STROKE PREDICTION USING HEALTH-CARE DATASET

IMPORTING LIBRARIES

In [1]:
```
1 import pandas as pd
2 import numpy as np
3 import matplotlib.pyplot as plt
4 import seaborn as sns
```

LOADING THE DATASET

In [2]:
```
1 df =pd.read_csv('C:/Users/hp/OneDrive/Desktop/healthcare-dataset-stroke-da
2
```

DATA PRE-PROCESSING

In [3]:
```
1 df.head()
```

Out[3]:

	id	gender	age	hypertension	heart_disease	ever_married	work_type	Residence_type
0	9046	Male	67.0	0	1	Yes	Private	Urban
1	51676	Female	61.0	0	0	Yes	Self-employed	Rural
2	31112	Male	80.0	0	1	Yes	Private	Rural
3	60182	Female	49.0	0	0	Yes	Private	Urban
4	1665	Female	79.0	1	0	Yes	Self-employed	Rural

]:

In [7
```
1 df.tail()
```

Out[7]:

	id	gender	age	hypertension	heart_disease	ever_married	work_type	Residence_typ
5105	18234	Female	80.0	1	0	Yes	Private	Urba
5106	44873	Female	81.0	0	0	Yes	Self-employed	Urba
5107	19723	Female	35.0	0	0	Yes	Self-employed	Rur
5108	37544	Male	51.0	0	0	Yes	Private	Rur
5109	44679	Female	44.0	0	0	Yes	Govt_job	Urba

In [7]:
```
1 df.shape
```

Out[7]:
```
(5110, 12)
```

In [8]:
```
1 df.columns
```

Out[8]:
```
Index(['id', 'gender', 'age', 'hypertension', 'heart_disease', 'ever_marrie
d',
       'work_type', 'Residence_type', 'avg_glucose_level', 'bmi',
       'smoking_status', 'stroke'],
      dtype='object')
```

In [12]:
```
1 df.duplicated().sum()
```

Out[12]:
```
0
```

NULL VALUES TREATEMENT

In [13]:
```
1 df.isnull().sum()
```

Out[13]:
```
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                201
smoking_status       0
stroke               0
dtype: int64
```

]:

In [14]:
```
1 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
```

In [15]:
```
1 df.describe()
```

Out[15]:

	id	age	hypertension	heart_disease	avg_glucose_level	bmi
count	5110.000000	5110.000000	5110.000000	5110.000000	5110.000000	4909.000000
mean	36517.829354	43.226614	0.097456	0.054012	106.147677	28.893237
std	21161.721625	22.612647	0.296607	0.226063	45.283560	7.854067
min	67.000000	0.080000	0.000000	0.000000	55.120000	10.300000
25%	17741.250000	25.000000	0.000000	0.000000	77.245000	23.500000
50%	36932.000000	45.000000	0.000000	0.000000	91.885000	28.100000
75%	54682.000000	61.000000	0.000000	0.000000	114.090000	33.100000
max	72940.000000	82.000000	1.000000	1.000000	271.740000	97.600000

In [17]:
```
1 df.nunique()
```

Out[17]:

```
id                   5110
gender                  3
age                   104
hypertension            2
heart_disease           2
ever_married            2
work_type               5
Residence_type          2
avg_glucose_level    3979
bmi                   418
smoking_status          4
stroke                  2
dtype: int64
```

]:

]:

In [4

```
1 df['bmi'].fillna(df['bmi'].mean(),inplace=True)
2 df.isnull().sum()
```

Out[4

```
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
```

EXPLORATORY DATA ANALYSIS

In [5]:

```
1 df.drop('id',axis=1,inplace=True)
2 df
```

Out[5]:

	gender	age	hypertension	heart_disease	ever_married	work_type	Residence_type	avg_
0	Male	67.0	0	1	Yes	Private	Urban	
1	Female	61.0	0	0	Yes	Self-employed	Rural	
2	Male	80.0	0	1	Yes	Private	Rural	
3	Female	49.0	0	0	Yes	Private	Urban	
4	Female	79.0	1	0	Yes	Self-employed	Rural	
...	...	...	...	...	...	...	...	
5105	Female	80.0	1	0	Yes	Private	Urban	
5106	Female	81.0	0	0	Yes	Self-employed	Urban	
5107	Female	35.0	0	0	Yes	Self-employed	Rural	
5108	Male	51.0	0	0	Yes	Private	Rural	
5109	Female	44.0	0	0	Yes	Govt_job	Urban	

5110 rows × 11 columns

]:

]:

In [6

```
df.drop('ever_married',axis=1,inplace=True)
df
```

Out[6

	gender	age	hypertension	heart_disease	work_type	Residence_type	avg_glucose_level
0	Male	67.0	0	1	Private	Urban	228.69
1	Female	61.0	0	0	Self-employed	Rural	202.21
2	Male	80.0	0	1	Private	Rural	105.92
3	Female	49.0	0	0	Private	Urban	171.23
4	Female	79.0	1	0	Self-employed	Rural	174.12
...	...	...	...	...	...	...	...
5105	Female	80.0	1	0	Private	Urban	83.75
5106	Female	81.0	0	0	Self-employed	Urban	125.20
5107	Female	35.0	0	0	Self-employed	Rural	82.99
5108	Male	51.0	0	0	Private	Rural	166.29
5109	Female	44.0	0	0	Govt_job	Urban	85.28

5110 rows × 10 columns

Label Encoding

In [7]:

```
from sklearn.preprocessing import LabelEncoder
enc=LabelEncoder()
```

In [8]:

```
Residence_type=enc.fit_transform(df['Residence_type'])
Residence_type
```

Out[8]:
```
array([1, 0, 0, ..., 0, 0, 1])
```

In [9]:

```
gender=enc.fit_transform(df['gender'])
gender
```

Out[9]:
```
array([1, 0, 1, ..., 0, 1, 0])
```

In [10]:

```
smoking_status=enc.fit_transform(df['smoking_status'])
```

In [18]:

```
work_type=enc.fit_transform(df['work_type'])

```

In [ ]:
```
1
```

]:

```
Residence_type=enc.fit_transform(df['Residence_type'])
```

In [19
```
df['work_type']=work_type
df['Residence type']=Residence_type
df['smoking status' ]=smoking_status
df['gender']=gender
```

In [38]:
```
df["Residence_type"]= df["Residence_type"].replace("Urban", 1)
df["Residence_type"]= df["Residence_type"].replace("Rural",0)

```

In [39]:
```
df.head()
```

Out[39]:

	gender	age	hypertension	heart_disease	work_type	Residence_type	avg_glucose_level	
0	1	67.0	0	1	2	1	228.69	36
1	0	61.0	0	0	3	0	202.21	28
2	1	80.0	0	1	2	0	105.92	32
3	0	49.0	0	0	2	1	171.23	34
4	0	79.0	1	0	3	0	174.12	24

In [40]:
```
df["smoking_status"]= df["smoking_status"].replace("never smoked",1)
df["smoking_status"]= df["smoking_status"].replace("Unknown",0)
df["smoking_status"]= df["smoking_status"].replace("formerly smoked", 2)
df["smoking_status"]= df["smoking_status"].replace("smokes",3)

```

n]:

I [21
```
1 df
```

Out[21]:

	gender	age	hypertension	heart_disease	work_type	Residence_type	avg_glucose_level
0	1	67.0	0	1	2	Urban	228.69
1	0	61.0	0	0	3	Rural	202.21
2	1	80.0	0	1	2	Rural	105.92
3	0	49.0	0	0	2	Urban	171.23
4	0	79.0	1	0	3	Rural	174.12
...	...	...	...	...	...	...	...
5105	0	80.0	1	0	2	Urban	83.75
5106	0	81.0	0	0	3	Urban	125.20
5107	0	35.0	0	0	3	Rural	82.99
5108	1	51.0	0	0	2	Rural	166.29
5109	0	44.0	0	0	0	Urban	85.28

5110 rows × 12 columns

In [22]:
```
1 df['smoking_status'].value_counts()
```

Out[22]:
```
1    1892
0    1544
2     885
3     789
Name: smoking_status, dtype: int64
```

In [41]:
```
1 df['Residence_type'].value_counts()
2
```

Out[41]:
```
1    2596
0    2514
Name: Residence_type, dtype: int64
```

HANDLING NULL VALUES

In [ ]:
```
1
```

In [ ]:
```
1
```

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```
df.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 5110 entries, 0 to 5109
Data columns (total 13 columns):
 #   Column             Non-Null Count  Dtype  
---  ------             --------------  -----  
 0   gender             5110 non-null   int64  
 1   age                5110 non-null   float64
 2   hypertension       5110 non-null   int64  
 3   heart_disease      5110 non-null   int64  
 4   work_type          5110 non-null   int64  
 5   Residence_type     5110 non-null   int64  
 6   avg_glucose_level  5110 non-null   float64
 7   bmi                5110 non-null   float64
 8   smoking_status     5110 non-null   int64  
 9   stroke             5110 non-null   int64  
 10  ever married       5110 non-null   int32  
 11  Residence type     5110 non-null   int32  
 12  smoking status     5110 non-null   int32  
dtypes: float64(3), int32(3), int64(7)
memory usage: 459.2 KB
```

In [42]:
```
1 X=df.drop('stroke',axis=1)
```

In [43]:
```
1 X.head()
```

Out[43]:

	gender	age	hypertension	heart_disease	work_type	Residence_type	avg_glucose_level	
0	1	67.0	0	1	2	1	228.69	36
1	0	61.0	0	0	3	0	202.21	28
2	1	80.0	0	1	2	0	105.92	32
3	0	49.0	0	0	2	1	171.23	34
4	0	79.0	1	0	3	0	174.12	24

In [28]:
```
1 Y=df['stroke']
2 Y.head()
```

Out[28]:
```
0    1
1    1
2    1
3    1
4    1
Name: stroke, dtype: int64
```

In [ ]:

SPLITTING DATA FOR TRAIN AND TEST

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```
1 from sklearn.model_selection import train_test_split
2 X_train, X_test, Y_train, Y_test=train_test_split(X,Y,test_size=0.2,rando
```

In [45]:

```
1 X_train
```

Out[45]:

	gender	age	hypertension	heart_disease	work_type	Residence_type	avg_glucose_level
2285	1	49.0	0	0	2	0	79.64
4733	1	67.0	0	0	2	0	83.16
3905	1	78.0	0	0	2	1	208.85
4700	1	47.0	0	0	2	0	110.14
4939	0	59.0	0	0	2	1	71.08
...	...	...	...	...	...	...	...
1180	0	62.0	0	0	2	0	82.57
3441	0	59.0	0	0	3	1	90.06
1344	1	47.0	0	0	2	0	86.37
4623	1	25.0	0	0	0	1	166.38
1289	0	80.0	0	0	3	0	72.61

4088 rows × 11 columns

In [46]:

```
1 Y_train
```

Out[46]:

```
2285    0
4733    0
3905    0
4700    0
4939    0
       ..
1180    0
3441    0
1344    0
4623    0
1289    0
Name: stroke, Length: 4088, dtype: int64
```

I [ ]:
```
1
```

n 47
```
X_test
```

Out[47]:

	gender	age	hypertension	heart_disease	work_type	Residence_type	avg_glucose_level
2413	0	58.00	0	0	2	0	100.42
1141	1	57.00	0	0	2	0	90.06
146	1	65.00	0	0	3	1	68.43
3883	0	1.64	0	0	4	1	69.89
1044	0	79.00	0	0	0	1	93.89
...	...	...	...	...	...	...	...
2261	1	59.00	0	0	2	1	60.35
4712	1	57.00	0	0	2	1	93.04
4971	0	63.00	0	0	2	1	57.06
2224	1	57.00	0	0	2	0	76.28
4825	0	14.00	0	0	4	1	71.80

1022 rows × 11 columns

In [48]:
```
1 Y_test
```

Out[48]:
```
2413    0
1141    0
146     1
3883    0
1044    0
       ..
2261    0
4712    0
4971    0
2224    0
4825    0
Name: stroke, Length: 1022, dtype: int64
```

In [ ]:

NORMALIZE

34

```
1 df.describe()
```

Out[34]:

	gender	age	hypertension	heart_disease	work_type	avg_glucose_level	5
count	5110.000000	5110.000000	5110.000000	5110.000000	5110.000000	5110.000000	
mean	0.414286	43.226614	0.097456	0.054012	2.167710	106.147677	
std	0.493044	22.612647	0.296607	0.226063	1.090293	45.283560	
min	0.000000	0.080000	0.000000	0.000000	0.000000	55.120000	
25%	0.000000	25.000000	0.000000	0.000000	2.000000	77.245000	
50%	0.000000	45.000000	0.000000	0.000000	2.000000	91.885000	
75%	1.000000	61.000000	0.000000	0.000000	3.000000	114.090000	
max	2.000000	82.000000	1.000000	1.000000	4.000000	271.740000	

In [49]:

```
1 from sklearn.preprocessing import StandardScaler
2 std = StandardScaler()
```

In [50]:

```
1 X_train_std = std.fit_transform(X_train)
2 X_test_std = std.transform(X_test)
```

In [51]:

```
1 X_train_std
```

Out[51]:

```
array([[ 1.19359699,  0.2521852 , -0.33069968, ...,  1.75888007,
        -1.01777039,  1.51158251],
       [ 1.19359699,  1.04686385, -0.33069968, ...,  0.79061967,
        -1.01777039, -0.35191245],
       [ 1.19359699,  1.5325008 , -0.33069968, ...,  0.79061967,
         0.98253988, -0.35191245],
       ...,
       [ 1.19359699,  0.16388757, -0.33069968, ...,  1.75888007,
        -1.01777039,  1.51158251],
       [ 1.19359699, -0.80738634, -0.33069968, ..., -0.17764073,
         0.98253988,  0.57983503],
       [-0.83780372,  1.62079843, -0.33069968, ..., -0.17764073,
        -1.01777039,  0.57983503]])
```

I [ ]:
```
1
```

n 52
```
X_test_std
```

Out[52]:
```
array([[-0.83780372,  0.64952452, -0.33069968, ...,  1.75888007,
        -1.01777039,  1.51158251],
       [ 1.19359699,  0.60537571, -0.33069968, ..., -1.14590113,
        -1.01777039, -1.28365994],
       [ 1.19359699,  0.95856622, -0.33069968, ...,  0.79061967,
         0.98253988, -0.35191245],
       ...,
       [-0.83780372,  0.87026859, -0.33069968, ..., -0.17764073,
         0.98253988,  0.57983503],
       [ 1.19359699,  0.60537571, -0.33069968, ...,  0.79061967,
        -1.01777039, -0.35191245],
       [-0.83780372, -1.29302329, -0.33069968, ..., -1.14590113,
         0.98253988, -1.28365994]])
```

LOGISTIC REGRESSION

In [53]:
```
1 from sklearn.linear_model import LogisticRegression
2 lr=LogisticRegression()
```

In [54]:
```
1 lr.fit(X_train_std,Y_train)
```

Out[54]:
```
LogisticRegression()
```

In [55]:
```
1  Y_pred_lr=lr.predict(X_test_std)
```

In [56]:
```
1 Y_pred_lr[:5]
```

Out[56]:
```
array([0, 0, 0, 0, 0], dtype=int64)
```

EVALUATION FOR LOGISTIC REGRESSION

In [57]:
```
1 from sklearn.metrics import accuracy_score
```

In [58]:
```
1 ac_lr=accuracy_score(Y_test,Y_pred_lr)
```

In [59]:
```
1 ac_lr*100
```

Out[59]:
```
93.9334637964775
```

KNN: KNEIGHBORS CLASSIFIER

In [ ]: 60

```
from sklearn.neighbors import KNeighborsClassifier
knn=KNeighborsClassifier(n_neighbors=5,p=2)
knn.fit(X_train, Y_train)
```

Out[60]:
```
KNeighborsClassifier()
```

In [61]:
```
# predictions
Y_pred=knn.predict(X_test)
Y_pred
```

```
C:\Users\hp\anaconda3\lib\site-packages\sklearn\neighbors\_classification.py:
228: FutureWarning: Unlike other reduction functions (e.g. `skew`, `kurtosis
`), the default behavior of `mode` typically preserves the axis it acts alon
g. In SciPy 1.11.0, this behavior will change: the default value of `keepdims
` will become False, the `axis` over which the statistic is taken will be eli
minated, and the value None will no longer be accepted. Set `keepdims` to Tru
e or False to avoid this warning.
  mode, _ = stats.mode(_y[neigh_ind, k], axis=1)
```

Out[61]:
```
array([0, 0, 0, ..., 0, 0, 0], dtype=int64)
```

In [62]:
```
Y_test
```

Out[62]:
```
2413    0
1141    0
146     1
3883    0
1044    0
       ..
2261    0
4712    0
4971    0
2224    0
4825    0
Name: stroke, Length: 1022, dtype: int64
```

EVALUATION FOR KNN

In [63]:
```
from sklearn.metrics import confusion_matrix
cm=confusion_matrix(Y_test, Y_pred)
cm
```

Out[63]:
```
array([[957,   3],
       [ 61,   1]], dtype=int64)
```

I [ ]:

n 64

```
from sklearn.metrics import classification_report
print(classification_report(Y_test, Y_pred))
```

```
              precision    recall  f1-score   support

           0       0.94      1.00      0.97       960
           1       0.25      0.02      0.03        62

    accuracy                           0.94      1022
   macro avg       0.60      0.51      0.50      1022
weighted avg       0.90      0.94      0.91      1022
```

In [ ]:

```
ac_lr=accuracy_score(Y_test,Y_pred_lr)
```

VISUALIZATIONS

In [4]:

```
df1=pd.read_csv('C:/Users/hp/OneDrive/Desktop/healthcare-dataset-stroke-da
df1.head()
```

Out[4]:

	id	gender	age	hypertension	heart_disease	ever_married	work_type	Residence_type
0	9046	Male	67.0	0	1	Yes	Private	Urban
1	51676	Female	61.0	0	0	Yes	Self-employed	Rural
2	31112	Male	80.0	0	1	Yes	Private	Rural
3	60182	Female	49.0	0	0	Yes	Private	Urban
4	1665	Female	79.0	1	0	Yes	Self-employed	Rural

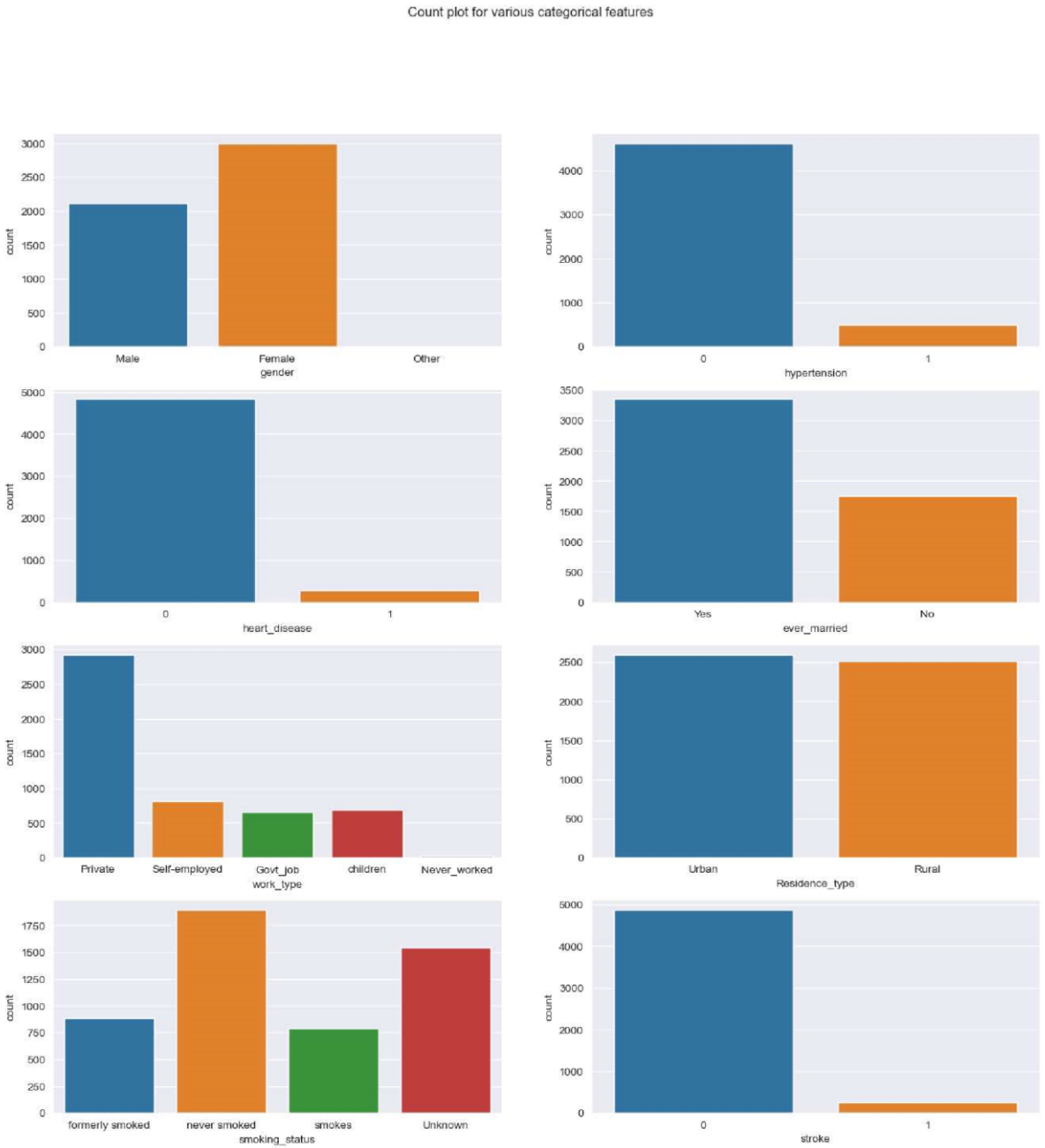
]:

BAR-GRAPHS

In [135

```
fig,axes = plt.subplots(4,2,figsize = (16,16))
sns.set_style('darkgrid')
fig.suptitle("Count plot for various categorical features")

sns. countplot (ax=axes[0,0],data=df1,x='gender')
sns. countplot (ax=axes[0,1],data=df1,x='hypertension')
sns.countplot (ax=axes [1,0],data=df1,x='heart_disease')
sns.countplot (ax=axes [1,1],data=df1,x='ever_married')
sns.countplot(ax=axes[2,0],data=df1,x='work_type')
sns.countplot (ax=axes[2,1],data=df1,x='Residence_type')
sns. countplot (ax=axes[3,0],data=df1,x='smoking_status')
sns.countplot (ax=axes[3,1],data=df1,x='stroke')
plt.show()
```



In [1]:

AGE

36

```
1 df1.groupby('gender').mean()[['age','stroke']]
```

Out[136]:

gender	age	stroke
Female	43.757395	0.047094
Male	42.483385	0.051064
Other	26.000000	0.000000

WORK TYPE

In [139]:

```
1 df1['work_type'].unique()
```

Out[139]:

```
array(['Private', 'Self-employed', 'Govt_job', 'children', 'Never_worked'],
      dtype=object)
```

In [140]:

```
1 df1['work_type'].value_counts()
```

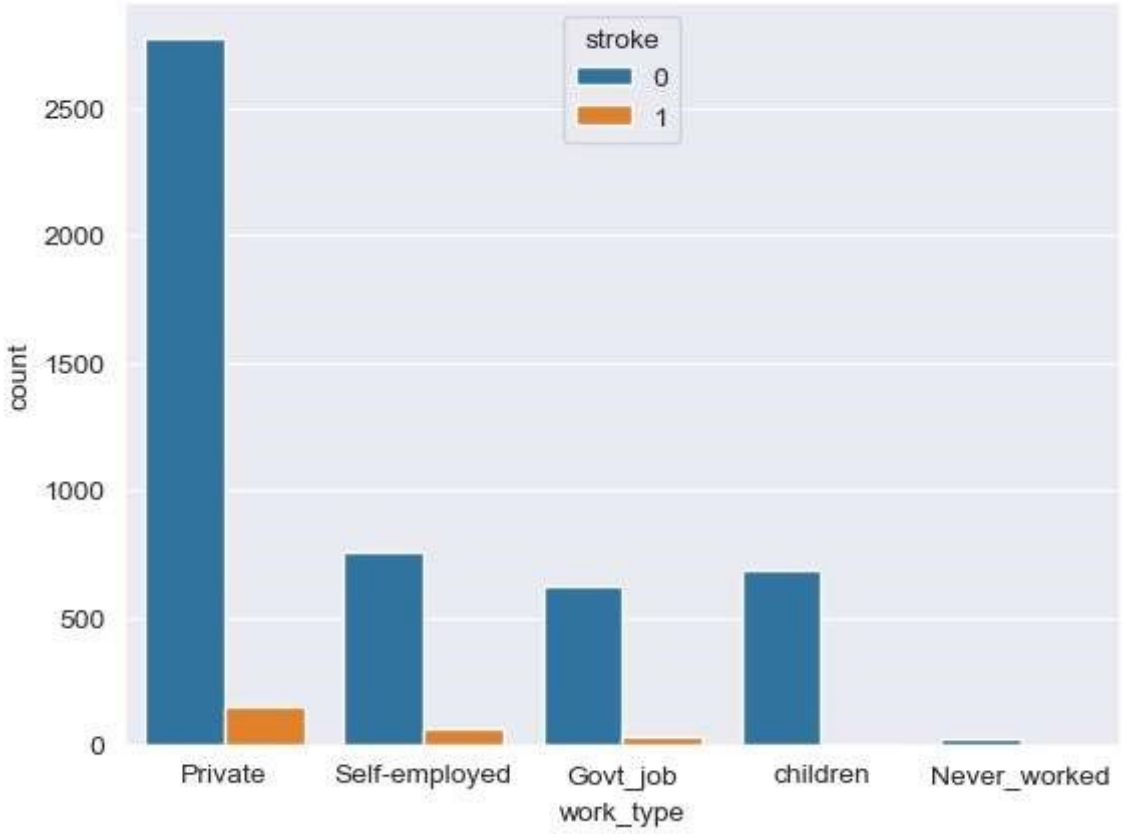
Out[140]:

```
Private          2925
Self-employed     819
children          687
Govt_job          657
Never_worked       22
Name: work_type, dtype: int64
```

Chances of stroke is more in men than women

In [142]:

```
1 sns.countplot(data=df1,x='work_type',hue='stroke')
2 plt.show()
```

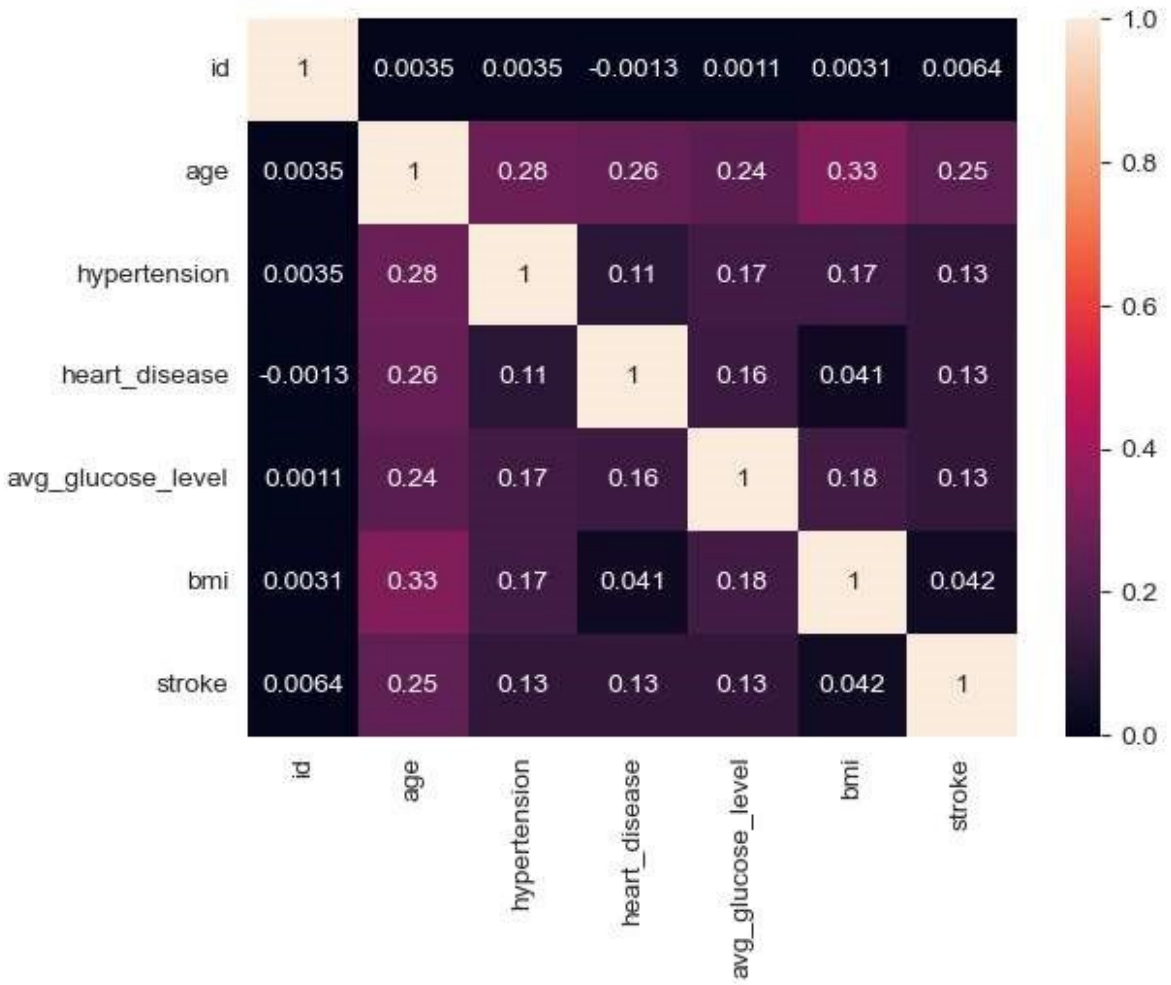


In [1]:

HEATMAP

43

```
1 sns.heatmap(df1.corr(),annot=True)
2 plt.show()
```

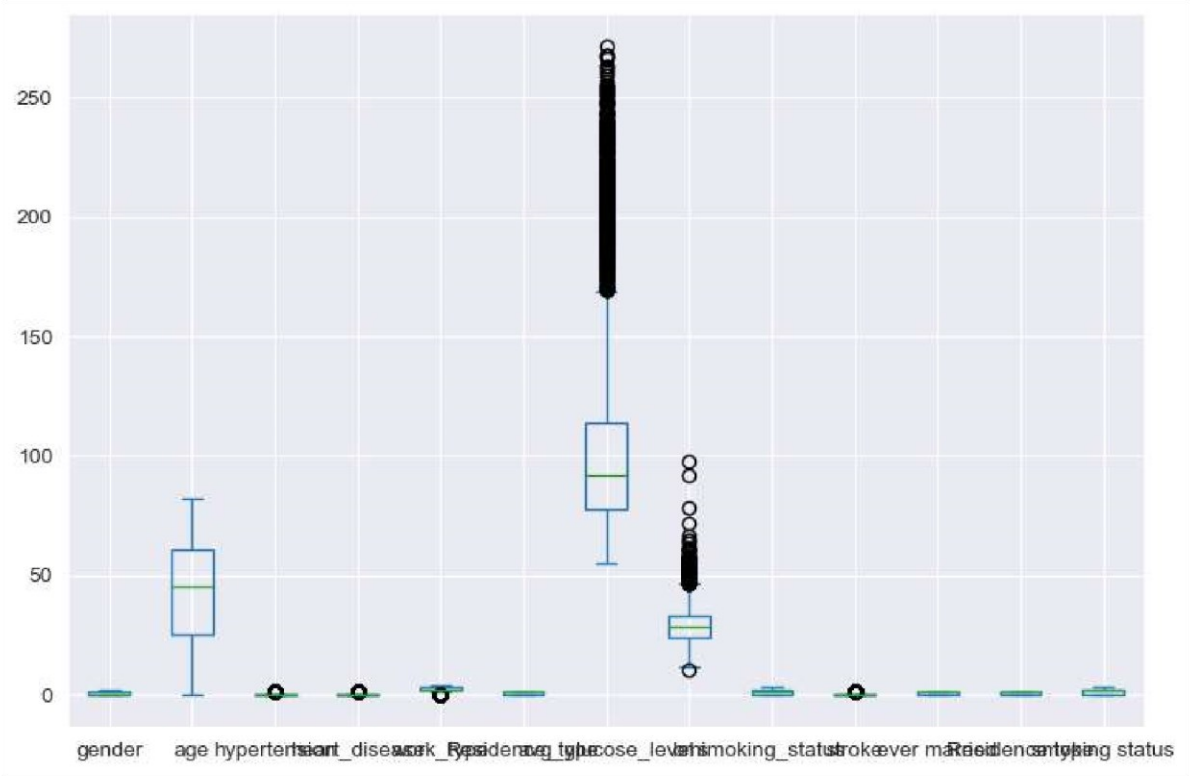


In [1]:

BOX-PLOT

47

```
1 df.plot(kind='box',figsize=(9,6))
2 plt.show()
```



In [154]:

```
1 df1.head()
```

Out[154]:

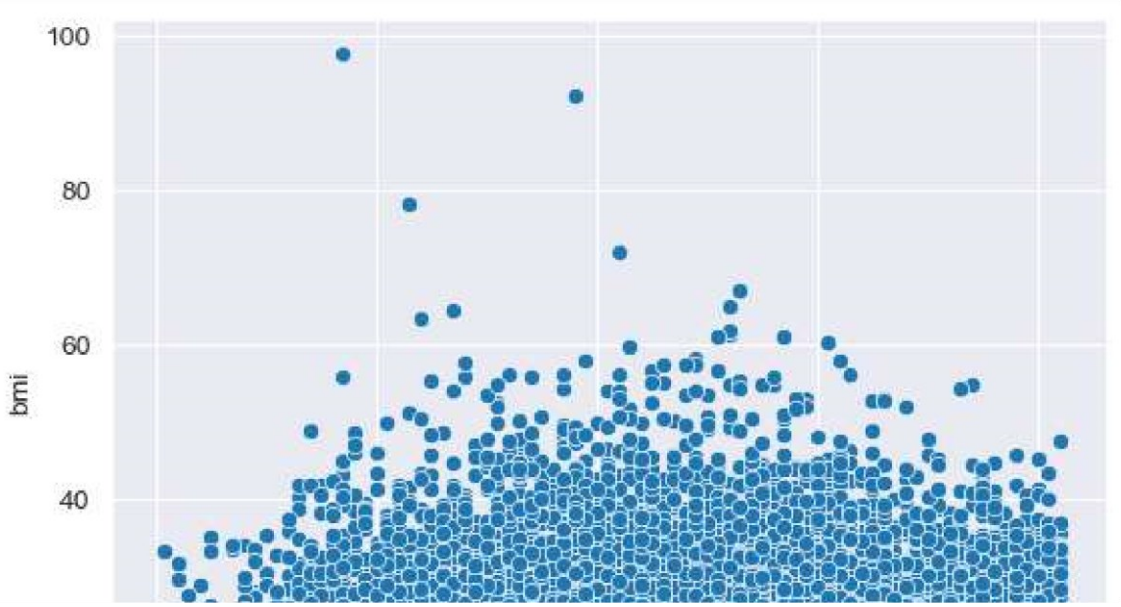
	id	gender	age	hypertension	heart_disease	ever_married	work_type	Residence_type
0	9046	Male	67.0	0	1	Yes	Private	Urban
1	51676	Female	61.0	0	0	Yes	Self-employed	Rural
2	31112	Male	80.0	0	1	Yes	Private	Rural
3	60182	Female	49.0	0	0	Yes	Private	Urban
4	1665	Female	79.0	1	0	Yes	Self-employed	Rural

In [1]:

SCATTER-PLOT

```
56 | 1 | sns.scatterplot(x='age',y='bmi',data=df1)
```

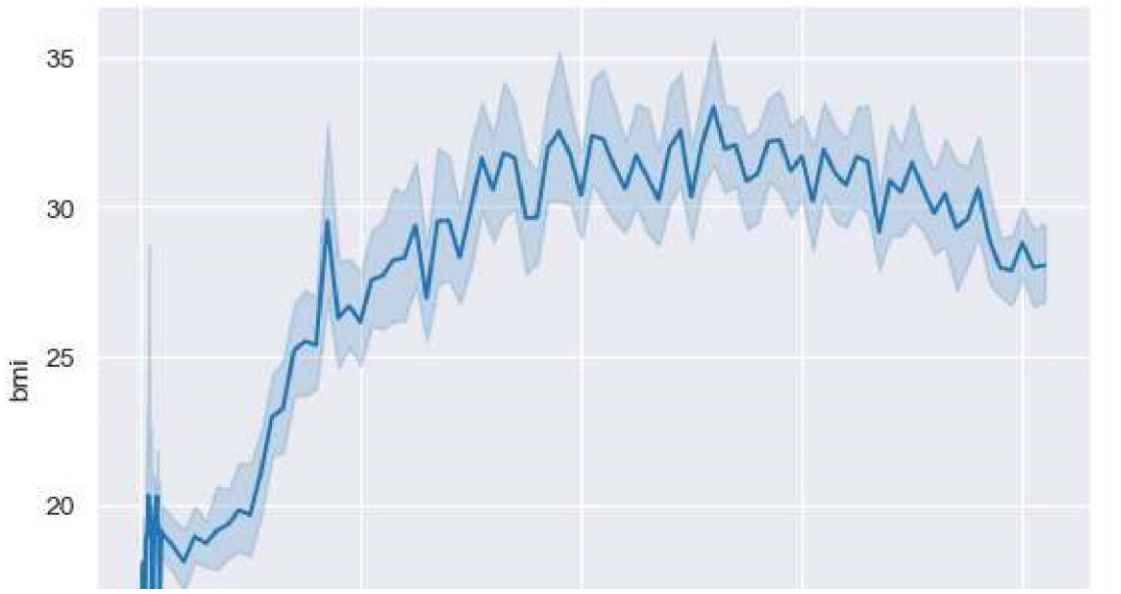
Out[156]: <AxesSubplot:xlabel='age', ylabel='bmi'>



LINE-PLOT

In [157]:
```
1 | sns.lineplot(x='age',y='bmi',data=df1)
```

Out[157]: <AxesSubplot:xlabel='age', ylabel='bmi'>



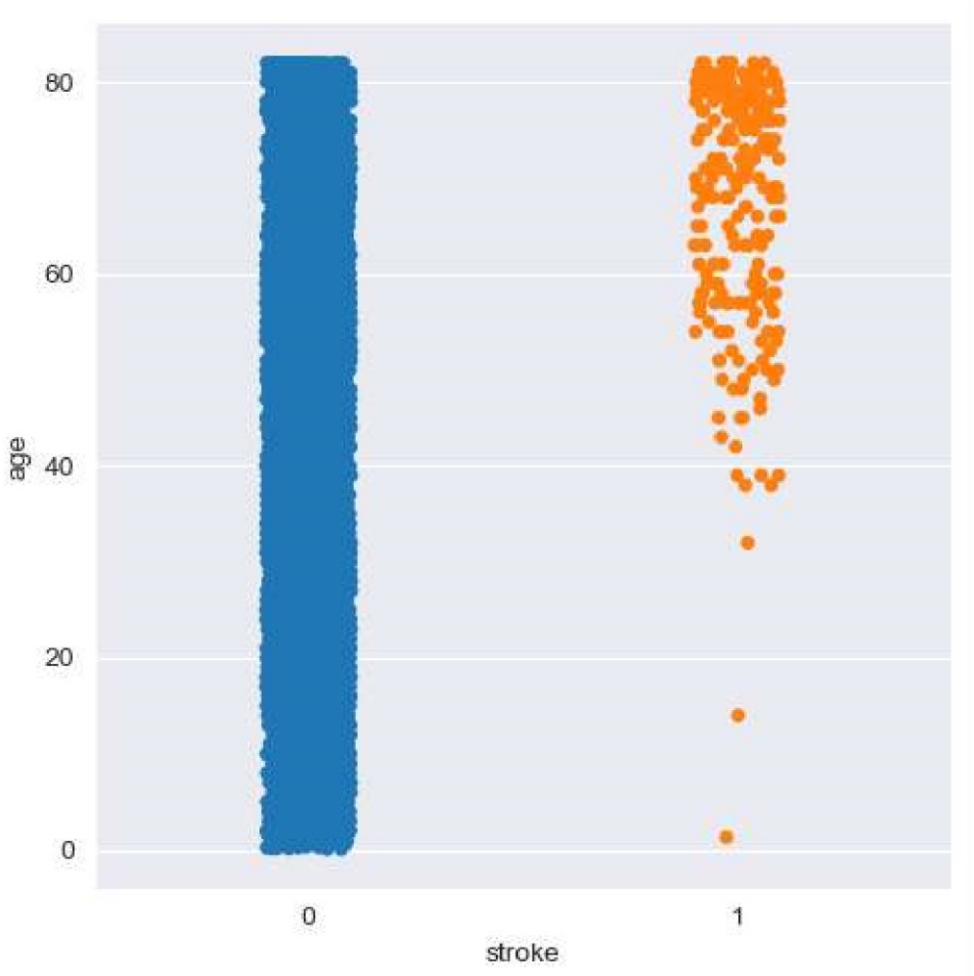
In [1]:

CAT-PLOT

61

```
1 sns.catplot(y='age',x='stroke',data=df1)
```

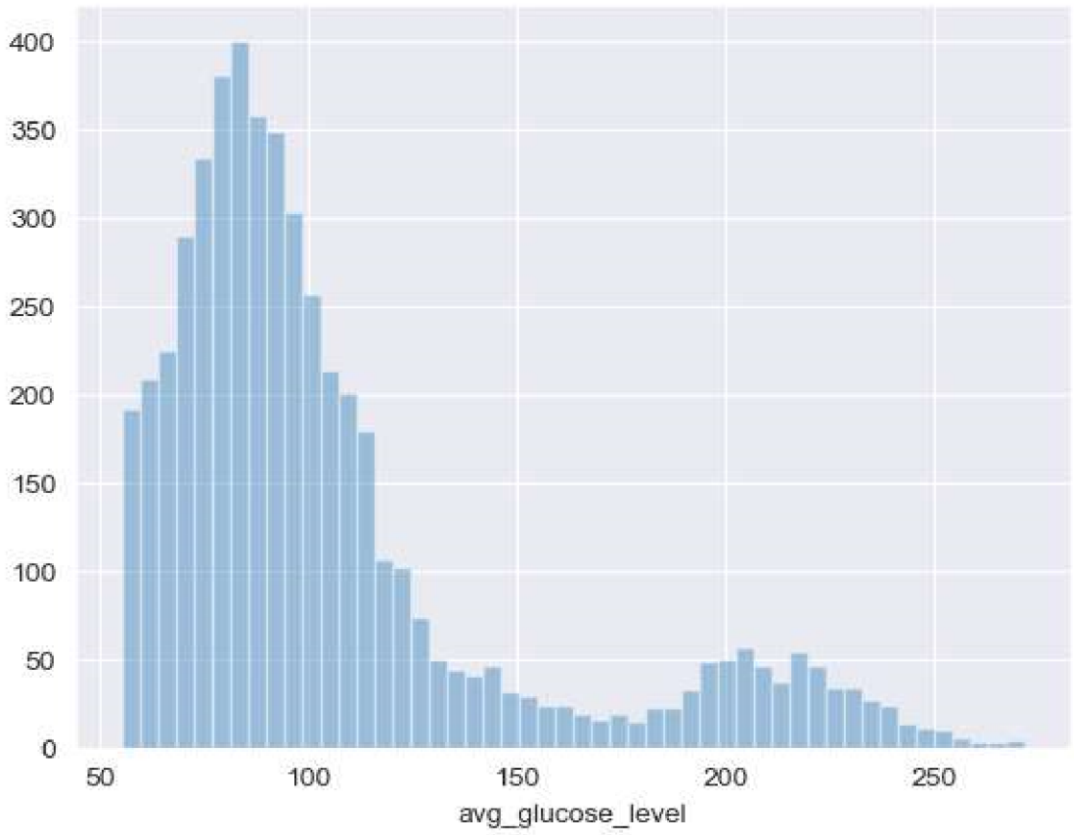
Out[161]: <seaborn.axisgrid.FacetGrid at 0x196fc6c3880>



In [164]:
```
1 sns.distplot(df1['avg_glucose_level'])
```

```
C:\Users\hp\anaconda3\lib\site-packages\seaborn\distributions.py:2619: Future
Warning: `distplot` is a deprecated function and will be removed in a future
version. Please adapt your code to use either `displot` (a figure-level funct
ion with similar flexibility) or `histplot` (an axes-level function for histo
grams).
  warnings.warn(msg, FutureWarning)
```

Out[164]: <AxesSubplot:xlabel='avg_glucose_level'>

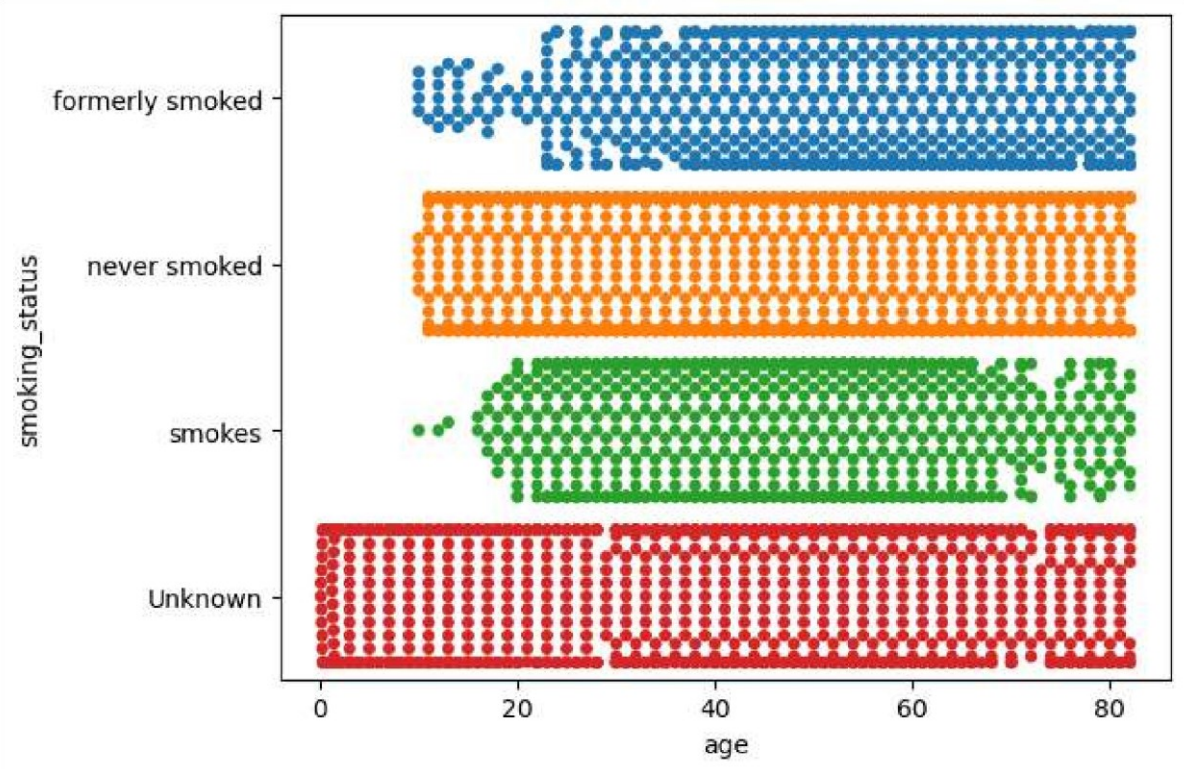


SWARNPLOT

In [5]:
```
1 sns.swarmplot(x='age',y='smoking_status',data=df1)
```

```
C:\Users\hp\anaconda3\lib\site-packages\seaborn\categorical.py:1296: UserWarn
ing: 50.7% of the points cannot be placed; you may want to decrease the size
of the markers or use stripplot.
  warnings.warn(msg, UserWarning)
C:\Users\hp\anaconda3\lib\site-packages\seaborn\categorical.py:1296: UserWarn
ing: 78.8% of the points cannot be placed; you may want to decrease the size
of the markers or use stripplot.
  warnings.warn(msg, UserWarning)
C:\Users\hp\anaconda3\lib\site-packages\seaborn\categorical.py:1296: UserWarn
ing: 70.1% of the points cannot be placed; you may want to decrease the size
of the markers or use stripplot.
  warnings.warn(msg, UserWarning)
```

Out[5]: <AxesSubplot:xlabel='age', ylabel='smoking_status'>



In [171]:
```
1 sns.pairplot(df1,hue="gender")
```

Out[171]: <seaborn.axisgrid.PairGrid at 0x196805a7dc0>

In [ ]:
```
1
```

In [ ]:
```
1
```

In [ ]:
```
1
```