Dimensionality Reduction with PCA

Medical Dataset

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In [1]:
```
# Import Libraries
import matplotlib.pyplot as plt
import pandas as pd
import numpy as np
import seaborn as sns
import missingno as msno
from scipy import stats
```

In [2]:
```
# Windows 10, Anaconda, JupyterLab, JupyterNotebook
# Jupyter environment version
!jupyter --version
```

```
jupyter core     : 4.6.3
jupyter-notebook : 6.0.3
qtconsole        : 4.7.2
ipython          : 7.13.0
ipykernel        : 5.1.4
jupyter client   : 6.1.2
jupyter lab      : 1.2.6
nbconvert        : 5.6.1
ipywidgets       : 7.5.1
nbformat         : 5.0.4
traitlets        : 4.3.3
```

In [3]:
```
# Python Environment version
import platform
print(platform.python_version())
```

```
3.7.7
```

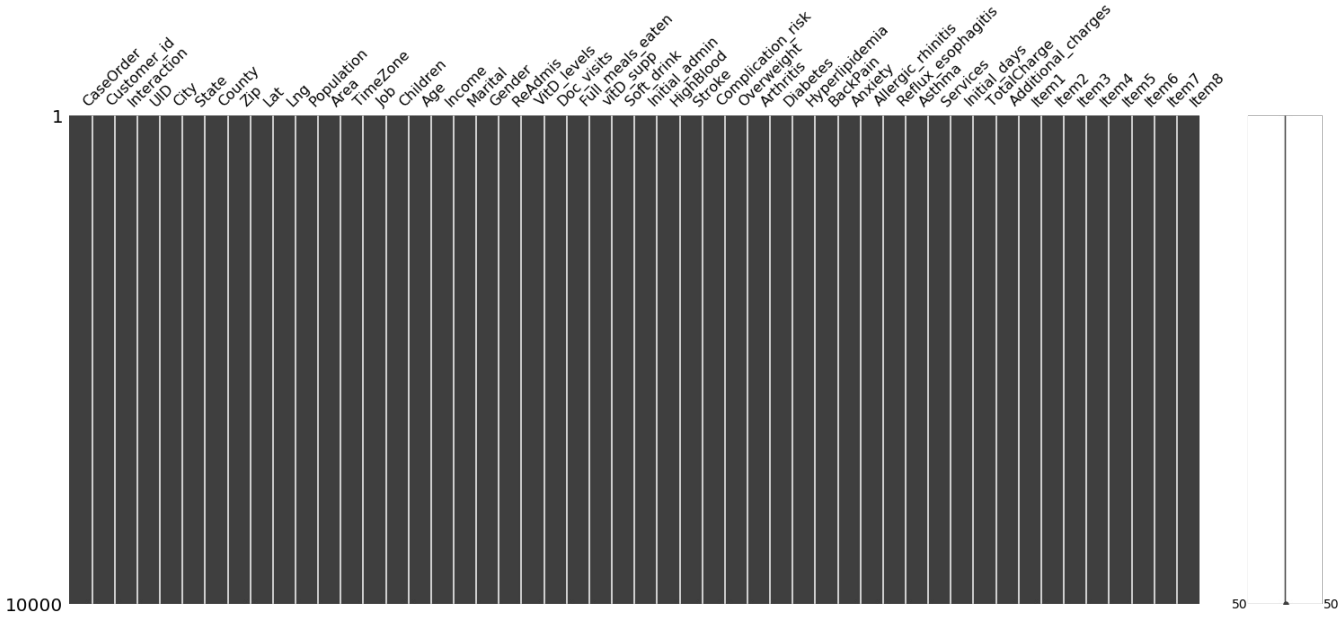
In [4]:
```
df = pd.read_csv('C:/Users/ericy/Desktop/medical_clean.csv')
```

In [5]:
```
df.isnull().sum()
```

Out[5]:
```
CaseOrder             0
Customer_id           0
Interaction           0
UID                   0
City                  0
State                 0
County                0
Zip                   0
Lat                   0
Lng                   0
Population            0
Area                  0
TimeZone              0
Job                   0
Children              0
Age                   0
Income                0
Marital               0
Gender                0
ReAdmis               0
VitD_levels           0
Doc_visits            0
Full_meals_eaten      0
vitD_supp             0
Soft_drink            0
Initial_admin         0
HighBlood             0
Stroke                0
Complication_risk     0
Overweight            0
Arthritis             0
Diabetes              0
Hyperlipidemia        0
BackPain              0
Anxiety               0
Allergic_rhinitis     0
Reflux_esophagitis    0
Asthma                0
Services              0
Initial_days          0
TotalCharge           0
Additional_charges    0
Item1                 0
Item2                 0
Item3                 0
Item4                 0
Item5                 0
Item6                 0
Item7                 0
Item8                 0
dtype: int64
```

In [6]:
```
msno.matrix(df)
```

Out[6]:
```
<matplotlib.axes._subplots.AxesSubplot at 0x1e102c43ec8>
```



Data Preprocessing

Step 1, Feature Selection and Data Exploration

In [7]:
```
# Duplicate Check
df.duplicated().sum()
```

Out[7]:
```
0
```

In [ ]:
```

```

In [9]:
```
# Removing unnecessary columns
# Selecting continuous dependent features
dfs = df[['Lat','Lng','Population','Income','Doc_visits','Full_meals_eaten','Children','VitD_levels','Additiona

dfs
```

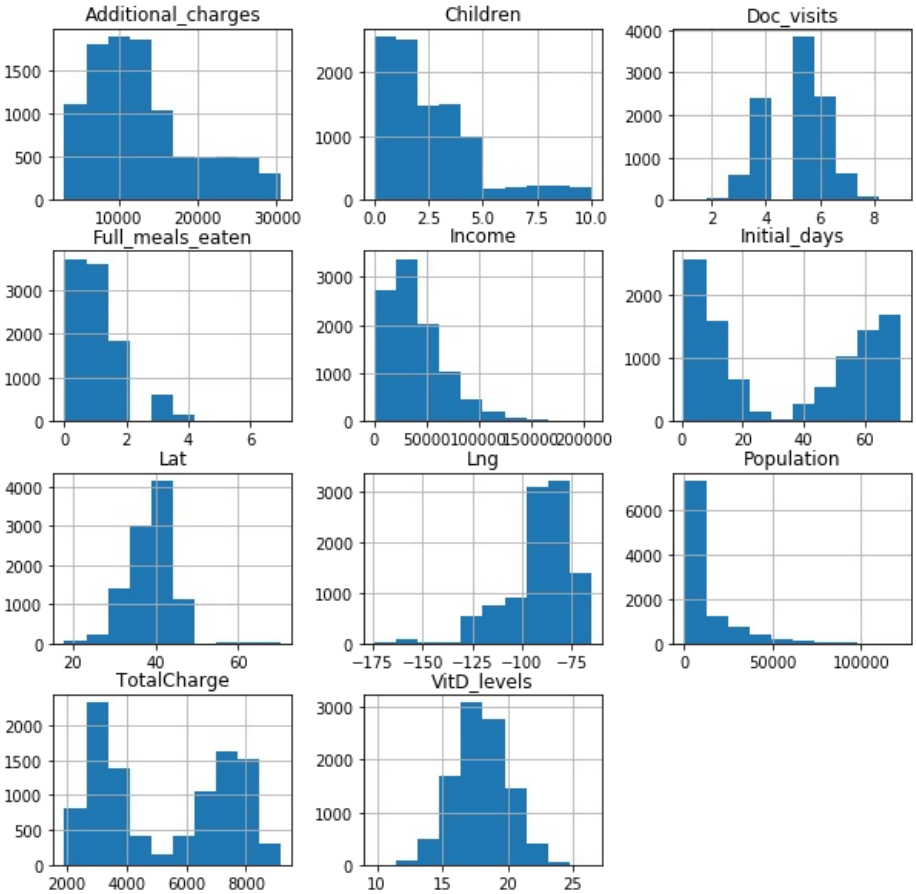
Out[9]:

	Lat	Lng	Population	Income	Doc_visits	Full_meals_eaten	Children	VitD_levels	Additional_charges	Initial_days	TotalCl
0	34.34960	-86.72508	2951	86575.93	6	0	1	19.141466	17939.403420	10.585770	3726.7(
1	30.84513	-85.22907	11303	46805.99	4	2	3	18.940352	17612.998120	15.129562	4193.19
2	43.54321	-96.63772	17125	14370.14	4	1	3	18.057507	17505.192460	4.772177	2434.23
3	43.89744	-93.51479	2162	39741.49	4	1	0	16.576858	12993.437350	1.714879	2127.83
4	37.59894	-76.88958	5287	1209.56	5	0	1	17.439069	3716.525786	1.254807	2113.07
...	...	...	...	...	...	...	...	...	...	...	
9995	36.42886	-78.23716	4762	45967.61	4	2	2	16.980860	8927.642000	51.561220	6850.94
9996	39.43609	-74.87302	1251	14983.02	5	0	4	18.177020	28507.150000	68.668240	7741.69
9997	36.36655	-87.29988	532	65917.81	4	2	3	17.129070	15281.210000	70.154180	8276.48
9998	44.10354	-102.01590	271	29702.32	5	2	3	19.910430	7781.678000	63.356900	7644.48
9999	40.49998	-80.19959	41524	62682.63	5	0	8	18.388620	11643.190000	70.850590	7887.55

10000 rows × 11 columns

In [10]:
```
dfs.hist(figsize=(10,10))
```

Out[10]:
```
array([[<matplotlib.axes._subplots.AxesSubplot object at 0x000001E104166488>,
        <matplotlib.axes._subplots.AxesSubplot object at 0x000001E10317F888>,
        <matplotlib.axes._subplots.AxesSubplot object at 0x000001E1031B9848>],
       [<matplotlib.axes._subplots.AxesSubplot object at 0x000001E1031F0948>,
        <matplotlib.axes._subplots.AxesSubplot object at 0x000001E10322AA08>,
        <matplotlib.axes._subplots.AxesSubplot object at 0x000001E103262B08>],
       [<matplotlib.axes._subplots.AxesSubplot object at 0x000001E10329BC08>,
        <matplotlib.axes._subplots.AxesSubplot object at 0x000001E1032D2D08>,
        <matplotlib.axes._subplots.AxesSubplot object at 0x000001E1032DD908>],
       [<matplotlib.axes._subplots.AxesSubplot object at 0x000001E103319B08>,
        <matplotlib.axes._subplots.AxesSubplot object at 0x000001E10337DFC8>,
        <matplotlib.axes._subplots.AxesSubplot object at 0x000001E1033BB148>]],
      dtype=object)
```



In [11]:
```
# Outlier removal method via Z-score, Code reference (Bushmanov, 2019)

num_data = dfs.select_dtypes(include=['number'])
cat_data = dfs.select_dtypes(exclude=['number'])
```

