D212 - DataMiningII_PA_jw

March 16, 2024

0.1 D212 - Data Mining II - PA1

0.1.1 Background Info:

You are an analyst on a team of analysts for a popular medical hospital chain with patients in almost every state in the United States. You have been asked to investigate the extent to which readmission is a problem for this chain of hospitals.The purpose of the analysis is to predict readmission based on other conditions and factors of the patient.

You have been asked to use PCA to analyze patient data to identify the principal variables of your patients, ultimately allowing better business and strategic decision-making for the hospital.

Question: "From information about previous patients who were readmitted, can we predict which patients are likely to be readmitted in the future?"

0.1.2 Import Libraries

[93]:
```
import pandas as pd
import seaborn as sns
import numpy as np
from sklearn.cluster import KMeans
from sklearn.preprocessing import LabelEncoder
from sklearn.preprocessing import MinMaxScaler
from sklearn.decomposition import PCA
import matplotlib.pyplot as plt
from sklearn.model_selection import train_test_split
from scipy import stats
%matplotlib inline
```

0.1.3 Load Data From medical_clean.csv

[94]:
```
# load data file
df = pd.read_csv('medical_clean.csv')
# quick test the data is present and see the shape
df.head()
```

[94]:
```
   CaseOrder Customer_id                            Interaction  \
0          1     C412403  8cd49b13-f45a-4b47-a2bd-173ffa932c2f
1          2     Z919181  d2450b70-0337-4406-bdbb-bc1037f1734c
2          3     F995323  a2057123-abf5-4a2c-abad-8ffe33512562
3          4     A879973  1dec528d-eb34-4079-adce-0d7a40e82205
4          5     C544523  5885f56b-d6da-43a3-8760-83583af94266

                                UID          City State        County    Zip  \
0  3a83ddb66e2ae73798bdf1d705dc0932           Eva    AL        Morgan  35621
1  176354c5eef714957d486009feabf195      Marianna    FL       Jackson  32446
2  e19a0fa00aeda885b8a436757e889bc9   Sioux Falls    SD     Minnehaha  57110
3  cd17d7b6d152cb6f23957346d11c3f07  New Richland    MN        Waseca  56072
4  d2f0425877b10ed6bb381f3e2579424a    West Point    VA  King William  23181

        Lat       Lng  …  TotalCharge Additional_charges Item1 Item2  Item3  \
0  34.34960 -86.72508  …  3726.702860       17939.403420     3     3      2
1  30.84513 -85.22907  …  4193.190458       17612.998120     3     4      3
2  43.54321 -96.63772  …  2434.234222       17505.192460     2     4      4
3  43.89744 -93.51479  …  2127.830423       12993.437350     3     5      5
4  37.59894 -76.88958  …  2113.073274        3716.525786     2     1      3

   Item4  Item5 Item6 Item7 Item8
0      2      4     3     3     4
1      4      4     4     3     3
2      4      3     4     3     3
3      3      4     5     5     5
4      3      5     3     4     3

[5 rows x 50 columns]
```

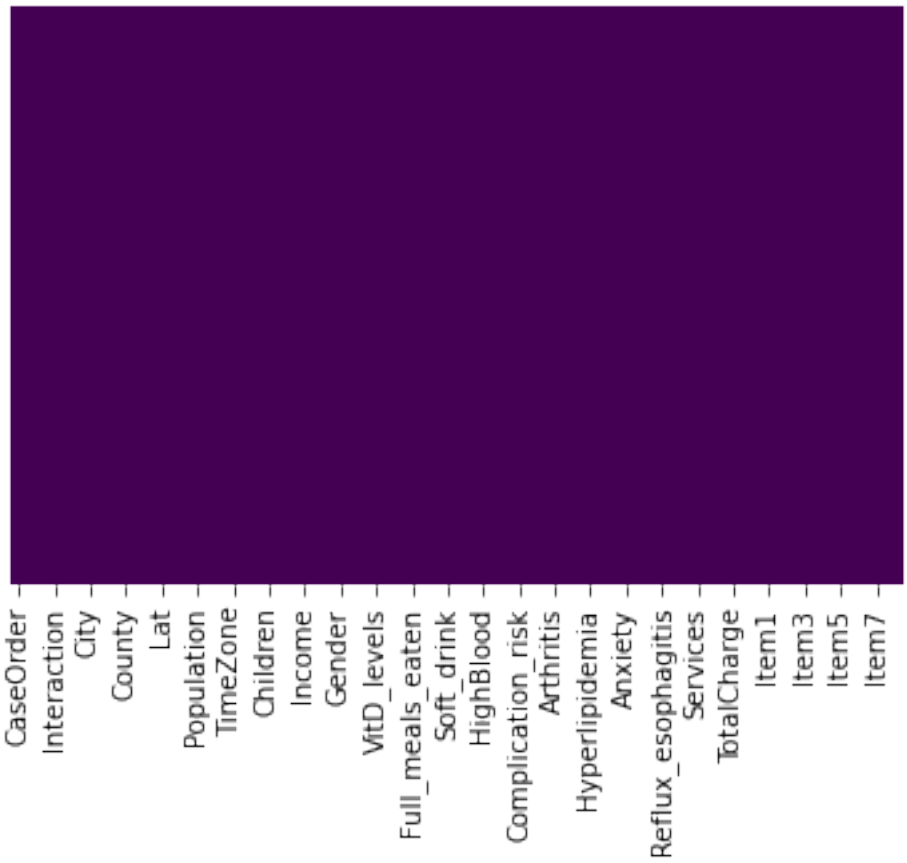
[95]:
```
df.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 10000 entries, 0 to 9999
Data columns (total 50 columns):
 #   Column              Non-Null Count  Dtype
---  ------              --------------  -----
 0   CaseOrder           10000 non-null  int64
 1   Customer_id         10000 non-null  object
 2   Interaction         10000 non-null  object
 3   UID                 10000 non-null  object
 4   City                10000 non-null  object
 5   State               10000 non-null  object
 6   County              10000 non-null  object
 7   Zip                 10000 non-null  int64
 8   Lat                 10000 non-null  float64
 9   Lng                 10000 non-null  float64
```

```
 10  Population          10000 non-null  int64
 11  Area                10000 non-null  object
 12  TimeZone            10000 non-null  object
 13  Job                 10000 non-null  object
 14  Children            10000 non-null  int64
 15  Age                 10000 non-null  int64
 16  Income              10000 non-null  float64
 17  Marital             10000 non-null  object
 18  Gender              10000 non-null  object
 19  ReAdmis             10000 non-null  object
 20  VitD_levels         10000 non-null  float64
 21  Doc_visits          10000 non-null  int64
 22  Full_meals_eaten    10000 non-null  int64
 23  vitD_supp           10000 non-null  int64
 24  Soft_drink          10000 non-null  object
 25  Initial_admin       10000 non-null  object
 26  HighBlood           10000 non-null  object
 27  Stroke              10000 non-null  object
 28  Complication_risk   10000 non-null  object
 29  Overweight          10000 non-null  object
 30  Arthritis           10000 non-null  object
 31  Diabetes            10000 non-null  object
 32  Hyperlipidemia      10000 non-null  object
 33  BackPain            10000 non-null  object
 34  Anxiety             10000 non-null  object
 35  Allergic_rhinitis   10000 non-null  object
 36  Reflux_esophagitis  10000 non-null  object
 37  Asthma              10000 non-null  object
 38  Services            10000 non-null  object
 39  Initial_days        10000 non-null  float64
 40  TotalCharge         10000 non-null  float64
 41  Additional_charges  10000 non-null  float64
 42  Item1               10000 non-null  int64
 43  Item2               10000 non-null  int64
 44  Item3               10000 non-null  int64
 45  Item4               10000 non-null  int64
 46  Item5               10000 non-null  int64
 47  Item6               10000 non-null  int64
 48  Item7               10000 non-null  int64
 49  Item8               10000 non-null  int64
dtypes: float64(7), int64(16), object(27)
memory usage: 3.8+ MB
```

0.1.4 Check for Missing Values

[96]:
```
# Mapping to view missing data...none present.
sns.heatmap(df.isnull(), yticklabels=False, cbar=False, cmap='viridis');
```



[97]:
```
df.describe()
```

[97]:
```
          CaseOrder           Zip           Lat           Lng     Population  \
count  10000.00000  10000.000000  10000.000000  10000.000000   10000.000000
mean    5000.50000  50159.323900     38.751099    -91.243080    9965.253800
std     2886.89568  27469.588208      5.403085     15.205998   14824.758614
min        1.00000    610.000000     17.967190   -174.209700       0.000000
25%     2500.75000  27592.000000     35.255120    -97.352982     694.750000
50%     5000.50000  50207.000000     39.419355    -88.397230    2769.000000
75%     7500.25000  72411.750000     42.044175    -80.438050   13945.000000
max    10000.00000  99929.000000     70.560990    -65.290170  122814.000000

           Children           Age         Income   VitD_levels    Doc_visits  \
count  10000.000000  10000.000000   10000.000000  10000.000000  10000.000000
mean       2.097200     53.511700   40490.495160     17.964262      5.012200
```

```
std        2.163659     20.638538   28521.153293      2.017231      1.045734
min        0.000000     18.000000     154.080000      9.806483      1.000000
25%        0.000000     36.000000   19598.775000     16.626439      4.000000
50%        1.000000     53.000000   33768.420000     17.951122      5.000000
75%        3.000000     71.000000   54296.402500     19.347963      6.000000
max       10.000000     89.000000  207249.100000     26.394449      9.000000

       …   TotalCharge  Additional_charges         Item1         Item2  \
count  …  10000.000000        10000.000000  10000.000000  10000.000000
mean   …   5312.172769        12934.528587      3.518800      3.506700
std    …   2180.393838         6542.601544      1.031966      1.034825
min    …   1938.312067         3125.703000      1.000000      1.000000
25%    …   3179.374015         7986.487755      3.000000      3.000000
50%    …   5213.952000        11573.977735      4.000000      3.000000
75%    …   7459.699750        15626.490000      4.000000      4.000000
max    …   9180.728000        30566.070000      8.000000      7.000000

              Item3         Item4         Item5         Item6         Item7  \
count  10000.000000  10000.000000  10000.000000  10000.000000  10000.000000
mean       3.511100      3.515100      3.496900      3.522500      3.494000
std        1.032755      1.036282      1.030192      1.032376      1.021405
min        1.000000      1.000000      1.000000      1.000000      1.000000
25%        3.000000      3.000000      3.000000      3.000000      3.000000
50%        4.000000      4.000000      3.000000      4.000000      3.000000
75%        4.000000      4.000000      4.000000      4.000000      4.000000
max        8.000000      7.000000      7.000000      7.000000      7.000000

              Item8
count  10000.000000
mean       3.509700
std        1.042312
min        1.000000
25%        3.000000
50%        3.000000
75%        4.000000
max        7.000000

[8 rows x 23 columns]
```

0.1.5 Describe and Explore Numeric Fields:

[98]:
```
df.describe(include = [np.number])
```

[98]:
```
          CaseOrder           Zip           Lat           Lng     Population  \
count  10000.00000  10000.000000  10000.000000  10000.000000   10000.000000
mean    5000.50000  50159.323900     38.751099    -91.243080    9965.253800
std     2886.89568  27469.588208      5.403085     15.205998   14824.758614
```

```
min        1.00000    610.000000     17.967190   -174.209700       0.000000
25%     2500.75000  27592.000000     35.255120    -97.352982     694.750000
50%     5000.50000  50207.000000     39.419355    -88.397230    2769.000000
75%     7500.25000  72411.750000     42.044175    -80.438050   13945.000000
max    10000.00000  99929.000000     70.560990    -65.290170  122814.000000

           Children           Age         Income   VitD_levels    Doc_visits  \
count  10000.000000  10000.000000   10000.000000  10000.000000  10000.000000
mean       2.097200     53.511700   40490.495160     17.964262      5.012200
std        2.163659     20.638538   28521.153293      2.017231      1.045734
min        0.000000     18.000000     154.080000      9.806483      1.000000
25%        0.000000     36.000000   19598.775000     16.626439      4.000000
50%        1.000000     53.000000   33768.420000     17.951122      5.000000
75%        3.000000     71.000000   54296.402500     19.347963      6.000000
max       10.000000     89.000000  207249.100000     26.394449      9.000000

       …   TotalCharge  Additional_charges         Item1         Item2  \
count  …  10000.000000        10000.000000  10000.000000  10000.000000
mean   …   5312.172769        12934.528587      3.518800      3.506700
std    …   2180.393838         6542.601544      1.031966      1.034825
min    …   1938.312067         3125.703000      1.000000      1.000000
25%    …   3179.374015         7986.487755      3.000000      3.000000
50%    …   5213.952000        11573.977735      4.000000      3.000000
75%    …   7459.699750        15626.490000      4.000000      4.000000
max    …   9180.728000        30566.070000      8.000000      7.000000

              Item3         Item4         Item5         Item6         Item7  \
count  10000.000000  10000.000000  10000.000000  10000.000000  10000.000000
mean       3.511100      3.515100      3.496900      3.522500      3.494000
std        1.032755      1.036282      1.030192      1.032376      1.021405
min        1.000000      1.000000      1.000000      1.000000      1.000000
25%        3.000000      3.000000      3.000000      3.000000      3.000000
50%        4.000000      4.000000      3.000000      4.000000      3.000000
75%        4.000000      4.000000      4.000000      4.000000      4.000000
max        8.000000      7.000000      7.000000      7.000000      7.000000

              Item8
count  10000.000000
mean       3.509700
std        1.042312
min        1.000000
25%        3.000000
50%        3.000000
75%        4.000000
max        7.000000

[8 rows x 23 columns]
```

