```
# --- Data cleaning: run this first ---
import numpy as np
import pandas as pd

# If you already have df loaded from the URL, skip loading again.
# Otherwise uncomment the two lines below to load it:
# url = "https://raw.githubusercontent.com/IBM/telco-customer-churn-on-icp4d/master/data/Telco-Customer-Churn.csv"
# df = pd.read_csv(url)

# 1) Trim whitespace from object columns (common dirty data issue)
obj_cols = df.select_dtypes(include=['object']).columns
df[obj_cols] = df[obj_cols].apply(lambda x: x.str.strip())

# 2) Replace empty strings with NaN
df.replace('', np.nan, inplace=True)

# 3) Fix TotalCharges (often stored as string and has blanks). Convert to numeric.
if 'TotalCharges' in df.columns:
    df['TotalCharges'] = pd.to_numeric(df['TotalCharges'], errors='coerce')

# 4) For any missing TotalCharges, fill using a sensible rule:
#    If tenure > 0, use MonthlyCharges * tenure; else 0.
if 'TotalCharges' in df.columns and 'MonthlyCharges' in df.columns and 'tenure' in df.columns:
    df['TotalCharges'] = df['TotalCharges'].fillna(df['MonthlyCharges'] * df['tenure'])
    df['TotalCharges'] = df['TotalCharges'].fillna(0)

# 5) Drop duplicate customerIDs (if any) and reset index
if 'customerID' in df.columns:
    df.drop_duplicates(subset='customerID', inplace=True)
df.reset_index(drop=True, inplace=True)

# 6) Cast categorical columns to category dtype (helps later)
cat_cols = ['gender','Partner','Dependents','PhoneService','MultipleLines','InternetService',
            'OnlineSecurity','OnlineBackup','DeviceProtection','TechSupport','StreamingTV',
            'StreamingMovies','Contract','PaperlessBilling','PaymentMethod','Churn']
for c in cat_cols:
    if c in df.columns:
        df[c] = df[c].astype('category')

# 7) Recreate TenureGroup (safe)
if 'tenure' in df.columns:
    bins = [0, 12, 24, 48, df['tenure'].max() + 1]
    labels = ['0-12 months', '1-2 years', '2-4 years', '4+ years']
    df['TenureGroup'] = pd.cut(df['tenure'], bins=bins, labels=labels, right=False)

# 8) Quick check of missing values
print("Missing values after cleaning:")
print(df.isnull().sum())
```

```
Missing values after cleaning:
customerID          0
gender              0
SeniorCitizen       0
Partner             0
Dependents          0
tenure              0
PhoneService        0
MultipleLines       0
InternetService     0
OnlineSecurity      0
OnlineBackup        0
DeviceProtection    0
TechSupport         0
StreamingTV         0
StreamingMovies     0
Contract            0
PaperlessBilling    0
PaymentMethod       0
MonthlyCharges      0
TotalCharges        0
Churn               0
TenureGroup         0
```