In [12]:
```
idx = np.all(stats.zscore(num_data) <3, axis=1)
```

In [13]:
```
dfs = pd.concat([num_data.loc[idx], cat_data.loc[idx]], axis=1)
```

In [14]:
```
dfs.info()
```

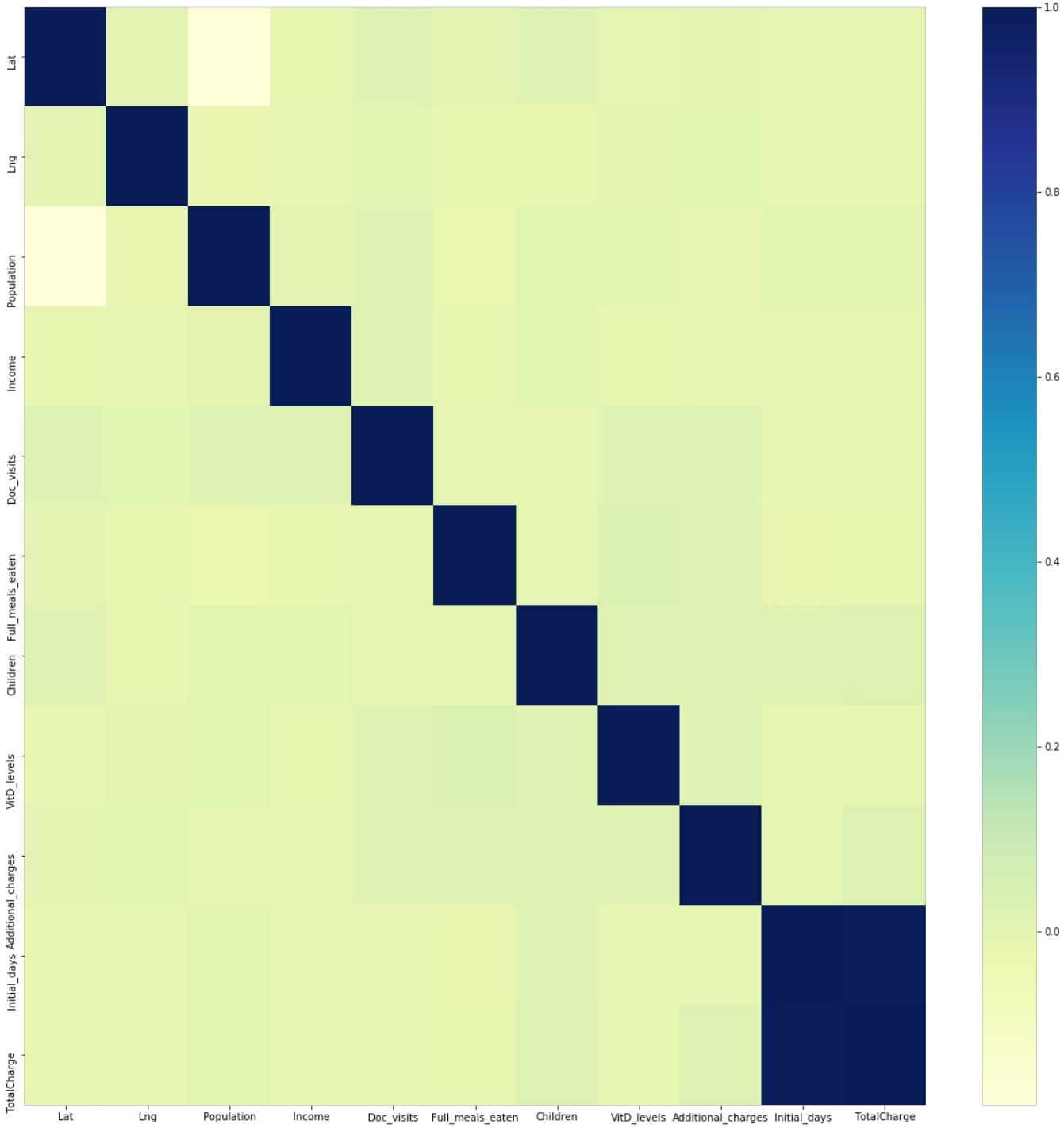
```
<class 'pandas.core.frame.DataFrame'>
Int64Index: 9348 entries, 0 to 9999
Data columns (total 11 columns):
 #   Column              Non-Null Count  Dtype  
---  ------              --------------  -----  
 0   Lat                 9348 non-null   float64
 1   Lng                 9348 non-null   float64
 2   Population          9348 non-null   int64  
 3   Income              9348 non-null   float64
 4   Doc_visits          9348 non-null   int64  
 5   Full_meals_eaten    9348 non-null   int64  
 6   Children            9348 non-null   int64  
 7   VitD_levels         9348 non-null   float64
 8   Additional_charges  9348 non-null   float64
 9   Initial_days        9348 non-null   float64
 10  TotalCharge         9348 non-null   float64
dtypes: float64(7), int64(4)
memory usage: 876.4 KB
```

In [15]:
```
dfs.corr()
```

Out[15]:

	Lat	Lng	Population	Income	Doc_visits	Full_meals_eaten	Children	VitD_levels	Additional_charges	Initia
Lat	1.000000	0.001799	-0.188077	-0.015718	0.007265	-0.001473	0.007512	-0.003017	-0.001230	-0.
Lng	0.001799	1.000000	-0.019119	-0.007951	0.002732	-0.015851	-0.013920	-0.000251	0.005215	-0.
Population	-0.188077	-0.019119	1.000000	0.000112	0.014135	-0.025150	0.006355	0.003940	-0.011665	0.
Income	-0.015718	-0.007951	0.000112	1.000000	0.010590	-0.013329	0.004629	-0.015816	-0.005076	-0.
Doc_visits	0.007265	0.002732	0.014135	0.010590	1.000000	-0.004594	-0.004692	0.011534	0.014290	-0.
Full_meals_eaten	-0.001473	-0.015851	-0.025150	-0.013329	-0.004594	1.000000	-0.005257	0.031522	0.018624	-0.
Children	0.007512	-0.013920	0.006355	0.004629	-0.004692	-0.005257	1.000000	0.008875	0.015530	0.
VitD_levels	-0.003017	-0.000251	0.003940	-0.015816	0.011534	0.031522	0.008875	1.000000	0.007627	-0.
Additional_charges	-0.001230	0.005215	-0.011665	-0.005076	0.014290	0.018624	0.015530	0.007627	1.000000	-0.
Initial_days	-0.008648	-0.006870	0.004276	-0.009244	-0.007122	-0.017448	0.020079	-0.006622	-0.002657	1.
TotalCharge	-0.011537	-0.006136	0.004841	-0.010998	-0.004482	-0.015222	0.020964	-0.003794	0.022870	0.

