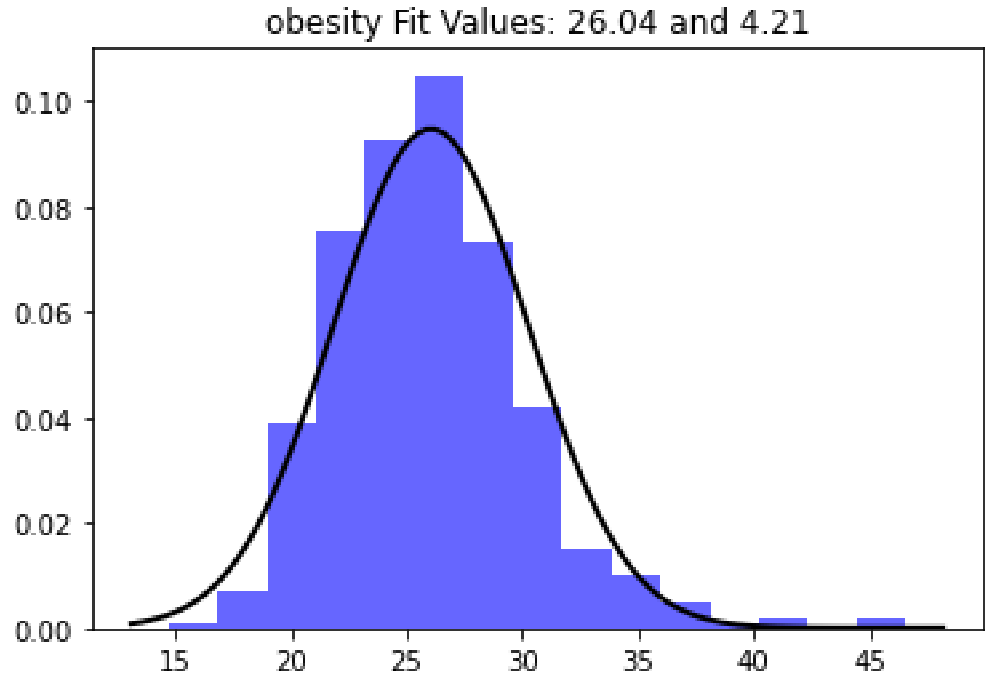


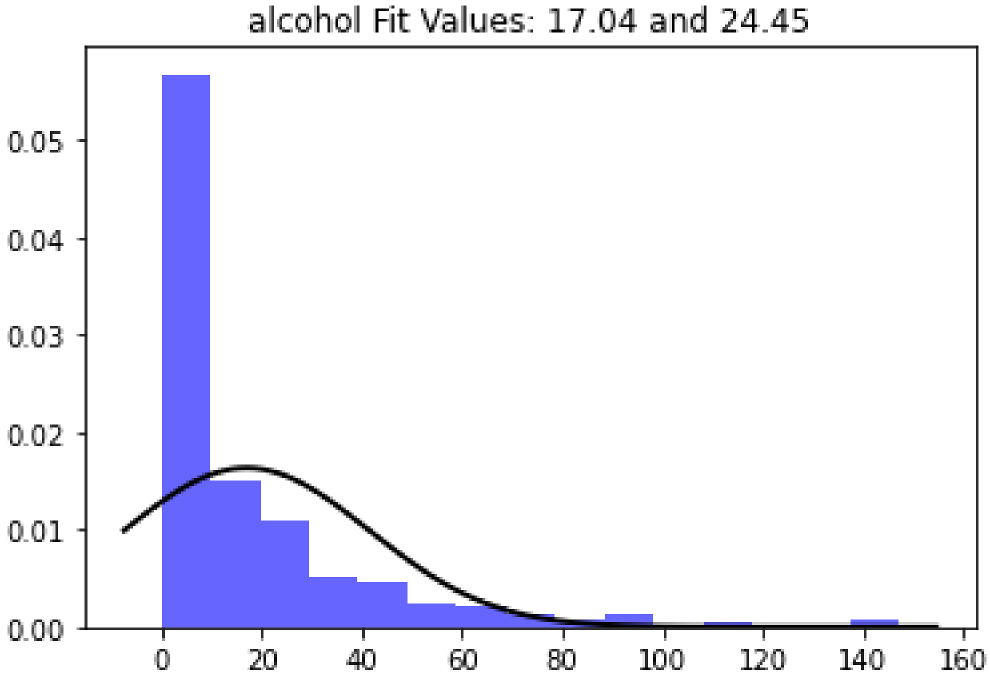

tobacco Fit Values: 3.64 and 4.59
0.25
0.20
0.15
0.10
0.05
0.00
0
5
10
15
20
25
30

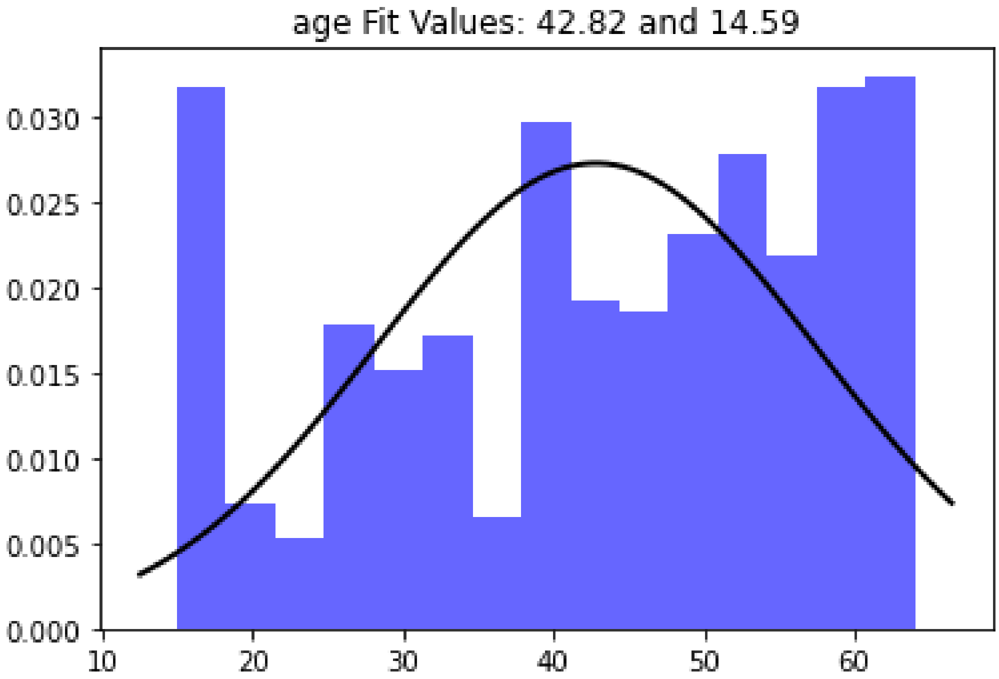

ldl Fit Values: 4.74 and 2.07
0.20
0.15
0.10
0.05
0.00
0
2
4
6
8
10
12
14
16


adiposity Fit Values: 25.41 and 7.77
0.05
0.04
0.03
0.02
0.01
0.00
5
10
15
20
25
30
35
40
45


typea Fit Values: 53.10 and 9.81
0.04
0.03
0.02
0.01
0.00
10
20
30
40
50
60
70
80

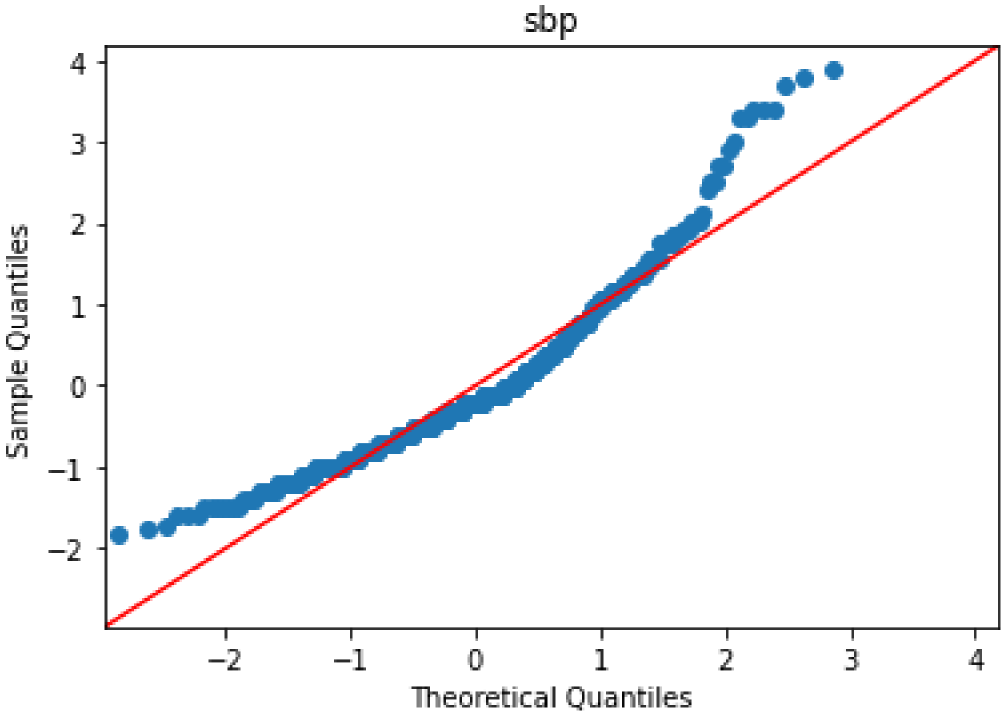

obesity Fit Values: 26.04 and 4.21
0.10
0.08
0.06
0.04
0.02
0.00
15
20
25
30
35
40
45

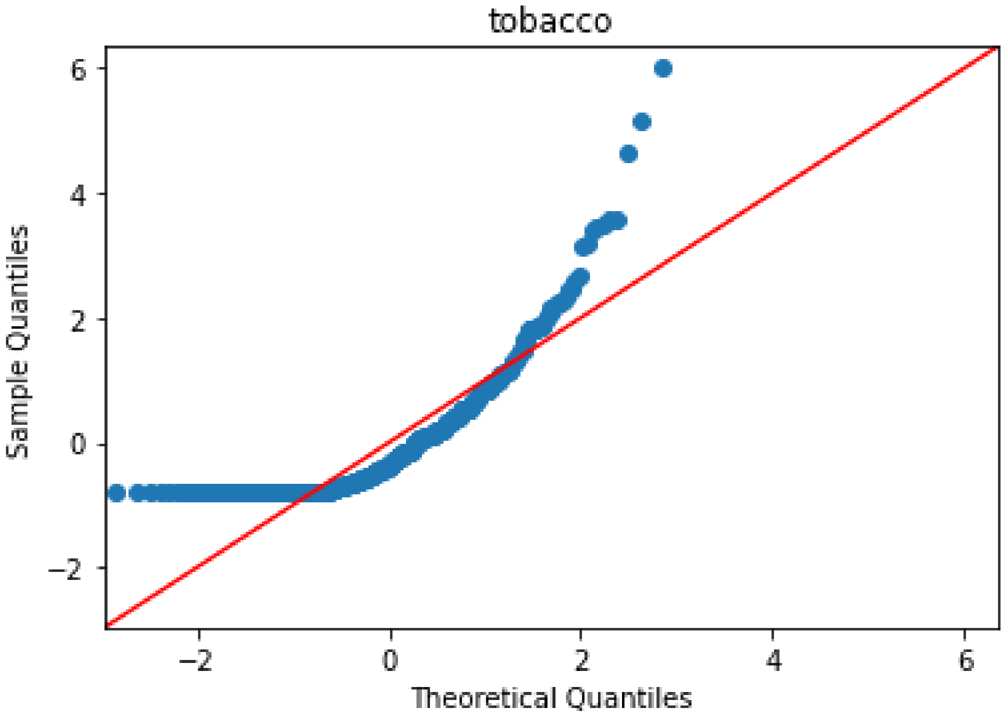

alcohol Fit Values: 17.04 and 24.45
0.05
0.04
0.03
0.02
0.01
0.00
0
20
40
60
80
100
120
140
160

