D212 - DataMiningII_PA_jw

January 8, 2023

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

[1]:
```
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

[3]:
```
# load data file
df = pd.read_csv('medical_clean.csv')
# quick test the data is present and see the shape
df.head()
```

[3]:
```
   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]
```

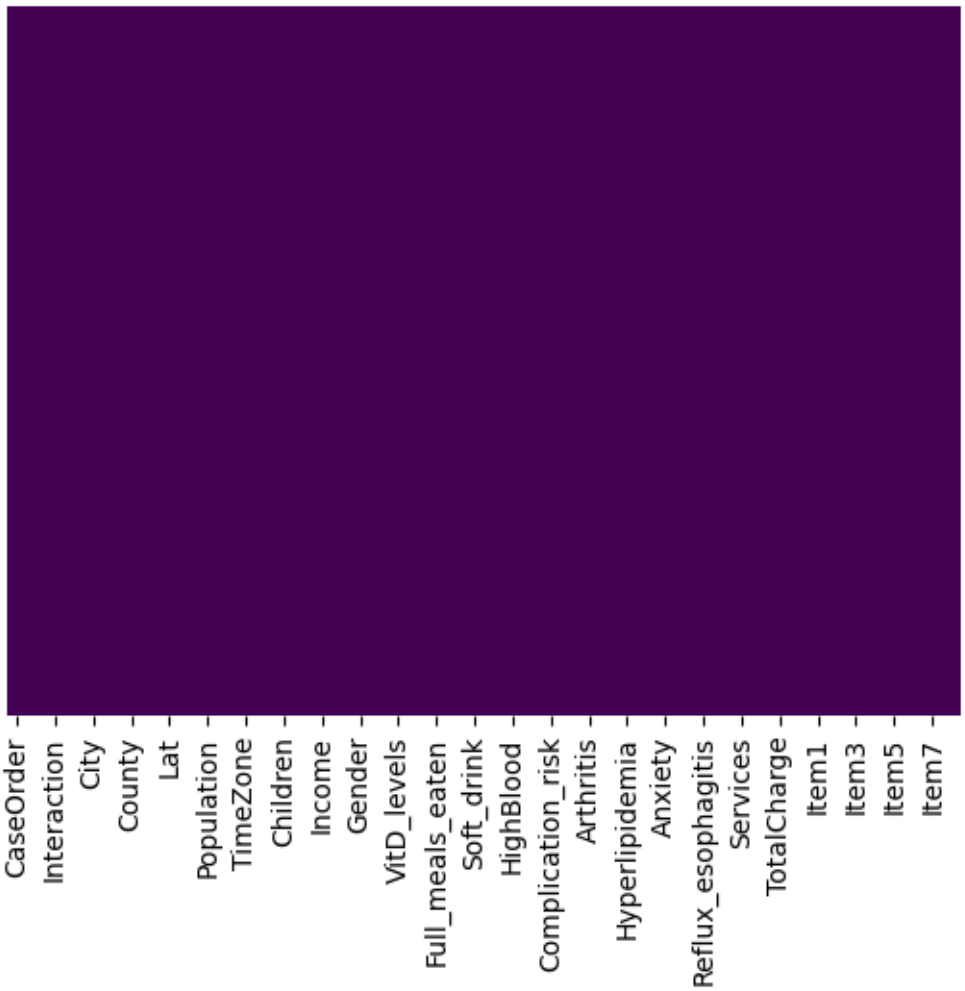
[4]:
```
df.info()
```

```
<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

[5]:
```
# Mapping to view missing data...none present.
sns.heatmap(df.isnull(), yticklabels=False, cbar=False, cmap='viridis');
```



[6]:
```
df.describe()
```

[6]:

	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:

[7]:
```
df.describe(include = [np.number])
```

[7]:

	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

[8]:
```
df_num = df.select_dtypes(include='number')
df_num.head()
```

[8]:

	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:

[9]:
```
df.describe(exclude=[np.number])
```

[9]:

	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

[10]:
```
df_cat = df.select_dtypes(exclude='number')
df_cat.head()
```

[10]:
```
  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

[11]:
```
df[['ReAdmis']].describe()
```

[11]:
```
       ReAdmis
count    10000
unique       2
top         No
freq      6331
```

[12]:
```
df.columns
```

[12]:
```
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

[13]:
```
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']]
```

[14]:
```
df_dummies = pd.get_dummies(df_temp)
df_dummies.head()
```

[14]:

	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]
```

[15]:
```
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

[16]:
```
df_dummies.columns
```

[16]:
```
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

[17]:
```
# 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
---------------
```

[17]:
```
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')
```

[18]:
```
# testing how to identify categorical data
for t in pca_df.dtypes:
    if t == "float64":
        print("yes")
```

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

[19]:
```
pca_df.dtypes
```

[19]:
```
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

[20]:
```
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
```

[21]:
```
pca_df_binary = dummify(pca_df)
pca_df_binary.head()
```

[21]:

	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]
```

[22]:
```
pca_df_binary.columns
```

[22]:
```
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')
```

[23]:
```
print('pca_df_target: ' + str(pca_df_target.shape))
print('------'*5)
```

