```
###Comparison of multiple distributions
#1. Descriptive Analysis
#2.Analysis of Variance
#3.Multiple t-test and Bonferroni correction
#4.Tukey's HSD


# Importing libraries
import pandas as pd
import matplotlib.pyplot as plt
from matplotlib.lines import Line2D
import seaborn as sns
from scipy import stats
from statsmodels.stats.multitest import multipletests
from statsmodels.stats import weightstats
import statsmodels.api as sm
from statsmodels.formula.api import ols



# Set the size of figures
sns.set(rc={'figure.figsize':(15,8)}, font_scale = 1.5)
sns.set_style({'font.family':'serif', 'font.serif':'Times New Roman'})


# Read data
df_babies = pd.read_csv('babies.csv', encoding="ISO-8859-1")
```

Part 1 - Descriptive Analysis

```
# Check for null values
df_babies.isnull().sum()
```

```
Unnamed: 0     0
id             0
pluralty       0
outcome        0
date           0
gestation      0
sex            0
wt            10
parity         0
race           0
age            0
ed             0
ht             0
wt1            0
drace          0
dage           0
ded            0
dht            0
dwt            0
marital        0
inc            0
smoke          0
time           0
number         0
dtype: int64
```

```
df_smoke_babies=df_babies.drop(columns=['gestation', 'pluralty','outcome','date','sex','parity','race','age
                                        'dht','dwt','marital','inc','time','number','id'])

# Drop the column with no name using iloc
df_smoke_babies = df_smoke_babies.drop(df_smoke_babies.columns[0], axis=1)


df_smoke_babies=df_smoke_babies[df_smoke_babies['smoke'] != 9]


# calculate parameters
babies = df_smoke_babies['wt'].describe()
babies.to_latex('describe.tex')
babies
```

```
<ipython-input-37-0685aed2de87>:3: FutureWarning: In future versions `DataFrame.to_latex` is expected t
  babies.to_latex('describe.tex')
count   1216.000
mean     119.562
std       18.140
min       55.000
25%      109.000
50%      120.000
75%      131.000
max      176.000
Name: wt, dtype: float64
```

```
# calculate the mean of each smoking categories
df_means = df_smoke_babies.groupby(['smoke']).describe()
df_means.to_latex('mean_smoke.tex')
df_means
```

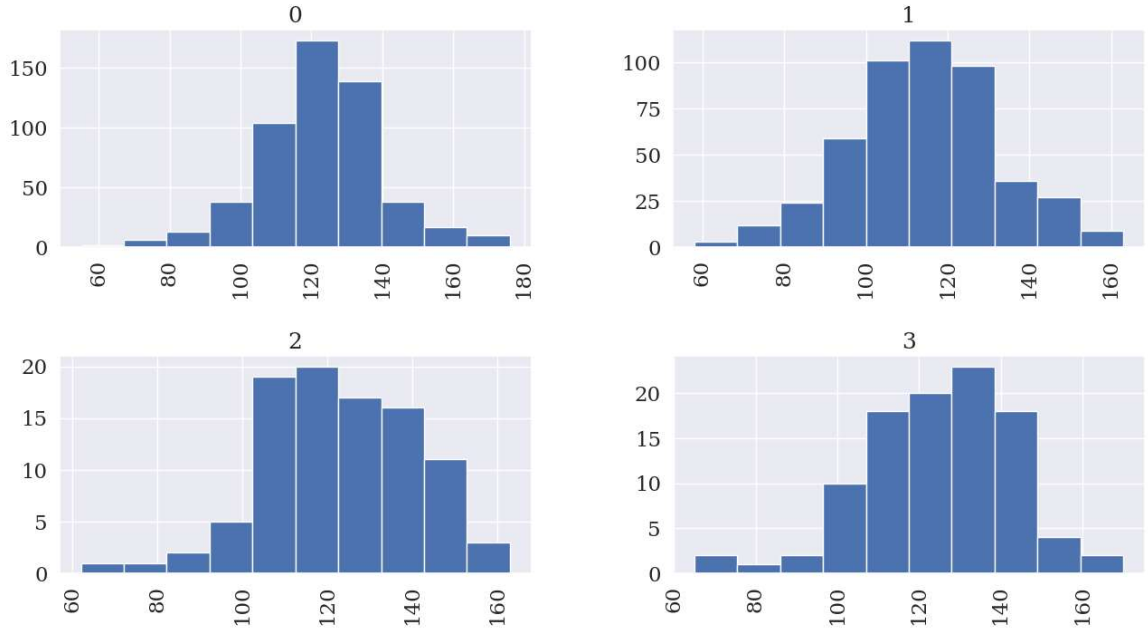
```
<ipython-input-38-fcf7f10373ee>:3: FutureWarning: In future versions `DataFrame.to_late
  df_means.to_latex('mean_smoke.tex')
```

