About Dataset

The data set includes information about:

Customers who left within the last month – the column is called Churn.

Services that each customer has signed up for – phone, multiple lines, internet, online security, online backup, device protection, tech support, and streaming TV and movies.

Customer account information – how long they've been a customer, contract, payment method, paperless billing, monthly charges, and total charges.

Demographic info about customers – gender, age range, and if they have partners and dependents

Churn - Whether the customer churned or not (Yes, No)

PhoneService - whether the customer has a phone service or not (Yes,No).

MultipleLines - whether the customer has a multiple line or not (Yes, No, No phone service).

InternetService - type of internet service the customer has (DSL, Fiber Optic, No).

OnlineSecurity - whether the customer has a online security or not (Yes, No).

OnlineBackup - whether the customer has a online backup or not (Yes, No).

DeviceProtection - whether the customer has a device protection or not (Yes, No).

TechSupport - whether the customer has a tech support or not (Yes,No).

StreamingTV - whether the customer has a streaming TV (Yes,No).

StreamingMovies - whether the customer has a streaming movies (Yes,No)

Tenure - how long customer has stayed in company.

Contract - type of contract customer has (Month-to-Month, One Year, Two Year).

PaperlessBilling - whether the customer has a paperless billing (Yes,No).

PaymentMethod - payment method used by customer (Electronic check, Mailed check, Bank transfer (automatic), Credit card (automatic)).

MonthlyCharges - amount charged to the customer monthly.

TotalCharges - the total amount charged to the customer.

CustomerID - Unique value for each customer.

gender - type of gender customer has (Male,Female).

SeniorCitizen - whether the customer is a senior citizen (Yes,No).

Partner - whether the customer has a partner or not (Yes, No).

Dependents - whether the customer has a dependents or not (Yes,No)

In [ ]:
```
# Importing required Libraries

import os, sys
import numpy as np
import pandas as pd
import matplotlib.pyplot as plt
import seaborn as sns
import statsmodels.api as sm
import scipy.stats as stats
import warnings
warnings.filterwarnings('ignore')
%matplotlib inline
sns.set()
pd.set_option('display.max_rows',None)
pd.set_option('display.max_columns',None)
sns.set_style('whitegrid')
```

In [ ]:
```
# Loading the dataset

df = pd.read_csv('/content/WA_Fn-UseC_-Telco-Customer-Churn.csv')
```

In [ ]:
```
# Columns present in the dataset

print("Columns in the dataset",df.columns)
```

```
Columns in the dataset Index(['customerID', 'gender', 'SeniorCitizen', 'Partner', 'Dependents',
       'tenure', 'PhoneService', 'MultipleLines', 'InternetService',
       'OnlineSecurity', 'OnlineBackup', 'DeviceProtection', 'TechSupport',
       'StreamingTV', 'StreamingMovies', 'Contract', 'PaperlessBilling',
       'PaymentMethod', 'MonthlyCharges', 'TotalCharges', 'Churn'],
      dtype='object')
```

In [ ]:
```
# Checking the first 10 rows of train dataset

df.head(10)
```

Out[4]:

	customerID	gender	SeniorCitizen	Partner	Dependents	tenure	PhoneService	MultipleLines	InternetService	OnlineSecurity	OnlineBackup	DeviceProtection	TechSupport	StreamingTV	StreamingMovies	Contract	PaperlessBilling	Payme
0	7590-VHVEG	Female	0	Yes	No	1	No	No phone service	DSL	No	Yes	No	No	No	No	Month-to-month	Yes	Electr
1	5575-GNVDE	Male	0	No	No	34	Yes	No	DSL	Yes	No	Yes	No	No	No	One year	No	Ma
2	3668-QPYBK	Male	0	No	No	2	Yes	No	DSL	Yes	Yes	No	No	No	No	Month-to-month	Yes	Ma
3	7795-CFOCW	Male	0	No	No	45	No	No phone service	DSL	Yes	No	Yes	Yes	No	No	One year	No	Ba (
4	9237-HQITU	Female	0	No	No	2	Yes	No	Fiber optic	No	No	No	No	No	No	Month-to-month	Yes	Electr
5	9305-CDSKC	Female	0	No	No	8	Yes	Yes	Fiber optic	No	No	Yes	No	Yes	Yes	Month-to-month	Yes	Electr
6	1452-KIOVK	Male	0	No	Yes	22	Yes	Yes	Fiber optic	No	Yes	No	No	Yes	No	Month-to-month	Yes	((
7	6713-OKOMC	Female	0	No	No	10	No	No phone service	DSL	Yes	No	No	No	No	No	Month-to-month	No	Ma
8	7892-POOKP	Female	0	Yes	No	28	Yes	Yes	Fiber optic	No	No	Yes	Yes	Yes	Yes	Month-to-month	Yes	Electr
9	6388-TABGU	Male	0	No	Yes	62	Yes	No	DSL	Yes	Yes	No	No	No	No	One year	No	Ba (

In [ ]:
```
# Checking the last 10 rows of train dataset:

df.tail(10)
```

Out[5]:

	customerID	gender	SeniorCitizen	Partner	Dependents	tenure	PhoneService	MultipleLines	InternetService	OnlineSecurity	OnlineBackup	DeviceProtection	TechSupport	StreamingTV	StreamingMovies	Contract	PaperlessBilling	Pa
7033	9767-FFLEM	Male	0	No	No	38	Yes	No	Fiber optic	No	No	No	No	No	No	Month-to-month	Yes	
7034	0639-TSIQW	Female	0	No	No	67	Yes	Yes	Fiber optic	Yes	Yes	Yes	No	Yes	No	Month-to-month	Yes	
7035	8456-QDAVC	Male	0	No	No	19	Yes	No	Fiber optic	No	No	No	No	Yes	No	Month-to-month	Yes	
7036	7750-EYXWZ	Female	0	No	No	12	No	No phone service	DSL	No	Yes	Yes	Yes	Yes	Yes	One year	No	El
7037	2569-WGERO	Female	0	No	No	72	Yes	No	No	No internet service	No internet service	No internet service	No internet service	No internet service	No internet service	Two year	Yes	
7038	6840-RESVB	Male	0	Yes	Yes	24	Yes	Yes	DSL	Yes	No	Yes	Yes	Yes	Yes	One year	Yes	
7039	2234-XADUH	Female	0	Yes	Yes	72	Yes	Yes	Fiber optic	No	Yes	Yes	No	Yes	Yes	One year	Yes	
7040	4801-JZAZL	Female	0	Yes	Yes	11	No	No phone service	DSL	Yes	No	No	No	No	No	Month-to-month	Yes	El
7041	8361-LTMKD	Male	1	Yes	No	4	Yes	Yes	Fiber optic	No	No	No	No	No	No	Month-to-month	Yes	
7042	3186-AJIEK	Male	0	No	No	66	Yes	No	Fiber optic	Yes	No	Yes	Yes	Yes	Yes	Two year	Yes	

In [ ]:
```
# Checking the number of rows and columns.

print("Total number of observations/rows in dataset are:", df.shape[0])
print("Total number of features/columns in dataset are:", df.shape[1])
```

```
Total number of observations/rows in dataset are: 7043
Total number of features/columns in dataset are: 21
```

In [ ]:
```
# Checking the basic info of the data.

df.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 7043 entries, 0 to 7042
Data columns (total 21 columns):
 #   Column            Non-Null Count  Dtype  
---  ------            --------------  -----  
 0   customerID        7043 non-null   object 
 1   gender            7043 non-null   object 
 2   SeniorCitizen     7043 non-null   int64  
 3   Partner           7043 non-null   object 
 4   Dependents        7043 non-null   object 
 5   tenure            7043 non-null   int64  
 6   PhoneService      7043 non-null   object 
 7   MultipleLines     7043 non-null   object 
 8   InternetService   7043 non-null   object 
 9   OnlineSecurity    7043 non-null   object 
 10  OnlineBackup      7043 non-null   object 
 11  DeviceProtection  7043 non-null   object 
 12  TechSupport       7043 non-null   object 
 13  StreamingTV       7043 non-null   object 
 14  StreamingMovies   7043 non-null   object 
 15  Contract          7043 non-null   object 
 16  PaperlessBilling  7043 non-null   object 
 17  PaymentMethod     7043 non-null   object 
 18  MonthlyCharges    7043 non-null   float64
 19  TotalCharges      7043 non-null   object 
 20  Churn             7043 non-null   object 
dtypes: float64(1), int64(2), object(18)
memory usage: 1.1+ MB
```

There are no missing values in the dataset

In [ ]:
```
# Since customerID is insignificant in predicting the customer churn, dropping the same:

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

In [ ]:
```
# Checking the data description of all the variables, which gives us the count, mean, std, minimum, 25th quartile,
# median, 75th quartile and maximum values in the respective numerical columns.

df.describe(include='all').T
```

Out[9]:

	count	unique	top	freq	mean	std	min	25%	50%	75%	max
gender	7043	2	Male	3555	NaN	NaN	NaN	NaN	NaN	NaN	NaN
SeniorCitizen	7043.0	NaN	NaN	NaN	0.162147	0.368612	0.0	0.0	0.0	0.0	1.0
Partner	7043	2	No	3641	NaN	NaN	NaN	NaN	NaN	NaN	NaN
Dependents	7043	2	No	4933	NaN	NaN	NaN	NaN	NaN	NaN	NaN
tenure	7043.0	NaN	NaN	NaN	32.371149	24.559481	0.0	9.0	29.0	55.0	72.0
PhoneService	7043	2	Yes	6361	NaN	NaN	NaN	NaN	NaN	NaN	NaN
MultipleLines	7043	3	No	3390	NaN	NaN	NaN	NaN	NaN	NaN	NaN
InternetService	7043	3	Fiber optic	3096	NaN	NaN	NaN	NaN	NaN	NaN	NaN
OnlineSecurity	7043	3	No	3498	NaN	NaN	NaN	NaN	NaN	NaN	NaN
OnlineBackup	7043	3	No	3088	NaN	NaN	NaN	NaN	NaN	NaN	NaN
DeviceProtection	7043	3	No	3095	NaN	NaN	NaN	NaN	NaN	NaN	NaN
TechSupport	7043	3	No	3473	NaN	NaN	NaN	NaN	NaN	NaN	NaN
StreamingTV	7043	3	No	2810	NaN	NaN	NaN	NaN	NaN	NaN	NaN
StreamingMovies	7043	3	No	2785	NaN	NaN	NaN	NaN	NaN	NaN	NaN
Contract	7043	3	Month-to-month	3875	NaN	NaN	NaN	NaN	NaN	NaN	NaN
PaperlessBilling	7043	2	Yes	4171	NaN	NaN	NaN	NaN	NaN	NaN	NaN
PaymentMethod	7043	4	Electronic check	2365	NaN	NaN	NaN	NaN	NaN	NaN	NaN
MonthlyCharges	7043.0	NaN	NaN	NaN	64.761692	30.090047	18.25	35.5	70.35	89.85	118.75
TotalCharges	7043	6531		11	NaN	NaN	NaN	NaN	NaN	NaN	NaN
Churn	7043	2	No	5174	NaN	NaN	NaN	NaN	NaN	NaN	NaN

In [ ]:
```
# Before Starting the Exploratory Data Analysis, Seeing how the data values look like for all the observations:

for i in df.columns:
    print("*"*50, i, "*"*50)
    print(set(df[i].to_list()))
```

********** gender **********
{'Female', 'Male'}
********** SeniorCitizen **********
{0, 1}
********** Partner **********
{'No', 'Yes'}
********** Dependents **********
{'No', 'Yes'}
********** tenure **********
{0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 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, 65, 66, 67, 68, 69, 70, 71, 72}
********** PhoneService **********
{'No', 'Yes'}
********** MultipleLines **********
{'No', 'Yes', 'No phone service'}
********** InternetService **********
{'No', 'Fiber optic', 'DSL'}
********** OnlineSecurity **********
{'No', 'No internet service', 'Yes'}
********** OnlineBackup **********
{'No', 'No internet service', 'Yes'}
********** DeviceProtection **********
{'No', 'No internet service', 'Yes'}
********** TechSupport **********
{'No', 'No internet service', 'Yes'}
********** StreamingTV **********
{'No', 'No internet service', 'Yes'}
********** StreamingMovies **********
{'No', 'No internet service', 'Yes'}
********** Contract **********
{'One year', 'Two year', 'Month-to-month'}
********** PaperlessBilling **********
{'No', 'Yes'}
********** PaymentMethod **********
{'Bank transfer (automatic)', 'Mailed check', 'Electronic check', 'Credit card (automatic)'}
********** MonthlyCharges **********
{18.95, 19.8, 20.65, 20.15, 20.2, 20.75, 24.95, 20.4, 24.25, 25.9, 19.95, 29.75, 29.85, 30.2, 24.3, 33.75, 30.15, 31.05, 35.45, 29.95, 30.4, 39.65, 35.9, 40.2, 42.3, 42.1, 44.35, 45.25, 45.55, 45.65, 45.3, 49.95, 49.55, 49.25, 49.05, 53.85, 54.4, 55.2, 56.95, 56.15, 55.3, 59.9, 59.6, 55.65, 54.65, 62.15, 64.7, 64.15, 66.15, 64.5, 66.85, 69.7, 70.7, 69.2, 69.5, 70.45, 74.8, 74.85, 76.2, 75.3, 78.9, 79.85, 80.65, 79.75, 79.2, 74.75, 84.5, 79.35, 82.05, 84.0, 85.2, 89.1, 90.05, 90.25, 89.9, 91.65, 94.4, 95.5, 96.35, 97.85, 95.45, 99.65, 100.35, 99.35, 102.45, 102.7, 103.8, 103.4, 104.15, 104.4, 104.6, 105.35, 108.0, 109.2, 103.7, 104.8, 105.5, 106.7, 108.45, 111.6, 110.5, 113.25, 111.05, 112.25, 24.75, 115.1, 115.05, 116.05, 25.25, 24.5, 25.75, 25.0, 25.5, 26.25, 26.0, 26.5, 28.5, 29.5, 29.25, 30.75, 30.5, 30.25, 31.0, 33.5, 34.25, 34.5, 34.0, 35.75, 35.5, 35.0, 35.25, 36.0, 36.25, 36.5, 38.5, 38.25, 39.0, 39.5, 40.25, 40.0, 40.75, 43.75, 43.25, 44.0, 44.75, 44.25, 44.5, 45.0, 45.75, 45.5, 46.0, 46.25, 48.75, 48.25, 49.5, 49.0, 49.75, 50.25, 50.0, 50.5, 50.75, 51.25, 51.0, 51.75, 51.5, 52.5, 52.0, 53.75, 53.5, 53.0, 54.75, 54.25, 54.0, 54.5, 55.0, 55.5, 55.25, 55.75, 56.0, 56.75, 56.25, 56.5, 57.75, 57.5, 58.75, 58.25, 58.5, 58.0, 59.75, 59.0, 59.5, 59.25, 60.0, 60.25, 60.5, 60.75, 61.5, 61.25, 61.75, 61.0, 62.25, 62.5, 63.25, 63.75, 64.25, 64.75, 64.0, 65.0, 65.5, 65.75, 65.25, 66.5, 66.25, 66.0, 66.75, 67.25, 67.5, 67.75, 68.75, 68.5, 68.25, 69.75, 69.0, 69.25, 70.0, 70.5, 70.75, 70.25, 71.5, 71.0, 71.25, 71.75, 72.75, 72.25, 72.0, 73.25, 73.5, 73.0, 73.75, 74.5, 74.25, 74.0, 75.0, 75.25, 75.5, 75.75, 76.5, 76.0, 76.75, 76.25, 77.75, 77.0, 77.5, 78.75, 78.0, 78.5, 78.25, 79.25, 79.5, 79.0, 80.0, 80.25, 80.5, 80.75, 81.0, 81.25, 81.5, 81.75, 82.5, 82.75, 82.0, 83.25, 83.75, 83.5, 83.0, 84.25, 84.75, 85.75, 85.5, 85.0, 85.25, 86.75, 86.0, 86.5, 86.25, 87.0, 87.25, 87.75, 88.0, 88.5, 88.75, 88.25, 89.25, 89.0, 89.75, 89.5, 90.0, 90.5, 90.75, 18.25, 18.75, 91.0, 91.5, 91.25, 91.75, 92.0, 92.5, 93.0, 93.5, 93.25, 93.75, 94.5, 94.25, 94.75, 94.0, 95.25, 95.0, 95.75, 19.5, 19.75, 19.25, 96.75, 96.5, 19.0, 96.0, 96.25, 97.0, 97.75, 97.25, 98.75, 98.25, 98.5, 98.0, 99.25, 99.0, 99.75, 99.5, 100.0, 100.75, 100.25, 20.25, 20.5, 101.75, 100.5, 20.0, 101.0, 101.5, 102.5, 102.0, 101.25, 102.25, 103.75, 103.25, 103.0, 103.5, 104.0, 104.5, 104.75, 104.25, 105.0, 105.25, 21.0, 21.25, 105.75, 106.0, 106.75, 106.5, 106.25, 107.5, 107.25, 107.0, 107.75, 108.5, 108.25, 108.75, 109.25, 109.5, 109.75, 109.0, 110.0, 110.75, 110.25, 111.25, 111.5, 111.75, 112.75, 113.0, 113.75, 114.5, 114.0, 114.75, 115.75, 115.0, 23.75, 115.5, 115.25, 116.25, 116.75, 116.0, 116.5, 23.5, 117.5, 118.75, 24.0, 18.4, 18.9, 19.4, 19.9, 19.65, 19.15, 20.9, 21.15, 23.65, 23.4, 23.9, 23.15, 24.9, 24.4, 24.15, 24.65, 25.15, 25.4, 25.65, 26.4, 26.9, 29.65, 29.9, 29.15, 29.4, 30.9, 31.65, 33.15, 33.65, 33.9, 34.65, 34.4, 35.4, 35.65, 35.15, 36.65, 36.15, 38.9, 39.9, 39.4, 39.15, 40.4, 40.65, 40.15, 40.9, 41.15, 41.9, 42.9, 42.4, 43.65, 43.9, 44.4, 44.65, 44.9, 44.15, 45.4, 45.15, 45.9, 46.4, 47.15, 47.4, 48.15, 48.9, 48.65, 48.4, 49.15, 49.9, 49.4, 49.65, 50.65, 50.15, 50.9, 50.4, 51.65, 51.4, 51.15, 52.15, 53.65, 53.9, 53.4, 53.15, 54.9, 54.15, 55.15, 55.9, 55.4, 56.4, 56.9, 56.65, 57.15, 57.65, 58.65, 58.9, 58.4, 59.4, 59.65, 59.15, 60.9, 60.15, 60.65, 60.4, 61.65, 61.9, 61.4, 61.15, 62.65, 63.15, 63.4, 63.9, 18.55, 64.9, 64.4, 64.65, 65.15, 65.65, 19.05, 65.4, 65.9, 66.4, 66.9, 66.65, 67.65, 67.4, 68.65, 68.4, 68.9, 68.15, 69.65, 69.9, 69.15, 69.4, 70.9, 70.15, 70.4, 70.65, 71.15, 71.9, 71.4, 71.65, 72.65, 72.9, 72.15, 73.9, 73.15, 73.65, 74.9, 74.4, 74.65, 74.15, 75.9, 75.15, 75.65, 75.4, 21.3, 76.9, 76.65, 76.4, 76.15, 77.4, 77.15, 77.9, 77.65, 78.4, 78.65, 78.15, 79.9, 79.15, 79.4, 79.65, 80.9, 80.4, 80.15, 81.15, 81.4, 81.65, 81.9, 82.4, 82.9, 82.65, 82.15, 83.4, 83.15, 83.9, 83.65, 84.15, 84.9, 84.4, 84.65, 85.4, 85.65, 85.15, 85.9, 23.05, 86.65, 86.15, 86.4, 86.9, 87.65, 87.9, 87.4, 87.15, 88.15, 88.9, 88.65, 88.4, 89.15, 89.65, 89.4, 75.05, 90.4, 90.15, 90.65, 90.9, 91.4, 91.15, 92.9, 92.65, 92.15, 92.4, 93.15, 93.4, 93.9, 93.65, 94.9, 94.65, 94.15, 76.55, 95.15, 95.4, 95.65, 95.9, 96.65, 96.15, 96.9, 96.4, 97.65, 97.9, 98.65, 98.9, 98.15, 98.4, 99.9, 99.4, 99.15, 77.8, 77.55, 100.9, 100.15, 100.65, 100.4, 101.9, 101.15, 101.4, 102.15, 102.65, 102.9, 102.4, 103.9, 103.15, 103.65, 104.65, 104.9, 105.65, 105.15, 105.9, 105.4, 106.9, 106.4, 106.65, 106.15, 107.15, 107.65, 107.9, 107.4, 108.15, 108.65, 108.4, 108.9, 109.9, 109.4, 109.15, 109.65, 110.65, 110.15, 110.9, 111.9, 111.65, 111.15, 111.4, 112.4, 112.9, 113.65, 113.4, 113.15, 114.65, 114.9, 115.65, 115.15, 29.3, 116.15, 116.4, 117.15, 118.65, 33.55, 34.55, 34.8, 34.05, 34.3, 35.8, 35.55, 35.05,

35.3, 36.05, 38.55, 38.8, 39.3, 39.55, 39.05, 40.05, 40.3, 40.55, 41.05, 43.8, 43.55, 43.3, 43.05, 44.8, 44.3, 44.05, 44.55, 45.05, 45.8, 46.3, 46.05, 47.8, 47.05, 48.55, 48.8, 49.3, 49.8, 50.
55, 50.05, 50.3, 50.8, 51.8, 51.05, 51.55, 51.3, 52.55, 52.3, 53.8, 53.3, 53.55, 54.8, 54.3, 54.55, 54.05, 55.05, 55.8, 55.55, 56.8, 56.05, 56.3, 56.55, 57.8, 57.55, 58.55, 59.8, 59.3, 59.55,
59.05, 60.3, 60.05, 60.8, 60.55, 61.05, 61.8, 61.55, 61.3, 62.8, 62.05, 62.55, 62.3, 63.3, 63.55, 63.8, 63.05, 64.8, 64.05, 64.3, 64.55, 65.55, 65.8, 65.05, 65.3, 66.8, 66.05, 66.3, 67.8, 67.0
5, 68.55, 68.8, 68.05, 68.3, 18.8, 69.3, 69.55, 69.05, 69.8, 19.3, 70.8, 70.05, 19.55, 70.3, 20.3, 71.55, 20.55, 20.05, 20.8, 70.55, 72.8, 21.05, 71.05, 71.3, 71.8, 73.8, 73.55, 73.05, 73.3, 2
3.8, 74.3, 74.05, 23.3, 23.55, 24.55, 24.05, 74.55, 24.8, 75.55, 25.3, 75.8, 25.05, 76.05, 25.55, 26.8, 26.05, 26.3, 76.8, 25.8, 76.3, 78.05, 78.3, 78.55, 78.8, 77.3, 79.3, 79.05, 79.55, 79.8,
29.05, 80.55, 29.8, 80.05, 80.3, 30.3, 81.8, 81.3, 80.8, 81.05, 81.55, 82.3, 30.55, 30.05, 82.55, 83.3, 83.55, 83.8, 83.05, 84.55, 84.8, 84.3, 84.05, 85.8, 85.3, 85.05, 85.55, 86.8, 86.05, 86.
3, 86.55, 87.05, 87.55, 87.8, 87.3, 88.55, 88.05, 88.8, 88.3, 89.05, 89.55, 89.8, 89.3, 90.3, 90.55, 90.8, 91.3, 91.55, 91.05, 91.8, 92.05, 92.55, 92.3, 93.05, 93.8, 93.55, 93.3, 94.05, 94.8,
94.3, 94.55, 95.05, 95.8, 95.3, 95.55, 96.05, 96.8, 96.55, 96.3, 97.55, 97.8, 97.05, 98.3, 98.8, 98.05, 98.55, 99.3, 99.8, 99.05, 99.55, 100.8, 100.55, 100.05, 100.3, 101.05, 101.55, 101.3, 10
1.8, 102.05, 102.55, 102.8, 103.05, 103.3, 104.3, 104.55, 104.05, 105.3, 105.55, 105.05, 105.8, 106.05, 106.8, 106.55, 106.3, 107.05, 107.55, 108.55, 108.05, 108.3, 108.8, 109.55, 109.8, 109.0
5, 109.3, 110.05, 110.3, 110.8, 110.55, 111.55, 111.8, 111.3, 112.55, 113.3, 113.05, 113.8, 114.05, 114.55, 114.3, 115.8, 115.55, 116.8, 116.3, 116.55, 117.8, 18.7, 19.2, 19.45, 19.7, 20.7, 2
0.45, 20.95, 21.2, 21.45, 22.95, 23.95, 23.45, 24.7, 24.45, 24.2, 25.7, 25.2, 25.45, 25.95, 26.2, 26.45, 28.45, 29.45, 29.2, 29.7, 30.45, 31.2, 33.45, 33.7, 34.7, 34.2, 34.95, 35.7, 35.2, 36.4
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Out[11]:

	gender	SeniorCitizen	Partner	Dependents	tenure	PhoneService	MultipleLines	InternetService	OnlineSecurity	OnlineBackup	DeviceProtection	TechSupport	StreamingTV	StreamingMovies	Contract	PaperlessBilling	PaymentMethod
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753	Male	0	No	Yes	0	Yes	No	No	No internet service	No internet service	No internet service	No internet service	No internet service	No internet service	Two year	No	Mailed check
936	Female	0	Yes	Yes	0	Yes	No	DSL	Yes	Yes	Yes	No	Yes	Yes	Two year	No	Mailed check
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3331	Male	0	Yes	Yes	0	Yes	No	No	No internet service	No internet service	No internet service	No internet service	No internet service	No internet service	Two year	No	Mailed check
3826	Male	0	Yes	Yes	0	Yes	Yes	No	No internet service	No internet service	No internet service	No internet service	No internet service	No internet service	Two year	No	Mailed check
4380	Female	0	Yes	Yes	0	Yes	No	No	No internet service	No internet service	No internet service	No internet service	No internet service	No internet service	Two year	No	Mailed check
5218	Male	0	Yes	Yes	0	Yes	No	No	No internet service	No internet service	No internet service	No internet service	No internet service	No internet service	One year	Yes	Mailed check
6670	Female	0	Yes	Yes	0	Yes	Yes	DSL	No	Yes	Yes	Yes	Yes	No	Two year	No	Mailed check
6754	Male	0	No	Yes	0	Yes	Yes	DSL	Yes	Yes	No	Yes	No	No	Two year	Yes	Bank transfer (automatic)

In [ ]:
```
# It can be seen that there are empty space for a few observations for which the tenure is 0, hence it is logical to impute the monthly charges to the
# total charges where the value is blank.

# First converting the datatype from object to numeric:

df['TotalCharges'] = pd.to_numeric(df['TotalCharges'], errors='coerce')
df['TotalCharges'].isnull().sum()
```

Out[12]:
```
11
```

In [ ]:
```
# Now imputing the values of monthly charges to the observations where NaN is present and tenure is 0:

df['TotalCharges'] = np.where(df['TotalCharges'].isnull() == True, df['MonthlyCharges'],df['TotalCharges'])
```

Exploratory Data Analysis

Univariate Analysis of the features

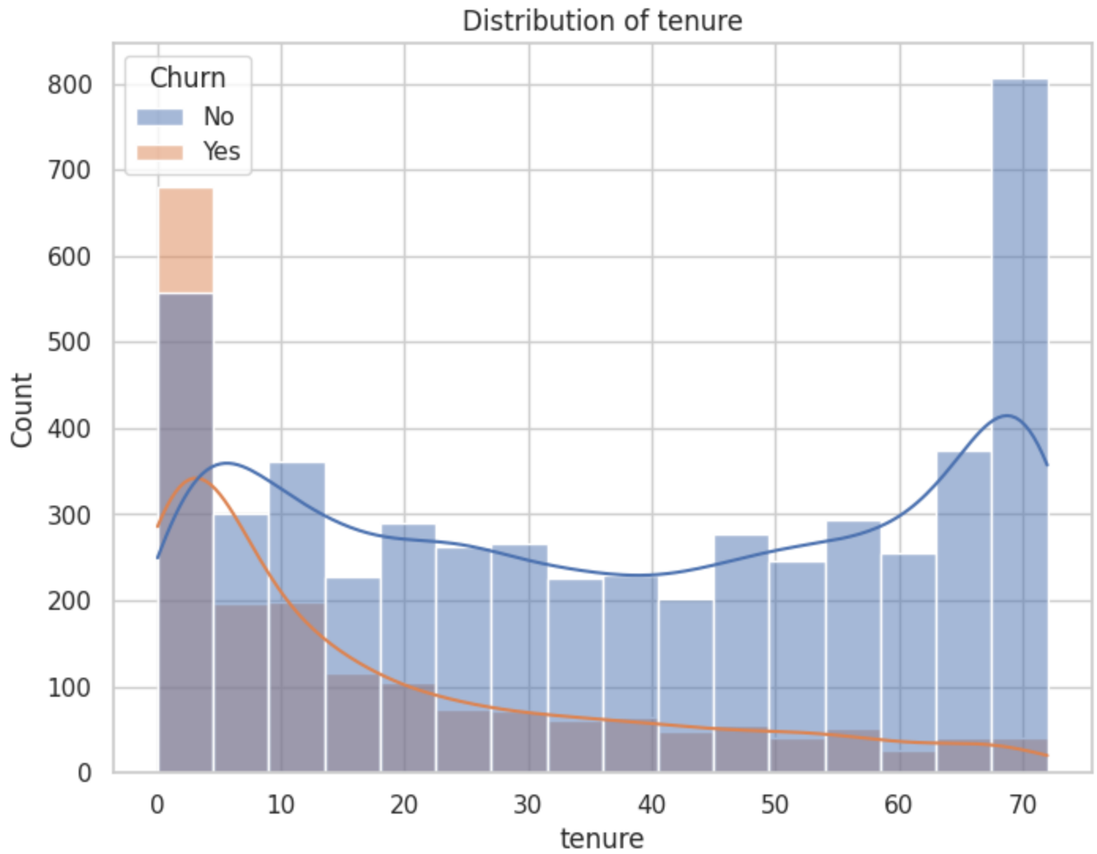
In [ ]:
```
df.columns
```

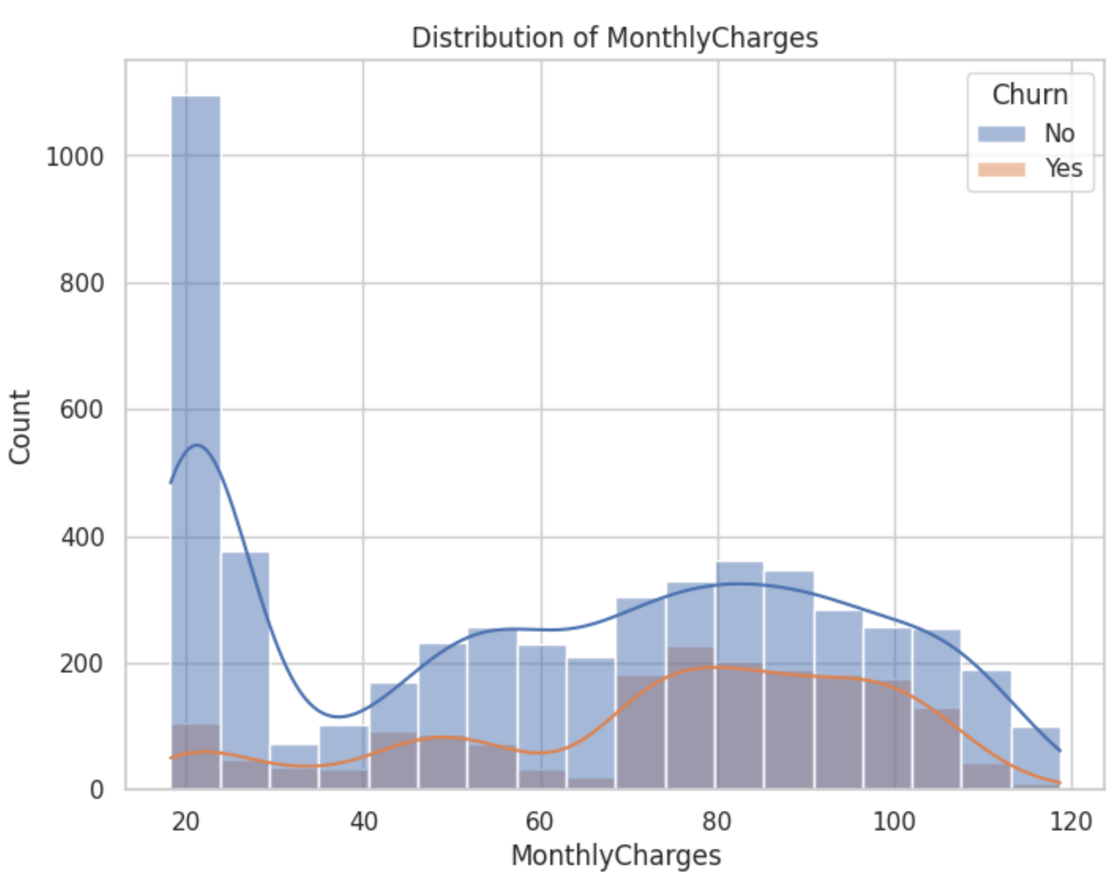
Out[14]:
```
Index(['gender', 'SeniorCitizen', 'Partner', 'Dependents', 'tenure',
       'PhoneService', 'MultipleLines', 'InternetService', 'OnlineSecurity',
       'OnlineBackup', 'DeviceProtection', 'TechSupport', 'StreamingTV',
       'StreamingMovies', 'Contract', 'PaperlessBilling', 'PaymentMethod',
       'MonthlyCharges', 'TotalCharges', 'Churn'],
      dtype='object')
```

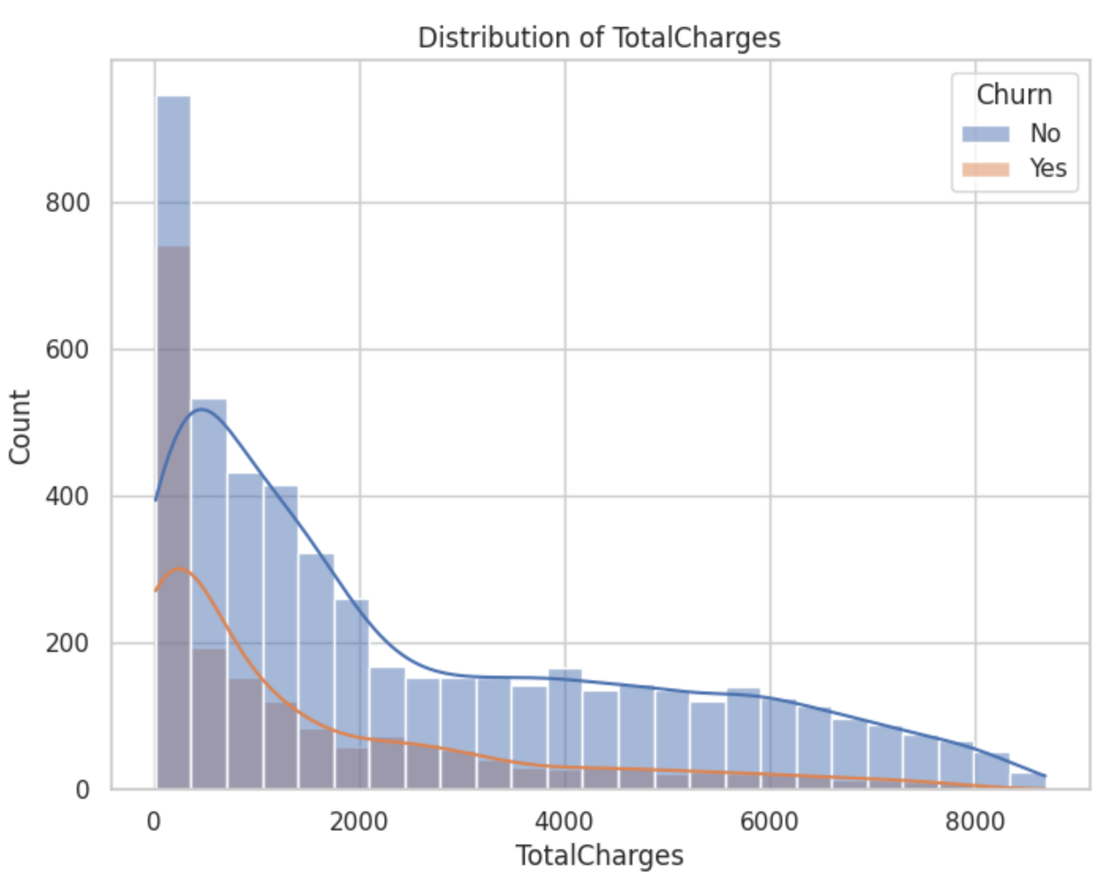
In [ ]:
```
num_fts = df[['tenure', 'MonthlyCharges', 'TotalCharges', 'Churn']]
cat_fts = df.drop(['tenure', 'MonthlyCharges', 'TotalCharges'],axis=1)
```

In [ ]:
```
# Checking how the numerical features are distributed

for i in num_fts.columns[:-1]:
    plt.figure(figsize=(8,6))
    sns.histplot(data=num_fts,x=i ,hue='Churn',kde = True)
    plt.title(f'Distribution of {i}')
    plt.show()
```




Distribution of MonthlyCharges
Churn
No
Yes
Count
0
200
400
600
800
1000
20
40
60
80
100
120
MonthlyCharges

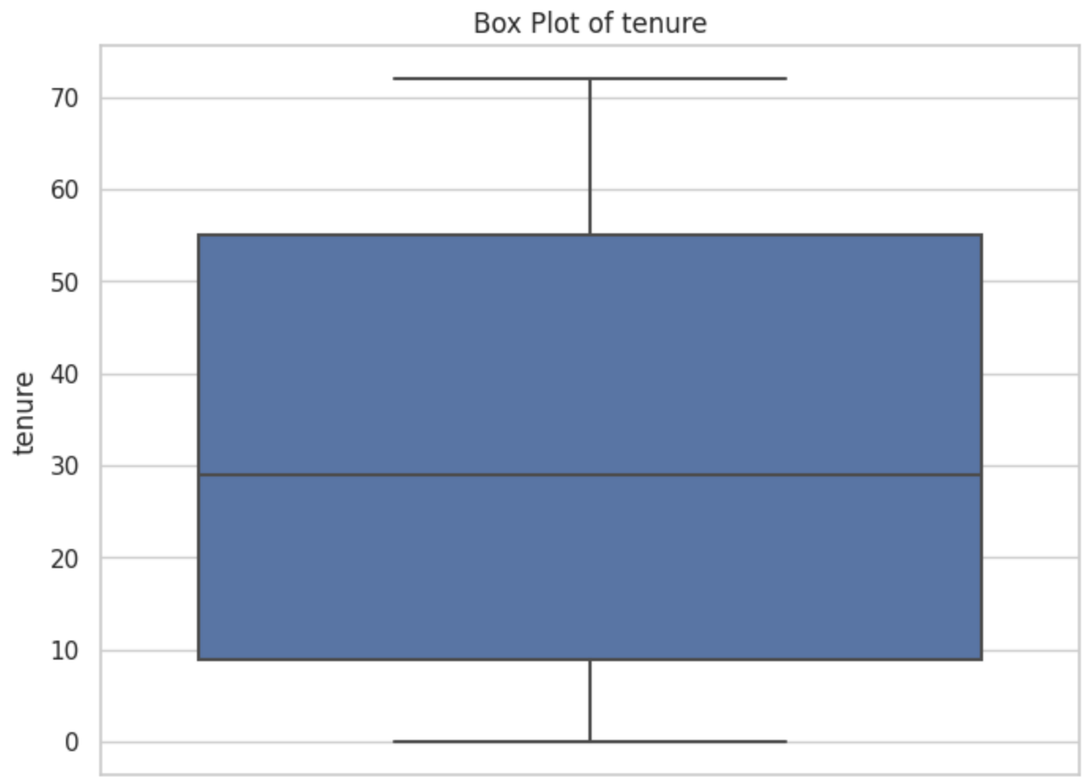


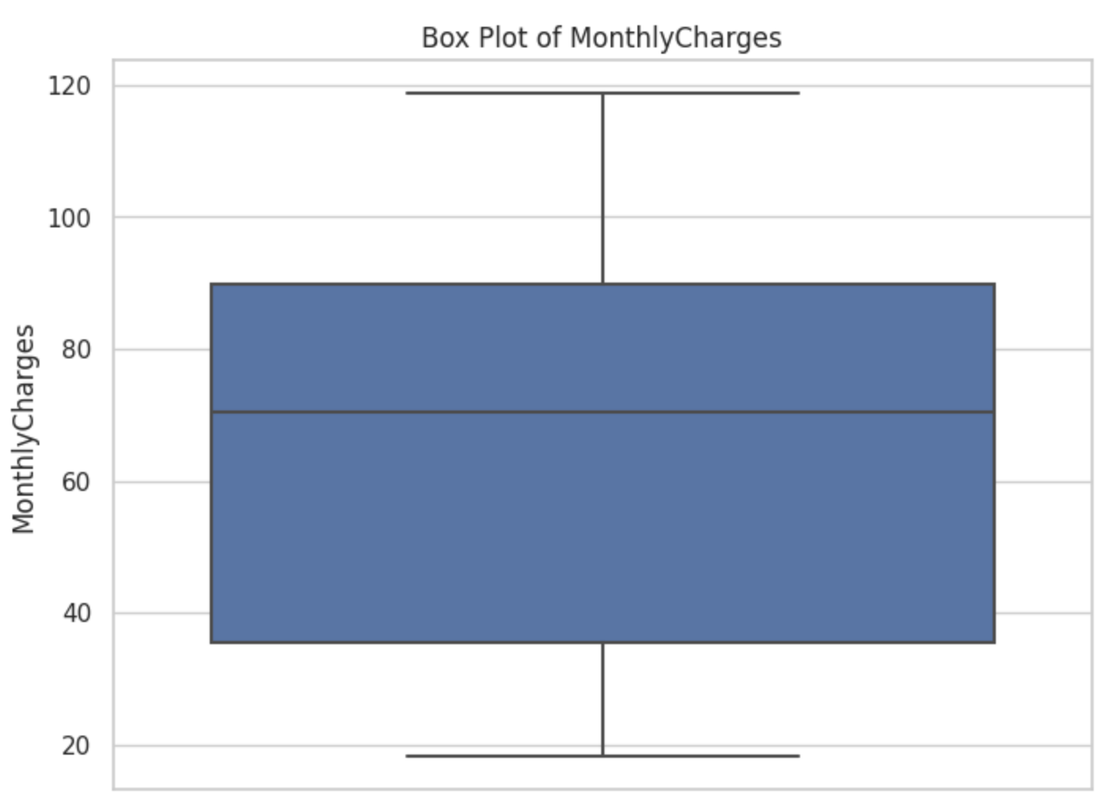
It is observed that the customers who are with the company for a long time are more likely to stay because of the increased trust

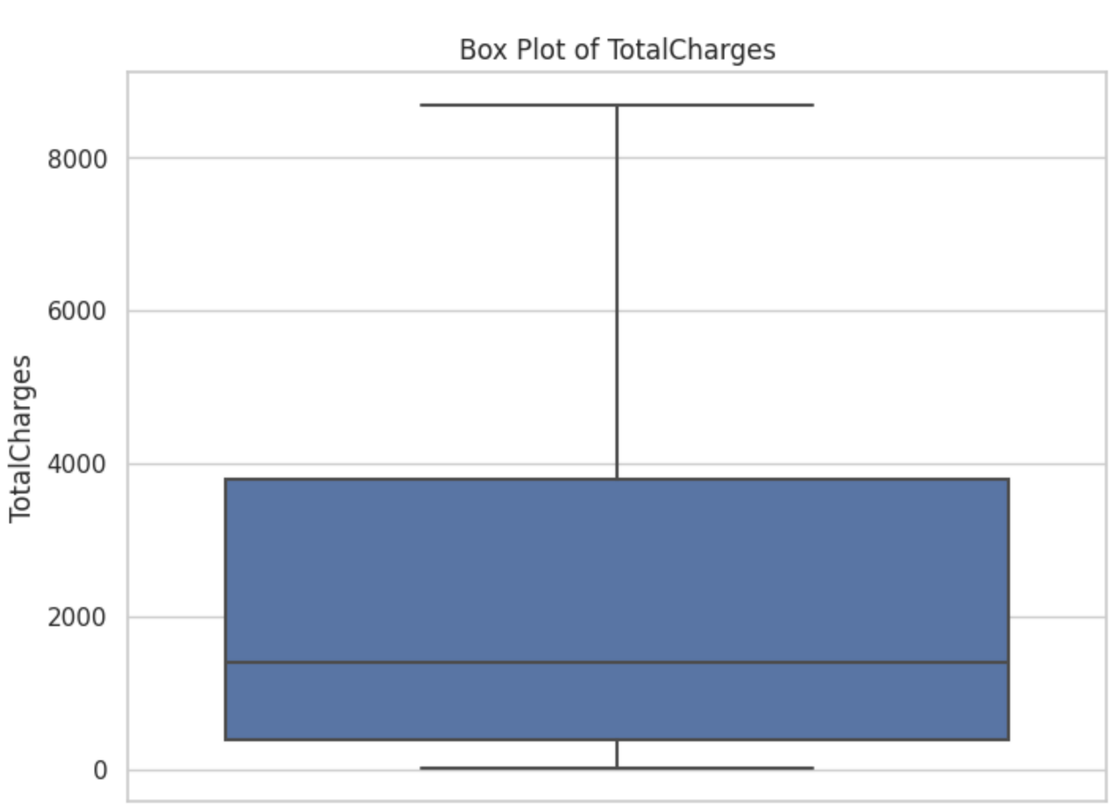
Customers with increased monthly charges have seen to be exiting the services of the company.

It can be seen that the customers utilising the maximum services with high total charges are more likely to stay and on the contrary those with less services and low total charges are more likely to quit.

In [ ]:
```
for i in num_fts.columns[:-1]:
    plt.figure(figsize=(8,6))
    sns.boxplot(data=num_fts,y=i)
    plt.title(f'Box Plot of {i}')
    plt.show()
```

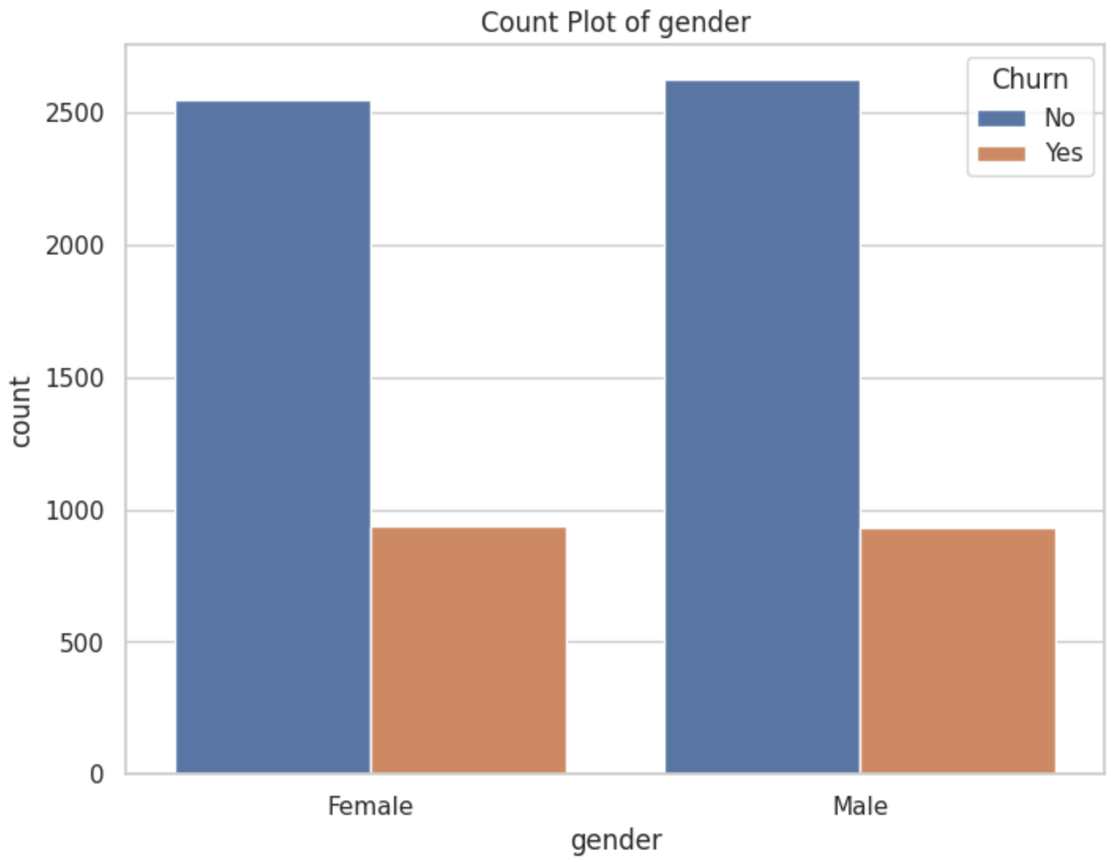


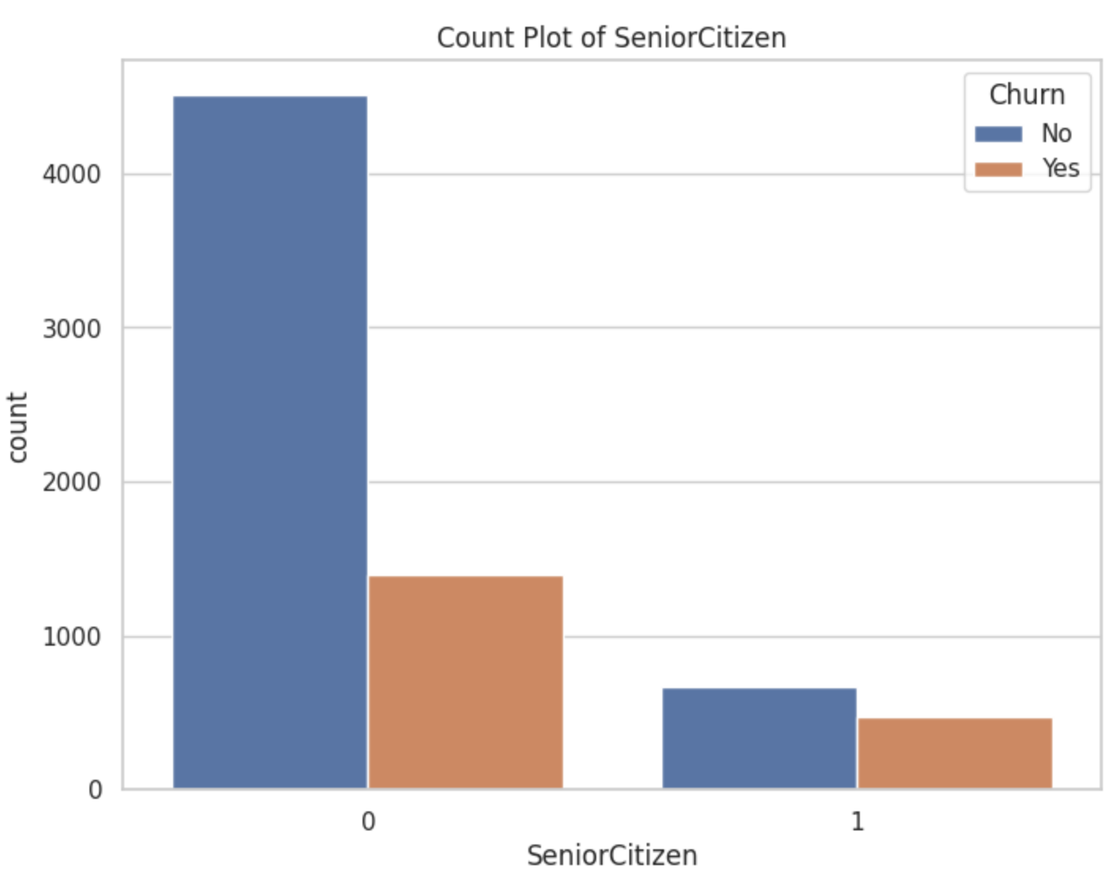

Box Plot of MonthlyCharges
MonthlyCharges
120
100
80
60
40
20

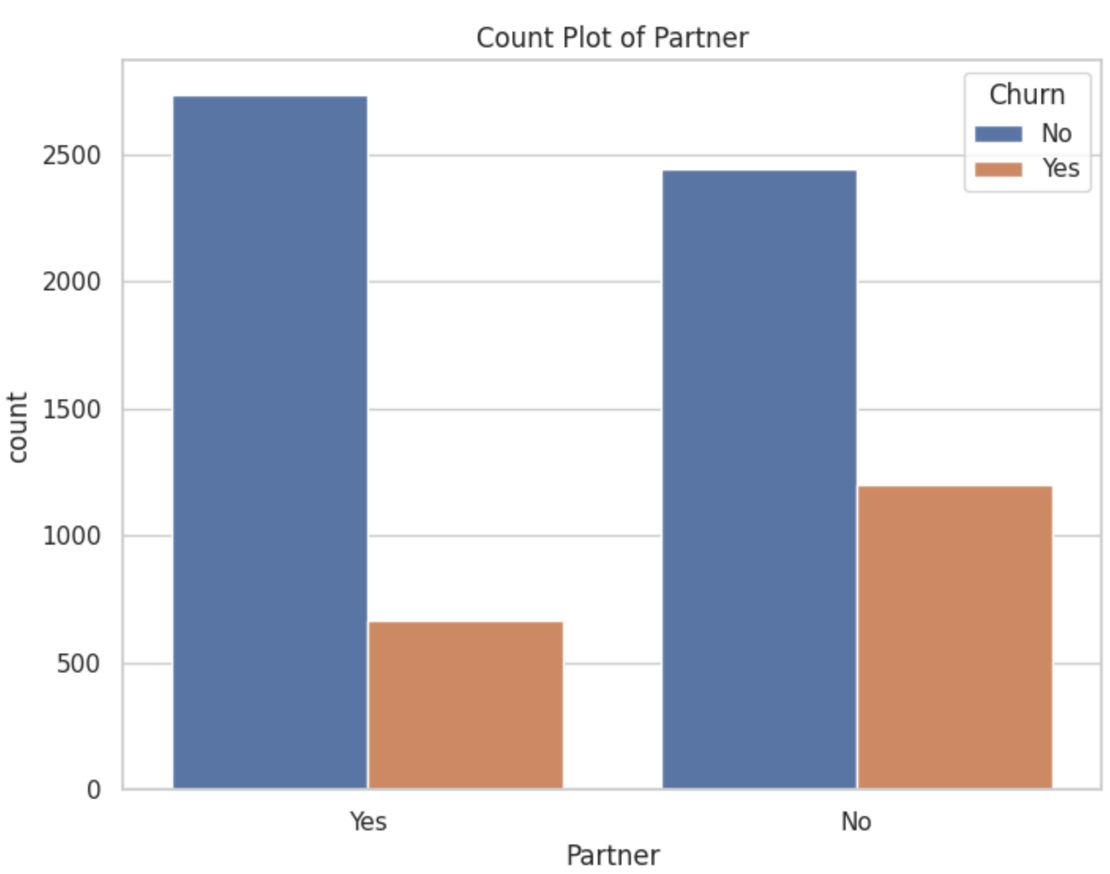

Box Plot of TotalCharges
TotalCharges
8000
6000
4000
2000
0

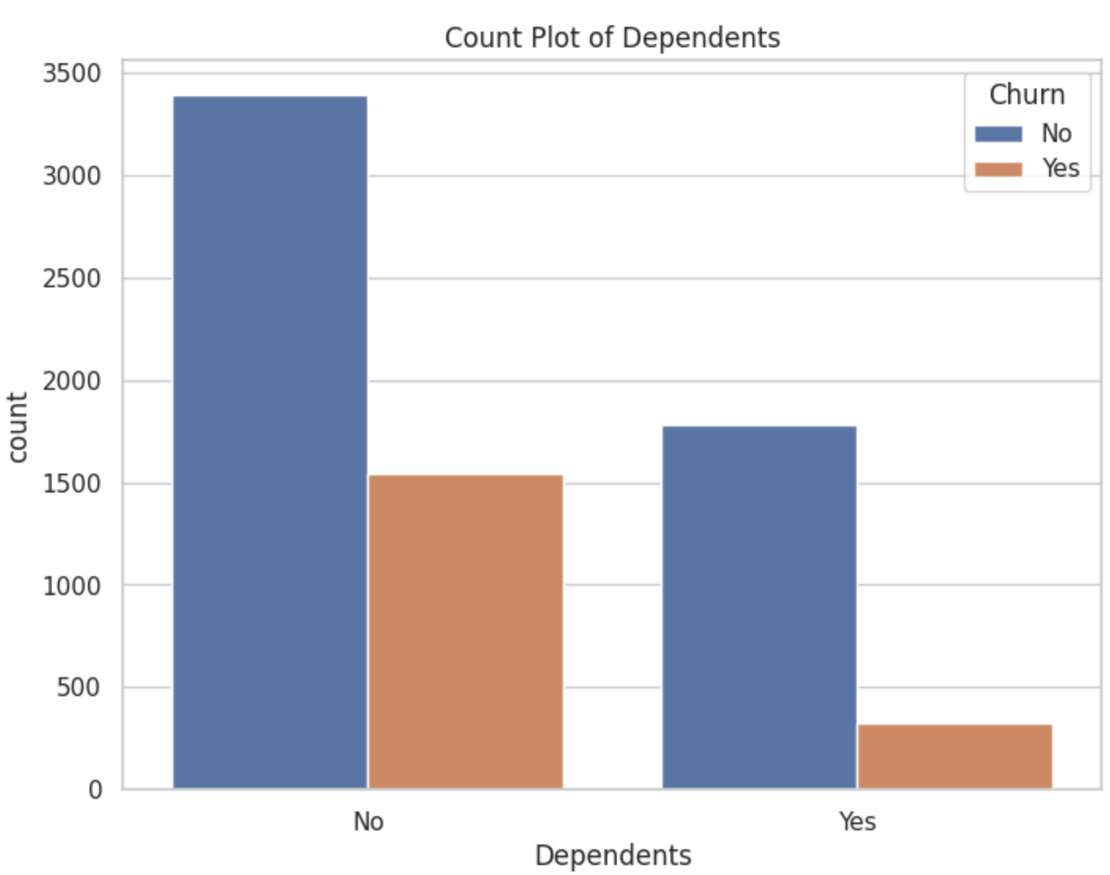
There is clearly no presence of outliers in almost all of the numerical features.

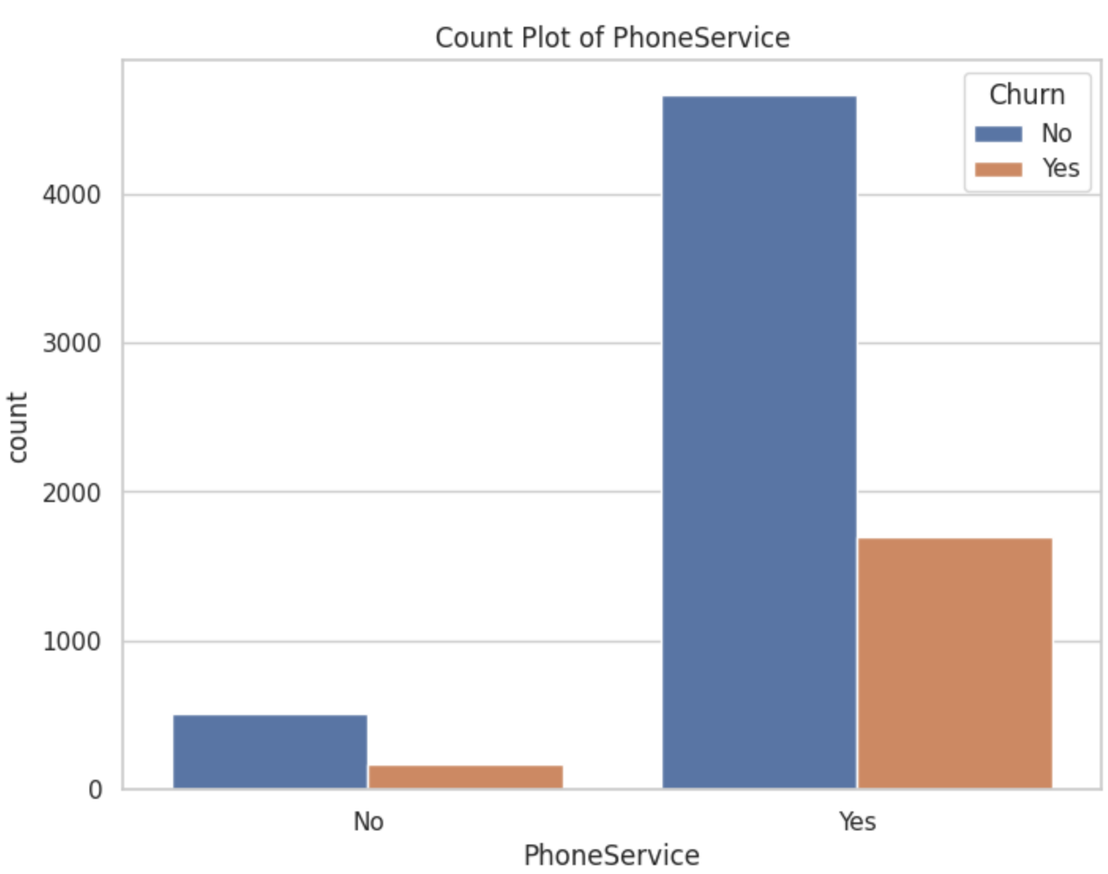
In [ ]:
```
for i in cat_fts.columns[:-1]:
    plt.figure(figsize=(8,6))
    sns.countplot(data=cat_fts, x=i, hue='Churn')
    plt.title(f'Count Plot of {i}')
    plt.show()
```

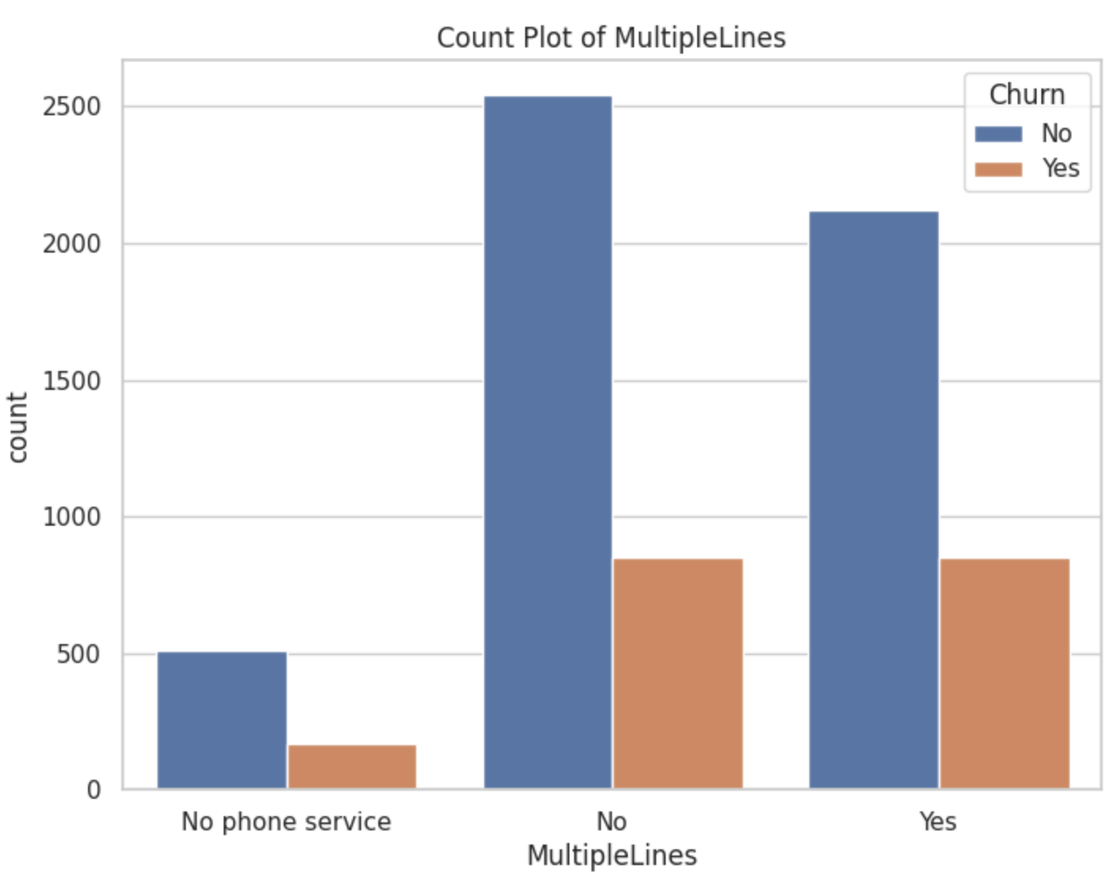


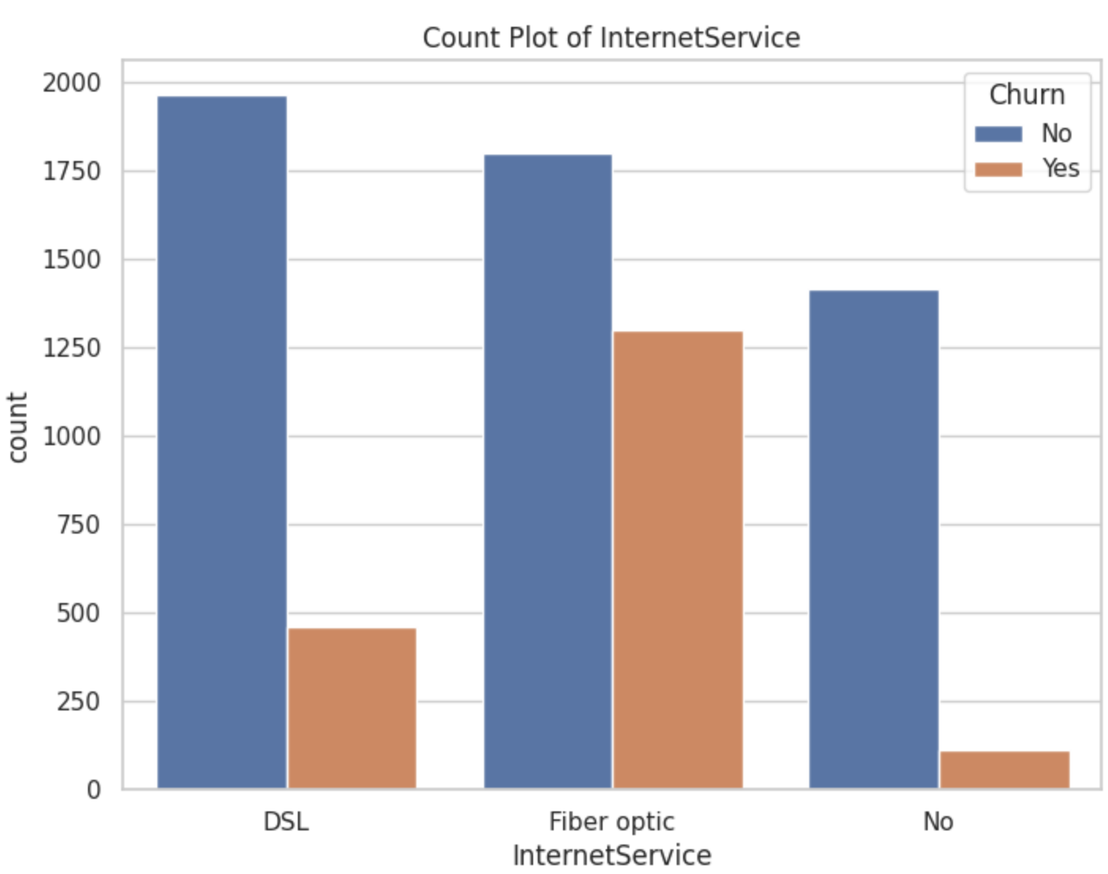

Count Plot of SeniorCitizen
Churn
No
Yes
count
4000
3000
2000
1000
0
0
1
SeniorCitizen

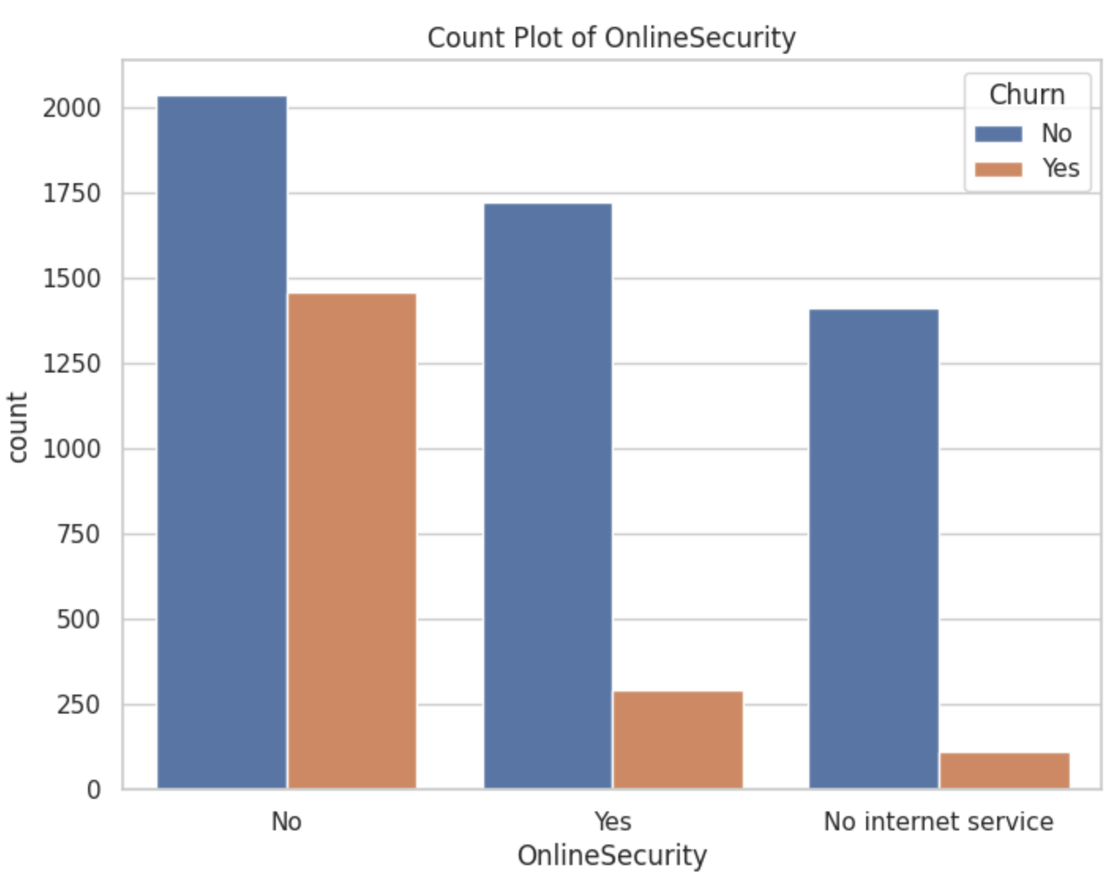

Count Plot of Partner
Churn
No
Yes
count
2500
2000
1500
1000
500
0
Yes
No
Partner

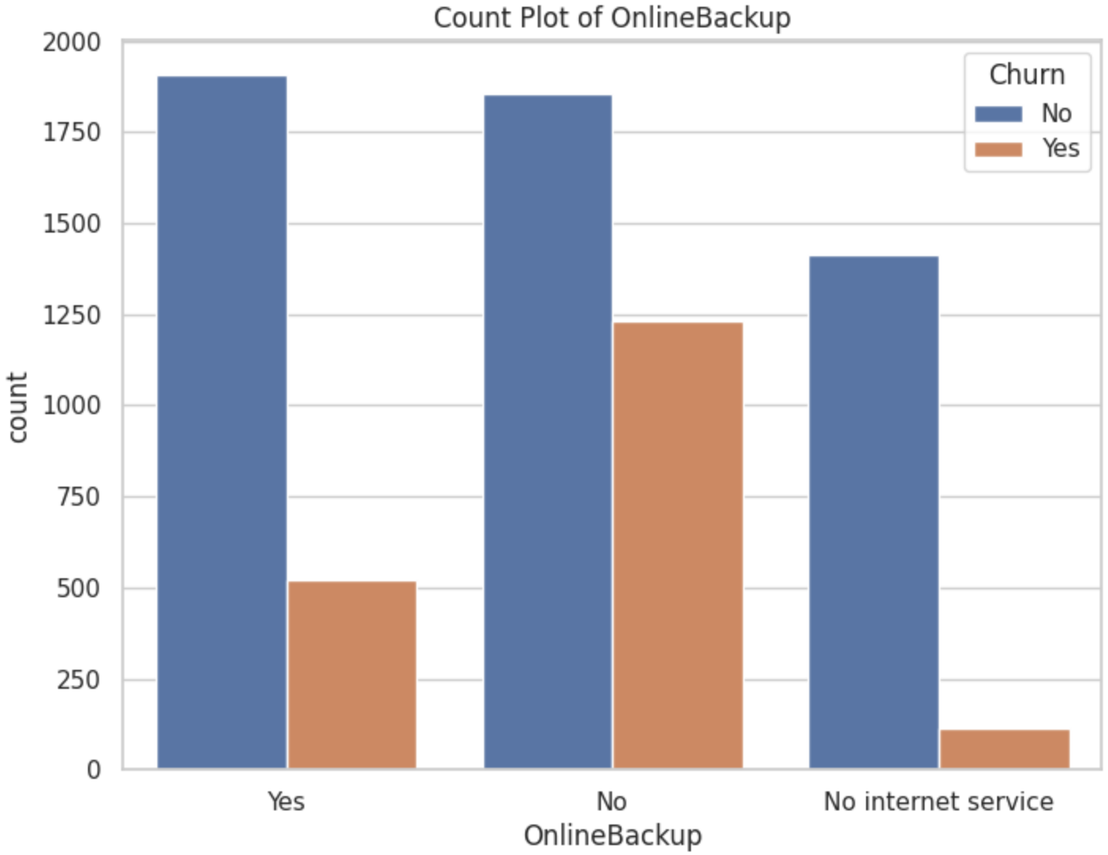

Count Plot of Dependents
Churn
No
Yes
count
3500
3000
2500
2000
1500
1000
500
0
No
Yes
Dependents

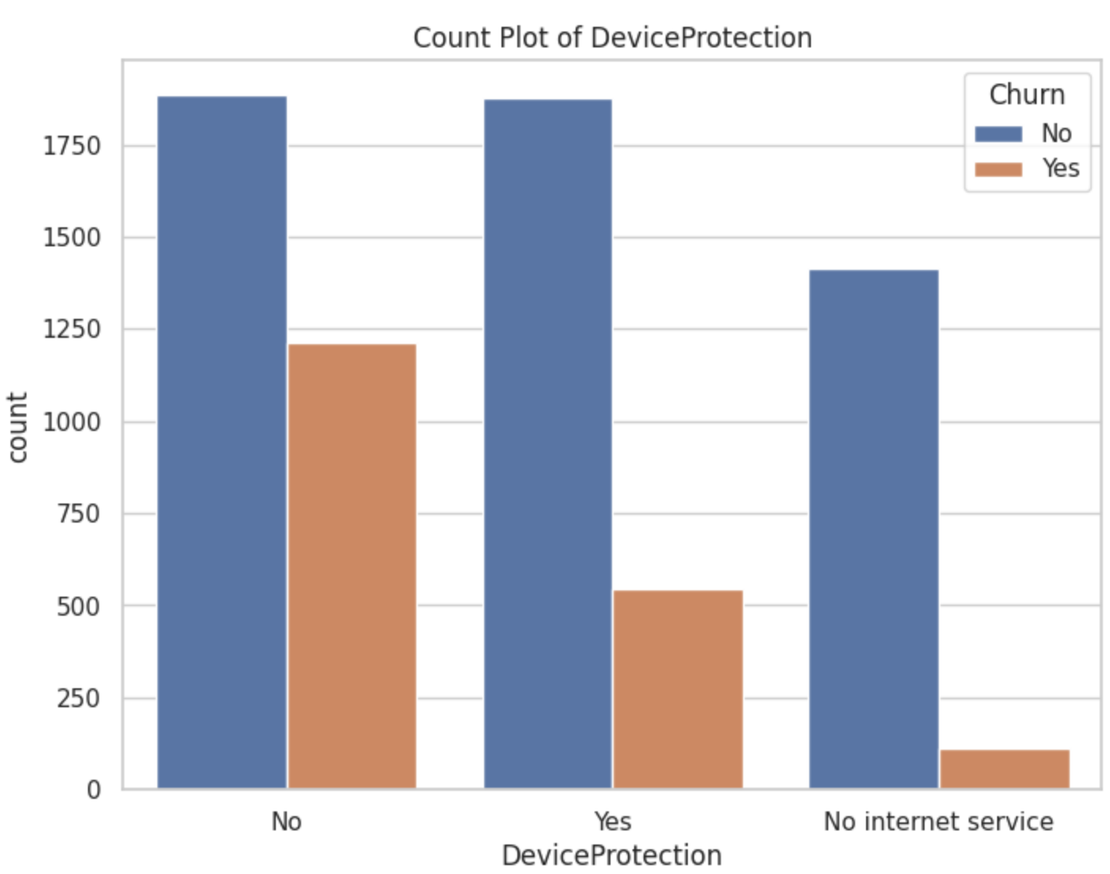

Count Plot of PhoneService
Churn
No
Yes
count
0
1000
2000
3000
4000
No
Yes
PhoneService

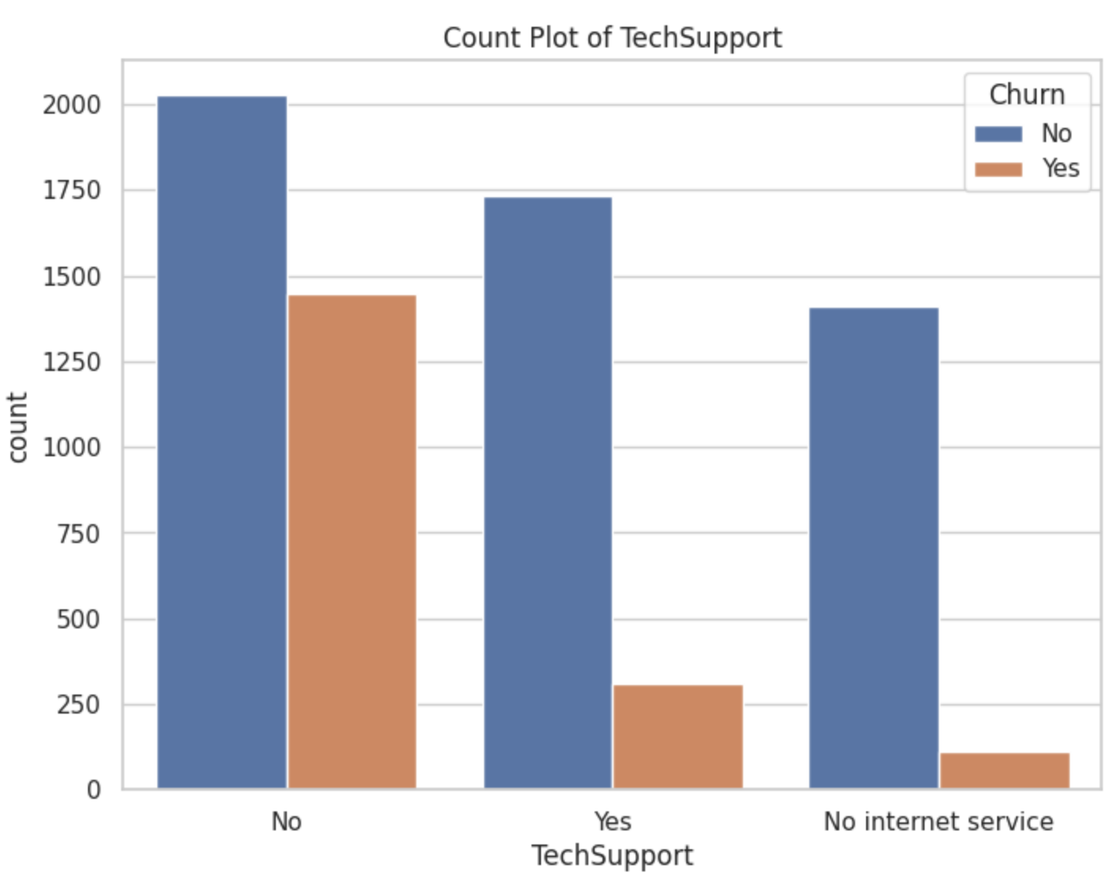

Count Plot of MultipleLines
Churn
No
Yes
count
2500
2000
1500
1000
500
0
No phone service
No
Yes
MultipleLines

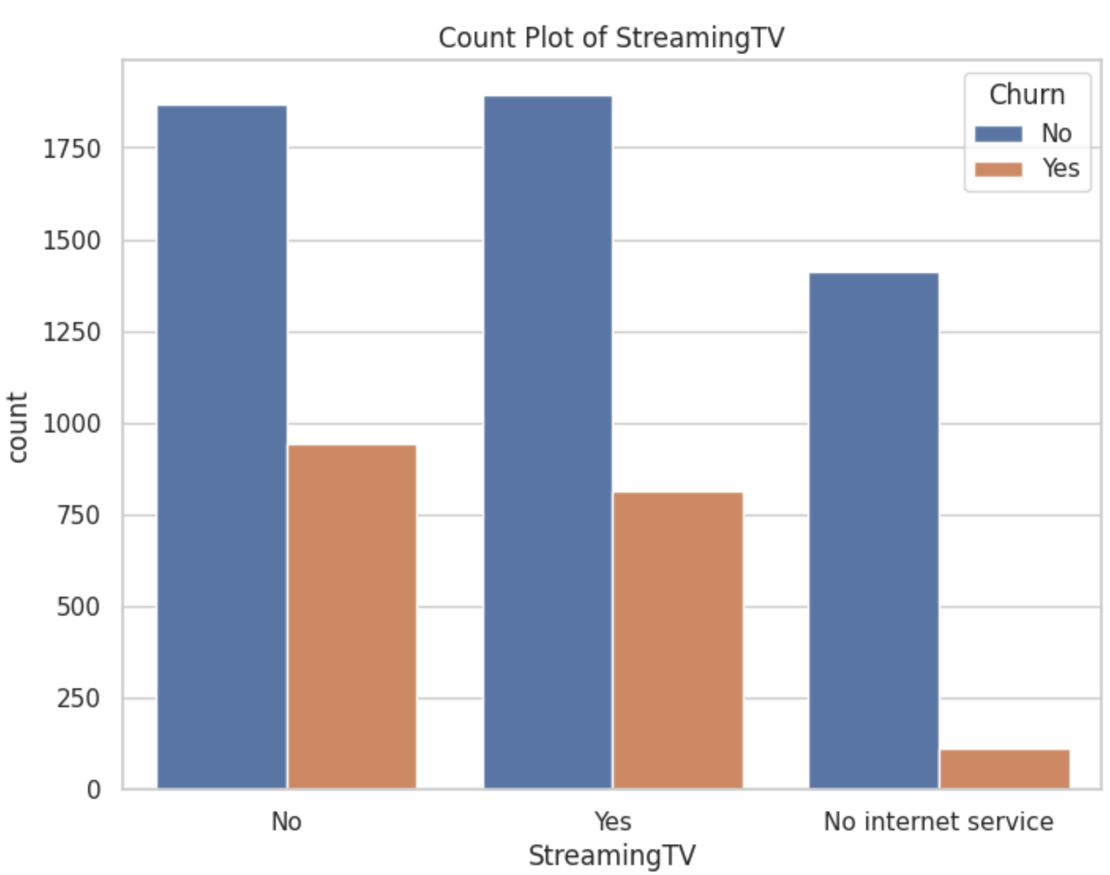

Count Plot of InternetService
Churn
No
Yes
count
2000
1750
1500
1250
1000
750
500
250
0
DSL
Fiber optic
No
InternetService

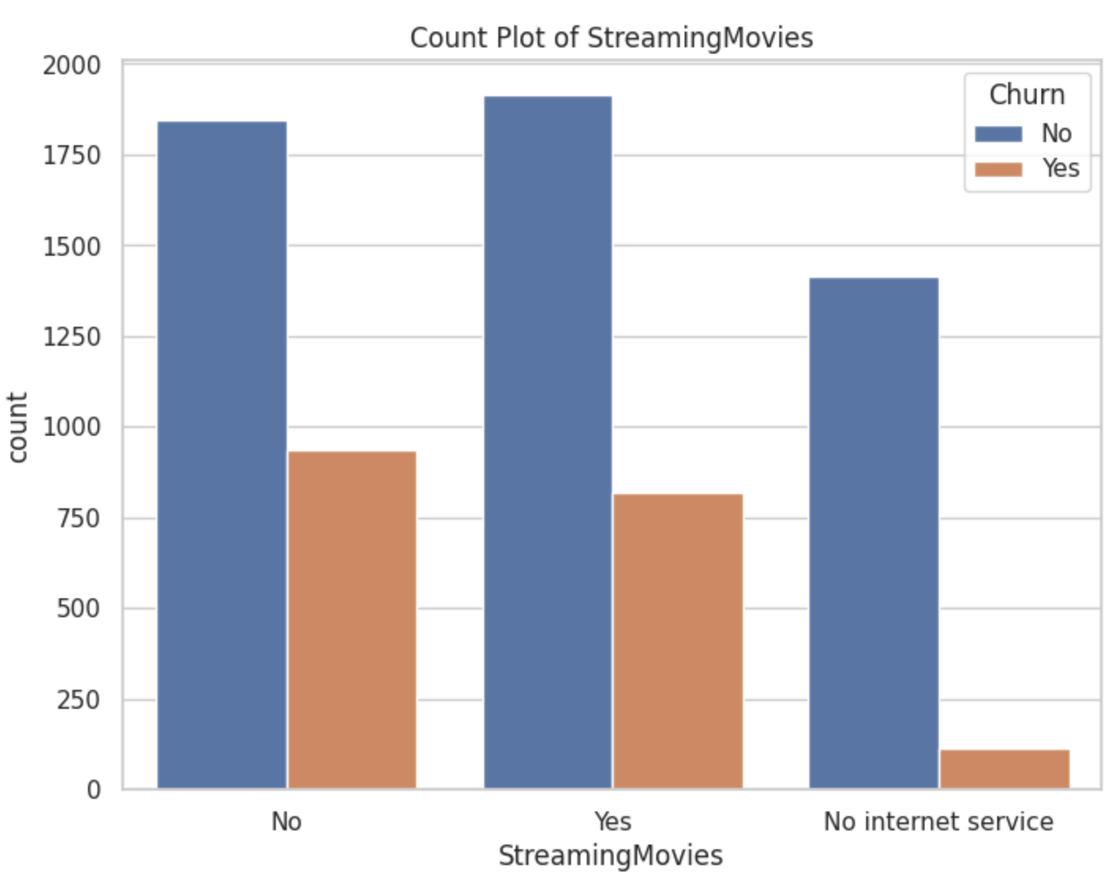

Count Plot of OnlineSecurity
Churn
No
Yes
count
2000
1750
1500
1250
1000
750
500
250
0
No
Yes
No internet service
OnlineSecurity

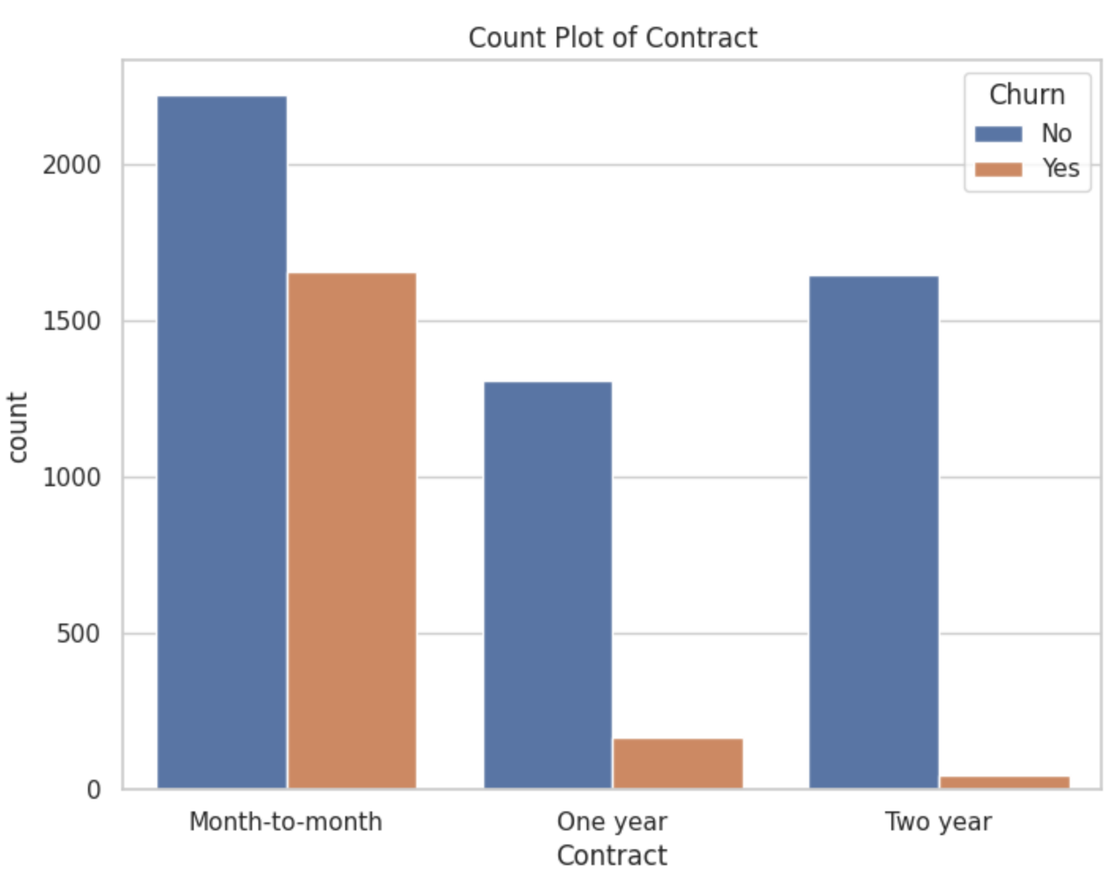

Count Plot of OnlineBackup
Churn
No
Yes
count
2000
1750
1500
1250
1000
750
500
250
0
Yes
No
No internet service
OnlineBackup

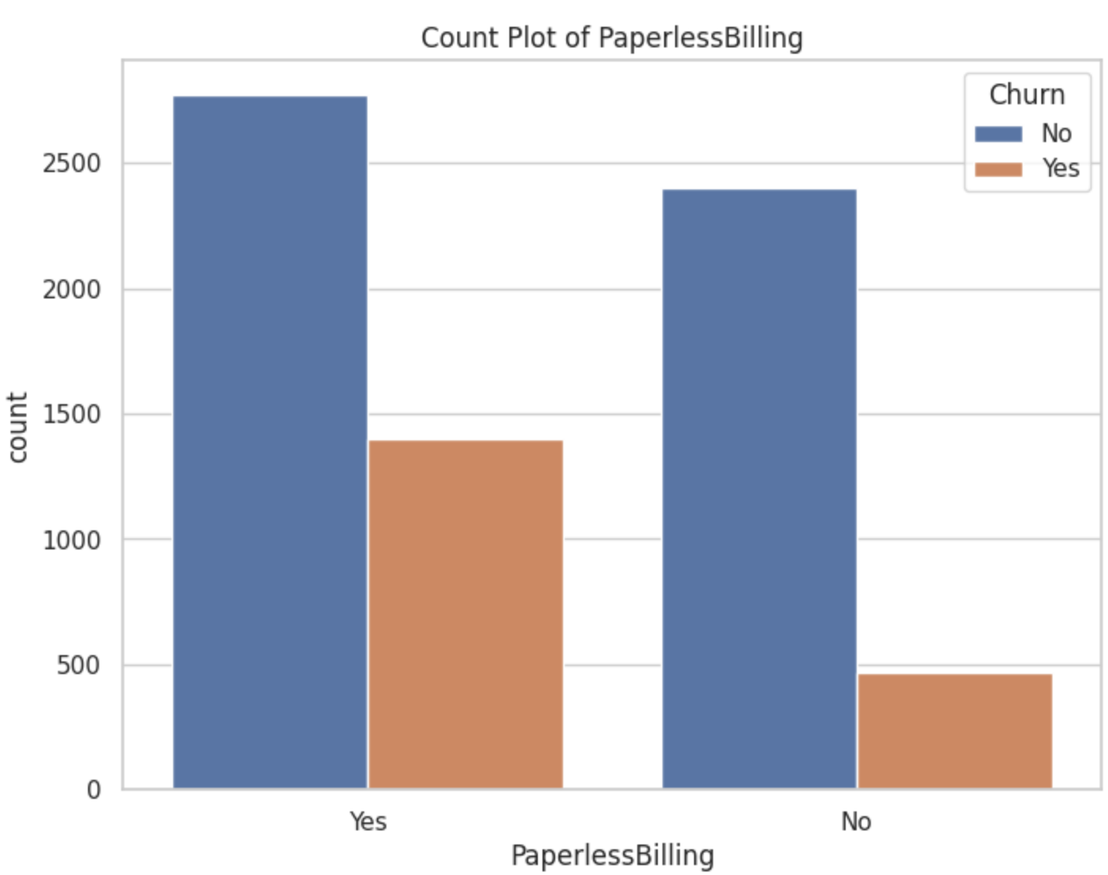

Count Plot of DeviceProtection
Churn
No
Yes
count
1750
1500
1250
1000
750
500
250
0
No
Yes
No internet service
DeviceProtection

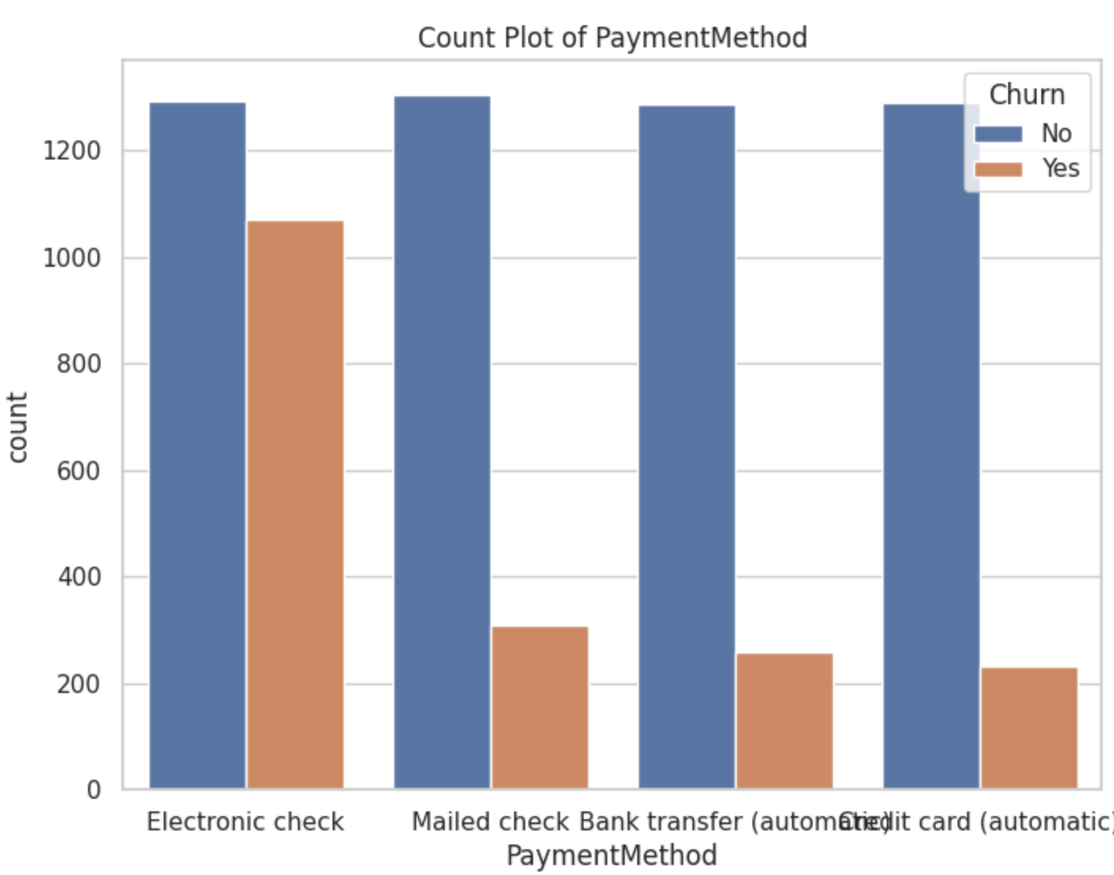

Count Plot of TechSupport
Churn
No
Yes
count
2000
1750
1500
1250
1000
750
500
250
0
No
Yes
No internet service
TechSupport


Count Plot of StreamingTV
Churn
No
Yes
count
0
250
500
750
1000
1250
1500
1750
No
Yes
No internet service
StreamingTV


Count Plot of StreamingMovies
Churn
No
Yes
count
2000
1750
1500
1250
1000
750
500
250
0
No
Yes
No internet service
StreamingMovies

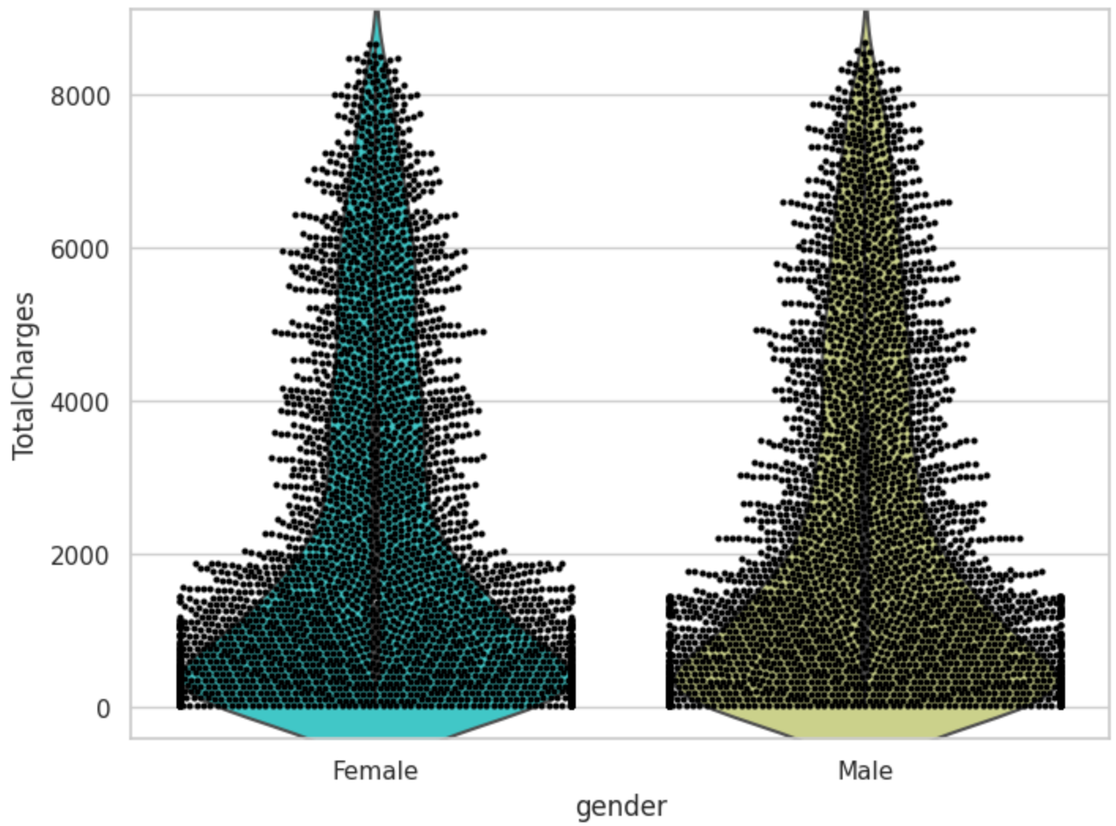

Count Plot of Contract
Churn
No
Yes
count
2000
1500
1000
500
0
Month-to-month
One year
Two year
Contract

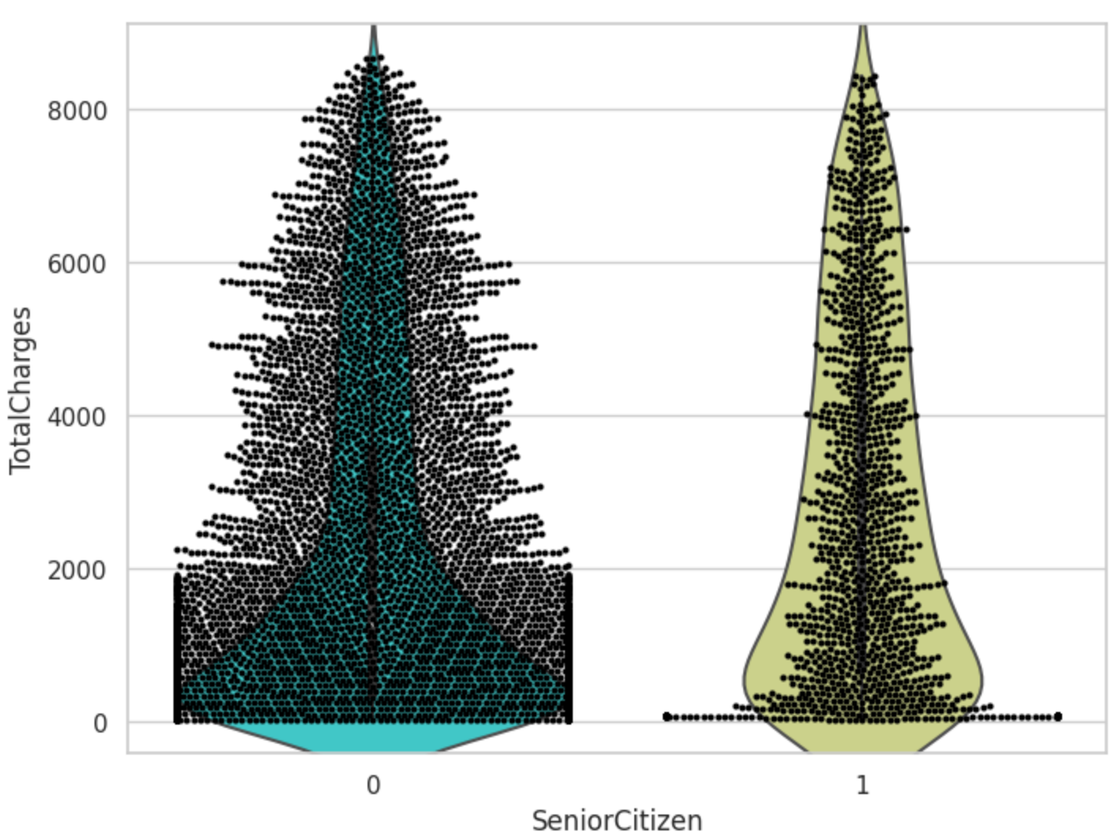

Count Plot of PaperlessBilling
Churn
No
Yes
count
2500
2000
1500
1000
500
0
Yes
No
PaperlessBilling

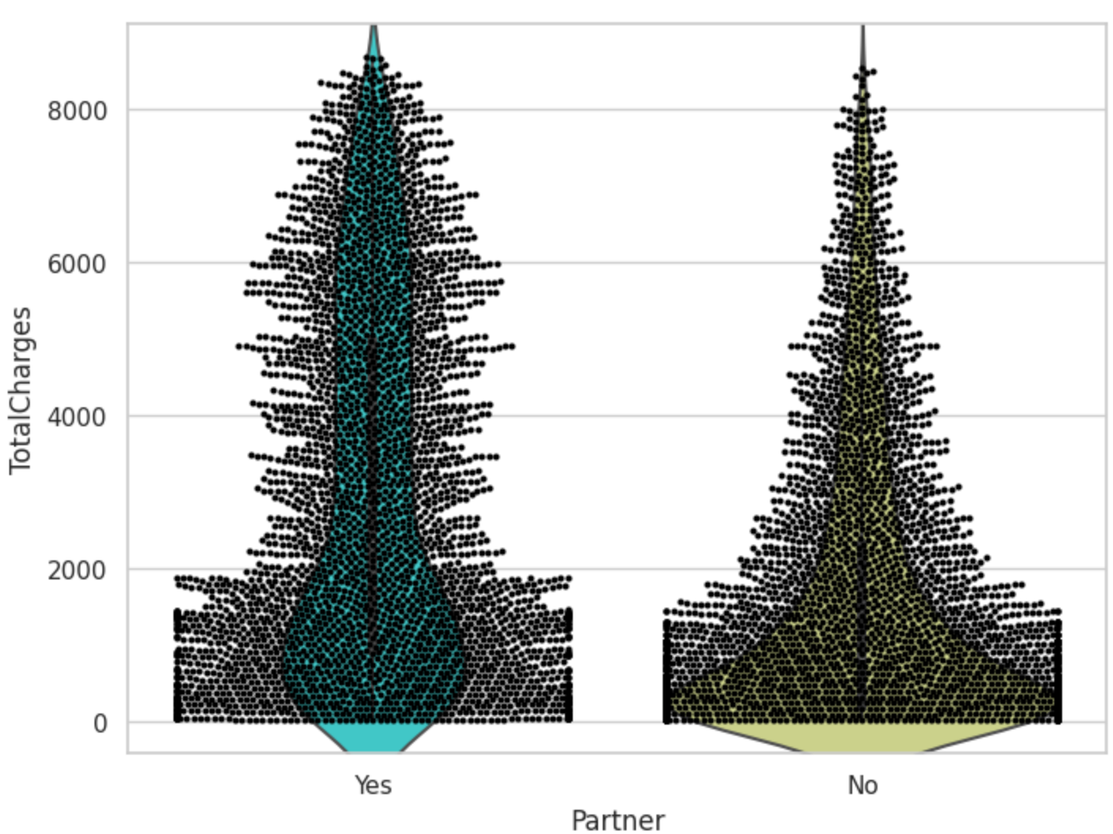


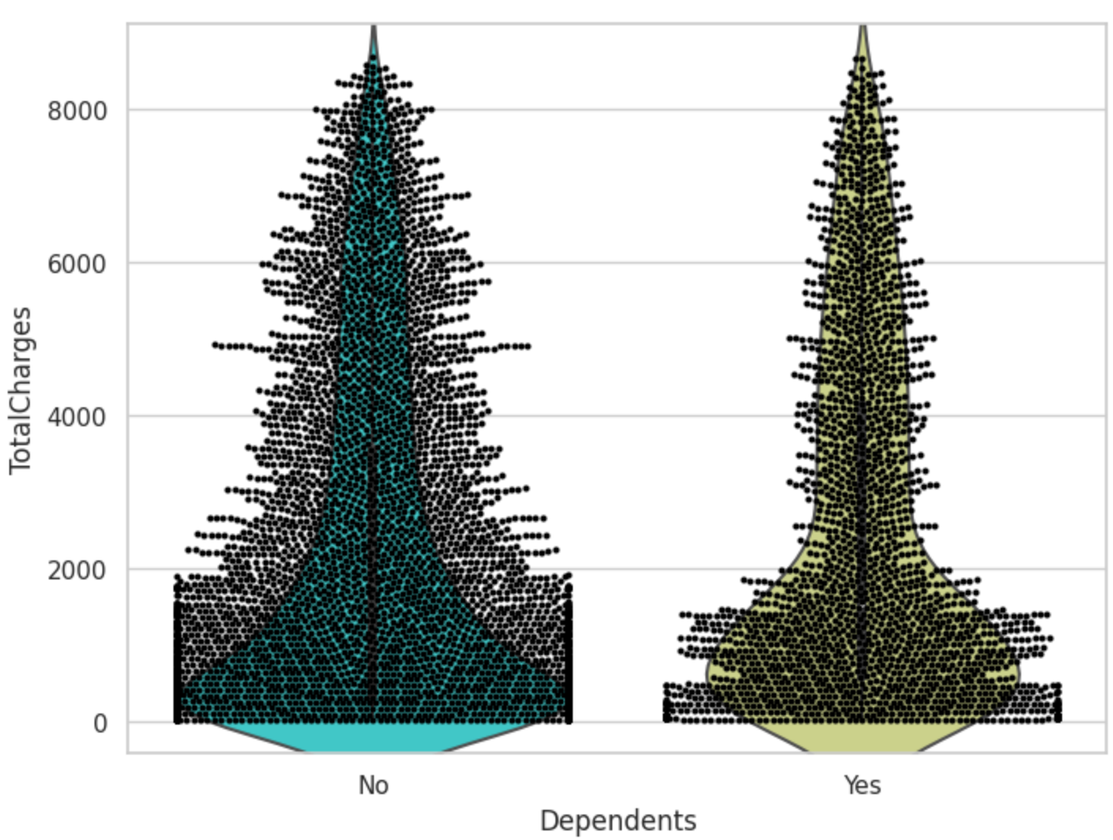
It can be observed that the churn rate is more for customers who have not opted for the services like OnlineSecurity, OnlineBackup, DeviceProtection, TechSupport, StreamingTV, StreamingMovies.

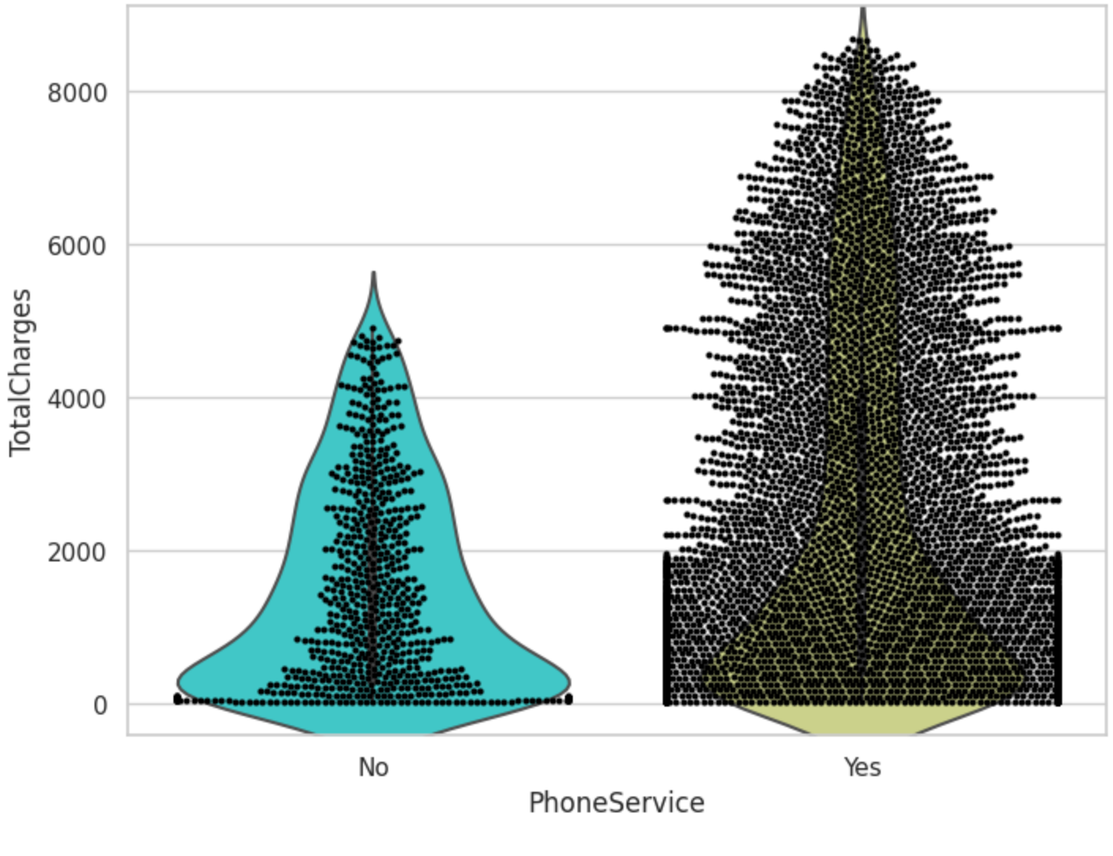
In [ ]:
```
for i in cat_fts.columns.drop(['Churn']):
    plt.figure(figsize=(8,6))
    sns.violinplot(x=i, y=df['TotalCharges'], data=cat_fts, palette='rainbow')
    sns.swarmplot(x=i, y=df['TotalCharges'], data=cat_fts, color='black',size=3)
    plt.show()
```

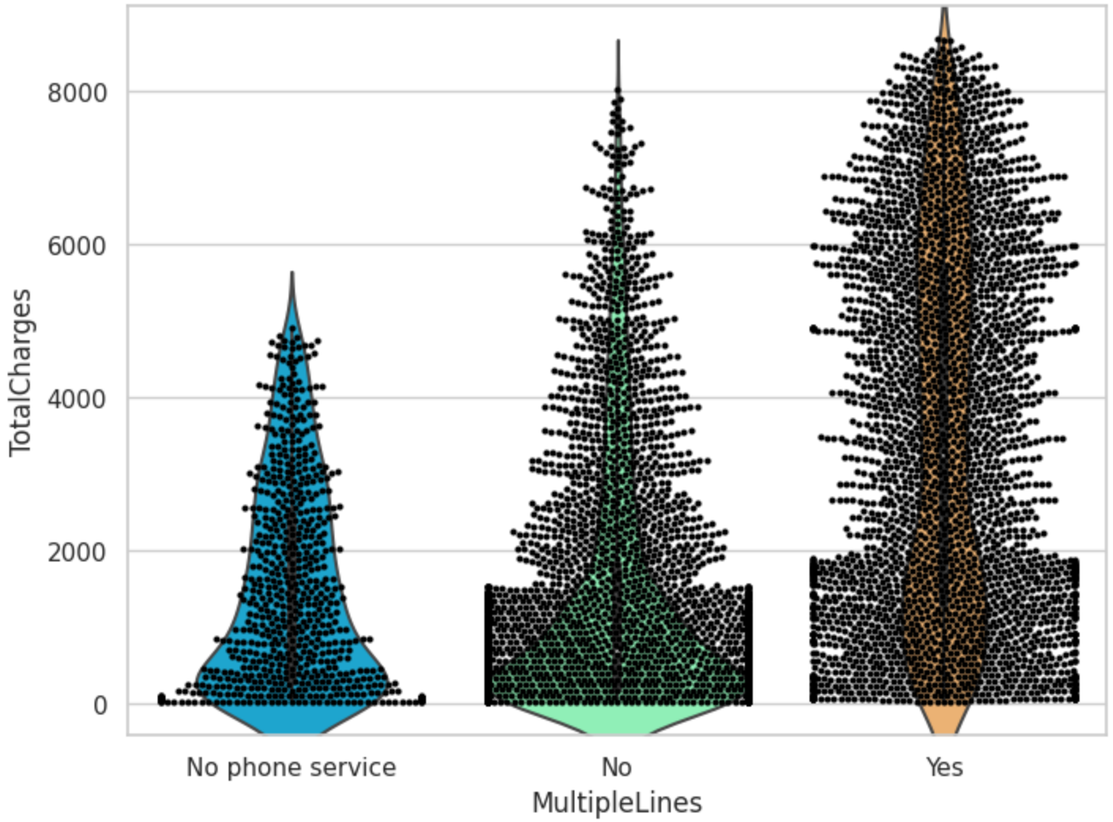


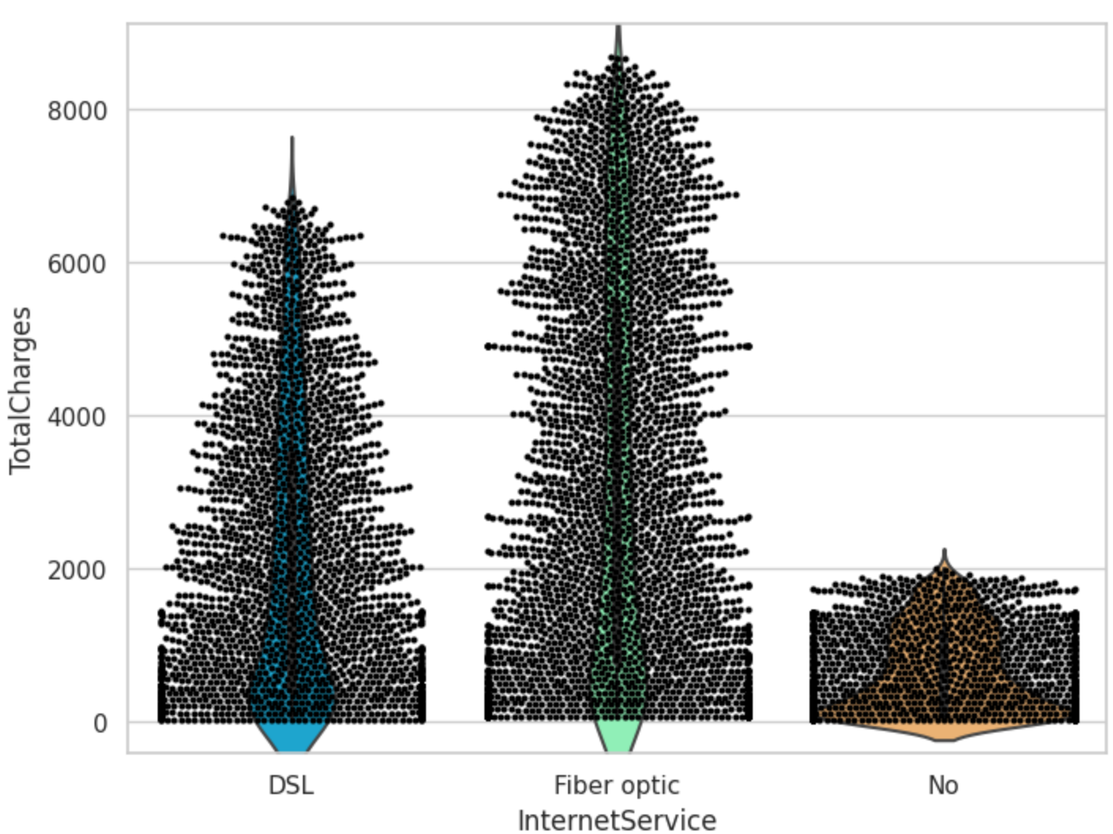

8000
6000
4000
2000
0
TotalCharges
0
1
SeniorCitizen

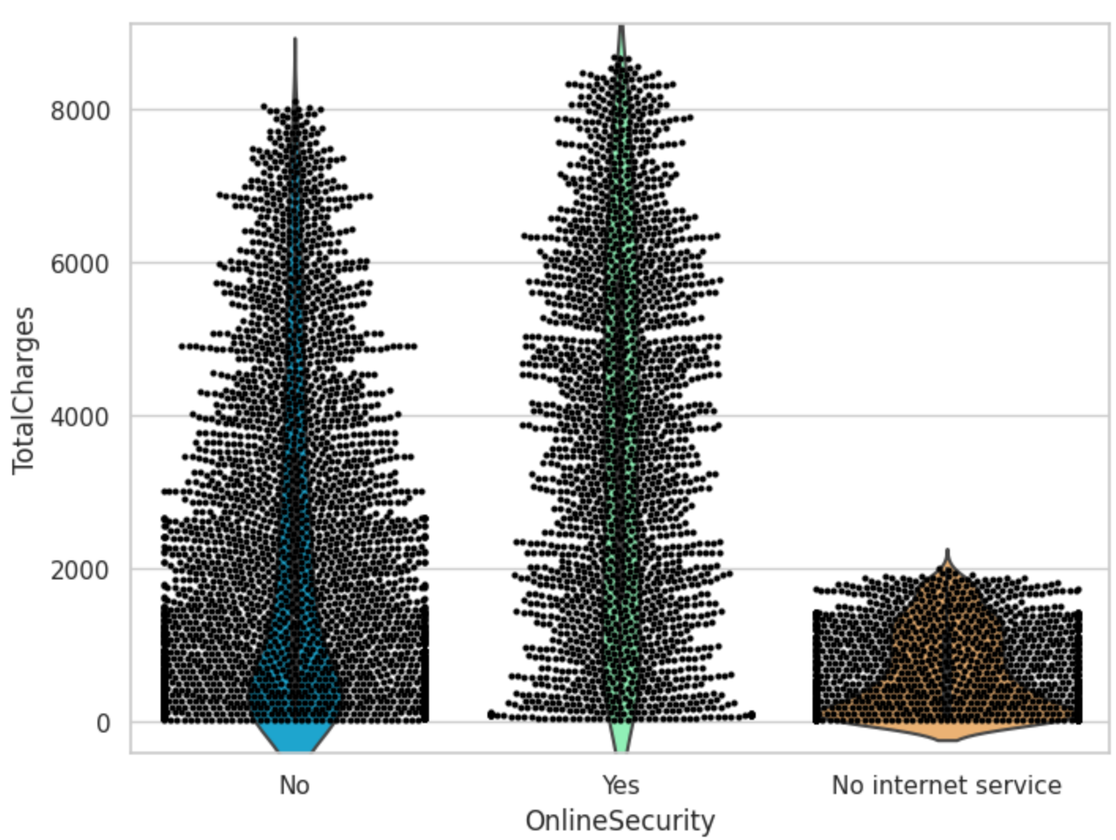

8000
6000
4000
2000
0
TotalCharges
Yes
No
Partner

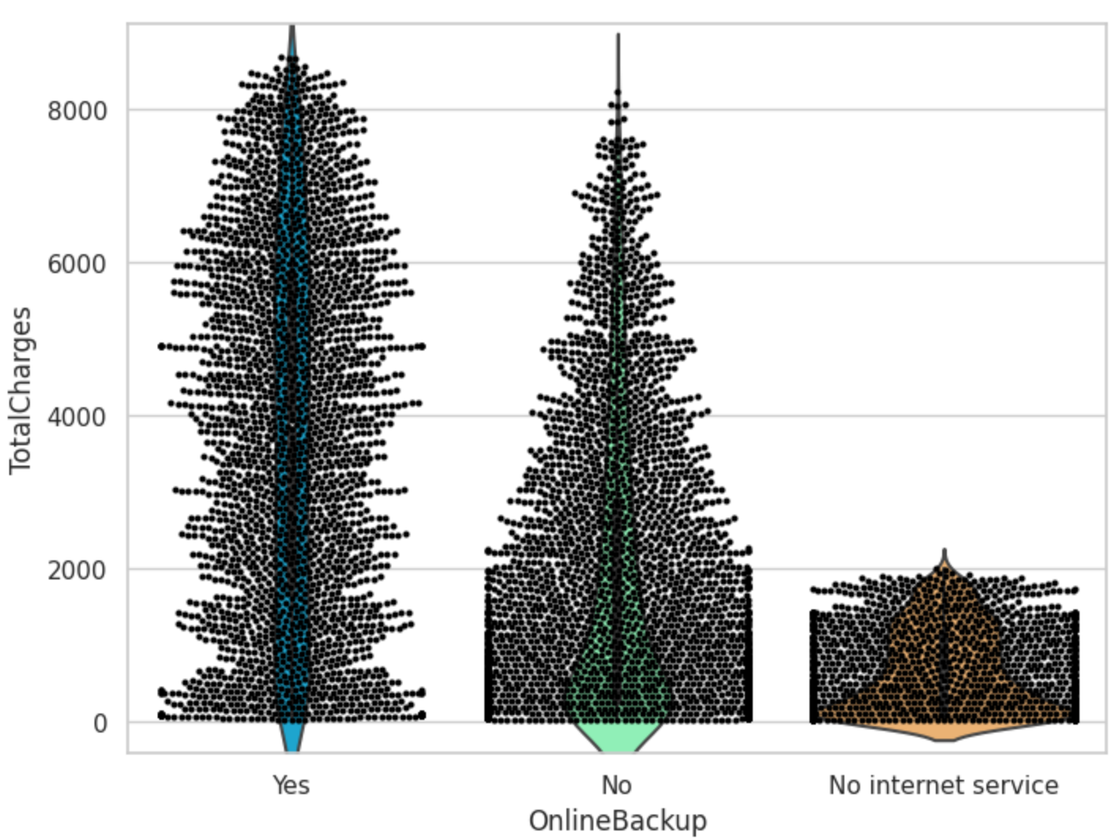

8000
6000
4000
2000
0
TotalCharges
No
Yes
Dependents

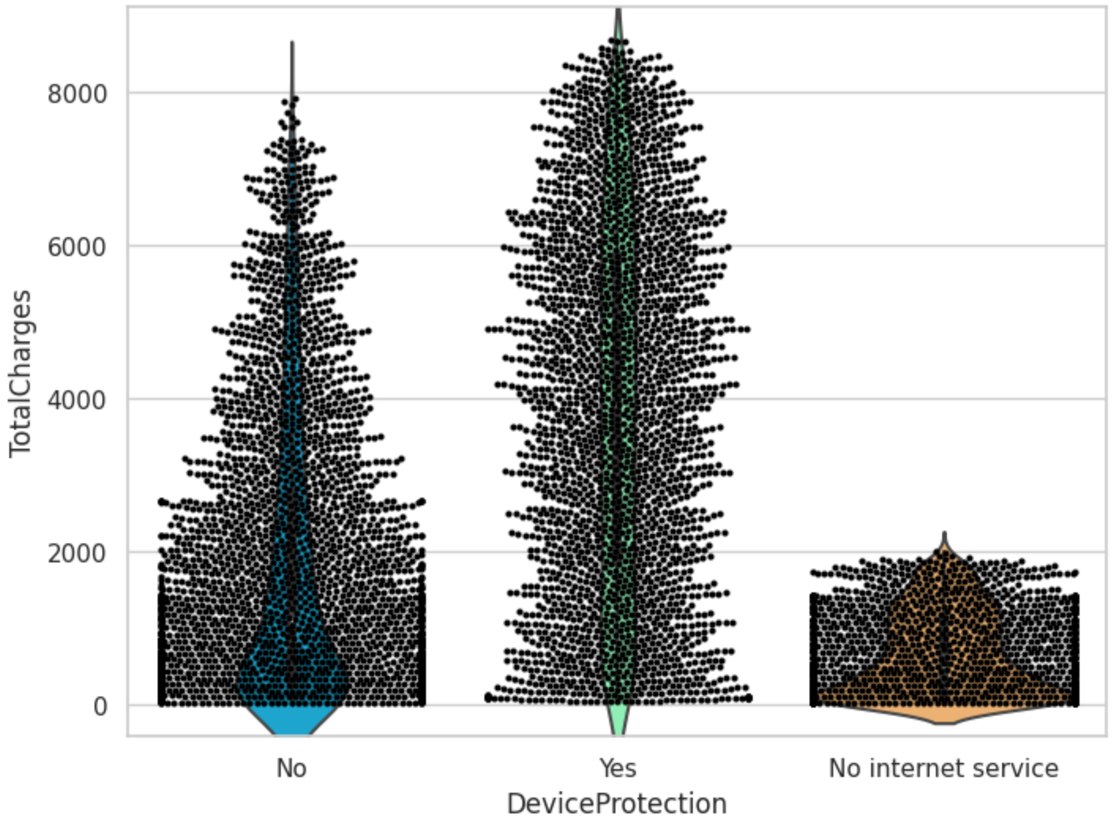

8000
6000
4000
2000
0
TotalCharges
No
Yes
PhoneService

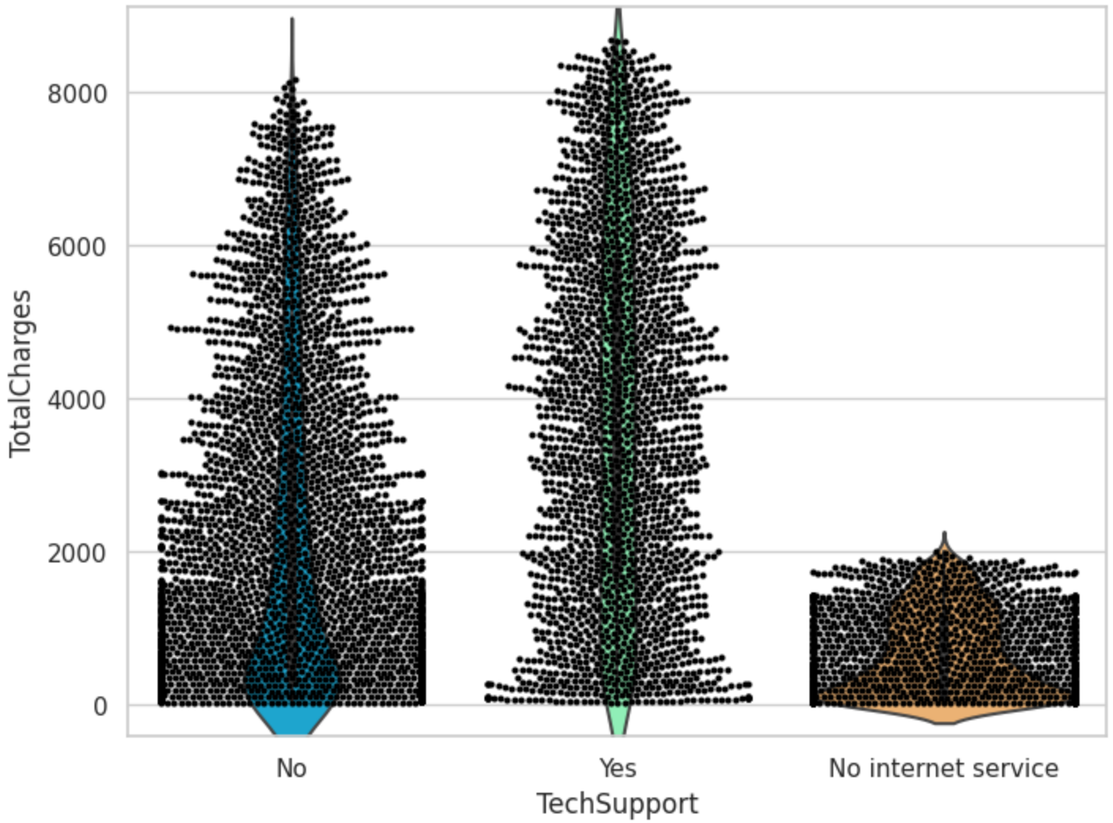

8000
6000
4000
2000
0
TotalCharges
No phone service
No
Yes
MultipleLines

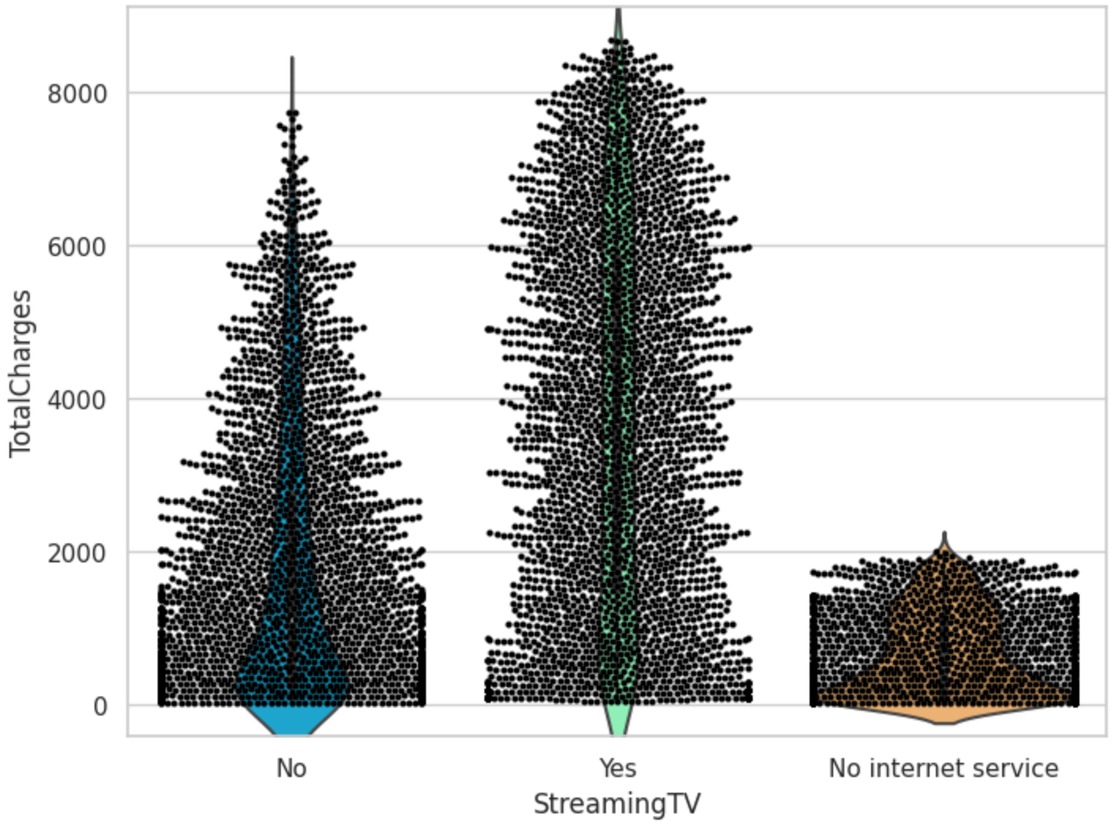

8000
6000
4000
2000
0
TotalCharges
DSL
Fiber optic
No
InternetService

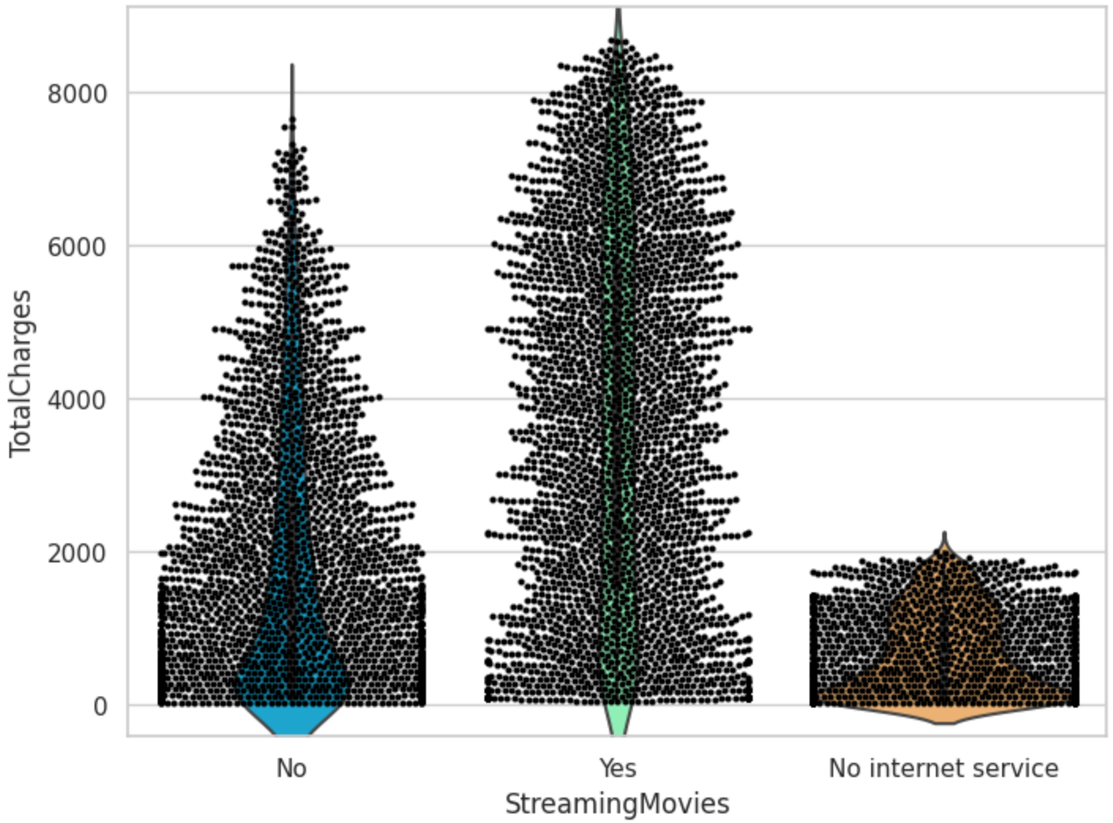

8000
6000
4000
2000
0
TotalCharges
No
Yes
No internet service
OnlineSecurity

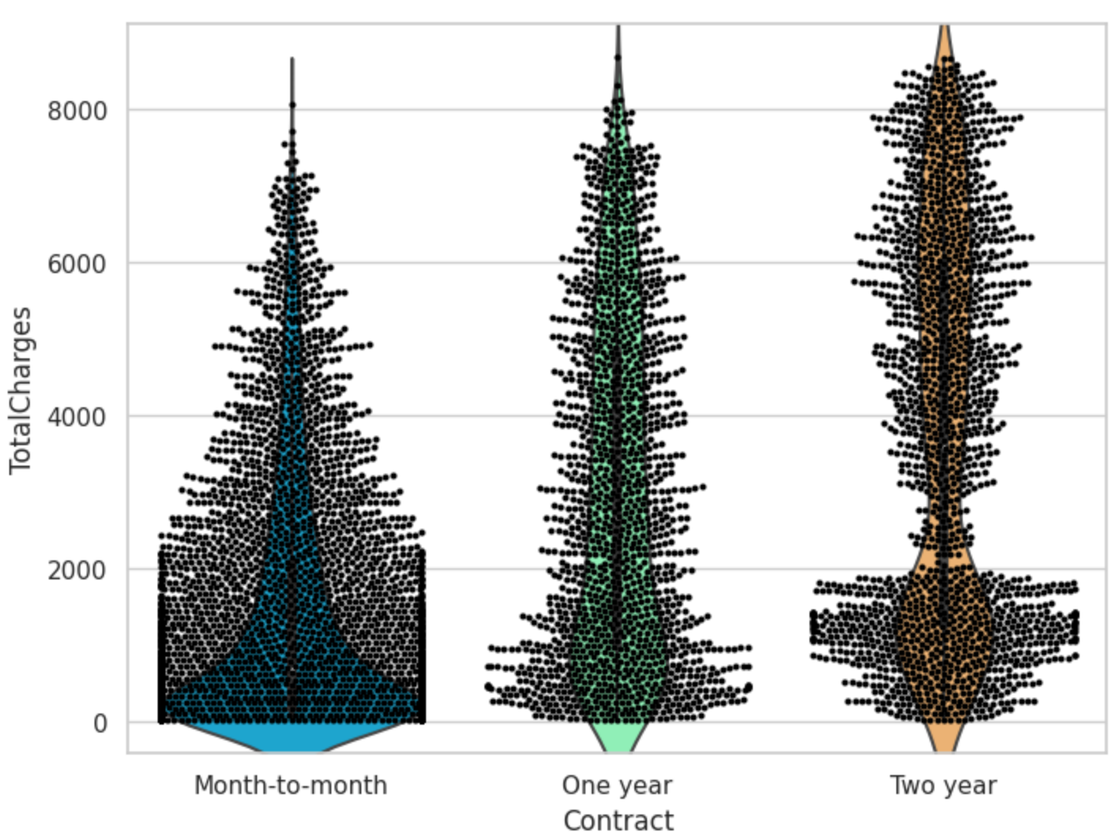

8000
6000
4000
2000
0
TotalCharges
Yes
No
No internet service
OnlineBackup

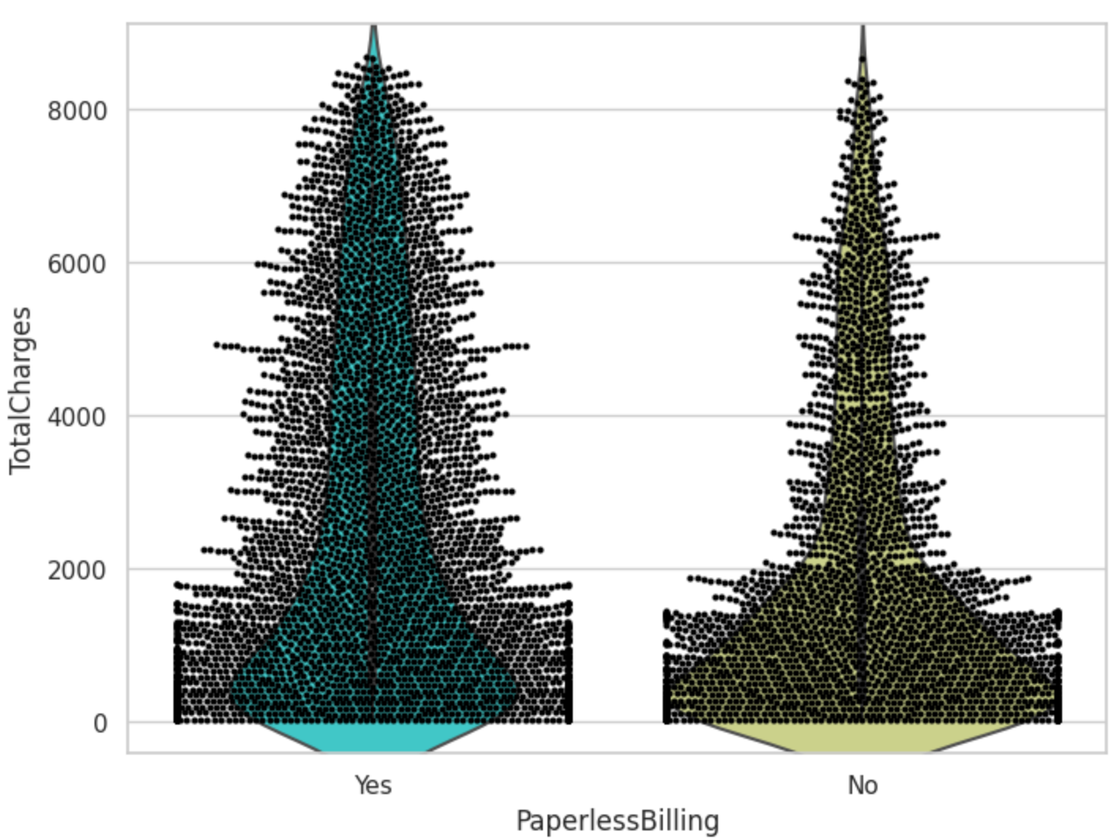

8000
6000
4000
2000
0
TotalCharges
No
Yes
No internet service
DeviceProtection

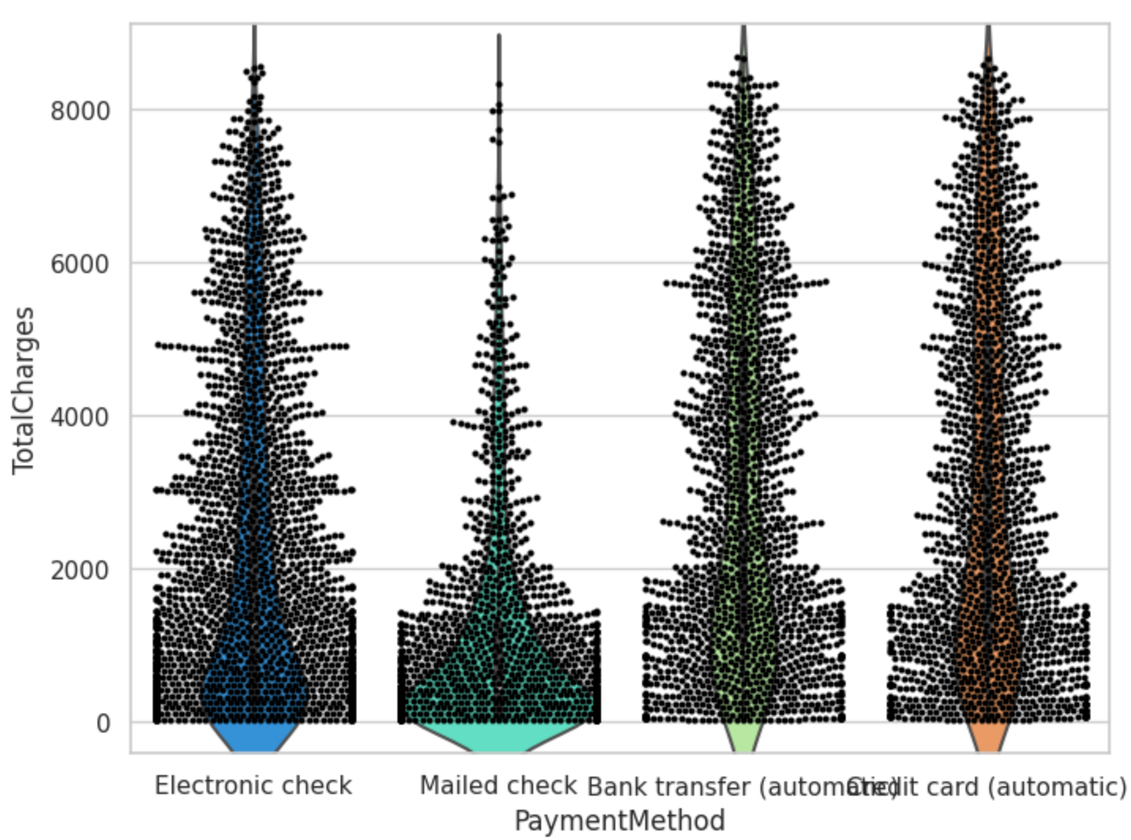

8000
6000
4000
2000
0
TotalCharges
No
Yes
No internet service
TechSupport


8000
6000
4000
2000
0
TotalCharges
No
Yes
No internet service
StreamingTV

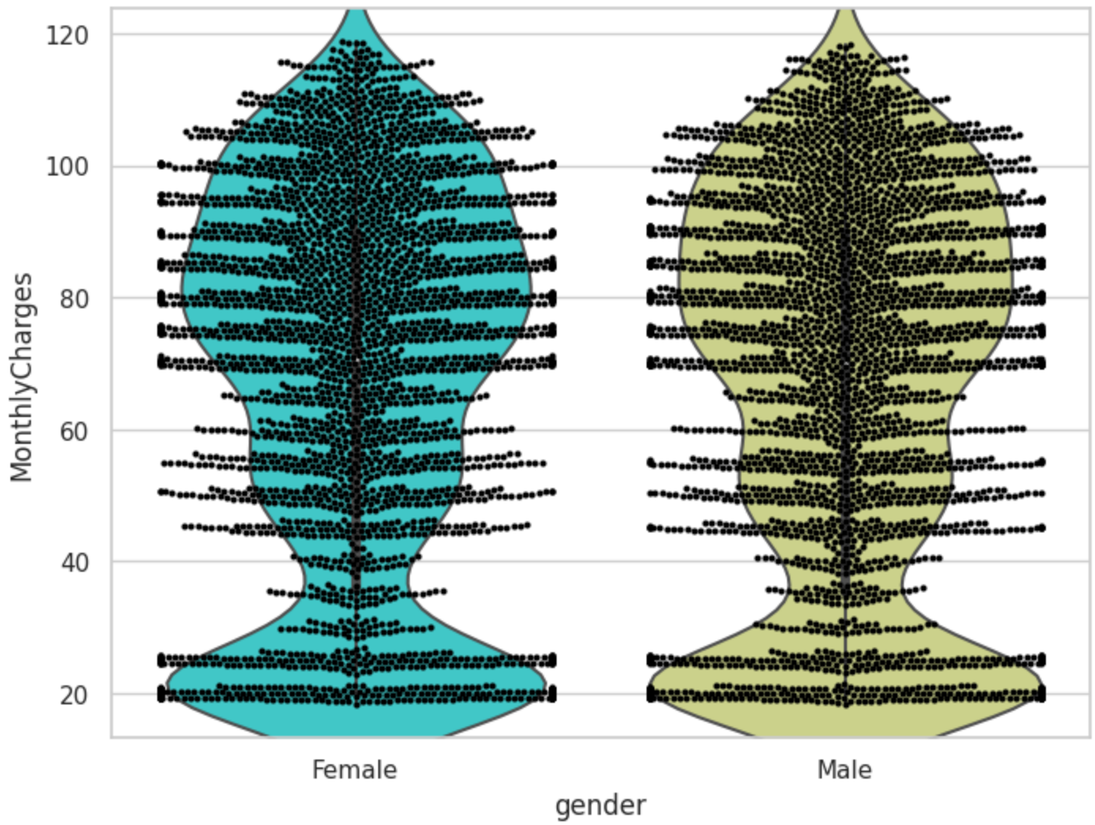

8000
6000
4000
2000
0
TotalCharges
No
Yes
No internet service
StreamingMovies

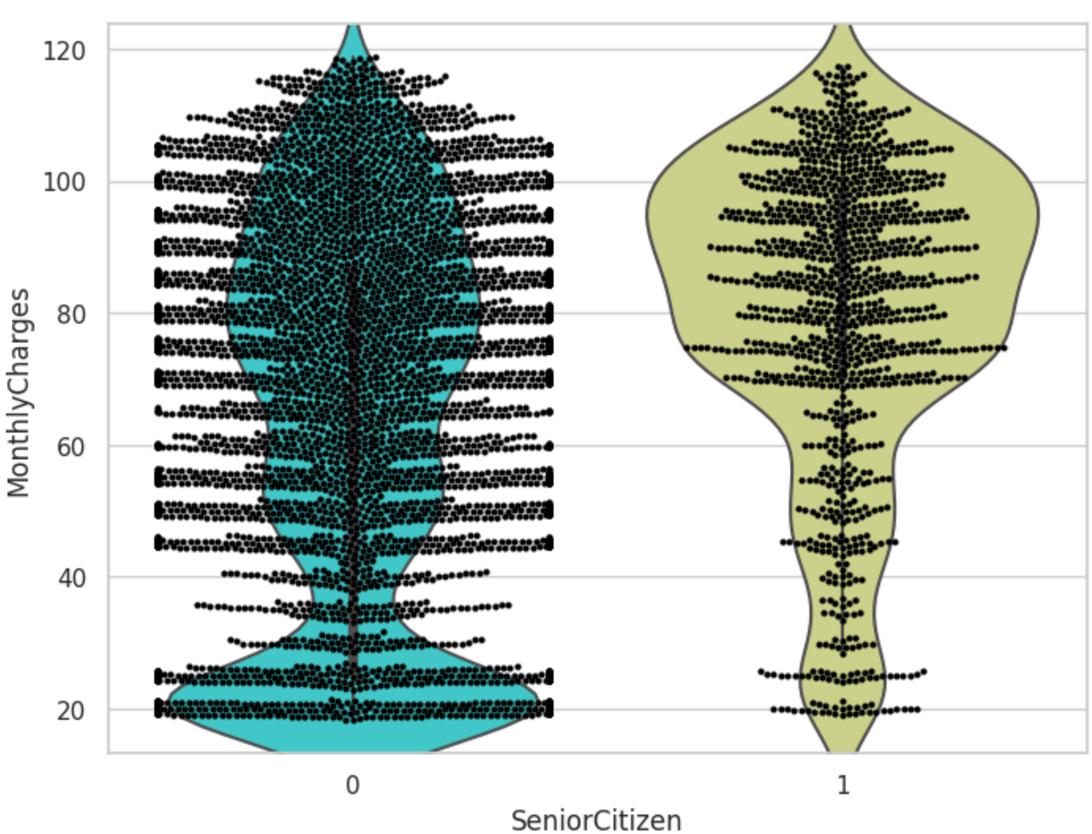

8000
6000
4000
2000
0
TotalCharges
Month-to-month
One year
Two year
Contract

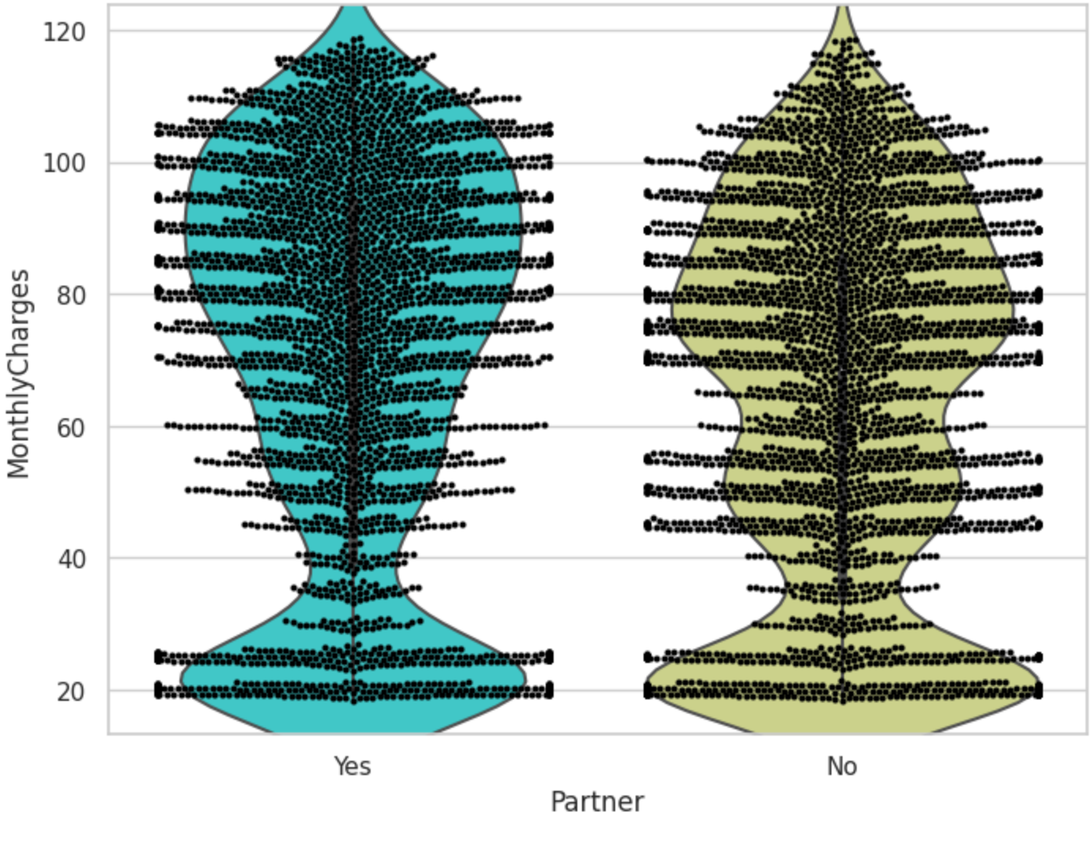

8000
6000
4000
2000
0
TotalCharges
Yes
No
PaperlessBilling

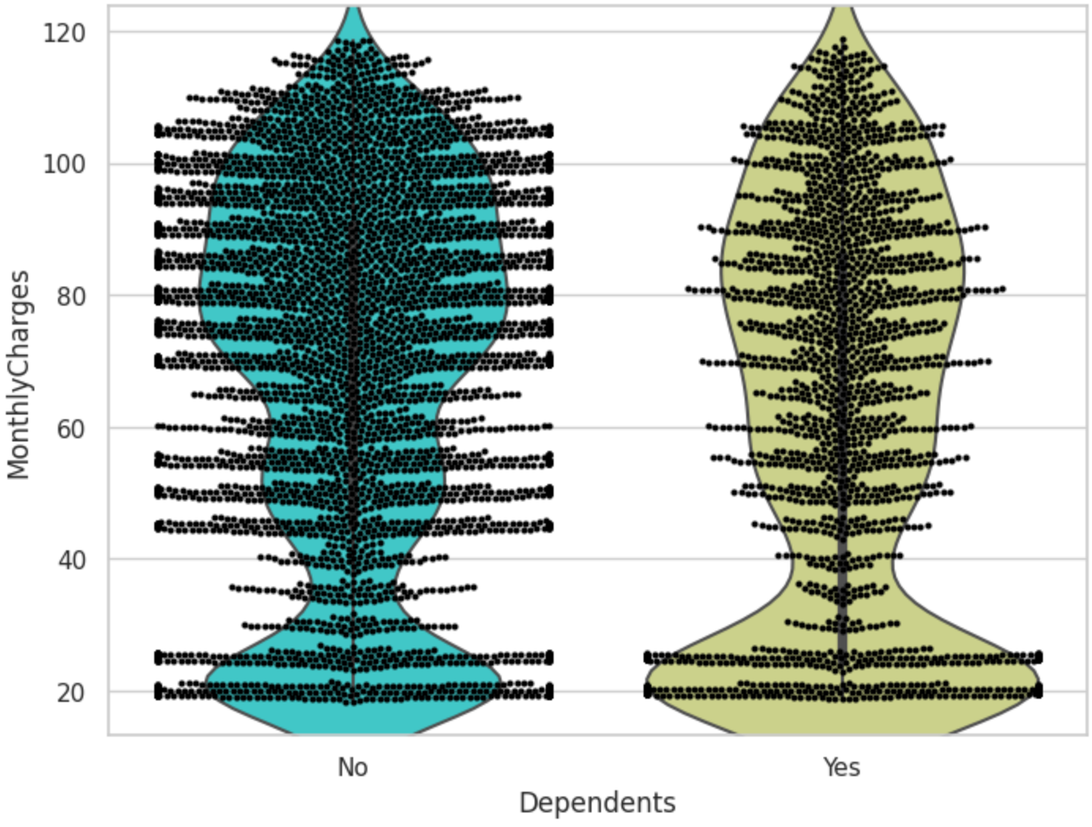

8000
6000
4000
2000
0
TotalCharges
Electronic check
Mailed check
Bank transfer (automatic)
Credit card (automatic)
PaymentMethod

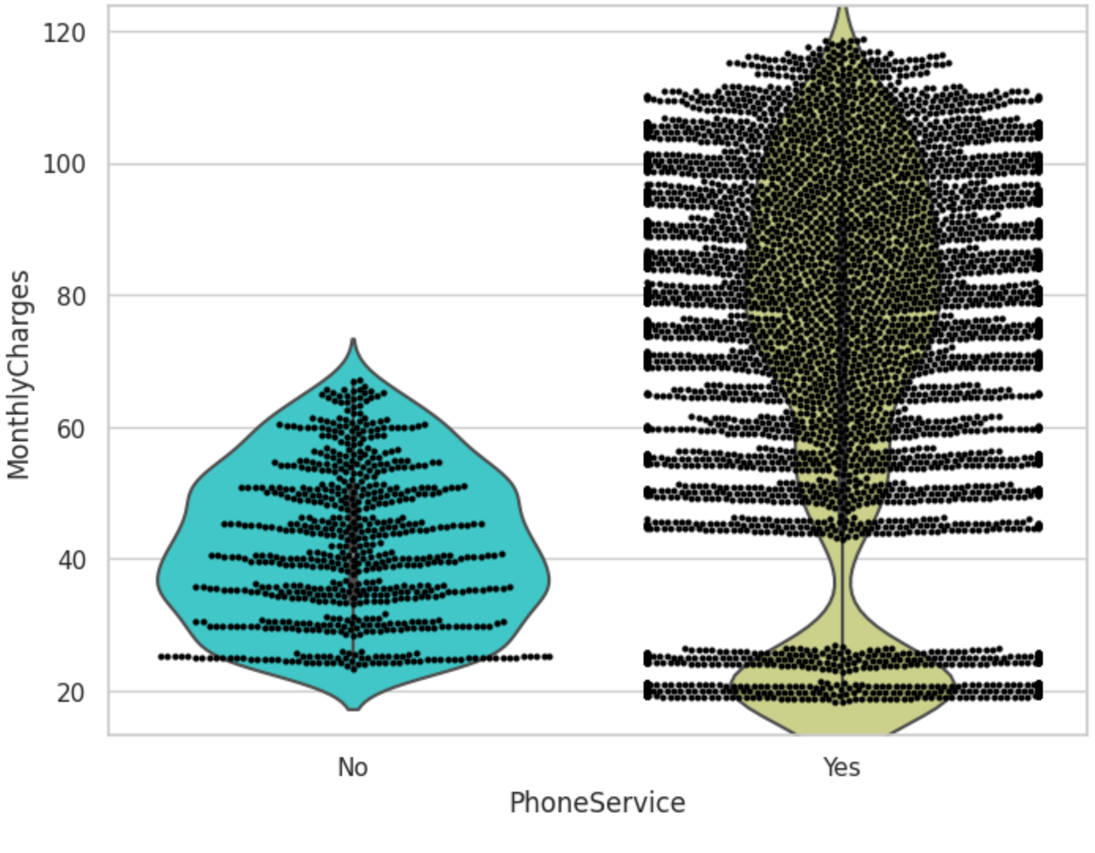
In [ ]:
```
for i in cat_fts.columns.drop(['Churn']):
    plt.figure(figsize=(8,6))
    sns.violinplot(x=i, y=df['MonthlyCharges'], data=cat_fts, palette='rainbow')
    sns.swarmplot(x=i, y=df['MonthlyCharges'], data=cat_fts, color='black',size=3)
    plt.show()
```

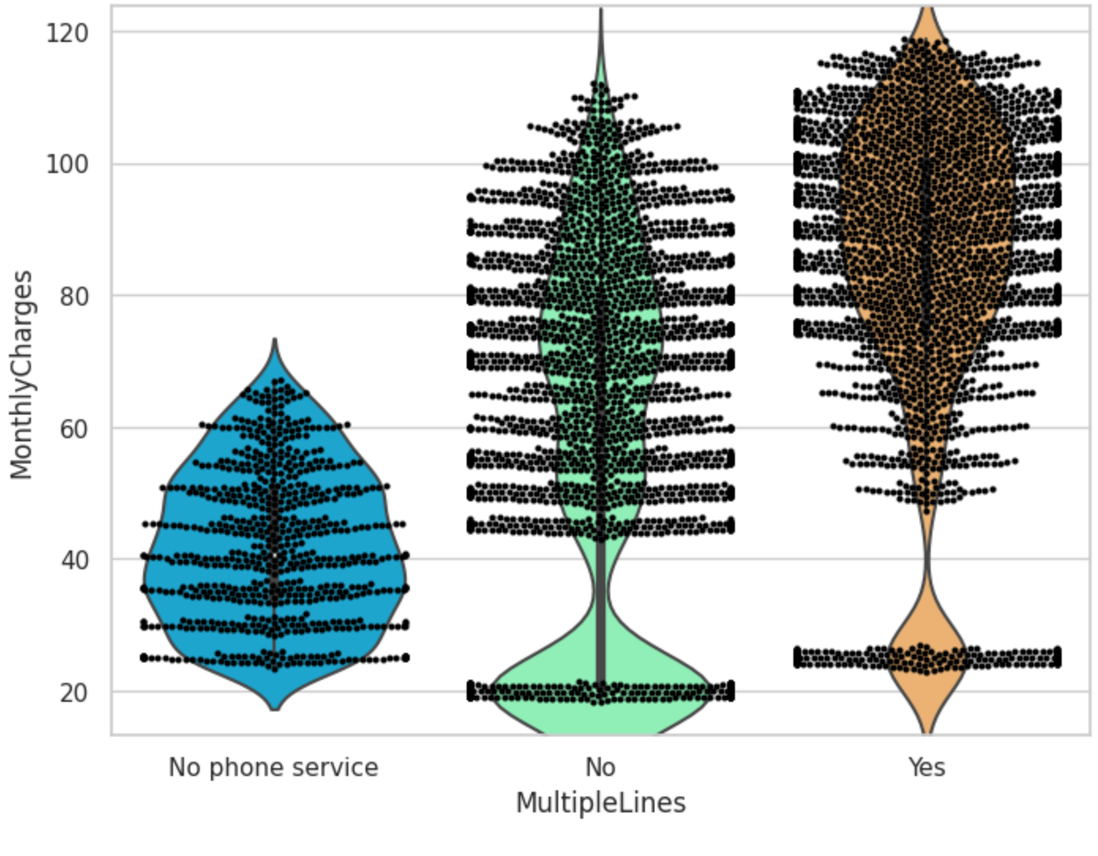


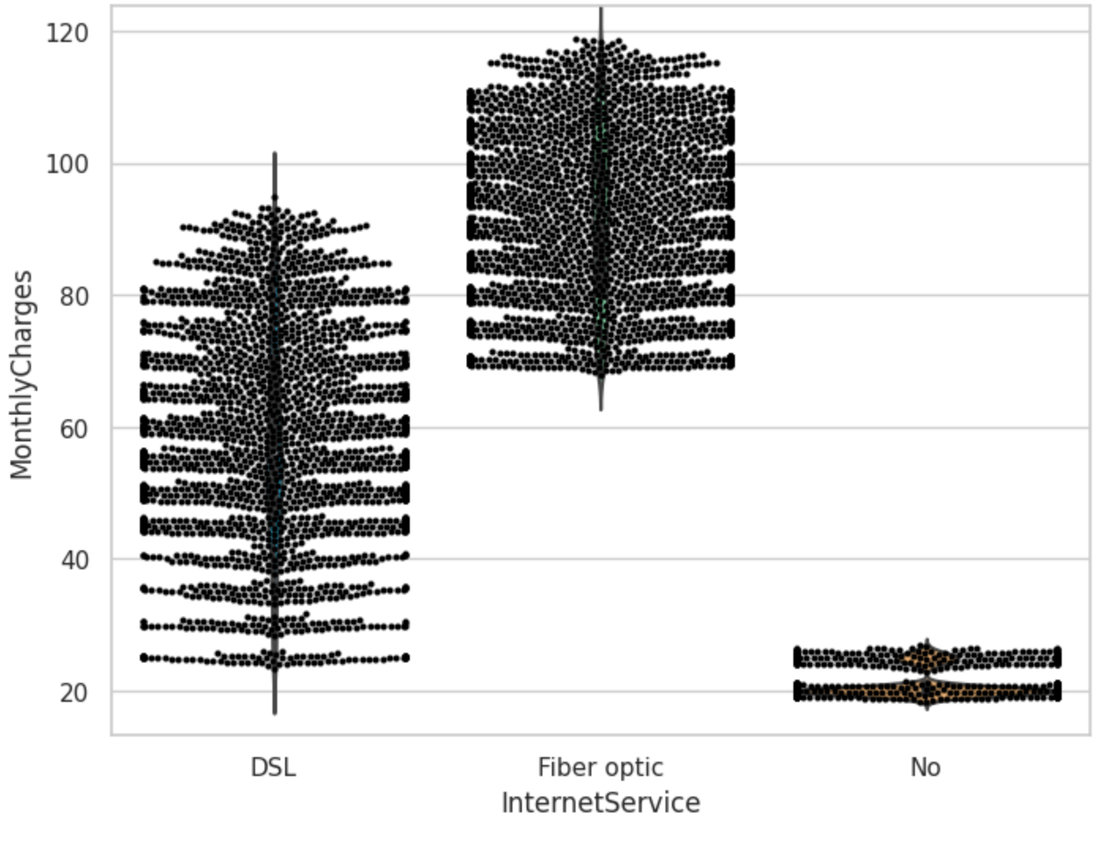

120
100
80
60
40
20
MonthlyCharges
0
1
SeniorCitizen

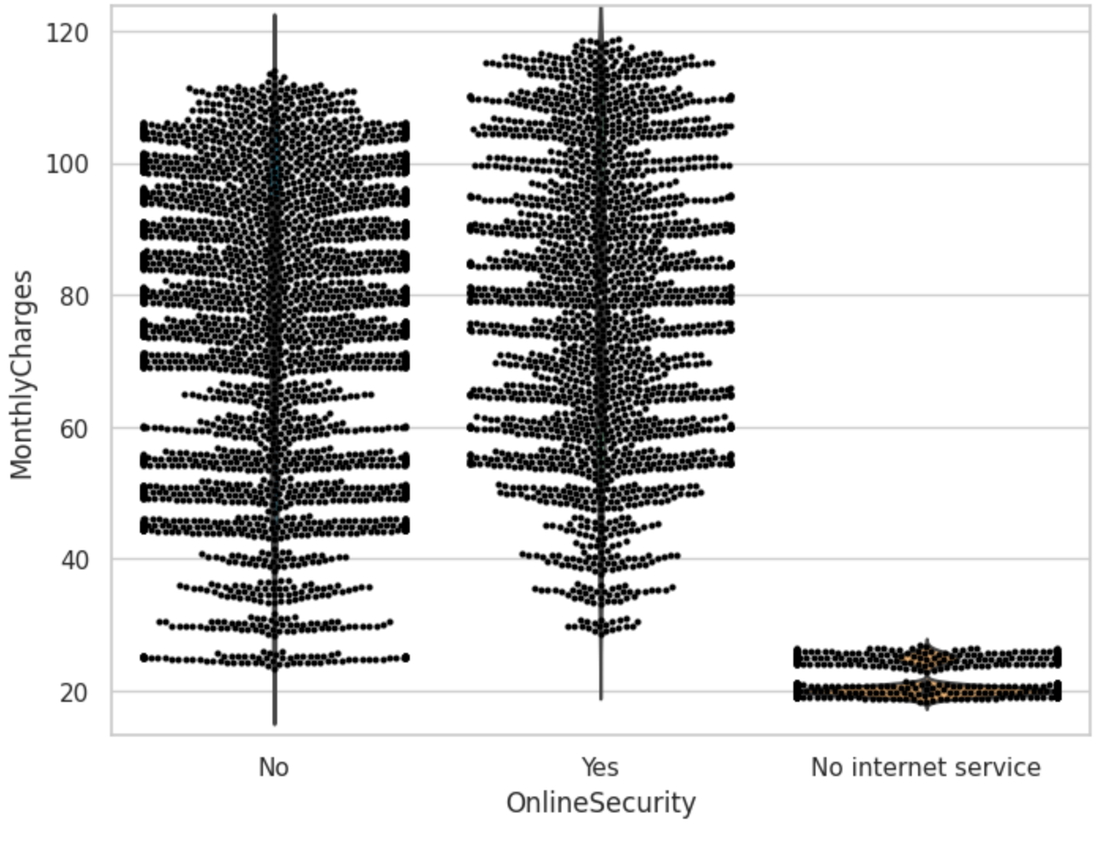

120
100
80
60
40
20
MonthlyCharges
Yes
No
Partner

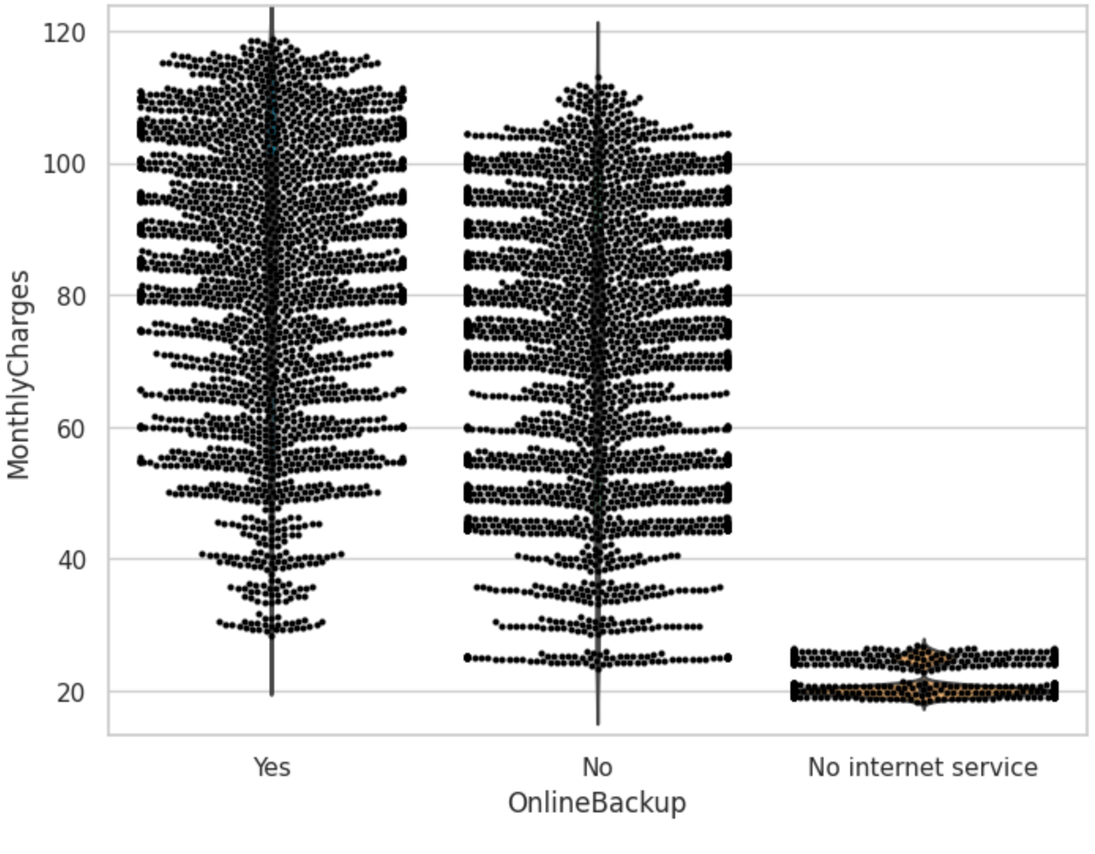

120
100
80
60
40
20
MonthlyCharges
No
Yes
Dependents

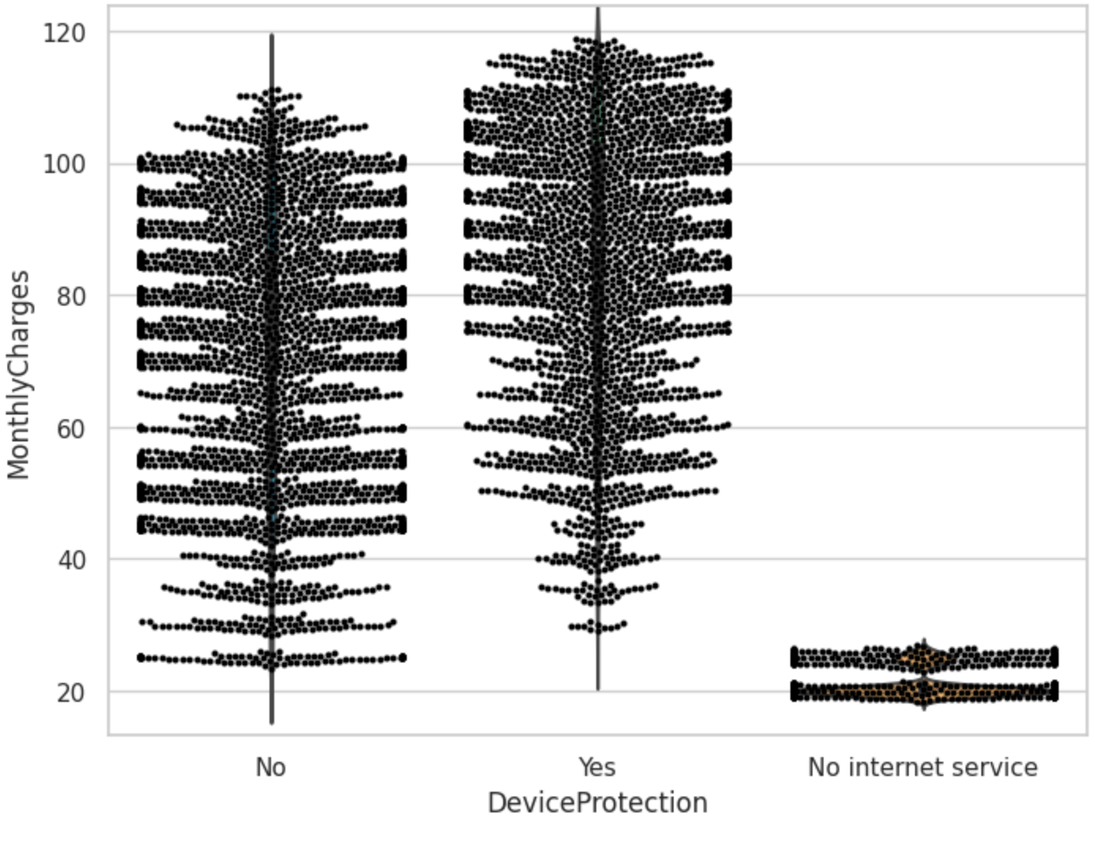

120
100
80
60
40
20
MonthlyCharges
No
Yes
PhoneService

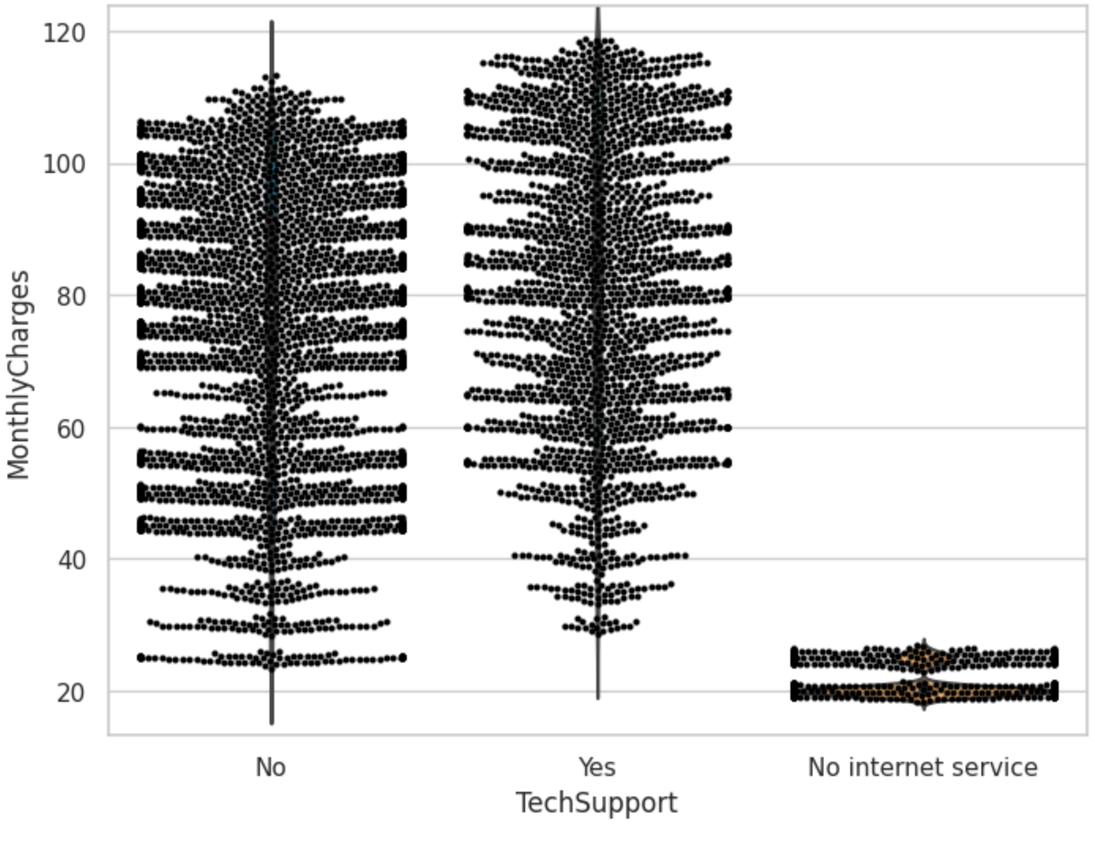

120
100
80
60
40
20
MonthlyCharges
No phone service
No
Yes
MultipleLines

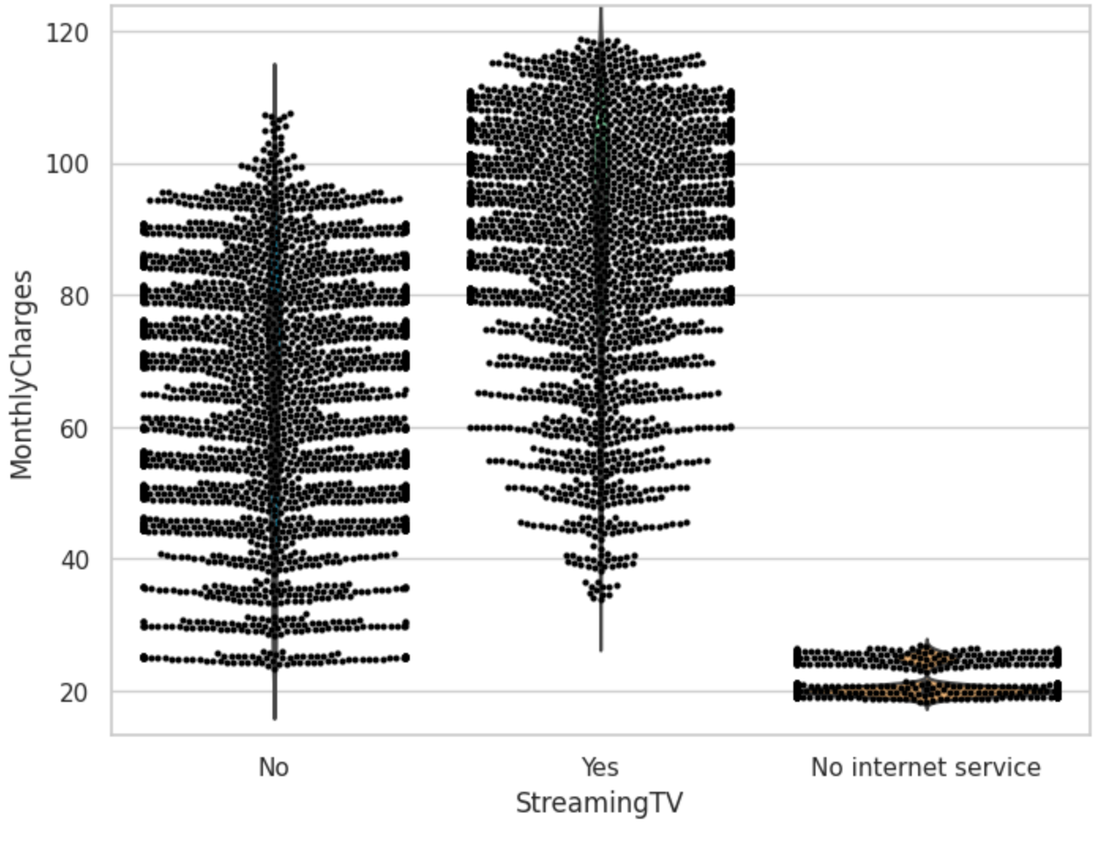

120
100
80
60
40
20
MonthlyCharges
DSL
Fiber optic
No
InternetService

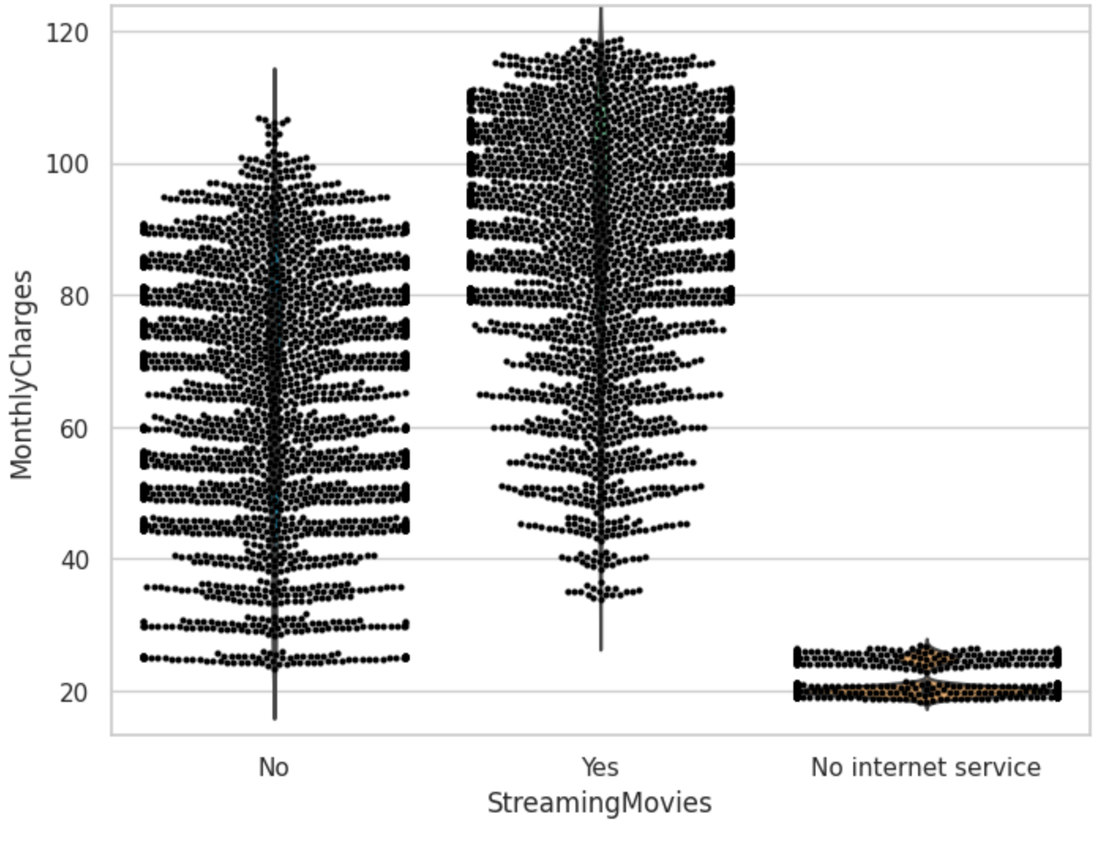

120
100
80
60
40
20
MonthlyCharges
No
Yes
No internet service
OnlineSecurity

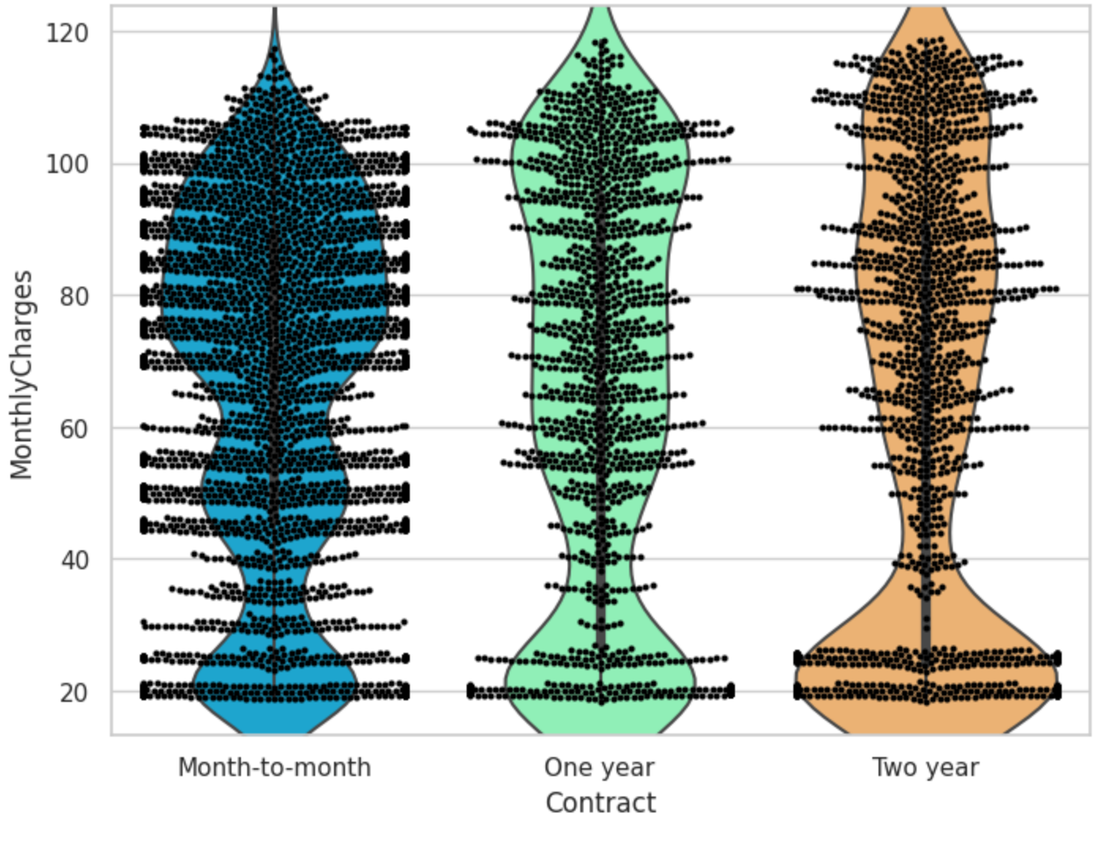

120
100
80
60
40
20
MonthlyCharges
Yes
No
No internet service
OnlineBackup

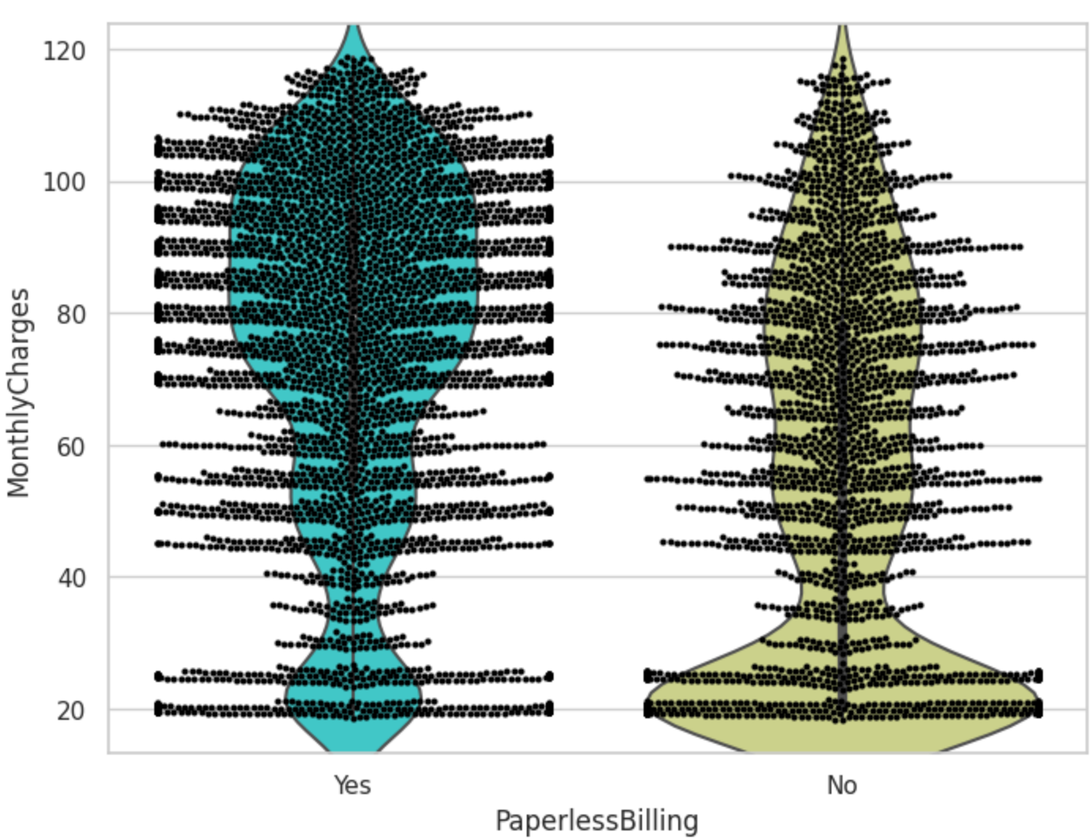

120
100
80
60
40
20
MonthlyCharges
No
Yes
No internet service
DeviceProtection

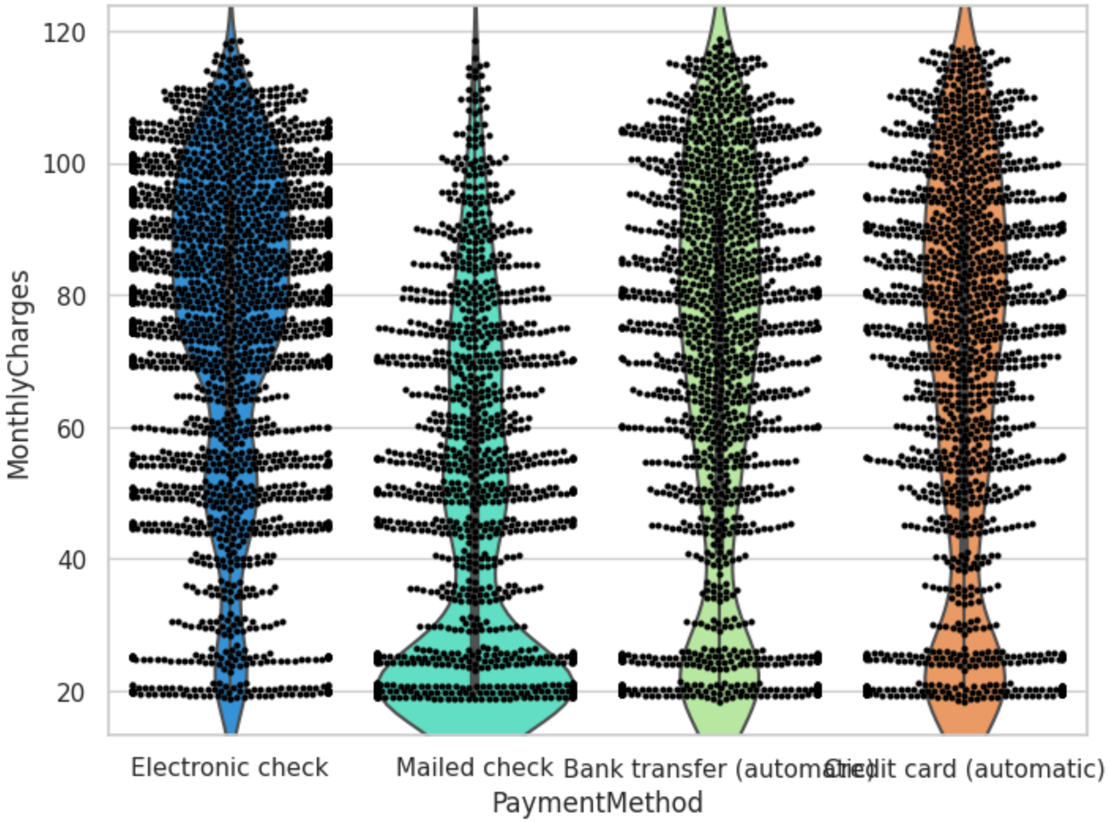

120
100
80
60
40
20
MonthlyCharges
No
Yes
No internet service
TechSupport


120
100
80
60
40
20
MonthlyCharges
No
Yes
No internet service
StreamingTV

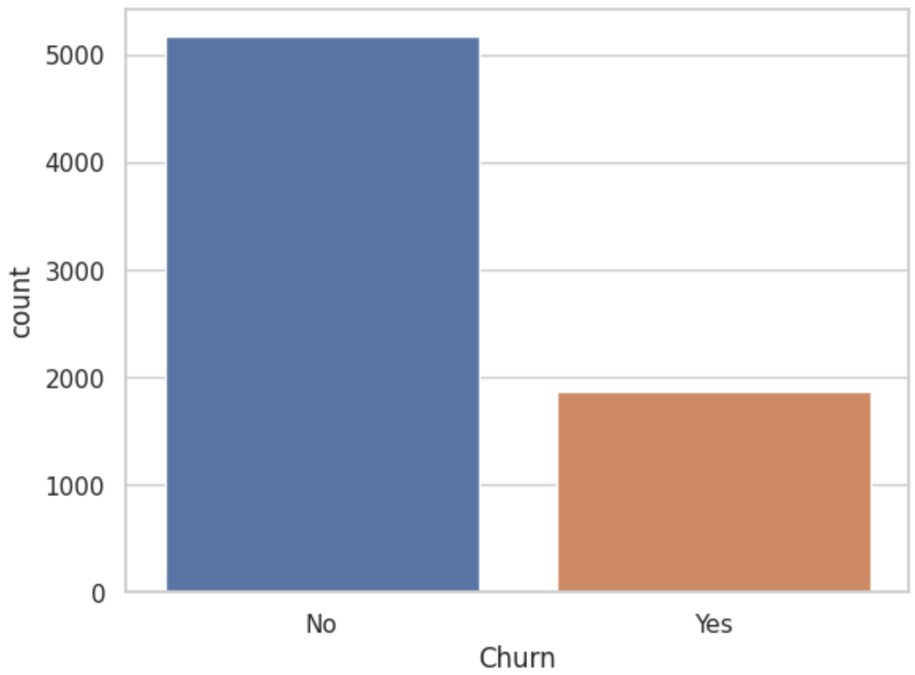

120
100
80
60
40
20
MonthlyCharges
No
Yes
No internet service
StreamingMovies


120
100
80
60
40
20
MonthlyCharges
Month-to-month
One year
Two year
Contract


120
100
80
60
40
20
MonthlyCharges
Yes
No
PaperlessBilling


120
100
80
60
40
20
MonthlyCharges
Electronic check
Mailed check
Bank transfer (automatic)
Credit card (automatic)
PaymentMethod

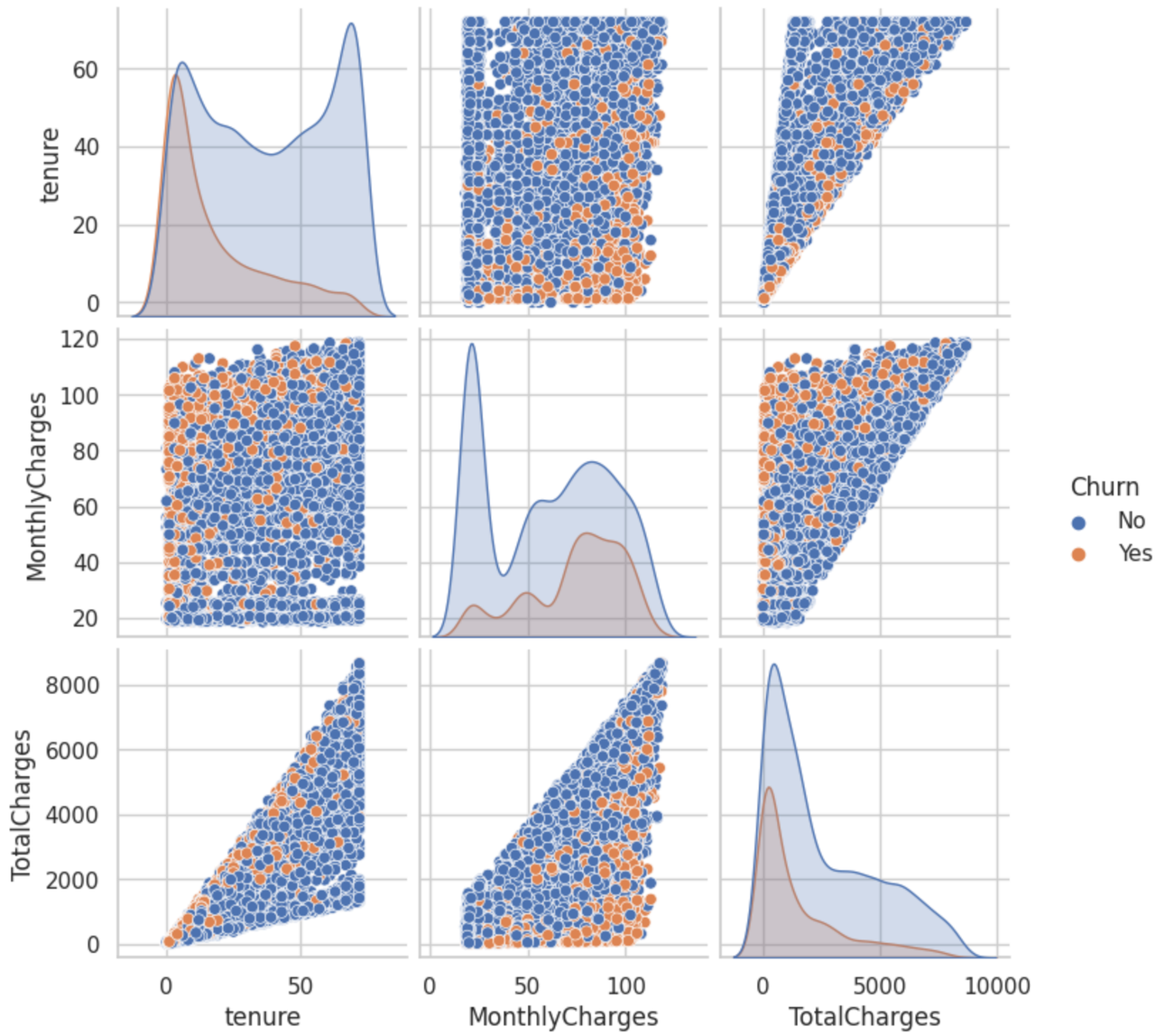
In [ ]:
```
sns.countplot(data=df, x = 'Churn')
plt.show()
```



In [ ]:
```
df['Churn'].value_counts()
```

Out[22]:
```
No     5174
Yes    1869
Name: Churn, dtype: int64
```

In [ ]:
```
sns.pairplot(num_fts, hue='Churn')
plt.show()
```



Multivariate Analysis

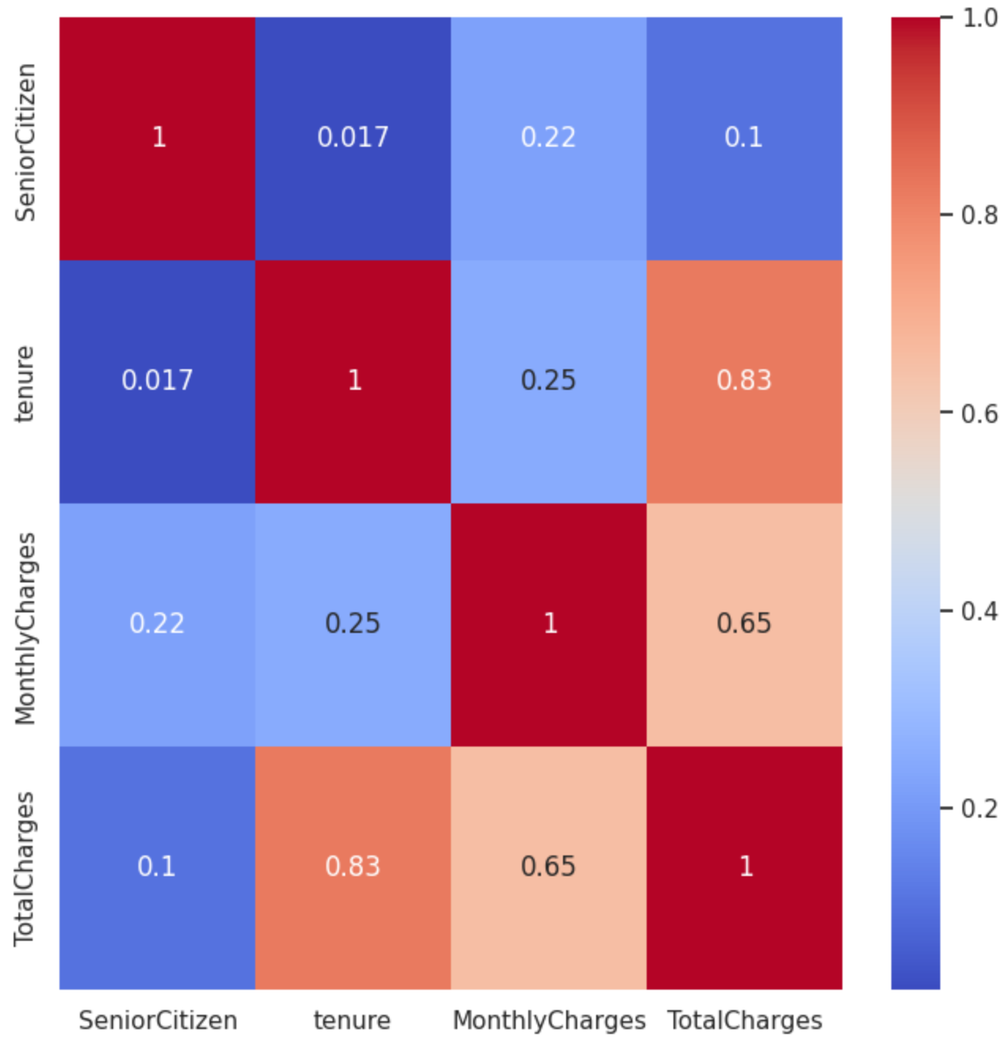
In [ ]:
```
df.corr()
```

Out[24]:

	SeniorCitizen	tenure	MonthlyCharges	TotalCharges
SeniorCitizen	1.000000	0.016567	0.220173	0.102997
tenure	0.016567	1.000000	0.247900	0.826164
MonthlyCharges	0.220173	0.247900	1.000000	0.651182
TotalCharges	0.102997	0.826164	0.651182	1.000000

In [ ]:
```
# The same can be visualised in the form of a heatmap.

plt.figure(figsize=(8,8))
sns.heatmap(df.corr(), annot=True, cmap='coolwarm')
plt.show()
```



Data Preprocessing

In [ ]:
```
# Taking a copy of the data for preprocessing and model building

df1 = df.copy()
```

Handling missing values

Missing values are already handled.

In [ ]:
```
pd.DataFrame(df1.isnull().sum()/len(df1)*100, columns = ['Null value %'], index = df1.columns)
```

Out[27]:

	Null value %
gender	0.0
SeniorCitizen	0.0
Partner	0.0
Dependents	0.0
tenure	0.0
PhoneService	0.0
MultipleLines	0.0
InternetService	0.0
OnlineSecurity	0.0
OnlineBackup	0.0
DeviceProtection	0.0
TechSupport	0.0
StreamingTV	0.0
StreamingMovies	0.0
Contract	0.0
PaperlessBilling	0.0
PaymentMethod	0.0
MonthlyCharges	0.0
TotalCharges	0.0
Churn	0.0

Checking the datatypes for label encoding and One hot encoding

In [ ]:
```
pd.DataFrame(df1.dtypes, columns = ['Datatype'], index = df1.columns)
```

Out[28]:

	Datatype
gender	object
SeniorCitizen	int64
Partner	object
Dependents	object
tenure	int64
PhoneService	object
MultipleLines	object
InternetService	object
OnlineSecurity	object
OnlineBackup	object
DeviceProtection	object
TechSupport	object
StreamingTV	object
StreamingMovies	object
Contract	object
PaperlessBilling	object
PaymentMethod	object
MonthlyCharges	float64
TotalCharges	float64
Churn	object

Label Encoding

In [ ]:
```
# Female: 0, Male: 1

df1['gender'] = df1['gender'].astype('category')
df1['gender'] = df1['gender'].cat.codes
```

In [ ]:
```
# No: 0, Yes: 1

df1['Partner'] = df1['Partner'].astype('category')
df1['Partner'] = df1['Partner'].cat.codes
```

In [ ]:
```
# No: 0, Yes: 1

df1['Dependents'] = df1['Dependents'].astype('category')
df1['Dependents'] = df1['Dependents'].cat.codes
```

In [ ]:
```
# No: 0, Yes: 1

df1['PhoneService'] = df1['PhoneService'].astype('category')
df1['PhoneService'] = df1['PhoneService'].cat.codes
```

In [ ]:
```
# No: 0, Yes: 1

df1['PaperlessBilling'] = df1['PaperlessBilling'].astype('category')
df1['PaperlessBilling'] = df1['PaperlessBilling'].cat.codes
```

In [ ]:
```
# No: 0, Yes: 1

df1['Churn'] = df1['Churn'].astype('category')
df1['Churn'] = df1['Churn'].cat.codes
```

In [ ]:
```
# One hot encoding

df1 = pd.get_dummies(data=df1, columns=['MultipleLines', 'InternetService', 'OnlineSecurity', 'OnlineBackup', 'DeviceProtection', 'TechSupport', 'StreamingTV', 'StreamingMovies', 'Contract', 'Pa
```

In [ ]:
```
pd.DataFrame(df1.dtypes, columns=['Datatypes'], index = df1.columns)
```

Out[36]:

	Datatypes
gender	int8
SeniorCitizen	int64
Partner	int8
Dependents	int8
tenure	int64
PhoneService	int8
PaperlessBilling	int8
MonthlyCharges	float64
TotalCharges	float64
Churn	int8
MultipleLines_No phone service	uint8
MultipleLines_Yes	uint8
InternetService_Fiber optic	uint8
InternetService_No	uint8
OnlineSecurity_No internet service	uint8
OnlineSecurity_Yes	uint8
OnlineBackup_No internet service	uint8
OnlineBackup_Yes	uint8
DeviceProtection_No internet service	uint8
DeviceProtection_Yes	uint8
TechSupport_No internet service	uint8
TechSupport_Yes	uint8
StreamingTV_No internet service	uint8
StreamingTV_Yes	uint8
StreamingMovies_No internet service	uint8
StreamingMovies_Yes	uint8
Contract_One year	uint8
Contract_Two year	uint8
PaymentMethod_Credit card (automatic)	uint8
PaymentMethod_Electronic check	uint8
PaymentMethod_Mailed check	uint8

Handling Outliers

There are no outliers in the dataset

Feature Scaling

In [ ]:
```
# Splitting the column into dependent and independent variables

x = df1.drop('Churn', axis=1)
y = df1['Churn']
```

In [ ]:
```
x.head()
```

Out[38]:

	gender	SeniorCitizen	Partner	Dependents	tenure	PhoneService	PaperlessBilling	MonthlyCharges	TotalCharges	MultipleLines_No phone service	MultipleLines_Yes	InternetService_Fiber optic	InternetService_No	OnlineSecurity_No internet service	OnlineSecurity_Yes	Onli in
0	0	0	1	0	1	0	1	29.85	29.85	1	0	0	0	0	0	
1	1	0	0	0	34	1	0	56.95	1889.50	0	0	0	0	0	1	
2	1	0	0	0	2	1	1	53.85	108.15	0	0	0	0	0	1	
3	1	0	0	0	45	0	0	42.30	1840.75	1	0	0	0	0	1	
4	0	0	0	0	2	1	1	70.70	151.65	0	0	1	0	0	0	

In [ ]:
```
# Scaling only the columns tenure, MonthlyCharges and TotalCharges using MinMax scaler

from sklearn.preprocessing import MinMaxScaler
sc_features = ['tenure', 'MonthlyCharges', 'TotalCharges']
scaler = MinMaxScaler()
x[sc_features] = scaler.fit_transform(x[sc_features])
```

In [ ]:
```
x.head()
```

Out[40]:

	gender	SeniorCitizen	Partner	Dependents	tenure	PhoneService	PaperlessBilling	MonthlyCharges	TotalCharges	MultipleLines_No phone service	MultipleLines_Yes	InternetService_Fiber optic	InternetService_No	OnlineSecurity_No internet service	OnlineSecurity_Yes	O
0	0	0	1	0	0.013889	0	1	0.115423	0.001275	1	0	0	0	0	0	
1	1	0	0	0	0.472222	1	0	0.385075	0.215867	0	0	0	0	0	1	
2	1	0	0	0	0.027778	1	1	0.354229	0.010310	0	0	0	0	0	1	
3	1	0	0	0	0.625000	0	0	0.239303	0.210241	1	0	0	0	0	1	
4	0	0	0	0	0.027778	1	1	0.521891	0.015330	0	0	1	0	0	0	

Imbalance Treatment of the Output variable

Approach 1: Since we are building a DNN model, trying first with imbalance data

Splitting the data into train and test

In [ ]:
```
from sklearn.model_selection import train_test_split

x_train, x_test, y_train, y_test = train_test_split(x, y, test_size=0.25, random_state=101)
```

In [ ]:
```
# importing necessary packages to build a DNN model

import tensorflow as tf
from tensorflow import keras
from keras.models import Sequential
from keras.layers import Dense, Dropout, BatchNormalization
```

In [ ]:
```
# Building API
model = Sequential()

# Adding First hidden layers
model.add(Dense(units=256, activation = 'relu', input_shape = (30,)))
model.add(Dropout(0.5))
model.add(BatchNormalization())

# Adding 2nd hidden layer
model.add(Dense(units=128, activation = 'relu')) # Consecutive neural network number can be reduced from the previous layer but not to be increased
model.add(Dropout(0.4))
model.add(BatchNormalization())

# Adding 3rd hidden layer
model.add(Dense(units=64, activation = 'relu'))
model.add(Dropout(0.3))
model.add(BatchNormalization())

# Adding Output layer
model.add(Dense(units=1, activation='sigmoid'))

# training the model
model.compile(optimizer='adam', loss='binary_crossentropy', metrics=['accuracy'])
```

In [ ]:
```
# Fitting the model:

history = model.fit(x_train, y_train, validation_data = (x_test, y_test), batch_size=32, epochs=100)
```

```
Epoch 1/100
166/166 [==============================] - 6s 12ms/step - loss: 0.6208 - accuracy: 0.6721 - val_loss: 0.4793 - val_accuracy: 0.7394
Epoch 2/100
166/166 [==============================] - 1s 7ms/step - loss: 0.5024 - accuracy: 0.7527 - val_loss: 0.4383 - val_accuracy: 0.7939
Epoch 3/100
166/166 [==============================] - 1s 7ms/step - loss: 0.4738 - accuracy: 0.7711 - val_loss: 0.4274 - val_accuracy: 0.7984
Epoch 4/100
166/166 [==============================] - 1s 7ms/step - loss: 0.4609 - accuracy: 0.7730 - val_loss: 0.4225 - val_accuracy: 0.7973
Epoch 5/100
166/166 [==============================] - 1s 7ms/step - loss: 0.4534 - accuracy: 0.7755 - val_loss: 0.4207 - val_accuracy: 0.7990
Epoch 6/100
166/166 [==============================] - 1s 7ms/step - loss: 0.4449 - accuracy: 0.7880 - val_loss: 0.4221 - val_accuracy: 0.8012
Epoch 7/100
166/166 [==============================] - 1s 7ms/step - loss: 0.4456 - accuracy: 0.7834 - val_loss: 0.4225 - val_accuracy: 0.7984
Epoch 8/100
166/166 [==============================] - 1s 7ms/step - loss: 0.4403 - accuracy: 0.7851 - val_loss: 0.4280 - val_accuracy: 0.7899
Epoch 9/100
166/166 [==============================] - 1s 7ms/step - loss: 0.4314 - accuracy: 0.7944 - val_loss: 0.4228 - val_accuracy: 0.8064
Epoch 10/100
166/166 [==============================] - 2s 9ms/step - loss: 0.4342 - accuracy: 0.7944 - val_loss: 0.4215 - val_accuracy: 0.7973
Epoch 11/100
166/166 [==============================] - 1s 8ms/step - loss: 0.4302 - accuracy: 0.7933 - val_loss: 0.4205 - val_accuracy: 0.8052
Epoch 12/100
166/166 [==============================] - 1s 7ms/step - loss: 0.4371 - accuracy: 0.7844 - val_loss: 0.4211 - val_accuracy: 0.8007
Epoch 13/100
166/166 [==============================] - 1s 7ms/step - loss: 0.4273 - accuracy: 0.7967 - val_loss: 0.4248 - val_accuracy: 0.8024
Epoch 14/100
166/166 [==============================] - 1s 7ms/step - loss: 0.4233 - accuracy: 0.7982 - val_loss: 0.4238 - val_accuracy: 0.8024
Epoch 15/100
166/166 [==============================] - 1s 7ms/step - loss: 0.4238 - accuracy: 0.8010 - val_loss: 0.4227 - val_accuracy: 0.8075
Epoch 16/100
166/166 [==============================] - 1s 7ms/step - loss: 0.4253 - accuracy: 0.7963 - val_loss: 0.4219 - val_accuracy: 0.8035
Epoch 17/100
166/166 [==============================] - 1s 7ms/step - loss: 0.4274 - accuracy: 0.7906 - val_loss: 0.4214 - val_accuracy: 0.8069
Epoch 18/100
166/166 [==============================] - 1s 7ms/step - loss: 0.4240 - accuracy: 0.7955 - val_loss: 0.4229 - val_accuracy: 0.8030
Epoch 19/100
166/166 [==============================] - 1s 7ms/step - loss: 0.4266 - accuracy: 0.7910 - val_loss: 0.4219 - val_accuracy: 0.8007
Epoch 20/100
166/166 [==============================] - 2s 10ms/step - loss: 0.4209 - accuracy: 0.8025 - val_loss: 0.4233 - val_accuracy: 0.8030
Epoch 21/100
166/166 [==============================] - 1s 7ms/step - loss: 0.4194 - accuracy: 0.8008 - val_loss: 0.4220 - val_accuracy: 0.8047
Epoch 22/100
166/166 [==============================] - 1s 7ms/step - loss: 0.4156 - accuracy: 0.8044 - val_loss: 0.4196 - val_accuracy: 0.8024
Epoch 23/100
166/166 [==============================] - 1s 7ms/step - loss: 0.4175 - accuracy: 0.8008 - val_loss: 0.4244 - val_accuracy: 0.7995
Epoch 24/100
166/166 [==============================] - 1s 8ms/step - loss: 0.4156 - accuracy: 0.7959 - val_loss: 0.4251 - val_accuracy: 0.8030
Epoch 25/100
166/166 [==============================] - 1s 7ms/step - loss: 0.4140 - accuracy: 0.8073 - val_loss: 0.4229 - val_accuracy: 0.8030
Epoch 26/100
166/166 [==============================] - 1s 7ms/step - loss: 0.4162 - accuracy: 0.7991 - val_loss: 0.4247 - val_accuracy: 0.7995
Epoch 27/100
166/166 [==============================] - 1s 7ms/step - loss: 0.4179 - accuracy: 0.8071 - val_loss: 0.4218 - val_accuracy: 0.8018
Epoch 28/100
166/166 [==============================] - 1s 7ms/step - loss: 0.4121 - accuracy: 0.8080 - val_loss: 0.4237 - val_accuracy: 0.8035
Epoch 29/100
166/166 [==============================] - 1s 9ms/step - loss: 0.4082 - accuracy: 0.8012 - val_loss: 0.4223 - val_accuracy: 0.8018
Epoch 30/100
166/166 [==============================] - 1s 8ms/step - loss: 0.4183 - accuracy: 0.7997 - val_loss: 0.4267 - val_accuracy: 0.7984
Epoch 31/100
```

```
166/166 [==============================] - 1s 7ms/step - loss: 0.4186 - accuracy: 0.8033 - val_loss: 0.4248 - val_accuracy: 0.8007
Epoch 32/100
166/166 [==============================] - 1s 7ms/step - loss: 0.4132 - accuracy: 0.8088 - val_loss: 0.4226 - val_accuracy: 0.8007
Epoch 33/100
166/166 [==============================] - 1s 7ms/step - loss: 0.4094 - accuracy: 0.8052 - val_loss: 0.4227 - val_accuracy: 0.8007
Epoch 34/100
166/166 [==============================] - 1s 7ms/step - loss: 0.4140 - accuracy: 0.8027 - val_loss: 0.4297 - val_accuracy: 0.7956
Epoch 35/100
166/166 [==============================] - 1s 7ms/step - loss: 0.4110 - accuracy: 0.8116 - val_loss: 0.4247 - val_accuracy: 0.7933
Epoch 36/100
166/166 [==============================] - 1s 7ms/step - loss: 0.4093 - accuracy: 0.8088 - val_loss: 0.4295 - val_accuracy: 0.7927
Epoch 37/100
166/166 [==============================] - 1s 7ms/step - loss: 0.4070 - accuracy: 0.8065 - val_loss: 0.4299 - val_accuracy: 0.7950
Epoch 38/100
166/166 [==============================] - 1s 7ms/step - loss: 0.4050 - accuracy: 0.8152 - val_loss: 0.4346 - val_accuracy: 0.7950
Epoch 39/100
166/166 [==============================] - 1s 9ms/step - loss: 0.4123 - accuracy: 0.8046 - val_loss: 0.4277 - val_accuracy: 0.7990
Epoch 40/100
166/166 [==============================] - 1s 7ms/step - loss: 0.4073 - accuracy: 0.8041 - val_loss: 0.4343 - val_accuracy: 0.7956
Epoch 41/100
166/166 [==============================] - 1s 7ms/step - loss: 0.4032 - accuracy: 0.8103 - val_loss: 0.4325 - val_accuracy: 0.7927
Epoch 42/100
166/166 [==============================] - 1s 7ms/step - loss: 0.4029 - accuracy: 0.8120 - val_loss: 0.4334 - val_accuracy: 0.7944
Epoch 43/100
166/166 [==============================] - 1s 7ms/step - loss: 0.4098 - accuracy: 0.8067 - val_loss: 0.4339 - val_accuracy: 0.7961
Epoch 44/100
166/166 [==============================] - 1s 7ms/step - loss: 0.4071 - accuracy: 0.8107 - val_loss: 0.4336 - val_accuracy: 0.7956
Epoch 45/100
166/166 [==============================] - 1s 7ms/step - loss: 0.4091 - accuracy: 0.8065 - val_loss: 0.4358 - val_accuracy: 0.7990
Epoch 46/100
166/166 [==============================] - 1s 7ms/step - loss: 0.4103 - accuracy: 0.8075 - val_loss: 0.4336 - val_accuracy: 0.7950
Epoch 47/100
166/166 [==============================] - 1s 7ms/step - loss: 0.4036 - accuracy: 0.8094 - val_loss: 0.4329 - val_accuracy: 0.7978
Epoch 48/100
166/166 [==============================] - 1s 8ms/step - loss: 0.4053 - accuracy: 0.8071 - val_loss: 0.4332 - val_accuracy: 0.7967
Epoch 49/100
166/166 [==============================] - 1s 9ms/step - loss: 0.4005 - accuracy: 0.8147 - val_loss: 0.4380 - val_accuracy: 0.7910
Epoch 50/100
166/166 [==============================] - 1s 7ms/step - loss: 0.3941 - accuracy: 0.8126 - val_loss: 0.4506 - val_accuracy: 0.7836
Epoch 51/100
166/166 [==============================] - 1s 7ms/step - loss: 0.4013 - accuracy: 0.8090 - val_loss: 0.4353 - val_accuracy: 0.7905
Epoch 52/100
166/166 [==============================] - 1s 7ms/step - loss: 0.4016 - accuracy: 0.8116 - val_loss: 0.4372 - val_accuracy: 0.7893
Epoch 53/100
166/166 [==============================] - 1s 7ms/step - loss: 0.3992 - accuracy: 0.8095 - val_loss: 0.4406 - val_accuracy: 0.7893
Epoch 54/100
166/166 [==============================] - 1s 7ms/step - loss: 0.4063 - accuracy: 0.8069 - val_loss: 0.4346 - val_accuracy: 0.7967
Epoch 55/100
166/166 [==============================] - 1s 7ms/step - loss: 0.4005 - accuracy: 0.8048 - val_loss: 0.4350 - val_accuracy: 0.7927
Epoch 56/100
166/166 [==============================] - 1s 7ms/step - loss: 0.3949 - accuracy: 0.8154 - val_loss: 0.4401 - val_accuracy: 0.7899
Epoch 57/100
166/166 [==============================] - 1s 7ms/step - loss: 0.3922 - accuracy: 0.8133 - val_loss: 0.4414 - val_accuracy: 0.7967
Epoch 58/100
166/166 [==============================] - 1s 9ms/step - loss: 0.3963 - accuracy: 0.8177 - val_loss: 0.4425 - val_accuracy: 0.7967
Epoch 59/100
166/166 [==============================] - 1s 8ms/step - loss: 0.3968 - accuracy: 0.8092 - val_loss: 0.4405 - val_accuracy: 0.7871
Epoch 60/100
166/166 [==============================] - 1s 7ms/step - loss: 0.3962 - accuracy: 0.8114 - val_loss: 0.4353 - val_accuracy: 0.7905
Epoch 61/100
166/166 [==============================] - 1s 7ms/step - loss: 0.3968 - accuracy: 0.8148 - val_loss: 0.4359 - val_accuracy: 0.7927
Epoch 62/100
```

```
166/166 [==============================] - 1s 7ms/step - loss: 0.3923 - accuracy: 0.8215 - val_loss: 0.4437 - val_accuracy: 0.7967
Epoch 63/100
166/166 [==============================] - 1s 7ms/step - loss: 0.3909 - accuracy: 0.8129 - val_loss: 0.4402 - val_accuracy: 0.7905
Epoch 64/100
166/166 [==============================] - 1s 7ms/step - loss: 0.3962 - accuracy: 0.8135 - val_loss: 0.4350 - val_accuracy: 0.7905
Epoch 65/100
166/166 [==============================] - 1s 7ms/step - loss: 0.3926 - accuracy: 0.8133 - val_loss: 0.4368 - val_accuracy: 0.7944
Epoch 66/100
166/166 [==============================] - 1s 7ms/step - loss: 0.3929 - accuracy: 0.8160 - val_loss: 0.4440 - val_accuracy: 0.7939
Epoch 67/100
166/166 [==============================] - 1s 7ms/step - loss: 0.3943 - accuracy: 0.8129 - val_loss: 0.4392 - val_accuracy: 0.7944
Epoch 68/100
166/166 [==============================] - 1s 9ms/step - loss: 0.3860 - accuracy: 0.8160 - val_loss: 0.4431 - val_accuracy: 0.7967
Epoch 69/100
166/166 [==============================] - 1s 7ms/step - loss: 0.3891 - accuracy: 0.8184 - val_loss: 0.4473 - val_accuracy: 0.7910
Epoch 70/100
166/166 [==============================] - 1s 7ms/step - loss: 0.3898 - accuracy: 0.8116 - val_loss: 0.4509 - val_accuracy: 0.7956
Epoch 71/100
166/166 [==============================] - 1s 7ms/step - loss: 0.3898 - accuracy: 0.8224 - val_loss: 0.4512 - val_accuracy: 0.7950
Epoch 72/100
166/166 [==============================] - 1s 7ms/step - loss: 0.3869 - accuracy: 0.8154 - val_loss: 0.4488 - val_accuracy: 0.7916
Epoch 73/100
166/166 [==============================] - 1s 7ms/step - loss: 0.3851 - accuracy: 0.8209 - val_loss: 0.4504 - val_accuracy: 0.7939
Epoch 74/100
166/166 [==============================] - 1s 7ms/step - loss: 0.3810 - accuracy: 0.8217 - val_loss: 0.4566 - val_accuracy: 0.7836
Epoch 75/100
166/166 [==============================] - 1s 7ms/step - loss: 0.3962 - accuracy: 0.8116 - val_loss: 0.4472 - val_accuracy: 0.7888
Epoch 76/100
166/166 [==============================] - 1s 7ms/step - loss: 0.3850 - accuracy: 0.8173 - val_loss: 0.4537 - val_accuracy: 0.7922
Epoch 77/100
166/166 [==============================] - 1s 7ms/step - loss: 0.3863 - accuracy: 0.8148 - val_loss: 0.4523 - val_accuracy: 0.7933
Epoch 78/100
166/166 [==============================] - 2s 9ms/step - loss: 0.3807 - accuracy: 0.8220 - val_loss: 0.4538 - val_accuracy: 0.7899
Epoch 79/100
166/166 [==============================] - 1s 7ms/step - loss: 0.3762 - accuracy: 0.8239 - val_loss: 0.4644 - val_accuracy: 0.7927
Epoch 80/100
166/166 [==============================] - 1s 7ms/step - loss: 0.3741 - accuracy: 0.8292 - val_loss: 0.4663 - val_accuracy: 0.7871
Epoch 81/100
166/166 [==============================] - 1s 7ms/step - loss: 0.3816 - accuracy: 0.8198 - val_loss: 0.4597 - val_accuracy: 0.7933
Epoch 82/100
166/166 [==============================] - 1s 7ms/step - loss: 0.3823 - accuracy: 0.8196 - val_loss: 0.4543 - val_accuracy: 0.7961
Epoch 83/100
166/166 [==============================] - 1s 7ms/step - loss: 0.3755 - accuracy: 0.8222 - val_loss: 0.4713 - val_accuracy: 0.7899
Epoch 84/100
166/166 [==============================] - 1s 7ms/step - loss: 0.3827 - accuracy: 0.8152 - val_loss: 0.4625 - val_accuracy: 0.7927
Epoch 85/100
166/166 [==============================] - 1s 6ms/step - loss: 0.3838 - accuracy: 0.8194 - val_loss: 0.4613 - val_accuracy: 0.7905
Epoch 86/100
166/166 [==============================] - 1s 7ms/step - loss: 0.3779 - accuracy: 0.8234 - val_loss: 0.4588 - val_accuracy: 0.7927
Epoch 87/100
166/166 [==============================] - 1s 8ms/step - loss: 0.3803 - accuracy: 0.8218 - val_loss: 0.4600 - val_accuracy: 0.7888
Epoch 88/100
166/166 [==============================] - 1s 8ms/step - loss: 0.3837 - accuracy: 0.8200 - val_loss: 0.4685 - val_accuracy: 0.7859
Epoch 89/100
166/166 [==============================] - 1s 7ms/step - loss: 0.3820 - accuracy: 0.8192 - val_loss: 0.4645 - val_accuracy: 0.7848
Epoch 90/100
166/166 [==============================] - 1s 7ms/step - loss: 0.3820 - accuracy: 0.8186 - val_loss: 0.4611 - val_accuracy: 0.7853
Epoch 91/100
166/166 [==============================] - 1s 7ms/step - loss: 0.3752 - accuracy: 0.8239 - val_loss: 0.4649 - val_accuracy: 0.7825
Epoch 92/100
166/166 [==============================] - 1s 7ms/step - loss: 0.3802 - accuracy: 0.8188 - val_loss: 0.4620 - val_accuracy: 0.7905
Epoch 93/100
```

```
166/166 [==============================] - 1s 7ms/step - loss: 0.3761 - accuracy: 0.8241 - val_loss: 0.4708 - val_accuracy: 0.7922
Epoch 94/100
166/166 [==============================] - 1s 7ms/step - loss: 0.3751 - accuracy: 0.8256 - val_loss: 0.4728 - val_accuracy: 0.7882
Epoch 95/100
166/166 [==============================] - 1s 7ms/step - loss: 0.3857 - accuracy: 0.8192 - val_loss: 0.4643 - val_accuracy: 0.7893
Epoch 96/100
166/166 [==============================] - 1s 7ms/step - loss: 0.3746 - accuracy: 0.8281 - val_loss: 0.4696 - val_accuracy: 0.7888
Epoch 97/100
166/166 [==============================] - 2s 9ms/step - loss: 0.3758 - accuracy: 0.8220 - val_loss: 0.4746 - val_accuracy: 0.7865
Epoch 98/100
166/166 [==============================] - 1s 7ms/step - loss: 0.3779 - accuracy: 0.8253 - val_loss: 0.4722 - val_accuracy: 0.7865
Epoch 99/100
166/166 [==============================] - 1s 7ms/step - loss: 0.3727 - accuracy: 0.8296 - val_loss: 0.4683 - val_accuracy: 0.7865
Epoch 100/100
166/166 [==============================] - 1s 7ms/step - loss: 0.3779 - accuracy: 0.8290 - val_loss: 0.4670 - val_accuracy: 0.7865
```

Approach 2: Building a DNN model, with balanced data

In [ ]:
```
y.value_counts()
```

Out[45]:
```
0    5174
1    1869
Name: Churn, dtype: int64
```

In [ ]:
```
from imblearn.over_sampling import RandomOverSampler
over_sampler = RandomOverSampler()
x_balanced, y_balanced = over_sampler.fit_resample(x,y)
```

In [ ]:
```
y_balanced.value_counts()
```

Out[47]:
```
0    5174
1    5174
Name: Churn, dtype: int64
```

In [ ]:
```
x_train, x_test, y_train, y_test = train_test_split(x_balanced, y_balanced, test_size = 0.3, random_state = 101)
```

In [ ]:
```
# Building API
model1 = Sequential()

# Adding First hidden layers
model1.add(Dense(units=256, activation = 'relu', input_shape = (30,)))
model1.add(Dropout(0.5))
model1.add(BatchNormalization())

# Adding 2nd hidden layer
model1.add(Dense(units=128, activation = 'relu')) # Consecutive neural network number can be reduced from the previous layer but not to be increased
model1.add(Dropout(0.4))
model1.add(BatchNormalization())

# Adding 3rd hidden layer
model1.add(Dense(units=64, activation = 'relu'))
model1.add(Dropout(0.3))
model1.add(BatchNormalization())

# Adding Output layer
model1.add(Dense(units=1, activation='sigmoid'))

# training the model
model1.compile(optimizer='adam', loss='binary_crossentropy', metrics=['accuracy'])
```

In [ ]:
```
# Fitting the model:

history1 = model1.fit(x_train, y_train, validation_data = (x_test, y_test), batch_size=32, epochs=100)
```

```
Epoch 1/100
227/227 [==============================] - 5s 10ms/step - loss: 0.6483 - accuracy: 0.6729 - val_loss: 0.5352 - val_accuracy: 0.7262
Epoch 2/100
227/227 [==============================] - 2s 8ms/step - loss: 0.5618 - accuracy: 0.7290 - val_loss: 0.4969 - val_accuracy: 0.7533
Epoch 3/100
227/227 [==============================] - 2s 7ms/step - loss: 0.5424 - accuracy: 0.7386 - val_loss: 0.4887 - val_accuracy: 0.7597
Epoch 4/100
227/227 [==============================] - 2s 7ms/step - loss: 0.5265 - accuracy: 0.7442 - val_loss: 0.4854 - val_accuracy: 0.7614
Epoch 5/100
227/227 [==============================] - 2s 7ms/step - loss: 0.5154 - accuracy: 0.7497 - val_loss: 0.4816 - val_accuracy: 0.7623
Epoch 6/100
227/227 [==============================] - 2s 7ms/step - loss: 0.5123 - accuracy: 0.7534 - val_loss: 0.4819 - val_accuracy: 0.7626
Epoch 7/100
227/227 [==============================] - 2s 7ms/step - loss: 0.5026 - accuracy: 0.7565 - val_loss: 0.4809 - val_accuracy: 0.7630
Epoch 8/100
227/227 [==============================] - 2s 7ms/step - loss: 0.4983 - accuracy: 0.7559 - val_loss: 0.4813 - val_accuracy: 0.7572
Epoch 9/100
227/227 [==============================] - 2s 9ms/step - loss: 0.4989 - accuracy: 0.7573 - val_loss: 0.4762 - val_accuracy: 0.7594
Epoch 10/100
227/227 [==============================] - 2s 8ms/step - loss: 0.4953 - accuracy: 0.7603 - val_loss: 0.4771 - val_accuracy: 0.7591
Epoch 11/100
227/227 [==============================] - 2s 7ms/step - loss: 0.4901 - accuracy: 0.7687 - val_loss: 0.4746 - val_accuracy: 0.7659
Epoch 12/100
227/227 [==============================] - 2s 7ms/step - loss: 0.4930 - accuracy: 0.7634 - val_loss: 0.4757 - val_accuracy: 0.7626
Epoch 13/100
227/227 [==============================] - 2s 7ms/step - loss: 0.4898 - accuracy: 0.7640 - val_loss: 0.4750 - val_accuracy: 0.7671
Epoch 14/100
227/227 [==============================] - 2s 7ms/step - loss: 0.4933 - accuracy: 0.7665 - val_loss: 0.4784 - val_accuracy: 0.7643
Epoch 15/100
227/227 [==============================] - 2s 7ms/step - loss: 0.4818 - accuracy: 0.7736 - val_loss: 0.4705 - val_accuracy: 0.7710
Epoch 16/100
227/227 [==============================] - 2s 9ms/step - loss: 0.4828 - accuracy: 0.7683 - val_loss: 0.4768 - val_accuracy: 0.7588
Epoch 17/100
227/227 [==============================] - 2s 7ms/step - loss: 0.4806 - accuracy: 0.7756 - val_loss: 0.4654 - val_accuracy: 0.7768
Epoch 18/100
227/227 [==============================] - 2s 7ms/step - loss: 0.4799 - accuracy: 0.7694 - val_loss: 0.4714 - val_accuracy: 0.7700
Epoch 19/100
227/227 [==============================] - 2s 7ms/step - loss: 0.4752 - accuracy: 0.7740 - val_loss: 0.4658 - val_accuracy: 0.7717
Epoch 20/100
227/227 [==============================] - 2s 7ms/step - loss: 0.4727 - accuracy: 0.7792 - val_loss: 0.4674 - val_accuracy: 0.7665
Epoch 21/100
227/227 [==============================] - 2s 7ms/step - loss: 0.4704 - accuracy: 0.7819 - val_loss: 0.4629 - val_accuracy: 0.7816
Epoch 22/100
227/227 [==============================] - 2s 7ms/step - loss: 0.4714 - accuracy: 0.7756 - val_loss: 0.4617 - val_accuracy: 0.7787
Epoch 23/100
227/227 [==============================] - 2s 9ms/step - loss: 0.4676 - accuracy: 0.7784 - val_loss: 0.4626 - val_accuracy: 0.7746
Epoch 24/100
227/227 [==============================] - 2s 7ms/step - loss: 0.4571 - accuracy: 0.7875 - val_loss: 0.4715 - val_accuracy: 0.7659
Epoch 25/100
227/227 [==============================] - 2s 7ms/step - loss: 0.4691 - accuracy: 0.7817 - val_loss: 0.4640 - val_accuracy: 0.7765
Epoch 26/100
227/227 [==============================] - 2s 7ms/step - loss: 0.4634 - accuracy: 0.7831 - val_loss: 0.4589 - val_accuracy: 0.7829
Epoch 27/100
227/227 [==============================] - 2s 7ms/step - loss: 0.4588 - accuracy: 0.7860 - val_loss: 0.4622 - val_accuracy: 0.7813
Epoch 28/100
227/227 [==============================] - 2s 7ms/step - loss: 0.4531 - accuracy: 0.7857 - val_loss: 0.4606 - val_accuracy: 0.7746
Epoch 29/100
227/227 [==============================] - 2s 9ms/step - loss: 0.4583 - accuracy: 0.7827 - val_loss: 0.4554 - val_accuracy: 0.7823
Epoch 30/100
227/227 [==============================] - 2s 8ms/step - loss: 0.4579 - accuracy: 0.7877 - val_loss: 0.4563 - val_accuracy: 0.7810
Epoch 31/100
```

```
227/227 [==============================] - 2s 7ms/step - loss: 0.4584 - accuracy: 0.7834 - val_loss: 0.4583 - val_accuracy: 0.7826
Epoch 32/100
227/227 [==============================] - 2s 7ms/step - loss: 0.4513 - accuracy: 0.7911 - val_loss: 0.4566 - val_accuracy: 0.7852
Epoch 33/100
227/227 [==============================] - 2s 7ms/step - loss: 0.4527 - accuracy: 0.7889 - val_loss: 0.4610 - val_accuracy: 0.7804
Epoch 34/100
227/227 [==============================] - 2s 7ms/step - loss: 0.4534 - accuracy: 0.7892 - val_loss: 0.4561 - val_accuracy: 0.7842
Epoch 35/100
227/227 [==============================] - 2s 7ms/step - loss: 0.4518 - accuracy: 0.7936 - val_loss: 0.4564 - val_accuracy: 0.7833
Epoch 36/100
227/227 [==============================] - 2s 8ms/step - loss: 0.4454 - accuracy: 0.7959 - val_loss: 0.4580 - val_accuracy: 0.7823
Epoch 37/100
227/227 [==============================] - 2s 8ms/step - loss: 0.4495 - accuracy: 0.7919 - val_loss: 0.4621 - val_accuracy: 0.7752
Epoch 38/100
227/227 [==============================] - 2s 7ms/step - loss: 0.4440 - accuracy: 0.7932 - val_loss: 0.4607 - val_accuracy: 0.7765
Epoch 39/100
227/227 [==============================] - 2s 7ms/step - loss: 0.4461 - accuracy: 0.7889 - val_loss: 0.4583 - val_accuracy: 0.7829
Epoch 40/100
227/227 [==============================] - 2s 7ms/step - loss: 0.4407 - accuracy: 0.7964 - val_loss: 0.4607 - val_accuracy: 0.7836
Epoch 41/100
227/227 [==============================] - 2s 7ms/step - loss: 0.4399 - accuracy: 0.7970 - val_loss: 0.4539 - val_accuracy: 0.7894
Epoch 42/100
227/227 [==============================] - 2s 7ms/step - loss: 0.4398 - accuracy: 0.7965 - val_loss: 0.4571 - val_accuracy: 0.7887
Epoch 43/100
227/227 [==============================] - 2s 8ms/step - loss: 0.4331 - accuracy: 0.7997 - val_loss: 0.4574 - val_accuracy: 0.7762
Epoch 44/100
227/227 [==============================] - 2s 7ms/step - loss: 0.4331 - accuracy: 0.8006 - val_loss: 0.4553 - val_accuracy: 0.7842
Epoch 45/100
227/227 [==============================] - 2s 7ms/step - loss: 0.4299 - accuracy: 0.8005 - val_loss: 0.4591 - val_accuracy: 0.7855
Epoch 46/100
227/227 [==============================] - 2s 7ms/step - loss: 0.4400 - accuracy: 0.7953 - val_loss: 0.4567 - val_accuracy: 0.7849
Epoch 47/100
227/227 [==============================] - 2s 7ms/step - loss: 0.4350 - accuracy: 0.8023 - val_loss: 0.4560 - val_accuracy: 0.7871
Epoch 48/100
227/227 [==============================] - 2s 7ms/step - loss: 0.4335 - accuracy: 0.8019 - val_loss: 0.4517 - val_accuracy: 0.7881
Epoch 49/100
227/227 [==============================] - 2s 7ms/step - loss: 0.4260 - accuracy: 0.8034 - val_loss: 0.4618 - val_accuracy: 0.7903
Epoch 50/100
227/227 [==============================] - 2s 9ms/step - loss: 0.4266 - accuracy: 0.8017 - val_loss: 0.4515 - val_accuracy: 0.7881
Epoch 51/100
227/227 [==============================] - 2s 8ms/step - loss: 0.4343 - accuracy: 0.7947 - val_loss: 0.4542 - val_accuracy: 0.7887
Epoch 52/100
227/227 [==============================] - 2s 7ms/step - loss: 0.4289 - accuracy: 0.8046 - val_loss: 0.4526 - val_accuracy: 0.7919
Epoch 53/100
227/227 [==============================] - 2s 7ms/step - loss: 0.4295 - accuracy: 0.8004 - val_loss: 0.4488 - val_accuracy: 0.7961
Epoch 54/100
227/227 [==============================] - 2s 7ms/step - loss: 0.4306 - accuracy: 0.7997 - val_loss: 0.4499 - val_accuracy: 0.7916
Epoch 55/100
227/227 [==============================] - 2s 7ms/step - loss: 0.4240 - accuracy: 0.8049 - val_loss: 0.4523 - val_accuracy: 0.7916
Epoch 56/100
227/227 [==============================] - 2s 7ms/step - loss: 0.4232 - accuracy: 0.8059 - val_loss: 0.4557 - val_accuracy: 0.7884
Epoch 57/100
227/227 [==============================] - 2s 9ms/step - loss: 0.4236 - accuracy: 0.8044 - val_loss: 0.4594 - val_accuracy: 0.7839
Epoch 58/100
227/227 [==============================] - 2s 7ms/step - loss: 0.4294 - accuracy: 0.8002 - val_loss: 0.4537 - val_accuracy: 0.7932
Epoch 59/100
227/227 [==============================] - 2s 7ms/step - loss: 0.4231 - accuracy: 0.8092 - val_loss: 0.4505 - val_accuracy: 0.7932
Epoch 60/100
227/227 [==============================] - 2s 7ms/step - loss: 0.4233 - accuracy: 0.8016 - val_loss: 0.4548 - val_accuracy: 0.7871
Epoch 61/100
227/227 [==============================] - 2s 7ms/step - loss: 0.4219 - accuracy: 0.8070 - val_loss: 0.4478 - val_accuracy: 0.7878
Epoch 62/100
```

```
227/227 [==============================] - 2s 7ms/step - loss: 0.4199 - accuracy: 0.8099 - val_loss: 0.4486 - val_accuracy: 0.7929
Epoch 63/100
227/227 [==============================] - 2s 7ms/step - loss: 0.4190 - accuracy: 0.8082 - val_loss: 0.4516 - val_accuracy: 0.7881
Epoch 64/100
227/227 [==============================] - 2s 9ms/step - loss: 0.4177 - accuracy: 0.8055 - val_loss: 0.4590 - val_accuracy: 0.7878
Epoch 65/100
227/227 [==============================] - 2s 7ms/step - loss: 0.4267 - accuracy: 0.8027 - val_loss: 0.4514 - val_accuracy: 0.7900
Epoch 66/100
227/227 [==============================] - 2s 7ms/step - loss: 0.4232 - accuracy: 0.8028 - val_loss: 0.4556 - val_accuracy: 0.7919
Epoch 67/100
227/227 [==============================] - 2s 7ms/step - loss: 0.4121 - accuracy: 0.8080 - val_loss: 0.4545 - val_accuracy: 0.7952
Epoch 68/100
227/227 [==============================] - 2s 7ms/step - loss: 0.4156 - accuracy: 0.8131 - val_loss: 0.4508 - val_accuracy: 0.8010
Epoch 69/100
227/227 [==============================] - 2s 7ms/step - loss: 0.4130 - accuracy: 0.8114 - val_loss: 0.4582 - val_accuracy: 0.7936
Epoch 70/100
227/227 [==============================] - 2s 7ms/step - loss: 0.4124 - accuracy: 0.8075 - val_loss: 0.4574 - val_accuracy: 0.7874
Epoch 71/100
227/227 [==============================] - 2s 9ms/step - loss: 0.4083 - accuracy: 0.8161 - val_loss: 0.4536 - val_accuracy: 0.7968
Epoch 72/100
227/227 [==============================] - 2s 7ms/step - loss: 0.4111 - accuracy: 0.8165 - val_loss: 0.4589 - val_accuracy: 0.7919
Epoch 73/100
227/227 [==============================] - 2s 7ms/step - loss: 0.4072 - accuracy: 0.8150 - val_loss: 0.4527 - val_accuracy: 0.7990
Epoch 74/100
227/227 [==============================] - 2s 7ms/step - loss: 0.4105 - accuracy: 0.8186 - val_loss: 0.4517 - val_accuracy: 0.7929
Epoch 75/100
227/227 [==============================] - 2s 7ms/step - loss: 0.4132 - accuracy: 0.8102 - val_loss: 0.4562 - val_accuracy: 0.7903
Epoch 76/100
227/227 [==============================] - 2s 7ms/step - loss: 0.4143 - accuracy: 0.8114 - val_loss: 0.4631 - val_accuracy: 0.7952
Epoch 77/100
227/227 [==============================] - 2s 7ms/step - loss: 0.4144 - accuracy: 0.8096 - val_loss: 0.4527 - val_accuracy: 0.8010
Epoch 78/100
227/227 [==============================] - 2s 9ms/step - loss: 0.4180 - accuracy: 0.8053 - val_loss: 0.4566 - val_accuracy: 0.7965
Epoch 79/100
227/227 [==============================] - 2s 7ms/step - loss: 0.4040 - accuracy: 0.8140 - val_loss: 0.4571 - val_accuracy: 0.8010
Epoch 80/100
227/227 [==============================] - 2s 7ms/step - loss: 0.4130 - accuracy: 0.8121 - val_loss: 0.4522 - val_accuracy: 0.7981
Epoch 81/100
227/227 [==============================] - 2s 7ms/step - loss: 0.4085 - accuracy: 0.8167 - val_loss: 0.4571 - val_accuracy: 0.7936
Epoch 82/100
227/227 [==============================] - 2s 7ms/step - loss: 0.4063 - accuracy: 0.8158 - val_loss: 0.4522 - val_accuracy: 0.8035
Epoch 83/100
227/227 [==============================] - 2s 7ms/step - loss: 0.4021 - accuracy: 0.8158 - val_loss: 0.4520 - val_accuracy: 0.8016
Epoch 84/100
227/227 [==============================] - 2s 7ms/step - loss: 0.4054 - accuracy: 0.8160 - val_loss: 0.4534 - val_accuracy: 0.7981
Epoch 85/100
227/227 [==============================] - 2s 8ms/step - loss: 0.4073 - accuracy: 0.8157 - val_loss: 0.4531 - val_accuracy: 0.8023
Epoch 86/100
227/227 [==============================] - 2s 7ms/step - loss: 0.4021 - accuracy: 0.8202 - val_loss: 0.4601 - val_accuracy: 0.7945
Epoch 87/100
227/227 [==============================] - 2s 7ms/step - loss: 0.4055 - accuracy: 0.8200 - val_loss: 0.4510 - val_accuracy: 0.7987
Epoch 88/100
227/227 [==============================] - 2s 7ms/step - loss: 0.4067 - accuracy: 0.8144 - val_loss: 0.4442 - val_accuracy: 0.8045
Epoch 89/100
227/227 [==============================] - 2s 7ms/step - loss: 0.4085 - accuracy: 0.8111 - val_loss: 0.4481 - val_accuracy: 0.8071
Epoch 90/100
227/227 [==============================] - 2s 7ms/step - loss: 0.3989 - accuracy: 0.8229 - val_loss: 0.4568 - val_accuracy: 0.8052
Epoch 91/100
227/227 [==============================] - 2s 8ms/step - loss: 0.3996 - accuracy: 0.8180 - val_loss: 0.4447 - val_accuracy: 0.8052
Epoch 92/100
227/227 [==============================] - 2s 8ms/step - loss: 0.3964 - accuracy: 0.8207 - val_loss: 0.4501 - val_accuracy: 0.8068
Epoch 93/100
```

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227/227 [==============================] - 2s 7ms/step - loss: 0.3961 - accuracy: 0.8189 - val_loss: 0.4490 - val_accuracy: 0.8039
Epoch 94/100
227/227 [==============================] - 2s 7ms/step - loss: 0.4006 - accuracy: 0.8132 - val_loss: 0.4475 - val_accuracy: 0.8064
Epoch 95/100
227/227 [==============================] - 2s 7ms/step - loss: 0.3907 - accuracy: 0.8220 - val_loss: 0.4546 - val_accuracy: 0.8023
Epoch 96/100
227/227 [==============================] - 2s 7ms/step - loss: 0.3995 - accuracy: 0.8231 - val_loss: 0.4394 - val_accuracy: 0.8077
Epoch 97/100
227/227 [==============================] - 2s 7ms/step - loss: 0.3937 - accuracy: 0.8208 - val_loss: 0.4443 - val_accuracy: 0.8077
Epoch 98/100
227/227 [==============================] - 2s 8ms/step - loss: 0.3971 - accuracy: 0.8205 - val_loss: 0.4468 - val_accuracy: 0.8006
Epoch 99/100
227/227 [==============================] - 2s 8ms/step - loss: 0.3908 - accuracy: 0.8271 - val_loss: 0.4382 - val_accuracy: 0.8084
Epoch 100/100
227/227 [==============================] - 2s 7ms/step - loss: 0.3999 - accuracy: 0.8155 - val_loss: 0.4380 - val_accuracy: 0.8077
```

Conclusion: It is observed that the DNN model is performing better with the balanced data with train accuracy of 81.55% and test accuracy of 80.77% compared to the imbalanced data with train accuracy of 82.90% and test accuracy of 78.65%. Hence the DNN model with balanced data is showing promising results and can be used in production.