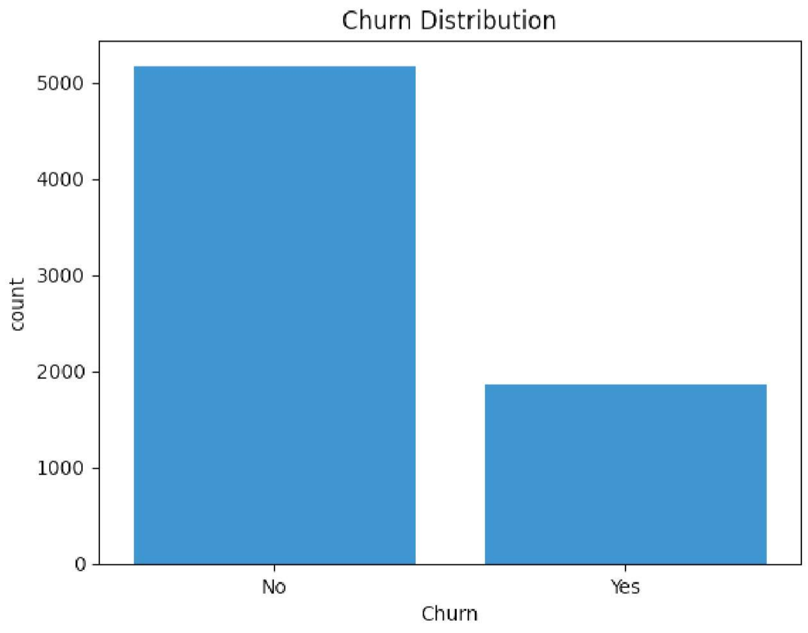
```
dtype: int64
```

```
# Step 2: Quick Overview (EDA)
import matplotlib.pyplot as plt
import seaborn as sns

# Column info and statistics
df.info()
df.describe()

# Churn distribution bar chart
sns.countplot(x='Churn', data=df)
plt.title('Churn Distribution')
plt.show()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 7043 entries, 0 to 7042
Data columns (total 22 columns):
 #   Column            Non-Null Count  Dtype   
---  ------            --------------  -----   
 0   customerID        7043 non-null   object  
 1   gender            7043 non-null   category
 2   SeniorCitizen     7043 non-null   int64   
 3   Partner           7043 non-null   category
 4   Dependents        7043 non-null   category
 5   tenure            7043 non-null   int64   
 6   PhoneService      7043 non-null   category
 7   MultipleLines     7043 non-null   category
 8   InternetService   7043 non-null   category
 9   OnlineSecurity    7043 non-null   category
 10  OnlineBackup      7043 non-null   category
 11  DeviceProtection  7043 non-null   category
 12  TechSupport       7043 non-null   category
 13  StreamingTV       7043 non-null   category
 14  StreamingMovies   7043 non-null   category
 15  Contract          7043 non-null   category
 16  PaperlessBilling  7043 non-null   category
 17  PaymentMethod     7043 non-null   category
 18  MonthlyCharges    7043 non-null   float64 
 19  TotalCharges      7043 non-null   float64 
 20  Churn             7043 non-null   category
 21  TenureGroup       7043 non-null   category
dtypes: category(17), float64(2), int64(2), object(1)
memory usage: 394.5+ KB
```



```
# Step 3: Total Customers & Churn Counts

# 1. Count total customers
total_customers = len(df)
```

```
print("Total customers:", total_customers)

# 2. Count churned vs active customers
churn_counts = df['Churn'].value_counts()
print("\nChurn counts:\n", churn_counts)
```

```
Total customers: 7043

Churn counts:
 Churn
No     5174
Yes    1869
Name: count, dtype: int64
```

```
# Step 4: Churn by Contract & Average Monthly Charges

# Churn rate by contract type
contract_churn = df.groupby('Contract')['Churn'].value_counts().unstack().fillna(0)
contract_churn['Churn Rate (%)'] = contract_churn['Yes'] / (contract_churn['Yes'] + contract_churn['No']) * 100
print("Churn by Contract Type:\n", contract_churn)

# Average monthly charges for churned vs retained
avg_monthly = df.groupby('Churn')['MonthlyCharges'].mean()
print("\nAverage Monthly Charges by Churn:\n", avg_monthly)
```

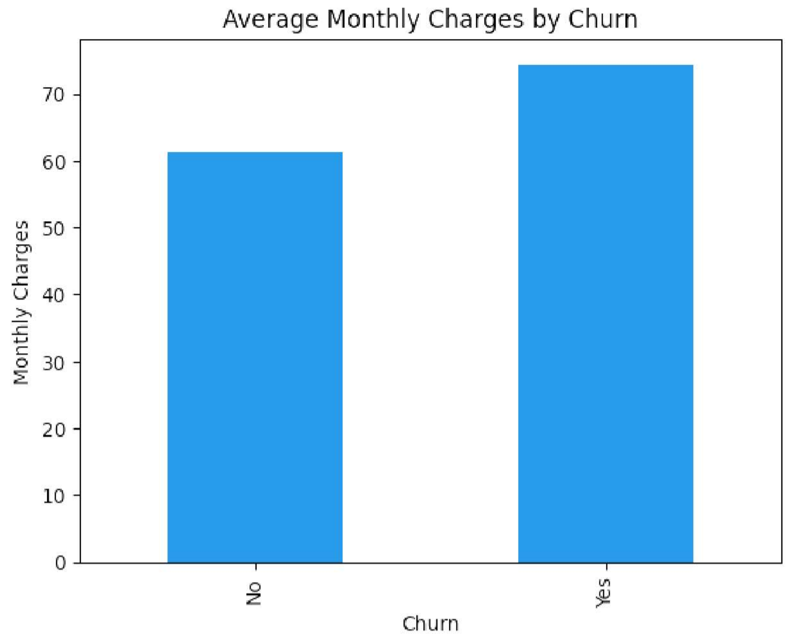
```
Churn by Contract Type:
 Churn             No   Yes  Churn Rate (%)
Contract
Month-to-month  2220  1655       42.709677
One year        1307   166       11.269518
Two year        1647    48        2.831858

Average Monthly Charges by Churn:
 Churn
No     61.265124
Yes    74.441332
Name: MonthlyCharges, dtype: float64
/tmp/ipython-input-688614196.py:4: FutureWarning: The default of observed=False is deprecated and will be changed to True i
  contract_churn = df.groupby('Contract')['Churn'].value_counts().unstack().fillna(0)
/tmp/ipython-input-688614196.py:9: FutureWarning: The default of observed=False is deprecated and will be changed to True i
  avg_monthly = df.groupby('Churn')['MonthlyCharges'].mean()
```

```
# Step 5: Visualizations

# Bar chart: Average Monthly Charges by Churn
df.groupby('Churn')['MonthlyCharges'].mean().plot(kind='bar')
plt.title('Average Monthly Charges by Churn')
plt.ylabel('Monthly Charges')
plt.show()
```

```
/tmp/ipython-input-1022924299.py:4: FutureWarning: The default of observed=False is deprecated and will be changed to True
  df.groupby('Churn')['MonthlyCharges'].mean().plot(kind='bar')
```



```
# Step 6a: Churn by Payment Method
payment_churn = df.groupby('PaymentMethod')['Churn'].value_counts().unstack().fillna(0)
payment_churn['Churn Rate (%)'] = payment_churn['Yes'] / (payment_churn['Yes'] + payment_churn['No']) * 100
print("Churn by Payment Method:\n", payment_churn)
```

```
Churn by Payment Method:
 Churn                        No   Yes  Churn Rate (%)
PaymentMethod
Bank transfer (automatic)  1286   258       16.709845
Credit card (automatic)    1290   232       15.243101
Electronic check           1294  1071       45.285412
Mailed check               1304   308       19.106700
/tmp/ipython-input-3686086198.py:2: FutureWarning: The default of observed=False is deprecated and will be changed to True
  payment_churn = df.groupby('PaymentMethod')['Churn'].value_counts().unstack().fillna(0)
```

```
# Step 6b: Churn by Internet Service
internet_churn = df.groupby('InternetService')['Churn'].value_counts().unstack().fillna(0)
internet_churn['Churn Rate (%)'] = internet_churn['Yes'] / (internet_churn['Yes'] + internet_churn['No']) * 100
print("Churn by Internet Service:\n", internet_churn)
```

```
Churn by Internet Service:
 Churn              No   Yes  Churn Rate (%)
InternetService
DSL              1962   459       18.959108
Fiber optic      1799  1297       41.892765
No               1413   113        7.404980
/tmp/ipython-input-3136162747.py:2: FutureWarning: The default of observed=False is deprecated and will be changed to True
  internet_churn = df.groupby('InternetService')['Churn'].value_counts().unstack().fillna(0)
```

```
# Step 7: Churn by Tenure Groups
# Create tenure ranges
bins = [0, 12, 24, 48, df['tenure'].max()]
labels = ['0-12 months', '1-2 years', '2-4 years', '4+ years']
df['TenureGroup'] = pd.cut(df['tenure'], bins=bins, labels=labels, right=False)

# Group by tenure and churn
tenure_churn = df.groupby('TenureGroup')['Churn'].value_counts().unstack().fillna(0)
tenure_churn['Churn Rate (%)'] = tenure_churn['Yes'] / (tenure_churn['Yes'] + tenure_churn['No']) * 100
print("Churn by Tenure Group:\n", tenure_churn)
```

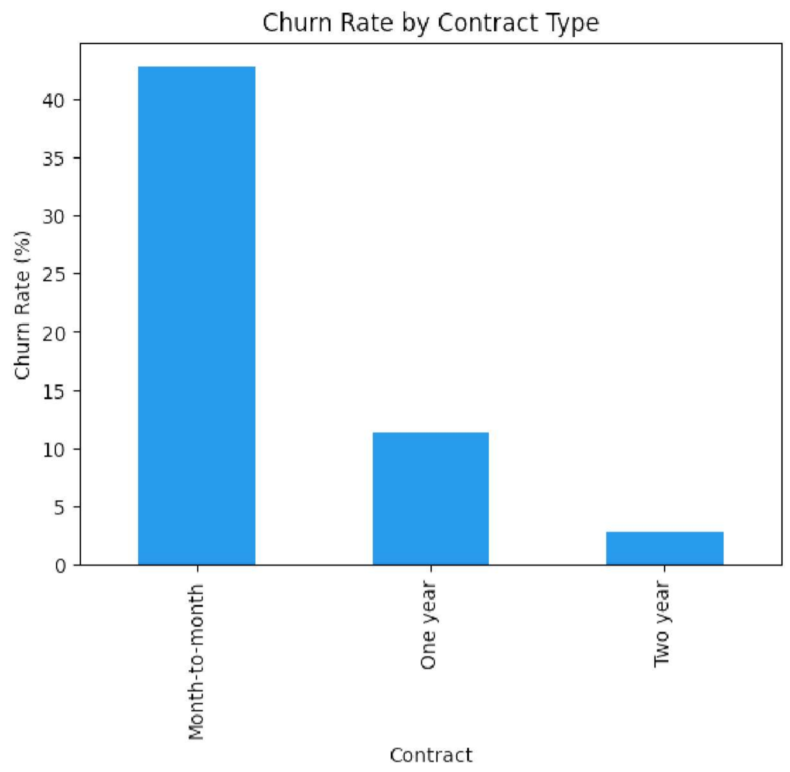
```
Churn by Tenure Group:
 Churn          No  Yes  Churn Rate (%)
TenureGroup
0-12 months  1070  999       48.284195
1-2 years     738  309       29.512894
2-4 years    1285  339       20.874384
4+ years     1725  216       11.128284
/tmp/ipython-input-3814933521.py:8: FutureWarning: The default of observed=False is deprecated and will be changed to True
  tenure_churn = df.groupby('TenureGroup')['Churn'].value_counts().unstack().fillna(0)
```

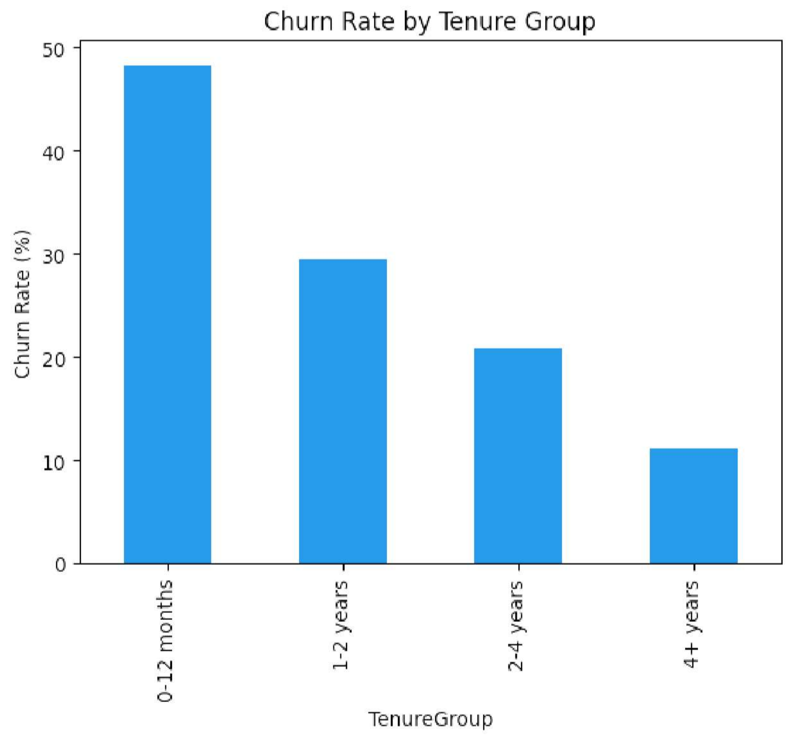
```
# Step 8: Revenue Lost Due to Churn
lost_revenue = df[df['Churn'] == 'Yes']['MonthlyCharges'].sum()
print("Total Monthly Charges Lost Due to Churn:", lost_revenue)
```

```
Total Monthly Charges Lost Due to Churn: 139130.85
```

```
# Step 9a: Churn Rate by Contract (Bar Chart)
contract_churn['Churn Rate (%)'].plot(kind='bar')
plt.title('Churn Rate by Contract Type')
plt.ylabel('Churn Rate (%)')
plt.show()

# Step 9b: Churn Rate by Tenure Group (Bar Chart)
tenure_churn['Churn Rate (%)'].plot(kind='bar')
plt.title('Churn Rate by Tenure Group')
plt.ylabel('Churn Rate (%)')
plt.show()
```





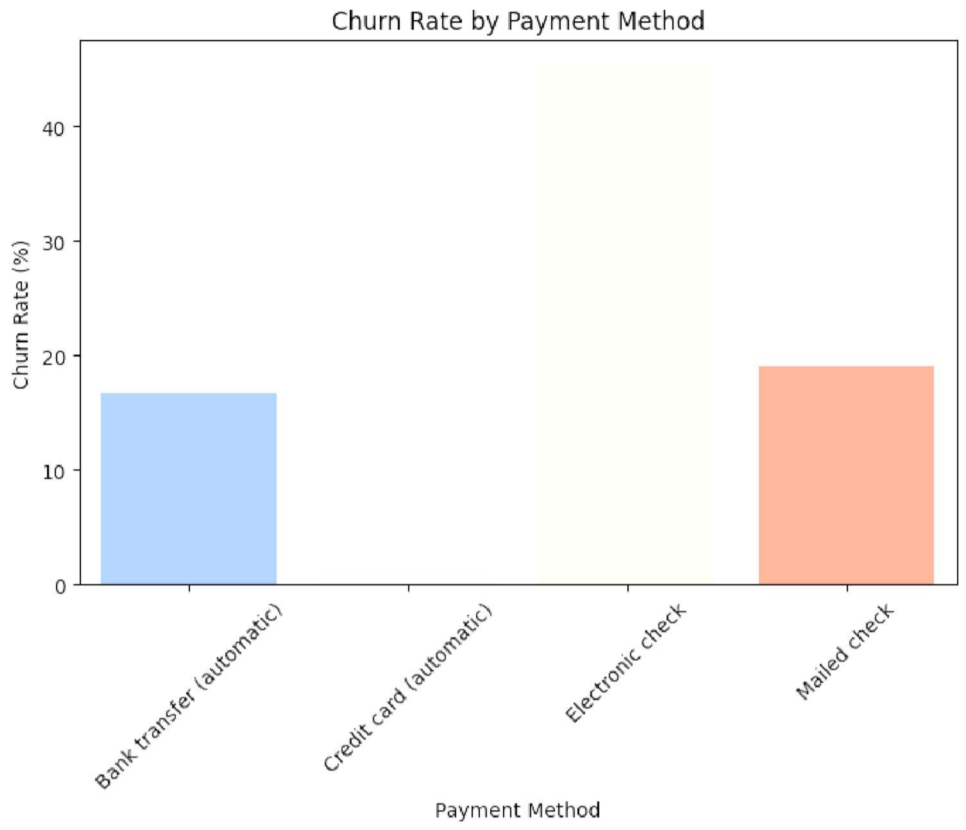
```
# Step 10a: Churn Rate by Payment Method
payment_churn = df.groupby('PaymentMethod')['Churn'].value_counts().unstack().fillna(0)
payment_churn['Churn Rate (%)'] = payment_churn['Yes'] / (payment_churn['Yes'] + payment_churn['No']) * 100

# Plot
plt.figure(figsize=(8,5))
sns.barplot(x=payment_churn.index, y=payment_churn['Churn Rate (%)'], palette="coolwarm")
plt.title('Churn Rate by Payment Method')
plt.ylabel('Churn Rate (%)')
plt.xlabel('Payment Method')
plt.xticks(rotation=45)
plt.show()
```

```
/tmp/ipython-input-1117402217.py:2: FutureWarning: The default of observed=False is deprecated and will be changed to True
  payment_churn = df.groupby('PaymentMethod')['Churn'].value_counts().unstack().fillna(0)
/tmp/ipython-input-1117402217.py:7: FutureWarning: 

Passing `palette` without assigning `hue` is deprecated and will be removed in v0.14.0. Assign the `x` variable to `hue` ar

  sns.barplot(x=payment_churn.index, y=payment_churn['Churn Rate (%)'], palette="coolwarm")
```



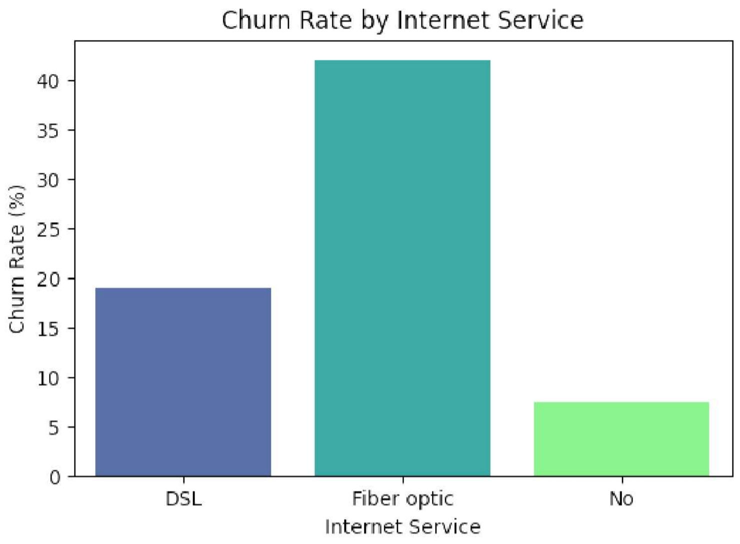
```
# Step 10b: Churn Rate by Internet Service
internet_churn = df.groupby('InternetService')['Churn'].value_counts().unstack().fillna(0)
internet_churn['Churn Rate (%)'] = internet_churn['Yes'] / (internet_churn['Yes'] + internet_churn['No']) * 100

# Plot
plt.figure(figsize=(6,4))
sns.barplot(x=internet_churn.index, y=internet_churn['Churn Rate (%)'], palette="viridis")
plt.title('Churn Rate by Internet Service')
plt.ylabel('Churn Rate (%)')
plt.xlabel('Internet Service')
plt.show()
```

```
/tmp/ipython-input-173656872.py:2: FutureWarning: The default of observed=False is deprecated and will be changed to True i
  internet_churn = df.groupby('InternetService')['Churn'].value_counts().unstack().fillna(0)
/tmp/ipython-input-173656872.py:7: FutureWarning:

Passing `palette` without assigning `hue` is deprecated and will be removed in v0.14.0. Assign the `x` variable to `hue` ar

  sns.barplot(x=internet_churn.index, y=internet_churn['Churn Rate (%)'], palette="viridis")
```

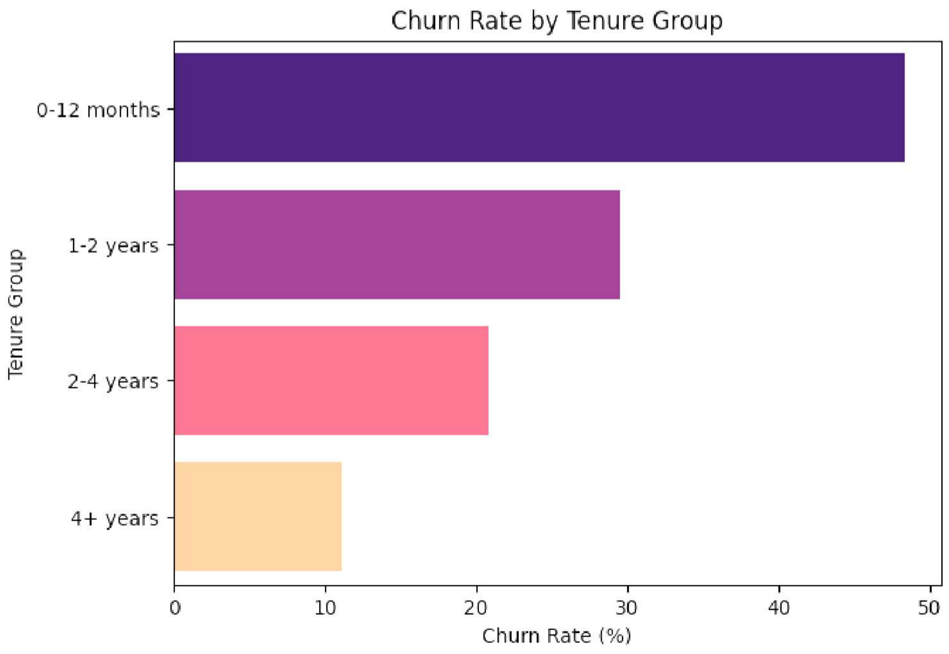


```
# Step 10c: Churn Rate by Tenure Group (Horizontal Bar)
plt.figure(figsize=(7,5))
sns.barplot(x=tenure_churn['Churn Rate (%)'], y=tenure_churn.index, palette="magma")
plt.title('Churn Rate by Tenure Group')
plt.xlabel('Churn Rate (%)')
plt.ylabel('Tenure Group')
plt.show()
```

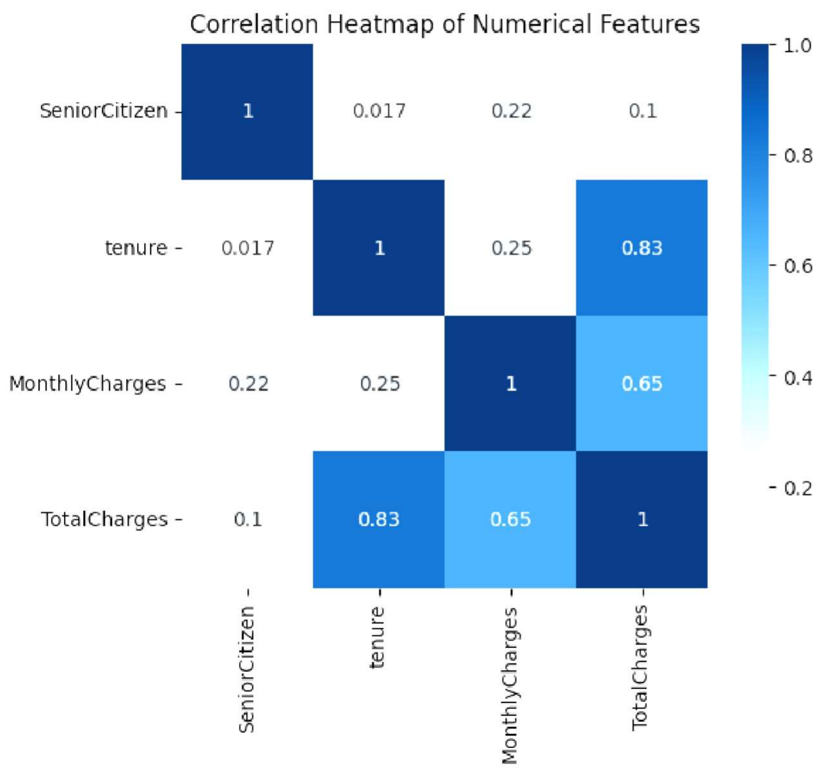
```
/tmp/ipython-input-664168179.py:3: FutureWarning:

Passing `palette` without assigning `hue` is deprecated and will be removed in v0.14.0. Assign the `y` variable to `hue` ar

  sns.barplot(x=tenure_churn['Churn Rate (%)'], y=tenure_churn.index, palette="magma")
```



```
# Step 10d: Correlation Heatmap
plt.figure(figsize=(6,5))
sns.heatmap(df.select_dtypes(include=['float64', 'int64']).corr(), annot=True, cmap="Blues")
plt.title('Correlation Heatmap of Numerical Features')
plt.show()
```



Final Insights: Customer Churn Analysis

1. Overall Churn

- Total customers: **7,043**
- Churned customers: **1,869**
- Overall churn rate: **26.54%**
- 💡 **Insight:** About **1 in 4 customers** leaves the company, showing that customer retention is a significant challenge.

2. Revenue Lost Due to Churn

- Total monthly revenue lost from churned customers: **$139,130.85**
- 💡 **Insight:** Churn has a direct financial impact, highlighting the importance of retention strategies.

3. Churn by Contract Type

Contract Type	No Churn	Yes Churn	Churn Rate (%)
Month-to-month	2220	1655	42.71
One year	1307	166	11.27
Two year	1647	48	2.83

- 💡 **Insight:** Customers on **short-term (month-to-month) contracts** are far more likely to churn than long-term contracts.
- Long-term contracts are effective for customer retention.

4. Churn by Tenure Group

Tenure Group	No Churn	Yes Churn	Churn Rate (%)
0-12 months	1070	999	48.28
1-2 years	738	309	29.51
2-4 years	1285	339	20.87
4+ years	1725	216	11.13

- 💡 **Insight: New customers churn the most**, nearly 50% in their first year.
- Retention improves as tenure increases, showing the importance of customer onboarding.

---

5. Churn by Payment Method

Payment Method	No Churn	Yes Churn	Churn Rate (%)
Bank transfer (automatic)	1286	258	16.71
Credit card (automatic)	1290	232	15.24