	wt							
	count	mean	std	min	25%	50%	75%	max
smoke								
0	540.000	122.861	17.060	55.000	113.750	124.000	132.250	176.000
1	481.000	114.108	17.973	58.000	102.000	115.000	126.000	163.000
2	95.000	123.084	17.804	62.000	112.000	122.000	136.500	163.000
3	100.000	124.630	18.570	65.000	112.000	124.500	138.000	170.000

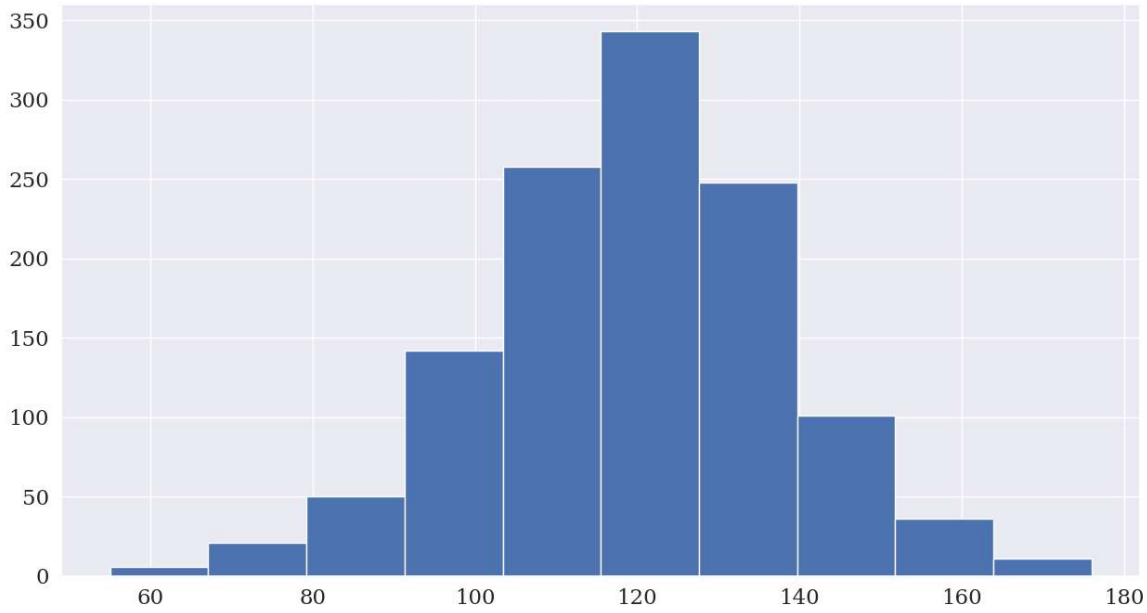
```
#Check is there any missing values in the Data set
na_count = df_smoke_babies.isna().sum()
na_count
```

```
wt       10
smoke     0
dtype: int64
```