```
print('pca_df_binary: ' + str(pca_df_binary.shape))
```

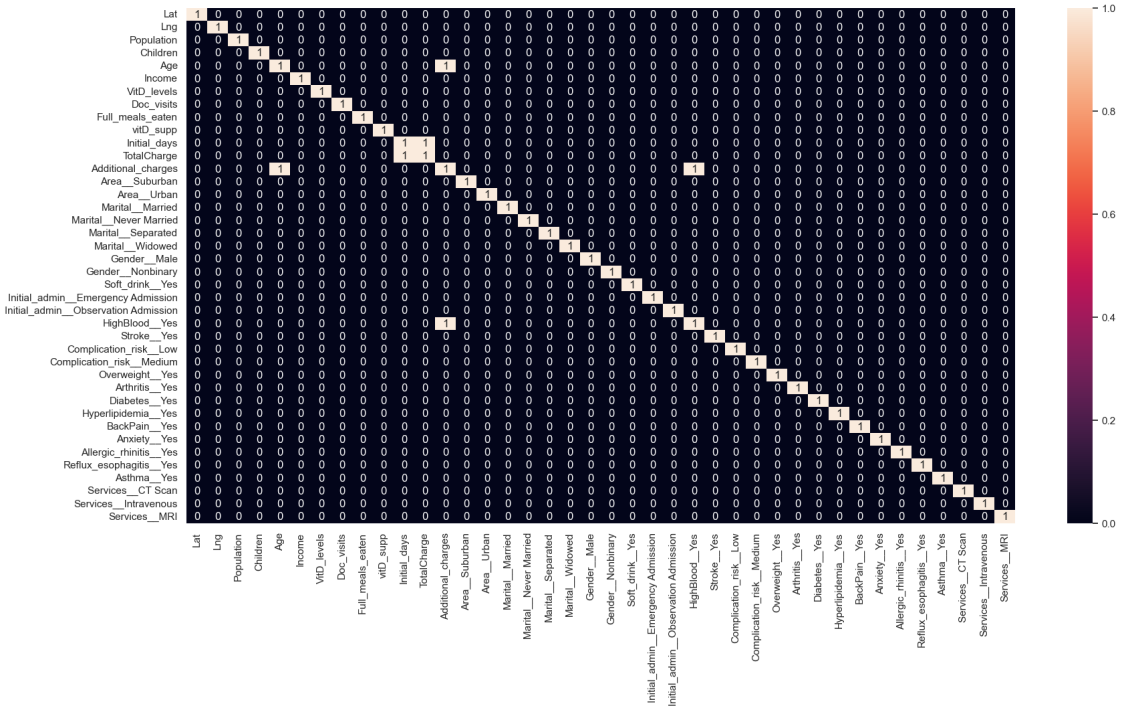
```
pca_df_target: (10000,)
------------------------------
pca_df_binary: (10000, 40)
```

[24]:
```
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
```

[25]:
```
# 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:

[26]:
```
pcs = PCA(n_components=3)
pcs.fit(pca_df_binary)
loadings = pd.DataFrame(pcs.components_, columns=pca_df_binary.columns)
loadings
```

[26]:

	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	…	

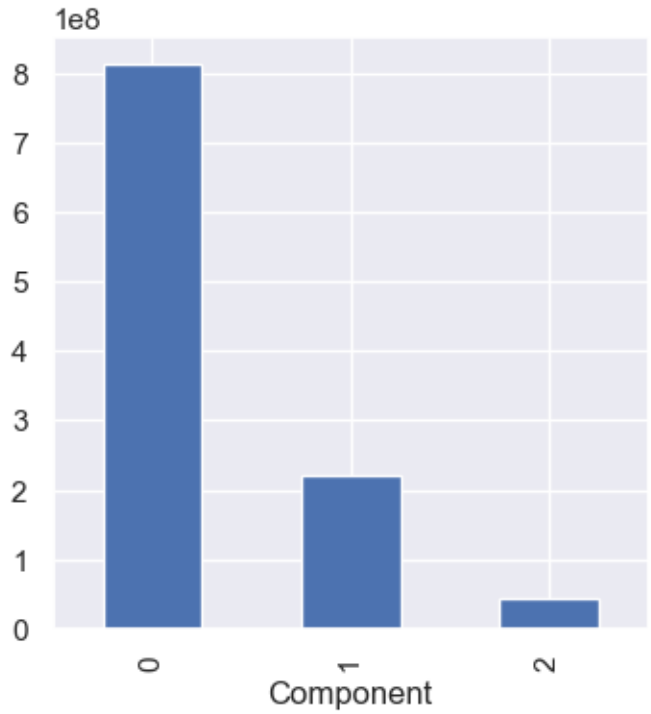
	Diabetes__Yes	Hyperlipidemia__Yes	BackPain__Yes	Anxiety__Yes	\
0	-1.585349e-07	1.434973e-07	1.716768e-07	-8.791170e-09	
1	-2.977246e-07	-2.001532e-07	2.111729e-07	-4.611059e-07	
2	1.586958e-07	-1.703362e-07	1.091828e-06	8.344441e-07	

	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]
```

[27]:
```
# 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')
```

[27]:
```
Text(0.5, 0, 'Component')
```

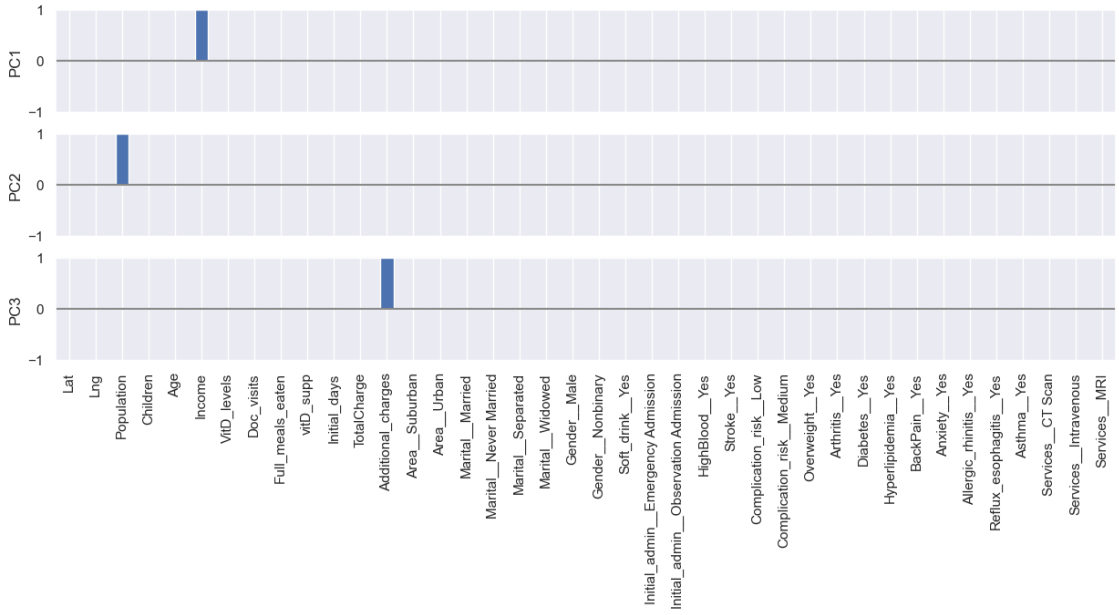


[28]:
```
pcs.components_.shape;
```

[29]:
```
# 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);
```

