D212_PA2_JWillis

March 16, 2024

0.1 D212 - Data Mining II - PA2

0.1.1 Background Info:

You are an analyst for a hospital that wants to better understand the characteristics of its patients. 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

[3]:
```
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

[4]:
```
# load data file
df = pd.read_csv('medical_clean.csv')
# quick test the data is present and see the shape
df.head()
```

[4]:

	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]
```

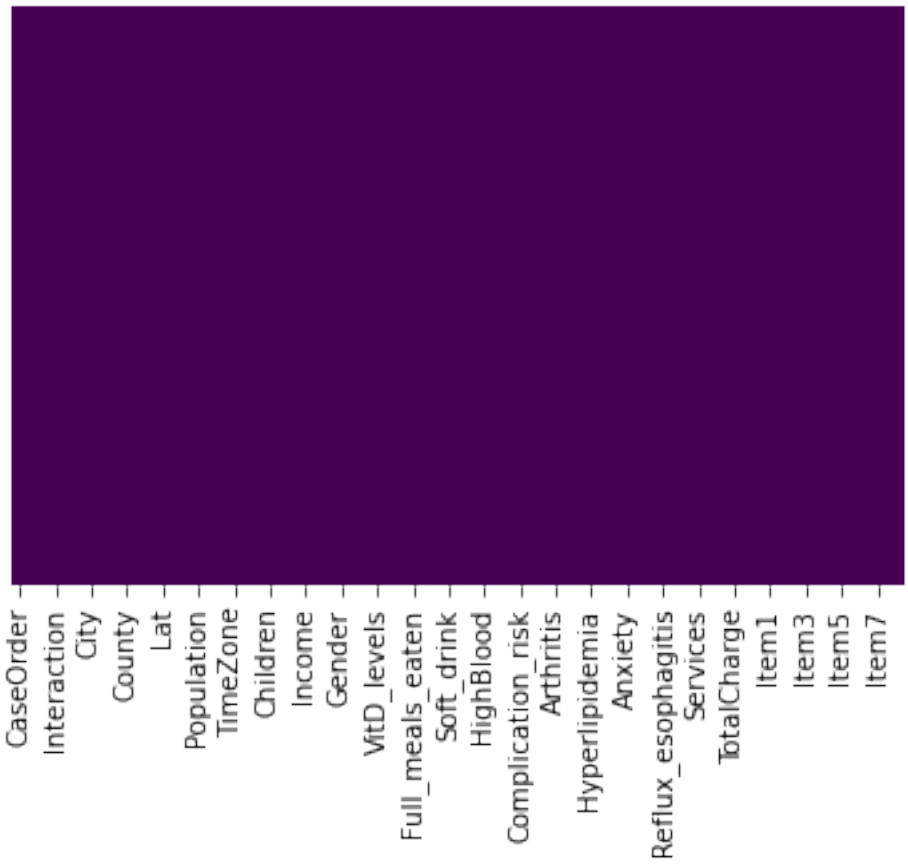
[5]:
```
df.info()
```

```
<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

[6]:
```
# Mapping to view missing data...none present.
sns.heatmap(df.isnull(), yticklabels=False, cbar=False, cmap='viridis');
```



[7]:
```
df.describe()
```

[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]
```

0.1.5 Describe and Explore Numeric Fields:

[8]:
```
df.describe(include = [np.number])
```

[8]:
```
         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

[9]:
```
df_num = df.select_dtypes(include='number')
df_num.head()
```

[9]:
```
   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:

[10]:
```
df.describe(exclude=[np.number])
```

[10]:
```
       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

[11]:
```
df_cat = df.select_dtypes(exclude='number')
df_cat.head()
```

[11]:
```
  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

[12]:
```
df[['ReAdmis']].describe()
```

[12]:
```
       ReAdmis
count    10000
unique       2
top         No
freq      6331
```

Describe Columns

[13]:
```
df.columns
```

[13]:
```
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

[14]:
```
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']]
```

[15]:
```
df_dummies = pd.get_dummies(df_temp)
df_dummies.head()
```

[15]:

	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]

[16]:
```
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
```

[17]:
```
df_dummies.columns
```

[17]:
```
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 Prep Dummies Data

[18]:
```
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']]
```

[19]:
```
df_dummies = pd.get_dummies(df_temp)
df_dummies.head()
```

[19]:

	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
```

0.1.9 Keep Only Necessary Columns

[21]:
```
# 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
---------------
```

[21]:
```
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')
```

[22]:
```
# testing how to identify categorical data
for t in pca_df.dtypes:
    if t == "float64":
        print("yes")
```

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

[23]:
```
pca_df.dtypes
```

[23]:
```
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
```

0.1.10 Create Dummies Function for specific datatypes, reduce multicoliniarity

[24]:
```
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
```

[25]:
```
pca_df_binary = dummify(pca_df)
pca_df_binary.head()
```

[25]:

	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]
```

[26]:
```
pca_df_binary.columns
```

[26]:
```
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')
```

[27]:
```
print('pca_df_target: ' + str(pca_df_target.shape))
print('------'*5)
print('pca_df_binary: ' + str(pca_df_binary.shape))
```

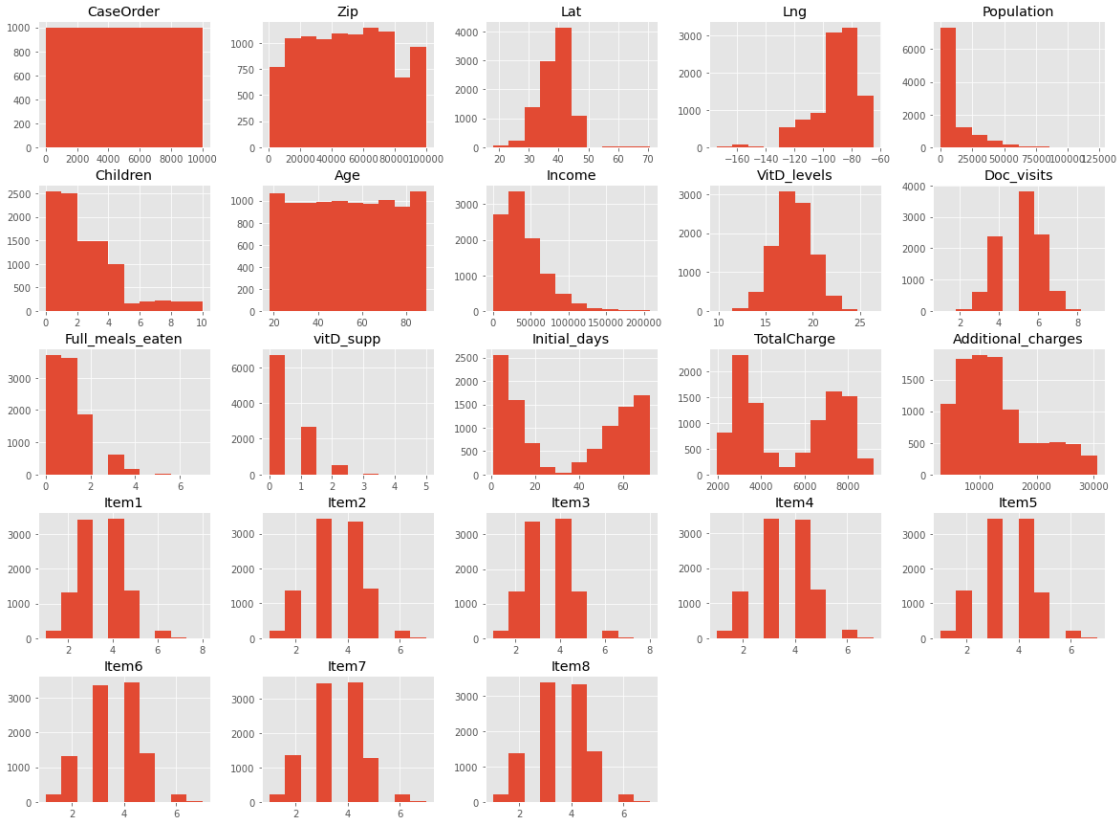
```
pca_df_target: (10000,)
------------------------------
pca_df_binary: (10000, 40)
```

[28]:
```
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
```

[29]:
```
# https://www.datacamp.com/community/tutorials/
  ↪preprocessing-in-data-science-part-1-centering-scaling-and-knn
plt.style.use('ggplot')
# df = pd.read_csv('http://archive.ics.uci.edu/ml/machine-learning-databases/
  ↪wine-quality/winequality-red.csv ' , sep = ';')
X = pca_df_binary.values # drop target variable
y1 = df_dummies['ReAdmis_Yes'].values
pd.DataFrame.hist(df, figsize = [20,15]);
```



[31]:
```
# https://realpython.com/knn-python/
# Correlations with target?
correlation_matrix = df_dummies.corr()

print(correlation_matrix["ReAdmis_Yes"] > 0.5)
```

```
Age                                    False
VitD_levels                            False
Doc_visits                             False
vitD_supp                              False
Initial_days                            True
TotalCharge                             True
Additional_charges                     False
Gender_Female                          False
Gender_Male                            False
Gender_Nonbinary                       False
ReAdmis_No                             False
ReAdmis_Yes                             True
Initial_admin_Elective Admission       False
Initial_admin_Emergency Admission      False
Initial_admin_Observation Admission    False
```

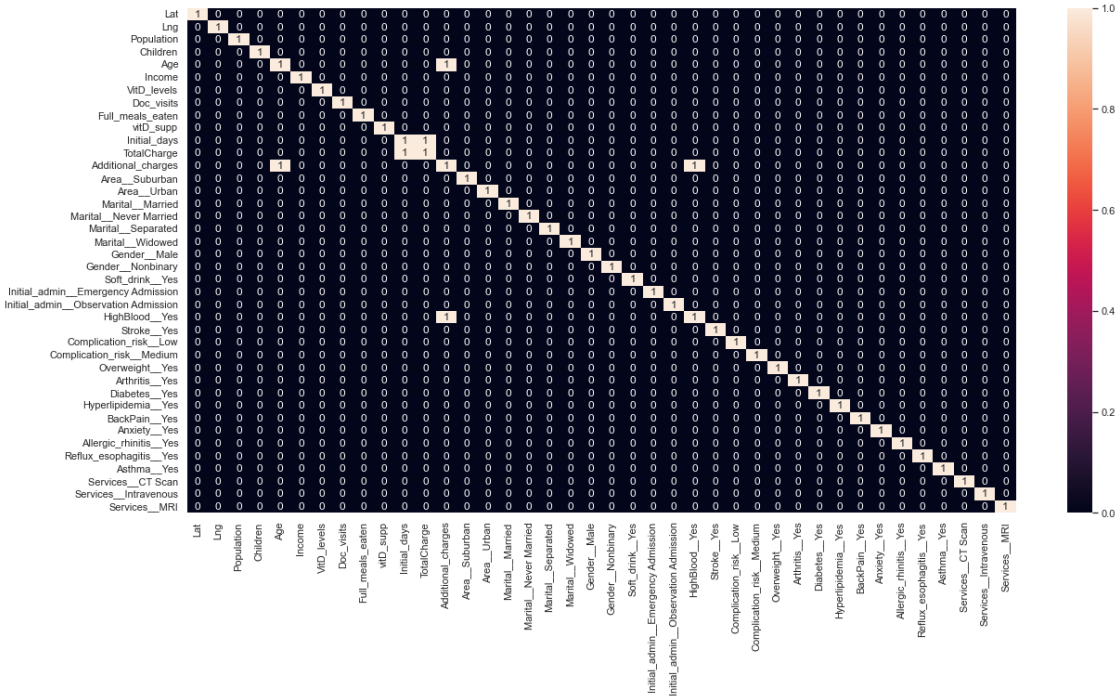
```
HighBlood_No                        False
HighBlood_Yes                       False
Stroke_No                           False
Stroke_Yes                          False
Complication_risk_High              False
Complication_risk_Low               False
Complication_risk_Medium            False
Overweight_No                       False
Overweight_Yes                      False
Arthritis_No                        False
Arthritis_Yes                       False
Diabetes_No                         False
Diabetes_Yes                        False
Hyperlipidemia_No                   False
Hyperlipidemia_Yes                  False
BackPain_No                         False
BackPain_Yes                        False
Anxiety_No                          False
Anxiety_Yes                         False
Allergic_rhinitis_No                False
Allergic_rhinitis_Yes               False
Reflux_esophagitis_No               False
Reflux_esophagitis_Yes              False
Asthma_No                           False
Asthma_Yes                          False
Services_Blood Work                 False
Services_CT Scan                    False
Services_Intravenous                False
Services_MRI                        False
Name: ReAdmis_Yes, dtype: bool
```

[35]:
```
# Focused featurs from correlation matrix
pruned_df = df_dummies[['Initial_days', 'TotalCharge', 'ReAdmis_Yes']]
```

[34]:
```
pruned_df.shape
```

[34]:
```
(10000, 3)
```

[30]:
```
# 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);
```


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
1.0
0.8
0.6
0.4
0.2
0.0

[ ]: