## 0.1 Libraries and Utilities

[ ]:
```
!pip install matplotlib==3.3.4 pywaffle==0.6.0 umap-learn
```

```
Requirement already satisfied: matplotlib==3.3.4 in
/usr/local/lib/python3.10/dist-packages (3.3.4)
Requirement already satisfied: pywaffle==0.6.0 in
/usr/local/lib/python3.10/dist-packages (0.6.0)
Requirement already satisfied: umap-learn in /usr/local/lib/python3.10/dist-
packages (0.5.6)
Requirement already satisfied: cycler>=0.10 in /usr/local/lib/python3.10/dist-
packages (from matplotlib==3.3.4) (0.12.1)
Requirement already satisfied: kiwisolver>=1.0.1 in
/usr/local/lib/python3.10/dist-packages (from matplotlib==3.3.4) (1.4.5)
Requirement already satisfied: numpy>=1.15 in /usr/local/lib/python3.10/dist-
packages (from matplotlib==3.3.4) (1.25.2)
Requirement already satisfied: pillow>=6.2.0 in /usr/local/lib/python3.10/dist-
packages (from matplotlib==3.3.4) (9.4.0)
Requirement already satisfied: pyparsing!=2.0.4,!=2.1.2,!=2.1.6,>=2.0.3 in
/usr/local/lib/python3.10/dist-packages (from matplotlib==3.3.4) (3.1.2)
Requirement already satisfied: python-dateutil>=2.1 in
/usr/local/lib/python3.10/dist-packages (from matplotlib==3.3.4) (2.8.2)
Requirement already satisfied: scipy>=1.3.1 in /usr/local/lib/python3.10/dist-
packages (from umap-learn) (1.11.4)
Requirement already satisfied: scikit-learn>=0.22 in
/usr/local/lib/python3.10/dist-packages (from umap-learn) (1.2.2)
Requirement already satisfied: numba>=0.51.2 in /usr/local/lib/python3.10/dist-
packages (from umap-learn) (0.58.1)
Requirement already satisfied: pynndescent>=0.5 in
/usr/local/lib/python3.10/dist-packages (from umap-learn) (0.5.12)
Requirement already satisfied: tqdm in /usr/local/lib/python3.10/dist-packages
(from umap-learn) (4.66.4)
Requirement already satisfied: llvmlite<0.42,>=0.41.0dev0 in
/usr/local/lib/python3.10/dist-packages (from numba>=0.51.2->umap-learn)
(0.41.1)
Requirement already satisfied: joblib>=0.11 in /usr/local/lib/python3.10/dist-
packages (from pynndescent>=0.5->umap-learn) (1.4.2)
Requirement already satisfied: six>=1.5 in /usr/local/lib/python3.10/dist-
packages (from python-dateutil>=2.1->matplotlib==3.3.4) (1.16.0)
Requirement already satisfied: threadpoolctl>=2.0.0 in
/usr/local/lib/python3.10/dist-packages (from scikit-learn>=0.22->umap-learn)
(3.5.0)
```

[ ]:
```
import warnings
warnings.filterwarnings('ignore')

# basic libraries
import os
```

```python
import numpy as np
import pandas as pd
import re
import string
from collections import Counter
import time

#visulaization modules
import missingno as msno
import matplotlib
import matplotlib.pyplot as plt
import seaborn as sns
import plotly.express as px
import plotly.graph_objs as go
from plotly.offline import iplot, init_notebook_mode
from pywaffle import Waffle


%matplotlib inline
init_notebook_mode(connected= True)




#Common model helpers
from sklearn.preprocessing import (StandardScaler,
                                   LabelEncoder,
                                   OneHotEncoder)
from sklearn import metrics
from sklearn.model_selection import train_test_split
from sklearn.metrics import (accuracy_score,
                             auc,
                             precision_score,
                             recall_score,
                             f1_score,
                             roc_auc_score,
                             confusion_matrix)
from sklearn.model_selection import (GridSearchCV,
                                     StratifiedKFold,
                                     cross_val_score)


# dimensionality reduction
from sklearn.decomposition import PCA
import pylab as pl

# imbalance dataset handling
```

```
from imblearn.datasets import make_imbalance
from imblearn.under_sampling import (RandomUnderSampler,
                                     ClusterCentroids,
                                     TomekLinks,
                                     NeighbourhoodCleaningRule,
                                     EditedNearestNeighbours,
                                     NearMiss)


from imblearn.over_sampling import (SMOTE,
                                    ADASYN)




# model algorithms
from sklearn.ensemble import (RandomForestClassifier,
                              AdaBoostClassifier,
                              GradientBoostingClassifier)
from sklearn.linear_model import LogisticRegression
from sklearn.neighbors import KNeighborsClassifier
from sklearn.tree import DecisionTreeClassifier
from sklearn.svm import SVC
from xgboost import XGBClassifier
from lightgbm import LGBMClassifier
```

## 0.2 Data Preprocessing

[ ]:
```
# loading data
df = pd.read_csv('17_Healthcare Stroke Analysis.csv', delimiter = ',', encoding␣
 ↪= 'utf-8')
df.head(3).T
```

[ ]:
```
                                 0              1              2
id                            9046          51676          31112
gender                        Male         Female           Male
age                           67.0           61.0           80.0
hypertension                     0              0              0
heart_disease                    1              0              1
ever_married                   Yes            Yes            Yes
work_type                  Private  Self-employed        Private
Residence_type               Urban          Rural          Rural
avg_glucose_level           228.69         202.21         105.92
bmi                           36.6            NaN           32.5
smoking_status     formerly smoked   never smoked   never smoked
```

```
stroke                              1              1              1
```

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

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 5110 entries, 0 to 5109
Data columns (total 12 columns):
 #   Column             Non-Null Count  Dtype
---  ------             --------------  -----
 0   id                 5110 non-null   int64
 1   gender             5110 non-null   object
 2   age                5110 non-null   float64
 3   hypertension       5110 non-null   int64
 4   heart_disease      5110 non-null   int64
 5   ever_married       5110 non-null   object
 6   work_type          5110 non-null   object
 7   Residence_type     5110 non-null   object
 8   avg_glucose_level  5110 non-null   float64
 9   bmi                4909 non-null   float64
 10  smoking_status     5110 non-null   object
 11  stroke             5110 non-null   int64
dtypes: float64(3), int64(4), object(5)
memory usage: 479.2+ KB
```

[ ]:
```python
# stats of numerical data
round (df.describe(exclude = 'object'), 2)
```

[ ]:
```
             id      age  hypertension  heart_disease  avg_glucose_level  \
count   5110.00  5110.00        5110.0        5110.00            5110.00
mean   36517.83    43.23           0.1           0.05             106.15
std    21161.72    22.61           0.3           0.23              45.28
min       67.00     0.08           0.0           0.00              55.12
25%    17741.25    25.00           0.0           0.00              77.24
50%    36932.00    45.00           0.0           0.00              91.88
75%    54682.00    61.00           0.0           0.00             114.09
max    72940.00    82.00           1.0           1.00             271.74

           bmi   stroke
count  4909.00  5110.00
mean     28.89     0.05
std       7.85     0.22
min      10.30     0.00
25%      23.50     0.00
50%      28.10     0.00
75%      33.10     0.00
max      97.60     1.00
```

[ ]:

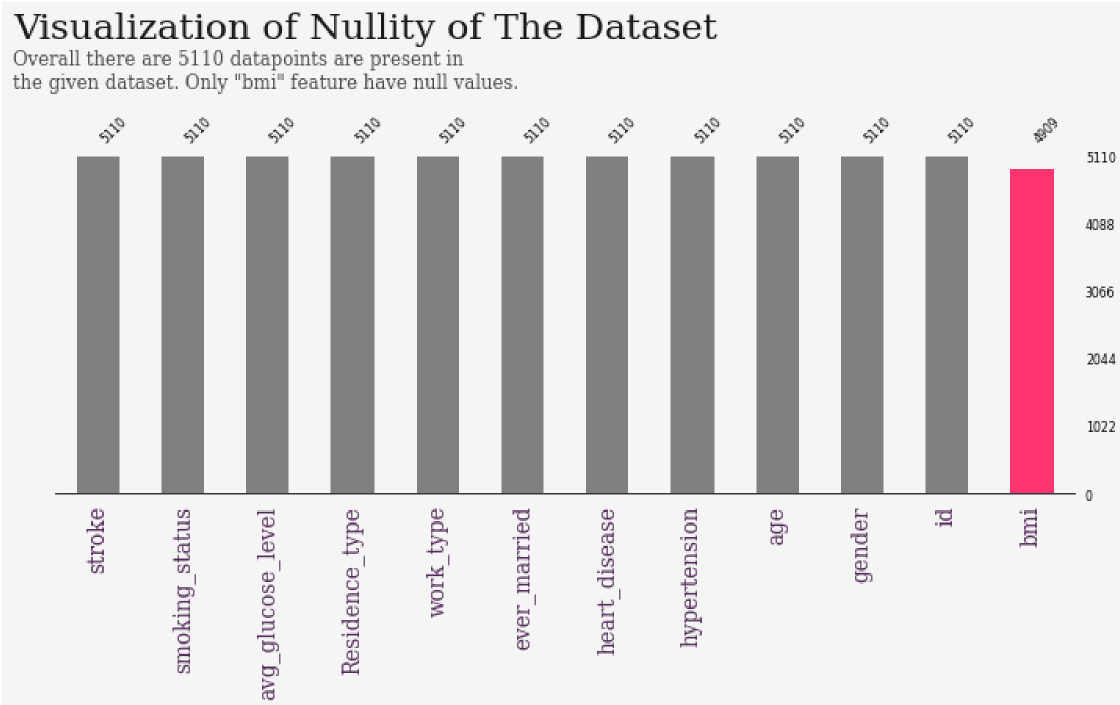
```
# stats of categorical data
round (df.describe(exclude = ['float', 'int64']),2)
```

[ ]:

|  | gender | ever_married | work_type | Residence_type | smoking_status |
|---|---|---|---|---|---|
| count | 5110 | 5110 | 5110 | 5110 | 5110 |
| unique | 3 | 2 | 5 | 2 | 4 |
| top | Female | Yes | Private | Urban | never smoked |
| freq | 2994 | 3353 | 2925 | 2596 | 1892 |

[ ]:

```
color =␣
↪['grey','grey','grey','grey','grey','grey','grey','grey','grey','grey','grey','#fe346e']
fig, ax = plt.subplots(figsize = (12,4), dpi = 70)
fig.patch.set_facecolor('#f6f5f5')
ax.set_facecolor('#f6f5f5')


msno.bar(df, sort = 'descending',
         color = color,
         ax = ax, fontsize =8,
         labels = 'off',filter = 'top')

ax.text(-1,1.35,'Visualization of Nullity of The Dataset',{'font': 'Serif',␣
↪'fontsize': 24,  'color':'black'},alpha = 0.9)
ax.text(-1,1.2,'Overall there are 5110 datapoints are present in \nthe given␣
↪dataset. Only "bmi" feature have null values.',{'font': 'Serif', 'fontsize':␣
↪12,  'color':'black'}, alpha = 0.7)

ax.set_xticklabels(ax.get_xticklabels(),rotation = 90,
                   ha = 'center', **{'font': 'Serif', 'fontsize': 14,'weight':
↪'normal','color':'#512b58'}, alpha = 1)
ax.set_yticklabels('')
ax.spines['bottom'].set_visible(True)

fig.show()
```




[ ]:
```
# handling missing values
df['bmi'] = df['bmi'].fillna(round (df['bmi'].median(), 2))
df.isnull().sum()
```

[ ]:
```
id                   0
gender               0
age                  0
hypertension         0
heart_disease        0
ever_married         0
work_type            0
Residence_type       0
avg_glucose_level    0
bmi                  0
smoking_status       0
stroke               0
dtype: int64
```

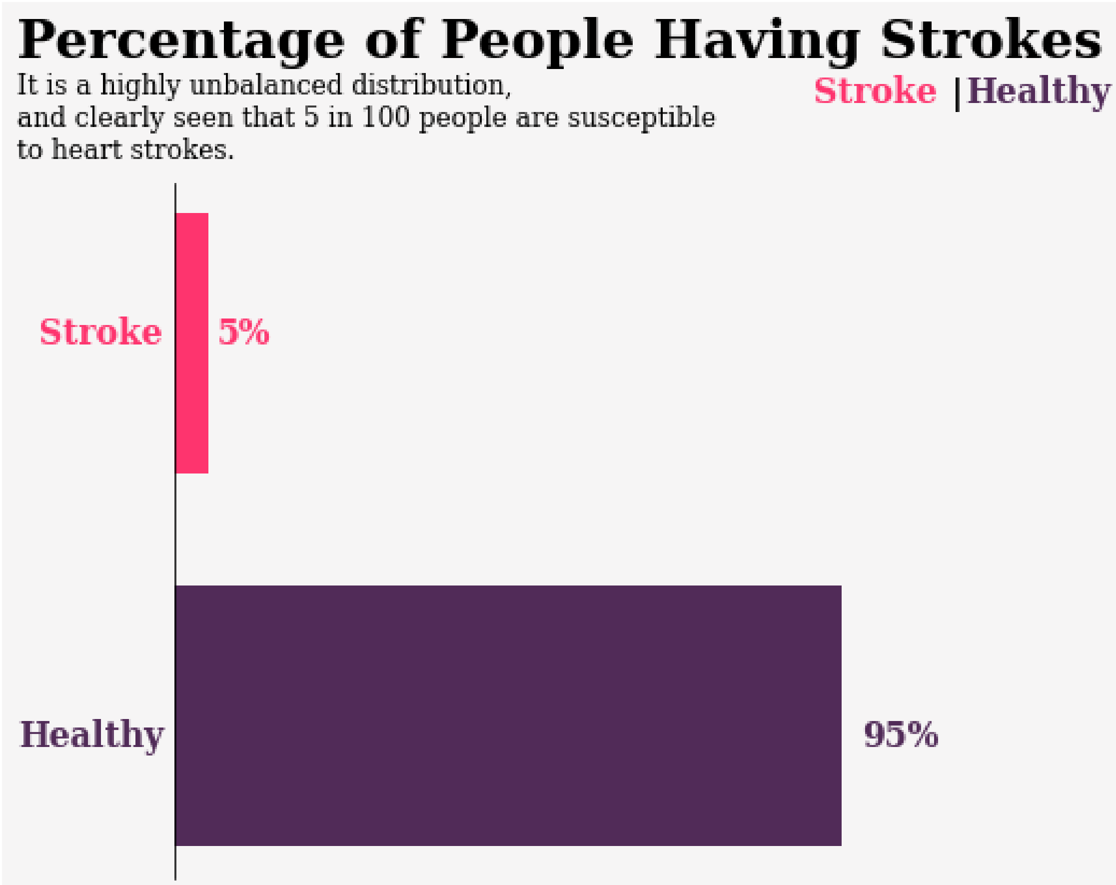
Only bmi feature have some missing data,which was be filled with the median of the same column. For feature extraction, binning was applied for all the continous values, binning values are taken from follow articles.

- body mass index binning
- Age binning
- average glucose binning

```
[ ]: ## binning of numerical variables

df['bmi_cat'] = pd.cut(df['bmi'], bins = [0, 19, 25,30,10000], labels =␣
 ↪['Underweight', 'Ideal', 'Overweight', 'Obesity'])
df['age_cat'] = pd.cut(df['age'], bins = [0,13,18, 45,60,200], labels =␣
 ↪['Children', 'Teens', 'Adults','Mid Adults','Elderly'])
df['glucose_cat'] = pd.cut(df['avg_glucose_level'], bins = [0,90,160,230,500],␣
 ↪labels = ['Low', 'Normal', 'High', 'Very High'])
```

### 0.3 Data Analysis

```
[ ]: x = pd.DataFrame( df.groupby(['stroke'])['stroke'].count())

# plot
fig, ax = plt.subplots(figsize = (6,6), dpi = 70)
ax.barh([1], x.stroke[1], height = 0.7, color = '#fe346e')
plt.text(-1150,-0.08, 'Healthy',{'font': 'Serif','weight':'bold','fontsize':␣
 ↪'16','style':'normal', 'color':'#512b58'})
plt.text(5000,-0.08, '95%',{'font':'Serif','weight':'bold' ,'fontsize':
 ↪'16','color':'#512b58'})
ax.barh([0], x.stroke[0], height = 0.7, color = '#512b58')
plt.text(-1000,1, 'Stroke', {'font': 'Serif','weight':'bold','fontsize':␣
 ↪'16','style':'normal', 'color':'#fe346e'})
plt.text(300,1, '5%',{'font':'Serif', 'weight':'bold','fontsize':'16','color':
 ↪'#fe346e'})

fig.patch.set_facecolor('#f6f5f5')
ax.set_facecolor('#f6f5f5')

plt.text(-1150,1.77, 'Percentage of People Having Strokes' ,{'font': 'Serif',␣
 ↪'fontsize': '25','weight':'bold', 'color':'black'})
plt.text(4650,1.65, 'Stroke ', {'font': 'Serif','weight':'bold','fontsize':␣
 ↪'16','weight':'bold','style':'normal', 'color':'#fe346e'})
plt.text(5650,1.65, '|', {'color':'black' , 'fontsize':'16', 'weight': 'bold'})
plt.text(5750,1.65, 'Healthy', {'font': 'Serif','weight':'bold', 'fontsize':␣
 ↪'16','style':'normal', 'weight':'bold','color':'#512b58'})
plt.text(-1150,1.5, 'It is a highly unbalanced distribution,\nand clearly seen␣
 ↪that 5 in 100 people are susceptible \nto heart strokes.',
        {'font':'Serif', 'fontsize':'12.5','color': 'black'})

ax.axes.get_xaxis().set_visible(False)
ax.axes.get_yaxis().set_visible(False)
ax.spines['bottom'].set_visible(False)
ax.spines['left'].set_visible(True)
ax.spines['right'].set_visible(False)
ax.spines['top'].set_visible(False)
```

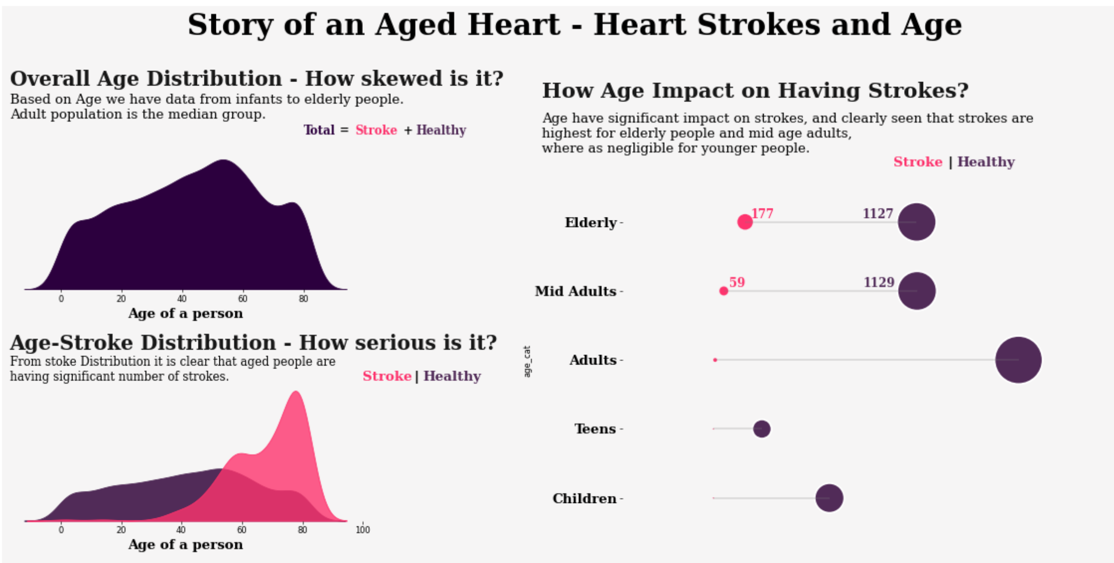



[ ]:
```
fig = plt.figure(figsize = (24,10), dpi = 60)

gs = fig.add_gridspec(10,24)
gs.update(wspace = 1, hspace = 0.05)


ax2 = fig.add_subplot(gs[1:4,0:8]) #distribution plot
ax3 = fig.add_subplot(gs[6:9, 0:8]) #hue distribution plot
ax1 = fig.add_subplot(gs[1:10,13:]) #dumbbell plot

# axes list
axes = [ ax1,ax2, ax3]

# setting of axes; visibility of axes and spines turn off
for ax in axes:
    ax.axes.get_yaxis().set_visible(False)
    ax.set_facecolor('#f6f5f5')

    for loc in ['left', 'right', 'top', 'bottom']:
```

```
        ax.spines[loc].set_visible(False)

fig.patch.set_facecolor('#f6f5f5')

ax1.axes.get_xaxis().set_visible(False)
ax1.axes.get_yaxis().set_visible(True)

# dumbbell plot of stoke and healthy people

stroke_age = df[df['stroke'] == 1].age_cat.value_counts()
healthy_age = df[df['stroke'] == 0].age_cat.value_counts()

ax1.hlines(y = ['Children', 'Teens', 'Adults', 'Mid Adults', 'Elderly'], xmin = [644,270,1691,1129,1127],
          xmax = [1,1,11,59,177], color = 'grey',**{'linewidth':0.5})


sns.scatterplot(y = stroke_age.index, x = stroke_age.values, s = stroke_age.values*2, color = '#fe346e', ax= ax1, alpha = 1)
sns.scatterplot(y = healthy_age.index, x = healthy_age.values, s = healthy_age.values*2, color = '#512b58', ax= ax1, alpha = 1)

ax1.axes.get_xaxis().set_visible(False)
ax1.set_xlim(xmin = -500, xmax = 2250)
ax1.set_ylim(ymin = -1,ymax = 5)

ax1.set_yticklabels( labels = ['Children', 'Teens', 'Adults', 'Mid Adults', 'Elderly'],fontdict = {'font':'Serif', 'fontsize':16,'fontweight':'bold', 'color':'black'})

ax1.text(-950,5.8, 'How Age Impact on Having Strokes?' ,{'font': 'Serif', 'fontsize': '25','weight':'bold', 'color':'black'},alpha = 0.9)
ax1.text(1000,4.8, 'Stroke ', {'font': 'Serif','weight':'bold','fontsize': '16','weight':'bold','style':'normal', 'color':'#fe346e'})
ax1.text(1300,4.8, '|', {'color':'black' , 'fontsize':'16', 'weight': 'bold'})
ax1.text(1350,4.8, 'Healthy', {'font': 'Serif','weight':'bold', 'fontsize': '16','style':'normal', 'weight':'bold','color':'#512b58'})
ax1.text(-950,5., 'Age have significant impact on strokes, and clearly seen that strokes are \nhighest for elderly people and mid age adults, \nwhere as negligible for younger people.',
        {'font':'Serif', 'fontsize':'16','color': 'black'})

ax1.text(stroke_age.values[0] + 30,4.05, stroke_age.values[0], {'font':'Serif', 'fontsize':14, 'weight':'bold', 'color':'#fe346e'})
ax1.text(healthy_age.values[2] - 300,4.05, healthy_age.values[2], {'font': 'Serif', 'fontsize':14, 'weight':'bold', 'color':'#512b58'})
```

```python
ax1.text(stroke_age.values[1] + 30,3.05, stroke_age.values[1], {'font':'Serif', 'fontsize':14, 'weight':'bold', 'color':'#fe346e'})
ax1.text(healthy_age.values[1] - 300,3.05, healthy_age.values[1], {'font': 'Serif', 'fontsize':14, 'weight':'bold', 'color':'#512b58'})




# distribution plots ---- only single variable

sns.kdeplot(data = df, x = 'age', ax = ax2, shade = True, color = '#2c003e', alpha = 1, )
ax2.set_xlabel('Age of a person', fontdict = {'font':'Serif', 'color': 'black', 'fontsize': 16,'weight':'bold' })
ax2.text(-17,0.025,'Overall Age Distribution - How skewed is it?', {'font': 'Serif', 'color': 'black','weight':'bold','fontsize':24}, alpha = 0.9)
ax2.text(-17,0.021, 'Based on Age we have data from infants to elderly people.\nAdult population is the median group.',
        {'font':'Serif', 'fontsize':'16','color': 'black'})
ax2.text(80,0.019, 'Total',{'font':'Serif', 'fontsize':'14','color': '#2c003e','weight':'bold'})
ax2.text(92,0.019, '=',{'font':'Serif', 'fontsize':'14','color': 'black','weight':'bold'})
ax2.text(97,0.019, 'Stroke',{'font':'Serif', 'fontsize':'14','color': '#fe346e','weight':'bold'})
ax2.text(113,0.019, '+',{'font':'Serif', 'fontsize':'14','color': 'black','weight':'bold'})
ax2.text(117,0.019, 'Healthy',{'font':'Serif', 'fontsize':'14','color': '#512b58','weight':'bold'})



# distribution plots with hue of strokes


sns.kdeplot(data = df[df['stroke'] == 0], x = 'age',ax = ax3, shade = True,  alpha = 1, color = '#512b58' )
sns.kdeplot(data = df[df['stroke'] == 1], x = 'age',ax = ax3, shade = True,  alpha = 0.8, color = '#fe346e')

ax3.set_xlabel('Age of a person', fontdict = {'font':'Serif', 'color': 'black', 'weight':'bold','fontsize': 16})

ax3.text(-17,0.0525,'Age-Stroke Distribution - How serious is it?', {'font': 'Serif', 'weight':'bold','color': 'black', 'fontsize':24}, alpha= 0.9)
```

```
ax3.text(-17,0.043,'From stoke Distribution it is clear that aged people are \nhaving significant number of strokes.', {'font':'Serif', 'color': 'black', 'fontsize':14})
ax3.text(100,0.043, 'Stroke ', {'font': 'Serif','weight':'bold','fontsize': '16','weight':'bold','style':'normal', 'color':'#fe346e'})
ax3.text(117,0.043, '|', {'color':'black' , 'fontsize':'16', 'weight': 'bold'})
ax3.text(120,0.043, 'Healthy', {'font': 'Serif','weight':'bold', 'fontsize': '16','style':'normal', 'weight':'bold','color':'#512b58'})

fig.text(0.25,1,'Story of an Aged Heart - Heart Strokes and Age',{'font': 'Serif', 'weight':'bold','color': 'black', 'fontsize':35})
fig.show()
```

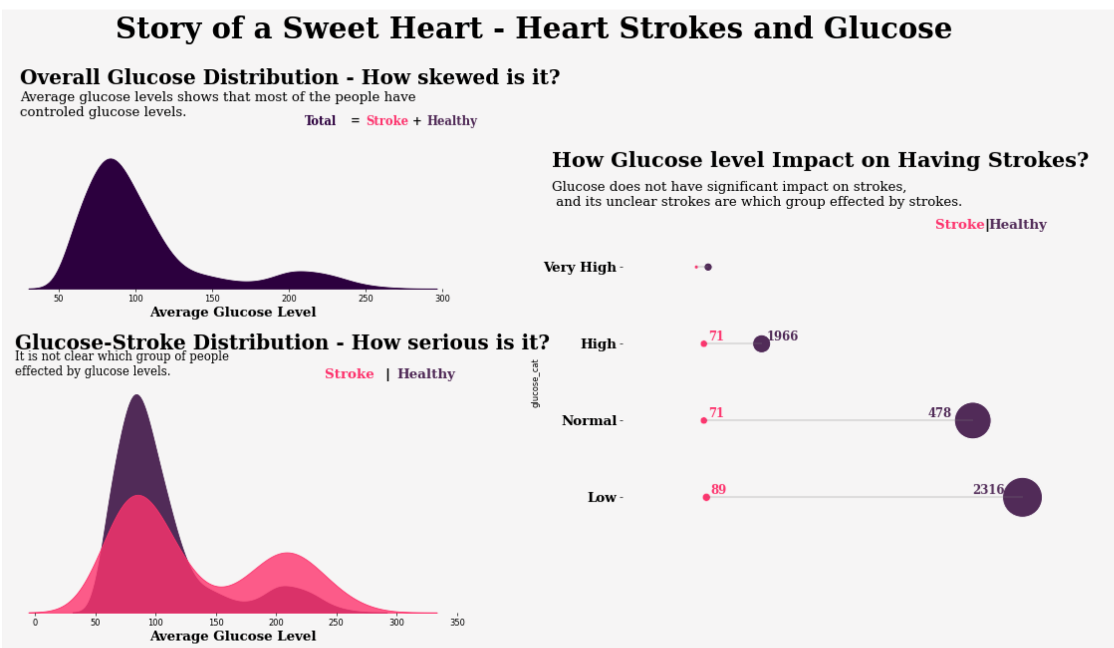



```
[ ]: # sugar distribution plots


fig = plt.figure(figsize = (24,10), dpi = 60)

gs = fig.add_gridspec(10,24)
gs.update(wspace = 1, hspace = 0.05)


ax2 = fig.add_subplot(gs[0:3,0:10]) #distribution plot
ax3 = fig.add_subplot(gs[5:10, 0:10]) #hue distribution plot
ax1 = fig.add_subplot(gs[0:,13:]) #dumbbell plot

# axes list
axes = [ ax1,ax2, ax3]
```

```python
# setting of axes; visibility of axes and spines turn off
for ax in axes:
    ax.axes.get_yaxis().set_visible(False)
    ax.set_facecolor('#f6f5f5')

    for loc in ['left', 'right', 'top', 'bottom']:
        ax.spines[loc].set_visible(False)

fig.patch.set_facecolor('#f6f5f5')

ax1.axes.get_xaxis().set_visible(False)
ax1.axes.get_yaxis().set_visible(True)

# dumbbell plot of stoke and healthy people

stroke_glu = df[df['stroke'] == 1].glucose_cat.value_counts()
healthy_glu = df[df['stroke'] == 0].glucose_cat.value_counts()

ax1.hlines(y = ['Low', 'Normal', 'High', 'Very High'], xmin =␣
↪[2316,1966,478,101],
          xmax = [89,71,71,18], color = 'grey',**{'linewidth':0.5})


sns.scatterplot(y = stroke_glu.index, x = stroke_glu.values, s = stroke_glu.
↪values, color = '#fe346e', ax= ax1, alpha = 1)
sns.scatterplot(y = healthy_glu.index, x = healthy_glu.values, s = healthy_glu.
↪values, color = '#512b58', ax= ax1, alpha = 1)

ax1.axes.get_xaxis().set_visible(False)
ax1.set_xlim(xmin = -500, xmax = 3000)
ax1.set_ylim(ymin = -1.5,ymax = 4.5)

ax1.set_yticklabels( labels = ['Low', 'Normal', 'High', 'Very High'],fontdict =␣
↪{'font':'Serif', 'fontsize':16,'fontweight':'bold', 'color':'black'})

ax1.text(-1000,4.3, 'How Glucose level Impact on Having Strokes?' ,{'font':␣
↪'Serif', 'fontsize': '25','weight':'bold', 'color':'black'})
ax1.text(1700,3.5, 'Stroke ', {'font': 'Serif','weight':'bold','fontsize':␣
↪'16','weight':'bold','style':'normal', 'color':'#fe346e'})
ax1.text(2050,3.5, '|', {'color':'black' , 'fontsize':'16', 'weight': 'bold'})
ax1.text(2075,3.5, 'Healthy', {'font': 'Serif','weight':'bold', 'fontsize':␣
↪'16','style':'normal', 'weight':'bold','color':'#512b58'})
ax1.text(-1000,3.8, 'Glucose does not have significant impact on strokes,\n and␣
↪its unclear strokes are which group effected by strokes.',
        {'font':'Serif', 'fontsize':'16','color': 'black'})
```

```python
ax1.text(stroke_glu.values[0] + 30,0.05, stroke_glu.values[0], {'font':'Serif', 'fontsize':14, 'weight':'bold', 'color':'#fe346e'})
ax1.text(healthy_glu.values[0] + -355,0.05, healthy_glu.values[0], {'font': 'Serif', 'fontsize':14, 'weight':'bold', 'color':'#512b58'})

ax1.text(stroke_glu.values[2] + 30,1.05, stroke_glu.values[2], {'font':'Serif', 'fontsize':14, 'weight':'bold', 'color':'#fe346e'})
ax1.text(healthy_glu.values[2] + 1170,1.05, healthy_glu.values[2], {'font': 'Serif', 'fontsize':14, 'weight':'bold', 'color':'#512b58'})

ax1.text(stroke_glu.values[1] + 30,2.05, stroke_glu.values[1], {'font':'Serif', 'fontsize':14, 'weight':'bold', 'color':'#fe346e'})
ax1.text(healthy_glu.values[1] - 1450,2.05, healthy_glu.values[1], {'font': 'Serif', 'fontsize':14, 'weight':'bold', 'color':'#512b58'})



# distribution plots ---- only single variable

sns.kdeplot(data = df, x = 'avg_glucose_level', ax = ax2, shade = True, color = '#2c003e', alpha = 1, )
ax2.set_xlabel('Average Glucose Level', fontdict = {'font':'Serif', 'color': 'black', 'fontsize': 16,'weight':'bold' })
ax2.text(25,0.025,'Overall Glucose Distribution - How skewed is it?', {'font': 'Serif', 'color': 'black','weight':'bold','fontsize':24})
ax2.text(25,0.021, 'Average glucose levels shows that most of the people have \ncontroled glucose levels.',
        {'font':'Serif', 'fontsize':'16','color': 'black'})
ax2.text(210,0.020, 'Total',{'font':'Serif', 'fontsize':'14','color': '#2c003e','weight':'bold'})
ax2.text(240,0.02, '=',{'font':'Serif', 'fontsize':'14','color': 'black','weight':'bold'})
ax2.text(250,0.02, 'Stroke',{'font':'Serif', 'fontsize':'14','color': '#fe346e','weight':'bold'})
ax2.text(280,0.02, '+',{'font':'Serif', 'fontsize':'14','color': 'black','weight':'bold'})
ax2.text(290,0.02, 'Healthy',{'font':'Serif', 'fontsize':'14','color': '#512b58','weight':'bold'})



# distribution plots with hue of strokes
```

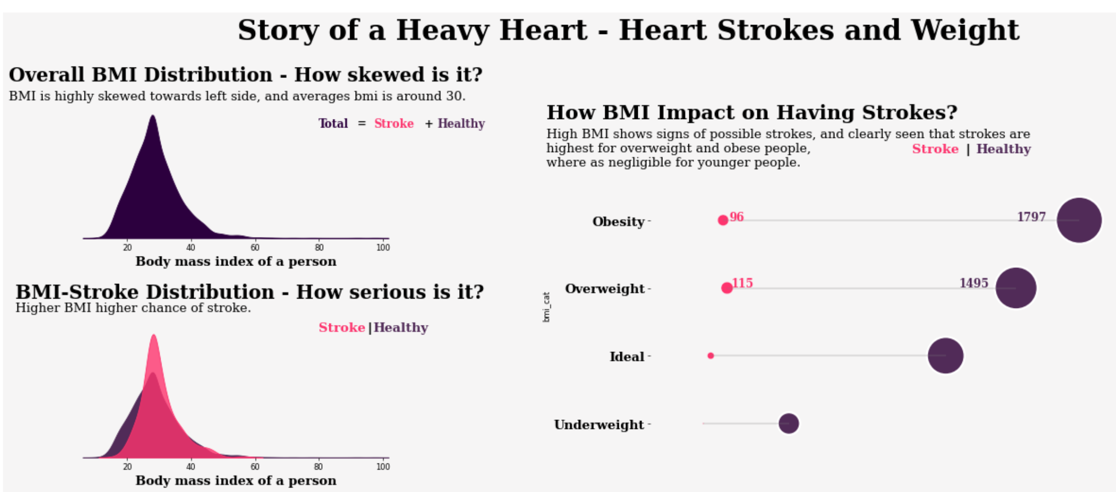
```python
sns.kdeplot(data = df[df['stroke'] == 0], x = 'avg_glucose_level',ax = ax3, shade = True,  alpha = 1, color = '#512b58' )
sns.kdeplot(data = df[df['stroke'] == 1], x = 'avg_glucose_level',ax = ax3, shade = True,  alpha = 0.8, color = '#fe346e')

ax3.set_xlabel('Average Glucose Level', fontdict = {'font':'Serif', 'color': 'black', 'weight':'bold','fontsize': 16})

ax3.text(-17,0.0195,'Glucose-Stroke Distribution - How serious is it?', {'font': 'Serif', 'weight':'bold','color': 'black', 'fontsize':24})
ax3.text(-17,0.0176,'It is not clear which group of people \neffected by glucose levels.', {'font':'Serif', 'color': 'black', 'fontsize':14})
ax3.text(240,0.0174, 'Stroke ', {'font': 'Serif','weight':'bold','fontsize': '16','weight':'bold','style':'normal', 'color':'#fe346e'})
ax3.text(290,0.0174, '|', {'color':'black' , 'fontsize':'16', 'weight': 'bold'})
ax3.text(300,0.0174, 'Healthy', {'font': 'Serif','weight':'bold', 'fontsize': '16','style':'normal', 'weight':'bold','color':'#512b58'})


fig.text(0.2,1.07,'Story of a Sweet Heart - Heart Strokes and Glucose',{'font': 'Serif', 'weight':'bold','color': 'black', 'fontsize':35})

fig.show()
```



[ ]:
```python
fig = plt.figure(figsize = (24,10),dpi = 60)

gs = fig.add_gridspec(10,24)
gs.update(wspace = 1, hspace = 0.05)


ax2 = fig.add_subplot(gs[1:4,0:8]) #distribution plot
ax3 = fig.add_subplot(gs[6:9, 0:8]) #hue distribution plot
ax1 = fig.add_subplot(gs[2:9,13:]) #dumbbell plot

# axes list
axes = [ ax1,ax2, ax3]

# setting of axes; visibility of axes and spines turn off
for ax in axes:
    ax.axes.get_yaxis().set_visible(False)
    ax.set_facecolor('#f6f5f5')

    for loc in ['left', 'right', 'top', 'bottom']:
        ax.spines[loc].set_visible(False)

fig.patch.set_facecolor('#f6f5f5')

ax1.axes.get_xaxis().set_visible(False)
ax1.axes.get_yaxis().set_visible(True)
ax1.set_xlim(xmin = -250,xmax = 2000)
ax1.set_ylim(ymin = -1,ymax =3.5)

# dumbbell plot of stoke and healthy people

stroke_bmi = df[df['stroke'] == 1].bmi_cat.value_counts()
healthy_bmi = df[df['stroke'] == 0].bmi_cat.value_counts()

ax1.hlines(y = ['Obesity', 'Overweight', 'Ideal', 'Underweight'], xmin =␣
 ↪[96,115,37,1],
          xmax = [1797,1495,1159,410], color = 'grey',**{'linewidth':0.5})


sns.scatterplot(y = stroke_bmi.index, x = stroke_bmi.values, s = stroke_bmi.
 ↪values*2, color = '#fe346e', ax= ax1, alpha = 1)
sns.scatterplot(y = healthy_bmi.index, x = healthy_bmi.values, s = healthy_bmi.
 ↪values*2, color = '#512b58', ax= ax1, alpha = 1)

ax1.set_yticklabels( labels = ['Obesity', 'Overweight', 'Ideal',␣
 ↪'Underweight'],fontdict = {'font':'Serif', 'fontsize':16,'fontweight':
 ↪'bold', 'color':'black'})
```

```
ax1.text(-750,-1.5, 'How BMI Impact on Having Strokes?' ,{'font': 'Serif',␣
↪'size': '25','weight':'bold', 'color':'black'})
ax1.text(1000,-1., 'Stroke ', {'font': 'Serif','weight':'bold','size':␣
↪'16','weight':'bold','style':'normal', 'color':'#fe346e'})
ax1.text(1250,-1, '|', {'color':'black' , 'size':'16', 'weight': 'bold'})
ax1.text(1300,-1, 'Healthy', {'font': 'Serif','weight':'bold', 'size':␣
↪'16','style':'normal', 'weight':'bold','color':'#512b58'})
ax1.text(-750,-0.8, 'High BMI shows signs of possible strokes, and clearly seen␣
↪that strokes are \nhighest for overweight and obese people, \nwhere as␣
↪negligible for younger people.',
        {'font':'Serif', 'size':'16','color': 'black'})



ax1.text(stroke_bmi.values[0] + 20 , 0.98, stroke_bmi.values[0], {'font':
↪'Serif', 'size':14, 'weight':'bold', 'color':'#fe346e'})
ax1.text(healthy_bmi.values[1] - 275 ,0.98, healthy_bmi.values[1], {'font':
↪'Serif', 'size':14, 'weight':'bold', 'color':'#512b58'})

ax1.text(stroke_bmi.values[1] + 30,0, stroke_bmi.values[1], {'font':'Serif',␣
↪'size':14, 'weight':'bold', 'color':'#fe346e'})
ax1.text(healthy_bmi.values[0] - 300,0, healthy_bmi.values[0], {'font':'Serif',␣
↪'size':14, 'weight':'bold', 'color':'#512b58'})




# distribution plots ---- only single variable

sns.kdeplot(data = df, x = 'bmi', ax = ax2, shade = True, color = '#2c003e',␣
↪alpha = 1, )
ax2.set_xlabel('Body mass index of a person', fontdict = {'font':'Serif',␣
↪'color': 'black', 'size': 16,'weight':'bold' })
ax2.text(-17,0.085,'Overall BMI Distribution - How skewed is it?', {'font':
↪'Serif', 'color': 'black','weight':'bold','size':24})
ax2.text(-17,0.075, 'BMI is highly skewed towards left side, and averages bmi␣
↪is around 30.',
        {'font':'Serif', 'size':'16','color': 'black'})
ax2.text(80,0.06, 'Total',{'font':'Serif', 'size':'14','color':␣
↪'#2c003e','weight':'bold'})
ax2.text(92,0.06, '=',{'font':'Serif', 'size':'14','color': 'black','weight':
↪'bold'})
ax2.text(97,0.06, 'Stroke',{'font':'Serif', 'size':'14','color':␣
↪'#fe346e','weight':'bold'})
ax2.text(113,0.06, '+',{'font':'Serif', 'size':'14','color': 'black','weight':
↪'bold'})
```

```python
ax2.text(117,0.06, 'Healthy',{'font':'Serif', 'size':'14','color':'#512b58','weight':'bold'})


# distribution plots with hue of strokes


sns.kdeplot(data = df[df['stroke'] == 0], x = 'bmi',ax = ax3, shade = True, alpha = 1, color = '#512b58' )
sns.kdeplot(data = df[df['stroke'] == 1], x = 'bmi',ax = ax3, shade = True, alpha = 0.8, color = '#fe346e')

ax3.set_xlabel('Body mass index of a person', fontdict = {'font':'Serif', 'color': 'black', 'weight':'bold','size': 16})

ax3.text(-15,0.12,'BMI-Stroke Distribution - How serious is it?', {'font':'Serif', 'weight':'bold','color': 'black', 'size':24})
ax3.text(-15,0.11,'Higher BMI higher chance of stroke.', {'font':'Serif', 'color': 'black', 'size':16})
ax3.text(80,0.095, 'Stroke ', {'font': 'Serif','weight':'bold','size':'16','weight':'bold','style':'normal', 'color':'#fe346e'})
ax3.text(95,0.095, '|', {'color':'black' , 'size':'16', 'weight': 'bold'})
ax3.text(97,0.095, 'Healthy', {'font': 'Serif','weight':'bold', 'size':'16','style':'normal', 'weight':'bold','color':'#512b58'})

fig.text(0.25,0.925,'Story of a Heavy Heart - Heart Strokes and Weight',{'font':'Serif', 'weight':'bold','color': 'black', 'size':35})

fig.show()
```

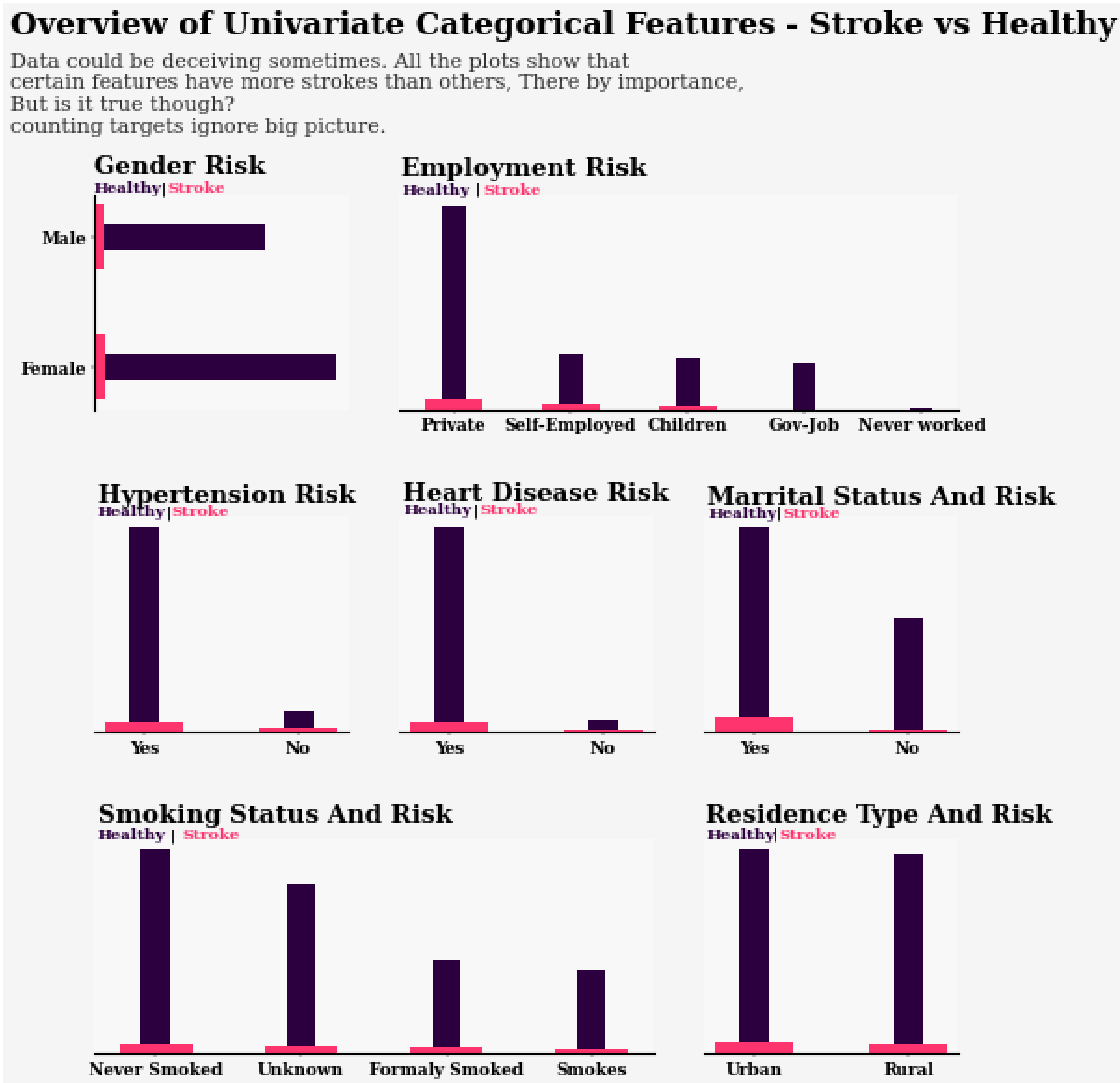


[ ]:
```
fig = plt.figure(figsize = (15,15),dpi = 40)

gs = fig.add_gridspec(3,3)
gs.update(wspace = 0.2, hspace = 0.5)


ax1 = fig.add_subplot(gs[0,0])
ax2 = fig.add_subplot(gs[0,1:])
ax3 = fig.add_subplot(gs[1,0])
ax4 = fig.add_subplot(gs[1,1])
ax5 = fig.add_subplot(gs[1,2])
ax6 = fig.add_subplot(gs[2,0:2])
ax7 = fig.add_subplot(gs[2,2])

axes = [ax1, ax2, ax3, ax4, ax5, ax6, ax7]

fig.patch.set_facecolor('#f5f5f5')

# setting of axes; visibility of axes and spines turn off
for ax in axes:
    ax.axes.get_yaxis().set_visible(False)
    ax.set_facecolor('#f8f8f8')
    ax.spines['bottom'].set_linewidth(2)
    for loc in ['left', 'right', 'top']:
        ax.spines[loc].set_visible(False)
        ax.spines[loc].set_linewidth(2)


title_args = {'font':'Serif', 'weight':'bold','color': 'black', 'size':24}
font_dict = {'size':16, 'family':'Serif', 'color':'black', 'weight':'bold'}
health_dict = {'font':'Serif', 'color': '#2c003e', 'size':15, 'weight':'bold'}
dash_dict = {'font':'Serif', 'color': 'black', 'size':15,'weight':'bold'}
stroke_dict = {'font':'Serif', 'color': '#fe346e', 'size':15,'weight':'bold'}

stroke_col = '#fe346e'
healthy_col = '#2c003e'

# Ax1: Gender- stroke distributions
healthy_gen = df[df['stroke'] == 0].gender.value_counts()
stroke_gen = df[df['stroke'] == 1].gender.value_counts()

ax1.barh( stroke_gen.index , width = healthy_gen.values[0:2], height = 0.2,␣
 ↪color = healthy_col)
ax1.barh( np.arange(len(stroke_gen.index)) , width = stroke_gen.values, height␣
 ↪= 0.5, color = stroke_col)
ax1.set_yticklabels(stroke_gen.index, **font_dict)
```

```
ax1.axes.get_yaxis().set_visible(True)
ax1.axes.get_xaxis().set_visible(False)
ax1.spines['bottom'].set_visible(False)
ax1.spines['left'].set_visible(True)
ax1.text(0,1.5, 'Gender Risk',**title_args)
ax1.text(0,1.35, 'Healthy',**health_dict)
ax1.text(790,1.35, '|',**dash_dict)
ax1.text(870,1.35, 'Stroke',**stroke_dict)

# Ax2: work type - stroke distributions
healthy_gen = df[df['stroke'] == 0].work_type.value_counts()
stroke_gen = df[df['stroke'] == 1].work_type.value_counts()

ax2.bar( healthy_gen.index , height = healthy_gen.values, width = 0.2, color = healthy_col)
ax2.bar( np.arange(len(stroke_gen.index)) , height = stroke_gen.values, width = 0.5, color= stroke_col)
ax2.set_xticklabels(['Private','Self-Employed','Children', 'Gov-Job','Never worked'], **font_dict)


ax2.text(-0.45,3200, 'Employment Risk',**title_args)
ax2.text(-0.45,2950, 'Healthy',**health_dict)
ax2.text(0.18,2950, '|',**dash_dict)
ax2.text(0.25,2950, 'Stroke',**stroke_dict)

# Ax3: hypertension - stroke distributions

healthy_gen = df[df['stroke'] == 0].hypertension.value_counts()
stroke_gen = df[df['stroke'] == 1].hypertension.value_counts()

ax3.bar(['Yes','No'] , height = healthy_gen.values, width = 0.2,color = healthy_col)
ax3.bar( stroke_gen.index, height = stroke_gen.values, width = 0.5,color= stroke_col)
ax3.set_xticklabels(['Yes','No'], **font_dict)

ax3.text(-0.3,5000, 'Hypertension Risk',**title_args)
ax3.text(-0.3,4700, 'Healthy',**health_dict)
ax3.text(0.14,4700, '|',**dash_dict)
ax3.text(0.18,4700, 'Stroke',**stroke_dict)


# Ax4: Heart Disease - stroke distributions

healthy_gen = df[df['stroke'] == 0].heart_disease.value_counts()
stroke_gen = df[df['stroke'] == 1].heart_disease.value_counts()
```

```
ax4.bar(['Yes','No'] , height = healthy_gen.values, width = 0.2,color =␣
 ↪healthy_col)
ax4.bar( stroke_gen.index, height = stroke_gen.values, width = 0.5,color=␣
 ↪stroke_col)
ax4.set_xticklabels(['Yes', 'No'],**font_dict)

ax4.text(-0.3,5250, 'Heart Disease Risk',**title_args)
ax4.text(-0.3,4950, 'Healthy',**health_dict)
ax4.text(0.15,4950, '|',**dash_dict)
ax4.text(0.20,4950, 'Stroke',**stroke_dict)


# Ax5: Married - stroke distributions
healthy_gen = df[df['stroke'] == 0].ever_married.value_counts()
stroke_gen = df[df['stroke'] == 1].ever_married.value_counts()

ax5.bar( healthy_gen.index , height = healthy_gen.values, width = 0.2,color =␣
 ↪healthy_col)
ax5.bar( np.arange(len(stroke_gen.index)) , height = stroke_gen.values, width =␣
 ↪0.5,color= stroke_col )
ax5.set_xticklabels(healthy_gen.index, **font_dict)

ax5.text(-0.3,3500, 'Marrital Status And Risk',**title_args)
ax5.text(-0.3,3300, 'Healthy',**health_dict)
ax5.text(0.14,3300, '|',**dash_dict)
ax5.text(0.18,3300, 'Stroke',**stroke_dict)




# Ax6: Smoking status - stroke distributions

healthy_gen = df[df['stroke'] == 0].smoking_status.value_counts()
stroke_gen = df[df['stroke'] == 1].smoking_status.value_counts()

ax6.bar( healthy_gen.index, height = healthy_gen.values, width = 0.2,color =␣
 ↪healthy_col)
ax6.bar( np.arange(len(stroke_gen.index)) , height = stroke_gen.values, width =␣
 ↪0.5,color= stroke_col)
ax6.set_xticklabels(['Never Smoked', 'Unknown','Formaly Smoked' ,'Smokes'],␣
 ↪**font_dict)

ax6.text(-0.4,2050, 'Smoking Status And Risk',**title_args)
ax6.text(-0.4,1900, 'Healthy',**health_dict)
ax6.text(0.095,1900, '|',**dash_dict)
```

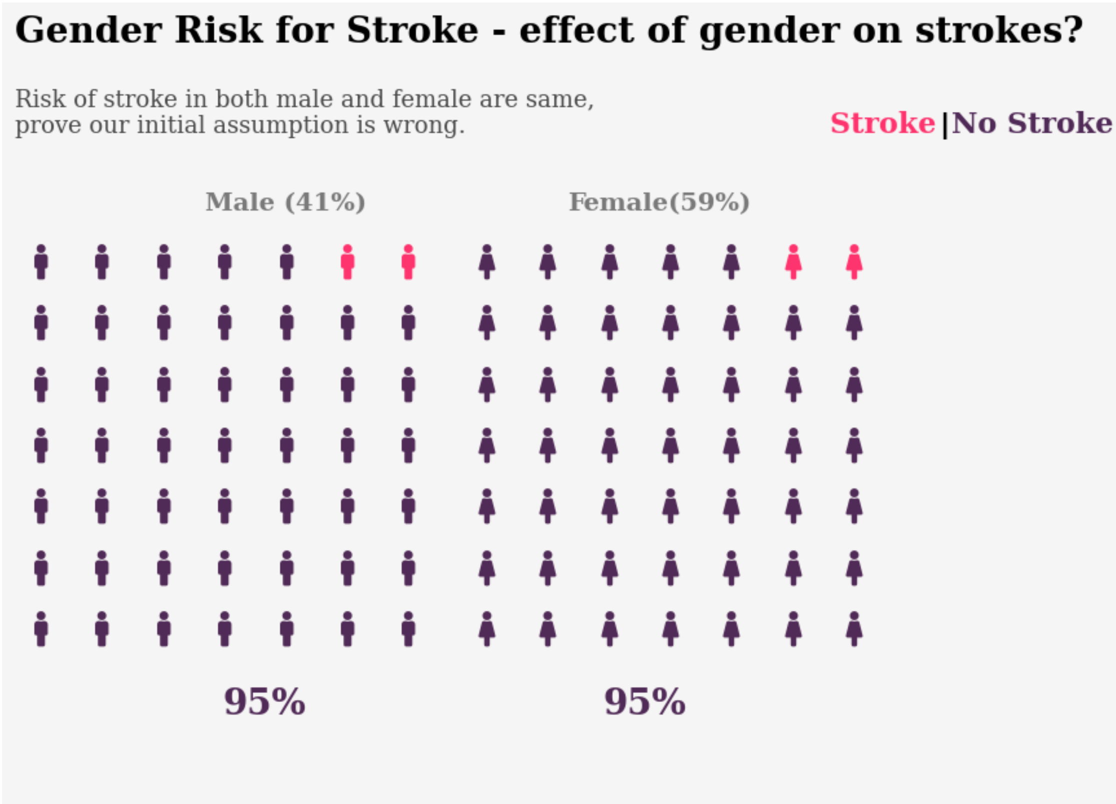
```
ax6.text(0.18,1900, 'Stroke',**stroke_dict)




# Ax7: Residence type - stroke distributions

healthy_gen = df[df['stroke'] == 0].Residence_type.value_counts()
stroke_gen = df[df['stroke'] == 1].Residence_type.value_counts()

ax7.bar( healthy_gen.index , height = healthy_gen.values, width = 0.2,color =␣
↪healthy_col)
ax7.bar( np.arange(len(stroke_gen.index)) , height = stroke_gen.values, width =␣
↪0.5,color= stroke_col)
ax7.set_xticklabels(healthy_gen.index, **font_dict)

ax7.text(-0.31,2800, 'Residence Type And Risk',**title_args)
ax7.text(-0.31,2600, 'Healthy',**health_dict)
ax7.text(0.12,2600,'|',**dash_dict)
ax7.text(0.165,2600, 'Stroke',**stroke_dict)

fig.text(0.05,1.025, 'Overview of Univariate Categorical Features - Stroke vs␣
↪Healthy', {'font':'Serif', 'color':'black','size':30, 'weight':'bold'})
fig.text(0.05,0.9375,'Data could be deceiving sometimes. All the plots show␣
↪that\ncertain features have more strokes than others, There by importance,␣
↪\nBut is it true though? \ncounting targets ignore big picture.',{'font':
↪'Serif', 'color':'black','size':20, 'weight':'normal'}, alpha = 0.8)


fig.show()
```




[ ]:
```
stroke_gen = df[df['stroke'] == 1]['gender'].value_counts()
healthy_gen = df[df['stroke'] == 0]['gender'].value_counts()

female = df['gender'].value_counts().values[0]
male =  df['gender'].value_counts().values[1]

stroke_female = int(round (stroke_gen.values[0] / female * 100, 0))
stroke_male = int(round( stroke_gen.values[1] / male *100, 0))
healthy_female = int(round(healthy_gen.values[0] / female * 100, 0))
healthy_male = int(round(healthy_gen.values[1] / male *100, 0))

female_per = int(round(female/(female+male) * 100, 0))
male_per = int(round(male/(female+male)* 100, 0))
```

```
fig = plt.figure(FigureClass = Waffle,
                 constrained_layout = True,
                 figsize = (7,10),
                 facecolor = '#f6f5f5',dpi = 100,

                 plots = {'121':
                          {
                           'rows':7,
                           'columns': 7,
                           'values' : [healthy_male,stroke_male],
                            'colors' : ['#512b58','#fe346e'],
                              'vertical' : True,
                              'interval_ratio_y': 0.1,
                              'interval_ratio_x': 0.1,
                              'icons' : 'male',
                              'icon_legend': False,
                              'icon_size':20,
                              'plot_anchor':'C',
                              'alpha':0.1
                          },

                          '122' :
                          {
                            'rows': 7,
                            'columns':7,
                            'values':[healthy_female,stroke_female],
                              'colors' : ['#512b58','#fe346e'],
                              'vertical': True,
                              'interval_ratio_y': 0.1,
                              'interval_ratio_x': 0.1,
                              'icons' : 'female',
                              'icon_legend' :False,
                              'icon_size':20,
                              'plot_anchor':'C',
                              'alpha':0.1

                           }
                         },

)
#fig.text ('asdfasdfasd0', {'font':'Serif', 'size':35, 'color':'black'} )


fig.text(0., 0.8, 'Gender Risk for Stroke - effect of gender on strokes?',␣
 ↪{'font':'Serif', 'size':20, 'color':'black', 'weight':'bold'})
```

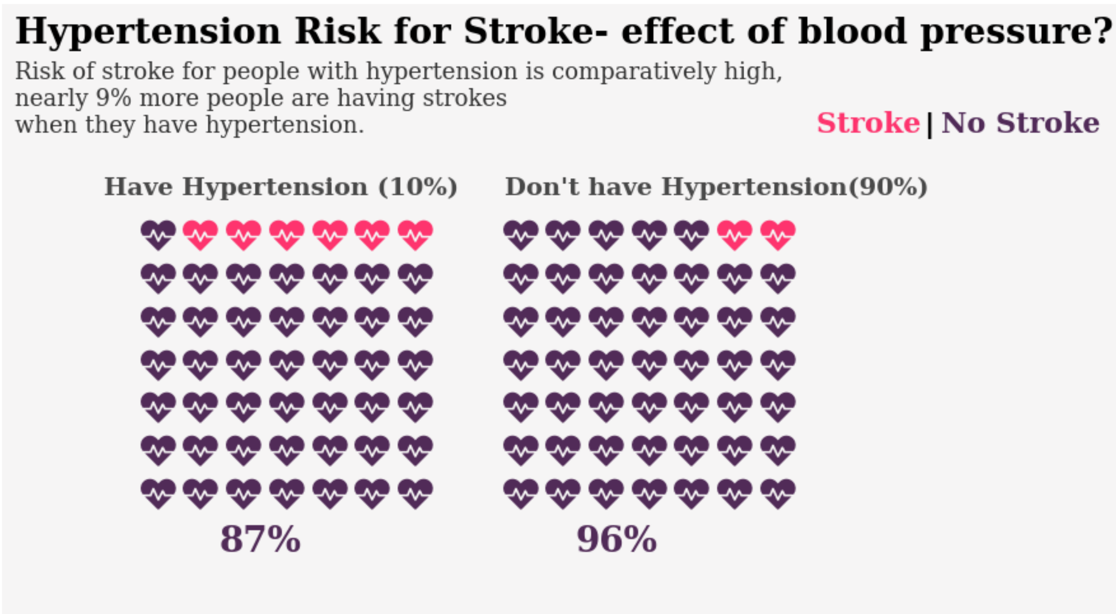
```
fig.text(0., 0.73, 'Risk of stroke in both male and female are same,\nprove our␣
↪initial assumption is wrong. ', {'font':'Serif', 'size':13, 'color':'black',␣
↪'weight':'normal'}, alpha = 0.7)
fig.text(0.24, 0.22, 'ooo', {'font':'Serif', 'size':16,'weight':'bold' ,'color':
↪'#f6f5f5'})
fig.text(0.65, 0.22, 'ooo', {'font':'Serif', 'size':16,'weight':'bold', 'color':
↪'#f6f5f5'})
fig.text(0.23, 0.28, '{}%'.format(healthy_male), {'font':'Serif', 'size':
↪20,'weight':'bold' ,'color':'#512b58'},alpha = 1,)
fig.text(0.65, 0.28, '{}%'.format(healthy_female), {'font':'Serif', 'size':
↪20,'weight':'bold', 'color':'#512b58'}, alpha = 1)
fig.text(0.21, 0.67, 'Male ({}%)'.format(male_per), {'font':'Serif', 'size':
↪14,'weight':'bold' ,'color':'black'},alpha = 0.5,)
fig.text(0.61, 0.67, 'Female({}%)'.format(female_per), {'font':'Serif', 'size':
↪14,'weight':'bold', 'color':'black'}, alpha = 0.5)
#fig.text(0., 0.8, 'Assumption was proven wrong', {'font':'Serif', 'size':24,␣
↪'color':'black', 'weight':'bold'})

fig.text(0.9,0.73, 'Stroke ', {'font': 'Serif','weight':'bold','Size':␣
↪'16','weight':'bold','style':'normal', 'color':'#fe346e'})
fig.text(1.02,0.73, '|', {'color':'black' , 'size':'16', 'weight': 'bold'})
fig.text(1.035,0.73, 'No Stroke', {'font': 'Serif','weight':'bold', 'Size':␣
↪'16','style':'normal', 'weight':'bold','color':'#512b58'},alpha = 1)


fig.show()
```




```
[ ]: stroke_hyper = df[df['stroke'] == 1]['hypertension'].value_counts()
healthy_hyper = df[df['stroke'] == 0]['hypertension'].value_counts()

no = df['hypertension'].value_counts().values[0]
yes = df['hypertension'].value_counts().values[1]

stroke_no = int(round(stroke_hyper.values[0] / no * 100, 0))
stroke_yes = int(round(stroke_hyper.values[1] / yes * 100, 0))
healthy_no = int(round(healthy_hyper.values[0] / no * 100, 0))
healthy_yes = int(round(healthy_hyper.values[1] / yes * 100, 0))

no_per = int(round(no / (no + yes) * 100, 0))
yes_per = int(round(yes / (no + yes) * 100, 0))

fig = plt.figure(
    FigureClass=Waffle,
    constrained_layout=True,
    figsize=(7, 7),
    facecolor='#f6f5f5', dpi=100,
    plots={
        '121': {
```

```
            'rows': 7,
            'columns': 7,
            'values': [stroke_yes, healthy_yes],
            'colors': ['#fe346e', '#512b58'],
            'vertical': True,
            'interval_ratio_x': 0.005,
            'interval_ratio_y': 0.005,
            'icons': 'heartbeat',
            'icon_legend': False,
            'icon_size': 20,
            'plot_anchor': 'C',
            'alpha': 1,
            'starting_location': 'NE'
        },
        '122': {
            'rows': 7,
            'columns': 7,
            'values': [stroke_no, healthy_no],
            'colors': ['#fe346e', '#512b58'],
            'vertical': True,
            'interval_ratio_x': 0.005,
            'interval_ratio_y': 0.005,
            'icons': 'heartbeat',
            'icon_legend': False,
            'icon_size': 20,
            'plot_anchor': 'C',
            'alpha': 1,
            'starting_location': 'NE'
        }
    }
)

fig.text(0.0, 0.85, 'Hypertension Risk for Stroke- effect of blood pressure?',␣
 ↪{'font': 'Serif', 'size': 20, 'color': 'black', 'weight': 'bold'})
fig.text(0.0, 0.75, 'Risk of stroke for people with hypertension is␣
 ↪comparatively high,\nnearly 9% more people are having strokes \nwhen they␣
 ↪have hypertension.', {'font': 'Serif', 'size': 13, 'color': 'black',␣
 ↪'weight': 'normal'}, alpha=0.8)
fig.text(0.24, 0.22, 'ooo', {'font': 'Serif', 'size': 16, 'weight': 'bold',␣
 ↪'color': '#f6f5f5'})
fig.text(0.65, 0.22, 'ooo', {'font': 'Serif', 'size': 16, 'weight': 'bold',␣
 ↪'color': '#f6f5f5'})
fig.text(0.23, 0.28, '{}%'.format(healthy_yes), {'font': 'Serif', 'size': 20,␣
 ↪'weight': 'bold', 'color': '#512b58'}, alpha=1)
fig.text(0.63, 0.28, '{}%'.format(healthy_no), {'font': 'Serif', 'size': 20,␣
 ↪'weight': 'bold', 'color': '#512b58'}, alpha=1)
```

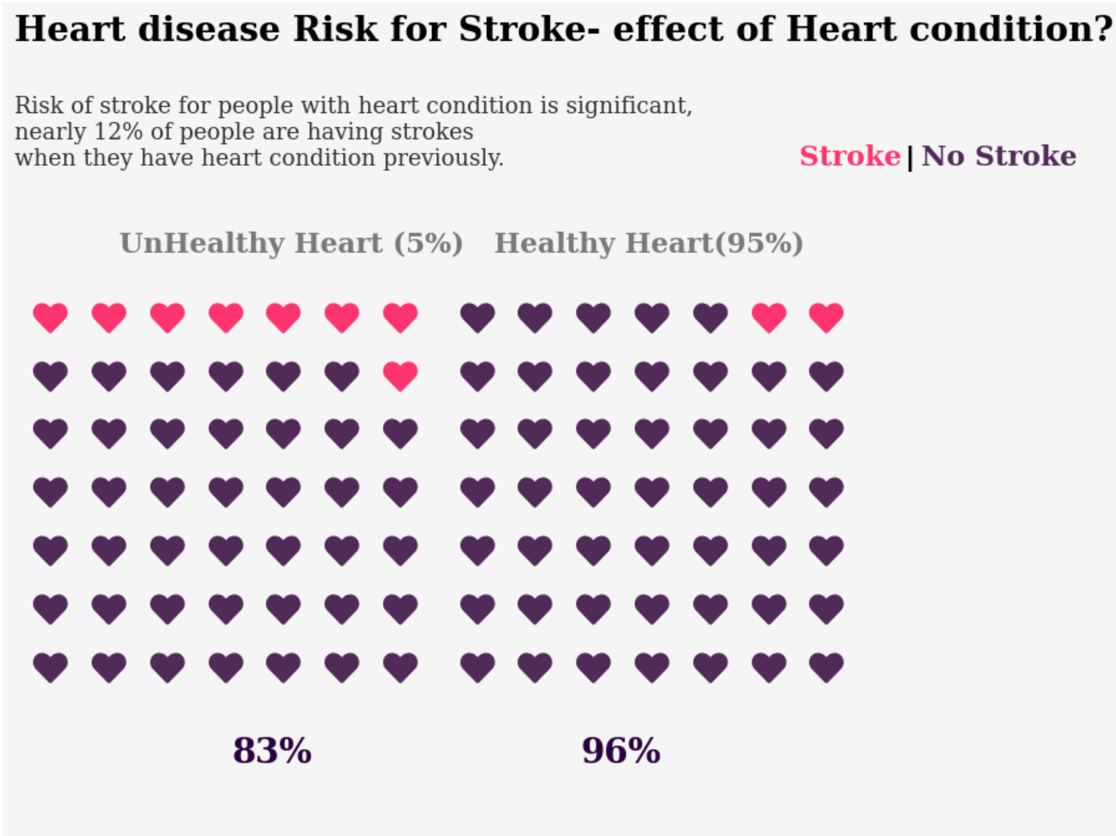
```
fig.text(0.1, 0.68, 'Have Hypertension ({}%)'.format(yes_per), {'font':␣
↪'Serif', 'size': 14, 'weight': 'bold', 'color': 'black'}, alpha=0.7)
fig.text(0.55, 0.68, "Don't have Hypertension({}%)".format(no_per), {'font':␣
↪'Serif', 'size': 14, 'weight': 'bold', 'color': 'black'}, alpha=0.7)
fig.text(0.90, 0.75, 'Stroke ', {'font': 'Serif', 'weight': 'bold', 'Size':␣
↪'16', 'weight': 'bold', 'style': 'normal', 'color': '#fe346e'})
fig.text(1.02, 0.75, '|', {'color': 'black', 'size': '16', 'weight': 'bold'})
fig.text(1.04, 0.75, 'No Stroke', {'font': 'Serif', 'weight': 'bold', 'Size':␣
↪'16', 'style': 'normal', 'weight': 'bold', 'color': '#512b58'}, alpha=1)

plt.show()
```




[ ]:
```
stroke_hyper = df[df['stroke'] == 1]['heart_disease'].value_counts()
healthy_hyper = df[df['stroke'] == 0]['heart_disease'].value_counts()

no = df['heart_disease'].value_counts().values[0]
yes =  df['heart_disease'].value_counts().values[1]

stroke_no = int(round (stroke_hyper.values[0] / no * 100, 0))
stroke_yes = int(round( stroke_hyper.values[1] / yes *100, 0))
healthy_no = int(round(healthy_hyper.values[0] / no * 100, 0))
healthy_yes = int(round(healthy_hyper.values[1] / yes *100, 0))

no_per = int(round(no/(no+yes) * 100, 0))
yes_per = int(round(yes/(no+yes)* 100, 0))
```

```
fig = plt.figure(FigureClass = Waffle,
                 constrained_layout = True,
                 figsize = (7,10),
                 facecolor = '#f6f5f5',dpi = 100,

                 plots = {'121':
                          {
                           'rows':7,
                           'columns': 7,
                           'values' : [stroke_yes,healthy_yes],
                            'colors' : ['#fe346e','#512b58'],
                              'vertical' : True,
                              'interval_ratio_x': 0.005,
                              'interval_ratio_y': 0.005,
                              'icons' : 'heart',
                              'icon_legend': False,
                              'icon_size':20,
                              'plot_anchor':'C',
                              'alpha':0.8,
                              'starting_location': 'NE'
                          },

                          '122' :
                          {
                            'rows': 7,
                            'columns':7,
                            'values':[stroke_no,healthy_no],
                              'colors' : ['#fe346e','#512b58'],
                              'vertical': True,
                              'interval_ratio_x': 0.005,
                              'interval_ratio_y':0.005,
                              'icons' : 'heart',
                              'icon_legend' :False,
                              'icon_size':20,
                              'plot_anchor':'C',
                              'alpha':0.8,
                              'starting_location': 'NE'

                           }
                         },

)
```

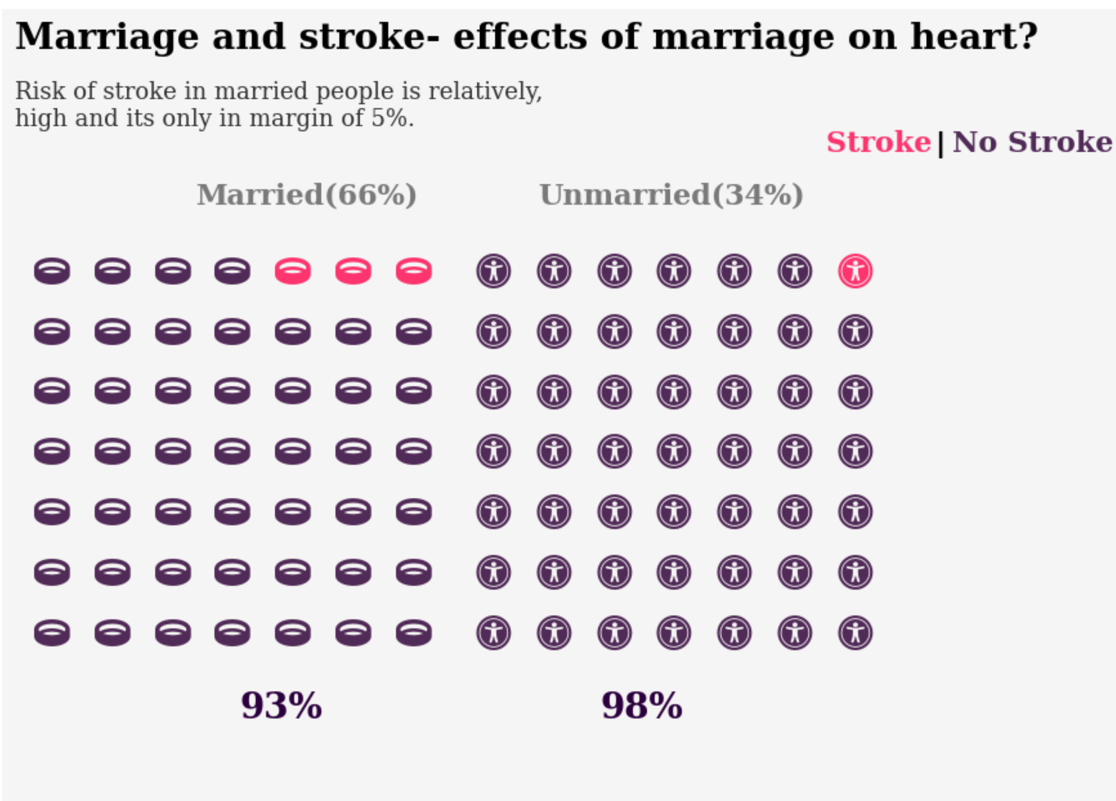
```
fig.text(0., 0.85, 'Heart disease Risk for Stroke- effect of Heart condition?',␣
↪{'font':'Serif', 'size':20, 'color':'black', 'weight':'bold'})
fig.text(0., 0.75, 'Risk of stroke for people with heart condition is␣
↪significant,\nnearly 12% of people are having strokes \nwhen they have heart␣
↪condition previously. ', {'font':'Serif', 'size':13, 'color':'black',␣
↪'weight':'normal'}, alpha = 0.8)
fig.text(0.24, 0.22, 'ooo', {'font':'Serif', 'size':16,'weight':'bold' ,'color':
↪'#f6f5f5'})
fig.text(0.65, 0.22, 'ooo', {'font':'Serif', 'size':16,'weight':'bold', 'color':
↪'#f6f5f5'})
fig.text(0.25, 0.27, '{}%'.format(healthy_yes), {'font':'Serif', 'size':
↪20,'weight':'bold' ,'color':'#2c003e'},alpha = 1,)
fig.text(0.65, 0.27, '{}%'.format(healthy_no), {'font':'Serif', 'size':
↪20,'weight':'bold', 'color':'#2c003e'}, alpha = 1)
fig.text(0.12, 0.68, 'UnHealthy Heart ({}%)'.format(yes_per), {'font':'Serif',␣
↪'size':16,'weight':'bold' ,'color':'black'},alpha = 0.5,)
fig.text(0.55, 0.68, "Healthy Heart({}%)".format(no_per), {'font':'Serif',␣
↪'size':16,'weight':'bold', 'color':'black'}, alpha = 0.5)
#fig.text(0., 0.8, 'Assumption was proven wrong', {'font':'Serif', 'size':24,␣
↪'color':'black', 'weight':'bold'})

fig.text(0.9,0.75, 'Stroke ', {'font': 'Serif','weight':'bold','Size':␣
↪'16','weight':'bold','style':'normal', 'color':'#fe346e'})
fig.text(1.02,0.75, '|', {'color':'black' , 'size':'16', 'weight': 'bold'})
fig.text(1.04,0.75, 'No Stroke', {'font': 'Serif','weight':'bold', 'Size':␣
↪'16','style':'normal', 'weight':'bold','color':'#512b58'},alpha = 1)


fig.show()
```




[ ]:
```
stroke_mary = df[df['stroke'] == 1]['ever_married'].value_counts()
healthy_mary = df[df['stroke'] == 0]['ever_married'].value_counts()

yes = df['ever_married'].value_counts().values[0]
no =  df['ever_married'].value_counts().values[1]

stroke_no = int(round (stroke_mary.values[1] / no * 100, 0))
stroke_yes = int(round( stroke_mary.values[0] / yes *100, 0))
healthy_no = int(round(healthy_mary.values[1] / no * 100, 0))
healthy_yes = int(round(healthy_mary.values[0] / yes *100, 0))

no_per = int(round(no/(no+yes) * 100, 0))
yes_per = int(round(yes/(no+yes)* 100, 0))




fig = plt.figure(FigureClass = Waffle,
                 constrained_layout = True,
                 figsize = (7,10),
                 facecolor = '#f6f5f5',dpi = 100,
```

```
                 plots = {'121':
                          {
                           'rows':7,
                           'columns': 7,
                           'values' : [stroke_yes,healthy_yes],
                            'colors' : ['#fe346e','#512b58'],
                              'vertical' : True,
                              'interval_ratio_x': 0.005,
                              'interval_ratio_y': 0.005,
                              'icons' : 'ring',
                              'icon_legend': False,
                              'icon_size':20,
                              'plot_anchor':'C',
                              'alpha':0.8,
                              'starting_location': 'NE'
                          },

                          '122' :
                          {
                            'rows': 7,
                            'columns':7,
                            'values':[stroke_no,healthy_no],
                              'colors' : ['#fe346e','#512b58'],
                              'vertical': True,
                              'interval_ratio_x': 0.005,
                              'interval_ratio_y':0.005,
                              'icons' : 'universal-access',
                              'icon_legend' :False,
                              'icon_size':20,
                              'plot_anchor':'C',
                              'alpha':0.8,
                              'starting_location': 'NE'

                           }
                         },

)


fig.text(0., 0.8, 'Marriage and stroke- effects of marriage on heart?', {'font':
 ↪'Serif', 'size':20, 'color':'black', 'weight':'bold'})
fig.text(0., 0.74, 'Risk of stroke in married people is relatively,\nhigh and␣
 ↪its only in margin of 5%.', {'font':'Serif', 'size':13, 'color':'black',␣
 ↪'weight':'normal'}, alpha = 0.8)
fig.text(0.24, 0.22, 'ooo', {'font':'Serif', 'size':16,'weight':'bold' ,'color':
 ↪'#f6f5f5'})
```

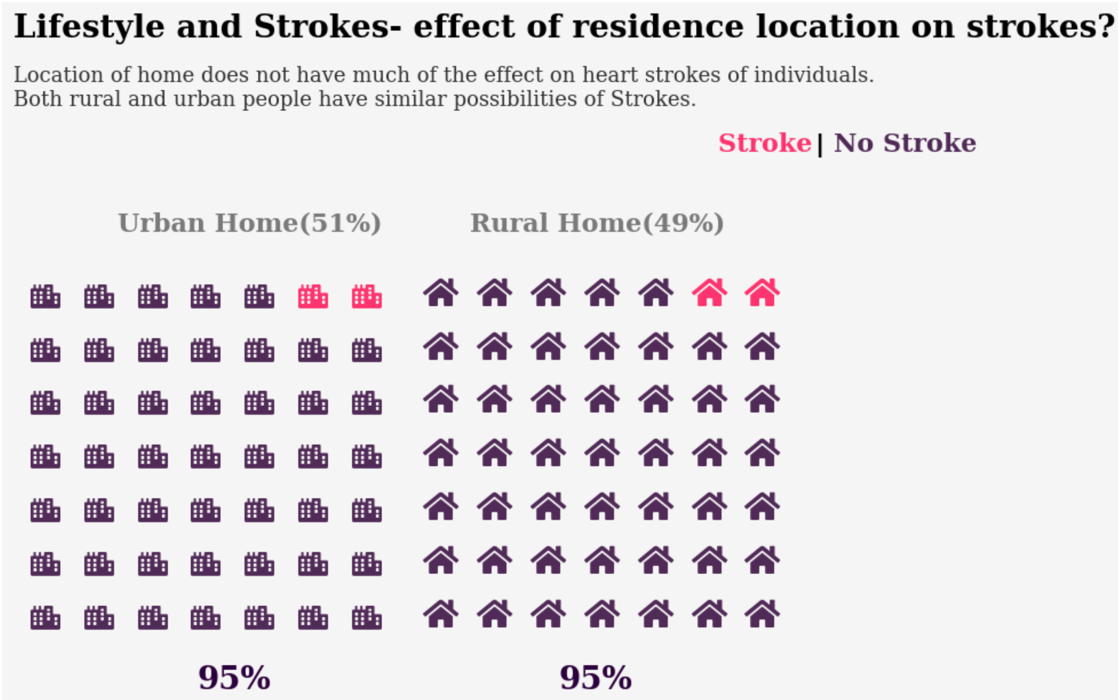
```python
fig.text(0.65, 0.22, 'ooo', {'font':'Serif', 'size':16,'weight':'bold', 'color':
↪'#f6f5f5'})
fig.text(0.25, 0.28, '{}%'.format(healthy_yes), {'font':'Serif', 'size':
↪20,'weight':'bold' , 'color':'#2c003e'}, alpha = 1,)
fig.text(0.65, 0.28, '{}%'.format(healthy_no), {'font':'Serif', 'size':
↪20,'weight':'bold', 'color':'#2c003e'}, alpha = 1)
fig.text(0.20, 0.68, 'Married({}%)'.format(yes_per), {'font':'Serif', 'size':
↪16,'weight':'bold' ,'color':'black'},alpha = 0.5,)
fig.text(0.58, 0.68, "Unmarried({}%)".format(no_per), {'font':'Serif', 'size':
↪16,'weight':'bold', 'color':'black'}, alpha = 0.5)
#fig.text(0., 0.8, 'Assumption was proven wrong', {'font':'Serif', 'size':24,␣
↪'color':'black', 'weight':'bold'})

fig.text(0.9,0.72, 'Stroke ', {'font': 'Serif','weight':'bold','Size':␣
↪'16','weight':'bold','style':'normal', 'color':'#fe346e'})
fig.text(1.02,0.72, '|', {'color':'black' , 'size':'16', 'weight': 'bold'})
fig.text(1.04,0.72, 'No Stroke', {'font': 'Serif','weight':'bold', 'Size':␣
↪'16','style':'normal', 'weight':'bold','color':'#512b58'},alpha = 1)



fig.show()
```



[ ]:

```
stroke_home = df[df['stroke'] == 1]['Residence_type'].value_counts()
healthy_home= df[df['stroke'] == 0]['Residence_type'].value_counts()

urban = df['Residence_type'].value_counts().values[0]
rural =  df['Residence_type'].value_counts().values[1]

stroke_urban = int(round (stroke_home.values[0] / urban * 100, 0))
stroke_rural= int(round( stroke_home.values[1] / rural *100, 0))
healthy_urban = int(round(healthy_home.values[0] / urban * 100, 0))
healthy_rural = int(round(healthy_home.values[1] / rural *100, 0))

urban_per = int(round(urban/(urban+rural) * 100, 0))
rural_per = int(round(rural/(urban+rural)* 100, 0))




fig = plt.figure(FigureClass = Waffle,
                 constrained_layout = True,
                 figsize = (7,10),
                 facecolor = '#f6f5f5',dpi = 100,

                 plots = {'121':
                          {
                           'rows':7,
                           'columns': 7,
                           'values' : [stroke_urban,healthy_urban],
                            'colors' : ['#fe346e','#512b58'],
                              'vertical' : True,
                              'interval_ratio_x': 0.005,
                              'interval_ratio_y': 0.005,
                              'icons' : 'city',
                              'icon_legend': False,
                              'icon_size':15,
                              'plot_anchor':'C',
                              'alpha':0.8,
                              'starting_location': 'NE'
                          },

                          '122' :
                          {
                            'rows': 7,
                            'columns':7,
                            'values':[stroke_rural,healthy_rural],
                              'colors' : ['#fe346e','#512b58'],
                              'vertical': True,
                              'interval_ratio_x': 0.005,
```

```
                              'interval_ratio_y':0.005,
                              'icons' : 'home',
                              'icon_legend' :False,
                              'icon_size':20,
                              'plot_anchor':'C',
                              'alpha':0.8,
                              'starting_location': 'NE'

                           }
                         },

)



fig.text(0., 0.85, 'Lifestyle and Strokes- effect of residence location on␣
 ↪strokes?', {'font':'Serif', 'size':20, 'color':'black', 'weight':'bold'})
fig.text(0., 0.79, 'Location of home does not have much of the effect on heart␣
 ↪strokes of individuals.\nBoth rural and urban people have similar␣
 ↪possibilities of Strokes.', {'font':'Serif', 'size':13, 'color':'black',␣
 ↪'weight':'normal'}, alpha =0.8)

fig.text(0.23, 0.28, '{}%'.format(healthy_urban), {'font':'Serif', 'size':
 ↪20,'weight':'bold' ,'color':'#2c003e'},alpha = 1,)
fig.text(0.68, 0.28, '{}%'.format(healthy_rural), {'font':'Serif', 'size':
 ↪20,'weight':'bold', 'color':'#2c003e'}, alpha = 1)
fig.text(0.13, 0.68, 'Urban Home({}%)'.format(urban_per), {'font':'Serif',␣
 ↪'size':16,'weight':'bold' ,'color':'black'},alpha = 0.5,)
fig.text(0.57, 0.68, "Rural Home({}%)".format(rural_per), {'font':'Serif',␣
 ↪'size':16,'weight':'bold', 'color':'black'}, alpha = 0.5)
#fig.text(0., 0.8, 'Assumption was proven wrong', {'font':'Serif', 'size':24,␣
 ↪'color':'black', 'weight':'bold'})

fig.text(0.88,0.75, 'Stroke ', {'font': 'Serif','weight':'bold','Size':␣
 ↪'16','weight':'bold','style':'normal', 'color':'#fe346e'})
fig.text(1,0.75, '|', {'color':'black' , 'size':'16', 'weight': 'bold'})
fig.text(1.025,0.75, 'No Stroke', {'font': 'Serif','weight':'bold', 'Size':␣
 ↪'16','style':'normal', 'weight':'bold','color':'#512b58'},alpha = 1)


fig.show()
```



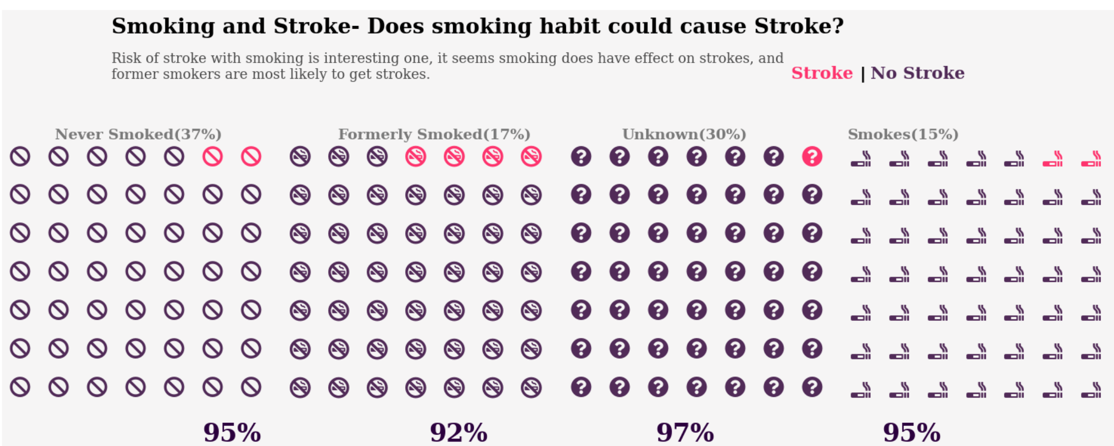

[ ]:

```python
smoke = df['smoking_status'].value_counts()
stroke_smoke = df[df['stroke'] == 1]['smoking_status'].value_counts()
healthy_smoke = df[df['stroke'] == 0]['smoking_status'].value_counts()

never = smoke.values[0]
unknown =  smoke.values[1]
former = smoke.values[2]
smokes = smoke.values[3]

stroke_never = int(round (stroke_smoke.values[0] / never * 100, 0))
stroke_unknown = int(round( stroke_smoke.values[2]  / unknown *100, 0))
stroke_former = int(round (stroke_smoke.values[1]  / former * 100, 0))
stroke_smokes = int(round( stroke_smoke.values[3]  / smokes *100, 0))

healthy_never = int(round(healthy_smoke.values[0] / never * 100, 0))
healthy_unknown = int(round(healthy_smoke.values[1] / unknown *100, 0))
healthy_former = int(round(healthy_smoke.values[2] / former * 100, 0))
healthy_smokes = int(round(healthy_smoke.values[3]/ smokes *100, 0))


never_per = int(round(never/(never+unknown+former+smokes) * 100, 0))
unknown_per = int(round(unknown/(never+unknown+former+smokes)* 100, 0))
former_per = int(round(former/(never+unknown+former+smokes) * 100, 0))
smokes_per = int(round(smokes/(never+unknown+former+smokes)* 100, 0))
```

```
fig = plt.figure(FigureClass = Waffle,
                 constrained_layout = True,
                 figsize = (15,20),
                 facecolor = '#f6f5f5',dpi = 100,

                 plots = {'141':
                          {
                           'rows':7,
                           'columns': 7,
                           'values' : [stroke_never,healthy_never],
                            'colors' : ['#fe346e','#512b58'],
                              'vertical' : True,
                              'interval_ratio_x': 0.005,
                              'interval_ratio_y': 0.005,
                              'icons' : 'ban',
                              'icon_legend': False,
                              'icon_size':20,
                              'plot_anchor':'C',
                              'alpha':0.8,
                              'starting_location': 'NE'
                          },

                          '142' :
                          {
                            'rows': 7,
                            'columns':7,
                            'values':[stroke_former,healthy_former],
                              'colors' : ['#fe346e','#512b58'],
                              'vertical': True,
                              'interval_ratio_x': 0.005,
                              'interval_ratio_y':0.005,
                              'icons' : 'smoking-ban',
                              'icon_legend' :False,
                              'icon_size':20,
                              'plot_anchor':'C',
                              'alpha':0.8,
                              'starting_location': 'NE'

                           },

                          '143':
                          {
                           'rows':7,
                           'columns': 7,
```

```
                        'values' : [stroke_unknown,healthy_unknown],
                         'colors' : ['#fe346e','#512b58'],
                           'vertical' : True,
                           'interval_ratio_x': 0.005,
                           'interval_ratio_y': 0.005,
                           'icons' : 'question-circle',
                           'icon_legend': False,
                           'icon_size':20,
                           'plot_anchor':'C',
                           'alpha':0.8,
                           'starting_location': 'NE'
                       },

                       '144' :
                       {
                         'rows': 7,
                         'columns':7,
                         'values':[stroke_smokes,healthy_smokes],
                           'colors' : ['#fe346e','#512b58'],
                           'vertical': True,
                           'interval_ratio_x': 0.006,
                           'interval_ratio_y':0.006,
                           'icons' : 'smoking',
                           'icon_legend' :False,
                           'icon_size':15,
                           'plot_anchor':'C',
                           'alpha':0.8,
                           'starting_location': 'NE'

                        }

                      },

)


fig.text(0.1, 0.65, 'Smoking and Stroke- Does smoking habit could cause Stroke?
 ↪', {'font':'Serif', 'size':20, 'color':'black', 'weight':'bold'})
fig.text(0.1, 0.62, 'Risk of stroke with smoking is interesting one, it seems␣
 ↪smoking does have effect on strokes, and \nformer smokers are most likely to␣
 ↪get strokes. ', {'font':'Serif', 'size':13, 'color':'black', 'weight':
 ↪'normal'}, alpha = 0.7)
fig.text(0.18, 0.38, '{}%'.format(healthy_never), {'font':'Serif', 'size':
 ↪24,'weight':'bold' ,'color':'#2c003e'},alpha = 1,)
fig.text(0.38, 0.38, '{}%'.format(healthy_former), {'font':'Serif', 'size':
 ↪24,'weight':'bold', 'color':'#2c003e'}, alpha = 1)
```

```
fig.text(0.58, 0.38, '{}%'.format(healthy_unknown), {'font':'Serif', 'size':24,'weight':'bold' ,'color':'#2c003e'},alpha = 1,)
fig.text(0.78, 0.38, '{}%'.format(healthy_smokes), {'font':'Serif', 'size':24,'weight':'bold', 'color':'#2c003e'}, alpha = 1)
fig.text(0.05, 0.58, 'Never Smoked({}%)'.format(never_per), {'font':'Serif', 'size':14,'weight':'bold' ,'color':'black'},alpha = 0.5,)
fig.text(0.30, 0.58, "Formerly Smoked({}%)".format(former_per), {'font':'Serif', 'size':14,'weight':'bold', 'color':'black'}, alpha = 0.5)
fig.text(0.55, 0.58, 'Unknown({}%)'.format(unknown_per), {'font':'Serif', 'size':14,'weight':'bold' ,'color':'black'},alpha = 0.5,)
fig.text(0.75, 0.58, "Smokes({}%)".format(smokes_per), {'font':'Serif', 'size':14,'weight':'bold', 'color':'black'}, alpha = 0.5)
#fig.text(0., 0.8, 'Assumption was proven wong', {'font':'Serif', 'size':24, 'color':'black', 'weight':'bold'})

fig.text(0.7,0.62, 'Stroke ', {'font': 'Serif','weight':'bold','Size': '16','weight':'bold','style':'normal', 'color':'#fe346e'})
fig.text(0.76,0.62, '|', {'color':'black' , 'size':'16', 'weight': 'bold'})
fig.text(0.77,0.62, 'No Stroke', {'font': 'Serif','weight':'bold', 'Size': '16','style':'normal', 'weight':'bold','color':'#512b58'},alpha = 1)



fig.show()
```



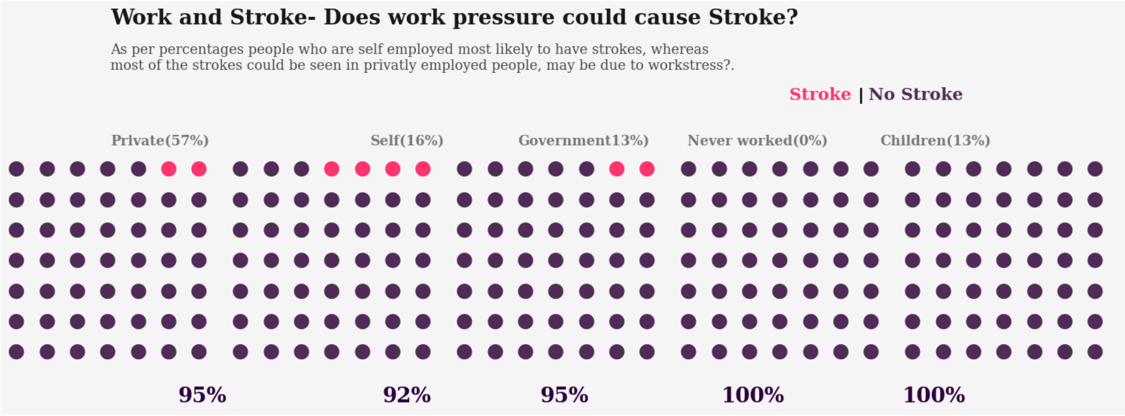

[ ]:
```
work = df['work_type'].value_counts()
stroke_work = df[df['stroke'] == 1]['work_type'].value_counts()
healthy_work = df[df['stroke'] == 0]['work_type'].value_counts()

private = work.values[0]
self =  work.values[1]
child = work.values[2]
```

```
gov = work.values[3]
never = work.values[4]

stroke_private = int(round (stroke_work.values[0] / private * 100, 0))
stroke_self = int(round( stroke_work.values[1]  / self *100, 0))
stroke_child = int(round (stroke_work.values[3]  / child * 100, 0))
stroke_gov = int(round( stroke_work.values[2]  / gov *100, 0))
stroke_never = int(round( 0, 0))

healthy_private = int(round(healthy_work.values[0] / private * 100, 0))
healthy_self = int(round(healthy_work.values[1] / self *100, 0))
healthy_child = int(round(healthy_work.values[2] / child * 100, 0))
healthy_gov = int(round(healthy_work.values[3]/ gov *100, 0))
healthy_never = int(round(healthy_work.values[4]/ never *100, 0))

private_per = int(round(private/(private+self+child+gov+never) * 100, 0))
self_per = int(round(self/(private+self+child+gov+never)* 100, 0))
child_per = int(round(child/(private+self+child+gov+never) * 100, 0))
gov_per = int(round(gov/(private+self+child+gov+never)* 100, 0))
never_per = int(round(never/(private+self+child+gov+never)* 100, 0))


fig = plt.figure(FigureClass = Waffle,
                 constrained_layout = True,
                 figsize = (15,20),
                 facecolor = '#f6f5f5',dpi = 100,

                 plots = {'151':
                          {
                           'rows':7,
                           'columns': 7,
                           'values' : [stroke_private,healthy_private],
                            'colors' : ['#fe346e','#512b58'],
                              'vertical' : True,
                              'interval_ratio_x': 0.005,
                              'interval_ratio_y': 0.005,
                              'icons' : 'circle',
                              'icon_legend': False,
                              'icon_size':15,
                              'plot_anchor':'C',
                              'alpha':0.2,
                              'starting_location': 'NE'
                          },

                          '152' :
                          {
                            'rows': 7,
```

```
                'columns':7,
                'values':[stroke_self,healthy_self],
                  'colors' : ['#fe346e','#512b58'],
                  'vertical': True,
                  'interval_ratio_x': 0.005,
                  'interval_ratio_y':0.005,
                  'icons' : 'circle',
                  'icon_legend' :False,
                  'icon_size':15,
                  'plot_anchor':'C',
                  'alpha':0.2,
                  'starting_location': 'NE'

               },

              '153':
              {
               'rows':7,
               'columns': 7,
               'values' : [stroke_gov,healthy_gov],
                'colors' : ['#fe346e','#512b58'],
                  'vertical' : True,
                  'interval_ratio_x': 0.005,
                  'interval_ratio_y': 0.005,
                  'icons' : 'circle',
                  'icon_legend': False,
                  'icon_size':15,
                  'plot_anchor':'C',
                  'alpha':0.2,
                  'starting_location': 'NE'
              },

              '154' :
              {
                'rows': 7,
                'columns':7,
                'values':[stroke_never,healthy_never],
                  'colors' : ['#fe346e','#512b58'],
                  'vertical': True,
                  'interval_ratio_x': 0.006,
                  'interval_ratio_y':0.006,
                  'icons' : 'circle',
                  'icon_legend' :False,
                  'icon_size':15,
                  'plot_anchor':'C',
                  'alpha':0.2,
                  'starting_location': 'NE'
```

```
                          },

                         '155' :
                         {
                           'rows': 7,
                           'columns':7,
                           'values':[stroke_child,healthy_child],
                             'colors' : ['#fe346e','#512b58'],
                             'vertical': True,
                             'interval_ratio_x': 0.006,
                             'interval_ratio_y':0.006,
                             'icons' : 'circle',
                             'icon_legend' :False,
                             'icon_size':15,
                             'plot_anchor':'C',
                             'alpha':0.2,
                             'starting_location': 'NE'

                          }

                        },

)


fig.text(0.1, 0.65, 'Work and Stroke- Does work pressure could cause Stroke?',␣
 ↪{'font':'Serif', 'size':20, 'color':'black', 'weight':'bold'},alpha = 0.9)
fig.text(0.1, 0.62, 'As per percentages people who are self employed most␣
 ↪likely to have strokes, whereas \nmost of the strokes could be seen in␣
 ↪privatly employed people, may be due to workstress?.', {'font':'Serif',␣
 ↪'size':13, 'color':'black', 'weight':'normal'}, alpha = 0.7)
fig.text(0.16, 0.40, '{}%'.format(healthy_private), {'font':'Serif', 'size':
 ↪20,'weight':'bold' ,'color':'#2c003e'},alpha = 1,)
fig.text(0.34, 0.40, '{}%'.format(healthy_self), {'font':'Serif', 'size':
 ↪20,'weight':'bold', 'color':'#2c003e'}, alpha = 1)
fig.text(0.48, 0.40, '{}%'.format(healthy_gov), {'font':'Serif', 'size':
 ↪20,'weight':'bold' ,'color':'#2c003e'},alpha = 1,)
fig.text(0.64, 0.40, '{}%'.format(healthy_never), {'font':'Serif', 'size':
 ↪20,'weight':'bold', 'color':'#2c003e'}, alpha = 1)
fig.text(0.8, 0.40, '{}%'.format(healthy_child), {'font':'Serif', 'size':
 ↪20,'weight':'bold', 'color':'#2c003e'}, alpha = 1)


fig.text(0.10, 0.57, 'Private({}%)'.format(private_per), {'font':'Serif',␣
 ↪'size':13,'weight':'bold' ,'color':'black'},alpha = 0.5,)
```

```
fig.text(0.33, 0.57, "Self({}%)".format(self_per), {'font':'Serif', 'size':
 ↪13,'weight':'bold', 'color':'black'}, alpha = 0.5)
fig.text(0.46, 0.57, 'Government{}%)'.format(gov_per), {'font':'Serif', 'size':
 ↪13,'weight':'bold' ,'color':'black'},alpha = 0.5,)
fig.text(0.61, 0.57, "Never worked({}%)".format(never_per), {'font':'Serif',␣
 ↪'size':13,'weight':'bold', 'color':'black'}, alpha = 0.5)
fig.text(0.78, 0.57, "Children({}%)".format(child_per), {'font':'Serif', 'size':
 ↪13,'weight':'bold', 'color':'black'}, alpha = 0.5)
#fig.text(0., 0.8, 'Assumption was proven wong', {'font':'Serif', 'size':24,␣
 ↪'color':'black', 'weight':'bold'})

fig.text(0.7,0.6, 'Stroke ', {'font': 'Serif','weight':'bold','Size':␣
 ↪'16','weight':'bold','style':'normal', 'color':'#fe346e'})
fig.text(0.76,0.6, '|', {'color':'black' , 'size':'16', 'weight': 'bold'})
fig.text(0.77,0.6, 'No Stroke', {'font': 'Serif','weight':'bold', 'Size':␣
 ↪'16','style':'normal', 'weight':'bold','color':'#512b58'},alpha = 1)


fig.show()
```

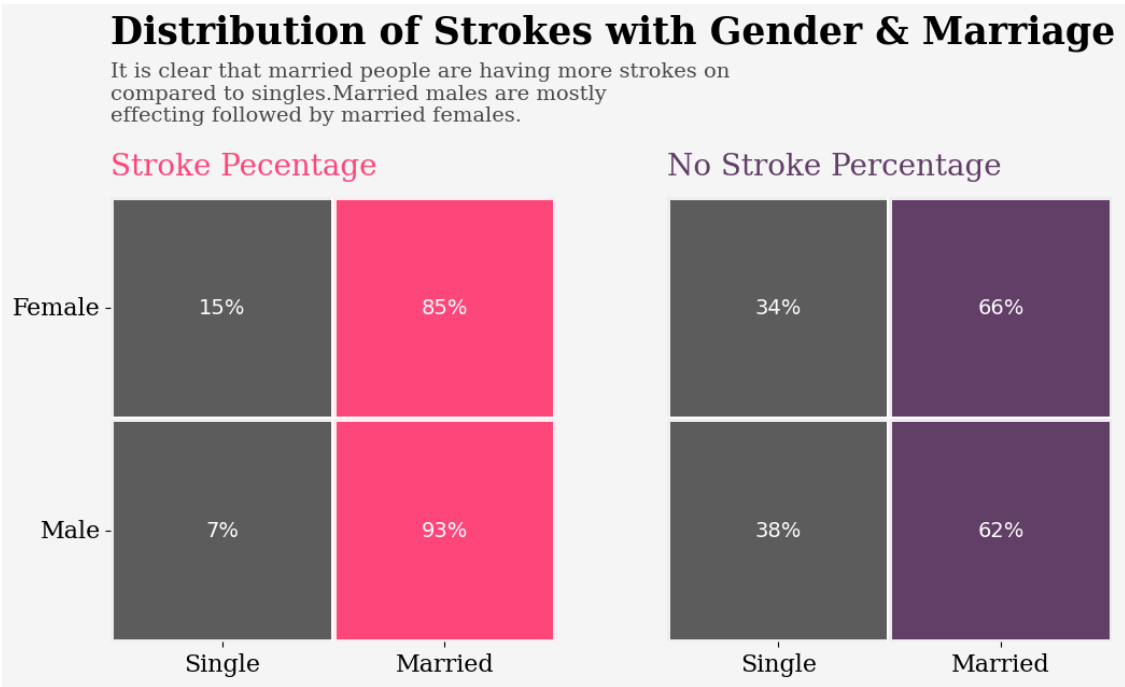



[ ]:

```
fig = plt.figure(figsize=(12,6),dpi = 100)
gs = fig.add_gridspec(1,2)
gs.update(wspace=0.25, hspace=0.5)

ax0 = fig.add_subplot(gs[0,0])
ax1 = fig.add_subplot(gs[0,1])

fig.patch.set_facecolor('#f6f5f5')
ax0.set_facecolor('#f6f5f5')
ax1.set_facecolor('#f6f5f5')
```

```
# ever_married, gender, residence, heart_disease and work_type

healthy = df[df['stroke']==0]
stroke = df[df['stroke']==1]


col1 = ["#4b4b4c","#fe346e"]
colormap1 = matplotlib.colors.LinearSegmentedColormap.from_list("", col1, N =
↪256)
col2 = ["#4b4b4c","#512b58"]
colormap2 = matplotlib.colors.LinearSegmentedColormap.from_list("", col2)

stroke = pd.
↪crosstab(stroke['gender'],[stroke['ever_married']],normalize='index')
no_stroke = pd.crosstab(healthy['gender'],[healthy['ever_married']],
↪normalize='index')

sns.heatmap(ax=ax0, data=stroke, linewidths= 0,
            square=True, cbar_kws={"orientation": "horizontal"},
↪cbar=False,linewidth=3, cmap = col1,annot=True, fmt='1.
↪0%',annot_kws={"fontsize":14}, alpha = 0.9)

sns.heatmap(ax=ax1, data=no_stroke[0:-1], linewidths=0,
            square=True, cbar_kws={"orientation": "horizontal"},
↪cbar=False,linewidth=3, cmap = col2,annot=True, fmt='1.
↪0%',annot_kws={"fontsize":14}, alpha = 0.9)


ax0.text(0, -0.69, 'Distribution of Strokes with Gender & Marriage', {'font':
↪'Serif', 'color':'black', 'weight':'bold','size':25})
ax0.text(0, -0.34, 'It is clear that married people are having more strokes on
↪\ncompared to singles.Married males are mostly \neffecting followed by
↪married females.', {'font':'Serif', 'color':'black','size':14}, alpha = 0.7)

ax0.text(0,-0.1,'Stroke Pecentage ', {'font':'serif', 'color':"#fe346e", 'size':
↪20},alpha = 0.9)
ax1.text(0,-0.1,'No Stroke Percentage', {'font':'serif', 'color':"#512b58",
↪'size':20}, alpha =0.9)

ax0.axes.set_xticklabels(['Single', 'Married'], {'font':'serif', 'color':
↪'black', 'size':16})
ax1.axes.set_xticklabels(['Single', 'Married'], {'font':'serif', 'color':
↪'black', 'size':16})

ax0.axes.set_yticklabels(['Female', 'Male'], {'font':'serif', 'color':'black',
↪'size':16}, rotation = 0)
```

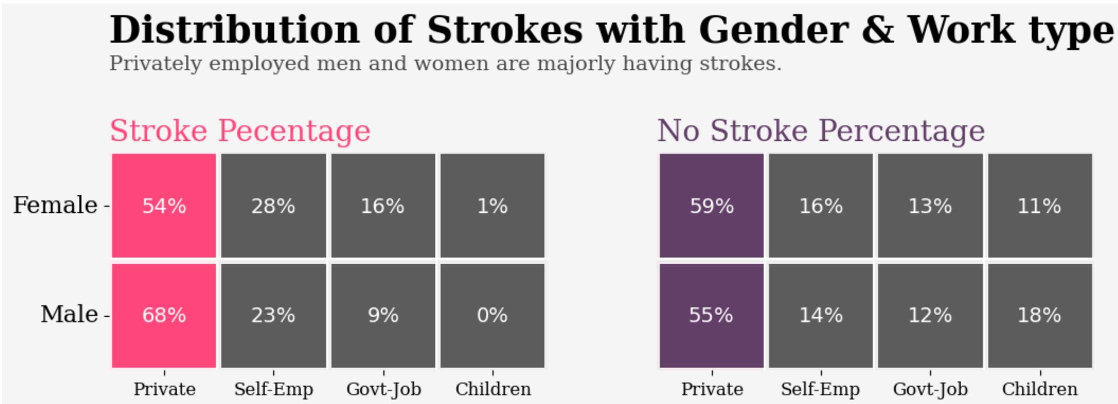
```
ax0.set_xlabel('')
ax0.set_ylabel('')
ax1.set_xlabel('')
ax1.set_ylabel('')
ax1.axes.get_yaxis().set_visible(False)
fig.show()
```




[ ]:
```
fig = plt.figure(figsize=(12,6), dpi = 100)
gs = fig.add_gridspec(1,2)
gs.update(wspace=0.25, hspace=0.5)

ax0 = fig.add_subplot(gs[0,0])
ax1 = fig.add_subplot(gs[0,1])

fig.patch.set_facecolor('#f6f5f5')
ax0.set_facecolor('#f6f5f5')
ax1.set_facecolor('#f6f5f5')