In [16]:
```
fig_dims = (20, 20)
fig, ax = plt.subplots(figsize=fig_dims)
sns.heatmap(dfs.corr(), ax=ax, cmap='YlGnBu')
plt.show()
```



Step 2, Check for Missing Data

In [17]:
```
# Check for and Handle any missing data
dfs.isnull().sum()
```

Out[17]:
```
Lat                  0
Lng                  0
Population           0
Income               0
Doc_visits           0
Full_meals_eaten     0
Children             0
VitD_levels          0
Additional_charges   0
Initial_days         0
TotalCharge          0
dtype: int64
```

In [18]:
```
dfs.isna().sum()
```

Out[18]:
```
Lat                  0
Lng                  0
Population           0
Income               0
Doc_visits           0
Full_meals_eaten     0
Children             0
VitD_levels          0
Additional_charges   0
Initial_days         0
TotalCharge          0
dtype: int64
```

In [19]:
```
dfs.isnull().any()
```

Out[19]:
```
Lat                  False
Lng                  False
Population           False
Income               False
Doc_visits           False
Full_meals_eaten     False
Children             False
VitD_levels          False
Additional_charges   False
Initial_days         False
TotalCharge          False
dtype: bool
```

In [20]:
```
dfs
```

Out[20]:

	Lat	Lng	Population	Income	Doc_visits	Full_meals_eaten	Children	VitD_levels	Additional_charges	Initial_days	TotalCl
0	34.34960	-86.72508	2951	86575.93	6	0	1	19.141466	17939.403420	10.585770	3726.7(
1	30.84513	-85.22907	11303	46805.99	4	2	3	18.940352	17612.998120	15.129562	4193.1(
2	43.54321	-96.63772	17125	14370.14	4	1	3	18.057507	17505.192460	4.772177	2434.2(
3	43.89744	-93.51479	2162	39741.49	4	1	0	16.576858	12993.437350	1.714879	2127.8(
4	37.59894	-76.88958	5287	1209.56	5	0	1	17.439069	3716.525786	1.254807	2113.0(
...	...	...	...	...	...	...	...	...	...	...	
9995	36.42886	-78.23716	4762	45967.61	4	2	2	16.980860	8927.642000	51.561220	6850.9(
9996	39.43609	-74.87302	1251	14983.02	5	0	4	18.177020	28507.150000	68.668240	7741.6(
9997	36.36655	-87.29988	532	65917.81	4	2	3	17.129070	15281.210000	70.154180	8276.4(
9998	44.10354	-102.01590	271	29702.32	5	2	3	19.910430	7781.678000	63.356900	7644.4(
9999	40.49998	-80.19959	41524	62682.63	5	0	8	18.388620	11643.190000	70.850590	7887.5(

9348 rows × 11 columns

In [ ]:
```

```

Standardization and PCA

In [21]:
```
from sklearn.decomposition import PCA
```

In [ ]:
```

```

In [22]:
```
#PCA
# PCA Dimenionality Reduction Techique, Code Reference (Larose, Larose, 2019)
```

In [23]:
```
#Define variables for PCA
med = dfs[['Lat','Lng','Population','Income','Doc_visits','Full_meals_eaten','Children','VitD_levels','Addition
```

In [24]:
```
med
```

Out[24]:

	Lat	Lng	Population	Income	Doc_visits	Full_meals_eaten	Children	VitD_levels	Additional_charges	Initial_days	TotalCl
0	34.34960	-86.72508	2951	86575.93	6	0	1	19.141466	17939.403420	10.585770	3726.7(
1	30.84513	-85.22907	11303	46805.99	4	2	3	18.940352	17612.998120	15.129562	4193.1
2	43.54321	-96.63772	17125	14370.14	4	1	3	18.057507	17505.192460	4.772177	2434.2
3	43.89744	-93.51479	2162	39741.49	4	1	0	16.576858	12993.437350	1.714879	2127.8
4	37.59894	-76.88958	5287	1209.56	5	0	1	17.439069	3716.525786	1.254807	2113.0
...	...	...	...	...	...	...	...	...	...	...	
9995	36.42886	-78.23716	4762	45967.61	4	2	2	16.980860	8927.642000	51.561220	6850.9
9996	39.43609	-74.87302	1251	14983.02	5	0	4	18.177020	28507.150000	68.668240	7741.6
9997	36.36655	-87.29988	532	65917.81	4	2	3	17.129070	15281.210000	70.154180	8276.4
9998	44.10354	-102.01590	271	29702.32	5	2	3	19.910430	7781.678000	63.356900	7644.4
9999	40.49998	-80.19959	41524	62682.63	5	0	8	18.388620	11643.190000	70.850590	7887.5

9348 rows × 11 columns

In [25]:
```
# Standardize data
# Code Reference (Data normalization with pandas, 2020)
med_normalized = (med-med.mean())/med.std()
```

In [26]:
```
med_normalized
```

Out[26]:

	Lat	Lng	Population	Income	Doc_visits	Full_meals_eaten	Children	VitD_levels	Additional_charges	Initial_days	TotalC
0	-0.862012	0.278990	-0.478865	1.876275	0.946286	-1.012064	-0.495635	0.594542	0.767523	-0.902922	-0.7
1	-1.560337	0.384368	0.211612	0.309608	-0.966957	1.035501	0.556766	0.493908	0.717572	-0.730283	-0.5
2	0.969970	-0.419245	0.692928	-0.968146	-0.966957	0.011719	0.556766	0.052144	0.701074	-1.123805	-1.3
3	1.040557	-0.199269	-0.544094	0.031314	-0.966957	0.011719	-1.021835	-0.688754	0.010624	-1.239966	-1.4
4	-0.214526	0.971792	-0.285743	-1.486584	-0.010336	-1.012064	-0.495635	-0.257315	-1.409056	-1.257446	-1.4
...	...	...	...	...	...	...	...	...	...	...	
9995	-0.447684	0.876870	-0.329146	0.276581	-0.966957	1.035501	0.030566	-0.486596	-0.611580	0.653916	0.7
9996	0.151557	1.113836	-0.619408	-0.944003	-0.010336	-1.012064	1.082967	0.111946	2.384744	1.303887	1.1
9997	-0.460101	0.238502	-0.678849	1.062484	-0.966957	1.035501	0.556766	-0.412434	0.360730	1.360344	1.3
9998	1.081625	-0.798078	-0.700426	-0.364162	-0.010336	1.035501	0.556766	0.979322	-0.786951	1.102086	1.0
9999	0.363555	0.738639	2.710044	0.935040	-0.010336	-1.012064	3.187769	0.217828	-0.196010	1.386804	1.1

9348 rows × 11 columns

In [27]:
```
# Read out cleaned dataset
med_normalized.to_excel('C:/Users/ericy/Desktop/D212.2.xlsx', index=False)
```

In [28]:
```
pca = PCA(n_components=med_normalized.shape[1])
```

In [29]:
```
pca.fit(med_normalized)
```

Out[29]:
```
PCA(n_components=11)
```

In [30]:
```
med_pca = pd.DataFrame(pca.transform(med_normalized),
                       columns=['PC1','PC2','PC3','PC4','PC5','PC6','PC7','PC8','PC9','PC10','PC11'])
```

In [31]:
```
loadings = pd.DataFrame(pca.components_.T,
                        columns =['PC1','PC2','PC3','PC4','PC5','PC6','PC7','PC8','PC9','PC10','PC11'],
                        index=med.columns)
loadings
```

Out[31]:

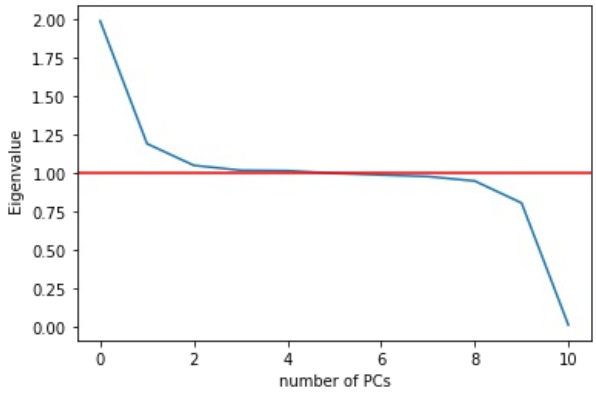
	PC1	PC2	PC3	PC4	PC5	PC6	PC7	PC8	PC9	PC10	PC11
Lat	-0.015930	-0.694288	-0.071949	0.081817	0.017799	0.037196	-0.134593	-0.078694	-0.050381	0.690861	0.002027
Lng	-0.009384	-0.072312	-0.157025	-0.356431	-0.606679	-0.394330	0.025417	0.474904	0.297104	0.070546	-0.000448
Population	0.010176	0.704501	0.036238	-0.018538	-0.017106	-0.045793	-0.053830	-0.073143	0.028218	0.700345	-0.000240
Income	-0.013701	0.070263	-0.293900	0.541177	-0.019915	0.365928	0.260638	0.631928	-0.093975	0.072310	0.001166
Doc_visits	-0.008338	0.028066	0.105343	0.352703	-0.635121	0.403332	-0.303991	-0.330680	0.298147	-0.083281	-0.001634
Full_meals_eaten	-0.023301	-0.088272	0.591670	-0.146195	0.190436	0.293050	0.367691	0.167477	0.569714	0.101261	-0.001194
Children	0.029611	-0.001838	0.163498	0.567260	0.252992	-0.568826	-0.329285	0.124946	0.369428	-0.050185	-0.000375
VitD_levels	-0.007585	0.005539	0.581081	-0.096957	-0.084461	0.111804	-0.493393	0.420997	-0.460952	-0.008231	-0.001796
Additional_charges	0.014191	-0.050021	0.396009	0.309482	-0.346416	-0.348171	0.575162	-0.181885	-0.370217	0.046709	-0.018194
Initial_days	0.706173	-0.013781	-0.005671	-0.015530	-0.001509	0.029184	-0.002310	0.013489	0.009127	0.005977	-0.706892
TotalCharge	0.706356	-0.013067	0.007929	-0.008298	-0.012058	0.020651	0.010934	0.008918	0.000771	0.005290	0.707078

Elbow Rule and Kaiser Criterion

In [32]:
```
cov_matrix = np.dot(med_normalized.T, med_normalized) / med.shape[0]
```

In [33]:
```
eigenvalues = [np.dot(eigenvector.T, np.dot(cov_matrix, eigenvector)) for eigenvector in pca.components_]
```

In [39]:
```
#Plot Elbow Graph
plt.plot(eigenvalues)
plt.xlabel('number of PCs')
plt.ylabel(' Eigenvalue')
plt.axhline(y=1, color='red')
plt.show()
```

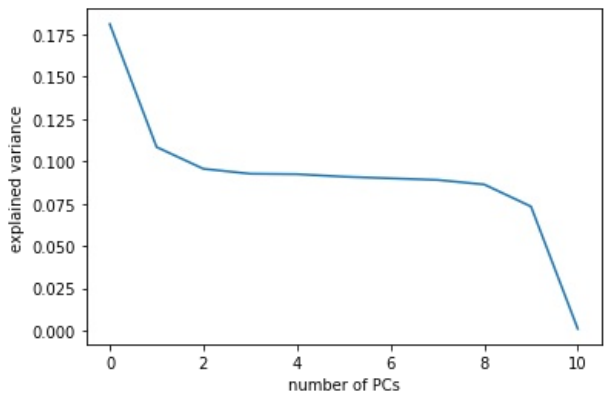


In [35]:
```
print(eigenvalues)
```

```
[1.9897425589857693, 1.1915801373668988, 1.050470223714036, 1.0184659912104532, 1.0154827922393348, 0.999291762
1580107, 0.9885689114449758, 0.9782773787132588, 0.9489950773023078, 0.8059454197926789, 0.0120030247788463]
```

Explained Variance

In [40]:
```
plt.plot(pca.explained_variance_ratio_)
plt.xlabel('number of PCs')
plt.ylabel('explained variance')
plt.show()
```



In [37]:
```
print(pca.explained_variance_ratio_)
```

```
[0.18090504 0.10833706 0.09550751 0.09259772 0.09232649 0.09085442
 0.08987952 0.08894382 0.08628151 0.0732756  0.0010913 ]
```

In [ ]: