Eric Yarger, D208 Task 2

Design research question, Select Variables from model

What variables from the data set are the most effective at predicting if a patient will be Readmitted?

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
from scipy.stats import zscore
```

In [2]:

```
# Read in medical_clean datafile
df = pd.read_csv('C:/Users/ericy/Desktop/medical_clean.csv')
```

Environment Details

In [3]:

```
# 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 [4]:

```
# Python Environment version
import platform
print(platform.python_version())
```

```
3.7.7
```

Cleaning, Preparation, Manipulation

In [5]:

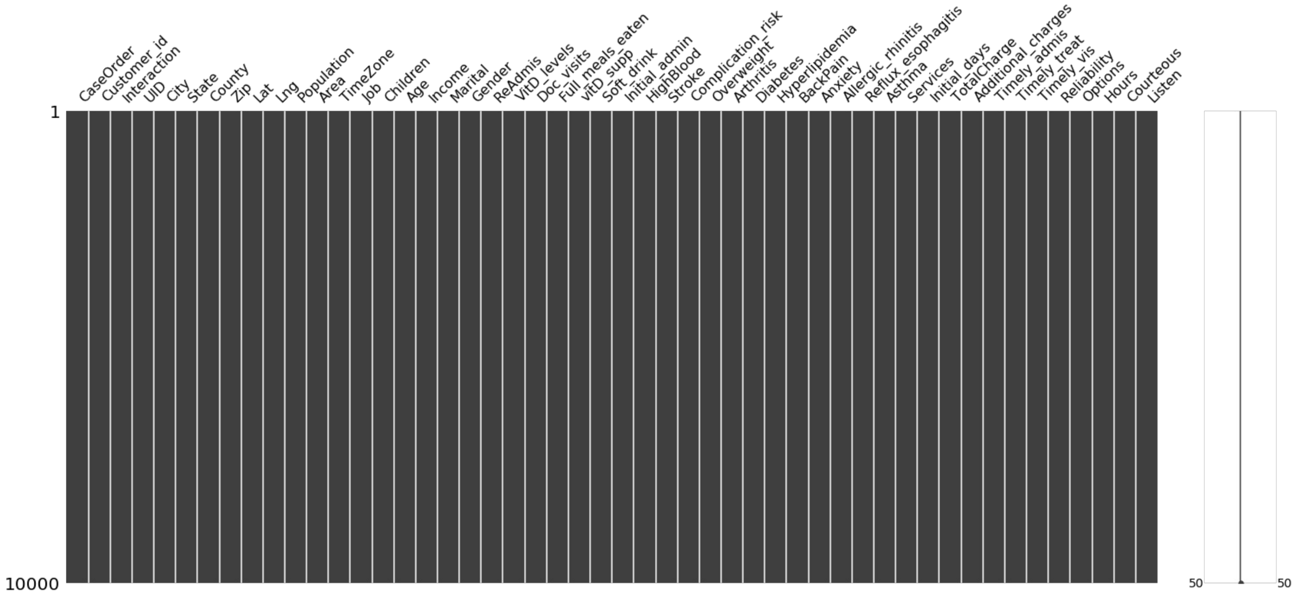
```
#Rename columns for dataset cohesiveness and readability
df.rename(columns={'Item1':'Timely_admis','Item2':'Timely_treat','Item3':'Timely_vis','Item4':'Reliability','Item
5':'Options','Item6':'Hours','Item7':'Courteous','Item8':'Listen'},inplace=True)
```

In [6]:

```
# Check for null values
msno.matrix(df)
```

Out[6]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x1fe44118c88>
```



In [7]:

```
# Overview of data set - type, null count, variable names
df.info()
```

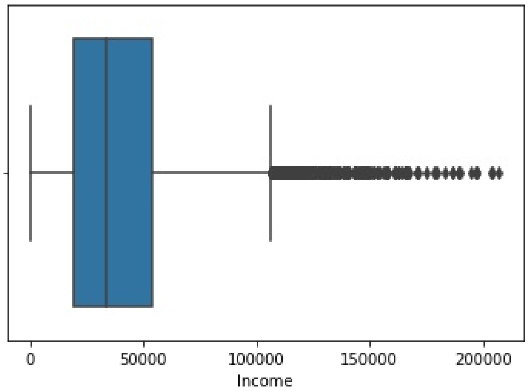
```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 10000 entries, 0 to 9999
Data columns (total 50 columns):
 #   Column              Non-Null Count  Dtype  
---  ------              --------------  -----  
 0   CaseOrder           10000 non-null  int64  
 1   Customer_id         10000 non-null  object 
 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  Timely_admis        10000 non-null  int64  
 43  Timely_treat        10000 non-null  int64  
 44  Timely_vis          10000 non-null  int64  
 45  Reliability         10000 non-null  int64  
 46  Options             10000 non-null  int64  
 47  Hours               10000 non-null  int64  
 48  Courteous           10000 non-null  int64  
 49  Listen              10000 non-null  int64  
dtypes: float64(7), int64(16), object(27)
memory usage: 3.8+ MB
```

In [8]:

```
sns.boxplot(df['Income'])
```

Out[8]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x1fe448f8688>
```

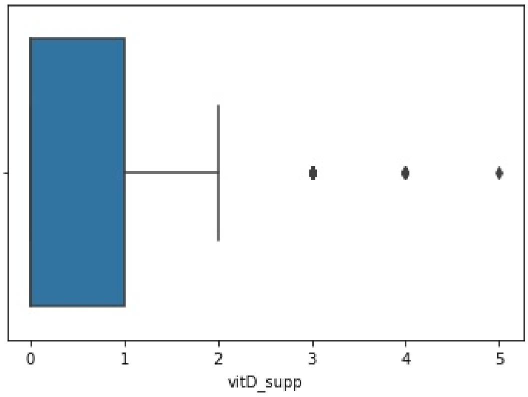


In [9]:

```
sns.boxplot(df['vitD_supp'])
```

Out[9]:

<matplotlib.axes._subplots.AxesSubplot at 0x1fe4351f348>

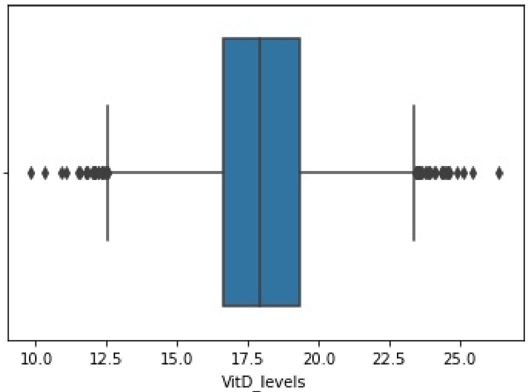


In [10]:

```
sns.boxplot(df['VitD_levels'])
```

Out[10]:

<matplotlib.axes._subplots.AxesSubplot at 0x1fe4358ca48>

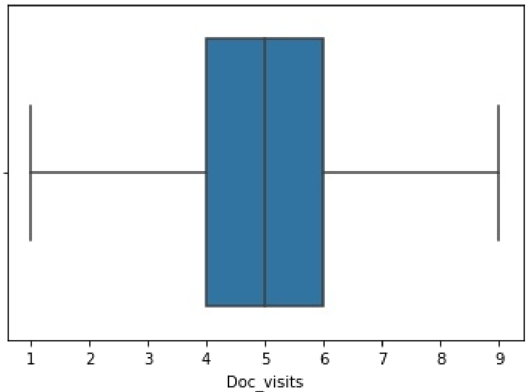


In [11]:

```
sns.boxplot(df['Doc_visits'])
```

Out[11]:

<matplotlib.axes._subplots.AxesSubplot at 0x1fe435efd08>

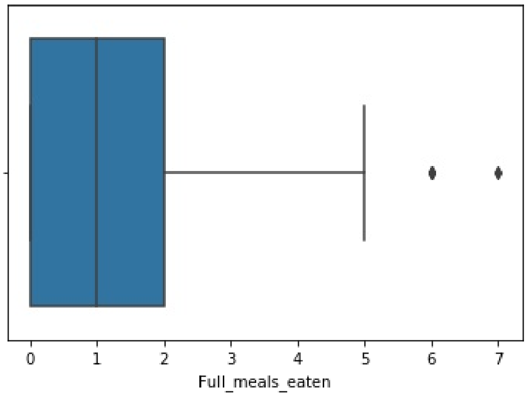


In [12]:

```
sns.boxplot(df['Full_meals_eaten'])
```

Out[12]:

<matplotlib.axes._subplots.AxesSubplot at 0x1fe43653608>

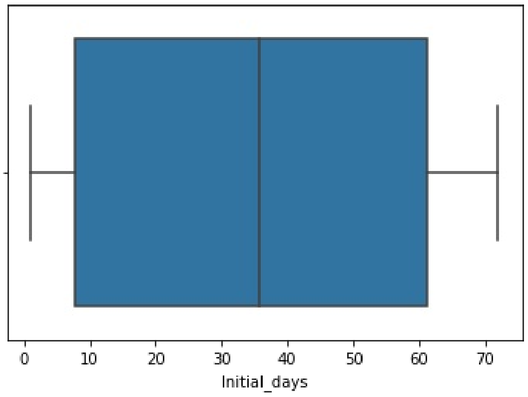


In [13]:

```
sns.boxplot(df['Initial_days'])
```

Out[13]:

<matplotlib.axes._subplots.AxesSubplot at 0x1fe436c3408>

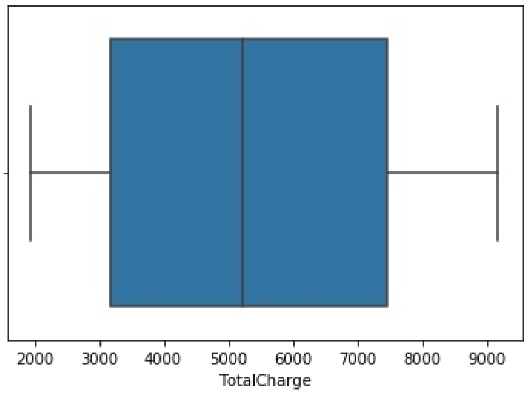


In [14]:

```
sns.boxplot(df['TotalCharge'])
```

Out[14]:

<matplotlib.axes._subplots.AxesSubplot at 0x1fe43737248>

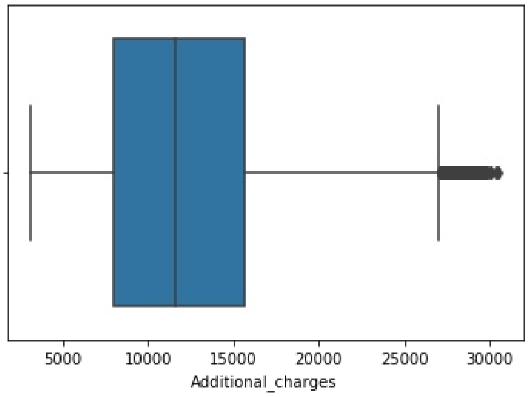


In [15]:

```
sns.boxplot(df['Additional_charges'])
```

Out[15]:

<matplotlib.axes._subplots.AxesSubplot at 0x1fe4377ab48>

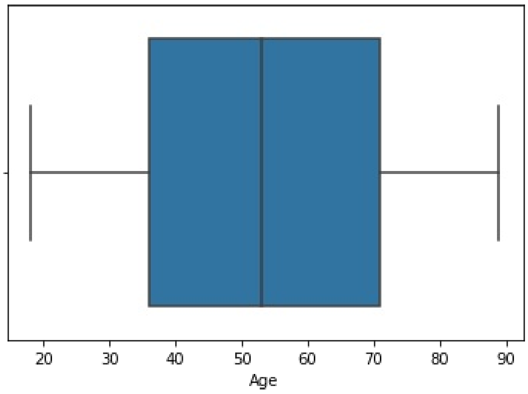


In [16]:

```
sns.boxplot(df['Age'])
```

Out[16]:

<matplotlib.axes._subplots.AxesSubplot at 0x1fe437ff308>

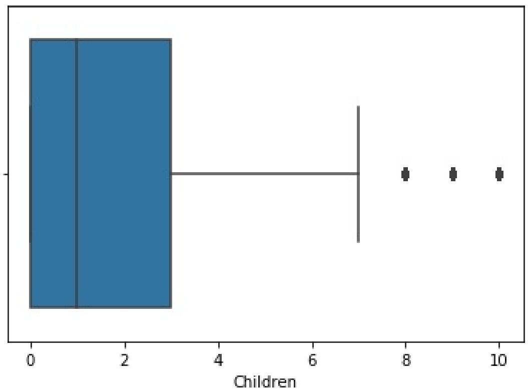


In [17]:

```
sns.boxplot(df['Children'])
```

Out[17]:

<matplotlib.axes._subplots.AxesSubplot at 0x1fe43860088>

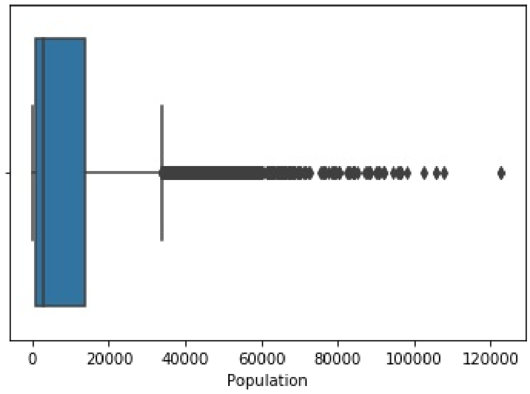


In [18]:

```
sns.boxplot(df['Population'])
```

Out[18]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x1fe438bf608>
```



In [19]:

```
# Outlier removal method via Z-score, Code reference (Bushmanov, 2019)
num_data = df.select_dtypes(include=['number'])
cat_data = df.select_dtypes(exclude=['number'])
```

In [20]:

```
idx = np.all(stats.zscore(num_data) <3, axis=1)
```

In [21]:

```
df = pd.concat([num_data.loc[idx], cat_data.loc[idx]], axis=1)
```

In [22]:

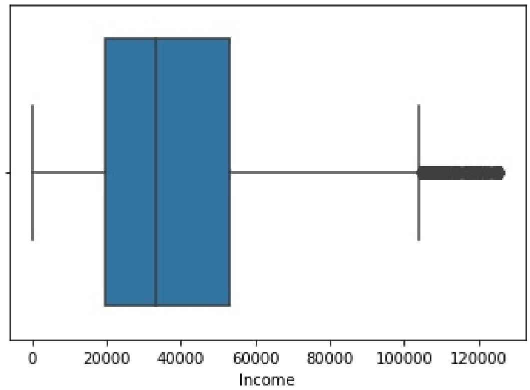
```
# Target variable, change responses to numerical binary
df['ReAdmis'].replace(('Yes','No'), (1,0), inplace=True)
```

In [23]:

```
sns.boxplot(df['Income'])
```

Out[23]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x1fe448ee808>
```

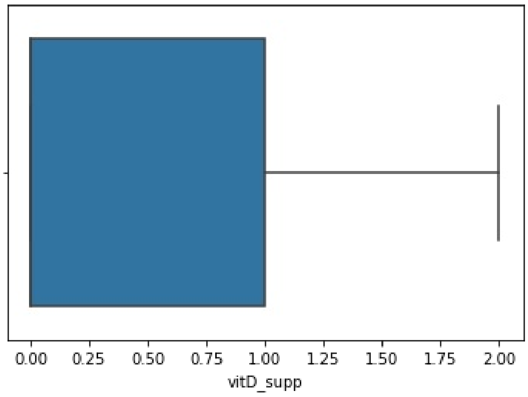


In [24]:

```
sns.boxplot(df['vitD_supp'])
```

Out[24]:

<matplotlib.axes._subplots.AxesSubplot at 0x1fe42fb2c48>

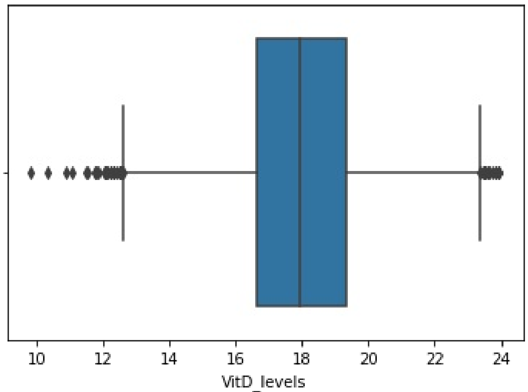


In [25]:

```
sns.boxplot(df['VitD_levels'])
```

Out[25]:

<matplotlib.axes._subplots.AxesSubplot at 0x1fe4302a9c8>

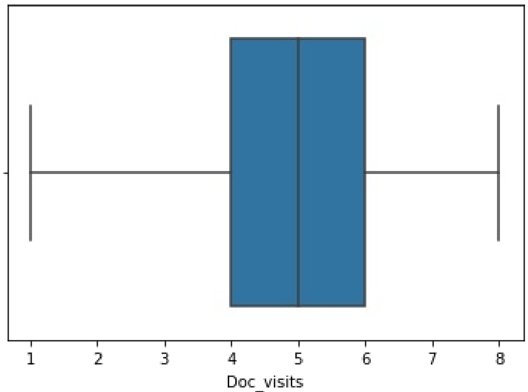


In [26]:

```
sns.boxplot(df['Doc_visits'])
```

Out[26]:

<matplotlib.axes._subplots.AxesSubplot at 0x1fe4308a708>

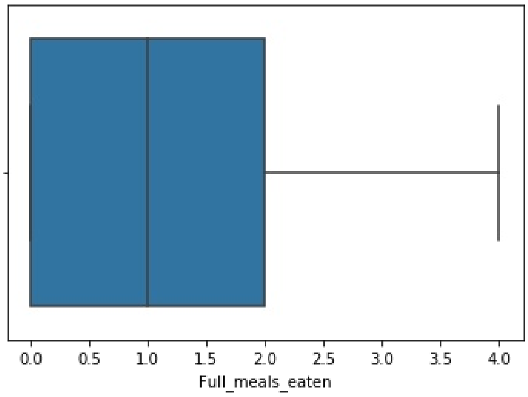


In [27]:

```
sns.boxplot(df['Full_meals_eaten'])
```

Out[27]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x1fe430f5448>
```

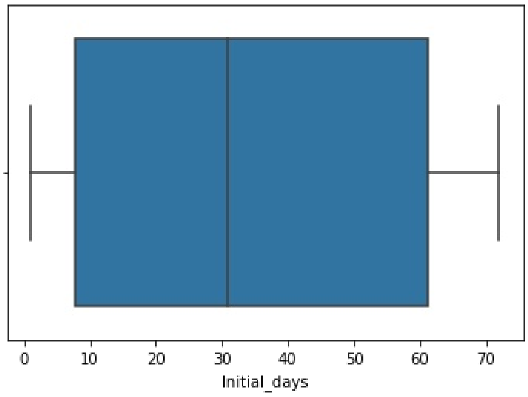


In [28]:

```
sns.boxplot(df['Initial_days'])
```

Out[28]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x1fe43105708>
```

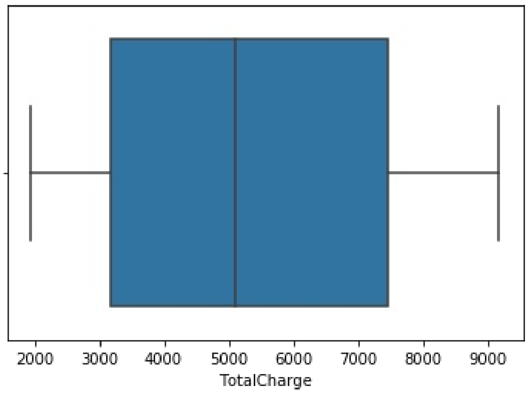


In [29]:

```
sns.boxplot(df['TotalCharge'])
```

Out[29]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x1fe45fedd88>
```

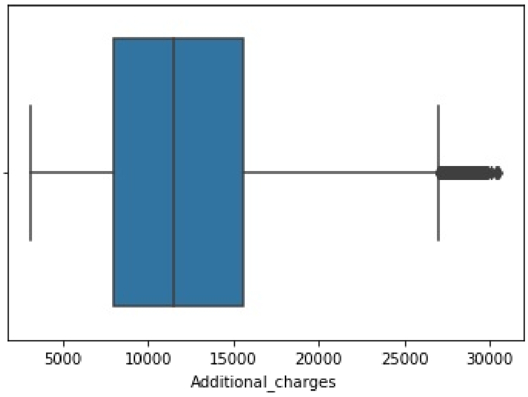


In [30]:

```
sns.boxplot(df['Additional_charges'])
```

Out[30]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x1fe46056208>
```

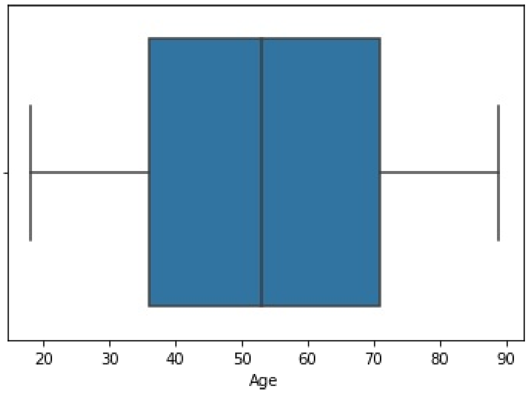


In [31]:

```
sns.boxplot(df['Age'])
```

Out[31]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x1fe460b5ec8>
```

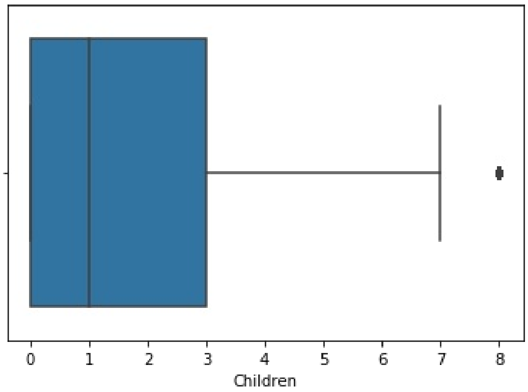


In [32]:

```
sns.boxplot(df['Children'])
```

Out[32]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x1fe46124108>
```

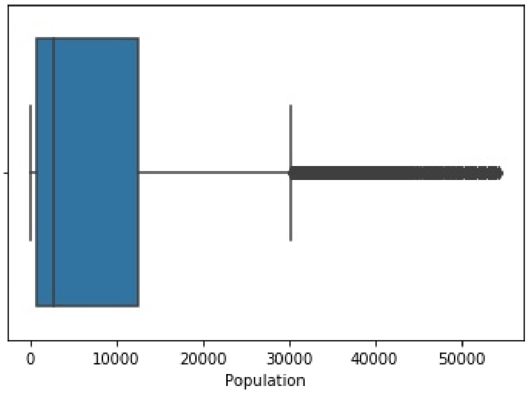


In [33]:

```
sns.boxplot(df['Population'])
```

Out[33]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x1fe46189288>
```



Univariate Visualization

Histograms

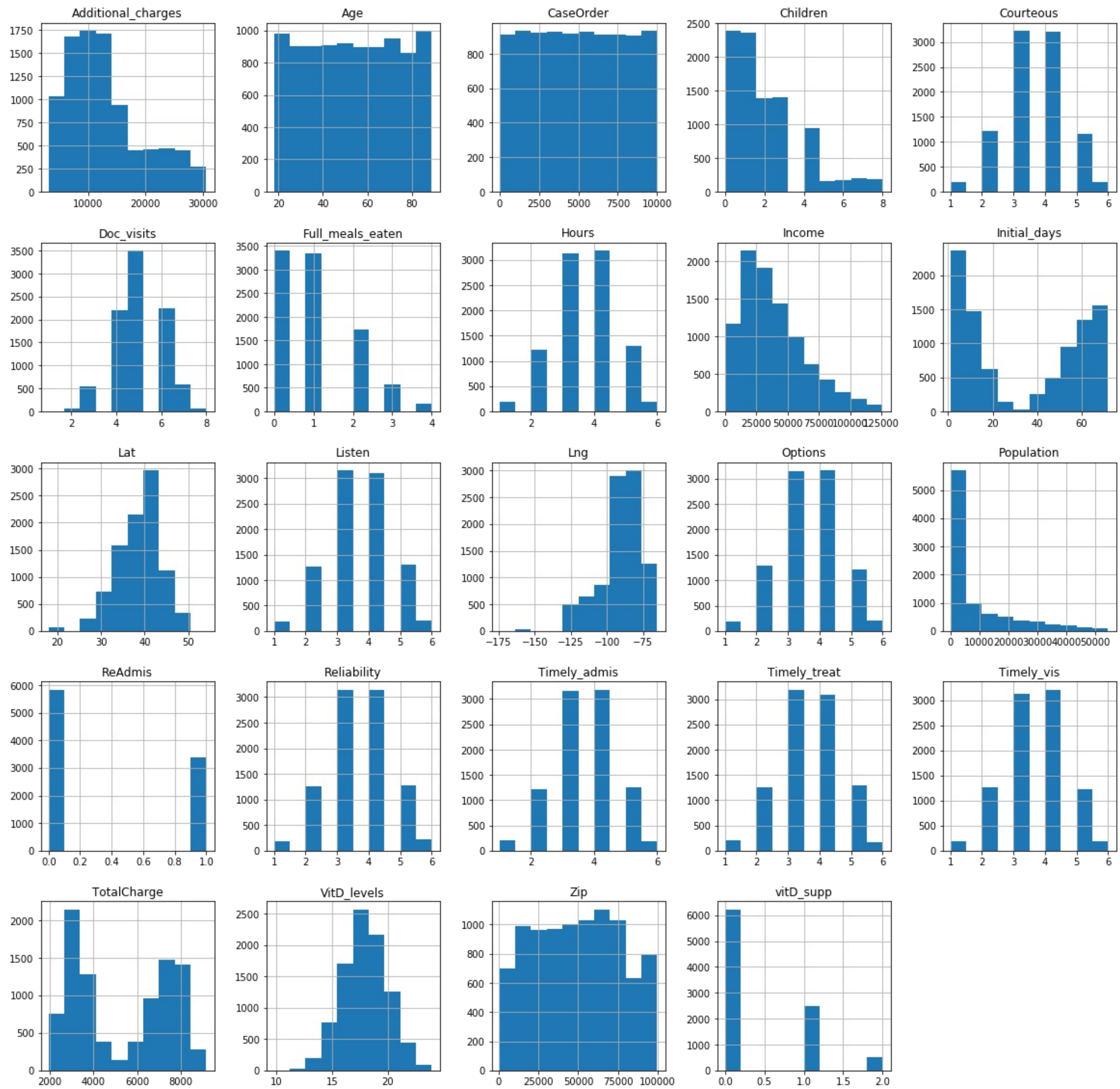
Identify Feature Distribution and Normality

In [34]:

```
df.hist(figsize=(20,20))
```

Out[34]:

```
array([[<matplotlib.axes._subplots.AxesSubplot object at 0x000001FE4623C888>,
        <matplotlib.axes._subplots.AxesSubplot object at 0x000001FE46267B48>,
        <matplotlib.axes._subplots.AxesSubplot object at 0x000001FE462A33C8>,
        <matplotlib.axes._subplots.AxesSubplot object at 0x000001FE462DC448>,
        <matplotlib.axes._subplots.AxesSubplot object at 0x000001FE46314588>],
       [<matplotlib.axes._subplots.AxesSubplot object at 0x000001FE4634C608>,
        <matplotlib.axes._subplots.AxesSubplot object at 0x000001FE46387708>,
        <matplotlib.axes._subplots.AxesSubplot object at 0x000001FE4650D848>,
        <matplotlib.axes._subplots.AxesSubplot object at 0x000001FE46519448>,
        <matplotlib.axes._subplots.AxesSubplot object at 0x000001FE46553608>],
       [<matplotlib.axes._subplots.AxesSubplot object at 0x000001FE465B9AC8>,
        <matplotlib.axes._subplots.AxesSubplot object at 0x000001FE465EFBC8>,
        <matplotlib.axes._subplots.AxesSubplot object at 0x000001FE4662ACC8>,
        <matplotlib.axes._subplots.AxesSubplot object at 0x000001FE46661E08>,
        <matplotlib.axes._subplots.AxesSubplot object at 0x000001FE4669BF08>],
       [<matplotlib.axes._subplots.AxesSubplot object at 0x000001FE466D3FC8>,
        <matplotlib.axes._subplots.AxesSubplot object at 0x000001FE46712148>,
        <matplotlib.axes._subplots.AxesSubplot object at 0x000001FE46749248>,
        <matplotlib.axes._subplots.AxesSubplot object at 0x000001FE46782348>,
        <matplotlib.axes._subplots.AxesSubplot object at 0x000001FE467BA488>],
       [<matplotlib.axes._subplots.AxesSubplot object at 0x000001FE467F5588>,
        <matplotlib.axes._subplots.AxesSubplot object at 0x000001FE4682C608>,
        <matplotlib.axes._subplots.AxesSubplot object at 0x000001FE46865748>,
        <matplotlib.axes._subplots.AxesSubplot object at 0x000001FE4689E888>,
        <matplotlib.axes._subplots.AxesSubplot object at 0x000001FE468D9988>]],
      dtype=object)
```



Bivariate Visualization

Scatterplots with

X-Axis = ReAdmis

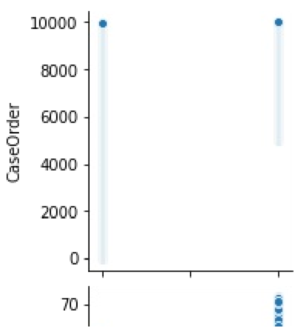
Y-Axis = Independent feature

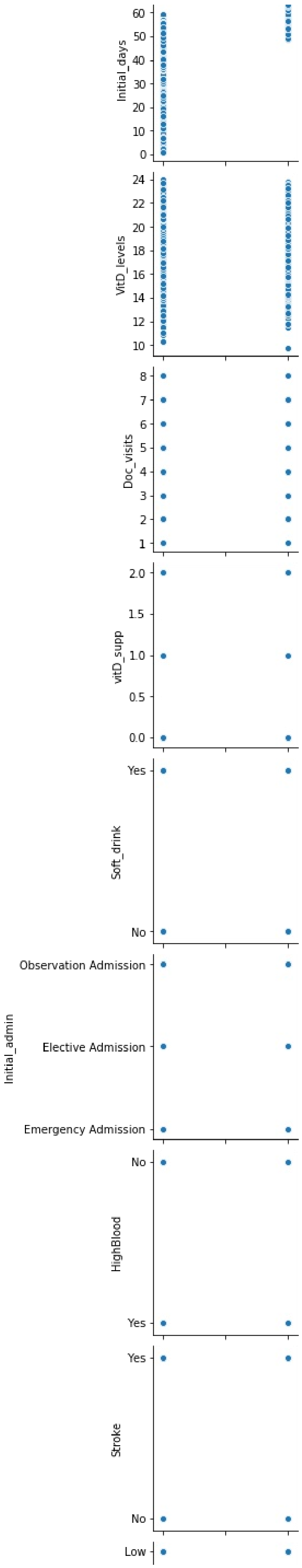
In [35]:

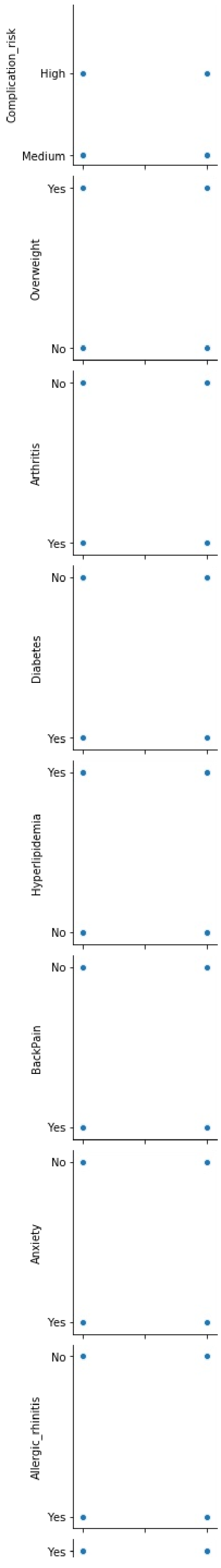
```
sns.pairplot(df, x_vars=['ReAdmis'], y_vars=['CaseOrder','Initial_days','VitD_levels','Doc_visits','vitD_supp','Soft_drink','Initial_admin','HighBlood','Stroke','Complication_risk','Overweight','Arthritis','Diabetes','Hyperlipidemia','BackPain','Anxiety','Allergic_rhinitis','Reflux_esophagitis','Asthma','Services','TotalCharge','Additional_charges'])
```

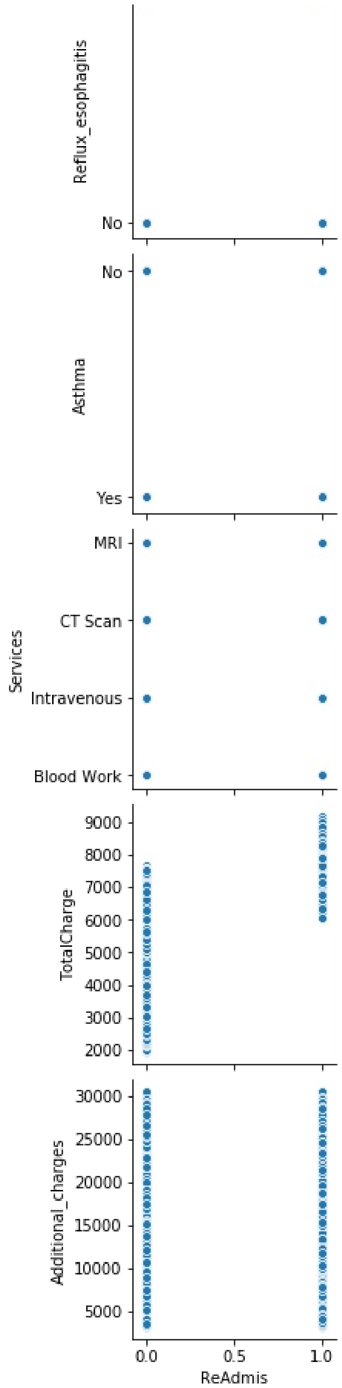
Out[35]:

<seaborn.axisgrid.PairGrid at 0x1fe47635fc8>




Initial_days
60
50
40
30
20
10
0
VitD_levels
24
22
20
18
16
14
12
10
Doc_visits
8
7
6
5
4
3
2
1
vitD_supp
2.0
1.5
1.0
0.5
0.0
Soft_drink
Yes
No
Initial_admin
Observation Admission
Elective Admission
Emergency Admission
HighBlood
No
Yes
Stroke
Yes
No
Low


Complication_risk
High
Medium
Overweight
Yes
No
Arthritis
No
Yes
Diabetes
No
Yes
Hyperlipidemia
Yes
No
BackPain
No
Yes
Anxiety
No
Yes
Allergic_rhinitis
No
Yes
Yes



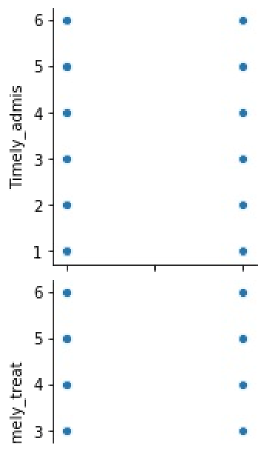
In [ ]:

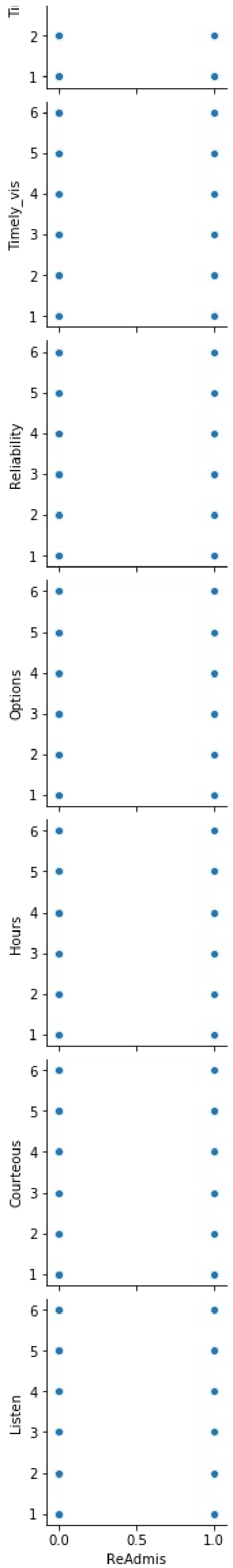
In [36]:

```
sns.pairplot(df, x_vars=['ReAdmis'], y_vars=['Timely_admis','Timely_treat','Timely_vis','Reliability','Options','Hours','Courteous','Listen'])
```

Out[36]:

<seaborn.axisgrid.PairGrid at 0x1fe486c1cc8>




Ti
Timely_vis
Reliability
Options
Hours
Courteous
Listen
ReAdmis
0.0
0.5
1.0

In [37]:

```
df.corr()
```

Out[37]:

	CaseOrder	Zip	Lat	Lng	Population	Children	Age	Income	VitD_levels	Doc_visits	...	A
CaseOrder	1.000000	0.010465	-0.012946	-0.012081	0.001489	0.017027	-0.003011	-0.012265	-0.015026	-0.006920	...	
Zip	0.010465	1.000000	-0.084258	-0.913573	0.012947	0.014307	-0.003327	0.010507	-0.010747	0.000257	...	
Lat	-0.012946	-0.084258	1.000000	0.001062	-0.187334	0.005874	-0.000132	-0.015414	-0.005158	0.004689	...	
Lng	-0.012081	-0.913573	0.001062	1.000000	-0.018263	-0.014141	0.002780	-0.008175	0.000931	0.002417	...	
Population	0.001489	0.012947	-0.187334	-0.018263	1.000000	0.007810	-0.018884	0.002162	0.004719	0.016088	...	
Children	0.017027	0.014307	0.005874	-0.014141	0.007810	1.000000	0.006050	0.003951	0.006542	-0.003467	...	
Age	-0.003011	-0.003327	-0.000132	0.002780	-0.018884	0.006050	1.000000	-0.003218	0.008795	0.010819	...	
Income	-0.012265	0.010507	-0.015414	-0.008175	0.002162	0.003951	-0.003218	1.000000	-0.015684	0.011179	...	
VitD_levels	-0.015026	-0.010747	-0.005158	0.000931	0.004719	0.006542	0.008795	-0.015684	1.000000	0.010297	...	
Doc_visits	-0.006920	0.000257	0.004689	0.002417	0.016088	-0.003467	0.010819	0.011179	0.010297	1.000000	...	
Full_meals_eaten	-0.020805	0.013077	-0.001353	-0.013120	-0.025711	-0.005112	0.008499	-0.012628	0.032606	-0.004586	...	
vitD_supp	0.026011	0.009348	0.005225	-0.001817	0.004134	-0.010125	0.009336	0.001478	-0.015671	0.002755	...	
Initial_days	0.831426	0.011103	-0.009938	-0.006659	0.004435	0.022122	0.009943	-0.006543	-0.007267	-0.008363	...	
TotalCharge	0.821397	0.010493	-0.012843	-0.005866	0.004758	0.022909	0.010785	-0.008523	-0.004403	-0.005363	...	
Additional_charges	-0.003178	0.001545	-0.001433	0.003290	-0.011835	0.014076	0.716409	-0.005190	0.006120	0.014611	...	
Timely_admis	-0.016607	-0.008630	0.008075	0.011933	0.004194	0.004097	0.005614	-0.004194	0.010499	0.003984	...	
Timely_treat	-0.005508	-0.002475	0.009184	-0.002521	0.016837	0.006169	0.004382	-0.012371	0.003697	0.004377	...	
Timely_vis	-0.006320	-0.010277	0.010924	0.002614	-0.004754	-0.002485	0.006990	-0.007394	-0.011930	-0.003794	...	
Reliability	-0.016204	0.001231	-0.011577	0.000283	-0.008892	-0.001091	0.003407	-0.003532	-0.016650	-0.006303	...	
Options	-0.004709	0.006290	0.000179	-0.002771	0.013720	0.003409	-0.013980	-0.005088	0.007878	-0.011124	...	
Hours	-0.006087	-0.001406	0.009542	-0.004637	0.007970	-0.002796	0.003434	0.003083	0.004610	0.009226	...	
Courteous	0.005102	-0.004203	0.009071	0.002070	0.010529	0.015894	0.009339	0.008516	-0.007461	0.005322	...	
Listen	-0.012319	-0.010159	0.004348	0.003871	-0.005522	-0.011509	0.002873	0.020238	-0.024347	0.006145	...	
ReAdmis	0.661462	0.009519	-0.012324	-0.004241	0.007563	0.023890	0.011880	-0.008669	0.002858	-0.002226	...	

24 rows × 24 columns

Dummies & Renaming

In [38]:

```
df.drop('CaseOrder',axis=1, inplace=True)
```

In [39]:

```
#Get dummies code reference (Pandas.get_dummies, N.d.)
df = pd.get_dummies(df, columns=['Area','Marital','Gender','Doc_visits','vitD_supp','Soft_drink','Initial_admin',
'HighBlood','Stroke','Complication_risk','Overweight','Arthritis','Diabetes','Hyperlipidemia','BackPain','Anxiety
','Allergic_rhinitis','Reflux_esophagitis','Asthma','Services'], drop_first=True)
```

In [40]:

```
df = pd.get_dummies(df, columns=['Timely_admis','Timely_treat','Timely_vis','Reliability','Options','Hours','Cour
teous','Listen'],drop_first=True)
```

In [41]:

```
df = pd.get_dummies(df, columns=['ReAdmis'],drop_first=True)
```

In [42]:

```
df = pd.get_dummies(df, columns=['Children'],drop_first=True)
```

In [43]:

```
#Rename features with spaces in name for future analysis
df.rename(columns={'Services_CT Scan':'Services_CT_Scan','Marital_Never Married':'Marital_Never_Married','Initial
_admin_Emergency Admission':'Initial_admin_Emergency_Admission','Initial_admin_Observation Admission':'Initial_ad
min_Observation_Admission'},inplace=True)
```

In [44]:

```
df.info()
```

```
<class 'pandas.core.frame.DataFrame'>
Int64Index: 9206 entries, 0 to 9999
Columns: 104 entries, Zip to Children_8
dtypes: float64(7), int64(4), object(8), uint8(85)
memory usage: 2.2+ MB
```

In [45]:

```
df.corr()
```

Out[45]:

	Zip	Lat	Lng	Population	Age	Income	VitD_levels	Full_meals_eaten	Initial_days	TotalCharge	..
Zip	1.000000	-0.084258	-0.913573	0.012947	-0.003327	0.010507	-0.010747	0.013077	0.011103	0.010493	..
Lat	-0.084258	1.000000	0.001062	-0.187334	-0.000132	-0.015414	-0.005158	-0.001353	-0.009938	-0.012843	..
Lng	-0.913573	0.001062	1.000000	-0.018263	0.002780	-0.008175	0.000931	-0.013120	-0.006659	-0.005866	..
Population	0.012947	-0.187334	-0.018263	1.000000	-0.018884	0.002162	0.004719	-0.025711	0.004435	0.004758	..
Age	-0.003327	-0.000132	0.002780	-0.018884	1.000000	-0.003218	0.008795	0.008499	0.009943	0.010785	..
...	...	...	...	...	...	...	...	...	...	...	..
Children_4	-0.010340	0.010405	0.009916	-0.003323	-0.003005	0.011490	-0.006051	0.003615	0.021351	0.021048	..
Children_5	0.003784	0.021356	-0.005049	0.005497	0.022290	0.008891	-0.001607	-0.011876	-0.001752	0.000456	..
Children_6	0.000098	-0.020881	0.008090	0.002481	-0.009710	0.006582	0.012478	0.008461	0.016965	0.017821	..
Children_7	0.009911	0.006720	-0.006050	-0.007526	-0.000799	0.003081	0.013216	-0.015356	0.005094	0.006228	..
Children_8	0.025547	0.006500	-0.028345	0.009924	0.015824	-0.011951	-0.003578	0.004367	0.008185	0.008947	..

96 rows x 96 columns

In [46]:

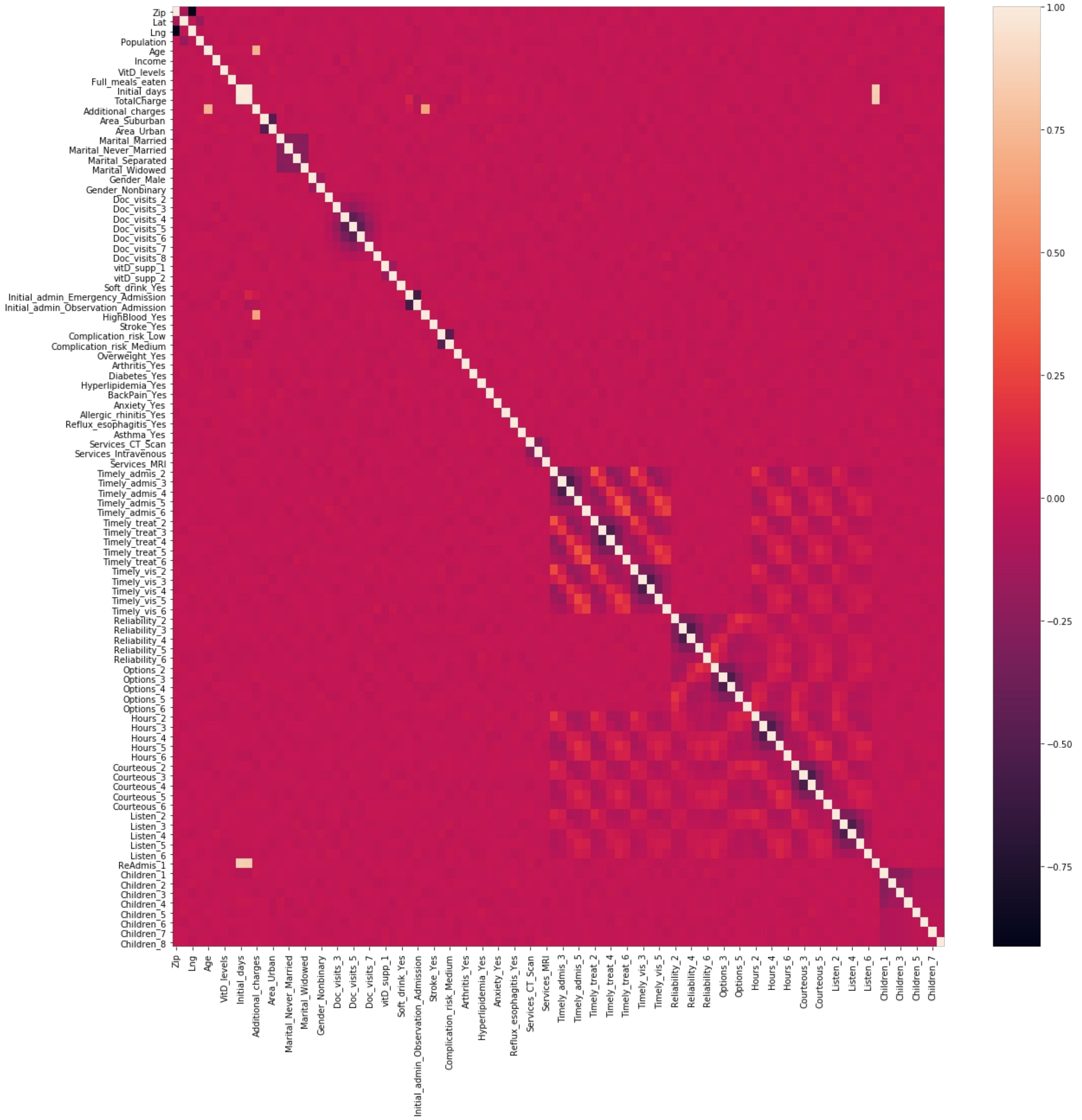
```
# Heatmap code reference (Seaborn.heatmap, N.d.)
import matplotlib
matplotlib.pyplot.figure(figsize=(20,20))
heatmap = sns.heatmap(df.corr()[['ReAdmis_1']].sort_values(by='ReAdmis_1', ascending=False), vmin=-1, vmax=1, ann
ot=True, cmap='BrBG')
heatmap.set_title('Variables correlating with ReAdmis Heatmap',pad=12)
```

Out[46]:

```
Text(0.5, 1, 'Variables correlating with ReAdmis Heatmap')
```

In [47]:

```
fig_dims = (20, 20)
fig, ax = plt.subplots(figsize=fig_dims)
sns.heatmap(df.corr(), ax=ax)
plt.show()
```



In [48]:

```
df.to_excel('C:/Users/ericy/Desktop/D208.2.full.xlsx', index=False)
```

Inital Feature Selection

Target variable is ReAdmis_1 Correlation > .02 for explanatory variable selection

In [49]:

```
abs(df.corr()["ReAdmis_1"][abs(df.corr()["ReAdmis_1"])>=0.02].drop('ReAdmis_1')).index.tolist()
```

Out[49]:

```
['Initial_days',
 'TotalCharge',
 'Services_CT_Scan',
 'Timely_admis_6',
 'Timely_vis_3',
 'Hours_6',
 'Listen_6',
 'Children_1',
 'Children_4']
```

In [50]:

```
# VIF technique code reference (Zach, 2020)
```

In [51]:

```
from patsy import dmatrices
from statsmodels.stats.outliers_influence import variance_inflation_factor
y, X = dmatrices('ReAdmis_1 ~ Initial_days+TotalCharge+Children_1+Children_4+Services_CT_Scan+Timely_vis_3+Timely
_admis_6+Listen_6+Hours_6', data=df, return_type='dataframe')
```

In [52]:

```
vif = pd.DataFrame()
vif['VIF'] = [variance_inflation_factor(X.values, i) for i in range(X.shape[1])]
vif['variable'] = X.columns
```

In [53]:

```
vif
```

Out[53]:

	VIF	variable
0	57.215523	Intercept
1	40.824852	Initial_days
2	40.825038	TotalCharge
3	1.041991	Children_1
4	1.041378	Children_4
5	1.001029	Services_CT_Scan
6	1.011761	Timely_vis_3
7	1.023459	Timely_admis_6
8	1.004894	Listen_6
9	1.017869	Hours_6

In [54]:

```
y, X = dmatrices('ReAdmis_1 ~ Initial_days+Children_1+Children_4+Services_CT_Scan+Timely_vis_3+Timely_admis_6+Lis
ten_6+Hours_6', data=df, return_type='dataframe')
```

In [55]:

```
vif = pd.DataFrame()
vif['VIF'] = [variance_inflation_factor(X.values, i) for i in range(X.shape[1])]
vif['variable'] = X.columns
```

In [56]:

```
vif
```

Out[56]:

	VIF	variable
0	4.053441	Intercept
1	1.002430	Initial_days
2	1.041870	Children_1
3	1.041375	Children_4
4	1.000610	Services_CT_Scan
5	1.011730	Timely_vis_3
6	1.023351	Timely_admis_6
7	1.004721	Listen_6
8	1.017866	Hours_6

C2: Summary Statistics for target variable & all predictor variables for inital model

In [57]:

```
dfi = df[[
 'ReAdmis_1',
 'Children_1',
    'Children_4',
 'Initial_days',
 'Services_CT_Scan',
 'Timely_vis_3',
 'Timely_admis_6',
 'Listen_6',
'Hours_6']]
```

In [58]:

```
dfi.to_excel('C:/Users/ericy/Desktop/D208.2.Selected.xlsx', index=False)
```

In [59]:

```
dfi['ReAdmis_1'].unique()
```

Out[59]:

```
array([0, 1], dtype=uint8)
```

In [60]:

```
dfi.info()
```

```
<class 'pandas.core.frame.DataFrame'>
Int64Index: 9206 entries, 0 to 9999
Data columns (total 9 columns):
 #   Column            Non-Null Count  Dtype
---  ------            --------------  -----
 0   ReAdmis_1         9206 non-null   uint8
 1   Children_1        9206 non-null   uint8
 2   Children_4        9206 non-null   uint8
 3   Initial_days      9206 non-null   float64
 4   Services_CT_Scan  9206 non-null   uint8
 5   Timely_vis_3      9206 non-null   uint8
 6   Timely_admis_6    9206 non-null   uint8
 7   Listen_6          9206 non-null   uint8
 8   Hours_6           9206 non-null   uint8
dtypes: float64(1), uint8(8)
memory usage: 215.8 KB
```

In [61]:

```
dfi.describe()
```

Out[61]:

	ReAdmis_1	Children_1	Children_4	Initial_days	Services_CT_Scan	Timely_vis_3	Timely_admis_6	Listen_6	Hours_6
count	9206.000000	9206.000000	9206.00000	9206.000000	9206.000000	9206.000000	9206.000000	9206.000000	9206.000000
mean	0.366935	0.256137	0.10189	34.399945	0.122855	0.339561	0.020747	0.022268	0.021399
std	0.481995	0.436522	0.30252	26.325319	0.328288	0.473586	0.142545	0.147562	0.144718
min	0.000000	0.000000	0.00000	1.001981	0.000000	0.000000	0.000000	0.000000	0.000000
25%	0.000000	0.000000	0.00000	7.881412	0.000000	0.000000	0.000000	0.000000	0.000000
50%	0.000000	0.000000	0.00000	30.841461	0.000000	0.000000	0.000000	0.000000	0.000000
75%	1.000000	1.000000	0.00000	61.157838	0.000000	1.000000	0.000000	0.000000	0.000000
max	1.000000	1.000000	1.00000	71.981490	1.000000	1.000000	1.000000	1.000000	1.000000

In [62]:

```
dfi.corr()
```

Out[62]:

	ReAdmis_1	Children_1	Children_4	Initial_days	Services_CT_Scan	Timely_vis_3	Timely_admis_6	Listen_6	Hours_
ReAdmis_1	1.000000	-0.025936	0.022959	0.852064	0.026087	0.021399	-0.023851	-0.020195	-0.02380
Children_1	-0.025936	1.000000	-0.197647	-0.035131	0.004024	0.001216	0.005373	-0.000857	-0.00594
Children_4	0.022959	-0.197647	1.000000	0.021351	0.004116	-0.008726	-0.001161	-0.002160	-0.01754
Initial_days	0.852064	-0.035131	0.021351	1.000000	0.010723	0.013412	-0.013688	-0.012797	-0.02178
Services_CT_Scan	0.026087	0.004024	0.004116	0.010723	1.000000	-0.016801	-0.005723	0.008555	0.00639
Timely_vis_3	0.021399	0.001216	-0.008726	0.013412	-0.016801	1.000000	-0.094715	-0.028930	-0.05055
Timely_admis_6	-0.023851	0.005373	-0.001161	-0.013688	-0.005723	-0.094715	1.000000	0.045175	0.11539
Listen_6	-0.020195	-0.000857	-0.002160	-0.012797	0.008555	-0.028930	0.045175	1.000000	0.04890
Hours_6	-0.023807	-0.005948	-0.017549	-0.021784	0.006397	-0.050554	0.115398	0.048904	1.00000

In [63]:

```
dfi.mean()
```

Out[63]:

```
ReAdmis_1            0.366935
Children_1           0.256137
Children_4           0.101890
Initial_days        34.399945
Services_CT_Scan     0.122855
Timely_vis_3         0.339561
Timely_admis_6       0.020747
Listen_6             0.022268
Hours_6              0.021399
dtype: float64
```

In [64]:

```
dfi.median()
```

Out[64]:

```
ReAdmis_1            0.000000
Children_1           0.000000
Children_4           0.000000
Initial_days        30.841461
Services_CT_Scan     0.000000
Timely_vis_3         0.000000
Timely_admis_6       0.000000
Listen_6             0.000000
Hours_6              0.000000
dtype: float64
```

In [65]:

```
dfi.mode()
```

Out[65]:

	ReAdmis_1	Children_1	Children_4	Initial_days	Services_CT_Scan	Timely_vis_3	Timely_admis_6	Listen_6	Hours_6
0	0.0	0.0	0.0	67.42139	0.0	0.0	0.0	0.0	0.0
1	NaN	NaN	NaN	70.32542	NaN	NaN	NaN	NaN	NaN

In [66]:

```
# C5: Prepared Dataset
dfi.to_csv('C:/Users/ericy/Desktop/D208.2_prepared.csv', index=False)
```

Initial Logistic Regression Model

In [67]:

```
# D1: Initial Logistic Regression with logit.  Code Reference (Cosine1509, 2022).
from statsmodels.formula.api import logit
```

In [68]:

```
re_log = logit('ReAdmis_1 ~  Initial_days + Children_1 + Children_4 + Services_CT_Scan + Timely_vis_3 + Timely_ad
mis_6 + Listen_6+ Hours_6', data=df).fit()
```

```
Optimization terminated successfully.
         Current function value: 0.048161
         Iterations 13
```

In [69]:

```
print(re_log.summary())
```

```
                           Logit Regression Results                           
==============================================================================
Dep. Variable:              ReAdmis_1   No. Observations:                 9206
Model:                          Logit   Df Residuals:                     9197
Method:                           MLE   Df Model:                            8
Date:                Tue, 05 Jul 2022   Pseudo R-squ.:                  0.9267
Time:                        14:09:23   Log-Likelihood:                -443.37
converged:                       True   LL-Null:                       -6051.1
Covariance Type:            nonrobust   LLR p-value:                     0.000
====================================================================================
                       coef    std err          z      P>|z|      [0.025      0.975]
------------------------------------------------------------------------------------
Intercept          -54.2497      2.606    -20.815      0.000     -59.358     -49.141
Initial_days         0.9959      0.048     20.902      0.000       0.903       1.089
Children_1          -0.3136      0.207     -1.516      0.129      -0.719       0.092
Children_4           0.1378      0.277      0.497      0.619      -0.405       0.681
Services_CT_Scan     0.9881      0.277      3.561      0.000       0.444       1.532
Timely_vis_3         0.4035      0.185      2.179      0.029       0.040       0.767
Timely_admis_6      -0.1088      0.669     -0.163      0.871      -1.420       1.202
Listen_6            -1.1492      0.556     -2.068      0.039      -2.238      -0.060
Hours_6             -0.4155      0.584     -0.711      0.477      -1.560       0.729
====================================================================================

Possibly complete quasi-separation: A fraction 0.74 of observations can be
perfectly predicted. This might indicate that there is complete
quasi-separation. In this case some parameters will not be identified.
```

Reduced Feature Selection

In [70]:

```
## K Nearast Neighbors & correlation for feature selection
# Code Reference (Feely, 2020), starting at 12:30 in video - going to minute 16:00
from sklearn.preprocessing import StandardScaler
from sklearn.pipeline import make_pipeline
from sklearn.model_selection import KFold
from sklearn.neighbors import KNeighborsRegressor
from sklearn.metrics import mean_squared_error, r2_score
from sklearn.model_selection import cross_val_predict
from sklearn.linear_model import LinearRegression
from math import sqrt
```

K Nearast Neighbors & correlation for feature selection

Code Reference (Feely, 2020), starting at 12:30 in video - going to minute 16:00

In [71]:

```
X=df[['Initial_days','Children_1','Children_4','Services_CT_Scan','Timely_vis_3','Timely_admis_6','Listen_6','Hou
rs_6']]
y = df.ReAdmis_1
B=df[['ReAdmis_1','Initial_days','Children_1','Children_4','Services_CT_Scan','Timely_vis_3','Timely_admis_6','Li
sten_6','Hours_6']]
```

In [72]:

```
cv = KFold(n_splits=10, random_state=0, shuffle=True)
classifier_pipeline = make_pipeline(StandardScaler(), KNeighborsRegressor(n_neighbors=10))
y_pred = cross_val_predict(classifier_pipeline, X, y, cv=cv)
print("RMSE: " + str(round(sqrt(mean_squared_error(y,y_pred)),2)))
print("Pseudo_R_squared: " + str(round(r2_score(y,y_pred),2)))
```

```
RMSE: 0.15
Pseudo_R_squared: 0.91
```

In [73]:

```
vals = [0.02,.022,.025,.03,.025,.04,.045,0.05,0.08,0.1,0.2]
for val in vals:
    features = abs(B.corr()["ReAdmis_1"][abs(df.corr()["ReAdmis_1"])>val].drop('ReAdmis_1')).index.tolist()

    X = B.drop(columns='ReAdmis_1')
    X=X[features]

    print(features)

    y_pred = cross_val_predict(classifier_pipeline, X, y, cv=cv)
    print("RMSE: " + str(round(sqrt(mean_squared_error(y,y_pred)),2)))
```

```
['Initial_days', 'Children_1', 'Children_4', 'Services_CT_Scan', 'Timely_vis_3', 'Timely_admis_6', '
Listen_6', 'Hours_6']
RMSE: 0.15
['Initial_days', 'Children_1', 'Children_4', 'Services_CT_Scan', 'Timely_admis_6', 'Hours_6']
RMSE: 0.14
['Initial_days', 'Children_1', 'Services_CT_Scan']
RMSE: 0.13
['Initial_days']
RMSE: 0.13
['Initial_days', 'Children_1', 'Services_CT_Scan']
RMSE: 0.13
['Initial_days']
RMSE: 0.13
['Initial_days']
RMSE: 0.13
['Initial_days']
RMSE: 0.13
['Initial_days']
RMSE: 0.13
['Initial_days']
RMSE: 0.13
['Initial_days']
RMSE: 0.13
```

E2 Inital Model evalutaion metrics, including confusion matrix

In [74]:

```
#Code Reference (Sklearn.metrics.confusion_matrix, N.d.), (Sklearn.metrics.accuracy_score, N.d.)
#Code Reference (Zach, 2021) for confusion matrix.
Xtest = df[['Initial_days','Children_1','Children_4','Services_CT_Scan','Timely_vis_3','Timely_admis_6','Listen_6
','Hours_6']]
ytest = df['ReAdmis_1']

p = re_log.predict(Xtest)
prediction = list(map(round, p))
```

In [75]:

```
#Confusion Matrix Initial Model
from sklearn.metrics import (confusion_matrix, accuracy_score)
conf_mat = confusion_matrix(ytest, prediction)
print ('Confusion Matrix : \n', conf_mat)
print ('Test Accuracy is ', accuracy_score(ytest, prediction))
```

```
Confusion Matrix :
 [[5727  101]
 [  94 3284]]
Test Accuracy is  0.9788181620682164
```

In [76]:

```
# Prediction Classification Report, Initial Model
from sklearn.metrics import classification_report
print(classification_report(ytest, prediction))
```

```
              precision    recall  f1-score   support

           0       0.98      0.98      0.98      5828
           1       0.97      0.97      0.97      3378

    accuracy                           0.98      9206
   macro avg       0.98      0.98      0.98      9206
weighted avg       0.98      0.98      0.98      9206
```

In [77]:

```python
# Predictions from the initial model used to perform the analysis
print(prediction)
```

```
[0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0
, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0
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0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0
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1, 0, 1, 0, 1, 0, 0, 1, 1, 1, 1, 0, 0, 1, 1, 1, 1, 1, 0, 0, 1, 1, 1, 1, 0, 1, 0, 1, 1, 1, 1, 1, 1, 0
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, 0, 1, 1, 1, 1, 1, 1, 0, 1, 0, 0, 1, 1, 0, 1, 1, 1, 1, 1, 1, 0, 0, 0, 1, 1, 1, 1]
```


Reduced model

Created from feature selection P(z) < .05 and RMSE minimization

In [78]:

```
#reduced_log = logit('ReAdmis_1 ~  Initial_days', data=df).fit()
reduced_log = logit('ReAdmis_1 ~  Initial_days+Services_CT_Scan', data=df).fit()
```

```
Optimization terminated successfully.
         Current function value: 0.048910
         Iterations 13
```

In [79]:

```
print(reduced_log.summary())
```

```
                           Logit Regression Results
==============================================================================
Dep. Variable:              ReAdmis_1   No. Observations:                 9206
Model:                          Logit   Df Residuals:                     9203
Method:                           MLE   Df Model:                            2
Date:                Tue, 05 Jul 2022   Pseudo R-squ.:                  0.9256
Time:                        14:09:36   Log-Likelihood:                -450.27
converged:                       True   LL-Null:                       -6051.1
Covariance Type:            nonrobust   LLR p-value:                     0.000
====================================================================================
                       coef    std err          z      P>|z|      [0.025      0.975]
------------------------------------------------------------------------------------
Intercept          -53.6643      2.561    -20.955      0.000     -58.684     -48.645
Initial_days         0.9858      0.047     21.022      0.000       0.894       1.078
Services_CT_Scan     0.9831      0.276      3.557      0.000       0.441       1.525
====================================================================================

Possibly complete quasi-separation: A fraction 0.73 of observations can be
perfectly predicted. This might indicate that there is complete
quasi-separation. In this case some parameters will not be identified.
```

E2 Reduced Model Evaluation Metrics, including confusion matrix

In [80]:

```
#Xtest1 = df[['Initial_days']]
Xtest1 = df[['Initial_days','Services_CT_Scan']]
ytest1 = df['ReAdmis_1']
```

In [81]:

```
# Confusion Matrix for Reduced Model
g = reduced_log.predict(Xtest1)
reduced_prediction = list(map(round, g))
```

In [82]:

```
from sklearn.metrics import (confusion_matrix, accuracy_score)
conf_mat1 = confusion_matrix(ytest1, reduced_prediction)
print ('Confusion Matrix : \n', conf_mat1)
print ('Test Accuracy is ', accuracy_score(ytest1, reduced_prediction))
```

```
Confusion Matrix :
 [[5727  101]
 [  94 3284]]
Test Accuracy is  0.9788181620682164
```

In [83]:

```
from sklearn.metrics import classification_report
```

In [84]:

```
# # Prediction Classification Report, Reduced Model
print(classification_report(ytest1, prediction))
```

```
              precision    recall  f1-score   support

           0       0.98      0.98      0.98      5828
           1       0.97      0.97      0.97      3378

    accuracy                           0.98      9206
   macro avg       0.98      0.98      0.98      9206
weighted avg       0.98      0.98      0.98      9206
```

In [85]:

```
# Predictions from the reduced model used to perform the analysis
print(reduced_prediction)
```

```
[0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0
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