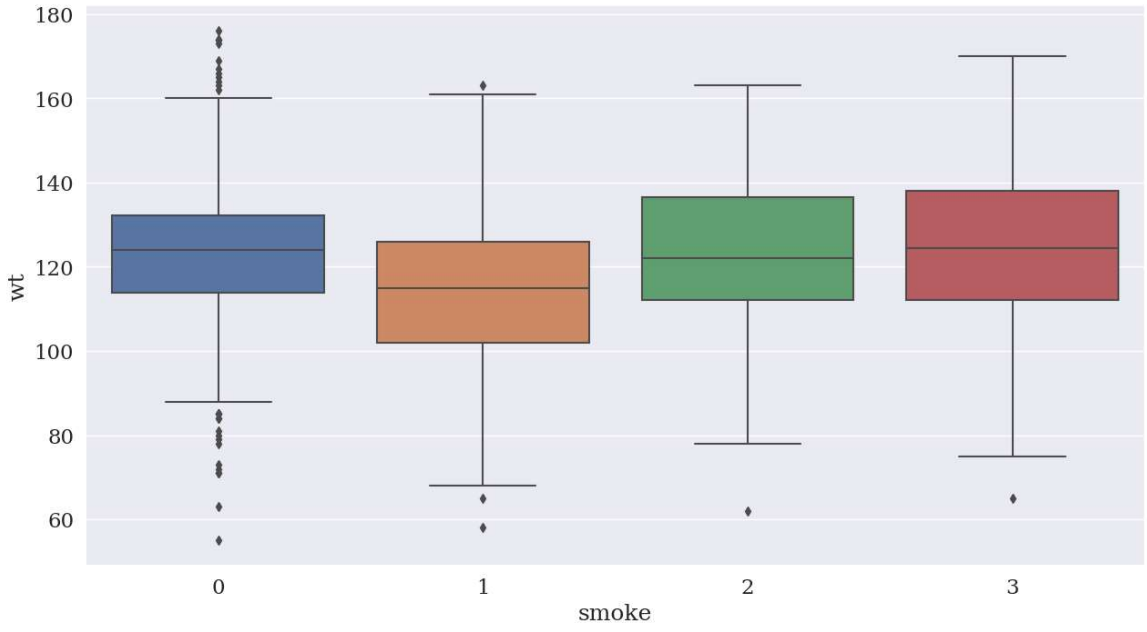
```
# Visualise data using histograms
df_smoke_babies['wt'].hist(by=df_smoke_babies['smoke'])
plt.savefig('histogram_category.pdf')
plt.show()
```




```
# Visualise overall distribution
df_smoke_babies['wt'].hist()
plt.savefig('histogram.pdf')
plt.show()
```




```
# Generate box plots to show variability within/between smoke category
sns.boxplot(x = 'smoke', y = 'wt', data = df_smoke_babies)
plt.savefig('boxplots.pdf')
plt.show()
```



```
# calculate sample variances
df_smoke_babies.groupby('smoke')['wt'].var()
```

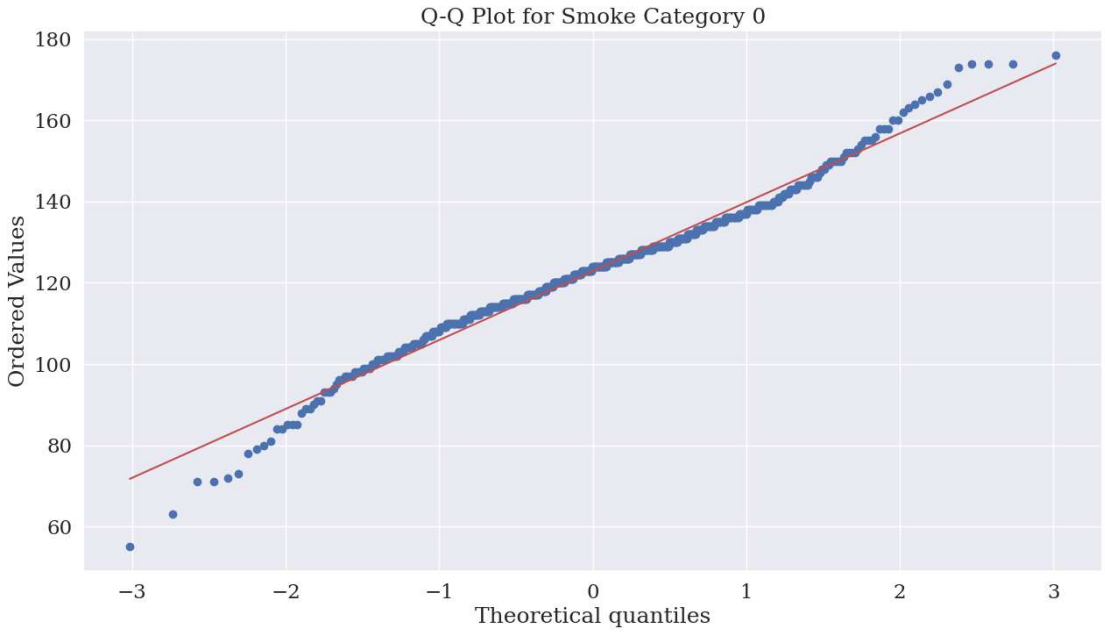
```
smoke
0   291.051
1   323.017
2   316.972
3   344.862
Name: wt, dtype: float64
```

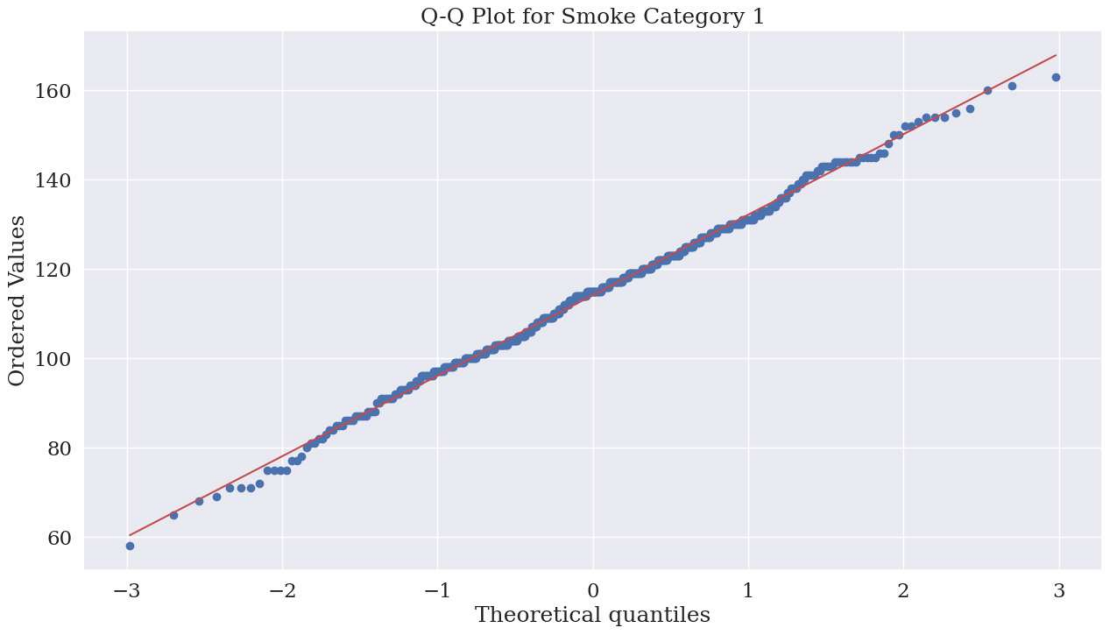
```
# Define function for Q-Q plot
def qq_plots(smoke_cat):
    fig = sm.qqplot(df_smoke_babies[df_smoke_babies['smoke'] == smoke_cat]['wt'], line = '45', fit = True)
    plt.savefig(smoke_cat + '.pdf')
    plt.title('QQ Plot for Smoking Category ' + smoke_cat)
    plt.savefig('qqplot.pdf')
    plt.show()
```

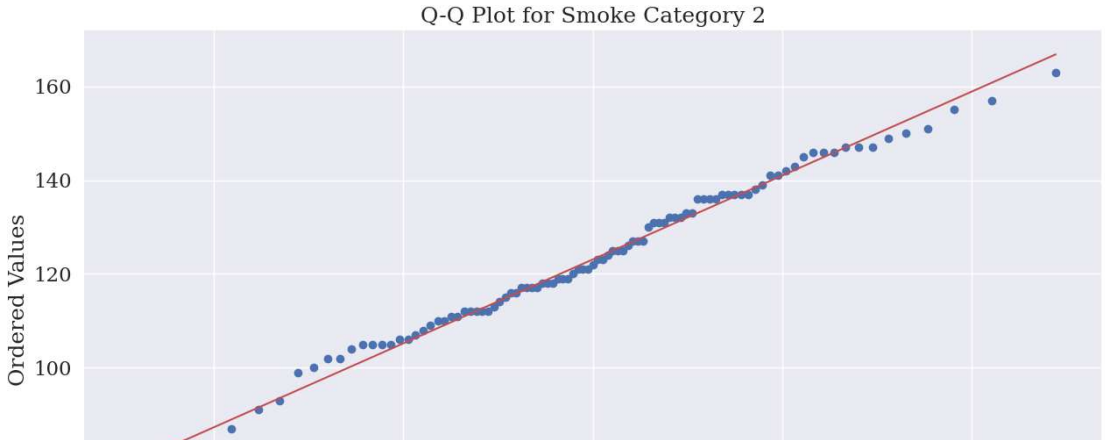
```
# Remove rows with non-finite values
df_smoke_babies = df_smoke_babies.dropna(subset=['wt'])

# Group the data by 'smoke' category
groups = df_smoke_babies.groupby('smoke')['wt']

# Generate Q-Q plots
for smoke, group in groups:
    stats.probplot(group, dist='norm', plot=plt)
    plt.title(f"Q-Q Plot for Smoke Category {smoke}")
    plt.show()
```


Q-Q Plot for Smoke Category 0
Ordered Values
Theoretical quantiles
180
160
140
120
100
80
60
−3
−2
−1
0
1
2
3


Q-Q Plot for Smoke Category 1
Ordered Values
Theoretical quantiles
160
140
120
100
80
60
−3
−2
−1
0
1
2
3


Q-Q Plot for Smoke Category 2
Ordered Values
160
140
120
100

Part 2 - Analysis of Variance

```
# Get group-wise data
smoke_groups = pd.unique(df_smoke_babies.smoke.values)
smoke_groups
l_data = [df_smoke_babies['wt'][df_smoke_babies.smoke == grp] for grp in smoke_groups]


# calculate F-ratio
pd.set_option('display.float_format', lambda x: '%.3f' % x)
model = ols('wt ~ smoke', data=df_smoke_babies).fit()
anova_table = sm.stats.anova_lm(model, typ=2)
anova_table.to_latex('anova_table.tex')
anova_table
```

```
<ipython-input-68-8e5aca16cc18>:5: FutureWarning: In future versions `DataFrame.to_late
  anova_table.to_latex('anova_table.tex')
```

	sum_sq	df	F	PR(>F)
smoke	190.563	1.000	0.579	0.447
Residual	399602.811	1214.000	NaN	NaN

```
# calculate p-value
f, p = stats.f_oneway(*l_data)
f, p
```

```
(25.723398227943612, 3.913951373335263e-16)
```

Part 3 - Multiple t-tests and Bonferroni Correction

```
# Apply t-test for two means that returns p-value for given pair of smoke category
def pairwise_testing(smoke_pair, equal_var):
    first_frame = df_smoke_babies[df_smoke_babies['smoke'] == smoke_pair[0]]['wt']
    second_frame = df_smoke_babies[df_smoke_babies['smoke'] == smoke_pair[1]]['wt']
    stat, p_value, df = weightstats.ttest_ind(first_frame, second_frame, alternative='two-sided', usevar='p
    return p_value


# Generate pairs of smoke category and applying t-test for each pair
p_values = []
comb_names = []
import itertools
for comb in itertools.combinations(smoke_groups, 2):
    comb_names.append('Category ' + str(comb[0]) + ' & ' +'Category '+ str(comb[1]))
    p_value = pairwise_testing(comb, True)
    p_values.append(p_value)


# Apply Bonferroni Correction
adjusted_result = multipletests(p_values, alpha = 0.05, method = 'bonferroni')


# Sort the results into a single dataframe
df_t_results = pd.DataFrame(columns = ['Smoke Pair', 'p-value', 'Adjusted p-value'])
df_t_results['Smoke Pair'] = comb_names
df_t_results['p-value'] = p_values
df_t_results['Rejected'] = df_t_results['p-value'] < 0.05
df_t_results['Adjusted p-value'] = adjusted_result[1]
df_t_results['Rejected_Adjusted'] = adjusted_result[0]


# Importing for Latex
df_t_results.to_latex('ttest_results.tex')
```

```
<ipython-input-53-852f1ebf3865>:2: FutureWarning: In future versions `DataFrame.to_latex` is expected t
  df_t_results.to_latex('ttest_results.tex')
```