```
/Users/jasonewillis/opt/anaconda3/lib/python3.9/site-
packages/numpy/core/fromnumeric.py:84: FutureWarning: In a future version,
DataFrame.max(axis=None) will return a scalar max over the entire DataFrame. To
retain the old behavior, use 'frame.max(axis=0)' or just 'frame.max()'
  return reduction(axis=axis, out=out, **passkwargs)
```



0.1.11 K-Means Clustering

[30]:
```
# 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()
```

[30]:

	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

[31]:
```
# Clusters --> ReAdmin vs Not ReAdmitted
kmeans = KMeans(n_clusters=2, init='k-means++', random_state=73).
 ↪fit(pca_df_binary_standardized)
```

```
/Users/jasonewillis/opt/anaconda3/lib/python3.9/site-
packages/sklearn/cluster/_kmeans.py:870: FutureWarning: The default value of
`n_init` will change from 10 to 'auto' in 1.4. Set the value of `n_init`
explicitly to suppress the warning
  warnings.warn(
```

[32]:
```
pca_df_binary_standardized['cluster'] = kmeans.labels_
pca_df_binary_standardized.head()
```

[32]:

	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]
```

[33]:
```
pca_df_binary_standardized.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 10000 entries, 0 to 9999
Data columns (total 41 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
 40  cluster                              10000 non-null  int32
dtypes: float64(40), int32(1)
memory usage: 3.1 MB
```

[34]:
```
# Identify cluster
df_cluster = pca_df_binary_standardized.copy()

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

[34]:

	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	

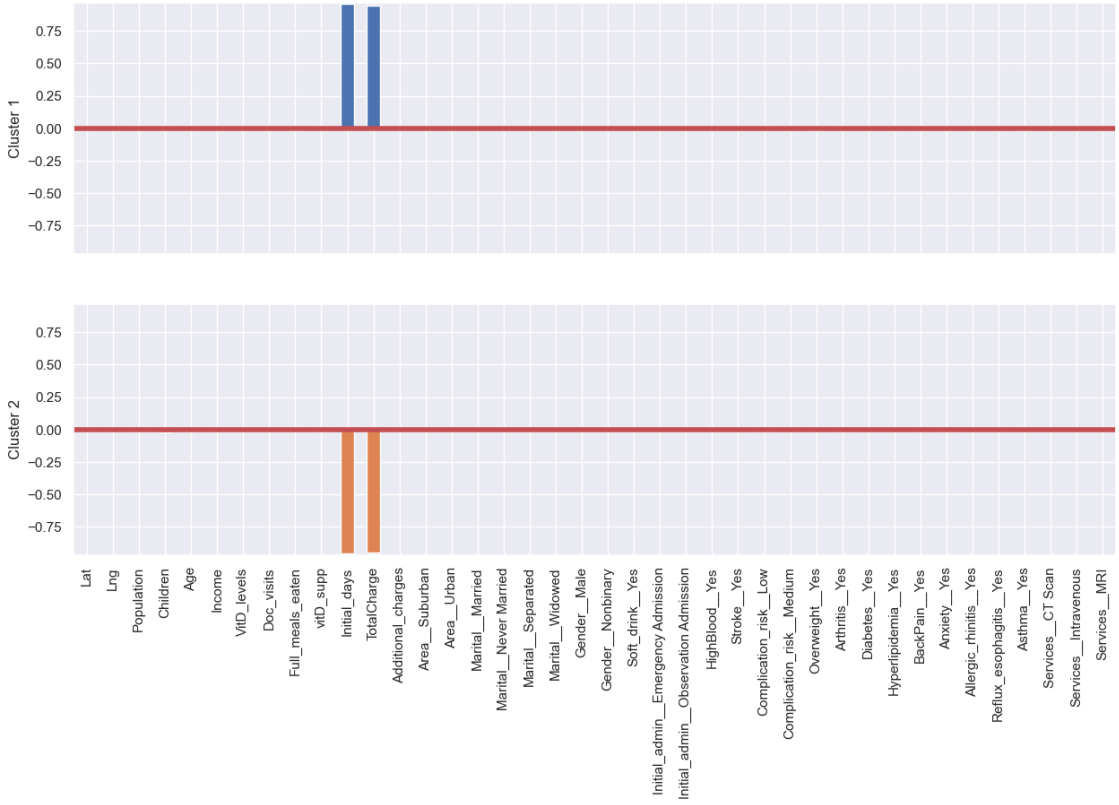
	Services__Intravenous	Services__MRI	cluster
0	-0.674985	-0.198749	1
1	1.481516	-0.198749	1
2	-0.674985	-0.198749	1
3	-0.674985	-0.198749	1

```
4              -0.674985       -0.198749         1

[5 rows x 41 columns]
```

[35]:
```
# Distinct Patient Clusters
from collections import Counter
Counter(kmeans.labels_)
```

[35]:
```
Counter({1: 5003, 0: 4997})
```

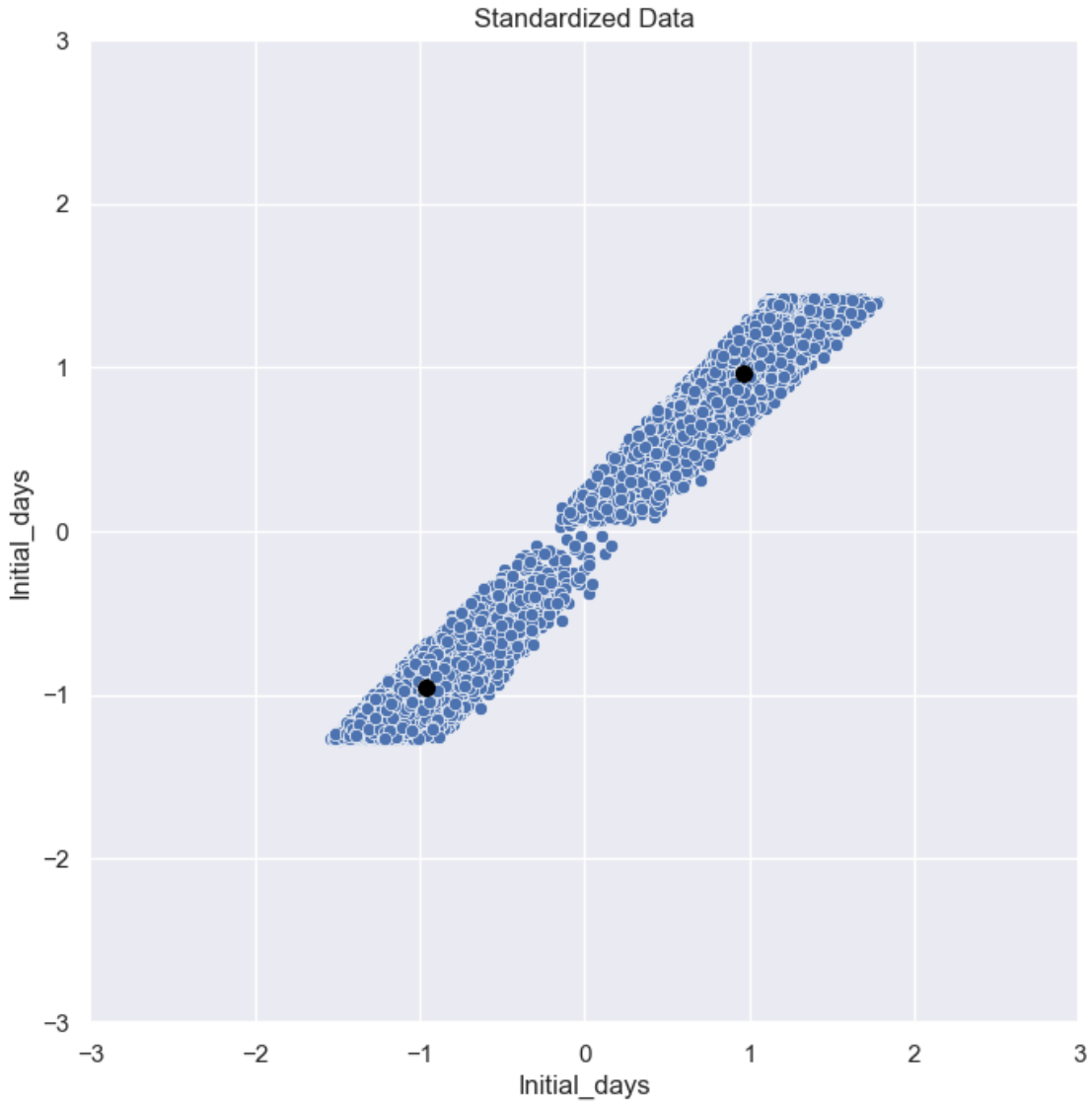
[36]:
```
centers = pd.DataFrame(kmeans.cluster_centers_, columns=df_cluster.columns[:-1])
centers_n = kmeans.cluster_centers_.shape[0]


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)
```



[37]:
```
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
```

[37]:
```
        Lat       Lng  Population  Children       Age    Income  VitD_levels  \
0 -0.001084 -0.010930    0.015112  0.021684  0.015650 -0.008714    -0.007201
1  0.001082  0.010912   -0.015088 -0.021650 -0.015625  0.008700     0.007189

   Doc_visits  Full_meals_eaten  vitD_supp  …  Diabetes__Yes  \
0   -0.010710          -0.017869   0.017866  …      -0.000406
1    0.010693           0.017841  -0.017837  …       0.000405

   Hyperlipidemia__Yes  BackPain__Yes  Anxiety__Yes  Allergic_rhinitis__Yes  \
0            -0.006627       0.016940      0.012765                0.004537
1             0.006616      -0.016913     -0.012745               -0.004530

   Reflux_esophagitis__Yes  Asthma__Yes  Services__CT Scan  \
0                 0.011443    -0.017808           0.006099
1                -0.011425     0.017780          -0.006089

   Services__Intravenous  Services__MRI
0              -0.012409       0.010628
1               0.012389      -0.010611

[2 rows x 40 columns]
```

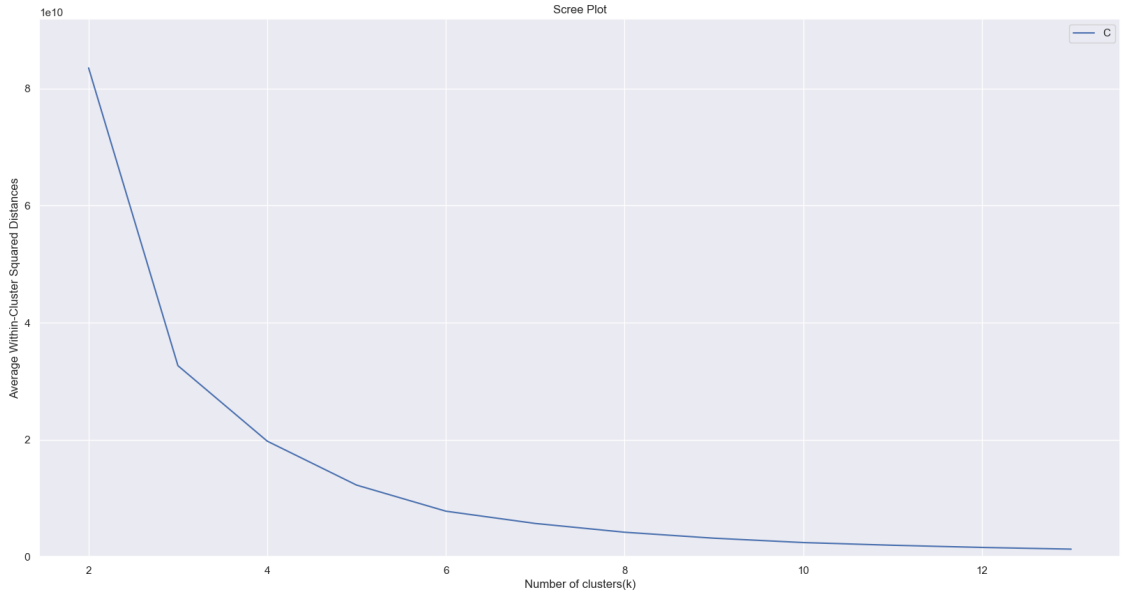
[38]:
```
fig, ax = plt.subplots(figsize=(8, 8))
ax = sns.scatterplot(x='TotalCharge', y='Initial_days', ax=ax,␣
 ↪data=pca_df_binary_standardized)
ax.set_xlim(-3, 3)
ax.set_ylim(-3, 3)
centers.plot.scatter(x='Initial_days', y='Initial_days', ax=ax, s=50,␣
 ↪color='black').set(title='Standardized Data');
```



[39]:
```
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)
```

```
/Users/jasonewillis/opt/anaconda3/lib/python3.9/site-
packages/sklearn/cluster/_kmeans.py:870: FutureWarning: The default value of
`n_init` will change from 10 to 'auto' in 1.4. Set the value of `n_init`
explicitly to suppress the warning
  warnings.warn(
/Users/jasonewillis/opt/anaconda3/lib/python3.9/site-
packages/sklearn/cluster/_kmeans.py:870: FutureWarning: The default value of
`n_init` will change from 10 to 'auto' in 1.4. Set the value of `n_init`
explicitly to suppress the warning
  warnings.warn(
/Users/jasonewillis/opt/anaconda3/lib/python3.9/site-
packages/sklearn/cluster/_kmeans.py:870: FutureWarning: The default value of
`n_init` will change from 10 to 'auto' in 1.4. Set the value of `n_init`
explicitly to suppress the warning
  warnings.warn(
/Users/jasonewillis/opt/anaconda3/lib/python3.9/site-
packages/sklearn/cluster/_kmeans.py:870: FutureWarning: The default value of
`n_init` will change from 10 to 'auto' in 1.4. Set the value of `n_init`
explicitly to suppress the warning
  warnings.warn(
/Users/jasonewillis/opt/anaconda3/lib/python3.9/site-
packages/sklearn/cluster/_kmeans.py:870: FutureWarning: The default value of
`n_init` will change from 10 to 'auto' in 1.4. Set the value of `n_init`
explicitly to suppress the warning
  warnings.warn(
/Users/jasonewillis/opt/anaconda3/lib/python3.9/site-
packages/sklearn/cluster/_kmeans.py:870: FutureWarning: The default value of
`n_init` will change from 10 to 'auto' in 1.4. Set the value of `n_init`
explicitly to suppress the warning
  warnings.warn(
/Users/jasonewillis/opt/anaconda3/lib/python3.9/site-
packages/sklearn/cluster/_kmeans.py:870: FutureWarning: The default value of
`n_init` will change from 10 to 'auto' in 1.4. Set the value of `n_init`
explicitly to suppress the warning
  warnings.warn(
/Users/jasonewillis/opt/anaconda3/lib/python3.9/site-
packages/sklearn/cluster/_kmeans.py:870: FutureWarning: The default value of
`n_init` will change from 10 to 'auto' in 1.4. Set the value of `n_init`
explicitly to suppress the warning
  warnings.warn(
/Users/jasonewillis/opt/anaconda3/lib/python3.9/site-
packages/sklearn/cluster/_kmeans.py:870: FutureWarning: The default value of
`n_init` will change from 10 to 'auto' in 1.4. Set the value of `n_init`
explicitly to suppress the warning
  warnings.warn(
/Users/jasonewillis/opt/anaconda3/lib/python3.9/site-
packages/sklearn/cluster/_kmeans.py:870: FutureWarning: The default value of
`n_init` will change from 10 to 'auto' in 1.4. Set the value of `n_init`
```

```
explicitly to suppress the warning
  warnings.warn(
/Users/jasonewillis/opt/anaconda3/lib/python3.9/site-
packages/sklearn/cluster/_kmeans.py:870: FutureWarning: The default value of
`n_init` will change from 10 to 'auto' in 1.4. Set the value of `n_init`
explicitly to suppress the warning
  warnings.warn(
/Users/jasonewillis/opt/anaconda3/lib/python3.9/site-
packages/sklearn/cluster/_kmeans.py:870: FutureWarning: The default value of
`n_init` will change from 10 to 'auto' in 1.4. Set the value of `n_init`
explicitly to suppress the warning
  warnings.warn(
```



[40]:
```
# 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)
```

[41]:
```
# 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']
```

[42]:
```
pca_df_binary_standardized_plus.head()
```

[42]:

	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  …  BackPain__Yes  Anxiety__Yes  \
0    0.944647         -0.993387  -0.634713  …       1.196129      1.452728
1   -0.967981          0.990609   0.956445  …      -0.836030     -0.688360
2   -0.967981         -0.001389  -0.634713  …      -0.836030     -0.688360
3   -0.967981         -0.001389  -0.634713  …      -0.836030     -0.688360
4   -0.011667         -0.993387   2.547602  …      -0.836030     -0.688360

   Allergic_rhinitis__Yes  Reflux_esophagitis__Yes  Asthma__Yes  \
0                1.239930                -0.839661     1.567361
1               -0.806497                 1.190957    -0.638015
2               -0.806497                -0.839661    -0.638015
3               -0.806497                 1.190957     1.567361
4                1.239930                -0.839661    -0.638015

   Services__CT Scan  Services__Intravenous  Services__MRI  cluster  \
0          -0.373632              -0.674985      -0.198749        1
1          -0.373632               1.481516      -0.198749        1
2          -0.373632              -0.674985      -0.198749        1
3          -0.373632              -0.674985      -0.198749        1
4           2.676428              -0.674985      -0.198749        1

   ReAdmis_Yes
0            0
1            0
2            0
3            0
4            0

[5 rows x 42 columns]
```

0.2.1 Save cleaned data to CSV

[43]:
```
pca_df_binary_standardized_plus.to_csv('cleaned_pca_df_binary_standardized_plus.
  ↪csv', index=False)
```

[44]:
```
# 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)
```

[45]:
```
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, 41)
X_Train Shape: (6700, 41)
y_Train Shape: (6700,)
X_Test Shape: (3300, 41)
y_Test Shape: (3300,)
```

[46]:
```
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  …

      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  cluster
```

```
8371          -0.373632              1.481516      -0.198749        0
5027           2.676428             -0.674985      -0.198749        0
9234          -0.373632             -0.674985      -0.198749        0
3944          -0.373632             -0.674985      -0.198749        1
6862          -0.373632             -0.674985      -0.198749        0

[5 rows x 41 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  …

     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  cluster
6252          2.676428              -0.674985      -0.198749        0
4684         -0.373632              -0.674985      -0.198749        1
1731         -0.373632               1.481516      -0.198749        1
4742         -0.373632              -0.674985      -0.198749        1
4521         -0.373632              -0.674985      -0.198749        1

[5 rows x 41 columns]
```

0.2.2 Describe Data Sets:

[47]:
```
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
```

[48]:
```
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'
 'cluster']
```

0.2.3 Verify No Missing Values:

[49]:
```
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
cluster                                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
cluster                                0
dtype: int64
```

[50]:
```
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
```

[51]:
```
train = X_train.copy()
# Concatinate ReAdmis_Yes Data Field
train['ReAdmis_Yes'] = y_train
train.head()
```

[51]:

	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	

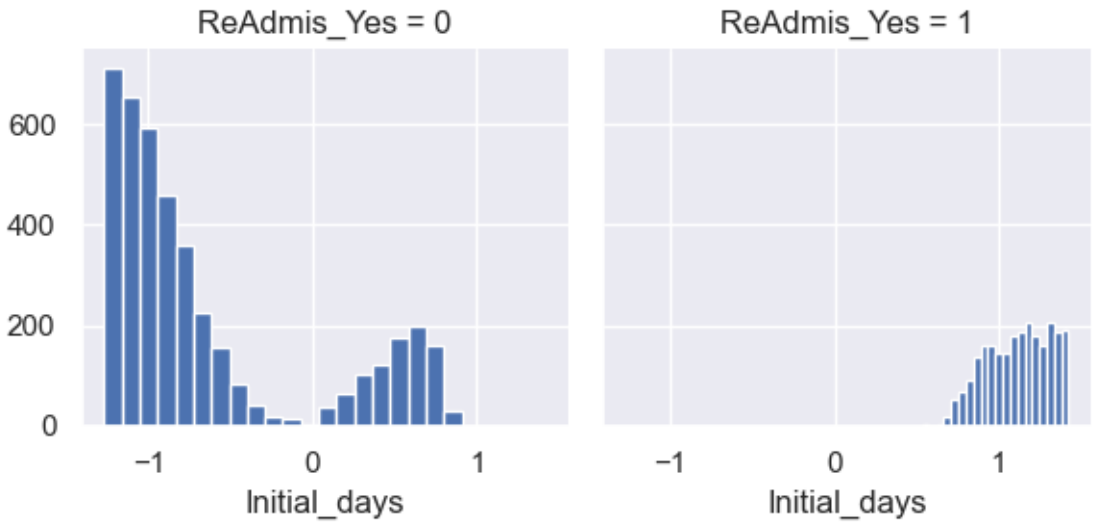
	VitD_levels	Doc_visits	Full_meals_eaten	vitD_supp	…	\
8371	-1.027936	-0.967981	0.990609	-0.634713	…	
5027	0.135836	-0.967981	1.982607	-0.634713	…	
9234	-0.157318	-0.967981	-0.001389	0.956445	…	
3944	-0.380859	-0.011667	-0.993387	0.956445	…	

```
6862     0.792105   -0.011667         -0.993387  -0.634713  …

      BackPain__Yes  Anxiety__Yes  Allergic_rhinitis__Yes  \
8371       1.196129     -0.688360               -0.806497
5027      -0.836030     -0.688360                1.239930
9234      -0.836030      1.452728                1.239930
3944       1.196129     -0.688360               -0.806497
6862       1.196129     -0.688360               -0.806497

      Reflux_esophagitis__Yes  Asthma__Yes  Services__CT Scan  \
8371                 1.190957     1.567361          -0.373632
5027                -0.839661     1.567361           2.676428
9234                -0.839661     1.567361          -0.373632
3944                -0.839661    -0.638015          -0.373632
6862                 1.190957     1.567361          -0.373632

      Services__Intravenous  Services__MRI  cluster  ReAdmis_Yes
8371               1.481516      -0.198749        0            0
5027              -0.674985      -0.198749        0            1
9234              -0.674985      -0.198749        0            0
3944              -0.674985      -0.198749        1            0
6862              -0.674985      -0.198749        0            1

[5 rows x 42 columns]
```

[52]:
```
# 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)
```

[52]:
```
   ReAdmis_Yes  Initial_days  TotalCharge
1            1      1.115040     1.104961
0            0     -0.643809    -0.638415
```

[53]:
```
#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);
```



[54]:
```
test = X_test.copy()
test['ReAdmis_Yes'] = y_test
test.head()
```

[54]:

	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	…	

	BackPain__Yes	Anxiety__Yes	Allergic_rhinitis__Yes	\
6252	1.196129	-0.688360	-0.806497	
4684	1.196129	-0.688360	1.239930	
1731	-0.836030	-0.688360	1.239930	
4742	-0.836030	-0.688360	1.239930	
4521	1.196129	1.452728	1.239930	

	Reflux_esophagitis__Yes	Asthma__Yes	Services__CT Scan	\
6252	1.190957	-0.638015	2.676428	
4684	1.190957	-0.638015	-0.373632	
1731	-0.839661	-0.638015	-0.373632	

```
4742                -0.839661    -0.638015          -0.373632
4521                 1.190957    -0.638015          -0.373632

      Services__Intravenous  Services__MRI  cluster  ReAdmis_Yes
6252               -0.674985      -0.198749        0            0
4684               -0.674985      -0.198749        1            0
1731                1.481516      -0.198749        1            0
4742               -0.674985      -0.198749        1            0
4521               -0.674985      -0.198749        1            0

[5 rows x 42 columns]
```

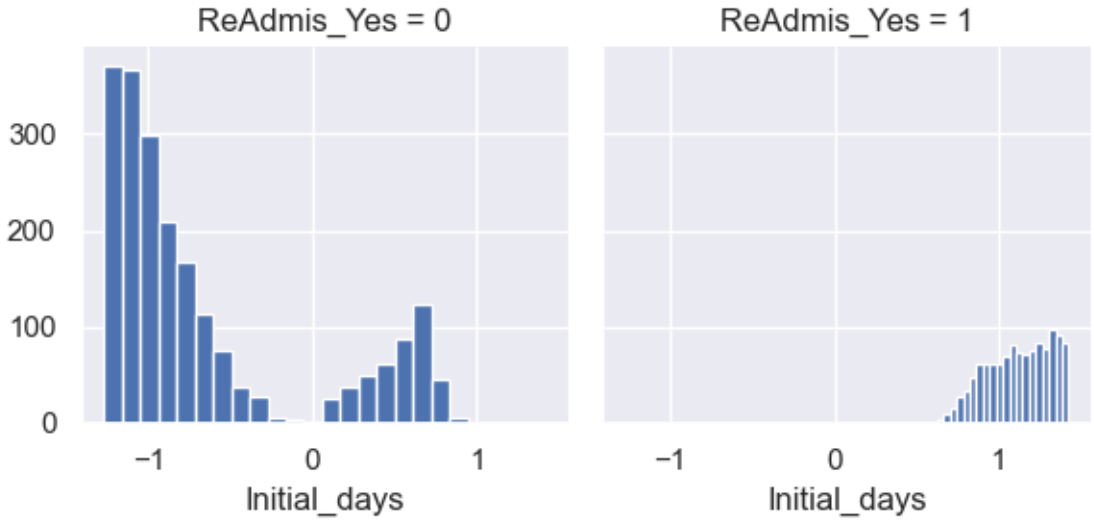
[55]:
```
test.shape
```

[55]:
```
(3300, 42)
```

[56]:
```
test[['ReAdmis_Yes', 'Initial_days', 'TotalCharge']].groupby(['ReAdmis_Yes'],␣
↪as_index=False).mean().sort_values(by='ReAdmis_Yes', ascending=False)
```

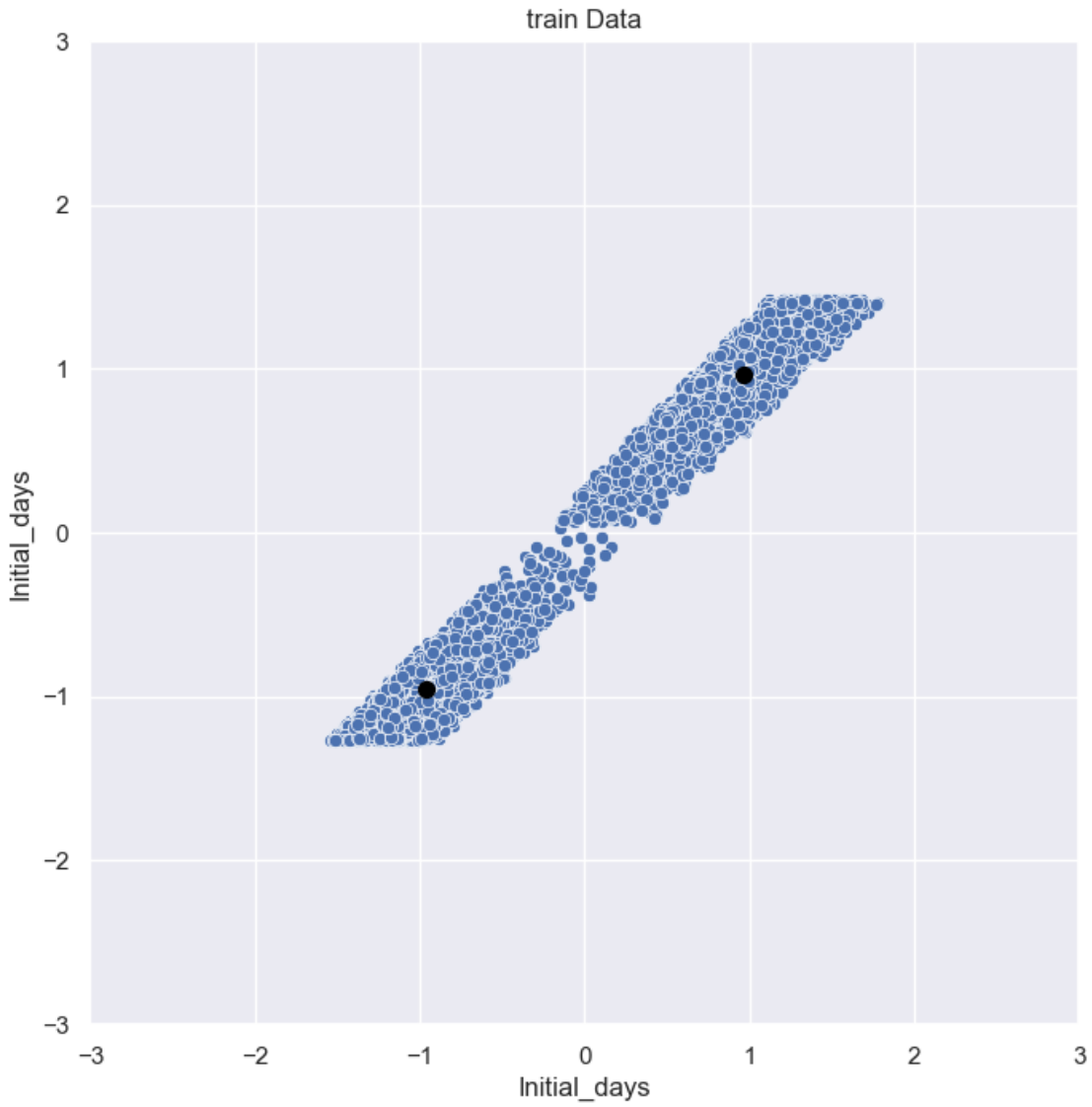
[56]:
```
   ReAdmis_Yes  Initial_days  TotalCharge
1            1      1.123243      1.11535
0            0     -0.655559     -0.65005
```

[57]:
```
g = sns.FacetGrid(test, col='ReAdmis_Yes')
g.map(plt.hist, 'Initial_days', bins=20);
```

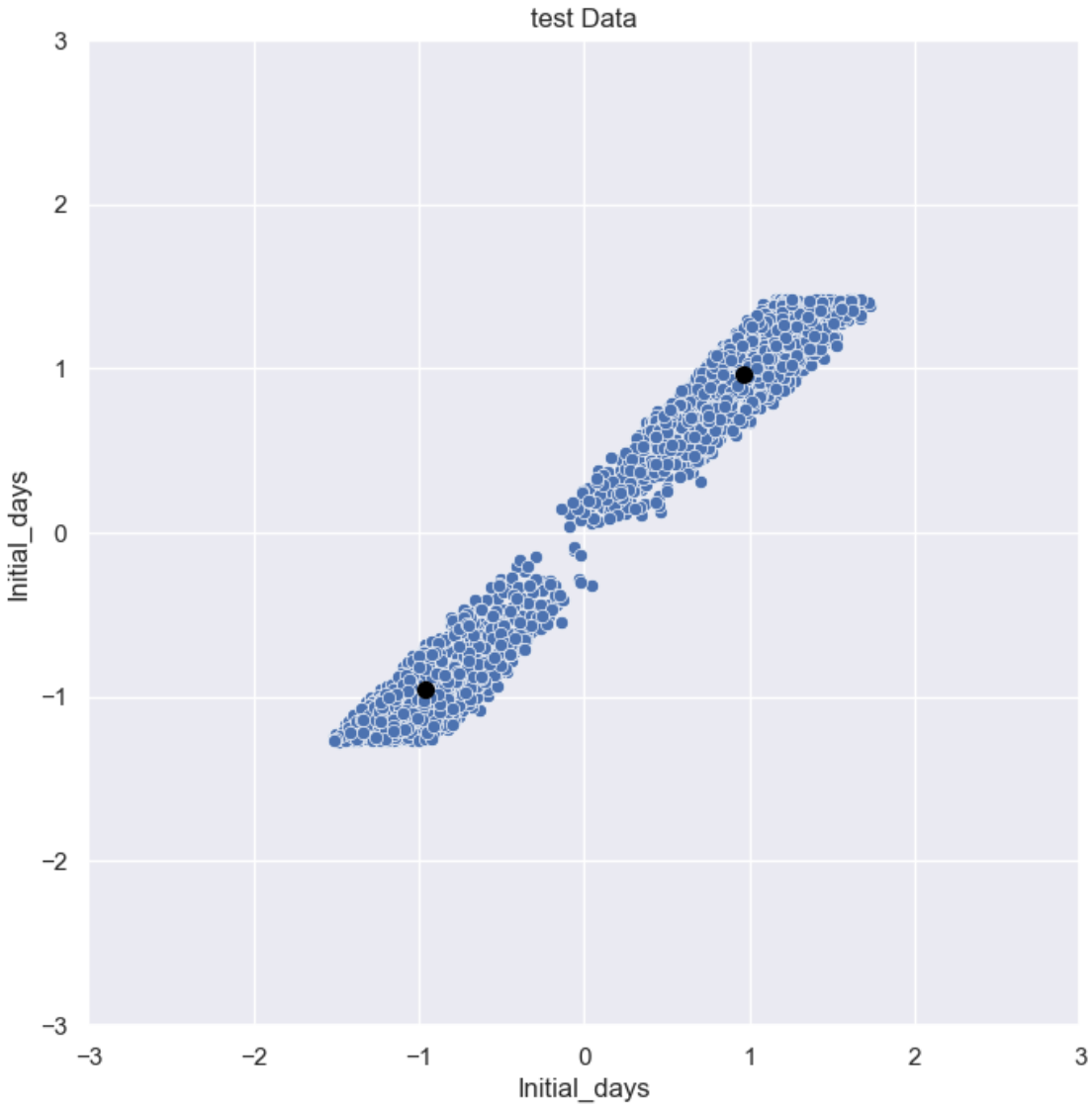


[58]:
```
fig, ax = plt.subplots(figsize=(8, 8))
ax = sns.scatterplot(x='TotalCharge', y='Initial_days', ax=ax, data=train)
ax.set_xlim(-3, 3)
```

```
ax.set_ylim(-3, 3)
centers.plot.scatter(x='Initial_days', y='Initial_days', \
                     ax=ax, s=50, color='black').set(title='train Data');
```



[59]:
```
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

[60]:
```
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)
```