

```

import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
%matplotlib inline
import seaborn as sns
from datetime import datetime

df1 = pd.read_csv('Medical Examinations.csv')
df2 = pd.read_csv('Hospitalisation details.csv')
df3 = pd.read_excel("Names.xlsx")
df4 = pd.merge(df1, df2 , on = "Customer ID", how = 'outer')
df = pd.merge(df3, df4 , on = "Customer ID", how = 'outer')
df.head()

```

	Customer ID	name	BMI	HBA1C	Heart Issues	Any Transplants	Cancer history
0	?	NaN	NaN	NaN	NaN	NaN	NaN
1	?	NaN	NaN	NaN	NaN	NaN	NaN
2	?	NaN	NaN	NaN	NaN	NaN	NaN
3	?	NaN	NaN	NaN	NaN	NaN	NaN
4	?	NaN	NaN	NaN	NaN	NaN	NaN

	NumberOfMajorSurgeries	smoker	year	month	date	children	charges
0	NaN	NaN	2004	Nov	6	0	1137.01
1	NaN	NaN	1999	Jun	9	1	2775.19
2	NaN	NaN	1985	Dec	20	2	6203.90
3	NaN	NaN	2000	Oct	13	0	35585.58
4	NaN	NaN	1992	Oct	6	0	36837.47

	Hospital tier	City tier	State ID
0	tier - 3	tier - 1	R1013
1	tier - 2	tier - 1	R1012
2	tier - 1	tier - 2	R1012
3	tier - 1	tier - 2	R1011
4	tier - 1	tier - 2	R1011

```
df.shape  
(2343, 17)
```

# replace space in col names with space

```
df.columns = df.columns.str.replace(' ', '')
```

df.columns

```
for col in df.columns:  
    df[col] = df[col].replace('?', '')
```

```
df.isna().sum()
```

Customer ID	0
name	8
BMI	8
HBA1C	8
Heart Issues	8
Any Transplants	8
Cancer history	8
NumberOfMajorSurgeries	8
smoker	8
year	0
month	0
date	0
children	0
charges	0
Hospital tier	0
City tier	0
State ID	0
dtype: int64	

```
df = df.dropna()
```

```
df.shape
```

```
(2335, 17)
```

```
df.isna().sum()
```

Customer ID	0
name	0
BMI	0

```

HBA1C          0
Heart Issues    0
Any Transplants 0
Cancer history  0
NumberOfMajorSurgeries 0
smoker          0
year           0
month          0
date           0
children       0
charges        0
Hospital tier   0
City tier       0
State ID       0
dtype: int64

df['Customer ID'] = df['Customer ID'].str.replace("Id", "" )
df['smoker'] = df['smoker'].str.replace("?", "" )
df['Hospital tier'] = df['Hospital tier'].str.replace("tier - ", "" )
df['City tier'] = df['City tier'].str.replace("tier - ", "" )

# Assuming 'StateID' is the column with state identifiers
# Replace all other states with 'Other'
df['State ID'] = df['State ID'].apply(lambda x: x if x in ['R1011',
'R1012', 'R1013'] else 'Other')

# Create dummy variables for the three states and drop the 'Other'
category (baseline)
state_dummies = pd.get_dummies(df['State ID'], drop_first=True)

# Concatenate dummy variables back to the original dataframe
df = pd.concat([df, state_dummies], axis=1)

df['State ID'] = df['State ID'].str.replace("R", "")

df['NumberOfMajorSurgeries'] =
df['NumberOfMajorSurgeries'].str.replace("No major surgery" , '0')

df.head(10)

```

	Customer ID	name	BMI	HBA1C	Heart Issues \
6	1	Hawks, Ms. Kelly	47.410	7.47	No
7	10	Benner, Ms. Brooke N.	38.060	10.79	No
8	100	Gollins, Mr. Daniel	48.200	4.84	No

9	1000	Schaefer, Mrs.	Stephanie A	39.170	4.15
No					
10	1001	D'Alessandro, Mr.	Patrick	26.410	5.99
yes					
11	1002	Wyss, Mrs.	Krista	30.630	5.80
yes					
12	1003	Rose, Ms.	Jenessa	31.730	7.32
yes					
13	1004	Hopper, Mr.	Ryan M.	30.700	5.16
No					
14	1005	Finneran, Mr.	Thomas	25.935	5.96
yes					
15	1006	Basham, Ms.	Amanda N.	35.900	4.85
yes					
Any Transplants Cancer history NumberOfMajorSurgeries smoker year					
month \					
6	No	No		0	yes 1968
Oct					
7	No	No		0	yes 1978
Dec					
8	No	No		0	yes 1977
Jun					
9	No	No		0	No 1989
Dec					
10	No	Yes		1	No 1969
Dec					
11	No	No		0	No 1976
Jun					
12	No	No		2	No 1970
Jun					
13	No	No		2	No 1972
Sep					
14	No	No		2	No 1966
Aug					
15	No	Yes		1	No 1969
Jun					
date children charges Hospital tier City tier State ID R1011					
R1012 \					
6	12	0	63770.43	1	3 1013 False
False					
7	29	0	48885.14	1	2 1013 False
False					
8	27	2	40284.38	1	3 1012 False
True					
9	17	3	11250.43	3	2 Other False
False					
10	30	2	11244.38	3	1 Other False

```

False
11    28         2  11217.35         3         2    Other  False
False
12    14         2  11187.66         3         2    1012  False
True
13     3         0  11186.20         3         2    Other  False
False
14     6         0  11165.42         3         1    Other  False
False
15    25         2  11163.57         3         2    1011   True
False

```

```

      R1013
6    True
7    True
8   False
9   False
10  False
11  False
12  False
13  False
14  False
15  False

```

```
df.isna().sum()
```

```

Customer ID      0
name             0
BMI              0
HBA1C            0
Heart Issues     0
Any Transplants  0
Cancer history   0
NumberOfMajorSurgeries  0
smoker           0
year             0
month            0
date             0
children         0
charges          0
Hospital tier    0
City tier        0
State ID         0
R1011            0
R1012            0
R1013            0
dtype: int64

```

```
df = pd.get_dummies(df, columns=['Heart Issues', 'Any Transplants',
'Cancer history', 'NumberOfMajorSurgeries'], drop_first=True)
```

```
df.shape
```

```
(2335, 22)
```

```
df.head()
```

	Customer ID		name	BMI	HBA1C	smoker	year
month \							
6	1		Hawks, Ms. Kelly	47.41	7.47	yes	1968
Oct							
7	10		Benner, Ms. Brooke N.	38.06	10.79	yes	1978
Dec							
8	100		Gollins, Mr. Daniel	48.20	4.84	yes	1977
Jun							
9	1000		Schaefer, Mrs. Stephanie A	39.17	4.15	No	1989
Dec							
10	1001		D'Alessandro, Mr. Patrick	26.41	5.99	No	1969
Dec							

	date	children	charges	...	State	ID	R1011	R1012	R1013	\
6	12	0	63770.43	...		1013	False	False	True	
7	29	0	48885.14	...		1013	False	False	True	
8	27	2	40284.38	...		1012	False	True	False	
9	17	3	11250.43	...		Other	False	False	False	
10	30	2	11244.38	...		Other	False	False	False	

	Heart Issues_yes	Any Transplants_yes	Cancer history_Yes	\
6	False	False	False	
7	False	False	False	
8	False	False	False	
9	False	False	False	
10	True	False	True	

	NumberOfMajorSurgeries_1	NumberOfMajorSurgeries_2	\
6	False	False	
7	False	False	
8	False	False	
9	False	False	
10	True	False	

	NumberOfMajorSurgeries_3
6	False
7	False
8	False
9	False
10	False

```
[5 rows x 22 columns]
```

```
df.shape
```

```
(2335, 22)
```

```
df.head()
```

	Customer ID		name	BMI	HBA1C	smoker	year
month \							
6	1		Hawks, Ms. Kelly	47.41	7.47	yes	1968
Oct							
7	10		Benner, Ms. Brooke N.	38.06	10.79	yes	1978
Dec							
8	100		Gollins, Mr. Daniel	48.20	4.84	yes	1977
Jun							
9	1000		Schaefer, Mrs. Stephanie A	39.17	4.15	No	1989
Dec							
10	1001		D'Alessandro, Mr. Patrick	26.41	5.99	No	1969
Dec							

	date	children	charges	...	State ID	R1011	R1012	R1013	\
6	12	0	63770.43	...	1013	False	False	True	
7	29	0	48885.14	...	1013	False	False	True	
8	27	2	40284.38	...	1012	False	True	False	
9	17	3	11250.43	...	Other	False	False	False	
10	30	2	11244.38	...	Other	False	False	False	

	Heart Issues_yes	Any Transplants_yes	Cancer history_Yes	\
6	False	False	False	
7	False	False	False	
8	False	False	False	
9	False	False	False	
10	True	False	True	

	NumberOfMajorSurgeries_1	NumberOfMajorSurgeries_2	\
6	False	False	
7	False	False	
8	False	False	
9	False	False	
10	True	False	

	NumberOfMajorSurgeries_3
6	False
7	False
8	False
9	False
10	False

```
[5 rows x 22 columns]
```

```
df.isna().sum()
```

Customer ID	0
name	0

```

BMI          0
HBA1C        0
smoker        0
year          0
month         0
date          0
children      0
charges       0
Hospital tier 0
City tier     0
State ID      0
R1011         0
R1012         0
R1013         0
Heart Issues_yes 0
Any Transplants_yes 0
Cancer history_Yes 0
NumberOfMajorSurgeries_1 0
NumberOfMajorSurgeries_2 0
NumberOfMajorSurgeries_3 0
dtype: int64

```

```
df['month'].dropna()
```

```

6      Oct
7      Dec
8      Jun
9      Dec
10     Dec
...
2336   Oct
2337   Dec
2338   Oct
2339   Oct
2340   Aug

```

```
Name: month, Length: 2335, dtype: object
```

```
df['month'] = pd.to_datetime(df['month'], format='%b').dt.month
```

```
current_date = datetime.now()
```

```
df = df.rename(columns={'date': 'day'})
```

```
df['DOB'] = pd.to_datetime(df[['year', 'month', 'day']])
```

```
current_date = pd.to_datetime(current_date)
```

```
df['DOB'] = pd.to_datetime(df['DOB'])
```

```
df['Age'] = current_date.year - df['DOB'].dt.year
```

```
df.shape
```



```
(2335, 24)
```

```
df.isna().sum()
```

```
Customer ID      0
name             0
BMI             0
HBA1C           0
smoker          0
year            0
month           3
day             0
children        0
charges         0
Hospital tier    0
City tier        0
State ID        0
R1011           0
R1012           0
R1013           0
Heart Issues_yes 0
Any Transplants_yes 0
Cancer history_Yes 0
NumberOfMajorSurgeries_1 0
NumberOfMajorSurgeries_2 0
NumberOfMajorSurgeries_3 0
DOB            5
Age            5
dtype: int64
```

```
df['month'].dropna
```

```
<bound method Series.dropna of 6      10.0
7      12.0
8      6.0
9      12.0
10     12.0
...
2336   10.0
2337   12.0
2338   10.0
2339   10.0
2340    8.0
Name: month, Length: 2335, dtype: float64>
```

```
df['Age'].dropna
```

```
<bound method Series.dropna of 6      56.0
7      46.0
8      47.0
9      35.0
```

```

10      55.0
...
2336    20.0
2337    53.0
2338    55.0
2339    43.0
2340    55.0
Name: Age, Length: 2335, dtype: float64>

```

```
df.isna().sum()
```

```

Customer ID      0
name              0
BMI              0
HBA1C            0
smoker           0
year             0
month            3
day              0
children          0
charges          0
Hospital tier     0
City tier         0
State ID         0
R1011            0
R1012            0
R1013            0
Heart Issues_yes 0
Any Transplants_yes 0
Cancer history_Yes 0
NumberOfMajorSurgeries_1 0
NumberOfMajorSurgeries_2 0
NumberOfMajorSurgeries_3 0
DOB              5
Age              5
dtype: int64

```

```

def Searching_gender(name):
    if "Mrs" in name or "Ms" in name:
        return 0
    else :
        return 1

```

```
df['Gender'] = df['name'].apply(Searching_gender)
```

```
df.head()
```

```

Customer ID      name      BMI  HBA1C  smoker  year
month \

```

6	1	Hawks, Ms. Kelly	47.41	7.47	yes	1968
10.0						
7	10	Benner, Ms. Brooke N.	38.06	10.79	yes	1978
12.0						
8	100	Gollins, Mr. Daniel	48.20	4.84	yes	1977
6.0						
9	1000	Schaefer, Mrs. Stephanie A	39.17	4.15	No	1989
12.0						
10	1001	D'Alessandro, Mr. Patrick	26.41	5.99	No	1969
12.0						

	day	children	charges	...	R1013	Heart	Issues_yes	Any
Transplants_yes \								
6	12	0	63770.43	...	True		False	
False								
7	29	0	48885.14	...	True		False	
False								
8	27	2	40284.38	...	False		False	
False								
9	17	3	11250.43	...	False		False	
False								
10	30	2	11244.38	...	False		True	
False								

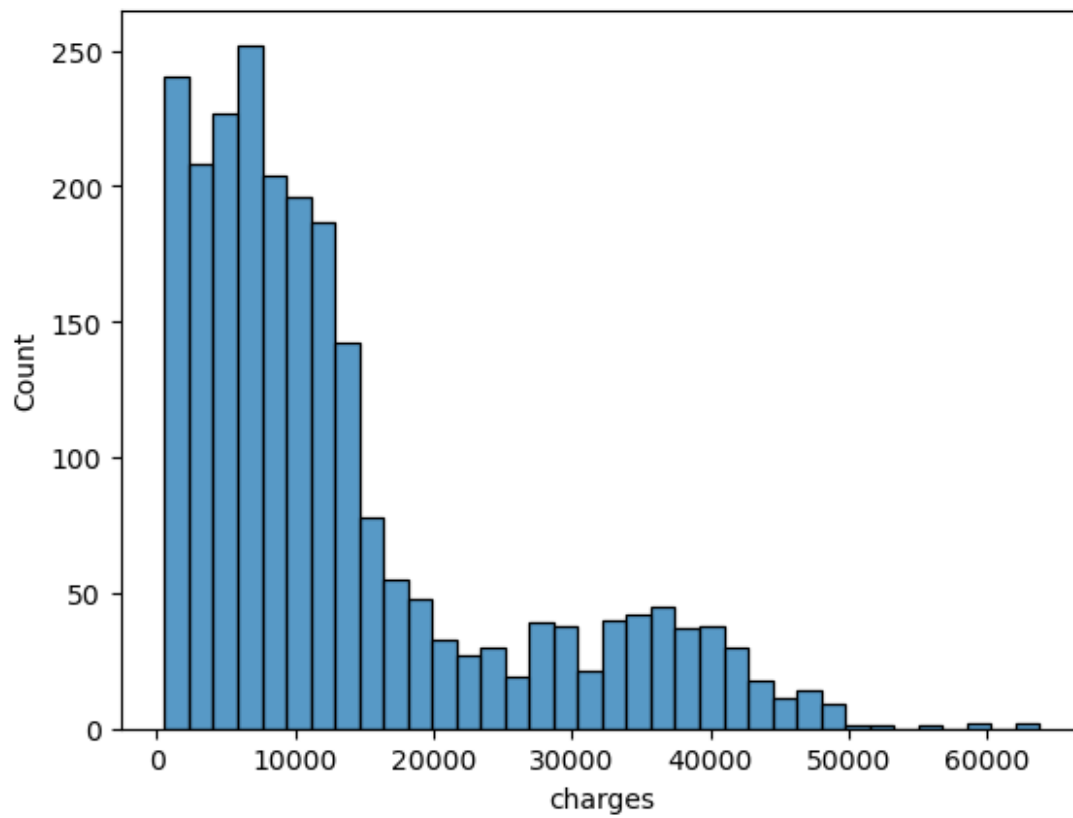
	Cancer history_Yes	NumberOfMajorSurgeries_1
NumberOfMajorSurgeries_2 \		
6	False	False
False		
7	False	False
False		
8	False	False
False		
9	False	False
False		
10	True	True
False		

	NumberOfMajorSurgeries_3	DOB	Age	Gender
6	False	1968-10-12	56.0	0
7	False	1978-12-29	46.0	0
8	False	1977-06-27	47.0	1
9	False	1989-12-17	35.0	0
10	False	1969-12-30	55.0	1

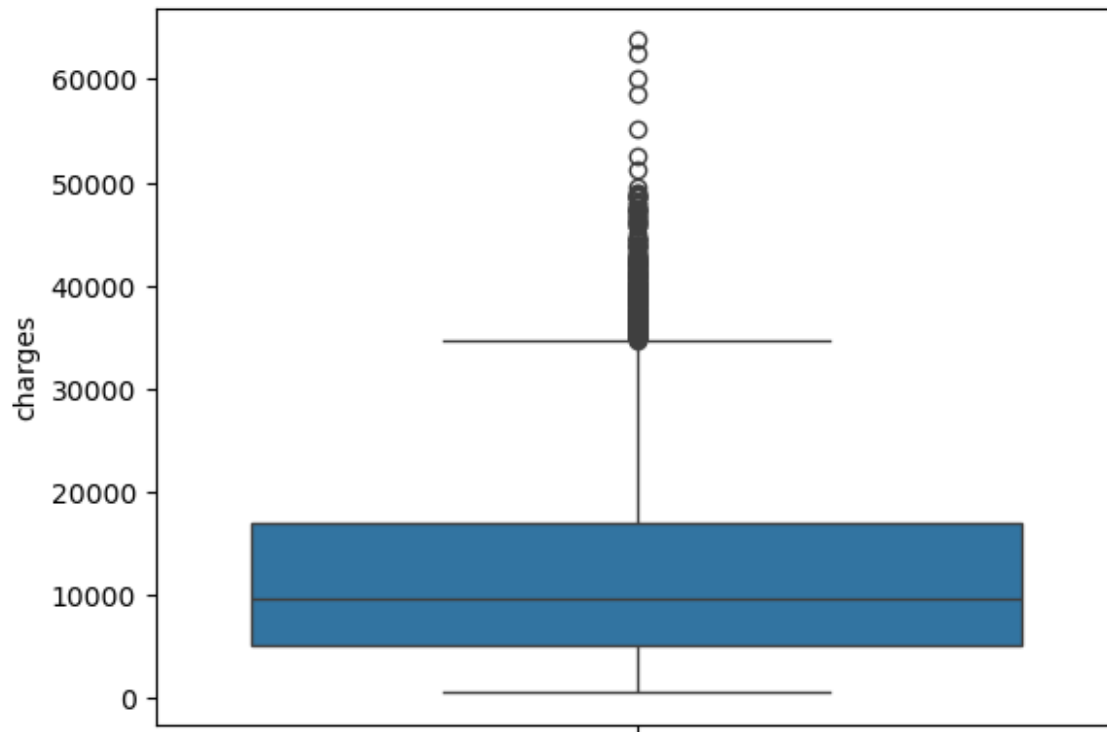
[5 rows x 25 columns]

```
sns.histplot(data=df, x = 'charges' )
```

```
<Axes: xlabel='charges', ylabel='Count'>
```

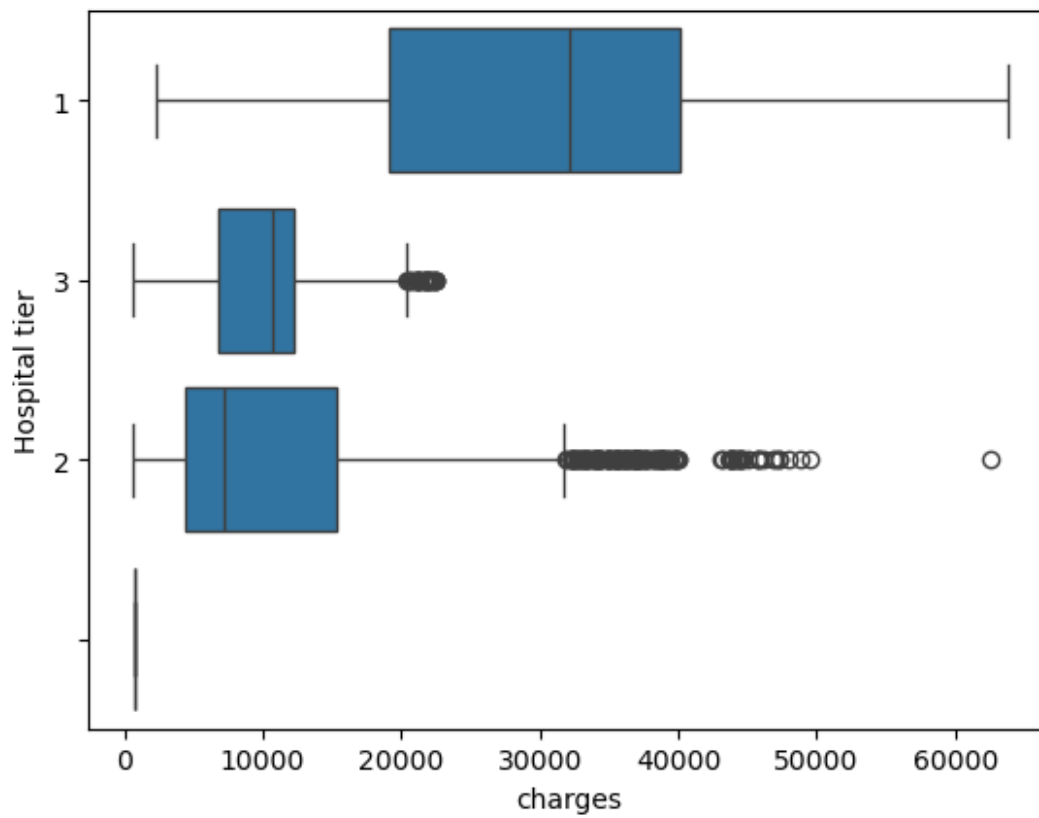


```
sns.boxplot(data = df , y = 'charges')  
<Axes: ylabel='charges'>
```

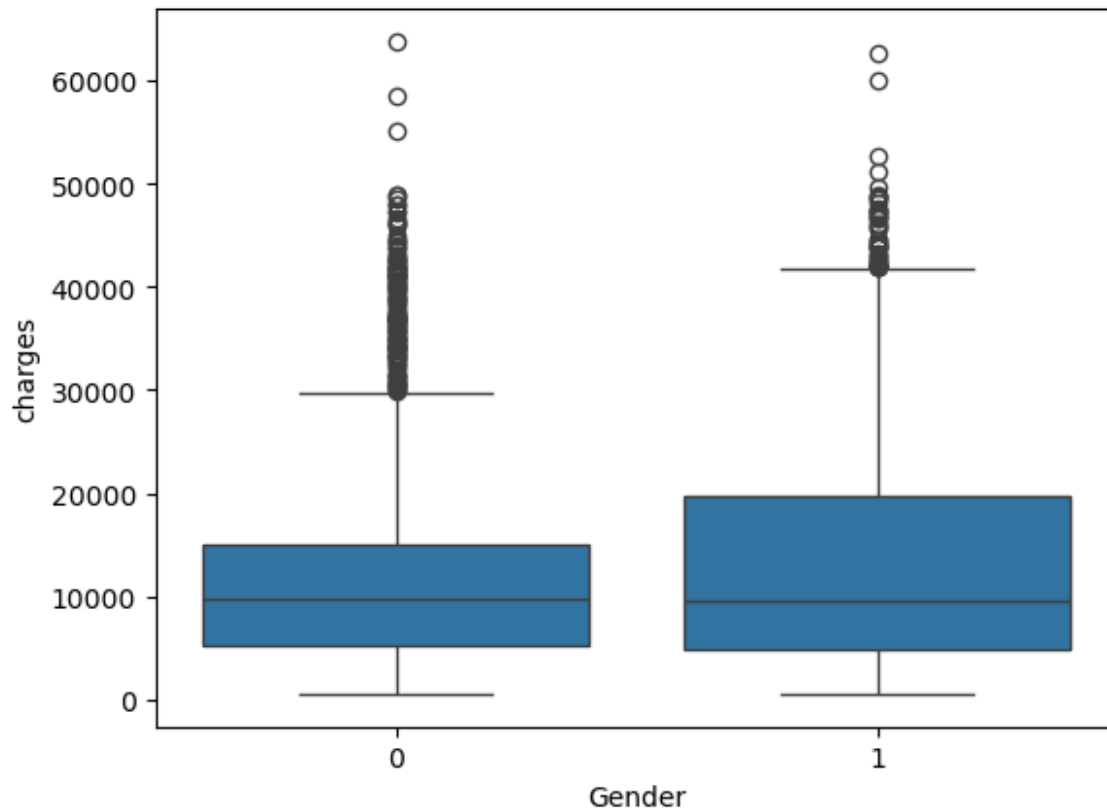


```
sns.swarmplot(data = df, x = 'charges')
```

```
sns.boxplot(data = df , x = 'charges' , y = 'Hospital tier')  
<Axes: xlabel='charges', ylabel='Hospital tier'>
```



```
sns.boxplot(data = df , y = 'charges' , x = 'Gender')  
<Axes: xlabel='Gender', ylabel='charges'>
```



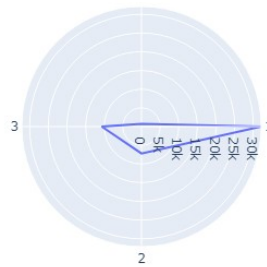
```
import plotly.express as px

median_charges = df.groupby('Hospital tier')
['charges'].median().reset_index()
# median_charges = median_charges[1:]
# median_charges['charges'] = median_charges.values

print(median_charges)
```

Hospital tier	charges
0	700.000
1	32097.435
2	7201.700
3	10665.440

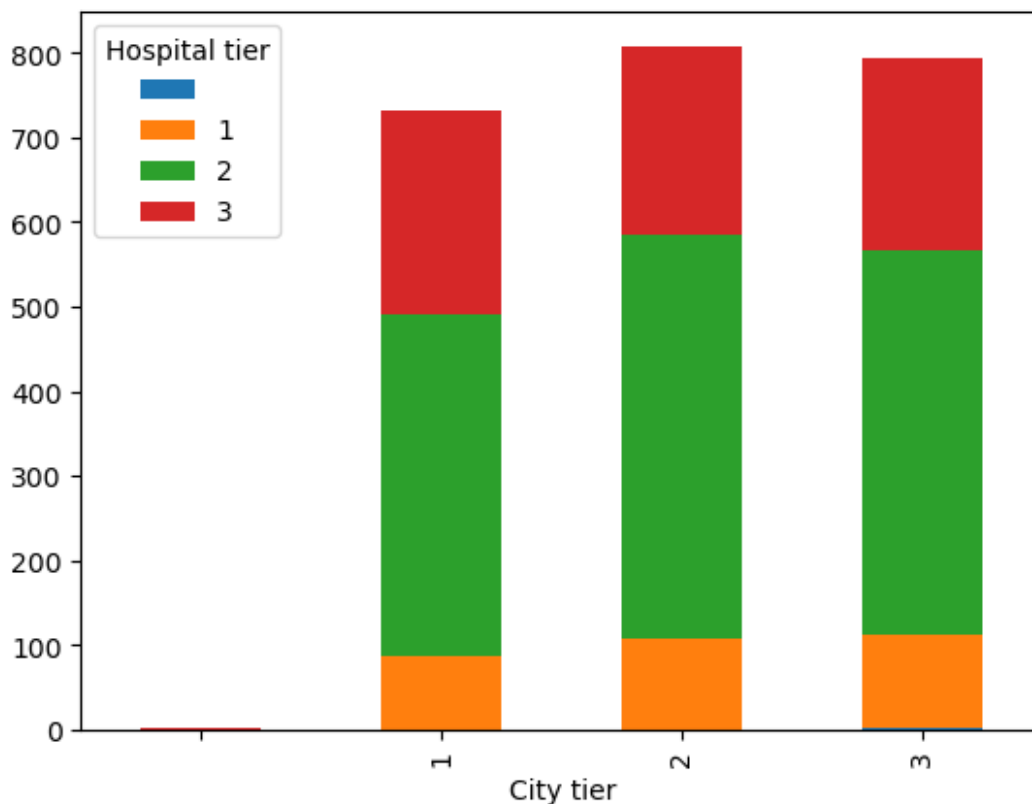
```
fig = px.line_polar(median_charges, r='charges', theta='Hospital
tier', line_close=True)
fig
```



Create a frequency table and a stacked bar chart to visualize the count of people in the different tiers of cities and hospitals

```
df.pivot_table(index= 'City tier', columns = 'Hospital tier', values =
'Customer ID', aggfunc = 'count').plot(kind = 'bar', stacked= True)
```

<Axes: xlabel='City tier'>



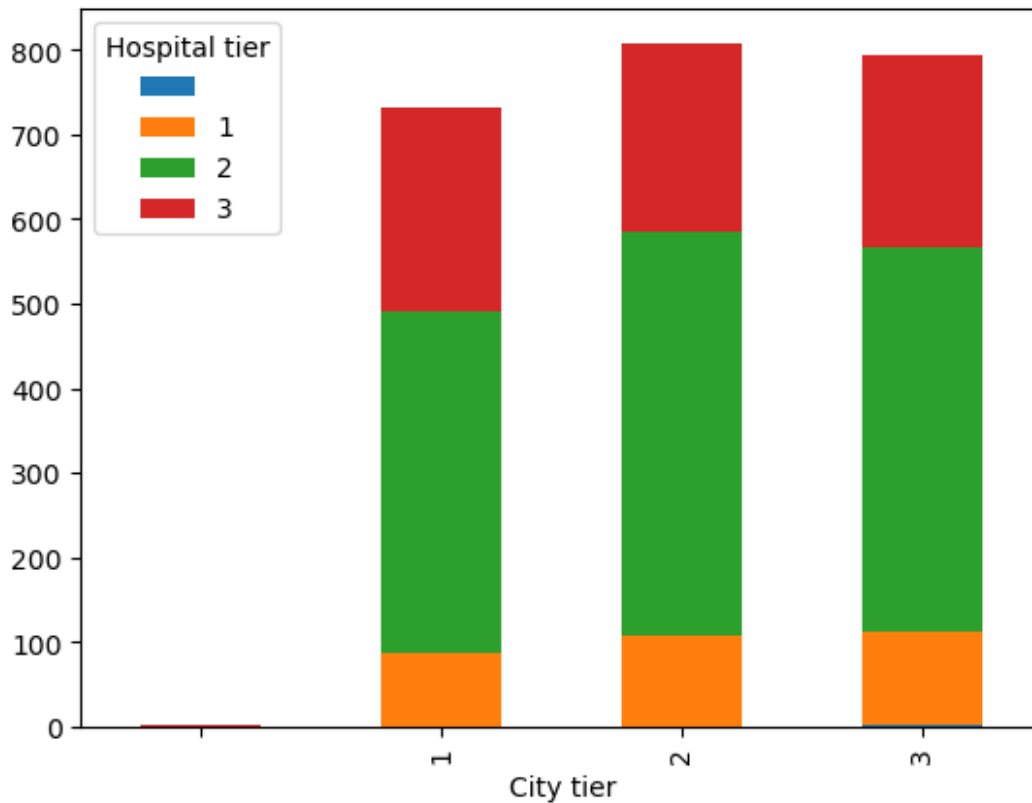


```
print(f"Frequency Table\n {df.groupby(['City tier','Hospital tier'])\n ['Customer ID'].count().unstack()}")
```

Frequency Table

Hospital tier		1	2	3
City tier				
	NaN	NaN	NaN	1.0
1	NaN	86.0	404.0	242.0
2	NaN	107.0	479.0	222.0
3	1.0	111.0	454.0	228.0

```
df.groupby(['City tier','Hospital tier'])['Customer ID'].count().unstack().plot(kind = 'bar', stacked = True)\n plt.show()
```



## Hypothesis Testing

```
import scipy.stats as stats
```

1. The average hospitalization costs for the three types of hospitals are not significantly different.

ho:  $\text{avg}(\text{chg}(\text{h tier } 1)) = \text{avg}(\text{chg}(\text{h tier } 2)) = \text{avg}(\text{chg}(\text{h tier } 3))$

h1:  $\text{avg}(\text{chg}(\text{h tier } 1)) \neq \text{avg}(\text{chg}(\text{h tier } 2)) \neq \text{avg}(\text{chg}(\text{h tier } 3))$  / at least one of them is different

```
mean_hosp_tier = df.groupby('Hospital tier')
['charges'].mean().reset_index()
mean_hosp_tier = mean_hosp_tier[1:]
mean_hosp_tier
```

	Hospital tier	charges
1	1	30129.198586
2	2	11873.619753
3	3	9462.269307

```
df.dtypes
```

Customer ID	object
name	object
BMI	float64
HBA1C	float64
smoker	object
year	object
month	float64
day	int64
children	int64
charges	float64
Hospital tier	object
City tier	object
State ID	object
R1011	bool
R1012	bool
R1013	bool
Heart Issues_yes	bool
Any Transplants_yes	bool
Cancer history_Yes	bool
NumberOfMajorSurgeries_1	bool
NumberOfMajorSurgeries_2	bool
NumberOfMajorSurgeries_3	bool
DOB	datetime64[ns]
Age	float64
Gender	int64
dtype:	object

```
htier_1_charges = df[df['Hospital tier'] == '1']['charges']
htier_2_charges = df[df['Hospital tier'] == '2']['charges']
htier_3_charges = df[df['Hospital tier'] == '3']['charges']
```

```
# print(f"Tier 1 charges mean: {tier_1_charges.mean()}")
f_stat, p_value = stats.f_oneway(htier_1_charges, htier_2_charges,
htier_3_charges)

print(f"F-statistic: {f_stat}")
print(f"P-value: {p_value}")

alpha = 0.05
if p_value < alpha:
    print(f"Reject the null hypothesis({p_value} < {alpha}): As there
is a significant difference between the average hospital charges.")
else:
    print(f"Fail to reject the null hypothesis({p_value} > {alpha}):
As the average charges are not significantly different.")

F-statistic: 498.1576330119755
P-value: 7.413410240056631e-181
Reject the null hypothesis(7.413410240056631e-181 < 0.05): As there is
a significant difference between the average hospital charges.
```

2. The average hospitalization costs for the three types of cities are not significantly different

ho: avg(chg(c tier 1)) = avg(chg(c tier 2)) = avg(chg(c tier 3))

h1: avg(chg(c tier 1)) <> avg(chg(c tier 2)) <> avg(chg(ctier 3))// at least one of them is different

```
mean_city_tier = df.groupby('City tier')
['charges'].mean().reset_index()
mean_city_tier = mean_city_tier[1:]
mean_city_tier
```

	City tier	charges
1	1	13051.351230
2	2	13461.221238
3	3	14057.093665

```
ctier_1_charges = df[df['City tier'] == '1']['charges']
ctier_2_charges = df[df['City tier'] == '2']['charges']
ctier_3_charges = df[df['City tier'] == '3']['charges']

# print(f"Tier 1 charges mean: {tier_1_charges.mean()}")
f_stat, p_value = stats.f_oneway(ctier_1_charges, ctier_2_charges,
ctier_3_charges)

print(f"F-statistic: {f_stat}")
print(f"P-value: {p_value}")
```

```

alpha = 0.05
if p_value < alpha:
    print(f"Reject the null hypothesis({p_value} < {alpha}): As there
is a significant difference between the average hospital charges.")
else:
    print(f"Fail to reject the null hypothesis({p_value} > {alpha}):
As the average charges are not significantly different.")

F-statistic: 1.3851347062585722
P-value: 0.2504960120936119
Fail to reject the null hypothesis(0.2504960120936119 > 0.05): As the
average charges are not significantly different.

```

### 3. The average hospitalization cost for smokers is not significantly different from the average cost for nonsmokers.

$H_0: \text{avg}(\text{chg}(\text{smoker})) = \text{avg}(\text{chg}(\text{nonsmokers}))$ 
 $H_1: \text{avg}(\text{chg}(\text{h tier 1})) \neq \text{avg}(\text{chg}(\text{h tier 2}))$  / at least one of them is different

```

smoker_charges = df.groupby('smoker')['charges'].count()
smoker_charges

smoker
      2
No    1845
yes    488
Name: charges, dtype: int64

smoking_charges = df[df['smoker'] == 'No']['charges']
non_smoking_charges = df[df['smoker'] == 'yes']['charges']

f_stat, p_value = stats.f_oneway(smoking_charges, non_smoking_charges)

print(f"F-statistic: {f_stat}")
print(f"P-value: {p_value}")

alpha = 0.05
if p_value < alpha:
    print(f"Reject the null hypothesis({p_value} < {alpha}): As there
is a significant difference between the average charges for smoker and
non smoker.")
else:
    print(f"Fail to reject the null hypothesis({p_value} > {alpha}):
As the average charges are not significantly different for smoker and
non smoker.")

```



```

0    Customer ID      2335 non-null    object
1    name             2335 non-null    object
2    BMI              2335 non-null    float64
3    HBA1C            2335 non-null    float64
4    smoker           2335 non-null    object
5    year             2335 non-null    object
6    month            2332 non-null    float64
7    day              2335 non-null    int64
8    children         2335 non-null    int64
9    charges          2335 non-null    float64
10   Hospital tier    2335 non-null    object
11   City tier        2335 non-null    object
12   State ID        2335 non-null    object
13   R1011            2335 non-null    bool
14   R1012            2335 non-null    bool
15   R1013            2335 non-null    bool
16   Heart Issues_yes 2335 non-null    bool
17   Any Transplants_yes 2335 non-null    bool
18   Cancer history_Yes 2335 non-null    bool
19   NumberOfMajorSurgeries_1 2335 non-null    bool
20   NumberOfMajorSurgeries_2 2335 non-null    bool
21   NumberOfMajorSurgeries_3 2335 non-null    bool
22   DOB              2330 non-null    datetime64[ns]
23   Age              2330 non-null    float64
24   Gender           2335 non-null    int64
dtypes: bool(9), datetime64[ns](1), float64(5), int64(3), object(7)
memory usage: 330.6+ KB

```

```
df.shape
```

```
(2335, 25)
```

```
df.drop(["Customer ID", 'name', 'year', 'month', 'day', 'DOB'],
inplace=True, axis=1)
```

```
df.shape
```

```
(2335, 19)
```

```
df.head()
```

```

      BMI  HBA1C smoker  children  charges Hospital tier City tier
State ID \
6    47.41   7.47   yes         0  63770.43         1         3
1013
7    38.06  10.79   yes         0  48885.14         1         2
1013
8    48.20   4.84   yes         2  40284.38         1         3
1012
9    39.17   4.15   No         3  11250.43         3         2
Other

```

10	26.41	5.99	No	2	11244.38	3	1
----	-------	------	----	---	----------	---	---

Other

	R1011	R1012	R1013	Heart Issues_yes	Any Transplants_yes	\
6	False	False	True	False	False	False
7	False	False	True	False	False	False
8	False	True	False	False	False	False
9	False	False	False	False	False	False
10	False	False	False	True	False	False

	Cancer history_Yes	NumberOfMajorSurgeries_1	NumberOfMajorSurgeries_2	\
6	False	False	False	False
7	False	False	False	False
8	False	False	False	False
9	False	False	False	False
10	False	True	True	True

	NumberOfMajorSurgeries_3	Age	Gender
6	False	56.0	0
7	False	46.0	0
8	False	47.0	1
9	False	35.0	0
10	False	55.0	1

```
from sklearn.preprocessing import LabelEncoder
```

```
df.isna().sum()
```

```
BMI 0
HBA1C 0
smoker 0
children 0
charges 0
Hospital tier 0
City tier 0
State ID 0
R1011 0
R1012 0
R1013 0
Heart Issues_yes 0
Any Transplants_yes 0
Cancer history_Yes 0
NumberOfMajorSurgeries_1 0
NumberOfMajorSurgeries_2 0
```

```

NumberOfMajorSurgeries_3    0
Age                          5
Gender                       0
dtype: int64

```

```

le = LabelEncoder()
df.head()

```

	BMI	HBA1C	smoker	children	charges	Hospital tier	City tier
State ID \							
6 1013	47.41	7.47	yes	0	63770.43	1	3
7 1013	38.06	10.79	yes	0	48885.14	1	2
8 1012	48.20	4.84	yes	2	40284.38	1	3
9 Other	39.17	4.15	No	3	11250.43	3	2
10 Other	26.41	5.99	No	2	11244.38	3	1

	R1011	R1012	R1013	Heart Issues_yes	Any Transplants_yes \
6	False	False	True	False	False
7	False	False	True	False	False
8	False	True	False	False	False
9	False	False	False	False	False
10	False	False	False	True	False

	Cancer history_Yes	NumberOfMajorSurgeries_1	NumberOfMajorSurgeries_2 \
6		False	False
7		False	False
8		False	False
9		False	False
10		True	True

	NumberOfMajorSurgeries_3	Age	Gender
6	False	56.0	0
7	False	46.0	0
8	False	47.0	1
9	False	35.0	0
10	False	55.0	1

```

df['State ID'] = le.fit_transform(df['State ID'])
df['R1011'] = le.fit_transform(df['R1011'])

```



```

df['R1012'] = le.fit_transform(df['R1012'])
df['R1013'] = le.fit_transform(df['R1013'])
df['NumberOfMajorSurgeries_1'] =
le.fit_transform(df['NumberOfMajorSurgeries_1'])
df['NumberOfMajorSurgeries_2'] =
le.fit_transform(df['NumberOfMajorSurgeries_2'])
df['NumberOfMajorSurgeries_3'] =
le.fit_transform(df['NumberOfMajorSurgeries_3'])

df["Heart Issues_yes"] = le.fit_transform(df["Heart Issues_yes"])
df["Any Transplants_yes"] = le.fit_transform(df["Any
Transplants_yes"])
df["Cancer history_Yes"] = le.fit_transform(df["Cancer history_Yes"])
df["smoker"] = le.fit_transform(df["smoker"])

df = df.drop(['State ID'], axis =1 )
df.head()

```

	BMI	HBA1C	smoker	children	charges	Hospital tier	City tier
R1011 \							
6	47.41	7.47	2	0	63770.43	1	3
0							
7	38.06	10.79	2	0	48885.14	1	2
0							
8	48.20	4.84	2	2	40284.38	1	3
0							
9	39.17	4.15	1	3	11250.43	3	2
0							
10	26.41	5.99	1	2	11244.38	3	1
0							

	R1012	R1013	Heart Issues_yes	Any Transplants_yes	Cancer
history_Yes \					
6	0	1	0	0	
0					
7	0	1	0	0	
0					
8	1	0	0	0	
0					
9	0	0	0	0	
0					
10	0	0	1	0	
1					

	NumberOfMajorSurgeries_1	NumberOfMajorSurgeries_2	\
6	0	0	
7	0	0	
8	0	0	
9	0	0	

10	1	0
----	---	---

	NumberOfMajorSurgeries_3	Age	Gender
6	0	56.0	0
7	0	46.0	0
8	0	47.0	1
9	0	35.0	0
10	0	55.0	1

```
corr = df.select_dtypes(include='int').corr()
print(corr)
```

	smoker	children	R1011	R1012
R1013 \				
smoker	1.000000	0.018288	0.335208	-0.103963
0.096361				
children	0.018288	1.000000	0.011482	0.005012
0.013194				
R1011	0.335208	0.011482	1.000000	-0.326328
0.340259				
R1012	-0.103963	0.005012	-0.326328	1.000000
0.340652				
R1013	-0.096361	-0.013194	-0.340259	-0.340652
1.000000				
Heart Issues_yes	-0.003722	0.024967	0.004812	0.022292
0.029270				
Any Transplants_yes	-0.026053	-0.142340	-0.059535	-0.068020
0.061767				
Cancer history_Yes	0.007360	-0.027918	0.013007	0.057813
0.066457				
NumberOfMajorSurgeries_1	0.006709	-0.009720	-0.020644	-0.011373
0.004103				
NumberOfMajorSurgeries_2	0.006425	-0.106761	0.017443	0.007805
0.017596				
NumberOfMajorSurgeries_3	0.026300	-0.019985	-0.004202	-0.004297
0.022517				
Gender	0.082951	0.017390	-0.004745	-0.009711
0.020753				

	Heart Issues_yes	Any Transplants_yes	\
smoker	-0.003722	-0.026053	
children	0.024967	-0.142340	
R1011	0.004812	-0.059535	
R1012	0.022292	-0.068020	
R1013	-0.029270	0.061767	
Heart Issues_yes	1.000000	-0.138683	
Any Transplants_yes	-0.138683	1.000000	
Cancer history_Yes	0.110060	-0.114974	
NumberOfMajorSurgeries_1	0.148108	0.240384	
NumberOfMajorSurgeries_2	0.153256	0.006098	

NumberOfMajorSurgeries_3	-0.079063	-0.025003
Gender	-0.001766	0.007670
	Cancer history_Yes	NumberOfMajorSurgeries_1
\		
smoker	0.007360	0.006709
children	-0.027918	-0.009720
R1011	0.013007	-0.020644
R1012	0.057813	-0.011373
R1013	-0.066457	0.004103
Heart Issues_yes	0.110060	0.148108
Any Transplants_yes	-0.114974	0.240384
Cancer history_Yes	1.000000	0.534364
NumberOfMajorSurgeries_1	0.534364	1.000000
NumberOfMajorSurgeries_2	-0.163522	-0.306013
NumberOfMajorSurgeries_3	-0.043738	-0.081852
Gender	-0.013951	-0.002551
	NumberOfMajorSurgeries_2	
NumberOfMajorSurgeries_3	\	
smoker	0.006425	
0.026300		
children	-0.106761	-
0.019985		
R1011	0.017443	-
0.004202		
R1012	0.007805	-
0.004297		
R1013	-0.017596	
0.022517		
Heart Issues_yes	0.153256	-
0.079063		
Any Transplants_yes	0.006098	-
0.025003		
Cancer history_Yes	-0.163522	-
0.043738		
NumberOfMajorSurgeries_1	-0.306013	-
0.081852		
NumberOfMajorSurgeries_2	1.000000	-

```

0.035560
NumberOfMajorSurgeries_3 -0.035560
1.000000
Gender 0.008765
0.000209

```

```

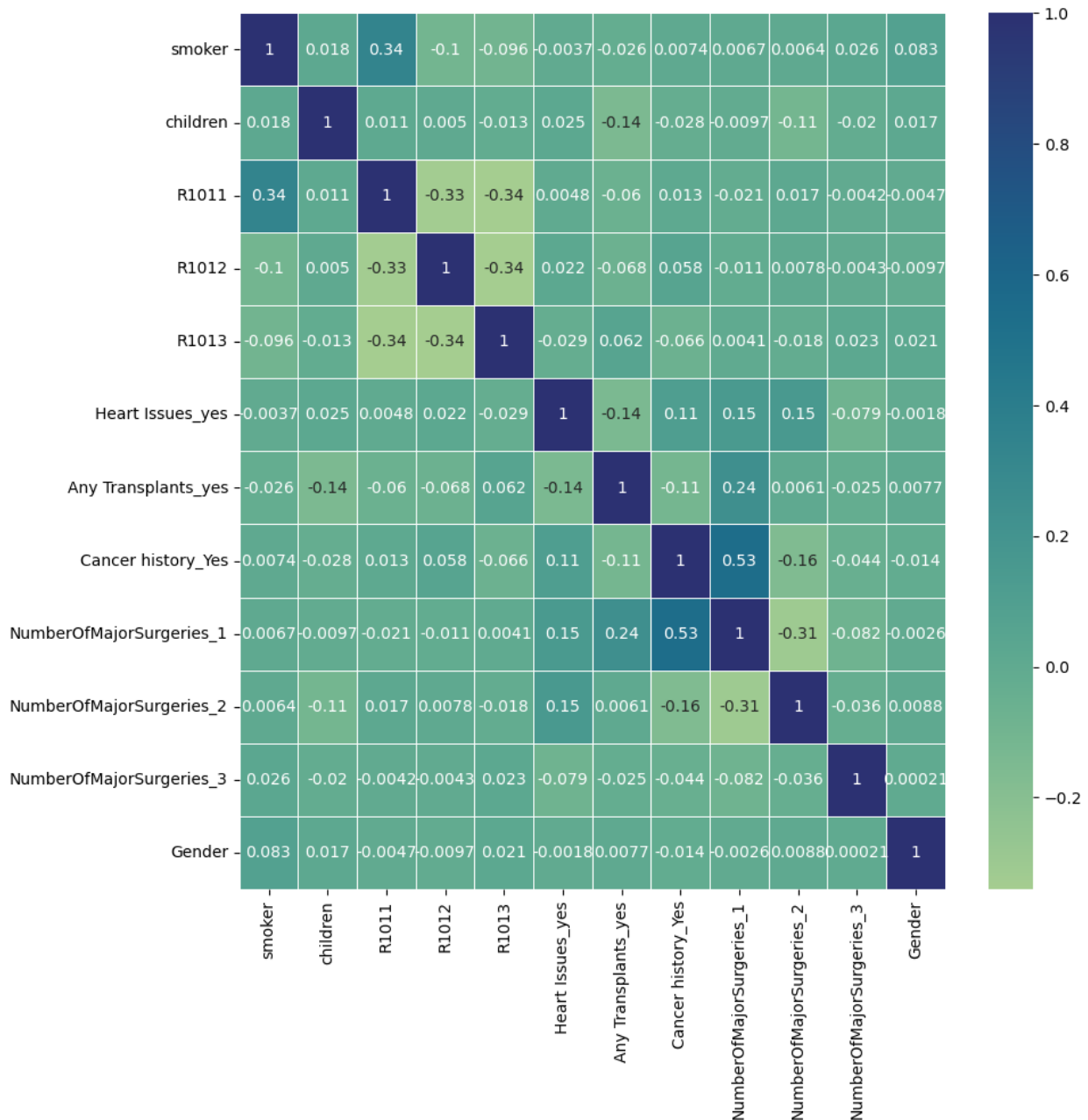
Gender
smoker 0.082951
children 0.017390
R1011 -0.004745
R1012 -0.009711
R1013 0.020753
Heart_Issues_yes -0.001766
Any_Transplants_yes 0.007670
Cancer_history_Yes -0.013951
NumberOfMajorSurgeries_1 -0.002551
NumberOfMajorSurgeries_2 0.008765
NumberOfMajorSurgeries_3 0.000209
Gender 1.000000

```

```

plt.figure(figsize=(10,10) )
sns.heatmap(corr, annot=True, linewidth=.5, cmap="crest")
plt.show()

```



1. Develop a regression model Linear or Ridge. Evaluate the model with k-fold cross validation. Also, ensure that you apply all the following suggestions:
  - Implement the stratified 5-fold cross validation technique for both model building and validation
  - Utilize effective standardization techniques and hyperparameter tuning
  - Incorporate sklearn-pipelines to streamline the workflow
  - Apply appropriate regularization techniques to address the bias-variance trade-off
  - Create five folds in the data, and introduce a variable to identify the folds
  - Develop Gradient Boost model and determine the variable importance scores, and identify the redundant variables

```
print(df['smoker'].unique())
df['smoker'] = df['smoker'].astype(str)
```

```
[2 1 0]
```

```
df['Age'] = df['Age'].fillna(0)
```

```
df = df[df['Hospital tier'] != '']
```

```
df.dropna
```

```
<bound method DataFrame.dropna of          BMI  HBA1C smoker  children  
charges Hospital tier City tier  R1011 \
```

```
6      47.41   7.47      2      0 63770.43      1      3
```

```
0
```

```
7      38.06  10.79      2      0 48885.14      1      2
```

```
0
```

```
8      48.20   4.84      2      2 40284.38      1      3
```

```
0
```

```
9      39.17   4.15      1      3 11250.43      3      2
```

```
0
```

```
10     26.41   5.99      1      2 11244.38      3      1
```

```
0
```

```
...      ...      ...      ...      ...      ...      ...      ...
```

```
...
```

```
2336  28.31   4.55      1      1 11272.33      3      2
```

```
0
```

```
2337  29.79   9.03      1      0 11265.71      3      1
```

```
0
```

```
2338  36.60   5.20      1      3 11264.54      3      2
```

```
1
```

```
2339  35.93   8.30      1      1 11255.29      3      1
```

```
0
```

```
2340  28.60   5.56      1      3 11253.42      3      1
```

```
1
```

```
          R1012  R1013  Heart Issues_yes  Any Transplants_yes  Cancer  
history_Yes \
```

```
6          0      1          0          0
```

```
0
```

```
7          0      1          0          0
```

```
0
```

```
8          1      0          0          0
```

```
0
```

```
9          0      0          0          0
```

```
0
```

```
10         0      0          1          0
```

```
1
```

```
...      ...      ...      ...      ...
```

```
...
```

```
2336         0      0          0          1
```

```
0
```

```
2337         0      0          0          0
```

0				
2338	0	0	1	0
1				
2339	0	0	1	0
0				
2340	0	0	1	0
1				

	NumberOfMajorSurgeries_1	NumberOfMajorSurgeries_2 \
6	0	0
7	0	0
8	0	0
9	0	0
10	1	0
...	...	...
2336	1	0
2337	0	0
2338	1	0
2339	0	0
2340	1	0

	NumberOfMajorSurgeries_3	Age	Gender
6	0	56.0	0
7	0	46.0	0
8	0	47.0	1
9	0	35.0	0
10	0	55.0	1
...	...	...	...
2336	0	20.0	1
2337	0	53.0	0
2338	0	55.0	1
2339	0	43.0	0
2340	0	55.0	1

[2334 rows x 18 columns]>

```
df = df[df['City tier'] != '']
```

```
df.isna().sum()
```

BMI	0
HBA1C	0
smoker	0
children	0
charges	0
Hospital tier	0
City tier	0
R1011	0
R1012	0
R1013	0

```
Heart Issues_yes      0
Any Transplants_yes   0
Cancer history_Yes    0
NumberOfMajorSurgeries_1  0
NumberOfMajorSurgeries_2  0
NumberOfMajorSurgeries_3  0
Age                   0
Gender                0
dtype: int64
```

```
x = df.drop(["charges"], axis=1)
y = df[['charges']]
```

```
from sklearn.preprocessing import StandardScaler
from sklearn.model_selection import train_test_split
```

```
x_train, x_test, y_train, y_test = train_test_split(x,y,
test_size=.20, random_state=10)
```

```
print(x_train.columns)
```

```
Index(['BMI', 'HBA1C', 'smoker', 'children', 'Hospital tier', 'City
tier',
      'R1011', 'R1012', 'R1013', 'Heart Issues_yes', 'Any
Transplants_yes',
      'Cancer history_Yes', 'NumberOfMajorSurgeries_1',
      'NumberOfMajorSurgeries_2', 'NumberOfMajorSurgeries_3', 'Age',
      'Gender'],
      dtype='object')
```

```
sc = StandardScaler()
```

```
df.info()
```

```
<class 'pandas.core.frame.DataFrame'>
```

```
Index: 2333 entries, 6 to 2340
```

```
Data columns (total 18 columns):
```

#	Column	Non-Null Count	Dtype
0	BMI	2333 non-null	float64
1	HBA1C	2333 non-null	float64
2	smoker	2333 non-null	object
3	children	2333 non-null	int64
4	charges	2333 non-null	float64
5	Hospital tier	2333 non-null	object
6	City tier	2333 non-null	object
7	R1011	2333 non-null	int64
8	R1012	2333 non-null	int64
9	R1013	2333 non-null	int64
10	Heart Issues_yes	2333 non-null	int64
11	Any Transplants_yes	2333 non-null	int64



```

12 Cancer_history_Yes      2333 non-null    int64
13 NumberOfMajorSurgeries_1 2333 non-null    int64
14 NumberOfMajorSurgeries_2 2333 non-null    int64
15 NumberOfMajorSurgeries_3 2333 non-null    int64
16 Age                    2333 non-null    float64
17 Gender                  2333 non-null    int64
dtypes: float64(4), int64(11), object(3)
memory usage: 346.3+ KB

x_train = sc.fit_transform(x_train)
x_test = sc.transform(x_test)  # Only transform the test set

from sklearn.linear_model import SGDRegressor

from sklearn.model_selection import GridSearchCV

params = {'alpha': [0.0001, 0.001, 0.01, 0.05, 0.1, 0.2, 0.3, 0.4, 0.5,
                    0.6, 0.7, 0.8, 0.9, 1.0, 2.0, 3.0, 4.0, 5.0, 6.0, 7.0, 8.0,
                    9.0, 10.0, 20, 50, 100, 500, 1000],
          'penalty': ['l2', 'l1', 'elasticnet']}

sgd = SGDRegressor()

# Cross Validation
folds = 5
model_cv = GridSearchCV(estimator = sgd,
                        param_grid = params,
                        scoring = 'neg_mean_absolute_error',
                        cv = folds,
                        return_train_score = True,
                        verbose = 1)
model_cv.fit(x_train, y_train)

Fitting 5 folds for each of 84 candidates, totalling 420 fits

C:\Users\DELL\anaconda3\lib\site-packages\sklearn\utils\
validation.py:1300: DataConversionWarning:

A column-vector y was passed when a 1d array was expected. Please
change the shape of y to (n_samples, ), for example using ravel().

C:\Users\DELL\anaconda3\lib\site-packages\sklearn\utils\
validation.py:1300: DataConversionWarning:

A column-vector y was passed when a 1d array was expected. Please
change the shape of y to (n_samples, ), for example using ravel().

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```

change the shape of y to (n\_samples, ), for example using ravel().

C:\Users\DELL\anaconda3\lib\site-packages\sklearn\utils\validation.py:1300: DataConversionWarning:

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C:\Users\DELL\anaconda3\lib\site-packages\sklearn\utils\validation.py:1300: DataConversionWarning:

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C:\Users\DELL\anaconda3\lib\site-packages\sklearn\utils\validation.py:1300: DataConversionWarning:

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C:\Users\DELL\anaconda3\lib\site-packages\sklearn\utils\validation.py:1300: DataConversionWarning:

A column-vector y was passed when a 1d array was expected. Please change the shape of y to (n\_samples, ), for example using ravel().

C:\Users\DELL\anaconda3\lib\site-packages\sklearn\utils\validation.py:1300: DataConversionWarning:

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C:\Users\DELL\anaconda3\lib\site-packages\sklearn\utils\validation.py:1300: DataConversionWarning:

A column-vector y was passed when a 1d array was expected. Please change the shape of y to (n\_samples, ), for example using ravel().

C:\Users\DELL\anaconda3\lib\site-packages\sklearn\utils\validation.py:1300: DataConversionWarning:

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C:\Users\DELL\anaconda3\lib\site-packages\sklearn\utils\validation.py:1300: DataConversionWarning:

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C:\Users\DELL\anaconda3\lib\site-packages\sklearn\utils\validation.py:1300: DataConversionWarning:

A column-vector y was passed when a 1d array was expected. Please change the shape of y to (n\_samples, ), for example using ravel().

C:\Users\DELL\anaconda3\lib\site-packages\sklearn\utils\validation.py:1300: DataConversionWarning:

A column-vector y was passed when a 1d array was expected. Please

change the shape of y to (n\_samples, ), for example using ravel().

C:\Users\DELL\anaconda3\lib\site-packages\sklearn\utils\validation.py:1300: DataConversionWarning:

A column-vector y was passed when a 1d array was expected. Please change the shape of y to (n\_samples, ), for example using ravel().

C:\Users\DELL\anaconda3\lib\site-packages\sklearn\utils\validation.py:1300: DataConversionWarning:

A column-vector y was passed when a 1d array was expected. Please change the shape of y to (n\_samples, ), for example using ravel().

C:\Users\DELL\anaconda3\lib\site-packages\sklearn\utils\validation.py:1300: DataConversionWarning:

A column-vector y was passed when a 1d array was expected. Please change the shape of y to (n\_samples, ), for example using ravel().

C:\Users\DELL\anaconda3\lib\site-packages\sklearn\utils\validation.py:1300: DataConversionWarning:

A column-vector y was passed when a 1d array was expected. Please change the shape of y to (n\_samples, ), for example using ravel().

C:\Users\DELL\anaconda3\lib\site-packages\sklearn\utils\validation.py:1300: DataConversionWarning:

A column-vector y was passed when a 1d array was expected. Please change the shape of y to (n\_samples, ), for example using ravel().

C:\Users\DELL\anaconda3\lib\site-packages\sklearn\utils\validation.py:1300: DataConversionWarning:

A column-vector y was passed when a 1d array was expected. Please change the shape of y to (n\_samples, ), for example using ravel().

C:\Users\DELL\anaconda3\lib\site-packages\sklearn\utils\validation.py:1300: DataConversionWarning:

A column-vector y was passed when a 1d array was expected. Please change the shape of y to (n\_samples, ), for example using ravel().

C:\Users\DELL\anaconda3\lib\site-packages\sklearn\utils\validation.py:1300: DataConversionWarning:

A column-vector y was passed when a 1d array was expected. Please change the shape of y to (n\_samples, ), for example using ravel().

C:\Users\DELL\anaconda3\lib\site-packages\sklearn\utils\

validation.py:1300: DataConversionWarning:

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```
validation.py:1300: DataConversionWarning:
```

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```

```
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```

```
GridSearchCV(cv=5, estimator=SGDRegressor(),
              param_grid={'alpha': [0.0001, 0.001, 0.01, 0.05, 0.1,
0.2, 0.3,
                                0.4, 0.5, 0.6, 0.7, 0.8, 0.9, 1.0,
2.0, 3.0,
                                4.0, 5.0, 6.0, 7.0, 8.0, 9.0, 10.0,
20, 50,
                                100, 500, 1000]},
              'penalty': ['l2', 'l1', 'elasticnet']},
              return_train_score=True,
              scoring='neg_mean_absolute_error',
              verbose=1)
```

```
model_cv.best_params_
```

```
{'alpha': 3.0, 'penalty': 'l1'}
```

```
sgd = SGDRegressor(alpha=100, penalty='l1')
```

```
sgd.fit(x_train, y_train)
```

```
C:\Users\DELL\anaconda3\lib\site-packages\sklearn\utils\
validation.py:1300: DataConversionWarning:
```

```
A column-vector y was passed when a 1d array was expected. Please
change the shape of y to (n_samples, ), for example using ravel().
```

```
SGDRegressor(alpha=100, penalty='l1')
```

```
sgd.score(x_test, y_test)
```

```
0.810085870773836
```

```
y_pred = sgd.predict(x_test)
```

```
from sklearn.metrics import mean_squared_error, mean_absolute_error
```

```
sgd_mae = mean_absolute_error(y_test, y_pred)
sgd_mse = mean_squared_error(y_test, y_pred)
sgd_rmse = sgd_mse**(1/2.0)
```

```
print("MAE:", sgd_mae)
print("MSE:", sgd_mse)
print("RMSE:", sgd_rmse)
```

```
MAE: 2923.6721318358836
MSE: 23009463.59012837
RMSE: 4796.81806931724
```

```
importance = sgd.coef_
```

```
pd.DataFrame(importance, index = x.columns, columns=['Feature_imp'])
```

	Feature_imp
BMI	2764.605088
HBA1C	105.910182
smoker	9151.729801
children	423.928068
Hospital tier	-1166.132902
City tier	0.000000
R1011	-117.393221
R1012	0.000000
R1013	-238.406365
Heart Issues_yes	0.000000
Any Transplants_yes	0.000000
Cancer history_Yes	0.000000
NumberOfMajorSurgeries_1	0.000000
NumberOfMajorSurgeries_2	42.105197
NumberOfMajorSurgeries_3	0.000000
Age	3207.180952
Gender	0.000000

```
from sklearn.ensemble import RandomForestRegressor
```

```
from sklearn.ensemble import GradientBoostingRegressor
```

```
gbr = GradientBoostingRegressor(n_estimators = 1000, random_state = 42)
```

```
# Train the model on training data
```

```
gbr.fit(x_train, y_train)
```

```
C:\Users\DELL\anaconda3\lib\site-packages\sklearn\ensemble\_gb.py:668:
DataConversionWarning:
```

```
A column-vector y was passed when a 1d array was expected. Please
change the shape of y to (n_samples, ), for example using ravel().
```

```

GradientBoostingRegressor(n_estimators=1000, random_state=42)

score = gbr.score(x_test,y_test)
score
0.8558911769170854

y_pred = gbr.predict(x_test)

gbr_mae = mean_absolute_error(y_test, y_pred)
gbr_mae
2383.382593984613

rf = RandomForestRegressor(n_estimators = 1000, random_state = 42)
rf.fit(x_train, y_train)

C:\Users\DELL\anaconda3\lib\site-packages\sklearn\base.py:1474:
DataConversionWarning:
A column-vector y was passed when a 1d array was expected. Please
change the shape of y to (n_samples,), for example using ravel().

RandomForestRegressor(n_estimators=1000, random_state=42)

score = rf.score(x_test,y_test)
score
0.8765514761902711

y_pred = rf.predict(x_test)

rf_mae = mean_absolute_error(y_test, y_pred)

rf_mae
2020.82529104925

```

Case

```

date = str(19881228)
date1 = pd.to_datetime(date, format = "%Y%m%d")

import datetime as dt

current_date = dt.datetime.now()
current_date

datetime.datetime(2024, 10, 3, 21, 30, 4, 507756)

```

```

date = pd.to_datetime("19881228", format="%Y%m%d")
age = (current_date - date).days
age

13063

age = int(13063/365)
age

35

height_m = 170/100
height_sq = height_m*height_m
BMI = 85/height_sq
np.round(BMI,2)

29.41

list = [[2,1,1,29.41,5.8,0,0,0,0,1,1,0,0,35,0,0,0]]

df.columns
Index(['BMI', 'HBA1C', 'smoker', 'children', 'charges', 'Hospital
tier',
      'City tier', 'R1011', 'R1012', 'R1013', 'Heart Issues_yes',
      'Any Transplants_yes', 'Cancer history_Yes',
      'NumberOfMajorSurgeries_1',
      'NumberOfMajorSurgeries_2', 'NumberOfMajorSurgeries_3', 'Age',
      'Gender'],
      dtype='object')

df = pd.DataFrame(list, columns=['children', 'Hospital tier', 'City
tier', 'BMI', 'HBA1C',
                                'Heart Issues', 'Any Transplants',
                                'Cancer history',
                                'NumberOfMajorSurgeries', 'smoker',
                                'State_ID_R1011',
                                'State_ID_R1012', 'State_ID_R1013',
                                'age', 'gender', 'NumberOfMajorSurgeries_2',
                                'NumberOfMajorSurgeries_3'])
df

```

0	children	Hospital tier	City tier	BMI	HBA1C	Heart Issues	\
0	2	1	1	29.41	5.8	0	
0	Any Transplants	Cancer history	NumberOfMajorSurgeries	smoker	\		
0	0	0	0	0	1		
0	State_ID_R1011	State_ID_R1012	State_ID_R1013	age	gender	\	
0	1	0	0	35	0		

```
    NumberOfMajorSurgeries_2  NumberOfMajorSurgeries_3
0                             0                             0
```

```
Hospital_cost = []
```

```
Cost1 = sgd.predict(df)
Hospital_cost.append(Cost1)
```

```
C:\Users\DELL\anaconda3\lib\site-packages\sklearn\base.py:486:
UserWarning:
```

```
X has feature names, but SGDRegressor was fitted without feature names
```

```
Cost2 = rf.predict(df)
Hospital_cost.append(Cost2)
```

```
C:\Users\DELL\anaconda3\lib\site-packages\sklearn\base.py:486:
UserWarning:
```

```
X has feature names, but RandomForestRegressor was fitted without
feature names
```

```
Cost3 = gbr.predict(df)
Hospital_cost.append(Cost3)
```

```
C:\Users\DELL\anaconda3\lib\site-packages\sklearn\base.py:486:
UserWarning:
```

```
X has feature names, but GradientBoostingRegressor was fitted without
feature names
```

```
avg_cost = np.mean(Hospital_cost)
avg_cost
```

```
38816.15101484794
```