Create DataFrame w/Number DataTypes Only

[99]:
```
df_num = df.select_dtypes(include='number')
df_num.head()
```

[99]:

	CaseOrder	Zip	Lat	Lng	Population	Children	Age	Income	…
0	1	35621	34.34960	-86.72508	2951	1	53	86575.93	
1	2	32446	30.84513	-85.22907	11303	3	51	46805.99	
2	3	57110	43.54321	-96.63772	17125	3	53	14370.14	
3	4	56072	43.89744	-93.51479	2162	0	78	39741.49	
4	5	23181	37.59894	-76.88958	5287	1	22	1209.56	

	VitD_levels	Doc_visits	…	TotalCharge	Additional_charges	Item1	…
0	19.141466	6	…	3726.702860	17939.403420	3	
1	18.940352	4	…	4193.190458	17612.998120	3	
2	18.057507	4	…	2434.234222	17505.192460	2	
3	16.576858	4	…	2127.830423	12993.437350	3	
4	17.439069	5	…	2113.073274	3716.525786	2	

	Item2	Item3	Item4	Item5	Item6	Item7	Item8
0	3	2	2	4	3	3	4
1	4	3	4	4	4	3	3
2	4	4	4	3	4	3	3
3	5	5	3	4	5	5	5
4	1	3	3	5	3	4	3

[5 rows x 23 columns]

0.1.6 Describe and Explore Categorical Fields:

[100]:
```
df.describe(exclude=[np.number])
```

[100]:

	Customer_id	Interaction	…
count	10000	10000	
unique	10000	10000	
top	C412403	8cd49b13-f45a-4b47-a2bd-173ffa932c2f	
freq	1	1	

	UID	City	State	County	Area	…
count	10000	10000	10000	10000	10000	
unique	10000	6072	52	1607	3	
top	3a83ddb66e2ae73798bdf1d705dc0932	Houston	TX	Jefferson	Rural	
freq	1	36	553	118	3369	

	TimeZone	Job	Marital	…
count	10000	10000	10000	…
unique	26	639	5	…
top	America/New_York	Outdoor activities/education manager	Widowed	…

```
freq                3889                                    29     2045  …

       Overweight Arthritis Diabetes Hyperlipidemia BackPain Anxiety  \
count       10000     10000    10000          10000    10000   10000
unique          2         2        2              2        2       2
top           Yes        No       No             No       No      No
freq         7094      6426     7262           6628     5886    6785

       Allergic_rhinitis Reflux_esophagitis Asthma    Services
count              10000               10000  10000       10000
unique                 2                   2      2           4
top                   No                  No     No  Blood Work
freq                6059                5865   7107        5265

[4 rows x 27 columns]
```

Create DataFrame w/Categorical DataTypes Only

[101]:
```
df_cat = df.select_dtypes(exclude='number')
df_cat.head()
```

[101]:
```
  Customer_id                           Interaction  \
0     C412403  8cd49b13-f45a-4b47-a2bd-173ffa932c2f
1     Z919181  d2450b70-0337-4406-bdbb-bc1037f1734c
2     F995323  a2057123-abf5-4a2c-abad-8ffe33512562
3     A879973  1dec528d-eb34-4079-adce-0d7a40e82205
4     C544523  5885f56b-d6da-43a3-8760-83583af94266

                                UID          City State        County  \
0  3a83ddb66e2ae73798bdf1d705dc0932           Eva    AL       Morgan
1  176354c5eef714957d486009feabf195      Marianna    FL      Jackson
2  e19a0fa00aeda885b8a436757e889bc9   Sioux Falls    SD    Minnehaha
3  cd17d7b6d152cb6f23957346d11c3f07  New Richland    MN       Waseca
4  d2f0425877b10ed6bb381f3e2579424a    West Point    VA  King William

       Area          TimeZone                                Job   Marital  \
0  Suburban   America/Chicago  Psychologist, sport and exercise  Divorced
1     Urban   America/Chicago      Community development worker   Married
2  Suburban   America/Chicago           Chief Executive Officer   Widowed
3  Suburban   America/Chicago               Early years teacher   Married
4     Rural  America/New_York       Health promotion specialist   Widowed

   … Overweight Arthritis Diabetes Hyperlipidemia BackPain Anxiety  \
0  …         No       Yes      Yes             No      Yes     Yes
1  …        Yes        No       No             No       No      No
2  …        Yes        No      Yes             No       No      No
3  …         No       Yes       No             No       No      No
```

```
4  …         No        No       No             Yes       No      No

  Allergic_rhinitis Reflux_esophagitis Asthma     Services
0               Yes                  No    Yes   Blood Work
1                No                 Yes     No  Intravenous
2                No                  No     No   Blood Work
3                No                 Yes    Yes   Blood Work
4               Yes                  No     No      CT Scan

[5 rows x 27 columns]
```

Describe Readmissions

[104]:
```
df[['ReAdmis']].describe()
```

[104]:
```
       ReAdmis
count    10000
unique       2
top         No
freq      6331
```

[105]:
```
df.columns
```

[105]:
```
Index(['CaseOrder', 'Customer_id', 'Interaction', 'UID', 'City', 'State',
       'County', 'Zip', 'Lat', 'Lng', 'Population', 'Area', 'TimeZone', 'Job',
       'Children', 'Age', 'Income', 'Marital', 'Gender', 'ReAdmis',
       'VitD_levels', 'Doc_visits', 'Full_meals_eaten', 'vitD_supp',
       'Soft_drink', 'Initial_admin', 'HighBlood', 'Stroke',
       'Complication_risk', 'Overweight', 'Arthritis', 'Diabetes',
       'Hyperlipidemia', 'BackPain', 'Anxiety', 'Allergic_rhinitis',
       'Reflux_esophagitis', 'Asthma', 'Services', 'Initial_days',
       'TotalCharge', 'Additional_charges', 'Item1', 'Item2', 'Item3', 'Item4',
       'Item5', 'Item6', 'Item7', 'Item8'],
      dtype='object')
```

0.1.7 Prep Dummies Data

[106]:
```
df_temp = df[['Age', 'Gender', 'ReAdmis', 'VitD_levels', 'Doc_visits',␣
 ↪'vitD_supp', 'Initial_admin', \
              'HighBlood', 'Stroke', 'Complication_risk', 'Overweight',␣
 ↪'Arthritis', 'Diabetes', 'Hyperlipidemia', \
              'BackPain', 'Anxiety', 'Allergic_rhinitis', 'Reflux_esophagitis',␣
 ↪'Asthma', 'Services', 'Initial_days', \
              'TotalCharge', 'Additional_charges']]
```

[107]:
```
df_dummies = pd.get_dummies(df_temp)
df_dummies.head()
```

[107]:
```
   Age  VitD_levels  Doc_visits  vitD_supp  Initial_days  TotalCharge  \
0   53    19.141466           6          0     10.585770  3726.702860
1   51    18.940352           4          1     15.129562  4193.190458
2   53    18.057507           4          0      4.772177  2434.234222
3   78    16.576858           4          0      1.714879  2127.830423
4   22    17.439069           5          2      1.254807  2113.073274

   Additional_charges  Gender_Female  Gender_Male  Gender_Nonbinary  …  \
0        17939.403420              0            1                 0  …
1        17612.998120              1            0                 0  …
2        17505.192460              1            0                 0  …
3        12993.437350              0            1                 0  …
4         3716.525786              1            0                 0  …

   Allergic_rhinitis_No  Allergic_rhinitis_Yes  Reflux_esophagitis_No  \
0                     0                      1                      1
1                     1                      0                      0
2                     1                      0                      1
3                     1                      0                      0
4                     0                      1                      1

   Reflux_esophagitis_Yes  Asthma_No  Asthma_Yes  Services_Blood Work  \
0                       0          0           1                    1
1                       1          1           0                    0
2                       0          1           0                    1
3                       1          0           1                    1
4                       0          1           0                    0

   Services_CT Scan  Services_Intravenous  Services_MRI
0                 0                     0             0
1                 0                     1             0
2                 0                     0             0
3                 0                     0             0
4                 1                     0             0

[5 rows x 44 columns]
```

[108]:
```
df_dummies.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 10000 entries, 0 to 9999
Data columns (total 44 columns):
 #   Column                              Non-Null Count  Dtype
---  ------                              --------------  -----
 0   Age                                 10000 non-null  int64
 1   VitD_levels                         10000 non-null  float64
 2   Doc_visits                          10000 non-null  int64
```

```
 3   vitD_supp                              10000 non-null  int64
 4   Initial_days                           10000 non-null  float64
 5   TotalCharge                            10000 non-null  float64
 6   Additional_charges                     10000 non-null  float64
 7   Gender_Female                          10000 non-null  uint8
 8   Gender_Male                            10000 non-null  uint8
 9   Gender_Nonbinary                       10000 non-null  uint8
 10  ReAdmis_No                             10000 non-null  uint8
 11  ReAdmis_Yes                            10000 non-null  uint8
 12  Initial_admin_Elective Admission       10000 non-null  uint8
 13  Initial_admin_Emergency Admission      10000 non-null  uint8
 14  Initial_admin_Observation Admission    10000 non-null  uint8
 15  HighBlood_No                           10000 non-null  uint8
 16  HighBlood_Yes                          10000 non-null  uint8
 17  Stroke_No                              10000 non-null  uint8
 18  Stroke_Yes                             10000 non-null  uint8
 19  Complication_risk_High                 10000 non-null  uint8
 20  Complication_risk_Low                  10000 non-null  uint8
 21  Complication_risk_Medium               10000 non-null  uint8
 22  Overweight_No                          10000 non-null  uint8
 23  Overweight_Yes                         10000 non-null  uint8
 24  Arthritis_No                           10000 non-null  uint8
 25  Arthritis_Yes                          10000 non-null  uint8
 26  Diabetes_No                            10000 non-null  uint8
 27  Diabetes_Yes                           10000 non-null  uint8
 28  Hyperlipidemia_No                      10000 non-null  uint8
 29  Hyperlipidemia_Yes                     10000 non-null  uint8
 30  BackPain_No                            10000 non-null  uint8
 31  BackPain_Yes                           10000 non-null  uint8
 32  Anxiety_No                             10000 non-null  uint8
 33  Anxiety_Yes                            10000 non-null  uint8
 34  Allergic_rhinitis_No                   10000 non-null  uint8
 35  Allergic_rhinitis_Yes                  10000 non-null  uint8
 36  Reflux_esophagitis_No                  10000 non-null  uint8
 37  Reflux_esophagitis_Yes                 10000 non-null  uint8
 38  Asthma_No                              10000 non-null  uint8
 39  Asthma_Yes                             10000 non-null  uint8
 40  Services_Blood Work                    10000 non-null  uint8
 41  Services_CT Scan                       10000 non-null  uint8
 42  Services_Intravenous                   10000 non-null  uint8
 43  Services_MRI                           10000 non-null  uint8
dtypes: float64(4), int64(3), uint8(37)
memory usage: 908.3 KB
```

Describe Columns

[109]:
```
df_dummies.columns
```

[109]:
```
Index(['Age', 'VitD_levels', 'Doc_visits', 'vitD_supp', 'Initial_days',
       'TotalCharge', 'Additional_charges', 'Gender_Female', 'Gender_Male',
       'Gender_Nonbinary', 'ReAdmis_No', 'ReAdmis_Yes',
       'Initial_admin_Elective Admission', 'Initial_admin_Emergency Admission',
       'Initial_admin_Observation Admission', 'HighBlood_No', 'HighBlood_Yes',
       'Stroke_No', 'Stroke_Yes', 'Complication_risk_High',
       'Complication_risk_Low', 'Complication_risk_Medium', 'Overweight_No',
       'Overweight_Yes', 'Arthritis_No', 'Arthritis_Yes', 'Diabetes_No',
       'Diabetes_Yes', 'Hyperlipidemia_No', 'Hyperlipidemia_Yes',
       'BackPain_No', 'BackPain_Yes', 'Anxiety_No', 'Anxiety_Yes',
       'Allergic_rhinitis_No', 'Allergic_rhinitis_Yes',
       'Reflux_esophagitis_No', 'Reflux_esophagitis_Yes', 'Asthma_No',
       'Asthma_Yes', 'Services_Blood Work', 'Services_CT Scan',
       'Services_Intravenous', 'Services_MRI'],
      dtype='object')
```

0.1.8 Keep Only Necessary Columns

[113]:
```
# Start pruning non-relavent features
# Create target and predictor series
pca_df_target = df_dummies['ReAdmis_Yes']
pca_df = df.drop(['CaseOrder', 'Interaction','Customer_id', 'UID', 'Job',␣
 ↪'Zip', 'City', 'County','ReAdmis','Item1', 'Item2', 'Item3',␣
 ↪'Item4','Item5', 'Item6', 'Item7', 'Item8'], axis=1)
pca_df_target.info()
print('---'*5)
pca_df.columns
```

```
<class 'pandas.core.series.Series'>
RangeIndex: 10000 entries, 0 to 9999
Series name: ReAdmis_Yes
Non-Null Count  Dtype
--------------  -----
10000 non-null  uint8
dtypes: uint8(1)
memory usage: 9.9 KB
---------------
```

[113]:
```
Index(['State', 'Lat', 'Lng', 'Population', 'Area', 'TimeZone', 'Children',
       'Age', 'Income', 'Marital', 'Gender', 'VitD_levels', 'Doc_visits',
       'Full_meals_eaten', 'vitD_supp', 'Soft_drink', 'Initial_admin',
       'HighBlood', 'Stroke', 'Complication_risk', 'Overweight', 'Arthritis',
       'Diabetes', 'Hyperlipidemia', 'BackPain', 'Anxiety',
       'Allergic_rhinitis', 'Reflux_esophagitis', 'Asthma', 'Services',
       'Initial_days', 'TotalCharge', 'Additional_charges'],
      dtype='object')
```

[114]:
```
# testing how to identify categorical data
for t in pca_df.dtypes:
    if t == "float64":
        print("yes")
```

```
yes
yes
yes
yes
yes
yes
yes
```

[115]:
```
pca_df.dtypes
```

[115]:
```
State                object
Lat                 float64
Lng                 float64
Population            int64
Area                 object
TimeZone             object
Children              int64
Age                   int64
Income              float64
Marital              object
Gender               object
VitD_levels         float64
Doc_visits            int64
Full_meals_eaten      int64
vitD_supp             int64
Soft_drink           object
Initial_admin        object
HighBlood            object
Stroke               object
Complication_risk    object
Overweight           object
Arthritis            object
Diabetes             object
Hyperlipidemia       object
BackPain             object
Anxiety              object
Allergic_rhinitis    object
Reflux_esophagitis   object
Asthma               object
Services             object
Initial_days        float64
TotalCharge         float64
```

```
Additional_charges    float64
dtype: object
```

0.1.9 Create Dummies Function for specific datatypes, reduce multicoliniarity

[116]:
```
def dummify(df, max_cols=10):
    # Get list of orig df cols
    df_cols = df.columns
    # Make copy of df
    df_dummy=df.copy()
    # ForEach Col, check if numeric.  If no, convert to binary
    for t in df_cols:
        if str(df_dummy[t].dtypes) not in ['float64', 'int64']:  # if numeric␣
 ↪var dissapears, check dtypes and add new ones as needed.
            # take non numerics, set (unique) list, then sort
            val_list = sorted(list(set(df_dummy[t])))
            if len(val_list) > 1 and len(val_list) <= max_cols:
                for v in val_list[1:]: # make 'no' the dummy var
                    df_dummy[t+"__"+str(v)]=df_dummy[t].apply(lambda x: 1 if x␣
 ↪== v else 0)
            df_dummy.drop([t],axis=1, inplace=True)
    return df_dummy
```

[117]:
```
pca_df_binary = dummify(pca_df)
pca_df_binary.head()
```

[117]:

	Lat	Lng	Population	Children	Age	Income	VitD_levels	\
0	34.34960	-86.72508	2951	1	53	86575.93	19.141466	
1	30.84513	-85.22907	11303	3	51	46805.99	18.940352	
2	43.54321	-96.63772	17125	3	53	14370.14	18.057507	
3	43.89744	-93.51479	2162	0	78	39741.49	16.576858	
4	37.59894	-76.88958	5287	1	22	1209.56	17.439069	

	Doc_visits	Full_meals_eaten	vitD_supp	…	Diabetes__Yes	\
0	6	0	0	…	1	
1	4	2	1	…	0	
2	4	1	0	…	1	
3	4	1	0	…	0	
4	5	0	2	…	0	

	Hyperlipidemia__Yes	BackPain__Yes	Anxiety__Yes	Allergic_rhinitis__Yes	\
0	0	1	1	1	
1	0	0	0	0	
2	0	0	0	0	
3	0	0	0	0	
4	1	0	0	1	

```
   Reflux_esophagitis__Yes  Asthma__Yes  Services__CT Scan  \
0                        0            1                  0
1                        1            0                  0
2                        0            0                  0
3                        1            1                  0
4                        0            0                  1

   Services__Intravenous  Services__MRI
0                      0              0
1                      1              0
2                      0              0
3                      0              0
4                      0              0

[5 rows x 40 columns]
```

[118]:
```
pca_df_binary.columns
```

[118]:
```
Index(['Lat', 'Lng', 'Population', 'Children', 'Age', 'Income', 'VitD_levels',
       'Doc_visits', 'Full_meals_eaten', 'vitD_supp', 'Initial_days',
       'TotalCharge', 'Additional_charges', 'Area__Suburban', 'Area__Urban',
       'Marital__Married', 'Marital__Never Married', 'Marital__Separated',
       'Marital__Widowed', 'Gender__Male', 'Gender__Nonbinary',
       'Soft_drink__Yes', 'Initial_admin__Emergency Admission',
       'Initial_admin__Observation Admission', 'HighBlood__Yes', 'Stroke__Yes',
       'Complication_risk__Low', 'Complication_risk__Medium',
       'Overweight__Yes', 'Arthritis__Yes', 'Diabetes__Yes',
       'Hyperlipidemia__Yes', 'BackPain__Yes', 'Anxiety__Yes',
       'Allergic_rhinitis__Yes', 'Reflux_esophagitis__Yes', 'Asthma__Yes',
       'Services__CT Scan', 'Services__Intravenous', 'Services__MRI'],
      dtype='object')
```

[164]:
```
print('pca_df_target: ' + str(pca_df_target.shape))
print('------'*5)
print('pca_df_binary: ' + str(pca_df_binary.shape))
```

```
pca_df_target: (10000,)
------------------------------
pca_df_binary: (10000, 40)
```

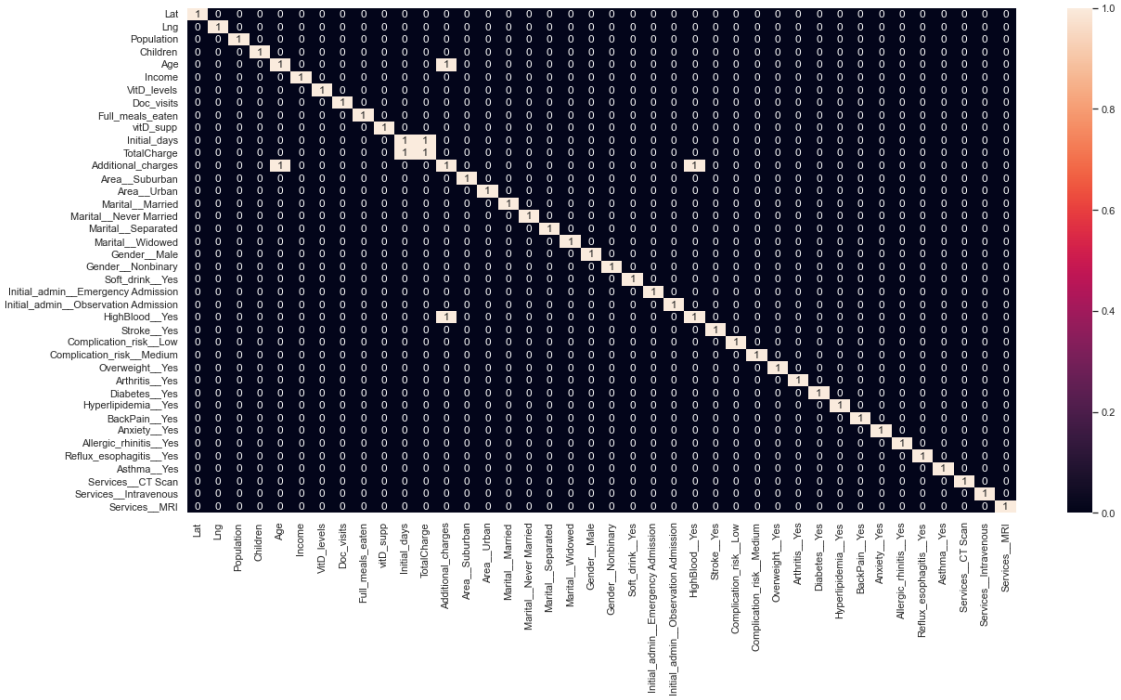
[169]:
```
print('pca_df_target: ' + str(pca_df_target.info()))
print('-------'*10)
print('pca_df_binary: ' + str(pca_df_binary.info()))
```

```
<class 'pandas.core.series.Series'>
RangeIndex: 10000 entries, 0 to 9999
Series name: ReAdmis_Yes
```

```
Non-Null Count  Dtype
--------------  -----
10000 non-null  uint8
dtypes: uint8(1)
memory usage: 9.9 KB
pca_df_target: None
------------------------------------------------------------------------
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 10000 entries, 0 to 9999
Data columns (total 40 columns):
 #   Column                                 Non-Null Count  Dtype
---  ------                                 --------------  -----
 0   Lat                                    10000 non-null  float64
 1   Lng                                    10000 non-null  float64
 2   Population                             10000 non-null  int64
 3   Children                               10000 non-null  int64
 4   Age                                    10000 non-null  int64
 5   Income                                 10000 non-null  float64
 6   VitD_levels                            10000 non-null  float64
 7   Doc_visits                             10000 non-null  int64
 8   Full_meals_eaten                       10000 non-null  int64
 9   vitD_supp                              10000 non-null  int64
 10  Initial_days                           10000 non-null  float64
 11  TotalCharge                            10000 non-null  float64
 12  Additional_charges                     10000 non-null  float64
 13  Area__Suburban                         10000 non-null  int64
 14  Area__Urban                            10000 non-null  int64
 15  Marital__Married                       10000 non-null  int64
 16  Marital__Never Married                 10000 non-null  int64
 17  Marital__Separated                     10000 non-null  int64
 18  Marital__Widowed                       10000 non-null  int64
 19  Gender__Male                           10000 non-null  int64
 20  Gender__Nonbinary                      10000 non-null  int64
 21  Soft_drink__Yes                        10000 non-null  int64
 22  Initial_admin__Emergency Admission     10000 non-null  int64
 23  Initial_admin__Observation Admission   10000 non-null  int64
 24  HighBlood__Yes                         10000 non-null  int64
 25  Stroke__Yes                            10000 non-null  int64
 26  Complication_risk__Low                 10000 non-null  int64
 27  Complication_risk__Medium              10000 non-null  int64
 28  Overweight__Yes                        10000 non-null  int64
 29  Arthritis__Yes                         10000 non-null  int64
 30  Diabetes__Yes                          10000 non-null  int64
 31  Hyperlipidemia__Yes                    10000 non-null  int64
 32  BackPain__Yes                          10000 non-null  int64
 33  Anxiety__Yes                           10000 non-null  int64
 34  Allergic_rhinitis__Yes                 10000 non-null  int64
 35  Reflux_esophagitis__Yes                10000 non-null  int64
```

```
 36  Asthma__Yes                          10000 non-null  int64
 37  Services__CT Scan                    10000 non-null  int64
 38  Services__Intravenous                10000 non-null  int64
 39  Services__MRI                        10000 non-null  int64
dtypes: float64(7), int64(33)
memory usage: 3.1 MB
pca_df_binary: None
```

[123]:
```
# Trying to make sense of numerical values, discover possible correlations
# Ref1: https://www.geeksforgeeks.org/
  ↪how-to-create-a-seaborn-correlation-heatmap-in-python/
# Ref2: https://medium.com/@szabo.bibor/
  ↪how-to-create-a-seaborn-correlation-heatmap-in-python-834c0686b88e
sns.set(rc = {'figure.figsize':(20,10)})
sns.heatmap(pca_df_binary.corr() > .5, annot=True);
```



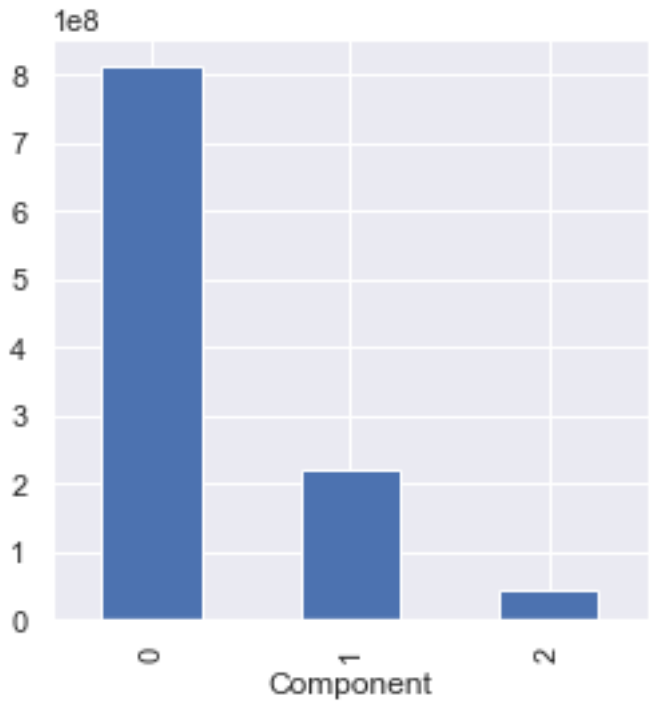
0.1.10 PCA Implementation:

[124]:
```
pcs = PCA(n_components=3)
pcs.fit(pca_df_binary)
loadings = pd.DataFrame(pcs.components_, columns=pca_df_binary.columns)
loadings
```

[124]:
```
        Lat           Lng  Population      Children       Age    Income  \
0 -0.000004 -3.587261e-06    0.003865  5.440645e-07 -0.000009  0.999989
1 -0.000076 -3.275443e-05    0.999985  3.507066e-07 -0.000027 -0.003868
2 -0.000003 -4.845344e-07    0.002573  4.538820e-06  0.002261  0.002384

    VitD_levels    Doc_visits  Full_meals_eaten     vitD_supp  …  \
0 -9.275008e-07  4.944224e-07     -4.038341e-07  2.789781e-08  …
1  3.726890e-07  8.841811e-07     -1.737526e-06  4.140808e-07  …
2  2.517049e-06  1.321269e-06      2.841736e-06  1.004700e-06  …

   Diabetes__Yes  Hyperlipidemia__Yes  BackPain__Yes  Anxiety__Yes  \
0  -1.585349e-07         1.434973e-07   1.716768e-07 -8.791170e-09
1  -2.977246e-07        -2.001532e-07   2.111729e-07 -4.611059e-07
2   1.586958e-07        -1.703362e-07   1.091828e-06  8.344441e-07

   Allergic_rhinitis__Yes  Reflux_esophagitis__Yes   Asthma__Yes  \
0           -2.391705e-08             2.854271e-07  9.372176e-08
1            2.531932e-07             4.731246e-07 -4.820788e-08
2            1.213957e-06            -8.320508e-07  9.760384e-07

   Services__CT Scan  Services__Intravenous  Services__MRI
0      -9.022682e-08           1.085814e-07  -1.665732e-08
1      -1.548047e-07          -3.278339e-08  -1.475024e-07
2       6.540989e-07          -7.727223e-08   2.942486e-07

[3 rows x 40 columns]
```

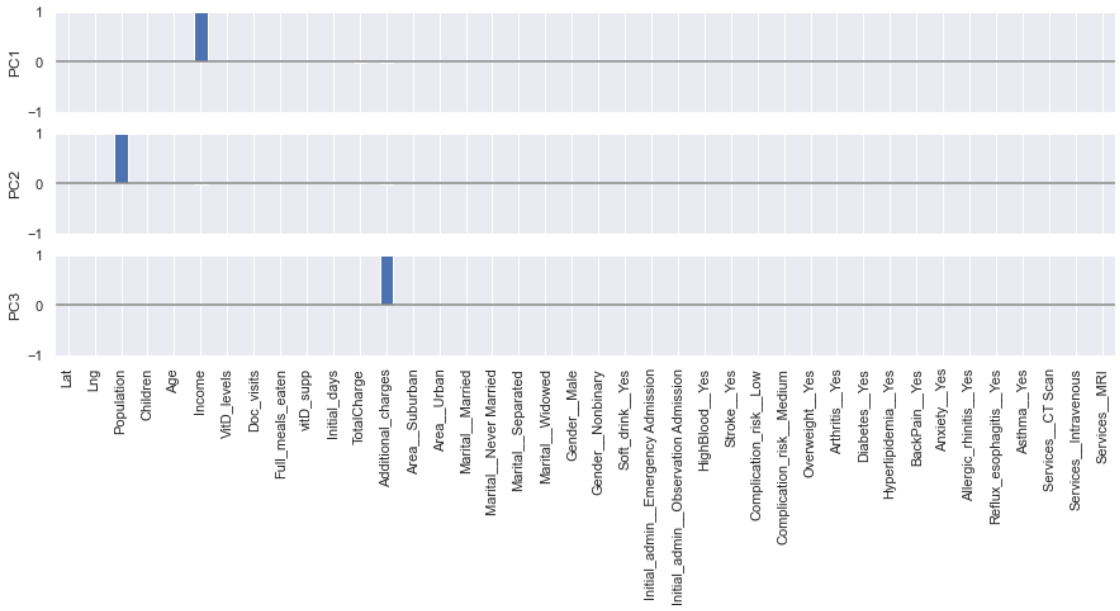
[125]:
```
# Tested...3 seems best
explained_variance = pd.DataFrame(pcs.explained_variance_)
ax = explained_variance.head(10).plot.bar(legend=False, figsize=(4, 4))
ax.set_xlabel('Component')
```

[125]:
```
Text(0.5, 0, 'Component')
```



[300]:
```
pcs.components_.shape;
```

[301]:
```
# ref: https://learning.oreilly.com/library/view/practical-statistics-for/
 ↪9781492072935/ch07.html#idm45782023655048

pcs_c_n=pcs.components_.shape[0]
loadings = pd.DataFrame(pcs.components_[0:pcs_c_n, :], columns=pca_df_binary.
 ↪columns)
maxPC = 1.01 * np.max(np.max(np.abs(loadings.loc[0:pcs_c_n, :])))

f, axes = plt.subplots(pcs_c_n, 1, figsize=(15, 5), sharex=True)
for i, ax in enumerate(axes):
    pc_loadings = loadings.loc[i, :]
    colors = ['C0' if l > 0 else 'C1' for l in pc_loadings]
    ax.axhline(color='#888888')
    pc_loadings.plot.bar(ax=ax, color=colors)
    ax.set_ylabel(f'PC{i+1}')
    ax.set_ylim(-maxPC, maxPC);
```



0.1.11 K-Means Clustering

[262]:
```
# http://mlreference.com/k-means-standardization-sklearn
# Preprocessing - Standardize Data

# Create the scalar.
from sklearn.preprocessing import StandardScaler

scaler = StandardScaler().fit(pca_df_binary)

# Standardize the columns.
pca_df_binary_standardized = pca_df_binary.copy()
standardized_data = scaler.transform(pca_df_binary)
pca_df_binary_standardized[pca_df_binary_standardized.columns] =␣
 ↪standardized_data
pca_df_binary_standardized.head()
```

[262]:

	Lat	Lng	Population	Children	Age	Income	VitD_levels	\
0	-0.814668	0.297134	-0.473168	-0.507129	-0.024795	1.615914	0.583603	
1	-1.463305	0.395522	0.090242	0.417277	-0.121706	0.221443	0.483901	
2	0.886966	-0.354788	0.482983	0.417277	-0.024795	-0.915870	0.046227	
3	0.952530	-0.149403	-0.526393	-0.969332	1.186592	-0.026263	-0.687811	
4	-0.213252	0.943984	-0.315586	-0.507129	-1.526914	-1.377325	-0.260366	

	Doc_visits	Full_meals_eaten	vitD_supp	…	Diabetes__Yes	\
0	0.944647	-0.993387	-0.634713	…	1.628589	

```
1   -0.967981          0.990609   0.956445  …      -0.614029
2   -0.967981         -0.001389  -0.634713  …       1.628589
3   -0.967981         -0.001389  -0.634713  …      -0.614029
4   -0.011667         -0.993387   2.547602  …      -0.614029

   Hyperlipidemia__Yes  BackPain__Yes  Anxiety__Yes  Allergic_rhinitis__Yes  \
0            -0.713268       1.196129      1.452728                1.239930
1            -0.713268      -0.836030     -0.688360               -0.806497
2            -0.713268      -0.836030     -0.688360               -0.806497
3            -0.713268      -0.836030     -0.688360               -0.806497
4             1.401998      -0.836030     -0.688360                1.239930

   Reflux_esophagitis__Yes  Asthma__Yes  Services__CT Scan  \
0                -0.839661     1.567361          -0.373632
1                 1.190957    -0.638015          -0.373632
2                -0.839661    -0.638015          -0.373632
3                 1.190957     1.567361          -0.373632
4                -0.839661    -0.638015           2.676428

   Services__Intravenous  Services__MRI
0              -0.674985      -0.198749
1               1.481516      -0.198749
2              -0.674985      -0.198749
3              -0.674985      -0.198749
4              -0.674985      -0.198749

[5 rows x 40 columns]
```

0.2 Set n_clusters

[290]:
```
# Clusters --> ReAdmin vs Not ReAdmitted
kmeans = KMeans(n_clusters=2, init='k-means++', random_state=73).
 ↪fit(pca_df_binary_standardized)
```

[291]:
```
pca_df_binary_standardized['cluster'] = kmeans.labels_
pca_df_binary_standardized.head()
```

[291]:
```
        Lat       Lng  Population  Children       Age    Income  VitD_levels  \
0 -0.814668  0.297134   -0.473168 -0.507129 -0.024795  1.615914     0.583603
1 -1.463305  0.395522    0.090242  0.417277 -0.121706  0.221443     0.483901
2  0.886966 -0.354788    0.482983  0.417277 -0.024795 -0.915870     0.046227
3  0.952530 -0.149403   -0.526393 -0.969332  1.186592 -0.026263    -0.687811
4 -0.213252  0.943984   -0.315586 -0.507129 -1.526914 -1.377325    -0.260366

   Doc_visits  Full_meals_eaten  vitD_supp  …  Hyperlipidemia__Yes  \
0    0.944647         -0.993387  -0.634713  …            -0.713268
1   -0.967981          0.990609   0.956445  …            -0.713268
```

```
2   -0.967981         -0.001389  -0.634713  …            -0.713268
3   -0.967981         -0.001389  -0.634713  …            -0.713268
4   -0.011667         -0.993387   2.547602  …             1.401998

   BackPain__Yes  Anxiety__Yes  Allergic_rhinitis__Yes  \
0       1.196129      1.452728                1.239930
1      -0.836030     -0.688360               -0.806497
2      -0.836030     -0.688360               -0.806497
3      -0.836030     -0.688360               -0.806497
4      -0.836030     -0.688360                1.239930

   Reflux_esophagitis__Yes  Asthma__Yes  Services__CT Scan  \
0                -0.839661     1.567361          -0.373632
1                 1.190957    -0.638015          -0.373632
2                -0.839661    -0.638015          -0.373632
3                 1.190957     1.567361          -0.373632
4                -0.839661    -0.638015           2.676428

   Services__Intravenous  Services__MRI  cluster
0              -0.674985      -0.198749        0
1               1.481516      -0.198749        0
2              -0.674985      -0.198749        0
3              -0.674985      -0.198749        0
4              -0.674985      -0.198749        0

[5 rows x 41 columns]
```

[226]:
```
pca_df_binary_standardized.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 10000 entries, 0 to 9999
Data columns (total 40 columns):
 #   Column                                Non-Null Count  Dtype
---  ------                                --------------  -----
 0   Lat                                   10000 non-null  float64
 1   Lng                                   10000 non-null  float64
 2   Population                            10000 non-null  float64
 3   Children                              10000 non-null  float64
 4   Age                                   10000 non-null  float64
 5   Income                                10000 non-null  float64
 6   VitD_levels                           10000 non-null  float64
 7   Doc_visits                            10000 non-null  float64
 8   Full_meals_eaten                      10000 non-null  float64
 9   vitD_supp                             10000 non-null  float64
 10  Initial_days                          10000 non-null  float64
 11  TotalCharge                           10000 non-null  float64
 12  Additional_charges                    10000 non-null  float64
```

```
 13  Area__Suburban                          10000 non-null  float64
 14  Area__Urban                             10000 non-null  float64
 15  Marital__Married                        10000 non-null  float64
 16  Marital__Never Married                  10000 non-null  float64
 17  Marital__Separated                      10000 non-null  float64
 18  Marital__Widowed                        10000 non-null  float64
 19  Gender__Male                            10000 non-null  float64
 20  Gender__Nonbinary                       10000 non-null  float64
 21  Soft_drink__Yes                         10000 non-null  float64
 22  Initial_admin__Emergency Admission      10000 non-null  float64
 23  Initial_admin__Observation Admission    10000 non-null  float64
 24  HighBlood__Yes                          10000 non-null  float64
 25  Stroke__Yes                             10000 non-null  float64
 26  Complication_risk__Low                  10000 non-null  float64
 27  Complication_risk__Medium               10000 non-null  float64
 28  Overweight__Yes                         10000 non-null  float64
 29  Arthritis__Yes                          10000 non-null  float64
 30  Diabetes__Yes                           10000 non-null  float64
 31  Hyperlipidemia__Yes                     10000 non-null  float64
 32  BackPain__Yes                           10000 non-null  float64
 33  Anxiety__Yes                            10000 non-null  float64
 34  Allergic_rhinitis__Yes                  10000 non-null  float64
 35  Reflux_esophagitis__Yes                 10000 non-null  float64
 36  Asthma__Yes                             10000 non-null  float64
 37  Services__CT Scan                       10000 non-null  float64
 38  Services__Intravenous                   10000 non-null  float64
 39  Services__MRI                           10000 non-null  float64
dtypes: float64(40)
memory usage: 3.1 MB
```

[227]:
```
# Identify cluster
df_cluster = pca_df_binary_standardized.copy()

df_cluster['cluster'] = kmeans.labels_
df_cluster.head()
```

[227]:

	Lat	Lng	Population	Children	Age	Income	VitD_levels	\
0	-0.814668	0.297134	-0.473168	-0.507129	-0.024795	1.615914	0.583603	
1	-1.463305	0.395522	0.090242	0.417277	-0.121706	0.221443	0.483901	
2	0.886966	-0.354788	0.482983	0.417277	-0.024795	-0.915870	0.046227	
3	0.952530	-0.149403	-0.526393	-0.969332	1.186592	-0.026263	-0.687811	
4	-0.213252	0.943984	-0.315586	-0.507129	-1.526914	-1.377325	-0.260366	

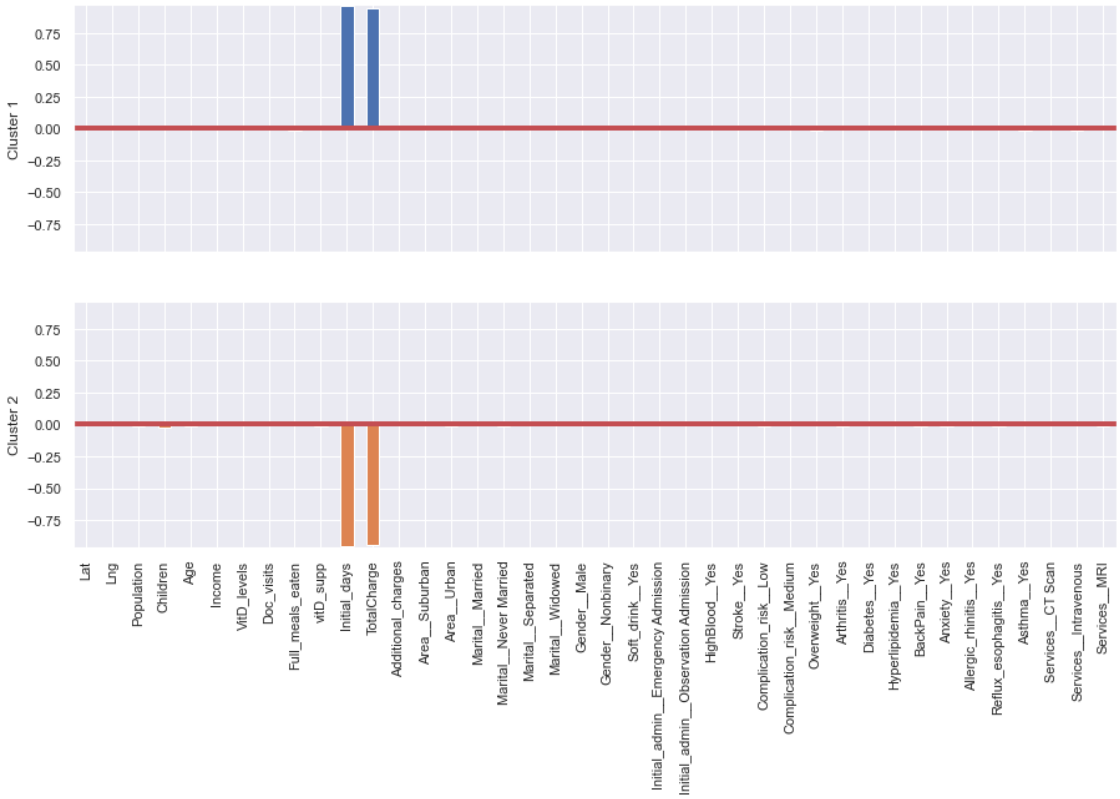
	Doc_visits	Full_meals_eaten	vitD_supp	…	Hyperlipidemia__Yes	\
0	0.944647	-0.993387	-0.634713	…	-0.713268	
1	-0.967981	0.990609	0.956445	…	-0.713268	
2	-0.967981	-0.001389	-0.634713	…	-0.713268	

```
3   -0.967981         -0.001389  -0.634713  …            -0.713268
4   -0.011667         -0.993387   2.547602  …             1.401998

   BackPain__Yes  Anxiety__Yes  Allergic_rhinitis__Yes  \
0       1.196129      1.452728                1.239930
1      -0.836030     -0.688360               -0.806497
2      -0.836030     -0.688360               -0.806497
3      -0.836030     -0.688360               -0.806497
4      -0.836030     -0.688360                1.239930

   Reflux_esophagitis__Yes  Asthma__Yes  Services__CT Scan  \
0                -0.839661     1.567361          -0.373632
1                 1.190957    -0.638015          -0.373632
2                -0.839661    -0.638015          -0.373632
3                 1.190957     1.567361          -0.373632
4                -0.839661    -0.638015           2.676428

   Services__Intravenous  Services__MRI  cluster
0              -0.674985      -0.198749        1
1               1.481516      -0.198749        1
2              -0.674985      -0.198749        1
3              -0.674985      -0.198749        1
4              -0.674985      -0.198749        1

[5 rows x 41 columns]
```

[228]:
```
# Distinct Patient Clusters
from collections import Counter
Counter(kmeans.labels_)
```

[228]:
```
Counter({1: 5003, 0: 4997})
```

[229]:
```
centers = pd.DataFrame(kmeans.cluster_centers_, columns=df_cluster.columns[:-1])
centers_n = kmeans.cluster_centers_.shape[0]


f, axes = plt.subplots(centers_n,1, figsize=(15,8), sharex=True)
for i, ax in enumerate(axes):
    center = centers.loc[i, :]
    maxPC = 1.01 * np.max(np.max(np.abs(center)))
    colors = ['C0' if l > 0 else 'C1' for l in center]
    ax.axhline(linewidth=4, color='r')
    center.plot.bar(ax=ax, color=colors)
    ax.set_ylabel(f'Cluster {i + 1}')
    ax.set_ylim(-maxPC, maxPC)
```



[230]:
```
centers = pd.DataFrame(kmeans.cluster_centers_, columns=['Lat', 'Lng',␣
 ↪'Population', 'Children', 'Age', 'Income', 'VitD_levels',
       'Doc_visits', 'Full_meals_eaten', 'vitD_supp', 'Initial_days',
       'TotalCharge', 'Additional_charges', 'Area__Suburban', 'Area__Urban',
       'Marital__Married', 'Marital__Never Married', 'Marital__Separated',
       'Marital__Widowed', 'Gender__Male', 'Gender__Nonbinary',
       'Soft_drink__Yes', 'Initial_admin__Emergency Admission',
       'Initial_admin__Observation Admission', 'HighBlood__Yes', 'Stroke__Yes',
       'Complication_risk__Low', 'Complication_risk__Medium',
       'Overweight__Yes', 'Arthritis__Yes', 'Diabetes__Yes',
       'Hyperlipidemia__Yes', 'BackPain__Yes', 'Anxiety__Yes',
       'Allergic_rhinitis__Yes', 'Reflux_esophagitis__Yes', 'Asthma__Yes',
       'Services__CT Scan', 'Services__Intravenous', 'Services__MRI'])
centers
```

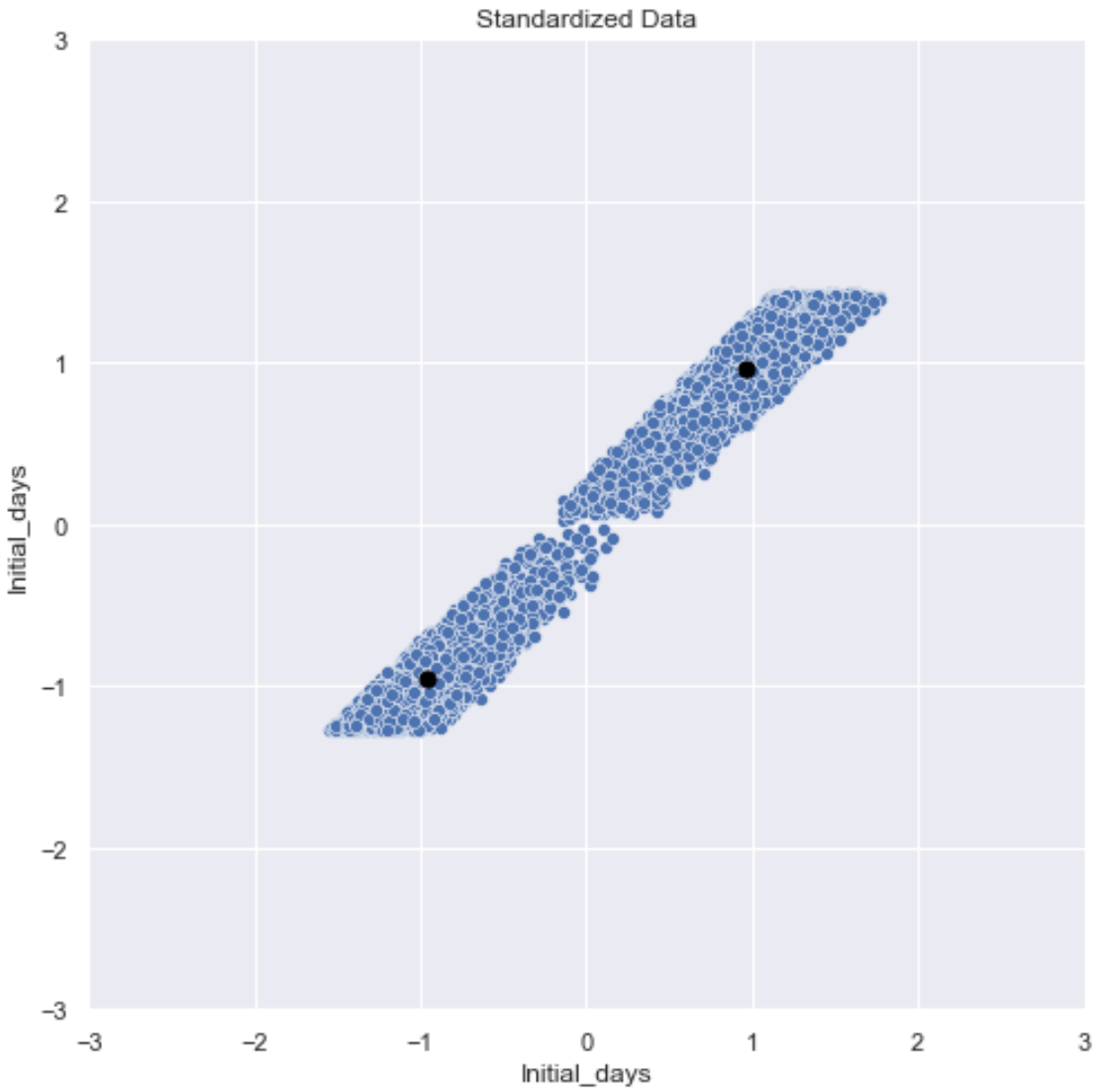
[230]:

	Lat	Lng	Population	Children	Age	Income	VitD_levels	\
0	-0.000936	-0.011008	0.014983	0.021671	0.015913	-0.008749	-0.007363	
1	0.000935	0.010995	-0.014965	-0.021645	-0.015894	0.008738	0.007354	

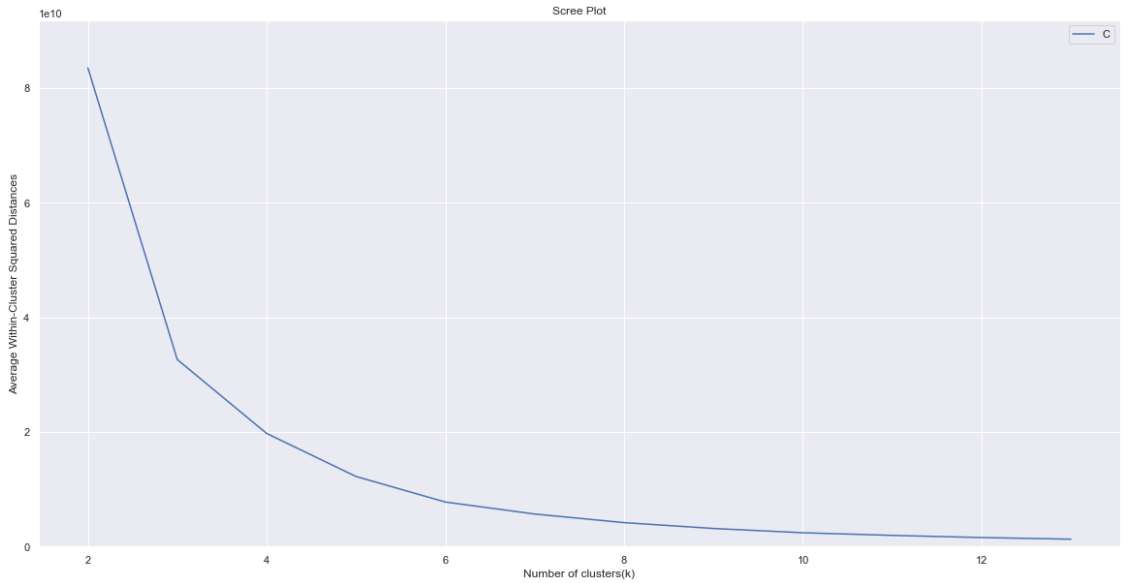
	Doc_visits	Full_meals_eaten	vitD_supp	…	Diabetes__Yes	\
0	-0.010710	-0.018064	0.017735	…	-0.000529	
1	0.010697	0.018043	-0.017714	…	0.000528	

```
   Hyperlipidemia__Yes  BackPain__Yes  Anxiety__Yes  Allergic_rhinitis__Yes  \
0            -0.006345       0.016769      0.012625                0.004375
1             0.006337      -0.016749     -0.012610               -0.004369

   Reflux_esophagitis__Yes  Asthma__Yes  Services__CT Scan  \
0                 0.011273    -0.017933           0.006023
1                -0.011259     0.017911          -0.006016

   Services__Intravenous  Services__MRI
0              -0.012542       0.010586
1               0.012526      -0.010573

[2 rows x 40 columns]
```

[ ]:
```
fig, ax = plt.subplots(figsize=(8, 8))
ax = sns.scatterplot(x='TotalCharge', y='Initial_days', ax=ax,␣
 ↪data=pca_df_binary_standardized)
ax.set_xlim(-3, 3)
ax.set_ylim(-3, 3)
centers.plot.scatter(x='Initial_days', y='Initial_days', ax=ax, s=50,␣
 ↪color='black').set(title='Standardized Data');
```



[ ]:
```
inertia = []
for n_clusters in range(2, 14):
    kmeans = KMeans(n_clusters=n_clusters, random_state=0).fit(df_dummies)
    inertia.append(kmeans.inertia_ / n_clusters)

inertias = pd.DataFrame({'n_clusters': range(2, 14), 'inertia': inertia})
ax = inertias.plot(x='n_clusters', y='inertia')
plt.title('Scree Plot')
plt.xlabel('Number of clusters(k)')
plt.ylabel('Average Within-Cluster Squared Distances')
plt.ylim((0, 1.1 * inertias.inertia.max()))
ax.legend('Clusters').set_visible(True)
```



[ ]:
```
# create dataset
#X, y = pca_df_binary_standardized
# split into train test sets
#X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.33)
#print(X_train.shape, X_test.shape, y_train.shape, y_test.shape)
```

[170]:
```
# Adding Target Field to df
pca_df_binary_standardized_plus = pca_df_binary_standardized.copy()
pca_df_binary_standardized_plus['ReAdmis_Yes'] = df_dummies['ReAdmis_Yes']
```

[171]:
```
pca_df_binary_standardized_plus.head()
```

[171]:

	Lat	Lng	Population	Children	Age	Income	VitD_levels	\
0	-0.814668	0.297134	-0.473168	-0.507129	-0.024795	1.615914	0.583603	
1	-1.463305	0.395522	0.090242	0.417277	-0.121706	0.221443	0.483901	
2	0.886966	-0.354788	0.482983	0.417277	-0.024795	-0.915870	0.046227	
3	0.952530	-0.149403	-0.526393	-0.969332	1.186592	-0.026263	-0.687811	
4	-0.213252	0.943984	-0.315586	-0.507129	-1.526914	-1.377325	-0.260366	

	Doc_visits	Full_meals_eaten	vitD_supp	…	Hyperlipidemia__Yes	\
0	0.944647	-0.993387	-0.634713	…	-0.713268	
1	-0.967981	0.990609	0.956445	…	-0.713268	
2	-0.967981	-0.001389	-0.634713	…	-0.713268	
3	-0.967981	-0.001389	-0.634713	…	-0.713268	
4	-0.011667	-0.993387	2.547602	…	1.401998	

	BackPain__Yes	Anxiety__Yes	Allergic_rhinitis__Yes	\
0	1.196129	1.452728	1.239930	

```
1      -0.836030     -0.688360               -0.806497
2      -0.836030     -0.688360               -0.806497
3      -0.836030     -0.688360               -0.806497
4      -0.836030     -0.688360                1.239930

   Reflux_esophagitis__Yes  Asthma__Yes  Services__CT Scan  \
0                -0.839661     1.567361          -0.373632
1                 1.190957    -0.638015          -0.373632
2                -0.839661    -0.638015          -0.373632
3                 1.190957     1.567361          -0.373632
4                -0.839661    -0.638015           2.676428

   Services__Intravenous  Services__MRI  ReAdmis_Yes
0              -0.674985      -0.198749            0
1               1.481516      -0.198749            0
2              -0.674985      -0.198749            0
3              -0.674985      -0.198749            0
4              -0.674985      -0.198749            0

[5 rows x 41 columns]
```

0.2.1 Save cleaned data to CSV

[176]:
```
pca_df_binary_standardized_plus.to_csv('cleaned_pca_df_binary_standardized_plus.
  ↪csv', index=False)
```

[177]:
```
# Create training and testing data
# https://scikit-learn.org/stable/modules/generated/sklearn.model_selection.
  ↪train_test_split.html
# X = predictor, y = response
X_train, X_test, y_train, y_test = train_test_split(pca_df_binary_standardized,␣
  ↪df_dummies['ReAdmis_Yes'], test_size=0.33, random_state=42)
```

[178]:
```
print("PCA_Standardized Shape: " + str(pca_df_binary_standardized.shape))
print("X_Train Shape: " + str(X_train.shape))
print("y_Train Shape: " + str(y_train.shape))
print("X_Test Shape: " + str(X_test.shape))
print("y_Test Shape: " + str(y_test.shape))
```

```
PCA_Standardized Shape: (10000, 40)
X_Train Shape: (6700, 40)
y_Train Shape: (6700,)
X_Test Shape: (3300, 40)
y_Test Shape: (3300,)
```

[179]:
```
print("***** Train_Set *****")
print(X_train.head())
```

```
print("\n")
print("***** Test_Set *****")
print(X_test.head())
```

```
***** Train_Set *****
          Lat       Lng  Population  Children       Age    Income  \
8371 -0.313238  0.627401   -0.426690 -0.969332  0.750493 -0.700692
5027 -2.210094  0.609127    0.097190  0.417277  0.605126  0.187865
9234 -0.518676  0.442590    0.465106 -0.969332 -1.478459  0.977979
3944  0.792480  1.002280    0.174362 -0.507129 -0.896993  0.218487
6862 -0.788833 -1.757797    0.348741  1.803886 -0.896993  0.177451

      VitD_levels  Doc_visits  Full_meals_eaten  vitD_supp  …  \
8371    -1.027936   -0.967981          0.990609  -0.634713  …
5027     0.135836   -0.967981          1.982607  -0.634713  …
9234    -0.157318   -0.967981         -0.001389   0.956445  …
3944    -0.380859   -0.011667         -0.993387   0.956445  …
6862     0.792105   -0.011667         -0.993387  -0.634713  …

      Diabetes__Yes  Hyperlipidemia__Yes  BackPain__Yes  Anxiety__Yes  \
8371       1.628589            -0.713268       1.196129     -0.688360
5027      -0.614029            -0.713268      -0.836030     -0.688360
9234      -0.614029            -0.713268      -0.836030      1.452728
3944      -0.614029            -0.713268       1.196129     -0.688360
6862      -0.614029            -0.713268       1.196129     -0.688360

      Allergic_rhinitis__Yes  Reflux_esophagitis__Yes  Asthma__Yes  \
8371               -0.806497                 1.190957     1.567361
5027                1.239930                -0.839661     1.567361
9234                1.239930                -0.839661     1.567361
3944               -0.806497                -0.839661    -0.638015
6862               -0.806497                 1.190957     1.567361

      Services__CT Scan  Services__Intravenous  Services__MRI
8371          -0.373632               1.481516      -0.198749
5027           2.676428              -0.674985      -0.198749
9234          -0.373632              -0.674985      -0.198749
3944          -0.373632              -0.674985      -0.198749
6862          -0.373632              -0.674985      -0.198749

[5 rows x 40 columns]


***** Test_Set *****
          Lat       Lng  Population  Children       Age    Income  \
6252 -0.873874  0.528136   -0.208530 -0.507129  0.653582  0.726271
4684  0.105079 -0.722315   -0.327391 -0.507129  0.217483 -0.226763
```

```
1731  0.066915 -0.359337   -0.554523 -0.507129  1.041226 -0.390756
4742  0.400256  1.196740    0.991684 -0.044926  1.089681  0.825839
4521  0.612512  1.263335    0.467400 -0.969332 -0.073250 -0.476741

      VitD_levels  Doc_visits  Full_meals_eaten  vitD_supp  …  \
6252     0.089884    0.944647         -0.001389   0.956445  …
4684     0.454914   -0.011667         -0.001389  -0.634713  …
1731     1.976174   -0.011667          0.990609  -0.634713  …
4742    -0.028400   -0.011667         -0.993387   0.956445  …
4521     1.062094   -0.011667          1.982607  -0.634713  …

      Diabetes__Yes  Hyperlipidemia__Yes  BackPain__Yes  Anxiety__Yes  \
6252       1.628589            -0.713268       1.196129     -0.688360
4684      -0.614029             1.401998       1.196129     -0.688360
1731      -0.614029             1.401998      -0.836030     -0.688360
4742      -0.614029            -0.713268      -0.836030     -0.688360
4521      -0.614029             1.401998       1.196129      1.452728

      Allergic_rhinitis__Yes  Reflux_esophagitis__Yes  Asthma__Yes  \
6252               -0.806497                 1.190957    -0.638015
4684                1.239930                 1.190957    -0.638015
1731                1.239930                -0.839661    -0.638015
4742                1.239930                -0.839661    -0.638015
4521                1.239930                 1.190957    -0.638015

      Services__CT Scan  Services__Intravenous  Services__MRI
6252           2.676428              -0.674985      -0.198749
4684          -0.373632              -0.674985      -0.198749
1731          -0.373632               1.481516      -0.198749
4742          -0.373632              -0.674985      -0.198749
4521          -0.373632              -0.674985      -0.198749

[5 rows x 40 columns]
```

0.2.2 Describe Data Sets:

[180]:
```
print("***** Train_Set *****")
print(y_train.describe())
print("\n")
print("***** Test_Set *****")
print(y_test.describe())
```

```
***** Train_Set *****
count    6700.000000
mean        0.370746
std         0.483041
min         0.000000
25%         0.000000
```

```
50%         0.000000
75%         1.000000
max         1.000000
Name: ReAdmis_Yes, dtype: float64


***** Test_Set *****
count    3300.000000
mean        0.359091
std         0.479807
min         0.000000
25%         0.000000
50%         0.000000
75%         1.000000
max         1.000000
Name: ReAdmis_Yes, dtype: float64
```

[181]:
```
print(X_train.columns.values)
```

```
['Lat' 'Lng' 'Population' 'Children' 'Age' 'Income' 'VitD_levels'
 'Doc_visits' 'Full_meals_eaten' 'vitD_supp' 'Initial_days' 'TotalCharge'
 'Additional_charges' 'Area__Suburban' 'Area__Urban' 'Marital__Married'
 'Marital__Never Married' 'Marital__Separated' 'Marital__Widowed'
 'Gender__Male' 'Gender__Nonbinary' 'Soft_drink__Yes'
 'Initial_admin__Emergency Admission'
 'Initial_admin__Observation Admission' 'HighBlood__Yes' 'Stroke__Yes'
 'Complication_risk__Low' 'Complication_risk__Medium' 'Overweight__Yes'
 'Arthritis__Yes' 'Diabetes__Yes' 'Hyperlipidemia__Yes' 'BackPain__Yes'
 'Anxiety__Yes' 'Allergic_rhinitis__Yes' 'Reflux_esophagitis__Yes'
 'Asthma__Yes' 'Services__CT Scan' 'Services__Intravenous' 'Services__MRI']
```

0.2.3 Verify No Missing Values:

[182]:
```
print("*****In the X_Train Set*****")
print(X_train.isna().sum())
print("\n")
print("*****In the X_Test Set*****")
print(X_test.isna().sum())
```

```
*****In the X_Train Set*****
Lat                                  0
Lng                                  0
Population                           0
Children                             0
Age                                  0
Income                               0
VitD_levels                          0
Doc_visits                           0
```

```
Full_meals_eaten                        0
vitD_supp                               0
Initial_days                            0
TotalCharge                             0
Additional_charges                      0
Area__Suburban                          0
Area__Urban                             0
Marital__Married                        0
Marital__Never Married                  0
Marital__Separated                      0
Marital__Widowed                        0
Gender__Male                            0
Gender__Nonbinary                       0
Soft_drink__Yes                         0
Initial_admin__Emergency Admission      0
Initial_admin__Observation Admission    0
HighBlood__Yes                          0
Stroke__Yes                             0
Complication_risk__Low                  0
Complication_risk__Medium               0
Overweight__Yes                         0
Arthritis__Yes                          0
Diabetes__Yes                           0
Hyperlipidemia__Yes                     0
BackPain__Yes                           0
Anxiety__Yes                            0
Allergic_rhinitis__Yes                  0
Reflux_esophagitis__Yes                 0
Asthma__Yes                             0
Services__CT Scan                       0
Services__Intravenous                   0
Services__MRI                           0
dtype: int64


*****In the X_Test Set*****
Lat                                     0
Lng                                     0
Population                              0
Children                                0
Age                                     0
Income                                  0
VitD_levels                             0
Doc_visits                              0
Full_meals_eaten                        0
vitD_supp                               0
Initial_days                            0
TotalCharge                             0
```

```
Additional_charges                        0
Area__Suburban                            0
Area__Urban                               0
Marital__Married                          0
Marital__Never Married                    0
Marital__Separated                        0
Marital__Widowed                          0
Gender__Male                              0
Gender__Nonbinary                         0
Soft_drink__Yes                           0
Initial_admin__Emergency Admission        0
Initial_admin__Observation Admission      0
HighBlood__Yes                            0
Stroke__Yes                               0
Complication_risk__Low                    0
Complication_risk__Medium                 0
Overweight__Yes                           0
Arthritis__Yes                            0
Diabetes__Yes                             0
Hyperlipidemia__Yes                       0
BackPain__Yes                             0
Anxiety__Yes                              0
Allergic_rhinitis__Yes                    0
Reflux_esophagitis__Yes                   0
Asthma__Yes                               0
Services__CT Scan                         0
Services__Intravenous                     0
Services__MRI                             0
dtype: int64
```

[183]:
```
print("*****In the y_train Set*****")
print(y_train.isna().sum())
print("\n")
print("*****In the y_test Set*****")
print(y_test.isna().sum())
print('--------'*5)
print('y_train:')
print(y_train)
```

```
*****In the y_train Set*****
0


*****In the y_test Set*****
0
----------------------------------------
y_train:
8371    0
```

```
5027    1
9234    0
3944    0
6862    1
       ..
5734    0
5191    1
5390    1
860     0
7270    0
Name: ReAdmis_Yes, Length: 6700, dtype: uint8
```

[184]:
```
train = X_train.copy()
# Concatinate ReAdmis_Yes Data Field
train['ReAdmis_Yes'] = y_train
train.head()
```

[184]:

	Lat	Lng	Population	Children	Age	Income	\
8371	-0.313238	0.627401	-0.426690	-0.969332	0.750493	-0.700692	
5027	-2.210094	0.609127	0.097190	0.417277	0.605126	0.187865	
9234	-0.518676	0.442590	0.465106	-0.969332	-1.478459	0.977979	
3944	0.792480	1.002280	0.174362	-0.507129	-0.896993	0.218487	
6862	-0.788833	-1.757797	0.348741	1.803886	-0.896993	0.177451	

	VitD_levels	Doc_visits	Full_meals_eaten	vitD_supp	…	\
8371	-1.027936	-0.967981	0.990609	-0.634713	…	
5027	0.135836	-0.967981	1.982607	-0.634713	…	
9234	-0.157318	-0.967981	-0.001389	0.956445	…	
3944	-0.380859	-0.011667	-0.993387	0.956445	…	
6862	0.792105	-0.011667	-0.993387	-0.634713	…	

	Hyperlipidemia__Yes	BackPain__Yes	Anxiety__Yes	\
8371	-0.713268	1.196129	-0.688360	
5027	-0.713268	-0.836030	-0.688360	
9234	-0.713268	-0.836030	1.452728	
3944	-0.713268	1.196129	-0.688360	
6862	-0.713268	1.196129	-0.688360	

	Allergic_rhinitis__Yes	Reflux_esophagitis__Yes	Asthma__Yes	\
8371	-0.806497	1.190957	1.567361	
5027	1.239930	-0.839661	1.567361	
9234	1.239930	-0.839661	1.567361	
3944	-0.806497	-0.839661	-0.638015	
6862	-0.806497	1.190957	1.567361	

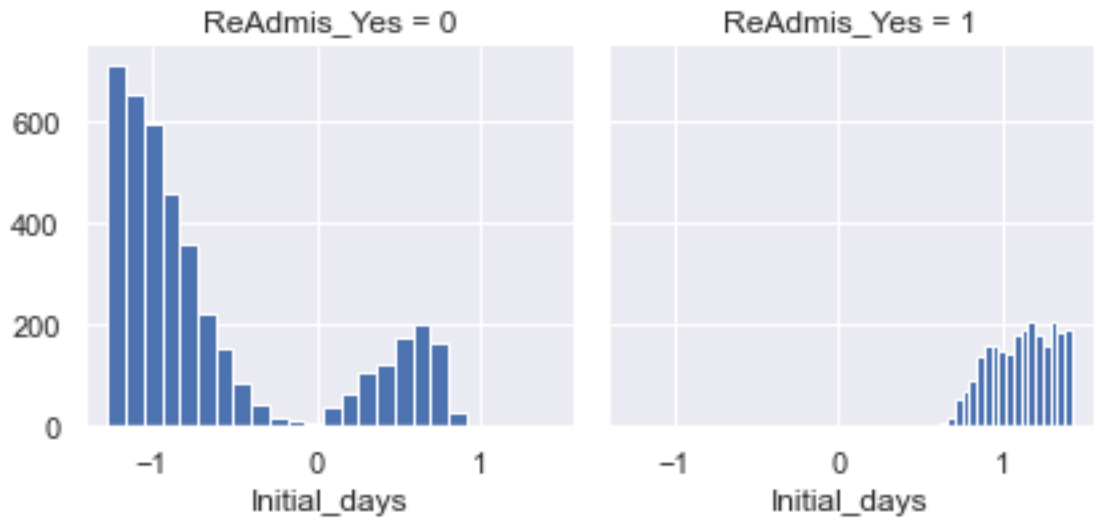
	Services__CT Scan	Services__Intravenous	Services__MRI	ReAdmis_Yes
8371	-0.373632	1.481516	-0.198749	0

```
5027          2.676428              -0.674985      -0.198749             1
9234         -0.373632              -0.674985      -0.198749             0
3944         -0.373632              -0.674985      -0.198749             0
6862         -0.373632              -0.674985      -0.198749             1

[5 rows x 41 columns]
```

[185]:
```
# Average of the train set grouped by ReAdmis_Yes
# pca_df_target = df['ReAdmis_Yes']
# pca_df = df
train[['ReAdmis_Yes', 'Initial_days', 'TotalCharge']].groupby(['ReAdmis_Yes'],␣
 ↪as_index=False).mean().sort_values(by='ReAdmis_Yes', ascending=False)
```

[185]:
```
   ReAdmis_Yes  Initial_days  TotalCharge
1            1      1.115040     1.104961
0            0     -0.643809    -0.638415
```

[186]:
```
#train[['ReAdmis_Yes', 'Initial_days', 'TotalCharge']].groupby(['ReAdmis_Yes'],␣
 ↪as_index=False).mean().sort_values(by='ReAdmis_Yes', ascending=False)

g = sns.FacetGrid(train, col='ReAdmis_Yes')
g.map(plt.hist, 'Initial_days', bins=20);
```



