

Insurance fraud detection is a challenging problem, given the variety of fraud patterns and relatively small ratio of known frauds in typical samples. While building detection models, the savings from loss prevention needs to be balanced with cost of false alerts.

Insurance frauds cover the range of improper activities which an individual may commit in order to achieve a favorable outcome from the insurance company. This could range from staging the incident, misrepresenting the situation including the relevant actors and the cause of incident and finally the extent of damage caused.

Potential situations could include:

- Covering-up for a situation that wasn't covered under insurance (e.g. drunk driving, performing risky acts, illegal activities etc.)
- Misrepresenting the context of the incident: This could include transferring the blame to incidents where the insured party is to blame, failure to take agreed upon safety measures
- Inflating the impact of the incident: Increasing the estimate of loss incurred either through addition of unrelated losses (faking losses) or attributing increased cost to the losses
- The insurance industry has grappled with the challenge of insurance claim fraud from the very start. On one hand, there is the challenge of impact to customer satisfaction through delayed payouts or prolonged investigation during a period of stress. Additionally, there are costs of investigation and pressure from insurance industry regulators. On the other hand, improper payouts cause a hit to profitability and encourage similar delinquent behavior from other policy holders.



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Import Packages

```
In [958]: import numpy as np # Linear algebra
import pandas as pd # data processing, CSV file I/O (e.g. pd.read_csv)
import seaborn as sns
import matplotlib.pyplot as plt
```

Data Read

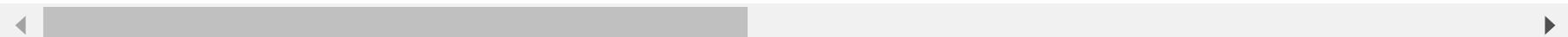
```
In [959]: df=pd.read_csv("file:///C:/Users/angsh/OneDrive/Desktop/PRAXIS/Own%20Projects/ML/insurance_claims.csv")
```

```
In [960]: df.head(2)
```

Out[960]:

	months_as_customer	age	policy_number	policy_bind_date	policy_state	policy_csl	policy_deductable	policy_annual_premium	umbrella_limit
0	328	48	521585	2014-10-17	OH	250/500	1000	1406.91	0
1	228	42	342868	2006-06-27	IN	250/500	2000	1197.22	5000000

2 rows × 40 columns

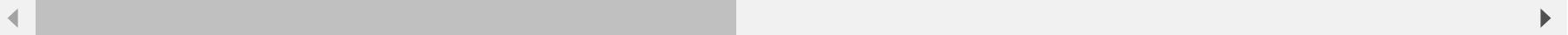


In [961]: df.tail(2)

Out[961]:

	months_as_customer	age	policy_number	policy_bind_date	policy_state	policy_csl	policy_deductable	policy_annual_premium	umbrella_limit
998	458	62	533940	2011-11-18	IL	500/1000	2000	1356.92	50000
999	456	60	556080	1996-11-11	OH	250/500	1000	766.19	

2 rows × 40 columns



EDA

In [962]: df.info()

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 1000 entries, 0 to 999
Data columns (total 40 columns):
 #   Column           Non-Null Count  Dtype  
--- 
 0   months_as_customer    1000 non-null   int64  
 1   age                  1000 non-null   int64  
 2   policy_number         1000 non-null   int64  
 3   policy_bind_date     1000 non-null   object  
 4   policy_state          1000 non-null   object  
 5   policy_csl            1000 non-null   object  
 6   policy_deductable    1000 non-null   int64  
 7   policy_annual_premium 1000 non-null   float64 
 8   umbrella_limit        1000 non-null   int64  
 9   insured_zip           1000 non-null   int64  
 10  insured_sex           1000 non-null   object  
 11  insured_education_level 1000 non-null   object  
 12  insured_occupation    1000 non-null   object  
 13  insured_hobbies       1000 non-null   object  
 14  insured_relationship  1000 non-null   object  
 15  capital-gains        1000 non-null   int64  
 16  capital-loss          1000 non-null   int64  
 17  incident_date         1000 non-null   object  
 18  incident_type         1000 non-null   object  
 19  collision_type        1000 non-null   object  
 20  incident_severity     1000 non-null   object  
 21  authorities_contacted 1000 non-null   object  
 22  incident_state        1000 non-null   object  
 23  incident_city          1000 non-null   object  
 24  incident_location      1000 non-null   object  
 25  incident_hour_of_the_day 1000 non-null   int64  
 26  number_of_vehicles_involved 1000 non-null   int64  
 27  property_damage        1000 non-null   object  
 28  bodily_injuries        1000 non-null   int64  
 29  witnesses              1000 non-null   int64  
 30  police_report_available 1000 non-null   object  
 31  total_claim_amount     1000 non-null   int64  
 32  injury_claim           1000 non-null   int64  
 33  property_claim          1000 non-null   int64  
 34  vehicle_claim           1000 non-null   int64  
 35  auto_make               1000 non-null   object
```

```
36 auto_model          1000 non-null  object
37 auto_year           1000 non-null  int64
38 fraud_reported     1000 non-null  object
39 _c39                0 non-null   float64
dtypes: float64(2), int64(17), object(21)
memory usage: 312.6+ KB
```

In [963]: df.shape

Out[963]: (1000, 40)

Check for Missing Values

In [964]: `df.isnull().sum()`

```
Out[964]: months_as_customer          0  
age                          0  
policy_number                 0  
policy_bind_date               0  
policy_state                  0  
policy_csl                     0  
policy_deductable              0  
policy_annual_premium           0  
umbrella_limit                 0  
insured_zip                   0  
insured_sex                    0  
insured_education_level         0  
insured_occupation              0  
insured_hobbies                 0  
insured_relationship             0  
capital-gains                  0  
capital-loss                   0  
incident_date                  0  
incident_type                  0  
collision_type                 0  
incident_severity                0  
authorities_contacted            0  
incident_state                  0  
incident_city                   0  
incident_location                0  
incident_hour_of_the_day          0  
number_of_vehicles_involved        0  
property_damage                  0  
bodily_injuries                  0  
witnesses                       0  
police_report_available            0  
total_claim_amount                0  
injury_claim                     0  
property_claim                   0  
vehicle_claim                     0  
auto_make                        0  
auto_model                       0  
auto_year                         0  
fraud_reported                   0  
_c39                           1000  
dtype: int64
```

```
In [965]: df.duplicated().sum()
```

```
Out[965]: 0
```

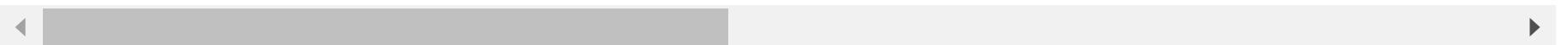
```
In [966]: df.drop('_c39',axis=1,inplace=True)
```

```
In [967]: # Deleteing the c_39 column as all the values in the feature set is NAN.  
df.head(2)
```

```
Out[967]:
```

	months_as_customer	age	policy_number	policy_bind_date	policy_state	policy_csl	policy_deductable	policy_annual_premium	umbrella_limit
0	328	48	521585	2014-10-17	OH	250/500	1000	1406.91	0
1	228	42	342868	2006-06-27	IN	250/500	2000	1197.22	5000000

2 rows × 39 columns



In [968]: df.describe().transpose()

Out[968]:

	count	mean	std	min	25%	50%	75%	max
months_as_customer	1000.0	2.039540e+02	1.151132e+02	0.00	115.7500	199.5	276.250	479.00
age	1000.0	3.894800e+01	9.140287e+00	19.00	32.0000	38.0	44.000	64.00
policy_number	1000.0	5.462386e+05	2.570630e+05	100804.00	335980.2500	533135.0	759099.750	999435.00
policy_deductable	1000.0	1.136000e+03	6.118647e+02	500.00	500.0000	1000.0	2000.000	2000.00
policy_annual_premium	1000.0	1.256406e+03	2.441674e+02	433.33	1089.6075	1257.2	1415.695	2047.59
umbrella_limit	1000.0	1.101000e+06	2.297407e+06	-1000000.00	0.0000	0.0	0.000	10000000.00
insured_zip	1000.0	5.012145e+05	7.170161e+04	430104.00	448404.5000	466445.5	603251.000	620962.00
capital-gains	1000.0	2.512610e+04	2.787219e+04	0.00	0.0000	0.0	51025.000	100500.00
capital-loss	1000.0	-2.679370e+04	2.810410e+04	-111100.00	-51500.0000	-23250.0	0.000	0.00
incident_hour_of_the_day	1000.0	1.164400e+01	6.951373e+00	0.00	6.0000	12.0	17.000	23.00
number_of_vehicles_involved	1000.0	1.839000e+00	1.018880e+00	1.00	1.0000	1.0	3.000	4.00
bodily_injuries	1000.0	9.920000e-01	8.201272e-01	0.00	0.0000	1.0	2.000	2.00
witnesses	1000.0	1.487000e+00	1.111335e+00	0.00	1.0000	1.0	2.000	3.00
total_claim_amount	1000.0	5.276194e+04	2.640153e+04	100.00	41812.5000	58055.0	70592.500	114920.00
injury_claim	1000.0	7.433420e+03	4.880952e+03	0.00	4295.0000	6775.0	11305.000	21450.00
property_claim	1000.0	7.399570e+03	4.824726e+03	0.00	4445.0000	6750.0	10885.000	23670.00
vehicle_claim	1000.0	3.792895e+04	1.888625e+04	70.00	30292.5000	42100.0	50822.500	79560.00
auto_year	1000.0	2.005103e+03	6.015861e+00	1995.00	2000.0000	2005.0	2010.000	2015.00

```
In [969]: df.columns
```

```
Out[969]: Index(['months_as_customer', 'age', 'policy_number', 'policy_bind_date',
       'policy_state', 'policy_csl', 'policy_deductable',
       'policy_annual_premium', 'umbrella_limit', 'insured_zip', 'insured_sex',
       'insured_education_level', 'insured_occupation', 'insured_hobbies',
       'insured_relationship', 'capital-gains', 'capital-loss',
       'incident_date', 'incident_type', 'collision_type', 'incident_severity',
       'authorities_contacted', 'incident_state', 'incident_city',
       'incident_location', 'incident_hour_of_the_day',
       'number_of_vehicles_involved', 'property_damage', 'bodily_injuries',
       'witnesses', 'police_report_available', 'total_claim_amount',
       'injury_claim', 'property_claim', 'vehicle_claim', 'auto_make',
       'auto_model', 'auto_year', 'fraud_reported'],
      dtype='object')
```

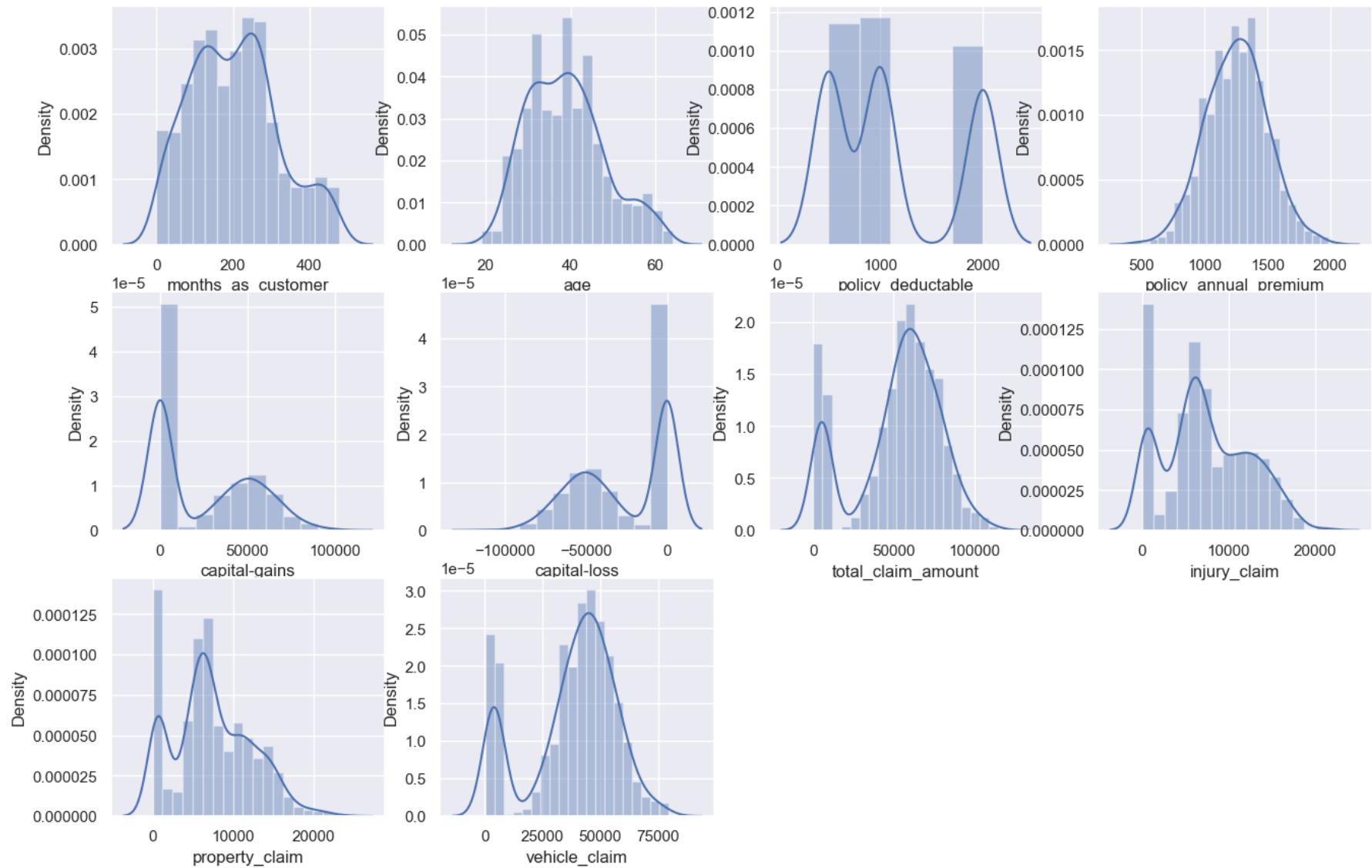
```
In [970]: df['fraud_reported'].value_counts()
```

```
Out[970]: N    753
Y    247
Name: fraud_reported, dtype: int64
```

```
In [971]: fraud=df[df['fraud_reported']=='Y']
```

```
In [972]: col=['months_as_customer','age','policy_deductable','policy_annual_premium','capital-gains','capital-loss','total_cla  
  
plt.figure(figsize=(16,14))  
k=1  
for i in col :  
    plt.subplot(4,4,k)  
    sns.distplot(df[i])  
    k=k+1  
plt.show()
```

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



All the above data are almost normally distributed

```
In [973]: # An umbrella policy is a policy that provides excess limits and gives additional excess coverage over the normal limit
df['umbrella_limit'].value_counts()
```

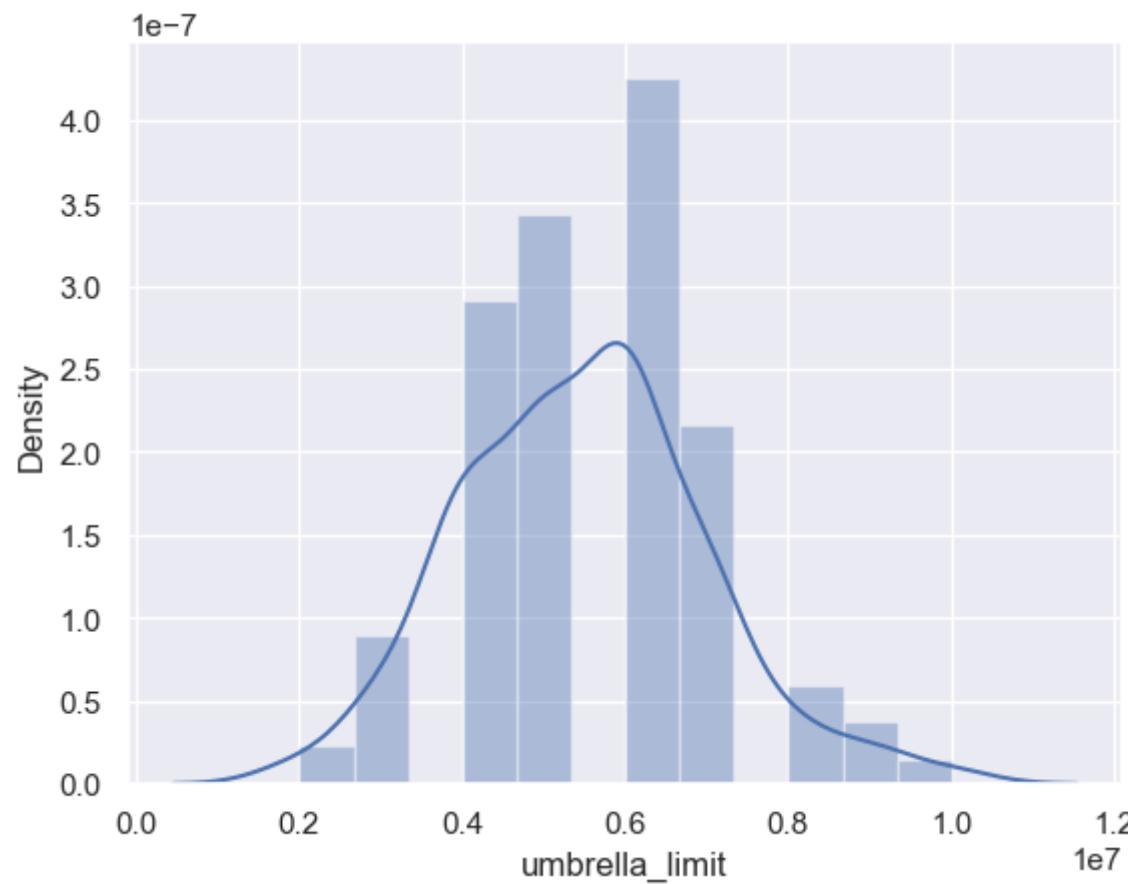
```
Out[973]: 0      798
6000000    57
5000000    46
4000000    39
7000000    29
3000000    12
8000000     8
9000000     5
2000000     3
10000000    2
-1000000    1
Name: umbrella_limit, dtype: int64
```

```
In [974]: a=df[df['umbrella_limit'] >0]
```

In [975]: #To know the distribution of the umbrella_limit
sns.distplot(a['umbrella_limit'])

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

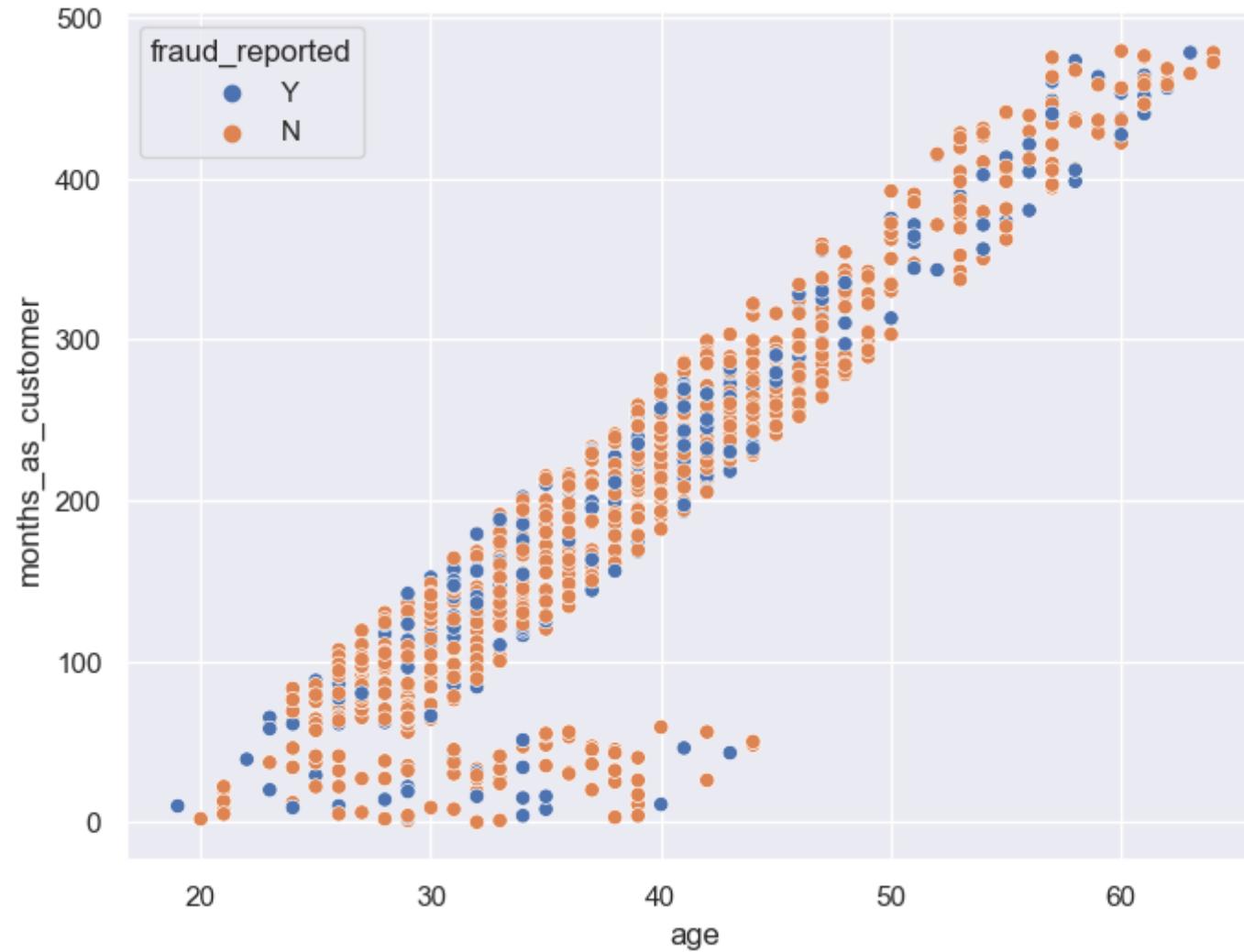
Out[975]: <AxesSubplot:xlabel='umbrella_limit', ylabel='Density'>



In [976]: df.columns

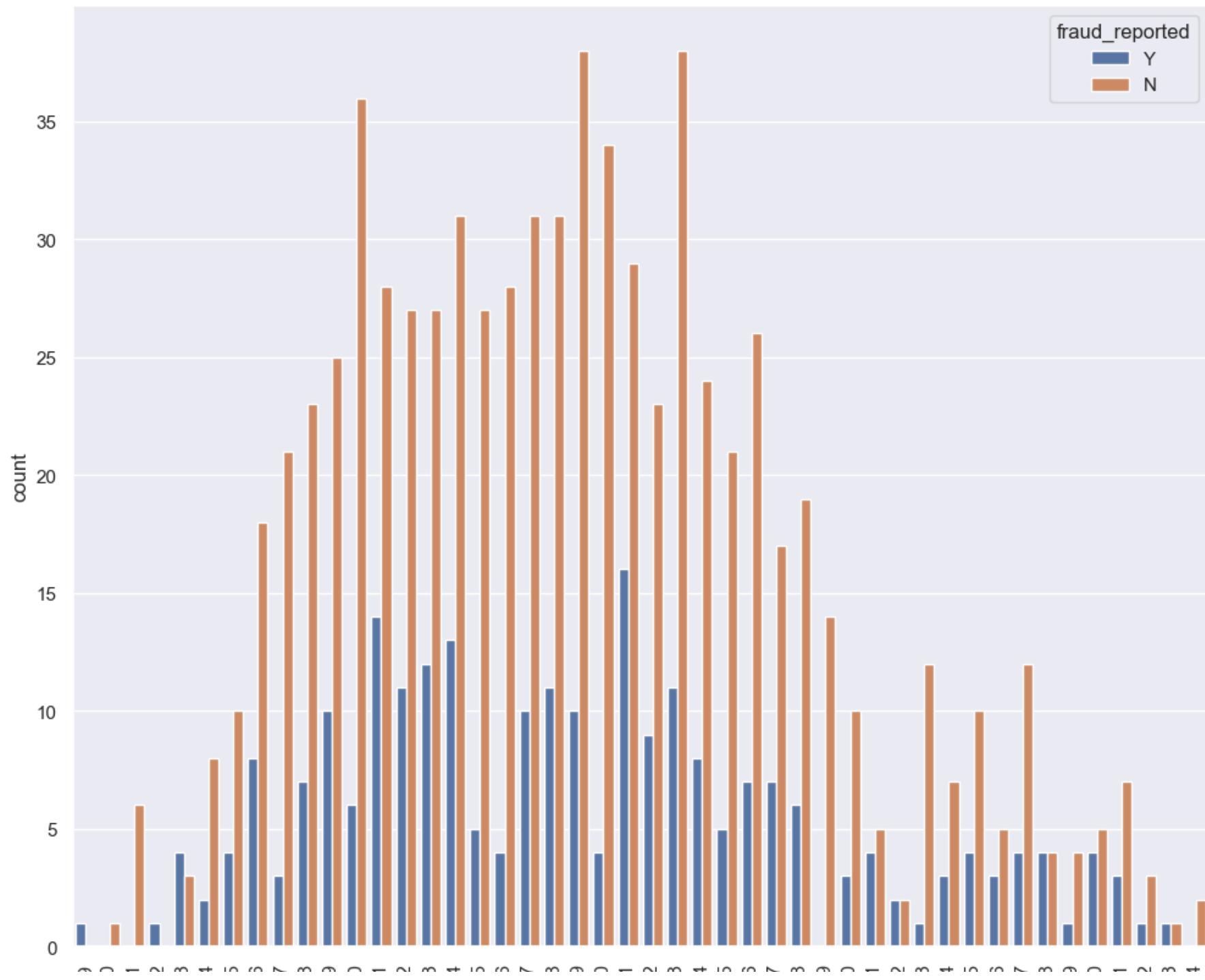
```
Out[976]: Index(['months_as_customer', 'age', 'policy_number', 'policy_bind_date',
       'policy_state', 'policy_csl', 'policy_deductable',
       'policy_annual_premium', 'umbrella_limit', 'insured_zip', 'insured_sex',
       'insured_education_level', 'insured_occupation', 'insured_hobbies',
       'insured_relationship', 'capital-gains', 'capital-loss',
       'incident_date', 'incident_type', 'collision_type', 'incident_severity',
       'authorities_contacted', 'incident_state', 'incident_city',
       'incident_location', 'incident_hour_of_the_day',
       'number_of_vehicles_involved', 'property_damage', 'bodily_injuries',
       'witnesses', 'police_report_available', 'total_claim_amount',
       'injury_claim', 'property_claim', 'vehicle_claim', 'auto_make',
       'auto_model', 'auto_year', 'fraud_reported'],
      dtype='object')
```

```
In [977]: plt.figure(figsize=(8,6))
sns.scatterplot(x='age', y='months_as_customer', hue='fraud_reported', data=df)
plt.grid(True)
plt.show()
```



We do not have any pattern which justifies if customers with more years with the company are claiming fraud insurance.

```
In [978]: plt.figure(figsize=(12,10))
sns.countplot(x='age',hue='fraud_reported',data=df)
plt.xticks(rotation=90)
plt.show()
```

15 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64
age

In [979]: # Taking a as a new dataframe where fraude reported is yes in the dataset.

```
a=df[df['fraud_reported'] == 'Y']
```

```
a[['policy_number','insured_occupation','insured_education_level','total_claim_amount']].sort_values('total_claim_amo
```

Out[979]:

	policy_number	insured_occupation	insured_education_level	total_claim_amount
149	217938	craft-repair	JD	112320
163	346940	prof-specialty	Masters	107900
479	753844	sales	MD	104610
145	515050	exec-managerial	Associate	99320
247	187775	other-service	JD	98670
91	127754	tech-support	Associate	98340
974	291006	transport-moving	JD	98280
23	115399	priv-house-serv	MD	98160
41	616337	transport-moving	Associate	97080
796	728025	machine-op-inspct	Masters	92730
926	752504	transport-moving	Masters	91520
848	953334	craft-repair	MD	90860
66	356590	tech-support	High School	89700
185	442795	tech-support	JD	88660
517	243226	armed-forces	High School	87960
628	730819	protective-serv	JD	87890
727	691115	farming-fishing	JD	86130
722	334749	handlers-cleaners	Associate	85900
829	951863	protective-serv	Masters	84920
593	209177	craft-repair	JD	84590

We have top 20 fraud claims with policy number and their occupation listed Policy number 217938 has claimed highest amount of 112320\$ and is working as craft-repair

```
In [980]: a['insured_education_level'].value_counts()
```

```
Out[980]: JD      42  
MD      38  
High School 36  
Associate 34  
PhD      33  
College   32  
Masters   32  
Name: insured_education_level, dtype: int64
```

```
In [981]: #People who have education Level as JD has claimed more fraud transactions
```

```
In [982]: a['insured_occupation'].value_counts()
```

```
Out[982]: exec-managerial    28  
craft-repair        22  
machine-op-inspct  22  
tech-support       22  
transport-moving   21  
sales              21  
prof-specialty    18  
armed-forces      17  
farming-fishing   16  
protective-serv   14  
priv-house-serv   12  
other-service      12  
handlers-cleaners 11  
adm-clerical      11  
Name: insured_occupation, dtype: int64
```

People who are working as exec-manager has claimed more fraud transactions

```
In [983]: sns.set(style="darkgrid")

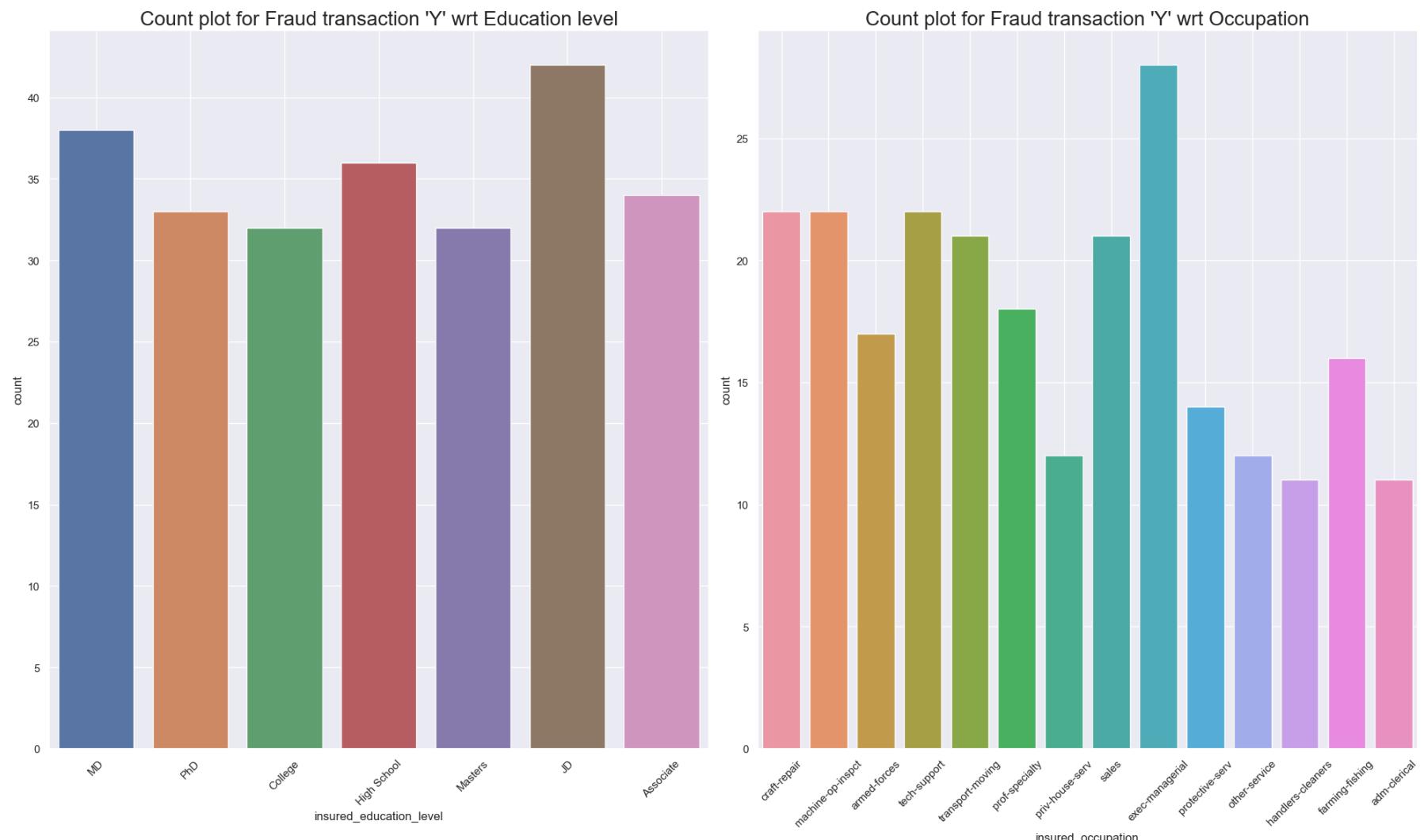
plt.figure(figsize=(20,12))
plt.subplot(1,2,1)
plt.title("Count plot for Fraud transaction 'Y' wrt Education level",fontsize=20)
sns.countplot('insured_education_level',data=a)
plt.xticks(rotation=45)
plt.grid(True)
plt.tight_layout()
plt.subplot(1,2,2)
plt.title("Count plot for Fraud transaction 'Y' wrt Occupation",fontsize=20)
sns.countplot('insured_occupation',data=a)
plt.xticks(rotation=45)
plt.grid(True)
plt.tight_layout()
plt.show()
```

C:\Users\angsh\anaconda3\lib\site-packages\seaborn_decorators.py:36: FutureWarning: Pass the following variable as a keyword arg: x. From version 0.12, the only valid positional argument will be `data`, and passing other arguments without an explicit keyword will result in an error or misinterpretation.

```
warnings.warn(
```

C:\Users\angsh\anaconda3\lib\site-packages\seaborn_decorators.py:36: FutureWarning: Pass the following variable as a keyword arg: x. From version 0.12, the only valid positional argument will be `data`, and passing other arguments without an explicit keyword will result in an error or misinterpretation.

```
warnings.warn(
```



People with occupation as Exec Manager seems to be doing more fraud transactions and people with JD level of education are also involved in more fraud transactions. Comparitively people with less education are claiming more fraud claims.

```
In [984]: #Looking at below maximum claim amount as per insured occupation and education level.  
a_claims=pd.pivot_table(a,values='total_claim_amount',index=['insured_occupation','insured_education_level']).sort_va  
cm = sns.light_palette("blue", as_cmap=True)  
a_claims.style.background_gradient(cmap=cm)
```

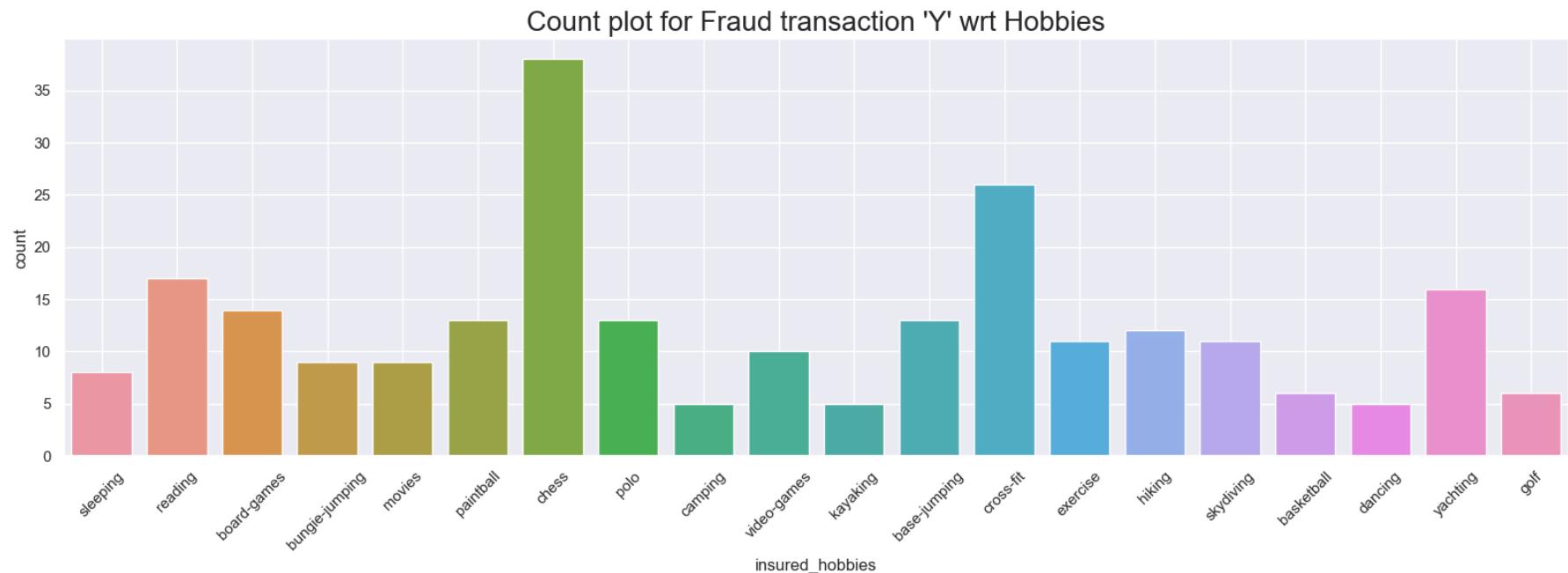
Out[984]:

		total_claim_amount	
insured_occupation	insured_education_level		
protective-serv	JD	87890.000000	
handlers-cleaners	Associate	85900.000000	
priv-house-serv	MD	81353.333333	
other-service	JD	81135.000000	
tech-support	Associate	80113.333333	
transport-moving	JD	79225.000000	
	Associate	76873.333333	
	High School	76010.000000	
protective-serv	MD	75290.000000	
	College	75185.000000	

People from occupation sector Protective-services and education level of JD has highest fraud claimed amount of 87,890\$

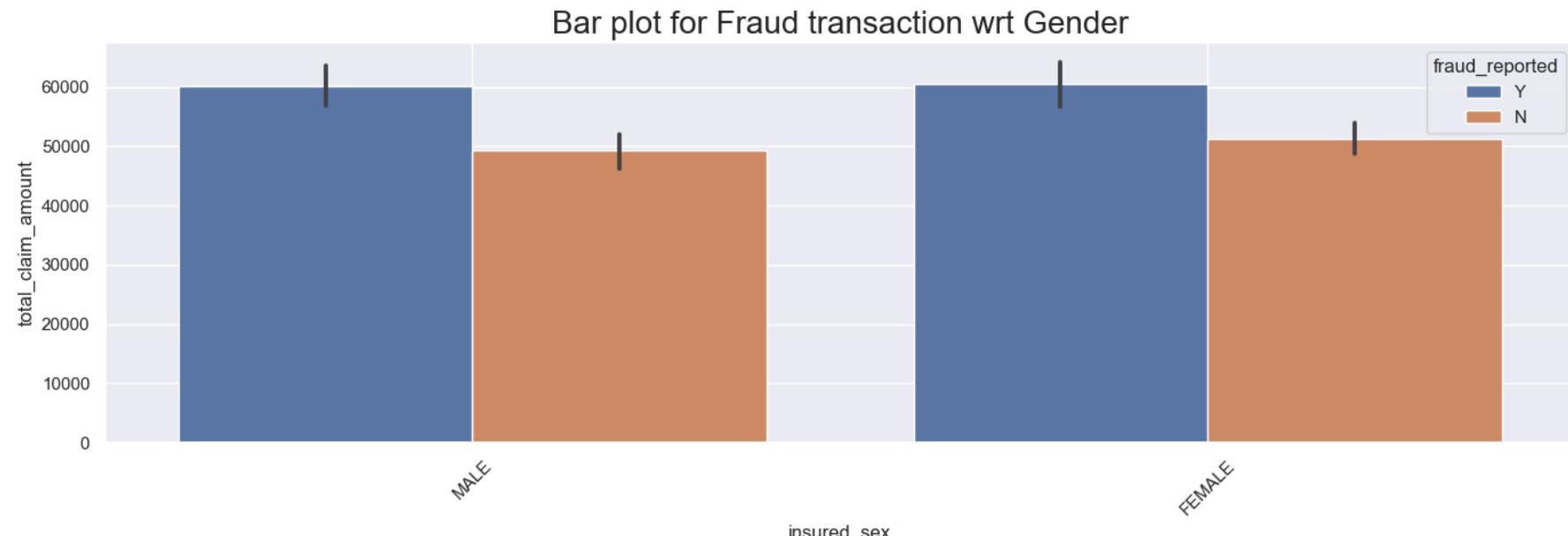
```
In [985]: plt.figure(figsize=(16,6))
plt.title("Count plot for Fraud transaction 'Y' wrt Hobbies", fontsize=20)
sns.countplot('insured_hobbies', data=a)
plt.xticks(rotation=45)
plt.grid(True)
plt.tight_layout()
plt.show()
```

C:\Users\angsh\anaconda3\lib\site-packages\seaborn_decorators.py:36: FutureWarning: Pass the following variable as a keyword arg: x. From version 0.12, the only valid positional argument will be `data`, and passing other arguments without an explicit keyword will result in an error or misinterpretation.
warnings.warn(



People who play more chess have claimed more fraud followed by crossfit

```
In [986]: plt.figure(figsize=(14,5))
plt.title("Bar plot for Fraud transaction wrt Gender", fontsize=20)
sns.barplot(x='insured_sex', y='total_claim_amount', hue='fraud_reported', data=df)
plt.xticks(rotation=45)
plt.grid(True)
plt.tight_layout()
plt.show()
```



Both Male and female have claimed same amount which are fraud

```
In [987]: a['insured_relationship'].value_counts()
```

```
Out[987]: other-relative    52
not-in-family      45
wife              42
own-child         39
husband           35
unmarried          34
Name: insured_relationship, dtype: int64
```

```
In [988]: # calculating profit based on capital gains and capital loss for the insurance company
profit=df['capital-gains']-df['capital-loss']
df1=df
df1['profit']=profit
```

```
In [989]: df1.columns
```

```
Out[989]: Index(['months_as_customer', 'age', 'policy_number', 'policy_bind_date',
       'policy_state', 'policy_csl', 'policy_deductable',
       'policy_annual_premium', 'umbrella_limit', 'insured_zip', 'insured_sex',
       'insured_education_level', 'insured_occupation', 'insured_hobbies',
       'insured_relationship', 'capital-gains', 'capital-loss',
       'incident_date', 'incident_type', 'collision_type', 'incident_severity',
       'authorities_contacted', 'incident_state', 'incident_city',
       'incident_location', 'incident_hour_of_the_day',
       'number_of_vehicles_involved', 'property_damage', 'bodily_injuries',
       'witnesses', 'police_report_available', 'total_claim_amount',
       'injury_claim', 'property_claim', 'vehicle_claim', 'auto_make',
       'auto_model', 'auto_year', 'fraud_reported', 'profit'],
      dtype='object')
```

```
In [990]: df[['policy_number', 'profit']].sort_values('profit', ascending=False)[0:20]
```

Out[990]:

	policy_number	profit
807	250833	192000
533	840806	164100
59	485372	153300
679	774303	151100
353	958785	150600
523	190588	149400
613	831053	148000
846	545506	142500
507	925128	142300
598	507545	141600
916	727443	141200
22	285496	140900
305	771236	139500
517	243226	139000
974	291006	138000
83	960680	137900
431	497347	136500
426	131478	136300
970	844129	136200
790	607259	136000

```
In [991]: # The policy number 250833 gives us the highest profit or low claim.
```

```
In [992]: df[['incident_date', 'incident_type', 'collision_type', 'incident_severity',
       'authorities_contacted', 'incident_state', 'incident_city',
       'incident_location', 'incident_hour_of_the_day',
       'number_of_vehicles_involved']]
```

Out[992]:

	incident_date	incident_type	collision_type	incident_severity	authorities_contacted	incident_state	incident_city	incident_location	incident_
0	2015-01-25	Single Vehicle Collision	Side Collision	Major Damage	Police	SC	Columbus	9935 4th Drive	
1	2015-01-21	Vehicle Theft		?	Minor Damage	Police	VA	Riverwood	6608 MLK Hwy
2	2015-02-22	Multi-vehicle Collision	Rear Collision	Minor Damage	Police	NY	Columbus	7121 Francis Lane	
3	2015-01-10	Single Vehicle Collision	Front Collision	Major Damage	Police	OH	Arlington	6956 Maple Drive	
4	2015-02-17	Vehicle Theft		?	Minor Damage	None	NY	Arlington	3041 3rd Ave
...
995	2015-02-22	Single Vehicle Collision	Front Collision	Minor Damage	Fire	NC	Northbrook	6045 Andromedia St	
996	2015-01-24	Single Vehicle Collision	Rear Collision	Major Damage	Fire	SC	Northbend	3092 Texas Drive	
997	2015-01-23	Multi-vehicle Collision	Side Collision	Minor Damage	Police	NC	Arlington	7629 5th St	
998	2015-02-26	Single Vehicle Collision	Rear Collision	Major Damage	Other	NY	Arlington	6128 Elm Lane	
999	2015-02-26	Parked Car		?	Minor Damage	Police	WV	Columbus	1416 Cherokee Ridge

1000 rows × 10 columns



In [993]: `pd.pivot_table(a, values=['number_of_vehicles_involved', 'total_claim_amount', 'vehicle_claim', 'incident_hour_of_the_day'])`

Out[993]:

		incident_hour_of_the_day	number_of_vehicles_involved	total_claim_amount	vehicle_claim
incident_type	collision_type				
Single Vehicle Collision	Front Collision	11.595238	1.000000	66596.190476	49030.000000
	Side Collision	11.787879	1.000000	68009.696970	48481.212121
	Rear Collision	11.071429	1.000000	65782.857143	47616.666667
Multi-vehicle Collision	Side Collision	11.432432	2.972973	62281.621622	45308.648649
	Front Collision	11.892857	2.964286	60970.000000	43860.000000
	Rear Collision	14.142857	3.081633	61152.448980	43474.693878
Parked Car	?	7.000000	1.000000	5093.750000	3711.250000
Vehicle Theft	?	5.375000	1.000000	5197.500000	3665.000000

For auto claims, single vehicle side collision have claimed highest

In [994]: `df['number_of_vehicles_involved'].nunique()`

Out[994]: 4

In [995]: `df['number_of_vehicles_involved'].value_counts()`

Out[995]:

1	581
3	358
4	31
2	30

Name: number_of_vehicles_involved, dtype: int64

```
In [996]: df['incident_type'].value_counts()
```

```
Out[996]: Multi-vehicle Collision      419  
Single Vehicle Collision      403  
Vehicle Theft                  94  
Parked Car                     84  
Name: incident_type, dtype: int64
```

```
In [997]: df['collision_type'].value_counts()
```

```
Out[997]: Rear Collision      292  
Side Collision                 276  
Front Collision                254  
?                            178  
Name: collision_type, dtype: int64
```

```
In [998]: # For collision type we have few ? values, which are nan values and has to be replaced/removed  
#Let us see for what kind of incident we have for value ?  
coll=a[['incident_type','collision_type']]  
coll
```

Out[998]:

	incident_type	collision_type
0	Single Vehicle Collision	Side Collision
1	Vehicle Theft	?
3	Single Vehicle Collision	Front Collision
5	Multi-vehicle Collision	Rear Collision
14	Single Vehicle Collision	Rear Collision
...
974	Multi-vehicle Collision	Side Collision
977	Multi-vehicle Collision	Side Collision
982	Multi-vehicle Collision	Front Collision
986	Single Vehicle Collision	Rear Collision
987	Single Vehicle Collision	Side Collision

247 rows × 2 columns

```
In [999]: res=coll.loc[coll['collision_type']=='?']  
res
```

Out[999]:

	incident_type	collision_type
1	Vehicle Theft	?
27	Vehicle Theft	?
196	Vehicle Theft	?
281	Vehicle Theft	?
364	Parked Car	?
365	Parked Car	?
373	Parked Car	?
437	Parked Car	?
474	Parked Car	?
478	Vehicle Theft	?
538	Parked Car	?
552	Vehicle Theft	?
597	Parked Car	?
635	Parked Car	?
837	Vehicle Theft	?
964	Vehicle Theft	?

```
In [1000]: res['incident_type'].value_counts()
```

Out[1000]: Vehicle Theft 8
Parked Car 8
Name: incident_type, dtype: int64

8 Cars which are parked and 8 cars which are theft have claimed fraud.

```
In [1001]: coll_df=df[['incident_type','collision_type']]
```

```
In [1002]: res_df=coll_df.loc[coll_df['collision_type']=='?']
```

```
In [1003]: res_df['incident_type'].value_counts()
```

```
Out[1003]: Vehicle Theft    94  
Parked Car      84  
Name: incident_type, dtype: int64
```

Cars which are theft and Parked are marked as ?, we can replace them with either NA or No collision

```
In [1004]: # Replace it with NA as some other values could bring the biasness.  
df['collision_type']=df['collision_type'].replace("?", "Not Applicable")
```

```
In [1005]: df['collision_type'].value_counts()
```

```
Out[1005]: Rear Collision    292  
Side Collision     276  
Front Collision    254  
Not Applicable     178  
Name: collision_type, dtype: int64
```

```
In [1006]: # Now, we are trying to see in which city the incidents are more  
a['incident_city'].value_counts()
```

```
Out[1006]: Arlington      44  
Columbus        39  
Springfield     38  
Hillsdale       35  
Northbend       34  
Riverwood       30  
Northbrook      27  
Name: incident_city, dtype: int64
```

People from Arlington have more auto related incidents which are claimed to be fraud

In [1007]: `pd.pivot_table(a,values=['total_claim_amount','vehicle_claim'],index=['incident_state','incident_city']).sort_values()`

Out[1007]:

		total_claim_amount	vehicle_claim
incident_state	incident_city		
SC	Riverwood	78980.000000	56553.333333
OH	Columbus	78100.000000	54670.000000
NC	Northbrook	76653.333333	55346.666667
WV	Northbrook	75205.000000	53997.500000
SC	Springfield	73116.666667	50267.500000
NY	Northbrook	69730.000000	50758.571429
NC	Springfield	69270.000000	51032.000000
NY	Springfield	67157.000000	47976.000000
OH	Northbrook	66550.000000	46585.000000
PA	Hillsdale	66480.000000	49860.000000
WV	Arlington	66077.142857	45911.428571
	Hillsdale	65931.666667	46198.333333
	Northbend	65786.000000	49410.000000
NY	Columbus	65067.777778	47463.333333
SC	Northbend	64135.555556	46540.000000
NY	Hillsdale	64012.857143	47301.428571
	Northbend	63797.500000	45491.250000
SC	Arlington	63037.500000	44675.000000
VA	Springfield	61665.000000	47475.000000
	Columbus	61635.000000	45662.500000

Riverwood city from SC state have claimed maximum amount of fraud for auto insurance

In [1008]: df.columns

```
Out[1008]: Index(['months_as_customer', 'age', 'policy_number', 'policy_bind_date',
       'policy_state', 'policy_csl', 'policy_deductable',
       'policy_annual_premium', 'umbrella_limit', 'insured_zip', 'insured_sex',
       'insured_education_level', 'insured_occupation', 'insured_hobbies',
       'insured_relationship', 'capital-gains', 'capital-loss',
       'incident_date', 'incident_type', 'collision_type', 'incident_severity',
       'authorities_contacted', 'incident_state', 'incident_city',
       'incident_location', 'incident_hour_of_the_day',
       'number_of_vehicles_involved', 'property_damage', 'bodily_injuries',
       'witnesses', 'police_report_available', 'total_claim_amount',
       'injury_claim', 'property_claim', 'vehicle_claim', 'auto_make',
       'auto_model', 'auto_year', 'fraud_reported', 'profit'],
      dtype='object')
```

In [1009]: # Trying to see the vehicle claim data.

```
a.loc[(a['property_claim'] == 0.0 )&(a['vehicle_claim'] != 0.0 )]
```

Out[1009]:

	months_as_customer	age	policy_number	policy_bind_date	policy_state	policy_csl	policy_deductable	policy_annual_premium	umbrella_limit
60	154	34	598554	1990-02-14	IN	100/300	500	795.23	
155	375	50	120485	2007-02-18	OH	100/300	1000	1275.39	
705	274	45	589094	2003-05-27	IN	250/500	1000	1353.53	
803	123	29	379268	2012-08-05	IN	250/500	500	1209.63	
843	297	48	264221	2014-07-28	IL	500/1000	1000	1243.68	
938	147	31	746630	1997-02-10	IN	250/500	500	1054.92	60000

6 rows × 39 columns



```
In [1010]: plt.figure(figsize=(16,8))
plt.subplot(2,1,1)
plt.title("Count plot for Auto make", fontsize=20)
sns.countplot('auto_make', data=df)
plt.xticks(rotation=45)
plt.grid(True)
plt.tight_layout()
plt.subplot(2,1,2)
plt.title("Count plot for Auto model", fontsize=20)
sns.countplot('auto_model', data=df)
plt.xticks(rotation=90)
plt.grid(True)
plt.tight_layout()
plt.show()
```

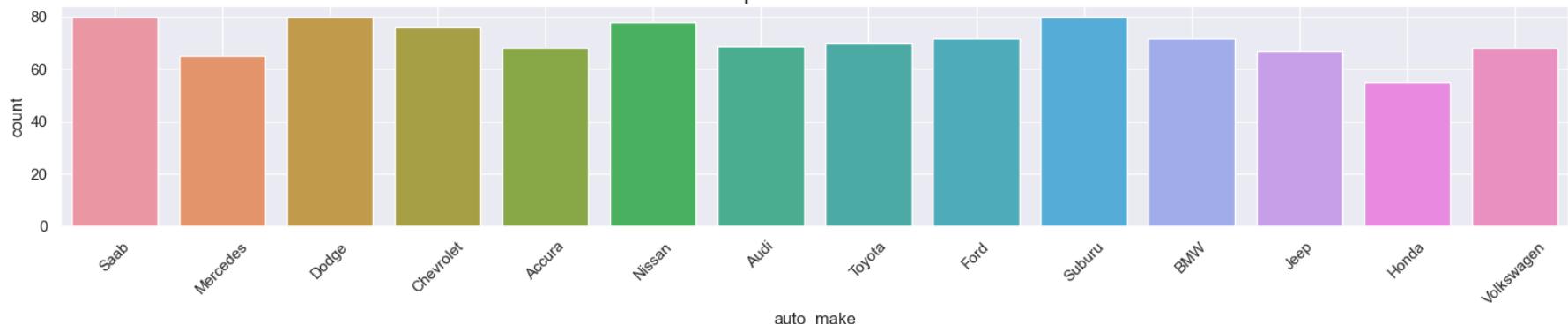
C:\Users\angsh\anaconda3\lib\site-packages\seaborn_decorators.py:36: FutureWarning: Pass the following variable as a keyword arg: x. From version 0.12, the only valid positional argument will be `data`, and passing other arguments without an explicit keyword will result in an error or misinterpretation.

```
    warnings.warn(
```

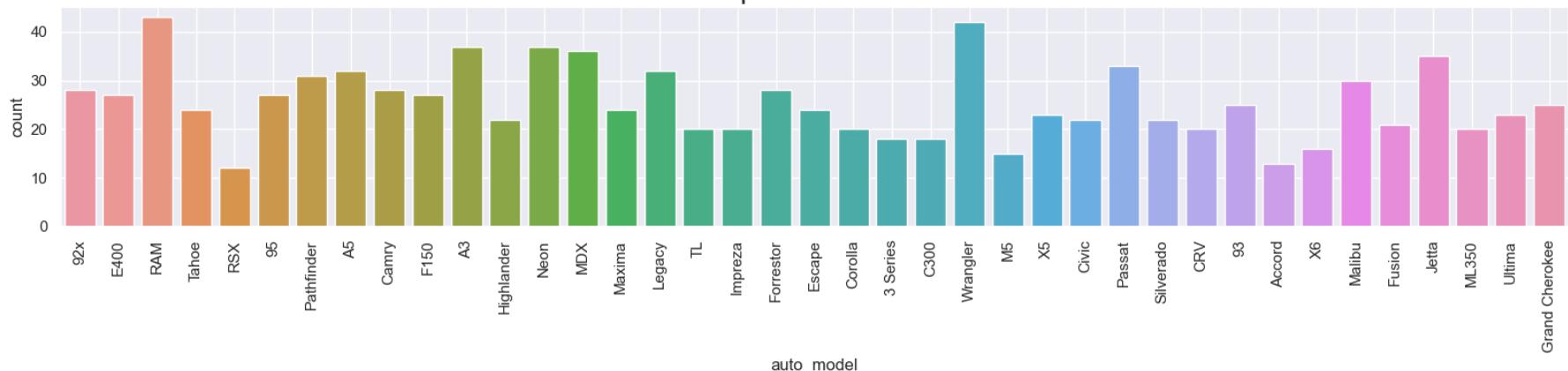
C:\Users\angsh\anaconda3\lib\site-packages\seaborn_decorators.py:36: FutureWarning: Pass the following variable as a keyword arg: x. From version 0.12, the only valid positional argument will be `data`, and passing other arguments without an explicit keyword will result in an error or misinterpretation.

```
    warnings.warn(
```

Count plot for Auto make



Count plot for Auto model



```
In [1011]: a['auto_make'].value_counts()
```

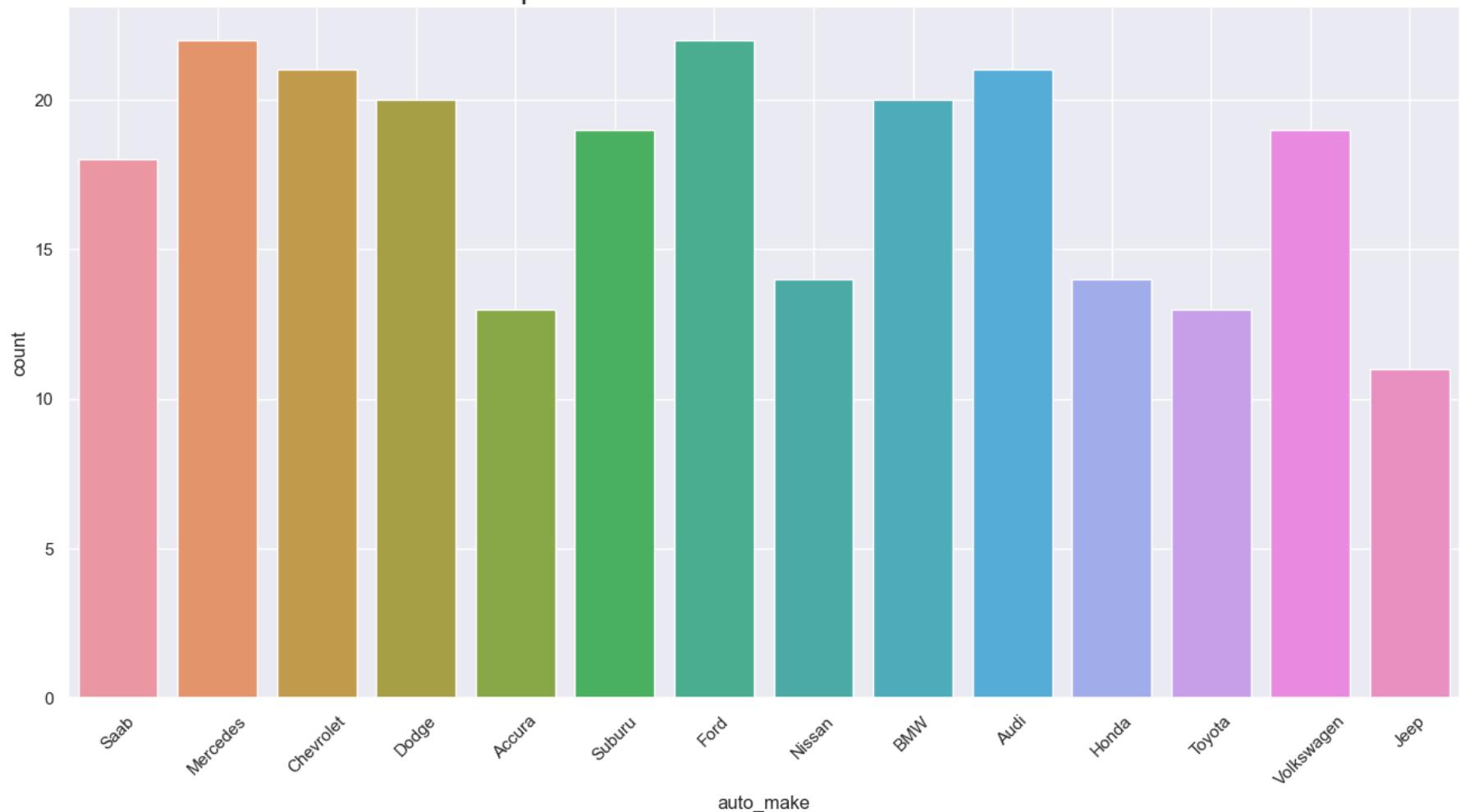
```
Out[1011]: Mercedes      22
Ford          22
Chevrolet    21
Audi          21
Dodge          20
BMW           20
Suburu        19
Volkswagen   19
Saab          18
Nissan        14
Honda         14
Accura        13
Toyota        13
Jeep          11
Name: auto_make, dtype: int64
```

```
In [1012]: plt.figure(figsize=(16,8))
plt.title("Count plot of Auto make which have Fraud claim", fontsize=20)
sns.countplot('auto_make', data=a)
plt.xticks(rotation=45)
plt.grid(True)
plt.show()
```

C:\Users\angsh\anaconda3\lib\site-packages\seaborn_decorators.py:36: FutureWarning: Pass the following variable as a keyword arg: x. From version 0.12, the only valid positional argument will be `data`, and passing other arguments without an explicit keyword will result in an error or misinterpretation.

```
    warnings.warn(
```

Count plot of Auto make which have Fraud claim



Auto make of 'Ford' and 'Mercedes' are having highest Fraud claim, 'Chevorlet' and 'Audi' also seems to be claimed equally having Fraud claims

In [1013]: # Vehicle claim as per auto make and model and policy number wise.
pd.pivot_table(a,values=['vehicle_claim'],index=['auto_model','auto_make','policy_number']).sort_values('vehicle_clai

Out[1013]:

vehicle_claim			
auto_model	auto_make	policy_number	vehicle_claim
Impreza	Suburu	217938	77760
TL	Accura	515050	76400
Tahoe	Chevrolet	291006	75600
Neon	Dodge	346940	75530
RAM	Dodge	115399	73620
Accord	Honda	127754	71520
Highlander	Toyota	209177	69210
Tahoe	Chevrolet	187775	68310
Escape	Ford	626208	67590
E400	Mercedes	728025	67440

Policy# 217938 who have Impreza-Suburu has claimed amount of 77,760\$ and is identified as Fraud claim

Data Preprocessing

```
In [1014]: df.columns
```

```
Out[1014]: Index(['months_as_customer', 'age', 'policy_number', 'policy_bind_date',
       'policy_state', 'policy_csl', 'policy_deductable',
       'policy_annual_premium', 'umbrella_limit', 'insured_zip', 'insured_sex',
       'insured_education_level', 'insured_occupation', 'insured_hobbies',
       'insured_relationship', 'capital-gains', 'capital-loss',
       'incident_date', 'incident_type', 'collision_type', 'incident_severity',
       'authorities_contacted', 'incident_state', 'incident_city',
       'incident_location', 'incident_hour_of_the_day',
       'number_of_vehicles_involved', 'property_damage', 'bodily_injuries',
       'witnesses', 'police_report_available', 'total_claim_amount',
       'injury_claim', 'property_claim', 'vehicle_claim', 'auto_make',
       'auto_model', 'auto_year', 'fraud_reported', 'profit'],
      dtype='object')
```

```
In [1015]: a['bodily_injuries'].value_counts()
```

```
Out[1015]: 2    90
0    80
1    77
Name: bodily_injuries, dtype: int64
```

```
In [1016]: a['police_report_available'].value_counts()
```

```
Out[1016]: ?    89
NO    86
YES   72
Name: police_report_available, dtype: int64
```

Even for the policies which have police report have done fraud claims

```
In [1017]: # Here, we again found ? values in police report, which need to be replace.  
df['police_report_available']=df['police_report_available'].replace("?", "Unknown")
```

```
In [1018]: df.columns
```

```
Out[1018]: Index(['months_as_customer', 'age', 'policy_number', 'policy_bind_date',  
       'policy_state', 'policy_csl', 'policy_deductable',  
       'policy_annual_premium', 'umbrella_limit', 'insured_zip', 'insured_sex',  
       'insured_education_level', 'insured_occupation', 'insured_hobbies',  
       'insured_relationship', 'capital-gains', 'capital-loss',  
       'incident_date', 'incident_type', 'collision_type', 'incident_severity',  
       'authorities_contacted', 'incident_state', 'incident_city',  
       'incident_location', 'incident_hour_of_the_day',  
       'number_of_vehicles_involved', 'property_damage', 'bodily_injuries',  
       'witnesses', 'police_report_available', 'total_claim_amount',  
       'injury_claim', 'property_claim', 'vehicle_claim', 'auto_make',  
       'auto_model', 'auto_year', 'fraud_reported', 'profit'],  
      dtype='object')
```

```
In [1019]: df.umbrella_limit.unique()
```

```
Out[1019]: array([    0,  5000000,  6000000,  4000000,  3000000,  8000000,  
       7000000,  9000000, 10000000, -1000000,  2000000], dtype=int64)
```

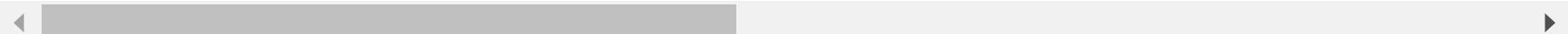
```
In [1020]: # Umbrella Limit can't be in negative. So, we need to replace it with 0.  
df['umbrella_limit']=df['umbrella_limit'].replace(-1000000,0)
```

In [1021]: df2=df
df2

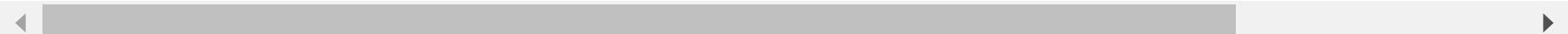
Out[1021]:

	months_as_customer	age	policy_number	policy_bind_date	policy_state	policy_csl	policy_deductable	policy_annual_premium	umbrella_limit
0	328	48	521585	2014-10-17	OH	250/500	1000	1406.91	
1	228	42	342868	2006-06-27	IN	250/500	2000	1197.22	50000
2	134	29	687698	2000-09-06	OH	100/300	2000	1413.14	50000
3	256	41	227811	1990-05-25	IL	250/500	2000	1415.74	60000
4	228	44	367455	2014-06-06	IL	500/1000	1000	1583.91	60000
...
995	3	38	941851	1991-07-16	OH	500/1000	1000	1310.80	
996	285	41	186934	2014-01-05	IL	100/300	1000	1436.79	
997	130	34	918516	2003-02-17	OH	250/500	500	1383.49	30000
998	458	62	533940	2011-11-18	IL	500/1000	2000	1356.92	50000
999	456	60	556080	1996-11-11	OH	250/500	1000	766.19	

1000 rows × 10 columns



In [1022]: # Dropping columns as they are not that important to find out fraud detect pattern.
df2=df2.drop(['policy_number','policy_bind_date','insured_zip','incident_date','authorities_contacted','profit','auto



In [1023]: df2.columns

```
Out[1023]: Index(['months_as_customer', 'age', 'policy_state', 'policy_csl',
       'policy_deductable', 'policy_annual_premium', 'umbrella_limit',
       'insured_sex', 'insured_education_level', 'insured_occupation',
       'insured_hobbies', 'insured_relationship', 'capital-gains',
       'capital-loss', 'incident_type', 'collision_type', 'incident_severity',
       'incident_state', 'incident_city', 'incident_location',
       'incident_hour_of_the_day', 'number_of_vehicles_involved',
       'property_damage', 'bodily_injuries', 'witnesses',
       'police_report_available', 'total_claim_amount', 'injury_claim',
       'property_claim', 'vehicle_claim', 'auto_year', 'fraud_reported'],
      dtype='object')
```

In [1024]: df2=pd.get_dummies(df2,columns=['policy_state','policy_csl','insured_sex','insured_education_level','insured_occupati
'insured_hobbies','insured_relationship','incident_type','collision_type','incident_s
'incident_city','incident_location','property_damage','police_report_available'],drop

In [1025]: # First dummy variable for each category is dropped to avoid multicollinearity in regression models.

In [1026]: df2.shape

```
Out[1026]: (1000, 1089)
```

```
In [1027]: df2.columns
```

```
Out[1027]: Index(['months_as_customer', 'age', 'policy_deductable',
       'policy_annual_premium', 'umbrella_limit', 'capital-gains',
       'capital-loss', 'incident_hour_of_the_day',
       'number_of_vehicles_involved', 'bodily_injuries',
       ...
       'incident_location_9918 Andromedia Drive',
       'incident_location_9929 Rock Drive', 'incident_location_9935 4th Drive',
       'incident_location_9942 Tree Ave', 'incident_location_9980 Lincoln Ave',
       'incident_location_9988 Rock Ridge', 'property_damage_NO',
       'property_damage_YES', 'police_report_available_Unknown',
       'police_report_available_YES'],
      dtype='object', length=1089)
```

```
In [1028]: df2['fraud_reported'].value_counts()
```

```
Out[1028]: N    753
Y    247
Name: fraud_reported, dtype: int64
```

```
In [1029]: # From here we can understand it is an imbalance dataset as the target features have imbalance data.
```

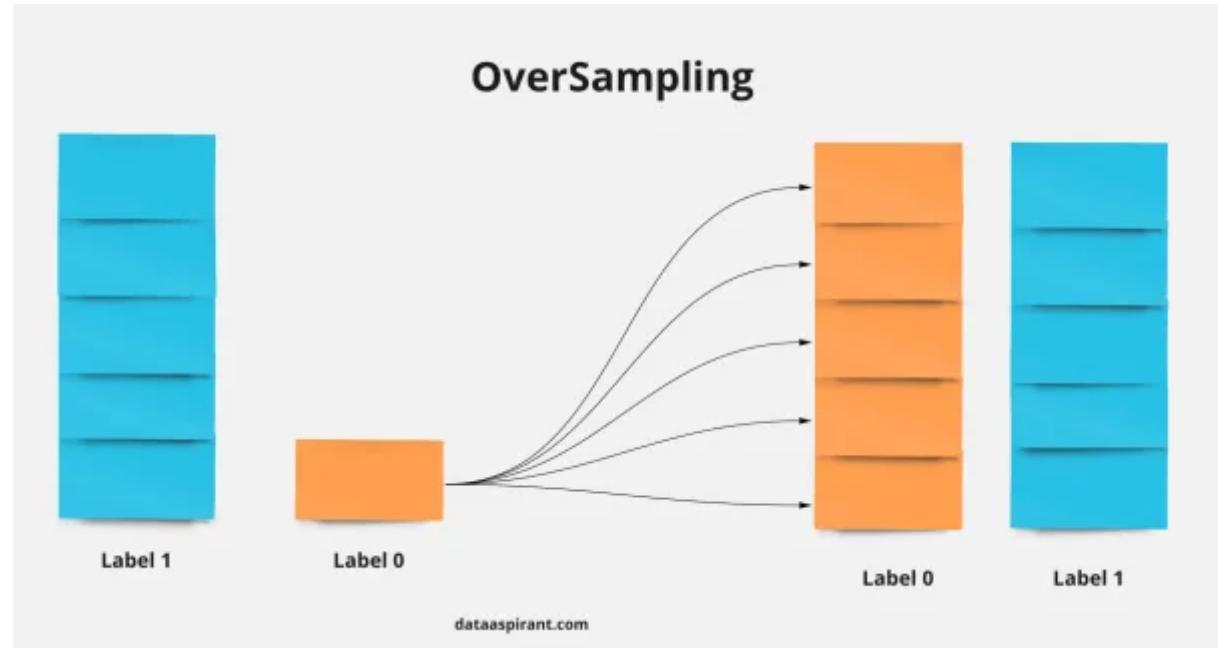
In [1030]: `df.isnull().sum()`

```
Out[1030]: months_as_customer          0
           age                      0
           policy_number            0
           policy_bind_date         0
           policy_state              0
           policy_csl                0
           policy_deductable         0
           policy_annual_premium     0
           umbrella_limit            0
           insured_zip                0
           insured_sex                0
           insured_education_level    0
           insured_occupation          0
           insured_hobbies             0
           insured_relationship        0
           capital-gains              0
           capital-loss                0
           incident_date               0
           incident_type               0
           collision_type              0
           incident_severity            0
           authorities_contacted       0
           incident_state               0
           incident_city                0
           incident_location             0
           incident_hour_of_the_day      0
           number_of_vehicles_involved   0
           property_damage              0
           bodily_injuries              0
           witnesses                     0
           police_report_available       0
           total_claim_amount            0
           injury_claim                  0
           property_claim                 0
           vehicle_claim                  0
           auto_make                     0
           auto_model                     0
           auto_year                     0
           fraud_reported                  0
           profit                         0
           dtype: int64
```

```
In [1031]: x=df2.drop(['fraud_reported'],axis=1)
```

```
In [1032]: y=df2['fraud_reported']
```

Up Sampling/Over sampling of Data



SMOTE Oversampling

In [1033]: `!pip install imbalanced-learn`

```
Requirement already satisfied: imbalanced-learn in c:\users\angsh\anaconda3\lib\site-packages (0.10.1)
Requirement already satisfied: numpy>=1.17.3 in c:\users\angsh\anaconda3\lib\site-packages (from imbalanced-learn)
(1.21.5)
Requirement already satisfied: scikit-learn>=1.0.2 in c:\users\angsh\anaconda3\lib\site-packages (from imbalanced-learn)
(1.0.2)
Requirement already satisfied: threadpoolctl>=2.0.0 in c:\users\angsh\anaconda3\lib\site-packages (from imbalanced-learn)
(2.2.0)
Requirement already satisfied: joblib>=1.1.1 in c:\users\angsh\anaconda3\lib\site-packages (from imbalanced-learn)
(1.2.0)
Requirement already satisfied: scipy>=1.3.2 in c:\users\angsh\anaconda3\lib\site-packages (from imbalanced-learn)
(1.9.1)
```

In [1034]: `from imblearn.over_sampling import SMOTE`

```
x_upsample, y_upsample = SMOTE().fit_resample(x, y)

print(x_upsample.shape)
print(y_upsample.shape)
```

```
(1506, 1088)
(1506,)
```

In [1035]: `y_upsample.value_counts()`

Out[1035]:

```
Y    753
N    753
Name: fraud_reported, dtype: int64
```

In [1036]: `# By sampling technique now we made the target variable as balance dataset.`

Machine Learning Modelling

```
In [1037]: from sklearn.model_selection import train_test_split  
X_train, X_test, y_train, y_test = train_test_split(x_upsample, y_upsample, test_size=0.2, random_state=42)
```

```
In [1038]: from sklearn.preprocessing import MinMaxScaler  
scaler = MinMaxScaler()  
#from sklearn.preprocessing import StandardScaler  
#sc=StandardScaler()  
X_train = pd.DataFrame(scaler.fit_transform(X_train),columns=list(X_train.columns))  
X_test = pd.DataFrame(scaler.transform(X_test),columns=list(X_test.columns))
```

```
In [1039]: from sklearn.linear_model import LogisticRegression  
  
# Create an instance of the LogisticRegression model  
logreg = LogisticRegression()  
  
# Fit the model on the training data  
logreg.fit(X_train, y_train)  
  
train_accuracy = logreg.score(X_train, y_train)  
print("Training Accuracy:", train_accuracy)
```

Training Accuracy: 0.9509966777408638

```
In [1040]: from sklearn.metrics import classification_report
```

```
# Predict the labels for the training data
y_pred_train = logreg.predict(X_train)

# Generate the classification report
classification_rep_train = classification_report(y_train, y_pred_train)

# Print the classification report
print("Classification Report (Training Data):")
print(classification_rep_train)
```

Classification Report (Training Data):				
	precision	recall	f1-score	support
N	0.95	0.96	0.95	611
Y	0.95	0.95	0.95	593
accuracy			0.95	1204
macro avg	0.95	0.95	0.95	1204
weighted avg	0.95	0.95	0.95	1204

```
In [1041]: # Predict the target variable for the testing data
```

```
y_pred = logreg.predict(X_test)

# Evaluate the model's performance
test_accuracy = logreg.score(X_test, y_test)
print("Testing Accuracy:", test_accuracy)
```

Testing Accuracy: 0.8543046357615894

```
In [1042]: clf=classification_report(y_pred,y_test)
print("Classification Report (Testing Data):")
print(clf)
```

```
Classification Report (Testing Data):
      precision    recall  f1-score   support

        N       0.87      0.83      0.85      150
        Y       0.84      0.88      0.86      152

    accuracy                           0.85      302
   macro avg       0.86      0.85      0.85      302
weighted avg       0.86      0.85      0.85      302
```

```
In [1044]: from sklearn.model_selection import train_test_split
X_train, X_test, y_train, y_test = train_test_split(x_upsample, y_upsample, test_size=0.2)
```

```
In [1045]: from sklearn.preprocessing import MinMaxScaler
scaler = MinMaxScaler()
X_train = pd.DataFrame(scaler.fit_transform(X_train),columns=list(X_train.columns))
X_test = pd.DataFrame(scaler.transform(X_test),columns=list(X_test.columns))
```

```
In [1046]: from sklearn.ensemble import RandomForestClassifier
from sklearn.model_selection import GridSearchCV

# Create a Random Forest classifier
rf_classifier = RandomForestClassifier()

# Define the hyperparameters and their possible values
param_grid = {
    'n_estimators': [50, 100, 200], # Number of trees in the forest
    'max_depth': [3, 3, 5], # Maximum depth of each tree
    'min_samples_split': [2, 5, 10], # Minimum number of samples required to split an internal node
    'min_samples_leaf': [1, 2, 4], # Minimum number of samples required to be at a Leaf node
    'max_features': ['auto', 'sqrt']] # Number of features to consider when looking for the best split
}

# Perform grid search with cross-validation
grid_search = GridSearchCV(estimator=rf_classifier, param_grid=param_grid, cv=5)
grid_search.fit(X_train, y_train)

# Get the best hyperparameters and the corresponding model
best_params = grid_search.best_params_
best_model = grid_search.best_estimator_

# Calculate the training score of the best model
training_score = best_model.score(X_train, y_train)

# Print the best hyperparameters and the training score
print("Best Hyperparameters:", best_params)
print("Training Score:", training_score)
```

```
Best Hyperparameters: {'max_depth': 5, 'max_features': 'sqrt', 'min_samples_leaf': 1, 'min_samples_split': 2, 'n_estimators': 100}
Training Score: 0.9086378737541528
```

```
In [1049]: from sklearn.metrics import classification_report
```

```
# Predict the labels for the training data
y_pred_train = grid_search.predict(X_train)

# Generate the classification report
classification_rep = classification_report(y_train, y_pred_train)

# Print the classification report
print("Classification Report(Training Data):")
print(classification_rep)
```

	precision	recall	f1-score	support
N	0.90	0.92	0.91	602
Y	0.92	0.90	0.91	602
accuracy			0.91	1204
macro avg	0.91	0.91	0.91	1204
weighted avg	0.91	0.91	0.91	1204

```
In [1051]: # Calculate the test score
test_score = grid_search.score(X_test, y_test)

# Print the test score
print("Test Score:", test_score)
```

Test Score: 0.8145695364238411

```
In [1052]: from sklearn.metrics import classification_report
```

```
# Predict the labels for the test data
y_pred_test = grid_search.predict(X_test)

# Generate the classification report
classification_rep_test = classification_report(y_test, y_pred_test)

# Print the classification report
print("Classification Report (Test Data):")
print(classification_rep_test)
```

Classification Report (Test Data):

	precision	recall	f1-score	support
N	0.78	0.88	0.83	151
Y	0.86	0.75	0.80	151
accuracy			0.81	302
macro avg	0.82	0.81	0.81	302
weighted avg	0.82	0.81	0.81	302

Conclusion

```
In [517]: # So, By comparing those above two models, it is found that at first Logistic regression is performing better than th
# But after doing the hyperparameter tuning with n_estimators, max_depth, min_samples_split, min_samples_leaf and max_
# With Grid search technique to search for the best combination of hyperparameters for a machine learning model,
# The training score is nearly at 91 percent and Test score is at 83 percent which signifies a good model to predict
```

```
In [ ]:
```