# ever_married, gender, residence, heart_disease and work_type

healthy = df[df['stroke']==0]
stroke = df[df['stroke']==1]
```

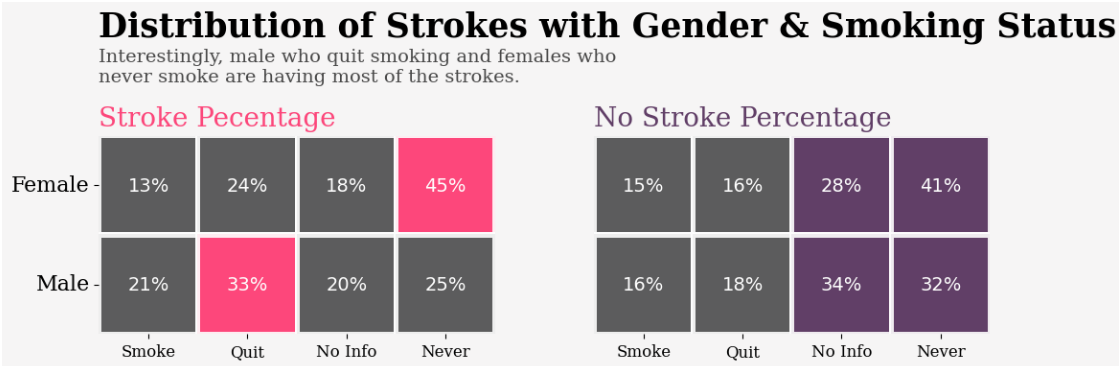
```
gender_order = ['Female','Male']
work_order = ['Private', 'Self-employed','Govt_job', 'children']


col1 = ["#4b4b4c","#fe346e"]
colormap1 = matplotlib.colors.LinearSegmentedColormap.from_list("", col1, N =␣
↪256)
col2 = ["#4b4b4c","#512b58"]
colormap2 = matplotlib.colors.LinearSegmentedColormap.from_list("", col2)

stroke = pd.crosstab(stroke['gender'],[stroke['work_type']],normalize='index').
↪loc[gender_order,work_order]
no_stroke = pd.crosstab(healthy['gender'],[healthy['work_type']],␣
↪normalize='index').loc[gender_order,work_order]

sns.heatmap(ax=ax0, data=stroke, linewidths= 0,
            square=True, cbar_kws={"orientation": "horizontal"},␣
↪cbar=False,linewidth=3, cmap = col1,annot=True, fmt='1.
↪0%',annot_kws={"fontsize":14}, alpha = 0.9)

sns.heatmap(ax=ax1, data=no_stroke, linewidths=0,
            square=True, cbar_kws={"orientation": "horizontal"},␣
↪cbar=False,linewidth=3, cmap = col2,annot=True, fmt='1.
↪0%',annot_kws={"fontsize":14}, alpha = 0.9)


ax0.text(0, -1., 'Distribution of Strokes with Gender & Work type', {'font':
↪'Serif', 'color':'black', 'weight':'bold','size':25})
ax0.text(0, -0.75, 'Privately employed men and women are majorly having strokes.
↪', {'font':'Serif', 'color':'black','size':14}, alpha = 0.7)

ax0.text(0,-0.1,'Stroke Pecentage ', {'font':'serif', 'color':"#fe346e", 'size':
↪20},alpha = 0.9)
ax1.text(0,-0.1,'No Stroke Percentage', {'font':'serif', 'color':"#512b58",␣
↪'size':20}, alpha =0.9)

ax0.axes.set_xticklabels(['Private', 'Self-Emp','Govt-Job', 'Children'],␣
↪{'font':'serif', 'color':'black', 'size':12})
ax1.axes.set_xticklabels(['Private', 'Self-Emp','Govt-Job', 'Children'],␣
↪{'font':'serif', 'color':'black', 'size':12})

ax0.axes.set_yticklabels(gender_order, {'font':'serif', 'color':'black', 'size':
↪16}, rotation = 0)

ax0.set_xlabel('')
ax0.set_ylabel('')
```

```
ax1.set_xlabel('')
ax1.set_ylabel('')
ax1.axes.get_yaxis().set_visible(False)
fig.show()
```



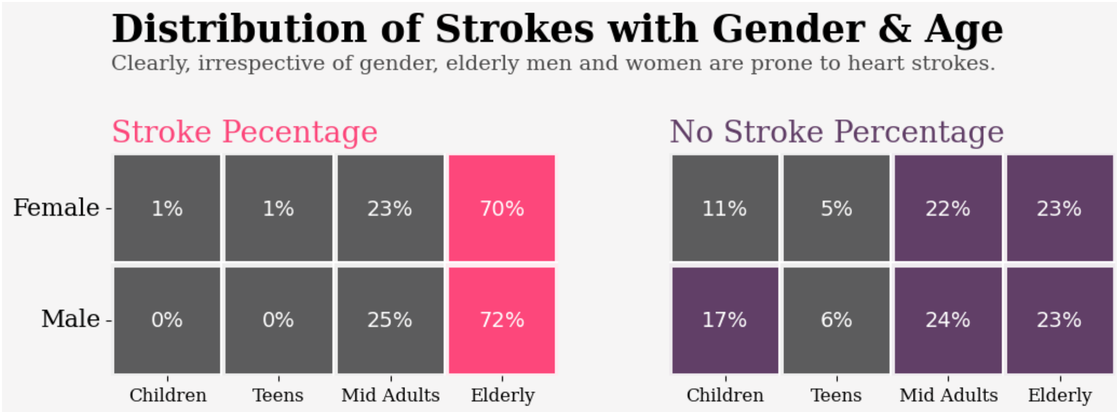

[ ]:
```
fig = plt.figure(figsize=(12,6), dpi = 100)
gs = fig.add_gridspec(1,2)
gs.update(wspace=0.25, hspace=0.5)

ax0 = fig.add_subplot(gs[0,0])
ax1 = fig.add_subplot(gs[0,1])

fig.patch.set_facecolor('#f6f5f5')
ax0.set_facecolor('#f6f5f5')
ax1.set_facecolor('#f6f5f5')


# ever_married, gender, residence, heart_disease and work_type

healthy = df[df['stroke']==0]
stroke = df[df['stroke']==1]

gender_order = ['Female','Male']
smoking_order = ['smokes', 'formerly smoked', 'Unknown', 'never smoked']


col1 = ["#4b4b4c","#fe346e"]
colormap1 = matplotlib.colors.LinearSegmentedColormap.from_list("", col1, N =
↪256)
col2 = ["#4b4b4c","#512b58"]
colormap2 = matplotlib.colors.LinearSegmentedColormap.from_list("", col2)
```

```
stroke = pd.
↪crosstab(stroke['gender'],[stroke['smoking_status']],normalize='index').
↪loc[gender_order,smoking_order]
no_stroke = pd.crosstab(healthy['gender'],[healthy['smoking_status']],␣
↪normalize='index').loc[gender_order,smoking_order]

sns.heatmap(ax=ax0, data=stroke, linewidths= 0,
            square=True, cbar_kws={"orientation": "horizontal"},␣
↪cbar=False,linewidth=3, cmap = col1,annot=True, fmt='1.
↪0%',annot_kws={"fontsize":14}, alpha = 0.9)

sns.heatmap(ax=ax1, data=no_stroke, linewidths=0,
            square=True, cbar_kws={"orientation": "horizontal"},␣
↪cbar=False,linewidth=3, cmap = col2,annot=True, fmt='1.
↪0%',annot_kws={"fontsize":14}, alpha = 0.9)


ax0.text(0, -1., 'Distribution of Strokes with Gender & Smoking Status',␣
↪{'font':'Serif', 'color':'black', 'weight':'bold','size':25})
ax0.text(0, -0.55, 'Interestingly, male who quit smoking and females who␣
↪\nnever smoke are having most of the strokes.', {'font':'Serif', 'color':
↪'black','size':14}, alpha = 0.7)

ax0.text(0,-0.1,'Stroke Pecentage ', {'font':'serif', 'color':"#fe346e", 'size':
↪20},alpha = 0.9)
ax1.text(0,-0.1,'No Stroke Percentage', {'font':'serif', 'color':"#512b58",␣
↪'size':20}, alpha =0.9)

ax0.axes.set_xticklabels(['Smoke', 'Quit','No Info', 'Never'], {'font':'serif',␣
↪'color':'black', 'size':12})
ax1.axes.set_xticklabels(['Smoke', 'Quit','No Info', 'Never'], {'font':'serif',␣
↪'color':'black', 'size':12})

ax0.axes.set_yticklabels(gender_order, {'font':'serif', 'color':'black', 'size':
↪16}, rotation = 0)

ax0.set_xlabel('')
ax0.set_ylabel('')
ax1.set_xlabel('')
ax1.set_ylabel('')
ax1.axes.get_yaxis().set_visible(False)
fig.show()
```



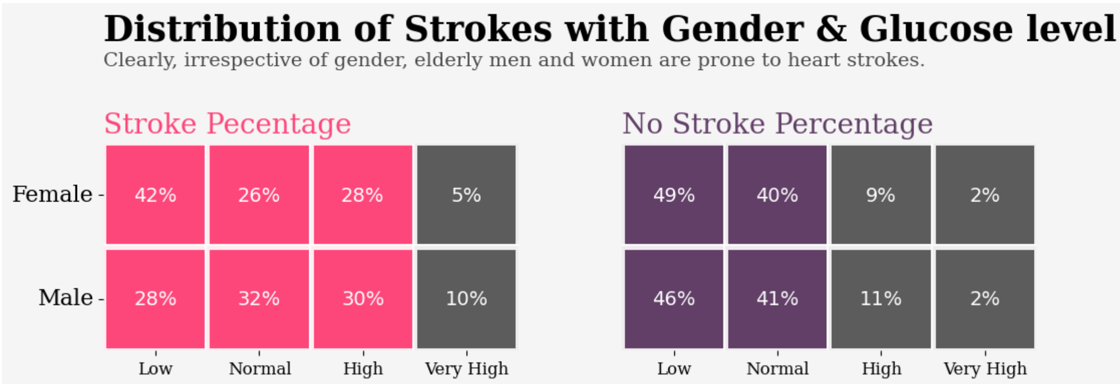

[ ]:
```
fig = plt.figure(figsize=(12,6), dpi = 100)
gs = fig.add_gridspec(1,2)
gs.update(wspace=0.25, hspace=0.5)

ax0 = fig.add_subplot(gs[0,0])
ax1 = fig.add_subplot(gs[0,1])

fig.patch.set_facecolor('#f6f5f5')
ax0.set_facecolor('#f6f5f5')
ax1.set_facecolor('#f6f5f5')


# ever_married, gender, residence, heart_disease and work_type

healthy = df[df['stroke']==0]
stroke = df[df['stroke']==1]

gender_order = ['Female','Male']
age_order = ['Children', 'Teens', 'Mid Adults', 'Elderly']


col1 = ["#4b4b4c","#fe346e"]
colormap1 = matplotlib.colors.LinearSegmentedColormap.from_list("", col1, N =␣
↪256)
col2 = ["#4b4b4c","#512b58"]
colormap2 = matplotlib.colors.LinearSegmentedColormap.from_list("", col2)

stroke = pd.crosstab(stroke['gender'],[stroke['age_cat']],normalize='index').
↪loc[gender_order,age_order]
no_stroke = pd.crosstab(healthy['gender'],[healthy['age_cat']],␣
↪normalize='index').loc[gender_order,age_order]

sns.heatmap(ax=ax0, data=stroke, linewidths= 0,
```

```
            square=True, cbar_kws={"orientation": "horizontal"},␣
 ↪cbar=False,linewidth=3, cmap = col1,annot=True, fmt='1.
 ↪0%',annot_kws={"fontsize":14}, alpha = 0.9)

sns.heatmap(ax=ax1, data=no_stroke, linewidths=0,
            square=True, cbar_kws={"orientation": "horizontal"},␣
 ↪cbar=False,linewidth=3, cmap = col2,annot=True, fmt='1.
 ↪0%',annot_kws={"fontsize":14}, alpha = 0.9)


ax0.text(0, -1., 'Distribution of Strokes with Gender & Age', {'font':'Serif',␣
 ↪'color':'black', 'weight':'bold','size':25})
ax0.text(0, -0.75, 'Clearly, irrespective of gender, elderly men and women are␣
 ↪prone to heart strokes.', {'font':'Serif', 'color':'black','size':14}, alpha␣
 ↪= 0.7)

ax0.text(0,-0.1,'Stroke Pecentage ', {'font':'serif', 'color':"#fe346e", 'size':
 ↪20},alpha = 0.9)
ax1.text(0,-0.1,'No Stroke Percentage', {'font':'serif', 'color':"#512b58",␣
 ↪'size':20}, alpha =0.9)

ax0.axes.set_xticklabels(age_order, {'font':'serif', 'color':'black', 'size':
 ↪12})
ax1.axes.set_xticklabels(age_order, {'font':'serif', 'color':'black', 'size':
 ↪12})

ax0.axes.set_yticklabels(gender_order, {'font':'serif', 'color':'black', 'size':
 ↪16}, rotation = 0)

ax0.set_xlabel('')
ax0.set_ylabel('')
ax1.set_xlabel('')
ax1.set_ylabel('')
ax1.axes.get_yaxis().set_visible(False)
fig.show()
```



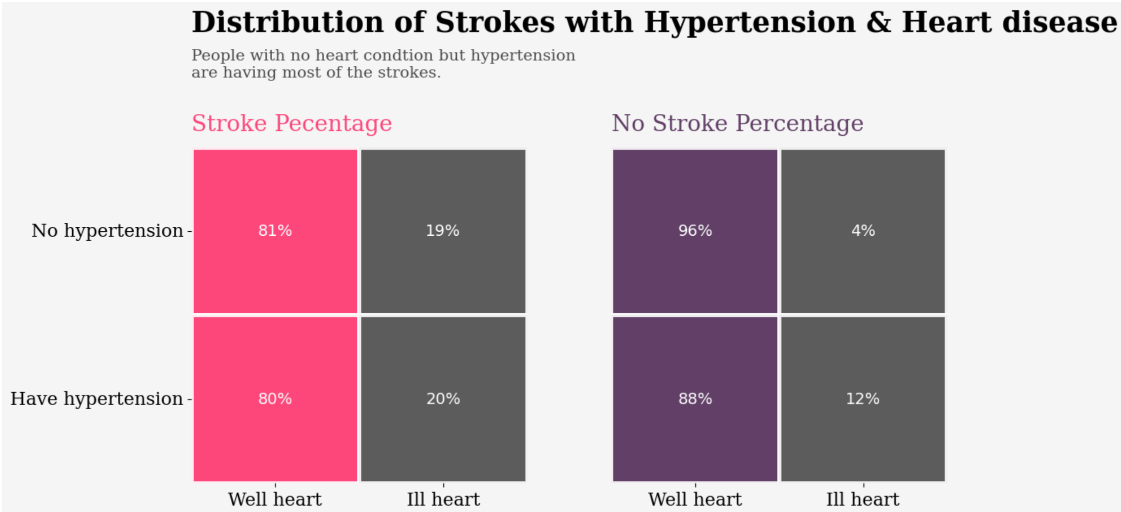

[ ]:
```
fig = plt.figure(figsize=(12,6), dpi = 100)
gs = fig.add_gridspec(1,2)
gs.update(wspace=0.25, hspace=0.5)

ax0 = fig.add_subplot(gs[0,0])
ax1 = fig.add_subplot(gs[0,1])

fig.patch.set_facecolor('#f6f5f5')
ax0.set_facecolor('#f6f5f5')
ax1.set_facecolor('#f6f5f5')


# ever_married, gender, residence, heart_disease and work_type

healthy = df[df['stroke']==0]
stroke = df[df['stroke']==1]

gender_order = ['Female','Male']
glucose_order = ['Low', 'Normal', 'High', 'Very High']


col1 = ["#4b4b4c","#fe346e"]
colormap1 = matplotlib.colors.LinearSegmentedColormap.from_list("", col1, N =␣
↪256)
col2 = ["#4b4b4c","#512b58"]
colormap2 = matplotlib.colors.LinearSegmentedColormap.from_list("", col2)

stroke = pd.
↪crosstab(stroke['gender'],[stroke['glucose_cat']],normalize='index').
↪loc[gender_order,glucose_order]
no_stroke = pd.crosstab(healthy['gender'],[healthy['glucose_cat']],␣
↪normalize='index').loc[gender_order,glucose_order]
```

```
sns.heatmap(ax=ax0, data=stroke, linewidths= 0,
            square=True, cbar_kws={"orientation": "horizontal"},␣
↪cbar=False,linewidth=3, cmap = col1,annot=True, fmt='1.
↪0%',annot_kws={"fontsize":14}, alpha = 0.9)

sns.heatmap(ax=ax1, data=no_stroke, linewidths=0,
            square=True, cbar_kws={"orientation": "horizontal"},␣
↪cbar=False,linewidth=3, cmap = col2,annot=True, fmt='1.
↪0%',annot_kws={"fontsize":14}, alpha = 0.9)


ax0.text(0, -1., 'Distribution of Strokes with Gender & Glucose level', {'font':
↪'Serif', 'color':'black', 'weight':'bold','size':25})
ax0.text(0, -0.75, 'Clearly, irrespective of gender, elderly men and women are␣
↪prone to heart strokes.', {'font':'Serif', 'color':'black','size':14}, alpha␣
↪= 0.7)

ax0.text(0,-0.1,'Stroke Pecentage ', {'font':'serif', 'color':"#fe346e", 'size':
↪20},alpha = 0.9)
ax1.text(0,-0.1,'No Stroke Percentage', {'font':'serif', 'color':"#512b58",␣
↪'size':20}, alpha =0.9)

ax0.axes.set_xticklabels(glucose_order, {'font':'serif', 'color':'black',␣
↪'size':12})
ax1.axes.set_xticklabels(glucose_order, {'font':'serif', 'color':'black',␣
↪'size':12})

ax0.axes.set_yticklabels(gender_order, {'font':'serif', 'color':'black', 'size':
↪16}, rotation = 0)

ax0.set_xlabel('')
ax0.set_ylabel('')
ax1.set_xlabel('')
ax1.set_ylabel('')
ax1.axes.get_yaxis().set_visible(False)
fig.show()
```



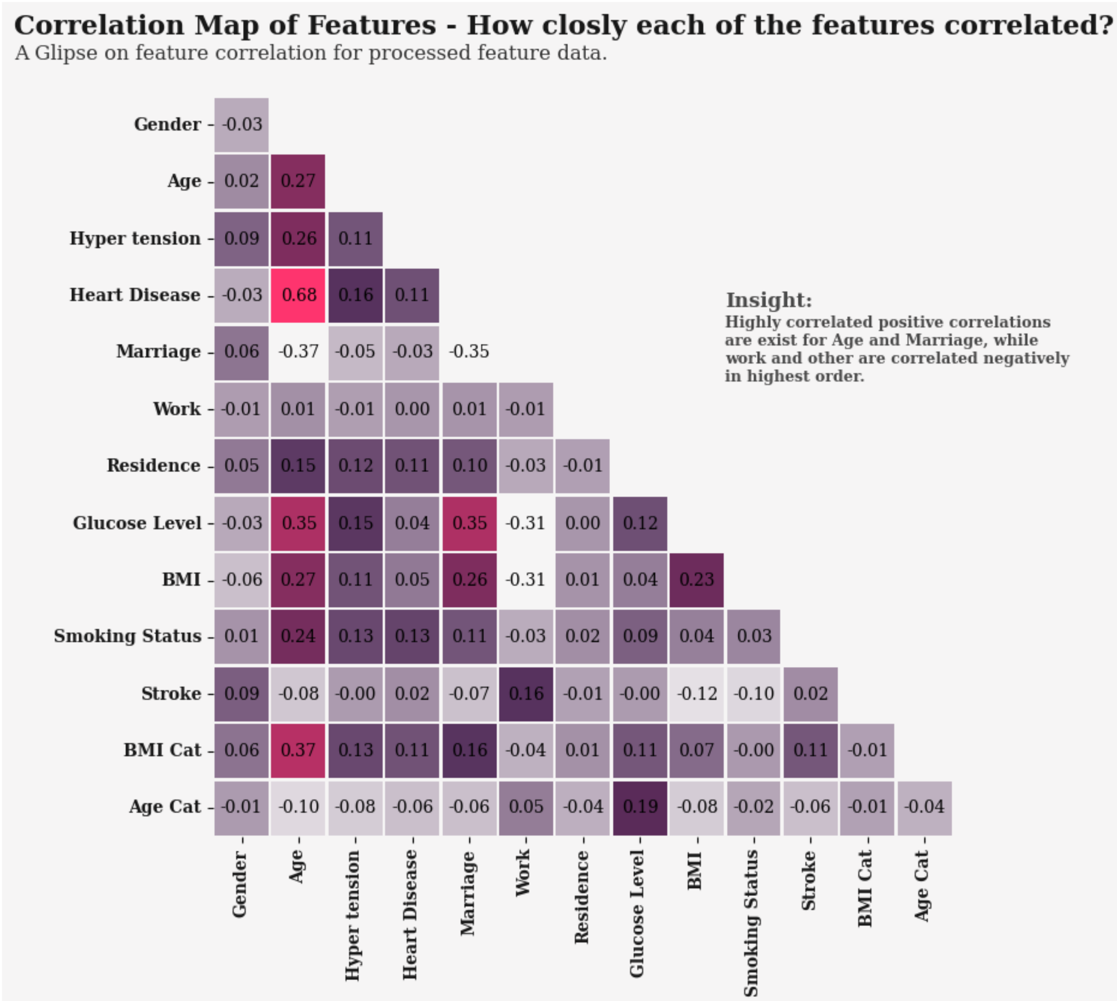

[ ]:
```
fig = plt.figure(figsize=(12,6))
gs = fig.add_gridspec(1,2)
gs.update(wspace=0.25, hspace=0.5)

ax0 = fig.add_subplot(gs[0,0])
ax1 = fig.add_subplot(gs[0,1])

fig.patch.set_facecolor('#f6f5f5')
ax0.set_facecolor('#f6f5f5')
ax1.set_facecolor('#f6f5f5')



# ever_married, gender, residence, heart_disease and work_type

healthy = df[df['stroke']==0]
stroke = df[df['stroke']==1]


col1 = ["#4b4b4c","#fe346e"]
colormap1 = matplotlib.colors.LinearSegmentedColormap.from_list("", col1, N =␣
↪256)
col2 = ["#4b4b4c","#512b58"]
colormap2 = matplotlib.colors.LinearSegmentedColormap.from_list("", col2)

stroke = pd.
↪crosstab(stroke['hypertension'],[stroke['heart_disease']],normalize='index')
no_stroke = pd.crosstab(healthy['hypertension'],[healthy['heart_disease']],␣
↪normalize='index')

sns.heatmap(ax=ax0, data=stroke, linewidths= 0,
            square=True, cbar_kws={"orientation": "horizontal"},␣
↪cbar=False,linewidth=3, cmap = col1,annot=True, fmt='1.
↪0%',annot_kws={"fontsize":14}, alpha = 0.9)
```

```
sns.heatmap(ax=ax1, data=no_stroke, linewidths=0,
            square=True, cbar_kws={"orientation": "horizontal"},␣
↪cbar=False,linewidth=3, cmap = col2,annot=True, fmt='1.
↪0%',annot_kws={"fontsize":14}, alpha = 0.9)


ax0.text(0, -0.69, 'Distribution of Strokes with Hypertension & Heart disease',␣
↪{'font':'Serif', 'color':'black', 'weight':'bold','size':25})
ax0.text(0, -0.42, 'People with no heart condtion but hypertension \nare having␣
↪most of the strokes.', {'font':'Serif', 'color':'black','size':14}, alpha =␣
↪0.7)

ax0.text(0,-0.1,'Stroke Pecentage ', {'font':'serif', 'color':"#fe346e", 'size':
↪20},alpha = 0.9)
ax1.text(0,-0.1,'No Stroke Percentage', {'font':'serif', 'color':"#512b58",␣
↪'size':20}, alpha =0.9)

ax0.axes.set_xticklabels(['Well heart', 'Ill heart'], {'font':'serif', 'color':
↪'black', 'size':16})
ax1.axes.set_xticklabels(['Well heart', 'Ill heart'], {'font':'serif', 'color':
↪'black', 'size':16})

ax0.axes.set_yticklabels(['No hypertension', 'Have hypertension'], {'font':
↪'serif', 'color':'black', 'size':16}, rotation= 0)

ax0.set_xlabel('')
ax0.set_ylabel('')
ax1.set_xlabel('')
ax1.set_ylabel('')
ax1.axes.get_yaxis().set_visible(False)
fig.show()
```



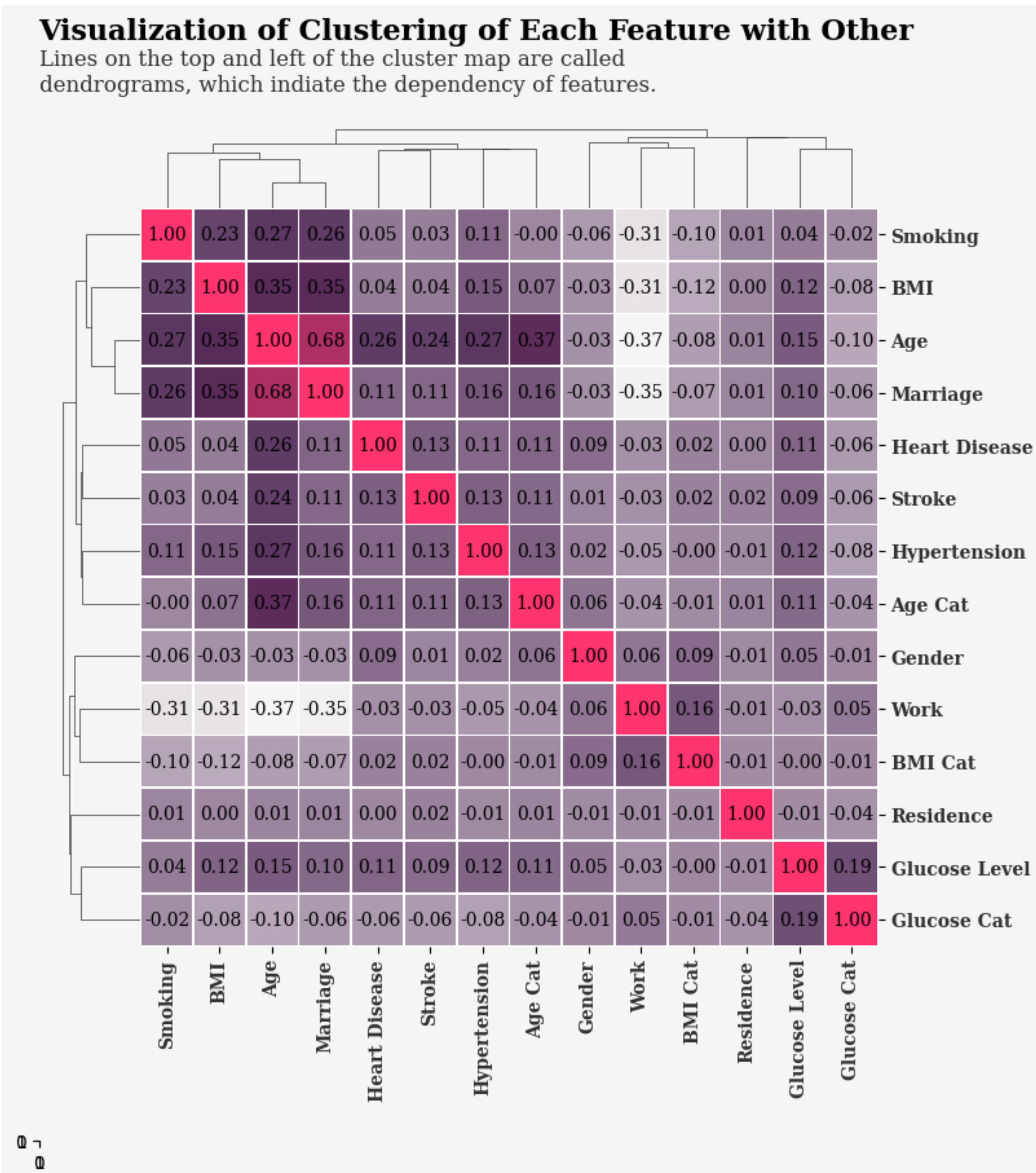

[ ]:
```
df_copy = df.copy()
# feature log transformations

df_copy['age'] = df_copy['age'].apply(lambda x: np.log(x+10)*3)
df_copy['avg_glucose_level'] = df_copy['avg_glucose_level'].apply(lambda x: np.
    ↪log(x+10)*2)
df_copy['bmi'] = df_copy['bmi'].apply(lambda x: np.log(x+10)*2)



# preprocessing - label enconding and numerical value scaling
ohe = OneHotEncoder()
ss = StandardScaler()
le = LabelEncoder()

## label encoding of ordinal categorical features
for col in df_copy.columns:
    df_copy[col] = le.fit_transform(df_copy[col])

cols = df_copy.columns
## normalizing with standard scaler of numerical features
df_copy[cols] = ss.fit_transform(df_copy[cols])


# correlation map for all the features
df_corr = df_copy.drop(columns = ['id']).corr()
mask = np.triu(np.ones_like(df_corr, dtype=bool))

fig, ax = plt.subplots(figsize = (8,8))
fig.patch.set_facecolor('#f6f5f5')
```

```
ax.set_facecolor('#f6f5f5')

mask = mask[1:, :-1]
corr = df_corr.iloc[1:,:-1].copy()


colors = ['#f6f5f5','#512b58','#fe346e']
colormap = matplotlib.colors.LinearSegmentedColormap.from_list("", colors)

# plot heatmap
sns.heatmap(corr, mask=mask, annot=True, fmt=".2f",cmap = colormap,
            vmin=-0.15, vmax=0.5, cbar_kws={"shrink": .5, }, ax = ax, cbar =␣
 ↪False,
            linewidth = 1,linecolor = '#f6f5f5', square = True,annot_kws =␣
 ↪{'font':'serif', 'size':10, 'color':'black'} )
# yticks
ax.tick_params(axis = 'y', rotation=0)
xticks = ['Gender', 'Age','Hyper tension', 'Heart Disease', 'Marriage', 'Work',␣
 ↪'Residence', 'Glucose Level', 'BMI', 'Smoking Status','Stroke','BMI␣
 ↪Cat','Age Cat']
yticks = ['Gender', 'Age','Hyper tension', 'Heart Disease', 'Marriage', 'Work',␣
 ↪'Residence', 'Glucose Level', 'BMI', 'Smoking Status','Stroke','BMI␣
 ↪Cat','Age Cat']
ax.set_xticklabels(xticks, {'font':'serif', 'size':10, 'weight':
 ↪'bold'},rotation = 90, alpha = 0.9)
ax.set_yticklabels(yticks, {'font':'serif', 'size':10, 'weight':'bold'},␣
 ↪rotation = 0, alpha = 0.9)
ax.text(-3.5,-1.1, 'Correlation Map of Features - How closly each of the␣
 ↪features correlated?',{'font':'serif', 'size': 16, 'weight':'bold'}, alpha =␣
 ↪0.9)
ax.text(-3.5,-0.65, 'A Glipse on feature correlation for processed feature data.
 ↪',{'font':'serif', 'size': 12, 'weight':'normal'}, alpha = 0.8)

ax.text(9,5, 'Highly correlated positive correlations \nare exist for Age and␣
 ↪Marriage, while \nwork and other are correlated negatively \nin highest␣
 ↪order.',{'font':'serif', 'size': 9, 'weight':'bold'},alpha = 0.7)
ax.text(9,3.7, 'Insight:',{'font':'serif', 'size': 12, 'weight':'bold'},alpha =␣
 ↪0.7)


fig.show()
```




```
[ ]: labels = ['Smoking', 'BMI','Age', 'Marriage', 'Heart Disease',␣
      ↪'Stroke','Hypertension', 'Age Cat', 'Gender', 'Work', 'BMI Cat',␣
      ↪'Residence','Glucose Level', 'Glucose Cat' ]



     g = sns.clustermap(df_corr, annot = True, fmt = '0.2f',
                        cbar= False, cbar_pos=(0,0, 0,0),linewidth = 0.5,
                        cmap = colormap,dendrogram_ratio=0.1,
                        facecolor = '#f6f5f5', figsize = (8,8),square = True,
                        annot_kws = {'font':'serif', 'size':10, 'color':'black'} )

     plt.gcf().set_facecolor('#f6f5f5')
     label_args = {'font':'serif', 'font':18, 'weight':'bold'}
     plt.setp(g.ax_heatmap.set_yticklabels(labels), rotation=0, fontsize = 10,␣
      ↪fontfamily = 'Serif', fontweight = 'bold', alpha = 0.8)   # For y axis
```

```
plt.setp(g.ax_heatmap.set_xticklabels(labels), rotation=90, fontsize = 10,␣
 ↪fontfamily = 'Serif', fontweight = 'bold', alpha = 0.8) # For x axis
g.fig.text(0,1.065,'Visualization of Clustering of Each Feature with␣
 ↪Other',{'font':'serif', 'size':16, 'weight':'bold'})
g.fig.text(0,1.015,'Lines on the top and left of the cluster map are called␣
 ↪\ndendrograms, which indiate the dependency of features.',{'font':'serif',␣
 ↪'size':12}, alpha = 0.8)
plt.show()
```



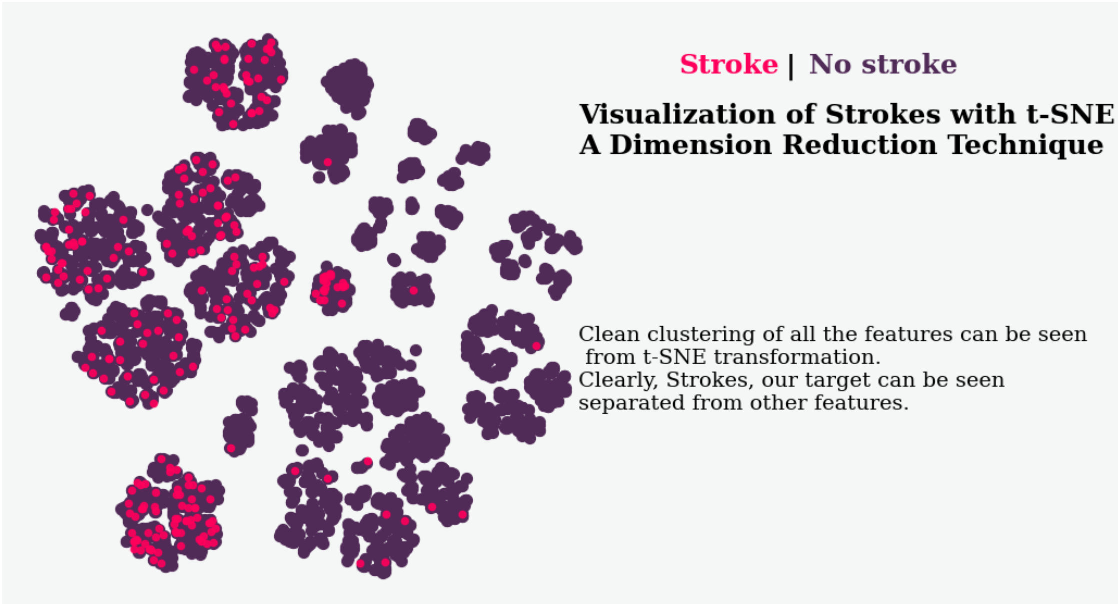
```
[ ]: # final data preprocessing and preperation

df_copy = df.copy()
# feature log transformations

df['age'] = df['age'].apply(lambda x: np.log(x+10)*3)
df['avg_glucose_level'] = df['avg_glucose_level'].apply(lambda x: np.
 ↪log(x+10)*2)
df['bmi'] = df['bmi'].apply(lambda x: np.log(x+10)*2)



# preprocessing - label enconding and numerical value scaling
ohe = OneHotEncoder()
ss = StandardScaler()
le = LabelEncoder()

X = df.drop(['stroke','id'], axis = 1)
y = df['stroke']

ordinal = ['age_cat',  'glucose_cat', 'bmi_cat','hypertension',␣
 ↪'heart_disease'] # label enconding
nominal =  ['gender', 'ever_married', 'work_type', 'Residence_type',␣
 ↪'smoking_status']
numerical = ['age','bmi', 'avg_glucose_level']

## label encoding of ordinal categorical features
for col in ordinal:
    X[col] = le.fit_transform(X[col])

## normalizing with standard scaler of numerical features
X[numerical] = ss.fit_transform(X[numerical])

## norminal data one hot encoding for categorical features
temp = X.drop(columns = nominal)
dummies = pd.get_dummies(X[nominal])
X = pd.concat([temp,dummies], axis = 1)
```

```
[ ]: from sklearn.manifold import TSNE
```

```
[ ]: # t-SNE transformation
tsne = TSNE(random_state=2021)
stroke_tsne = tsne.fit_transform(X)
```

```
[ ]: # Create figure
fig = plt.figure(figsize=(7, 7))
gs = fig.add_gridspec(1, 1)
```

```python
gs.update(wspace=0.4, hspace=0.5)
ax0 = fig.add_subplot(gs[0, 0])

# Change background color
background_color = "#f5f6f6"
fig.patch.set_facecolor(background_color)  # figure background color
ax0.set_facecolor(background_color)

# Scatter plot for the two classes
ax0.scatter(stroke_tsne[df['stroke'] == 0][:, 0], stroke_tsne[df['stroke'] == 0][:, 1], c='#512b58', alpha=1, s=50)
ax0.scatter(stroke_tsne[df['stroke'] == 1][:, 0], stroke_tsne[df['stroke'] == 1][:, 1], c='#ff005c', alpha=0.9, s=20)

# Add text annotations
ax0.text(80, -25, 'Clean clustering of all the features can be seen\n from t-SNE transformation. \nClearly, Strokes, our target can be seen \nseparated from other features.', fontsize=14, fontfamily='serif')
ax0.text(80, 45, 'Visualization of Strokes with t-SNE\nA Dimension Reduction Technique', fontsize=18, fontweight='bold', fontfamily='serif')

# Remove axis spines
for s in ["top", "right", "left", "bottom"]:
    ax0.spines[s].set_visible(False)

# Remove axis ticks
ax0.set_xticks([])
ax0.set_yticks([])

# Add legend
fig.text(1, 0.8, "Stroke", fontweight="bold", fontfamily='serif', fontsize=18, color='#ff005c')
fig.text(1.14, 0.8, "|", fontweight="bold", fontfamily='serif', fontsize=18, color='black')
fig.text(1.17, 0.8, "No stroke", fontweight="bold", fontfamily='serif', fontsize=18, color='#512b58')

# Show plot
plt.show()
```



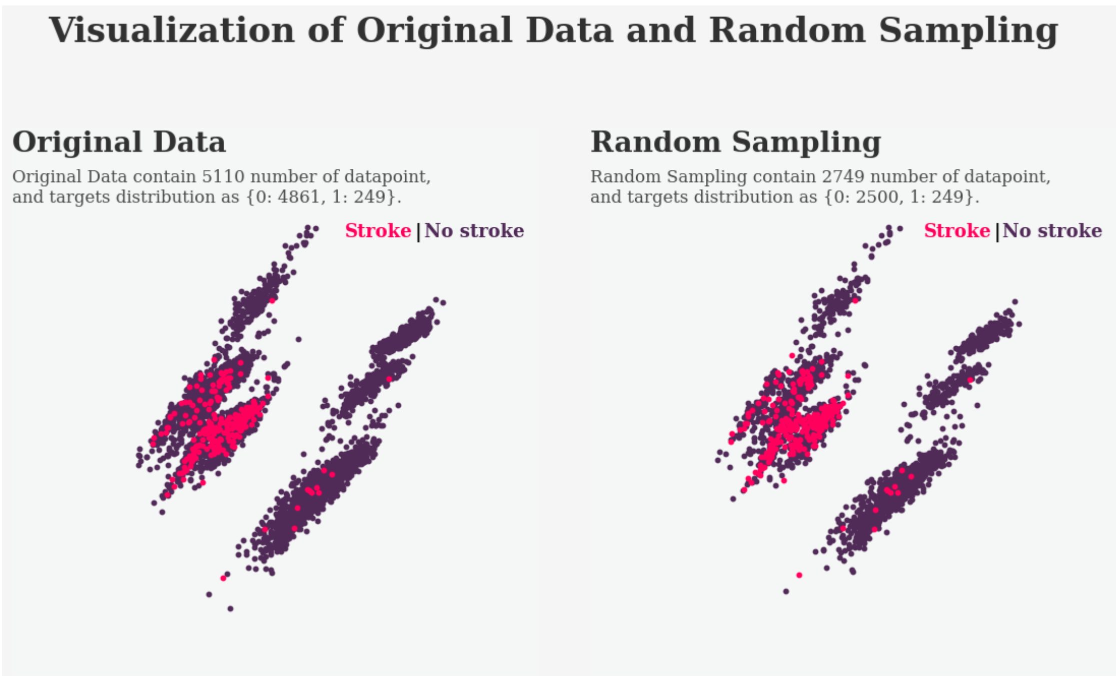

### 0.4 Visualization of Data Balancing with Data Sampling techniques

[ ]:
```
##### visualization class for dimension reduction and plotting result

class sampling():

    def __init__(self,feat,tar,method,ax):
        self.feat = feat
        self.tar = tar
        self.method = method
        self.ax = ax


    # under sampling visualization

    def visualize_data(self):

        temp_y = pd.DataFrame({'y':self.tar})

        # dimension reduction
        pca = PCA(n_components= 2).fit_transform(self.feat)

        self.ax.set_facecolor('#f5f6f6')
        # plotting4
        self.ax.scatter(pca[temp_y['y'] == 0][:,0], pca[temp_y['y'] == 0][:,1],␣
 ↪c = '#512b58', s = 10)
```

```
        self.ax.scatter(pca[temp_y['y'] == 1][:,0], pca[temp_y['y'] == 1][:,1],␣
↪c = '#ff005c', s =10)

        for loc in ['left','right','top', 'bottom']:
            self.ax.spines[loc].set_visible(False)
        self.ax.axes.get_xaxis().set_visible(False)
        self.ax.axes.get_yaxis().set_visible(False)
        self.ax.set_xticklabels('')
        self.ax.set_yticklabels('')
        self.ax.set_xlim(xmin = -6, xmax = 6)
        self.ax.set_ylim(ymin = -5, ymax = 6)


        self.ax.text(1.6,3.8,"Stroke", fontweight="bold", fontfamily='serif',␣
↪fontsize=13, color='#ff005c')
        self.ax.text(3.2,3.8,"|", fontweight="bold", fontfamily='serif',␣
↪fontsize=13, color='black')
        self.ax.text(3.4,3.8,"No stroke", fontweight="bold",␣
↪fontfamily='serif', fontsize=13, color='#512b58')
        self.ax.text(-6,5.5,self.method, {'font': 'serif', 'weight': 'bold',␣
↪'size': 20}, alpha = 0.8)
        self.ax.text(-6,4.5,'{} contain {} number of datapoint, \nand targets␣
↪distribution as {}.'.format(self.method,len(self.feat), {0:Counter(self.
↪tar)[0],1:Counter(self.tar)[1]}), {'font': 'serif', 'weight': 'normal',␣
↪'size': 12}, alpha = 0.7)
```

[ ]:
```
fig = plt.figure(figsize =(14,7))

gs = fig.add_gridspec(1,2)
gs.update(wspace = 0.1, hspace = 0.1)

ax1 = fig.add_subplot(gs[0,0])
ax2 = fig.add_subplot(gs[0,1])

axes = [ax1, ax2]

fig.patch.set_facecolor('#f5f5f5')

# setting of axes; visibility of axes and spines turn off
for ax in axes:
    ax.axes.get_yaxis().set_visible(False)
    ax.set_facecolor('#f8f8f8')


random_state = 2021

# Original Data
```

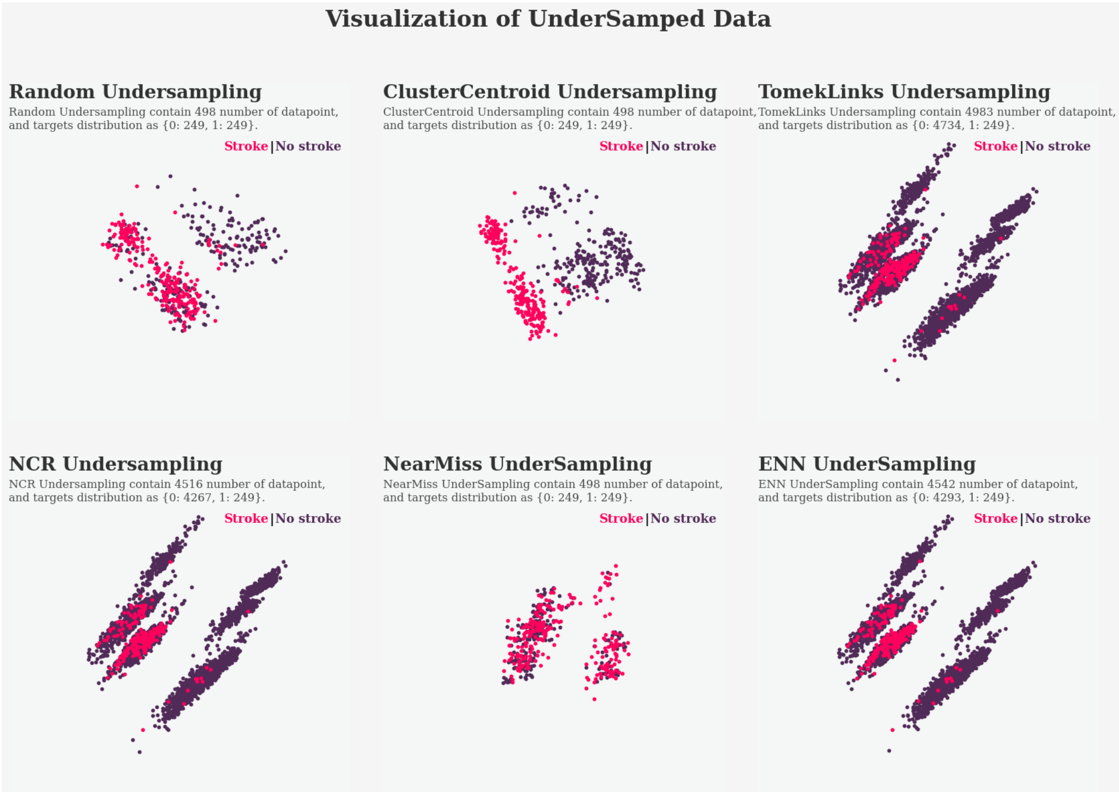
```
sampling(X,y.ravel(),'Original Data',ax=ax1).visualize_data()


#randomundersampling
X_rs, y_rs = make_imbalance(X, y.ravel(),random_state= 2021, sampling_strategy␣
↪={ 0: 2500, 1:249},)
sampling(X_rs,y_rs,'Random Sampling',ax=ax2).visualize_data()
fig.text(0.15,1,'Visualization of Original Data and Random Sampling', {'font':␣
↪'serif', 'weight': 'bold', 'size': 24}, alpha = 0.8)
fig.show()
```




[ ]:
```
fig = plt.figure(figsize =(21,21))

gs = fig.add_gridspec(3,3)
gs.update(wspace = 0.1, hspace = 0.1)

ax1 = fig.add_subplot(gs[0,0])
ax2 = fig.add_subplot(gs[0,1])
ax3 = fig.add_subplot(gs[0,2])

ax4 = fig.add_subplot(gs[1,0])
ax5 = fig.add_subplot(gs[1,1])
ax6 = fig.add_subplot(gs[1,2])
```

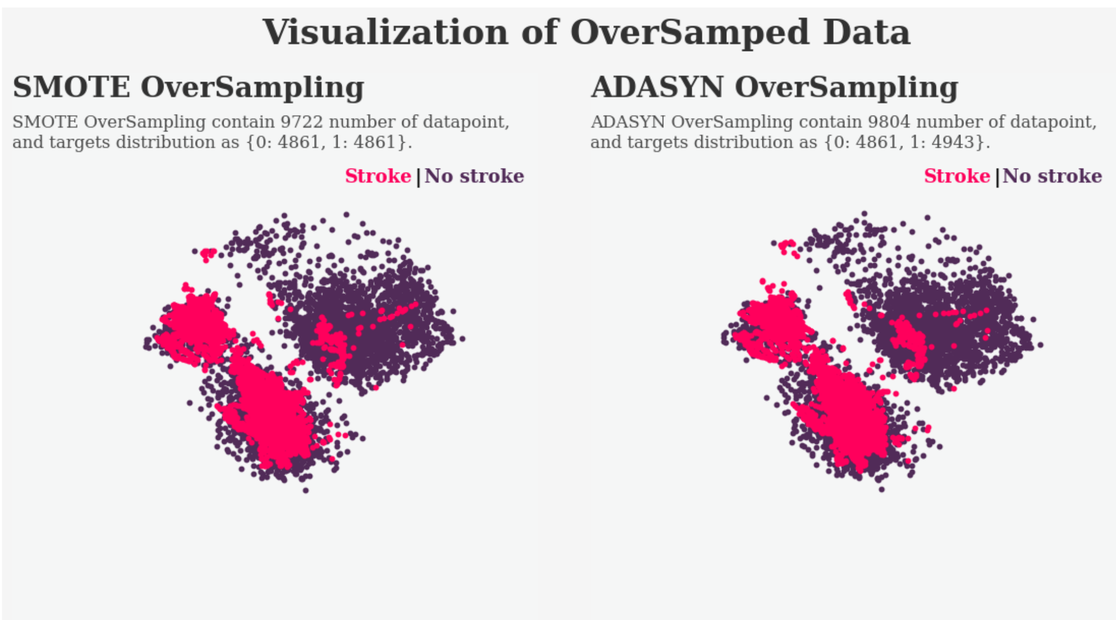
```python
axes = [ax1, ax2, ax3, ax4, ax5, ax6]

fig.patch.set_facecolor('#f5f5f5')

# setting of axes; visibility of axes and spines turn off
for ax in axes:
    ax.axes.get_yaxis().set_visible(False)
    ax.set_facecolor('#f8f8f8')


random_state = 2021

# RandomUnderSampler
sampler = RandomUnderSampler(random_state = random_state)
X_rs, y_rs = sampler.fit_resample(X, y.ravel())
sampling(X_rs,y_rs,'Random Undersampling',ax=ax1).visualize_data()


# ClusterCentroids
sampler = ClusterCentroids(random_state = random_state)
X_rs, y_rs = sampler.fit_resample(X, y.ravel())
sampling(X_rs,y_rs,'ClusterCentroid Undersampling',ax=ax2).visualize_data()

# TomekLinks
sampler = TomekLinks()
X_rs, y_rs = sampler.fit_resample(X, y.ravel())
sampling(X_rs,y_rs,'TomekLinks Undersampling',ax=ax3).visualize_data()


# NeighbourhoodCleaningRule
sampler = NeighbourhoodCleaningRule()
X_rs, y_rs = sampler.fit_resample(X, y.ravel())
sampling(X_rs,y_rs,'NCR Undersampling',ax=ax4).visualize_data()


# NearMiss
sampler = NearMiss()
X_rs, y_rs = sampler.fit_resample(X,y.ravel())
sampling(X_rs,y_rs,'NearMiss UnderSampling',ax=ax5).visualize_data()



# EditedNearestNeighbours
sampler = EditedNearestNeighbours()
X_rs, y_rs = sampler.fit_resample(X, y)
sampling(X_rs,y_rs,'ENN UnderSampling',ax=ax6).visualize_data()
```

```
fig.text(0.35,0.92,'Visualization of UnderSamped Data', {'font': 'serif',␣
↪'weight': 'bold', 'size': 24}, alpha = 0.8)
fig.show()
```




```
[ ]: fig = plt.figure(figsize =(14,7))

gs = fig.add_gridspec(1,2)
gs.update(wspace = 0.1, hspace = 0.1)

ax1 = fig.add_subplot(gs[0,0])
ax2 = fig.add_subplot(gs[0,1])


axes = [ax1, ax2]

fig.patch.set_facecolor('#f5f5f5')

# setting of axes; visibility of axes and spines turn off
for ax in axes:
    ax.axes.get_yaxis().set_visible(False)
    ax.set_facecolor('#f8f8f8')
```

```
random_state = 2021


# SMOTESampler
sampler = SMOTE()
X_rs, y_rs = sampler.fit_resample(X, y.ravel())
sampling(X_rs,y_rs,'SMOTE OverSampling',ax=ax1).visualize_data()


# ADASYNSampler
sampler = ADASYN()
X_rs, y_rs = sampler.fit_resample(X, y.ravel())
sampling(X_rs,y_rs,'ADASYN OverSampling',ax=ax2).visualize_data()

fig.text(0.3,0.92,'Visualization of OverSamped Data', {'font': 'serif',␣
↪'weight': 'bold', 'size': 24}, alpha = 0.8)
fig.show()
```




## 0.5 Modelling and Results

[ ]:
```
# training and testing data split

X_train, X_test, y_train, y_test = train_test_split(X,y, test_size = 0.25,␣
↪shuffle = True, random_state = 2021)
```

```
#smoteresampling
smote = SMOTE()
X_resample, y_resample = smote.fit_resample(X_train, y_train.ravel())

print('Shape of Training features: {}'.format(X_resample.shape))
print('Shape of Training targets: {}'.format(y_resample.shape))
print('Shape of Testing features: {}'.format(X_test.shape))
print('Shape of Testing targets: {}'.format(y_test.shape))
```

```
Shape of Training features: (7284, 24)
Shape of Training targets: (7284,)
Shape of Testing features: (1278, 24)
Shape of Testing targets: (1278,)
```

[ ]:
```
# Null accuracy Score for current data
NUll_acc = round (max(y_test.mean(), 1 - y_test.mean()), 2)

print('Null Accuracy Score for Current Data is {}'.format(NUll_acc))
```

```
Null Accuracy Score for Current Data is 0.95
```

[ ]:
```
#### predictions with resampled data


def predictions(x_set,y_set):
    t1 = time.time()
    print('Classification Process Starts....')
    accuracy,precision,recall,f1,auc,conf_mat= [],[],[],[],[],[]

    random_state = 2021

    ##classifiers list
    classifiers = []
    classifiers.append(SVC(random_state=random_state, probability = True))
    classifiers.append(DecisionTreeClassifier(random_state=random_state))
    classifiers.
 ↪append(AdaBoostClassifier(DecisionTreeClassifier(random_state=random_state)))
    classifiers.append(RandomForestClassifier(random_state=random_state))
    classifiers.append(GradientBoostingClassifier(random_state=random_state))
    classifiers.append(KNeighborsClassifier())
    classifiers.append(LogisticRegression(random_state = random_state))
    classifiers.append(XGBClassifier(random_state = random_state,eval_metric =␣
 ↪'logloss',learning_rate = 0.054))
    classifiers.append(LGBMClassifier(random_state = random_state,learning_rate␣
 ↪= 0.067))
```

```
    for classifier in classifiers:

        t =time.time()
        print('fitting on classifier with parameters: {}'.format(classifier))

        #classifier and fitting
        clf = classifier
        clf.fit(x_set,y_set)

        #predictions
        y_preds = clf.predict(X_test)
        y_probs = clf.predict_proba(X_test)

        # metrics
        accuracy.append((round(accuracy_score(y_test,y_preds),2))*100)
        precision.append((round(precision_score(y_test,y_preds),2))*100)
        recall.append((round(recall_score(y_test,y_preds),2))*100)
        f1.append((round(f1_score(y_test,y_preds),2))*100)
        auc.append((round (roc_auc_score(y_test,y_probs[:,1]), 2))*100)
        conf_mat.append(confusion_matrix(y_test,y_preds))

        elapsed = time.time() - t
        print('Done and elapsed time is {}seconds'.format(round(elapsed,3)))
        print('\n')
    results_df = pd.DataFrame({"Accuracy Score":accuracy,"Precision Score":
↪precision,
                    "Recall Score":recall, "f1 Score":f1,"AUC Score":auc,
                    "Confusion Matrix":conf_mat,
                    "Algorithm":["SVC","DecisionTree","AdaBoost",
                                 "RandomForest","GradientBoosting",
                                 "KNeighboors","LogisticRegression",
                                 "XGBoost", "LightGBM"]})

    results_df = (results_df.sort_values(by = 'Algorithm', ascending = False)
                  .reset_index(drop =  True))
    t2 = time.time() - t1
    print('\nClassification is Completed and results are strored in dataframe.
↪\ntotal time elapsed is {}seconds'.format(t2))
    print('****************************************************************\n\n')

    return results_df
```

[ ]:
```
orig_results = predictions(X_train,y_train)
resamp_results = predictions(X_resample,y_resample)
```

```
Classification Process Starts…
```

```
fitting on classifier with parameters: SVC(probability=True, random_state=2021)
Done and elapsed time is 3.053seconds


fitting on classifier with parameters: DecisionTreeClassifier(random_state=2021)
Done and elapsed time is 0.11seconds


fitting on classifier with parameters:
AdaBoostClassifier(estimator=DecisionTreeClassifier(random_state=2021))
Done and elapsed time is 0.108seconds


fitting on classifier with parameters: RandomForestClassifier(random_state=2021)
Done and elapsed time is 1.186seconds


fitting on classifier with parameters:
GradientBoostingClassifier(random_state=2021)
Done and elapsed time is 1.335seconds


fitting on classifier with parameters: KNeighborsClassifier()
Done and elapsed time is 0.4seconds


fitting on classifier with parameters: LogisticRegression(random_state=2021)
Done and elapsed time is 0.203seconds


fitting on classifier with parameters: XGBClassifier(base_score=None,
booster=None, callbacks=None,
              colsample_bylevel=None, colsample_bynode=None,
              colsample_bytree=None, device=None, early_stopping_rounds=None,
              enable_categorical=False, eval_metric='logloss',
              feature_types=None, gamma=None, grow_policy=None,
              importance_type=None, interaction_constraints=None,
              learning_rate=0.054, max_bin=None, max_cat_threshold=None,
              max_cat_to_onehot=None, max_delta_step=None, max_depth=None,
              max_leaves=None, min_child_weight=None, missing=nan,
              monotone_constraints=None, multi_strategy=None, n_estimators=None,
              n_jobs=None, num_parallel_tree=None, random_state=2021, …)
Done and elapsed time is 1.541seconds


fitting on classifier with parameters: LGBMClassifier(learning_rate=0.067,
random_state=2021)
[LightGBM] [Warning] Found whitespace in feature_names, replace with underlines
```

```
[LightGBM] [Info] Number of positive: 190, number of negative: 3642
[LightGBM] [Info] Auto-choosing row-wise multi-threading, the overhead of
testing was 0.000765 seconds.
You can set `force_row_wise=true` to remove the overhead.
And if memory is not enough, you can set `force_col_wise=true`.
[LightGBM] [Info] Total Bins 654
[LightGBM] [Info] Number of data points in the train set: 3832, number of used
features: 22
[LightGBM] [Info] [binary:BoostFromScore]: pavg=0.049582 -> initscore=-2.953264
[LightGBM] [Info] Start training from score -2.953264
Done and elapsed time is 0.385seconds



Classification is Completed and results are strored in dataframe.
total time elapsed is 8.357976913452148seconds
***************************************************************


Classification Process Starts…
fitting on classifier with parameters: SVC(probability=True, random_state=2021)
Done and elapsed time is 11.161seconds


fitting on classifier with parameters: DecisionTreeClassifier(random_state=2021)
Done and elapsed time is 0.056seconds


fitting on classifier with parameters:
AdaBoostClassifier(estimator=DecisionTreeClassifier(random_state=2021))
Done and elapsed time is 0.063seconds


fitting on classifier with parameters: RandomForestClassifier(random_state=2021)
Done and elapsed time is 0.813seconds


fitting on classifier with parameters:
GradientBoostingClassifier(random_state=2021)
Done and elapsed time is 1.309seconds


fitting on classifier with parameters: KNeighborsClassifier()
Done and elapsed time is 0.179seconds


fitting on classifier with parameters: LogisticRegression(random_state=2021)
Done and elapsed time is 0.119seconds
```

```
fitting on classifier with parameters: XGBClassifier(base_score=None,
booster=None, callbacks=None,
              colsample_bylevel=None, colsample_bynode=None,
              colsample_bytree=None, device=None, early_stopping_rounds=None,
              enable_categorical=False, eval_metric='logloss',
              feature_types=None, gamma=None, grow_policy=None,
              importance_type=None, interaction_constraints=None,
              learning_rate=0.054, max_bin=None, max_cat_threshold=None,
              max_cat_to_onehot=None, max_delta_step=None, max_depth=None,
              max_leaves=None, min_child_weight=None, missing=nan,
              monotone_constraints=None, multi_strategy=None, n_estimators=None,
              n_jobs=None, num_parallel_tree=None, random_state=2021, …)
Done and elapsed time is 0.287seconds


fitting on classifier with parameters: LGBMClassifier(learning_rate=0.067,
random_state=2021)
[LightGBM] [Warning] Found whitespace in feature_names, replace with underlines
[LightGBM] [Info] Number of positive: 3642, number of negative: 3642
[LightGBM] [Info] Auto-choosing row-wise multi-threading, the overhead of
testing was 0.001480 seconds.
You can set `force_row_wise=true` to remove the overhead.
And if memory is not enough, you can set `force_col_wise=true`.
[LightGBM] [Info] Total Bins 810
[LightGBM] [Info] Number of data points in the train set: 7284, number of used
features: 22
[LightGBM] [Info] [binary:BoostFromScore]: pavg=0.500000 -> initscore=0.000000
Done and elapsed time is 0.218seconds



Classification is Completed and results are strored in dataframe.
total time elapsed is 14.21110987663269seconds
***************************************************************
```

[ ]:
```python
def multi_visualize(data, vmin = -0.5, vmax = 1):
    fig = plt.figure(figsize =(24,24))
    gs = fig.add_gridspec(8,6)
    gs.update(wspace = 0.2, hspace = 0.1)

    ax1 = fig.add_subplot(gs[0,0])
    ax2 = fig.add_subplot(gs[0,1])
    ax3 = fig.add_subplot(gs[0,2])
```

```
ax4 = fig.add_subplot(gs[1,0])
ax5 = fig.add_subplot(gs[1,1])
ax6 = fig.add_subplot(gs[1,2])

ax7 = fig.add_subplot(gs[2,0])
ax8 = fig.add_subplot(gs[2,1])
ax9 = fig.add_subplot(gs[2,2])

ax10 = fig.add_subplot(gs[0,3])
ax11 = fig.add_subplot(gs[0,4])
ax12 = fig.add_subplot(gs[0,5])

ax13 = fig.add_subplot(gs[1,3])
ax14 = fig.add_subplot(gs[1,4])
ax15 = fig.add_subplot(gs[1,5])

ax16 = fig.add_subplot(gs[2,3])
ax17 = fig.add_subplot(gs[2,4])
ax18 = fig.add_subplot(gs[2,5])


axes1 = [ax1, ax2, ax3, ax4, ax5, ax6, ax7, ax8, ax9]
axes2 = [ax10, ax11, ax12, ax13, ax14, ax15, ax16, ax17, ax18]

axes = [axes1,axes2]

fig.patch.set_facecolor('#f6f5f5')

# setting of axes; visibility of axes and spines turn off
for ax_list in axes:
    for ax in ax_list:
        ax.axes.get_yaxis().set_visible(False)
        ax.axes.get_xaxis().set_visible(False)
        ax.set_facecolor('#f6f5f5')

colors = ['#512b58','#fe346e']
colormap = matplotlib.colors.LinearSegmentedColormap.from_list("", colors)


for ax_list in axes:

    if ax_list == axes1:
        res_df = data[0]
    else:
        res_df = data[1]
```

```
        alg = res_df['Algorithm']
        cf = res_df['Confusion Matrix']
        auc = res_df['AUC Score']
        f1 = res_df['f1 Score']
        forig = data[0]['f1 Score']
        fresam = data[1]['f1 Score']

        n = 0
        for ax in ax_list:
            cf_mat = cf[n]

            #### annotations
            labels = ['True Neg','False Pos','False Neg','True Pos']
            counts = ["{0:0.0f}".format(value) for value in cf_mat.flatten()]
            percentages = ["{0:.2%}".format(value) for value in cf_mat.
↪flatten()/np.sum(cf_mat)]

            #### final annotations
            label = (np.array([f'{v1}\n{v2}\n{v3}' for v1,v2,v3 in␣
↪zip(labels,counts,percentages)])).reshape(2,2)

            #### heatmap
            sns.heatmap(data = cf_mat, vmin = vmin, vmax =vmax, cmap =␣
↪['grey'],linewidth=2,linecolor = '#f6f5f5',
                ax = ax, annot = label, fmt ='', cbar = False, annot_kws =␣
↪{'font':'serif','size':10, 'color':'white','weight':'bold'}, alpha =0.8)

            #### subtitle
            if ax_list == axes1:
                ax.text(0,-0,'{}'.format(alg[n]),{'font':'serif','size':12,␣
↪'color':'black', 'weight':'bold'})
            else:
                ax.text(0,-0,'SMOTE {}'.format(alg[n]),{'font':'serif','size':
↪12, 'color':'black', 'weight':'bold'})


            #### Auc and F1 score plotting

            if ax_list == axes2:
                if (fresam[n] > forig[n]) & (auc[n] > 75):
                    ax.scatter( 1 , 1 , s = 3500, c = '#fe346e')
                    ax.text(0.75,1.1, ' F1: {}\nAUC: {}'.
↪format(int(round(f1[n],1)), int(round(auc[n],1))),{'font':'serif','size':12,␣
↪'color':'black', 'weight':'bold'})
                else:
```

```
                    ax.scatter( 1 , 1 , s = 3500, c = 'white')
                    ax.text(0.75,1.1, ' F1: {}\nAUC: {}'.format(int(round(f1[n],1)), int(round(auc[n],1))),{'font':'serif','size':12,'color':'black', 'weight':'bold'})

            else:
                if (forig[n] > 5 ) & (auc[n] > 75):
                    ax.scatter( 1 , 1 , s = 3500, c = '#512b58', alpha = 0.9)
                    ax.text(0.75,1.1, ' F1: {}\nAUC: {}'.format(int(round(f1[n],1)), int(round(auc[n],1))),{'font':'serif','size':12,'color':'white', 'weight':'bold'})
                else:
                    ax.scatter( 1 , 1 , s = 3500, c = 'white')
                    ax.text(0.75,1.1, ' F1: {}\nAUC: {}'.format(int(round(f1[n],1)), int(round(auc[n],1))),{'font':'serif','size':12,'color':'black', 'weight':'bold'})


            n +=1
        if ax_list == axes1:
            ax1.text(0,-0.55,'Visualization of Results with - Original Data',{'font':'serif','size':24, 'color':'black', 'weight':'bold'},)
        else:
            ax10.text(0,-0.55,'Visualization of Results with - Oversampled Data',{'font':'serif','size':24, 'color':'black', 'weight':'bold'}, alpha = 0.9)


    fig.show()
```

[ ]:
```
multi_visualize(data = [orig_results, resamp_results], vmin=30,vmax = 100)
```