[187]:
```
test = X_test.copy()
test['ReAdmis_Yes'] = y_test
test.head()
```

[187]:
```
            Lat       Lng  Population  Children       Age    Income  \
6252 -0.873874  0.528136   -0.208530 -0.507129  0.653582  0.726271
```

```
4684  0.105079 -0.722315   -0.327391 -0.507129  0.217483 -0.226763
1731  0.066915 -0.359337   -0.554523 -0.507129  1.041226 -0.390756
4742  0.400256  1.196740    0.991684 -0.044926  1.089681  0.825839
4521  0.612512  1.263335    0.467400 -0.969332 -0.073250 -0.476741

      VitD_levels  Doc_visits  Full_meals_eaten  vitD_supp  …  \
6252     0.089884    0.944647         -0.001389   0.956445  …
4684     0.454914   -0.011667         -0.001389  -0.634713  …
1731     1.976174   -0.011667          0.990609  -0.634713  …
4742    -0.028400   -0.011667         -0.993387   0.956445  …
4521     1.062094   -0.011667          1.982607  -0.634713  …

      Hyperlipidemia__Yes  BackPain__Yes  Anxiety__Yes  \
6252            -0.713268       1.196129     -0.688360
4684             1.401998       1.196129     -0.688360
1731             1.401998      -0.836030     -0.688360
4742            -0.713268      -0.836030     -0.688360
4521             1.401998       1.196129      1.452728

      Allergic_rhinitis__Yes  Reflux_esophagitis__Yes  Asthma__Yes  \
6252               -0.806497                 1.190957    -0.638015
4684                1.239930                 1.190957    -0.638015
1731                1.239930                -0.839661    -0.638015
4742                1.239930                -0.839661    -0.638015
4521                1.239930                 1.190957    -0.638015

      Services__CT Scan  Services__Intravenous  Services__MRI  ReAdmis_Yes
6252           2.676428              -0.674985      -0.198749            0
4684          -0.373632              -0.674985      -0.198749            0
1731          -0.373632               1.481516      -0.198749            0
4742          -0.373632              -0.674985      -0.198749            0
4521          -0.373632              -0.674985      -0.198749            0

[5 rows x 41 columns]
```

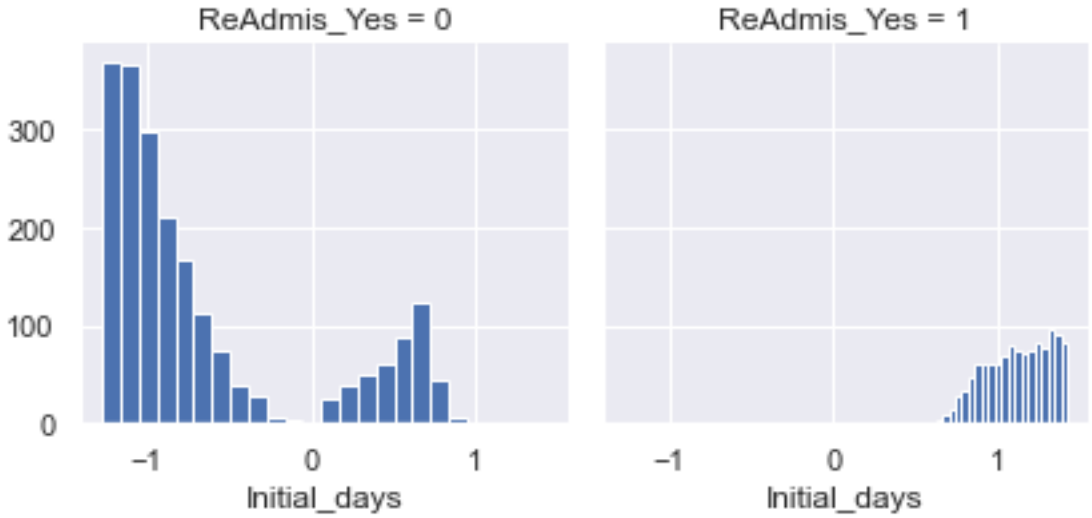
[197]:
```
test.shape
```

[197]:
```
(3300, 41)
```

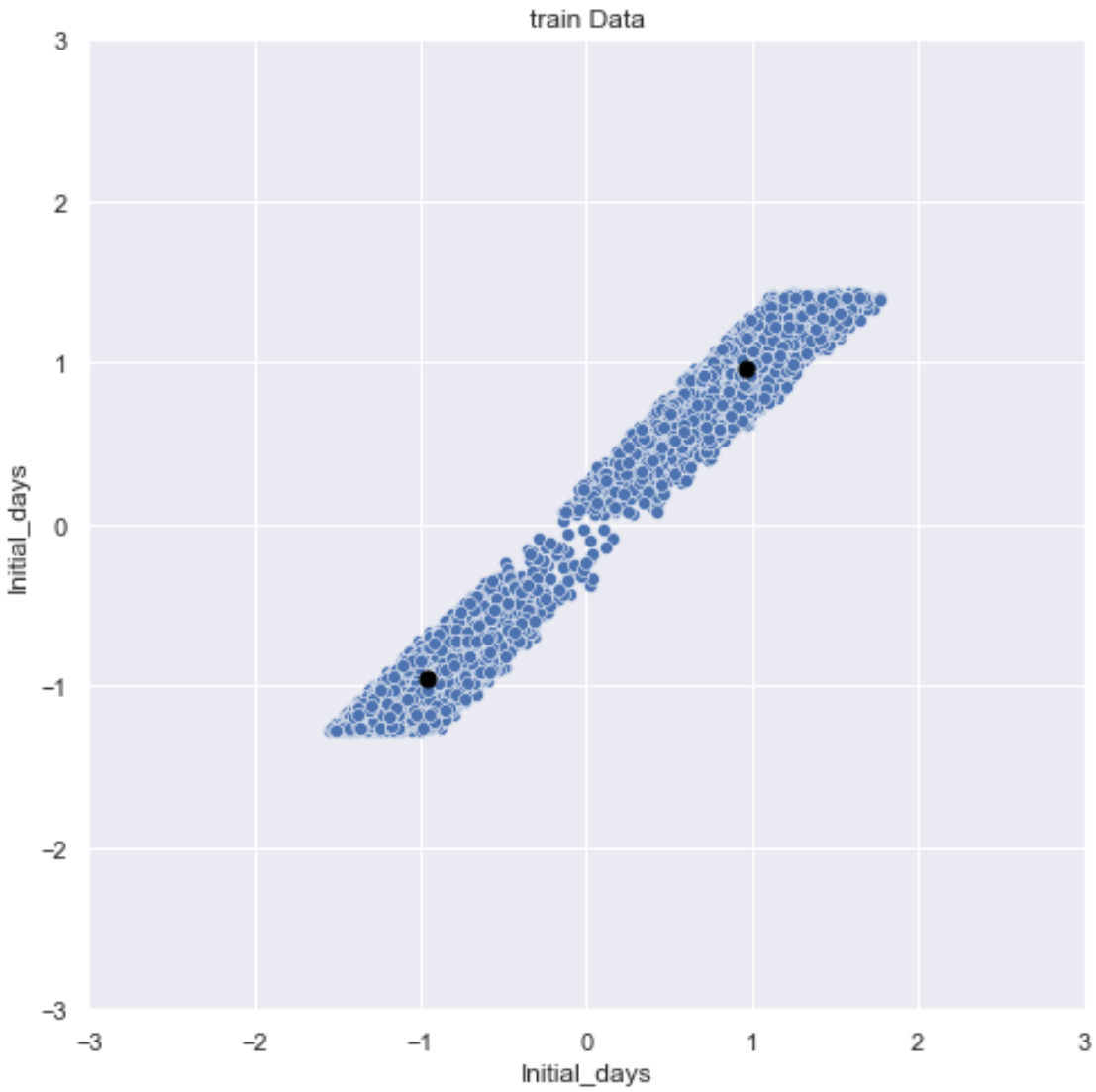
[188]:
```
test[['ReAdmis_Yes', 'Initial_days', 'TotalCharge']].groupby(['ReAdmis_Yes'],␣
↪as_index=False).mean().sort_values(by='ReAdmis_Yes', ascending=False)
```

[188]:
```
   ReAdmis_Yes  Initial_days  TotalCharge
1            1      1.123243      1.11535
0            0     -0.655559     -0.65005
```

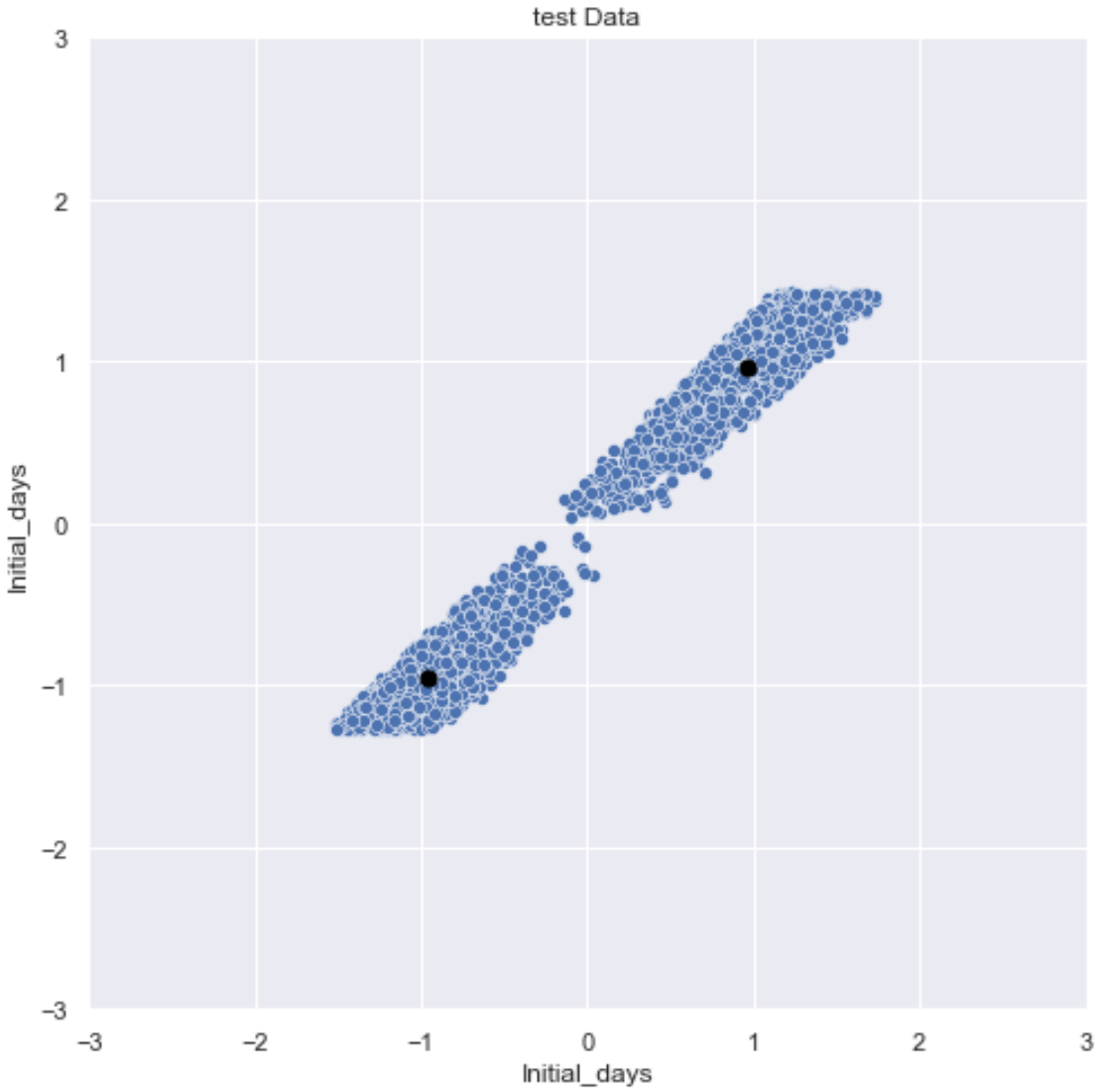
[189]:
```
g = sns.FacetGrid(test, col='ReAdmis_Yes')
g.map(plt.hist, 'Initial_days', bins=20);
```



[190]:
```
fig, ax = plt.subplots(figsize=(8, 8))
ax = sns.scatterplot(x='TotalCharge', y='Initial_days', ax=ax, data=train)
ax.set_xlim(-3, 3)
ax.set_ylim(-3, 3)
centers.plot.scatter(x='Initial_days', y='Initial_days', \
                     ax=ax, s=50, color='black').set(title='train Data');
```



[191]:
```
fig, ax = plt.subplots(figsize=(8, 8))
ax = sns.scatterplot(x='TotalCharge', y='Initial_days', ax=ax, data=test)
ax.set_xlim(-3, 3)
ax.set_ylim(-3, 3)
centers.plot.scatter(x='Initial_days', y='Initial_days', \
                     ax=ax, s=50, color='black').set(title='test Data');
```



0.3 Export Data

[307]:
```
pca_df_binary_standardized_plus.to_csv('cleaned_pca_df_binary_standardized_plus.
  ↪csv', index=False)
X_train.to_csv('X_train_data.csv', index=False)
X_test.to_csv('X_test_data.csv', index=False)
y_train.to_csv('y_train_data.csv', index=False)
y_test.to_csv('y_test_data.csv', index=False)
```