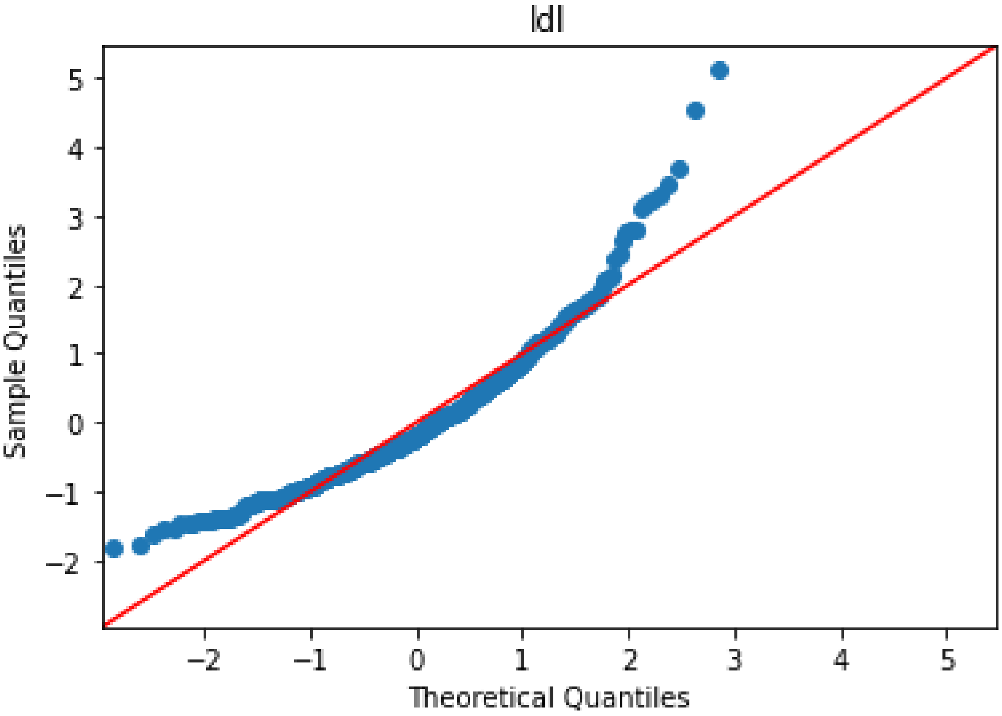


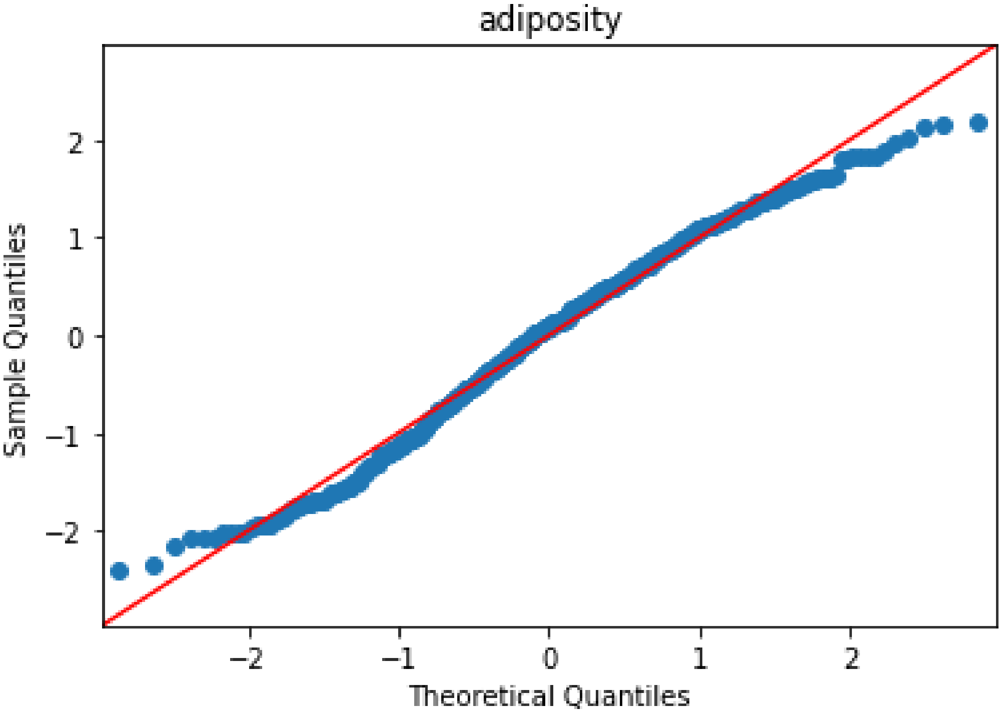
```
Saving complete!
```

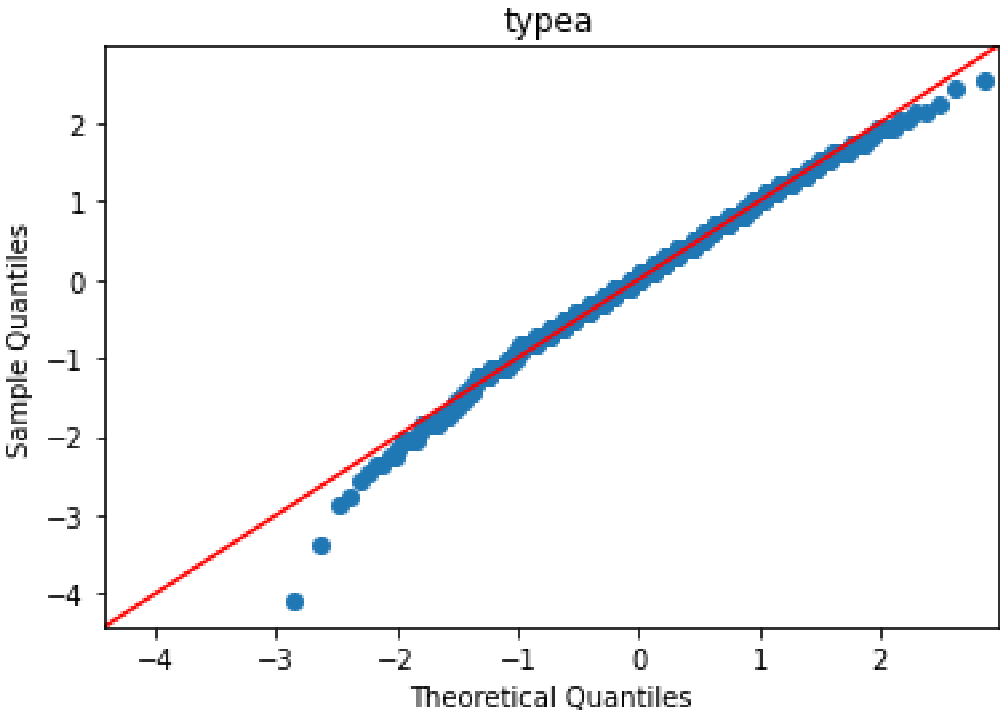
[8]:
```
for feature in df.select_dtypes(include=np.number).iloc[:,:8]:
    sm.qqplot(df[feature], line = "45", fit = True)
    title = feature
    plt.title(title)
    plt.savefig(feature +" qqplot.jpg", dpi = 600)
    plt.show()
```

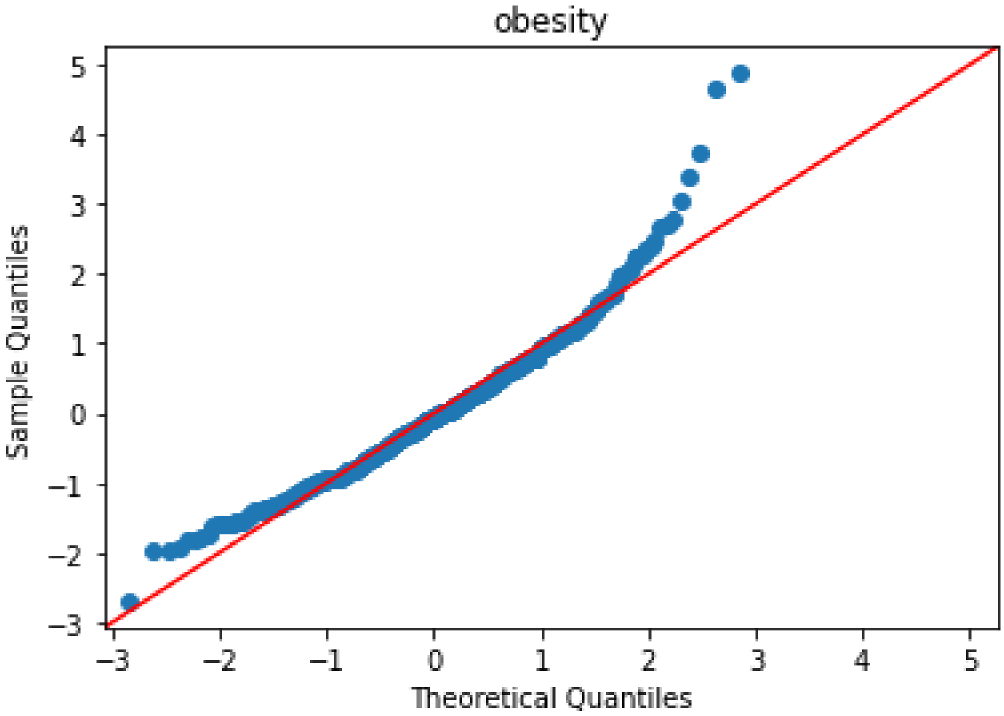

sbp
Sample Quantiles
Theoretical Quantiles
4
3
2
1
0
−1
−2
−2
−1
0
1
2
3
4

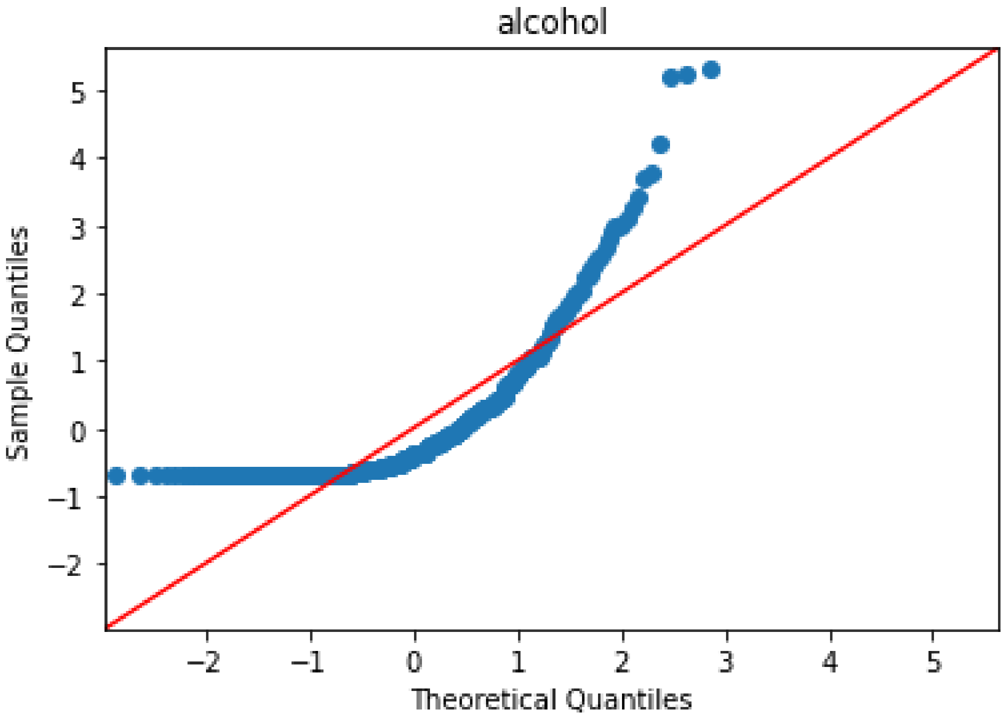

tobacco
Sample Quantiles
Theoretical Quantiles
6
4
2
0
−2
−2
0
2
4
6

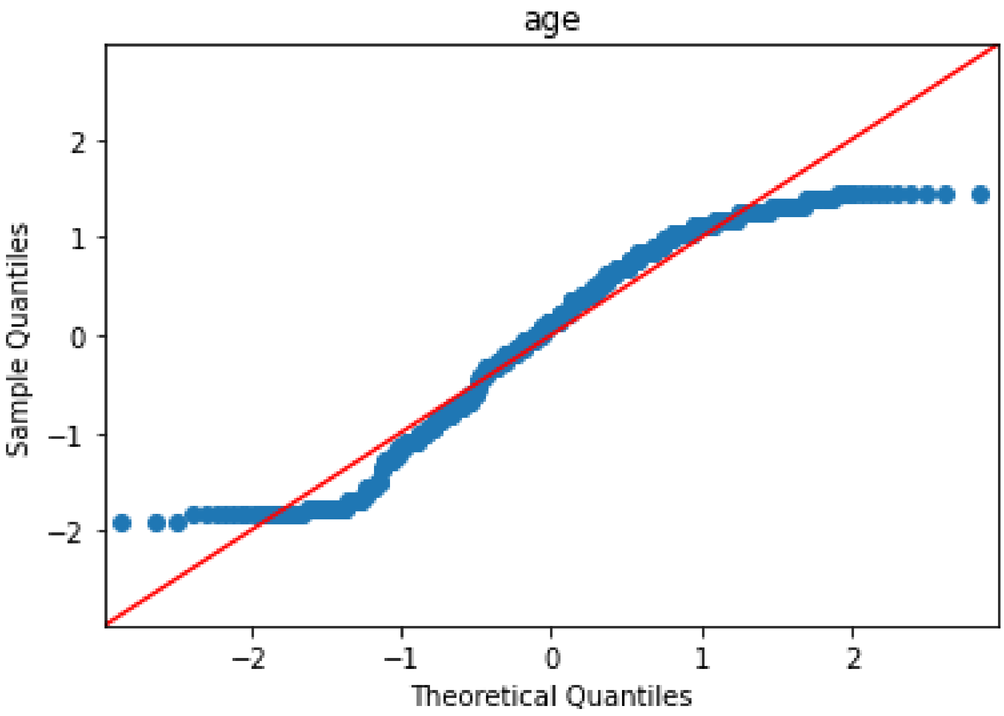

ldl
Sample Quantiles
5
4
3
2
1
0
−1
−2
Theoretical Quantiles
−2
−1
0
1
2
3
4
5


adiposity
Sample Quantiles
2
1
0
−1
−2
Theoretical Quantiles
−2
−1
0
1
2


typea
Sample Quantiles
Theoretical Quantiles
2
1
0
−1
−2
−3
−4
−4
−3
−2
−1
0
1
2


obesity
Sample Quantiles
Theoretical Quantiles
5
4
3
2
1
0
−1
−2
−3
−3
−2
−1
0
1
2
3
4
5


alcohol
Sample Quantiles
5
4
3
2
1
0
−1
−2
−2
−1
0
1
2
3
4
5
Theoretical Quantiles


age
Sample Quantiles
2
1
0
−1
−2
−2
−1
0
1
2
Theoretical Quantiles

```
[9]: df_model = pd.get_dummies(df, prefix=['famhist'])
     df_model.head()
```

```
[9]:        sbp  tobacco   ldl  adiposity  typea  obesity  alcohol  age  chd  \
     names
     1      160    12.00  5.73      23.11     49    25.30    97.20   52    1
     2      144     0.01  4.41      28.61     55    28.87     2.06   63    1
     3      118     0.08  3.48      32.28     52    29.14     3.81   46    0
     4      170     7.50  6.41      38.03     51    31.99    24.26   58    1
     5      134    13.60  3.50      27.78     60    25.99    57.34   49    1

            famhist_Absent  famhist_Present
     names
     1                   0                1
     2                   1                0
     3                   0                1
     4                   0                1
     5                   0                1
```

```
[10]: X = df_model.drop(columns = "chd")
      y = df_model["chd"]
```

```
[11]: formula = "chd ~ sbp + tobacco + ldl + adiposity + typea + obesity + alcohol +␣
       ↪age + famhist_Absent + famhist_Present"

      log_reg = smf.glm(formula = formula, data=df_model, family=sm.families.
       ↪Binomial()).fit()

      log_reg.summary()
```

```
[11]: <class 'statsmodels.iolib.summary.Summary'>
      """
                       Generalized Linear Model Regression Results
      ==============================================================================
      Dep. Variable:                    chd   No. Observations:                  462
      Model:                            GLM   Df Residuals:                      452
      Model Family:                Binomial   Df Model:                            9
      Link Function:                  Logit   Scale:                          1.0000
      Method:                          IRLS   Log-Likelihood:                -236.07
      Date:                Tue, 01 Nov 2022   Deviance:                       472.14
      Time:                        16:24:22   Pearson chi2:                     452.
      No. Iterations:                     5   Pseudo R-squ. (CS):             0.2353
      Covariance Type:            nonrobust
      ================================================================================
      ===
                            coef    std err          z      P>|z|      [0.025
      0.975]
```

```
--------------------------------------------------------------------------------
---
Intercept         -3.7920      0.871     -4.353      0.000      -5.500
-2.084
sbp                0.0065      0.006      1.135      0.256      -0.005
0.018
tobacco            0.0794      0.027      2.984      0.003       0.027
0.132
ldl                0.1739      0.060      2.915      0.004       0.057
0.291
adiposity          0.0186      0.029      0.635      0.526      -0.039
0.076
typea              0.0396      0.012      3.214      0.001       0.015
0.064
obesity           -0.0629      0.044     -1.422      0.155      -0.150
0.024
alcohol            0.0001      0.004      0.027      0.978      -0.009
0.009
age                0.0452      0.012      3.728      0.000       0.021
0.069
famhist_Absent    -2.3587      0.447     -5.279      0.000      -3.234
-1.483
famhist_Present   -1.4333      0.454     -3.159      0.002      -2.323
-0.544
================================================================================
===
"""
```

[12]:

```
df_transform = df.copy()
df_transform["sbp"] = np.power(df["sbp"], -2.0)
df_transform["tobacco"] = np.power(df["tobacco"], 0.4)
df_transform["ldl"] = np.power(df["ldl"], 0.1)
df_transform["obesity"] = np.power(df["obesity"], -0.4)
df_transform["alcohol"] = np.power(df["alcohol"], 0.4)
```

[13]:

```
df_transform.head()
```

[13]:

```
            sbp   tobacco       ldl  adiposity  famhist  typea   obesity  \
names
1      0.000039  2.701920  1.190736      23.11  Present     49  0.274632
2      0.000048  0.158489  1.159962      28.61   Absent     55  0.260508
3      0.000072  0.364113  1.132812      32.28  Present     52  0.259540
4      0.000035  2.238847  1.204164      38.03  Present     51  0.250031
5      0.000056  2.840636  1.133462      27.78  Present     60  0.271692

        alcohol  age  chd
names
```

```
1       6.238304    52    1
2       1.335202    63    1
3       1.707536    46    0
4       3.580604    58    1
5       5.051066    49    1
```

[14]:
```
df_transform.iloc[:,:8].describe()
```

[14]:
```
              sbp     tobacco         ldl   adiposity       typea     obesity  \
count  462.000000  462.000000  462.000000  462.000000  462.000000  462.000000
mean     0.000055    1.260970    1.159087   25.406732   53.103896    0.273360
std      0.000014    0.942649    0.049116    7.780699    9.817534    0.017073
min      0.000021    0.000000    0.997982    6.740000   13.000000    0.215140
25%      0.000046    0.307415    1.126213   19.775000   47.000000    0.261865
50%      0.000056    1.319508    1.158108   26.115000   53.000000    0.272470
75%      0.000065    1.977630    1.191976   31.227500   60.000000    0.285380
max      0.000098    3.959696    1.313876   42.490000   78.000000    0.341250

          alcohol
count  462.000000
mean     2.263569
std      1.799918
min      0.000000
25%      0.763885
50%      2.239993
75%      3.558795
max      7.364637
```

[15]:
```
df_transform.skew()
```

```
C:\Users\matth\AppData\Local\Temp/ipykernel_23600/2581206598.py:1:
FutureWarning: Dropping of nuisance columns in DataFrame reductions (with
'numeric_only=None') is deprecated; in a future version this will raise
TypeError.  Select only valid columns before calling the reduction.
  df_transform.skew()
```

[15]:
```
sbp          0.063304
tobacco      0.134728
ldl          0.028745
adiposity   -0.214646
typea       -0.346438
obesity     -0.000273
alcohol      0.400945
age         -0.381734
chd          0.648095
dtype: float64
```

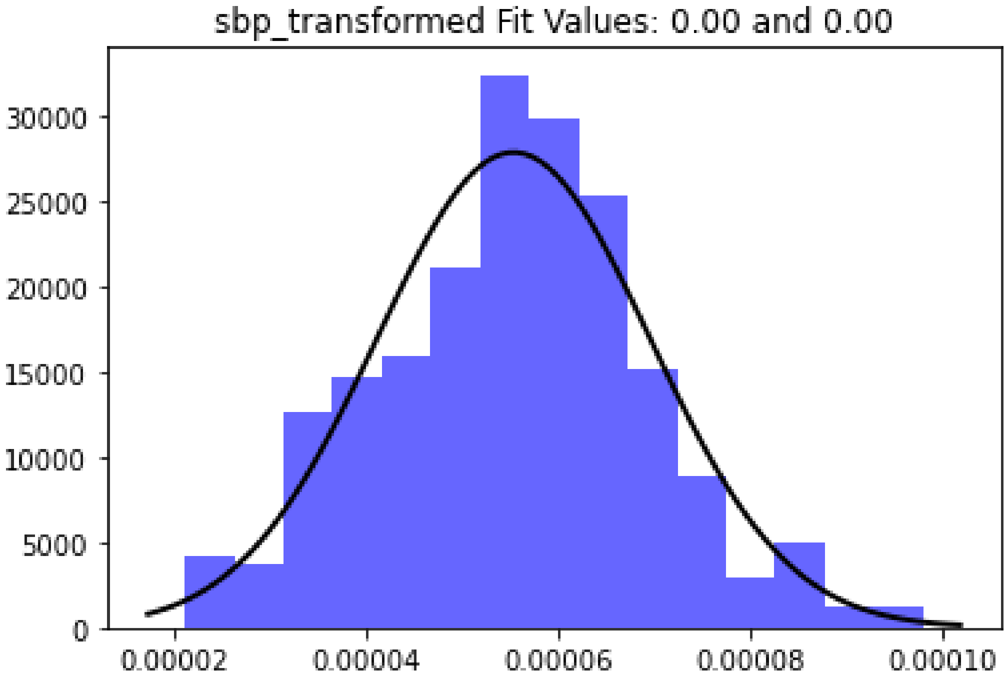
[16]:

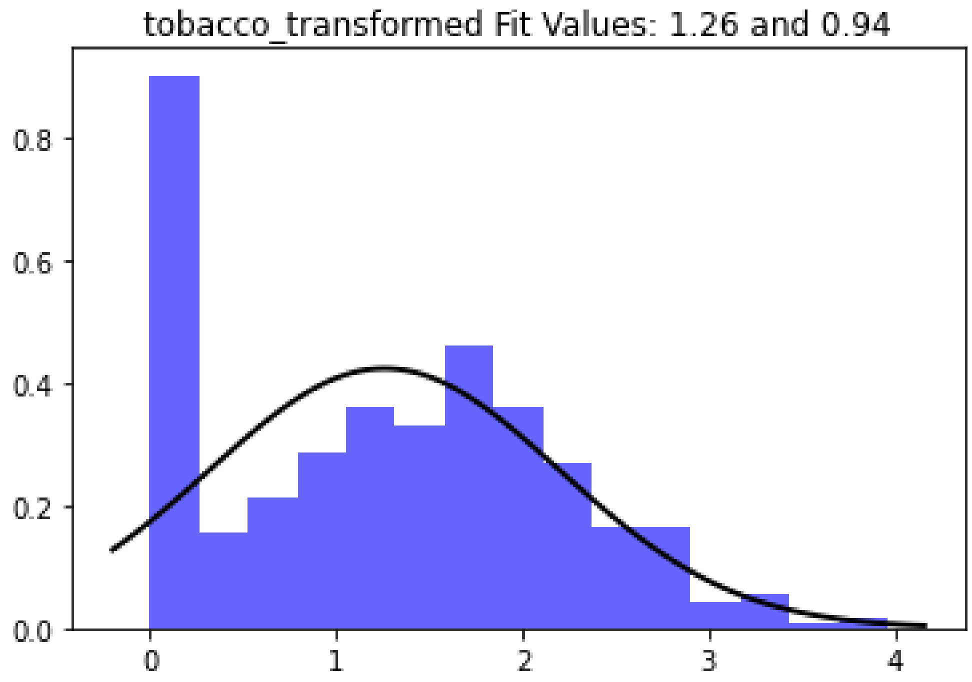
```
eda = pp.ProfileReport(df_transform)
eda.to_file("HeartDisease_transformed_Report.html")
```

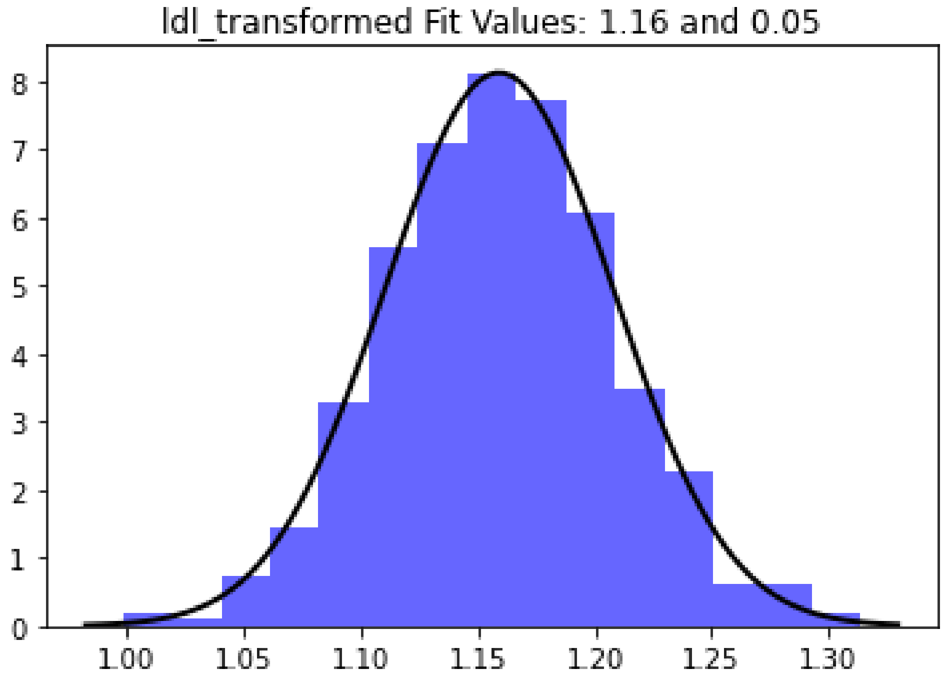
```
Summarize dataset:   0%|          | 0/5 [00:00<?, ?it/s]

Generate report structure:   0%|          | 0/1 [00:00<?, ?it/s]

Render HTML:   0%|          | 0/1 [00:00<?, ?it/s]

Export report to file:   0%|          | 0/1 [00:00<?, ?it/s]
```

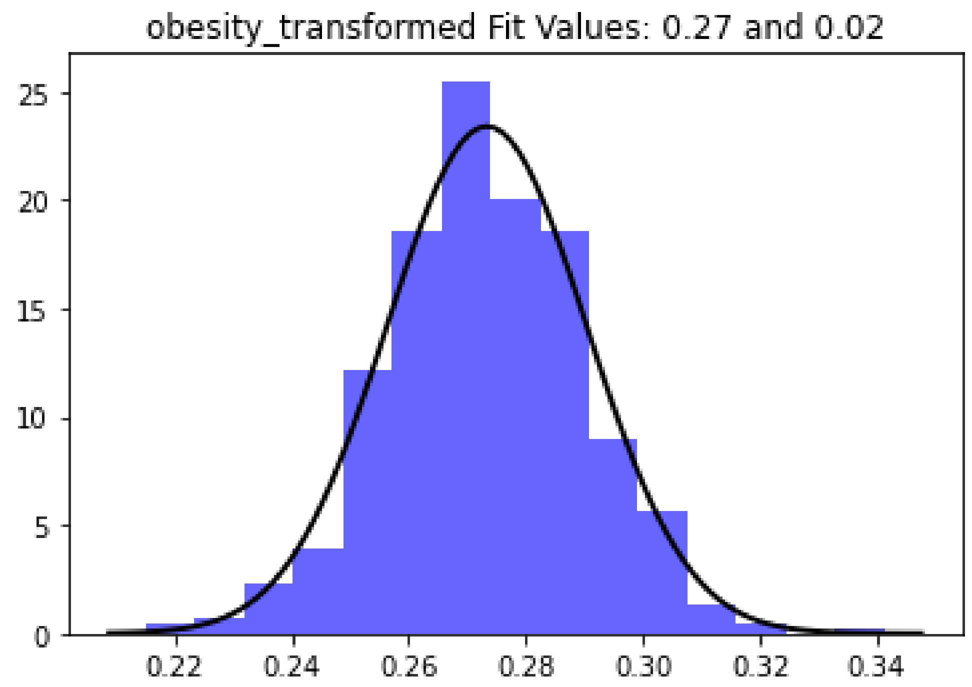
[17]:

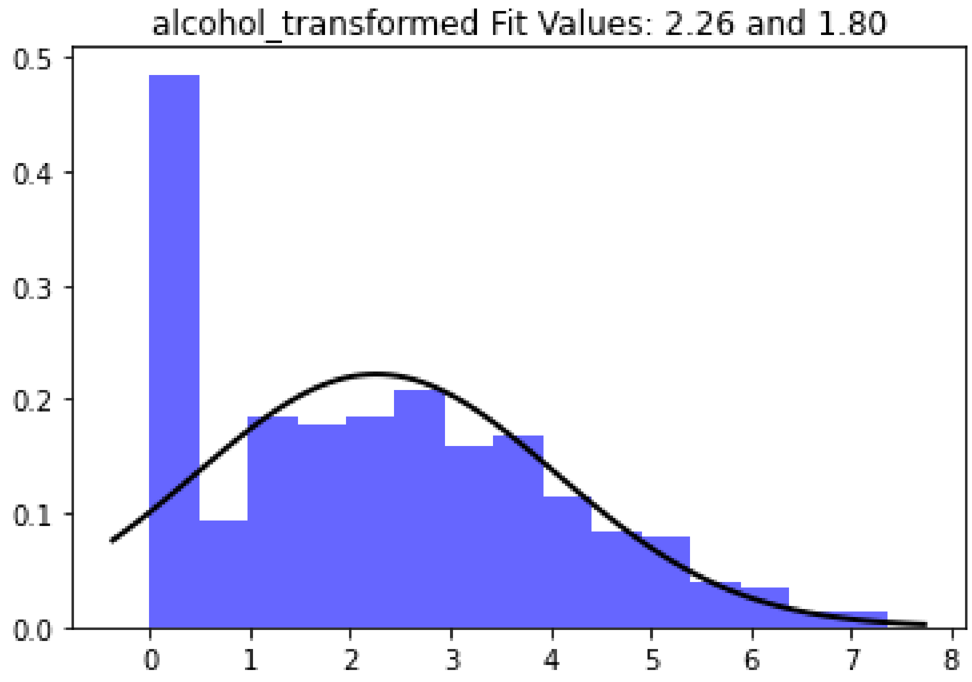
```
feature_list = ["sbp", "tobacco", "ldl", "obesity", "alcohol"]
for feature in feature_list:
    mu, std = norm.fit(df_transform[feature])

    plt.hist(df_transform[feature], bins=15, density=True, alpha=0.6, color='b')

    xmin, xmax = plt.xlim()
    x = np.linspace(xmin, xmax, 100)
    p = norm.pdf(x, mu, std)

    plt.plot(x, p, 'k', linewidth=2)
    title = feature + "_transformed Fit Values: {:.2f} and {:.2f}".format(mu,␣
 ↪std)
    plt.title(title)
    plt.savefig(feature +"_transformed histogram.jpg", dpi = 600)
    plt.show()
print("Saving complete!")
```




tobacco_transformed Fit Values: 1.26 and 0.94
0.0
0.2
0.4
0.6
0.8
0
1
2
3
4

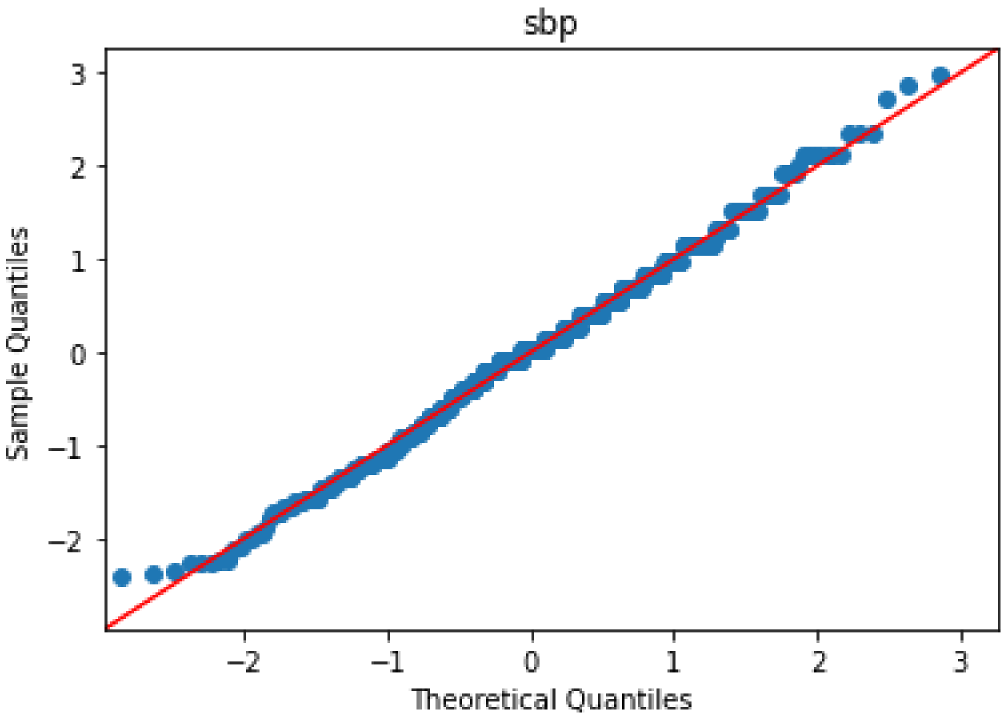

ldl_transformed Fit Values: 1.16 and 0.05
0
1
2
3
4
5
6
7
8
1.00
1.05
1.10
1.15
1.20
1.25
1.30

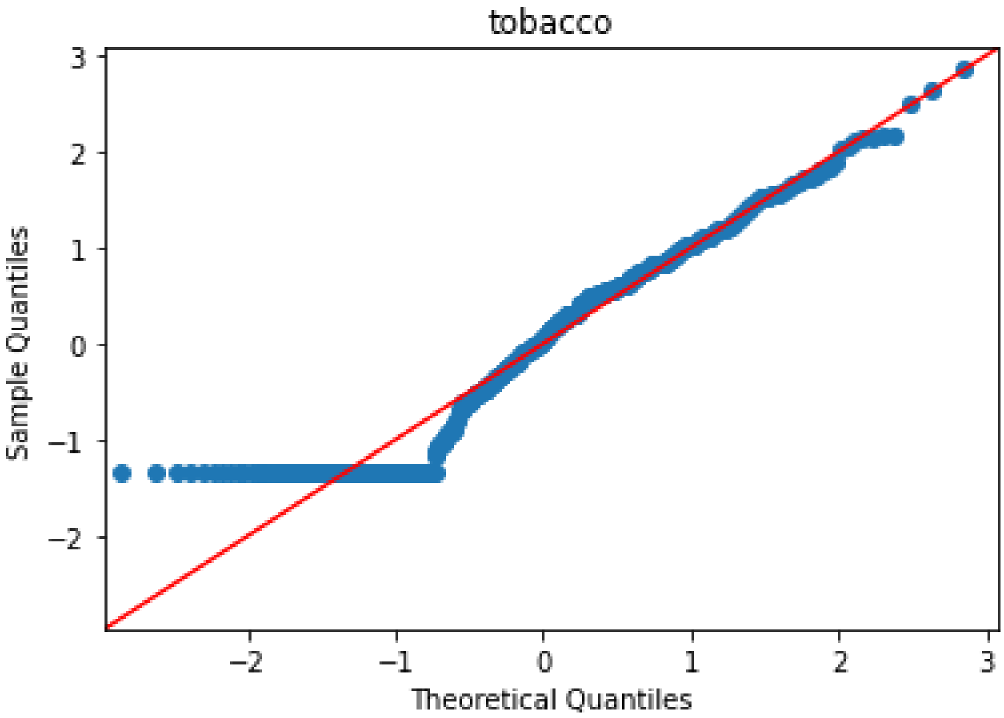


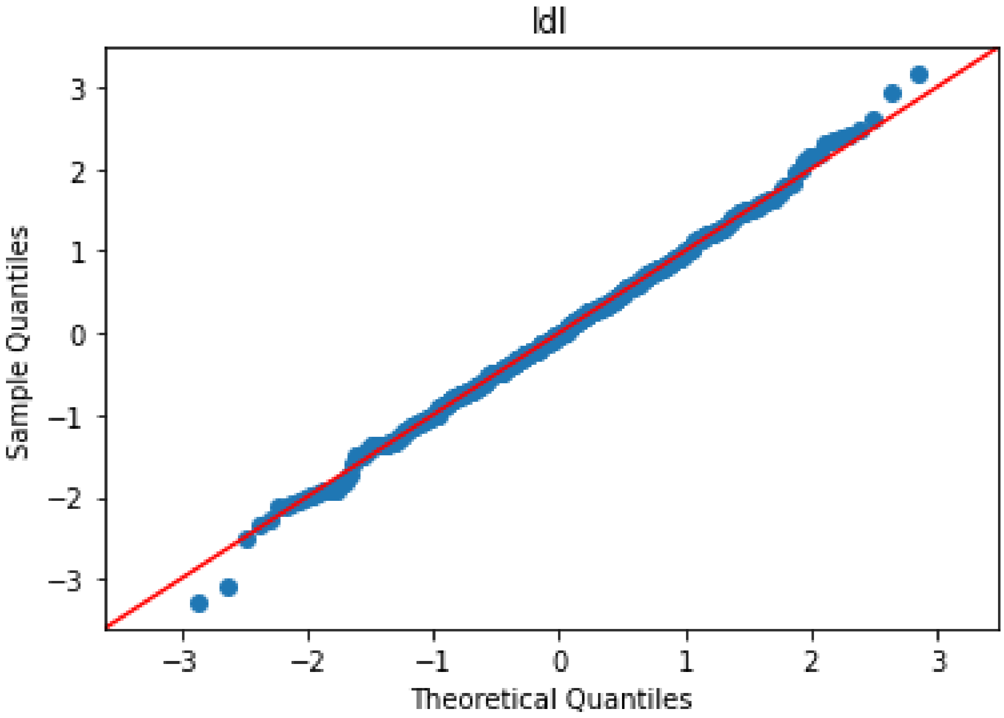


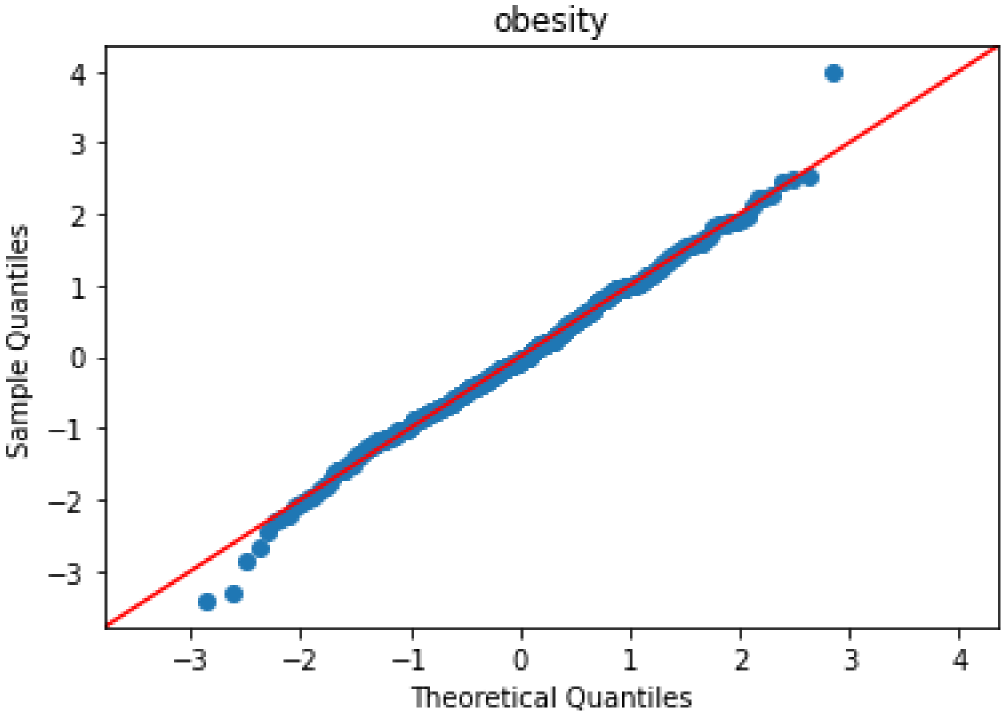
```
Saving complete!
```

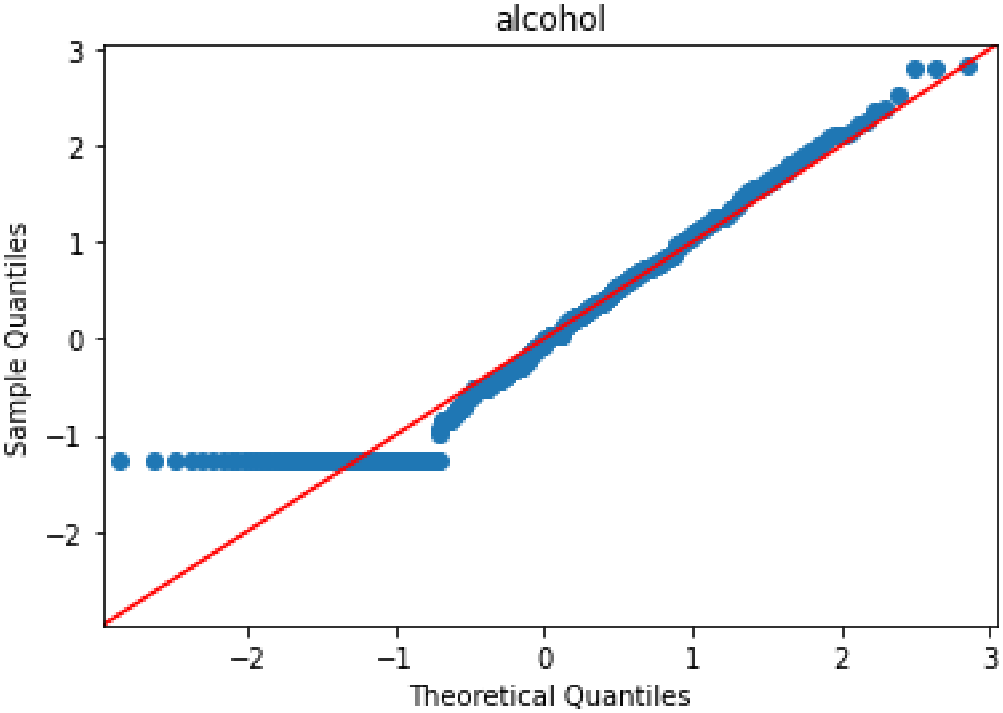
```
[18]: for feature in feature_list:
          sm.qqplot(df_transform[feature], line = "45", fit = True)
          title = feature
          plt.title(title)
          plt.savefig(feature +"_transformed qqplot.jpg", dpi = 600)
          plt.show()
```




tobacco
Sample Quantiles
Theoretical Quantiles
3
2
1
0
−1
−2
−2
−1
0
1
2
3


ldl
Sample Quantiles
Theoretical Quantiles
3
2
1
0
−1
−2
−3
−3
−2
−1
0
1
2
3


obesity
Sample Quantiles
Theoretical Quantiles
4
3
2
1
0
−1
−2
−3
−3
−2
−1
0
1
2
3
4


alcohol
Sample Quantiles
Theoretical Quantiles
3
2
1
0
−1
−2
−2
−1
0
1
2
3

[19]:
```
df_model = pd.get_dummies(df_transform, prefix=['famhist'])
df_model.head()
```

[19]:
```
            sbp   tobacco       ldl  adiposity  typea   obesity   alcohol  \
names
1      0.000039  2.701920  1.190736      23.11     49  0.274632  6.238304
2      0.000048  0.158489  1.159962      28.61     55  0.260508  1.335202
3      0.000072  0.364113  1.132812      32.28     52  0.259540  1.707536
4      0.000035  2.238847  1.204164      38.03     51  0.250031  3.580604
5      0.000056  2.840636  1.133462      27.78     60  0.271692  5.051066

       age  chd  famhist_Absent  famhist_Present
names
1       52    1               0                1
2       63    1               1                0
3       46    0               0                1
4       58    1               0                1
5       49    1               0                1
```

[20]:
```
X_transform = df_model.drop(columns = "chd")
```

[21]:
```
formula = "chd ~ sbp + tobacco + ldl + adiposity + typea + obesity + alcohol +␣
 ↪age + famhist_Absent + famhist_Present"

log_full = smf.glm(formula = formula, data=df_model, family=sm.families.
 ↪Binomial()).fit()
log_full.summary()
```

[21]:
```
<class 'statsmodels.iolib.summary.Summary'>
"""
                 Generalized Linear Model Regression Results
==============================================================================
Dep. Variable:                    chd   No. Observations:                  462
Model:                            GLM   Df Residuals:                      452
Model Family:                Binomial   Df Model:                            9
Link Function:                  Logit   Scale:                          1.0000
Method:                          IRLS   Log-Likelihood:                -234.97
Date:                Tue, 01 Nov 2022   Deviance:                       469.95
Time:                        16:24:57   Pearson chi2:                     450.
No. Iterations:                     5   Pseudo R-squ. (CS):             0.2390
Covariance Type:            nonrobust
================================================================================
===
                      coef    std err          z      P>|z|      [0.025
0.975]
--------------------------------------------------------------------------------
---
```

```
Intercept          -13.9631      3.352     -4.165      0.000     -20.534
-7.392
sbp              -4800.4981   8559.784     -0.561      0.575   -2.16e+04
1.2e+04
tobacco             0.4414      0.141      3.124      0.002       0.164
0.718
ldl                 7.6975      2.717      2.833      0.005       2.372
13.023
adiposity           0.0345      0.030      1.145      0.252      -0.025
0.094
typea               0.0392      0.012      3.193      0.001       0.015
0.063
obesity            22.4078     11.475      1.953      0.051      -0.082
44.898
alcohol             0.0012      0.065      0.019      0.985      -0.126
0.128
age                 0.0422      0.012      3.397      0.001       0.018
0.067
famhist_Absent     -7.4285      1.681     -4.420      0.000     -10.722
-4.135
famhist_Present    -6.5346      1.680     -3.891      0.000      -9.826
-3.243
================================================================================
===
"""
```

```
[22]: formula = "chd ~ tobacco + ldl + typea + age + famhist_Absent + famhist_Present"

      log_reduced = smf.glm(formula = formula, data=df_model, family=sm.families.
       ↪Binomial()).fit()

      log_reduced.summary()
```

```
[22]: <class 'statsmodels.iolib.summary.Summary'>
      """
                       Generalized Linear Model Regression Results
      ==============================================================================
      Dep. Variable:                    chd   No. Observations:                  462
      Model:                            GLM   Df Residuals:                      456
      Model Family:                Binomial   Df Model:                            5
      Link Function:                  Logit   Scale:                          1.0000
      Method:                          IRLS   Log-Likelihood:                -237.21
      Date:                Tue, 01 Nov 2022   Deviance:                       474.43
      Time:                        16:24:57   Pearson chi2:                     464.
      No. Iterations:                     5   Pseudo R-squ. (CS):             0.2316
      Covariance Type:            nonrobust
      ================================================================================
===
                      coef    std err          z      P>|z|      [0.025
0.975]
--------------------------------------------------------------------------------
---
Intercept          -8.9966      1.962     -4.585      0.000     -12.842
-5.151
tobacco             0.4430      0.135      3.283      0.001       0.179
0.708
ldl                 6.9682      2.465      2.826      0.005       2.136
11.800
typea               0.0366      0.012      3.010      0.003       0.013
0.060
age                 0.0486      0.010      4.657      0.000       0.028
0.069
famhist_Absent     -4.9365      0.981     -5.030      0.000      -6.860
-3.013
famhist_Present    -4.0601      0.994     -4.086      0.000      -6.007
-2.113
================================================================================
===
"""
```

[23]:

```
X_transform_reduce = df_model.drop(columns = ["chd", "sbp", "adiposity",␣
 ↪"obesity", "alcohol"])
```

[24]:

```
y1 = log_reg.predict(X)
y2 = log_full.predict(X_transform)
y3 = log_reduced.predict(X_transform_reduce)
```

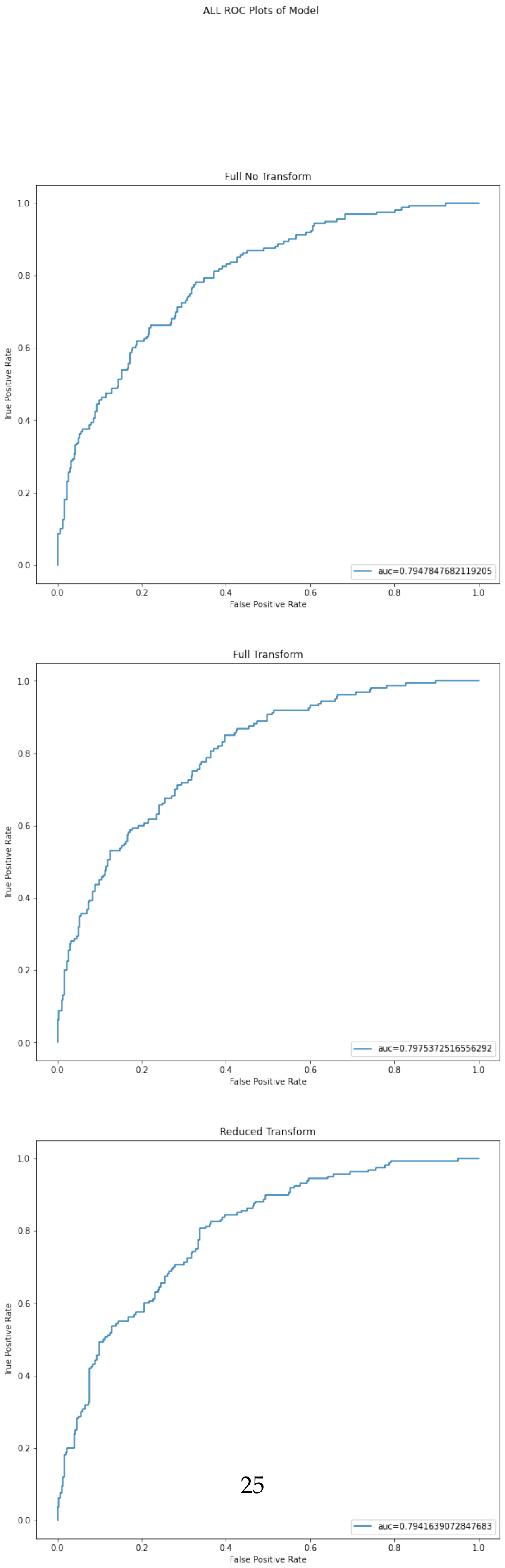
[25]:

```
fpr1, tpr1, _ = metrics.roc_curve(y,  y1)
fpr2, tpr2, _ = metrics.roc_curve(y,  y2)
fpr3, tpr3, _ = metrics.roc_curve(y,  y3)
auc1 = metrics.auc(fpr1, tpr1)
auc2 = metrics.auc(fpr2, tpr2)
auc3 = metrics.auc(fpr3, tpr3)
```

[26]:

```
fig, axs = plt.subplots(3, figsize=(10, 30))
fig.suptitle('ALL ROC Plots of Model')
axs[0].plot(fpr1,tpr1,label="auc="+str(auc1))
axs[0].set_title('Full No Transform')

axs[1].plot(fpr2,tpr2,label="auc="+str(auc2))
axs[1].set_title('Full Transform')

axs[2].plot(fpr3,tpr3,label="auc="+str(auc3))
axs[2].set_title('Reduced Transform')
```

```
for ax in axs.flat:
    ax.set(xlabel='False Positive Rate', ylabel='True Positive Rate')
    ax.legend(loc=4)
plt.savefig("AUC Curves.jpg", dpi = 600)
plt.show()
```


ALL ROC Plots of Model
Full No Transform
True Positive Rate
False Positive Rate
0.0
0.2
0.4
0.6
0.8
1.0
auc=0.7947847682119205
Full Transform
True Positive Rate
False Positive Rate
0.0
0.2
0.4
0.6
0.8
1.0
auc=0.7975372516556292
Reduced Transform
True Positive Rate
False Positive Rate
0.0
0.2
0.4
0.6
0.8
1.0
auc=0.7941639072847683