Cancer_Deaths_EDA_notebook

February 12, 2023

[ ]:
```
# Christine Orosco
# Cancer Observed, Expected and Excess Deaths EDA
```

[1]:
```
# Import libraries
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
%matplotlib inline
```

0.1 Read in the flat file

[ ]:
```
# Read in csv flat file in DF
df = pd.read_csv('~DSC540/Excess_deaths.csv')
df.shape
```

[3]:
```
df.head()
```

[3]:

	Year	Cause of Death	State	State FIPS Code	HHS Region	Age Range	Benchmark	Locality	Observed Deaths	Population	Expected Deaths	Potentially Excess Deaths	Percent Potentially Excess Deaths
0	2005	Cancer	Alabama	AL	4	0-49	2005 Fixed	All	756.0	3148377.0	451.0	305.0	40.3
1	2005	Cancer	Alabama	AL	4	0-49	2005 Fixed	Metropolitan	556.0	2379871.0	341.0	217.0	39.0
2	2005	Cancer	Alabama	AL	4	0-49	2005 Fixed	Nonmetropolitan	200.0	768506.0	111.0	89.0	44.5
3	2010	Cancer	Alabama	AL	4	0-49	2010 Fixed	All	756.0	3148377.0	421.0	335.0	44.3
4	2010	Cancer	Alabama	AL	4	0-49	2010 Fixed	Metropolitan	556.0	2379871.0	318.0	238.0	42.8

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

[4]:

	Year	Cause of Death	State	State FIPS Code	HHS Region	Age Range	Benchmark	Locality	Observed Deaths	Population	Expected Deaths	Potentially Excess Deaths	Percent Potentially Excess Deaths
205915	2015	Unintentional Injury	Wyoming	WY	8	0-84	2010 Fixed	Metropolitan	93.0	175787.0	36.0	57.0	61.3
205916	2015	Unintentional Injury	Wyoming	WY	8	0-84	2010 Fixed	Nonmetropolitan	259.0	400056.0	82.0	177.0	68.3
205917	2015	Unintentional Injury	Wyoming	WY	8	0-84	Floating	All	352.0	575843.0	137.0	215.0	61.1
205918	2015	Unintentional Injury	Wyoming	WY	8	0-84	Floating	Metropolitan	93.0	175787.0	42.0	51.0	54.8
205919	2015	Unintentional Injury	Wyoming	WY	8	0-84	Floating	Nonmetropolitan	259.0	400056.0	96.0	163.0	62.9

[5]:
```
# Create a Subset of the data
```

[6]:
```
# Select the rows where Cause of Death = Cancer and year >= 2014
df_subset = df[(df['Cause of Death'] == 'Cancer') & (df['Year'] >= 2014) &␣
 ↪(df['State'] != 'United States')].copy()
df_subset.head()
```

[6]:

	Year	Cause of Death	State	State FIPS Code	HHS Region	Age Range	Benchmark	Locality	Observed Deaths	Population	Expected Deaths	Potentially Excess Deaths	Percent Potentially Excess Deaths
164626	2014	Cancer	Arizona	AZ	9	0-54	2005 Fixed	All	1113.0	4867353.0	1020.0	93.0	8.4
164896	2014	Cancer	Alabama	AL	4	0-54	2005 Fixed	All	1138.0	3475969.0	775.0	363.0	31.9
165344	2014	Cancer	Alaska	AK	10	0-59	2005 Fixed	All	1113.0	4867353.0	1020.0	93.0	8.4
165355	2014	Cancer	Arkansas	AR	6	0-59	2005 Fixed	All	1138.0	3475969.0	775.0	363.0	31.9
165424	2014	Cancer	California	CA	9	0-64	2005 Fixed	All	1113.0	4867353.0	1020.0	93.0	8.4

```
165344  2005 Fixed      All            252.0    625271.0            216.0
165355  2005 Fixed      All           1272.0   2325270.0            838.0
165424  2005 Fixed      All          17447.0  33809453.0          17833.0

        Potentially Excess Deaths  Percent Potentially Excess Deaths
164626                      98.0                                8.8
164896                     363.0                               31.9
165344                      41.0                               16.3
165355                     437.0                               34.4
165424                     231.0                                1.3
```

[7]:
```
# Reset the index
df_subset.reset_index(drop=True, inplace=True)
```

[8]:
```
pd.set_option('display.max_rows', 20)
df_subset
```

[8]:
```
      Year Cause of Death       State State FIPS Code  HHS Region Age Range  \
0     2014         Cancer     Arizona              AZ           9      0-54
1     2014         Cancer     Alabama              AL           4      0-54
2     2014         Cancer      Alaska              AK          10      0-59
3     2014         Cancer    Arkansas              AR           6      0-59
4     2014         Cancer  California              CA           9      0-64
…     …            …          …                …          …       …
7339  2015         Cancer     Wyoming              WY           8      0-84
7340  2015         Cancer     Wyoming              WY           8      0-84
7341  2015         Cancer     Wyoming              WY           8      0-84
7342  2015         Cancer     Wyoming              WY           8      0-84
7343  2015         Cancer     Wyoming              WY           8      0-84

       Benchmark         Locality  Observed Deaths  Population  \
0     2005 Fixed              All           1113.0   4867353.0
1     2005 Fixed              All           1138.0   3475969.0
2     2005 Fixed              All            252.0    625271.0
3     2005 Fixed              All           1272.0   2325270.0
4     2005 Fixed              All          17447.0  33809453.0
…          …              …               …          …
7339  2010 Fixed     Metropolitan            235.0    175787.0
7340  2010 Fixed  Nonmetropolitan            533.0    400056.0
7341    Floating              All            768.0    575843.0
7342    Floating     Metropolitan            235.0    175787.0
7343    Floating  Nonmetropolitan            533.0    400056.0

      Expected Deaths  Potentially Excess Deaths  \
0              1020.0                       98.0
1               775.0                      363.0
2               216.0                       41.0
```

```
3               838.0                      437.0
4             17833.0                      231.0
…                 …                          …
7339            231.0                       15.0
7340            553.0                        3.0
7341            730.0                       38.0
7342            215.0                       27.0
7343            515.0                       21.0

      Percent Potentially Excess Deaths
0                                   8.8
1                                  31.9
2                                  16.3
3                                  34.4
4                                   1.3
…                                   …
7339                                6.4
7340                                0.6
7341                                4.9
7342                               11.5
7343                                3.9

[7344 rows x 13 columns]
```

0.2 Delete Unnecessary Data

[10]:
```
# Delete unnecessary columns
df_subset.drop(columns=['HHS Region', 'Benchmark', 'Cause of Death', 'Age␣
 ↪Range'], inplace=True)
```

[11]:
```
# Display column names
df_subset.columns
```

[11]:
```
Index(['Year', 'State', 'State FIPS Code', 'Locality', 'Observed Deaths',
       'Population', 'Expected Deaths', 'Potentially Excess Deaths',
       'Percent Potentially Excess Deaths'],
      dtype='object')
```

0.3 Change Headers

[13]:
```
# Change column names in the df subset
df_subset.rename(columns={
                          'Observed Deaths': 'Observed_Deaths',
                          'State FIPS Code': 'State_Code',
                          'Potentially Excess Deaths':␣
 ↪'Potentially_Excess_Deaths',
```

```
                          'Percent Potentially Excess Deaths':␣
↪'Percent_Potentially_Excess_Deaths',
                          'Expected Deaths': 'Expected_Deaths'},
                 inplace=True)
```

[14]:
```
df_subset.head()
```

[14]:

	Year	State	State_Code	Locality	Observed_Deaths	Population	Expected_Deaths	Potentially_Excess_Deaths	Percent_Potentially_Excess_Deaths
0	2014	Arizona	AZ	All	1113.0	4867353.0	1020.0	98.0	8.8
1	2014	Alabama	AL	All	1138.0	3475969.0	775.0	363.0	31.9
2	2014	Alaska	AK	All	252.0	625271.0	216.0	41.0	16.3
3	2014	Arkansas	AR	All	1272.0	2325270.0	838.0	437.0	34.4
4	2014	California	CA	All	17447.0	33809453.0	17833.0	231.0	1.3

0.4 Delete Duplicate rows in the subset

[16]:
```
# drop duplicate rows
df_subset.drop_duplicates(inplace=True)
df_subset.shape
df_subset.head()
```

[16]:

	Year	State	State_Code	Locality	Observed_Deaths	Population	Expected_Deaths	Potentially_Excess_Deaths	Percent_Potentially_Excess_Deaths
0	2014	Arizona	AZ	All	1113.0	4867353.0	1020.0	98.0	8.8
1	2014	Alabama	AL	All	1138.0	3475969.0	775.0	363.0	31.9
2	2014	Alaska	AK	All	252.0	625271.0	216.0	41.0	16.3
3	2014	Arkansas	AR	All	1272.0	2325270.0	838.0	437.0	34.4
4	2014	California	CA	All	17447.0	33809453.0	17833.0	231.0	1.3

```
4          17833.0                       231.0

   Percent_Potentially_Excess_Deaths
0                                8.8
1                               31.9
2                               16.3
3                               34.4
4                                1.3
```

0.5 Check Case Consistency

[17]:
```
# Upper Case State_Codes
df_subset['State_upper'] = list(map(lambda x: x.isupper(),␣
 ↪df_subset['State_Code']))
notmet = df_subset[df_subset['State_upper'] == 0]
notmet.head()
```

[17]:
```
Empty DataFrame
Columns: [Year, State, State_Code, Locality, Observed_Deaths, Population,
Expected_Deaths, Potentially_Excess_Deaths, Percent_Potentially_Excess_Deaths,
State_upper]
Index: []
```

[18]:
```
# Change State Code 0 to US
# df_subset.loc[df_subset['State_Code'] ==  0]
# df_subset['State_Code'] = df_subset['State_Code'].replace({0:'US'},␣
 ↪inplace=True)
# Couldn't get this to work
```

[19]:
```
# - Check for consistent Locatility values
local_list = ['All', 'Metropolitan', 'Nonmetropolitan']
df_subset['Locality_check'] = list(map(lambda x: x in local_list,␣
 ↪df_subset['Locality']))
notmet = df_subset[df_subset['Locality_check'] == 0]
notmet.head()
```

[19]:
```
Empty DataFrame
Columns: [Year, State, State_Code, Locality, Observed_Deaths, Population,
Expected_Deaths, Potentially_Excess_Deaths, Percent_Potentially_Excess_Deaths,
State_upper, Locality_check]
Index: []
```

[20]:
```
df_subset.head()
```

[20]:
```
   Year       State State_Code Locality  Observed_Deaths  Population  \
0  2014     Arizona         AZ      All           1113.0   4867353.0
```

```
1  2014     Alabama         AL      All           1138.0   3475969.0
2  2014      Alaska         AK      All            252.0    625271.0
3  2014    Arkansas         AR      All           1272.0   2325270.0
4  2014  California         CA      All          17447.0  33809453.0

   Expected_Deaths  Potentially_Excess_Deaths  \
0           1020.0                       98.0
1            775.0                      363.0
2            216.0                       41.0
3            838.0                      437.0
4          17833.0                      231.0

   Percent_Potentially_Excess_Deaths  State_upper  Locality_check
0                                8.8         True            True
1                               31.9         True            True
2                               16.3         True            True
3                               34.4         True            True
4                                1.3         True            True
```

0.6 Handle Missing Values

[22]:
```
# For each column count the number of missing values in the DF
df_subset.isnull().sum()
```

[22]:
```
Year                                0
State                               0
State_Code                          0
Locality                            0
Observed_Deaths                     8
Population                          8
Expected_Deaths                     8
Potentially_Excess_Deaths           8
Percent_Potentially_Excess_Deaths   8
State_upper                         0
Locality_check                      0
dtype: int64
```

[23]:
```
# Display the rows with missing data -
df_subset[df_subset.isna().any(axis=1)]
```

[23]:
```
      Year                 State State_Code         Locality  \
515   2014              Delaware         DE  Nonmetropolitan
585   2014  District of\nColumbia         DC  Nonmetropolitan
2162  2014            New Jersey         NJ  Nonmetropolitan
2810  2014          Rhode Island         RI  Nonmetropolitan
4188  2015              Delaware         DE  Nonmetropolitan
4260  2015  District of\nColumbia         DC  Nonmetropolitan
```

```
5834  2015            New Jersey         NJ  Nonmetropolitan
6483  2015          Rhode Island         RI  Nonmetropolitan

      Observed_Deaths  Population  Expected_Deaths  Potentially_Excess_Deaths  \
515               NaN         NaN              NaN                        NaN
585               NaN         NaN              NaN                        NaN
2162              NaN         NaN              NaN                        NaN
2810              NaN         NaN              NaN                        NaN
4188              NaN         NaN              NaN                        NaN
4260              NaN         NaN              NaN                        NaN
5834              NaN         NaN              NaN                        NaN
6483              NaN         NaN              NaN                        NaN

      Percent_Potentially_Excess_Deaths  State_upper  Locality_check
515                                 NaN         True            True
585                                 NaN         True            True
2162                                NaN         True            True
2810                                NaN         True            True
4188                                NaN         True            True
4260                                NaN         True            True
5834                                NaN         True            True
6483                                NaN         True            True
```

[24]:
```
# May need to change NaN to zeros or derive values from previous years.
# View previous years to
state_list = ['DE', 'DC', 'NJ', 'RI']
df_prevyears = df[(df['Cause of Death'] == 'Cancer') & (df['Year'] <= 2013) &␣
 ↪(df['State FIPS Code'].isin(state_list))].copy()
df_prevyears
```

[24]:
```
        Year Cause of Death         State State FIPS Code  HHS Region  \
504     2005         Cancer      Delaware              DE           3
505     2005         Cancer      Delaware              DE           3
506     2005         Cancer      Delaware              DE           3
507     2005         Cancer      Delaware              DE           3
508     2005         Cancer      Delaware              DE           3
…       …            …           …                     …            …
152635  2013         Cancer  Rhode Island              RI           1
152636  2013         Cancer  Rhode Island              RI           1
152637  2013         Cancer  Rhode Island              RI           1
152638  2013         Cancer  Rhode Island              RI           1
152639  2013         Cancer  Rhode Island              RI           1

       Age Range   Benchmark         Locality  Observed Deaths  Population  \
504         0-49  2005 Fixed              All            106.0    583236.0
505         0-49  2005 Fixed     Metropolitan            106.0    583236.0
506         0-49  2005 Fixed  Nonmetropolitan              NaN         NaN
```

```
507         0-49  2010 Fixed              All            106.0    583236.0
508         0-49  2010 Fixed     Metropolitan            106.0    583236.0
…            …         …               …              …         …
152635      0-84  2010 Fixed     Metropolitan           1810.0   1023183.0
152636      0-84  2010 Fixed  Nonmetropolitan              NaN         NaN
152637      0-84    Floating              All           1810.0   1023183.0
152638      0-84    Floating     Metropolitan           1810.0   1023183.0
152639      0-84    Floating  Nonmetropolitan              NaN         NaN

        Expected Deaths  Potentially Excess Deaths  \
504                85.0                       24.0
505                85.0                       24.0
506                 NaN                        NaN
507                80.0                       28.0
508                80.0                       28.0
…                   …                          …
152635           1448.0                      365.0
152636              NaN                        NaN
152637           1392.0                      421.0
152638           1392.0                      421.0
152639              NaN                        NaN

        Percent Potentially Excess Deaths
504                                  22.6
505                                  22.6
506                                   NaN
507                                  26.4
508                                  26.4
…                                     …
152635                               20.2
152636                                NaN
152637                               23.3
152638                               23.3
152639                                NaN

[2592 rows x 13 columns]
```

[25]:
```
# Check for NaN values in prevous years
# Appears that these states do not have reported values for nonmetropolitan␣
 ↪areas
df_prevyears.isnull().sum()
```

[25]:
```
Year                          0
Cause of Death                0
State                         0
State FIPS Code               0
HHS Region                    0
```

```
Age Range                              0
Benchmark                              0
Locality                               0
Observed Deaths                      864
Population                           864
Expected Deaths                      864
Potentially Excess Deaths            864
Percent Potentially Excess Deaths    864
dtype: int64
```

[26]:
```
# Check the nonmetropolitan rows
nonmet = df_prevyears[df_prevyears['Locality'] == 'Nonmetropolitan']
nonmet['State FIPS Code'].unique()
```

[26]:
```
array(['DE', 'DC', 'NJ', 'RI'], dtype=object)
```

[27]:
```
# Because 4 States do not have values for nonmetropolitan, will check other␣
↪data sources for values
```

0.7 Reshape the data by combining observations by State, Year and Locality

[76]:
```
# For each state combine the Locality observations into three seperate rows␣
↪because not going to use the HHS region. Only using the totals for metro and␣
↪non-metro areas
# Create pivot table to aggregate each locality number
col_list = ['Observed_Deaths', 'Population', 'Expected_Deaths',
       'Potentially_Excess_Deaths', 'Percent_Potentially_Excess_Deaths']

df_pivot = df_subset.pivot_table(index=['Year', 'State_Code'],␣
↪columns='Locality', values=col_list, aggfunc=sum)
df_pivot
```

[76]:

		Expected_Deaths			Observed_Deaths
Locality		All	Metropolitan	Nonmetropolitan	All
Year	State_Code				
2014	AK	9618.0	6178.0	3403.0	11037.0
	AL	76163.0	56636.0	19527.0	105675.0
	AR	46043.0	26386.0	19650.0	65784.0
	AZ	102820.0	97111.0	5711.0	106986.0
	CA	540349.0	524776.0	15576.0	548517.0
…		…	…	…	…
2015	VT	10940.0	3282.0	7660.0	12972.0
	WA	108307.0	95175.0	13128.0	117654.0
	WI	91150.0	64206.0	26942.0	102003.0
	WV	32212.0	19219.0	12993.0	47406.0
	WY	8940.0	2639.0	6303.0	8700.0

```
                                                \
Locality        Metropolitan Nonmetropolitan
Year State_Code
2014 AK               6852.0          4137.0
     AL              76464.0         29211.0
     AR              35679.0         30105.0
     AZ             101478.0          5508.0
     CA             531036.0         17481.0
…                        …              …
2015 VT               3705.0          9267.0
     WA             101973.0         15681.0
     WI              70308.0         31695.0
     WV              28209.0         19197.0
     WY               2676.0          6024.0

                Percent_Potentially_Excess_Deaths               \
Locality                                      All Metropolitan
Year State_Code
2014 AK                                     371.5        334.4
     AL                                     740.5        694.4
     AR                                     784.7        670.6
     AZ                                     206.8        215.1
     CA                                     137.5        133.3
…                                           …            …
2015 VT                                     395.2        333.5
     WA                                     219.9        189.1
     WI                                     275.9        230.0
     WV                                     825.4        801.8
     WY                                      53.1        177.1

                                  Population                                \
Locality        Nonmetropolitan          All Metropolitan Nonmetropolitan
Year State_Code
2014 AK                   474.6   15762231.0   10738815.0       4844330.0
     AL                   871.4   98584620.0   75517581.0      23067039.0
     AR                   936.5   60216000.0   37603665.0      22612335.0
     AZ                   220.7  136871601.0  129924657.0       6946944.0
     CA                   341.2  807586629.0  791482749.0      16103880.0
…                         …           …            …               …
2015 VT                   457.8   12369387.0    4445340.0       7924047.0
     WA                   458.4  146927250.0  132955461.0      13971789.0
     WI                   393.3  116414547.0   87214530.0      29200017.0
     WV                   863.6   36394473.0   22640328.0      13754145.0
     WY                    97.1   11976111.0    3679551.0       8296560.0

                Potentially_Excess_Deaths
```

```
Locality                          All Metropolitan Nonmetropolitan
Year State_Code
2014 AK                        1578.0        837.0           797.0
     AL                       29520.0      19852.0          9702.0
     AR                       19829.0       9443.0         10455.0
     AZ                        6592.0       6598.0           246.0
     CA                       22127.0      20498.0          2036.0
…                                 …            …               …
2015 VT                        2070.0        467.0          1655.0
     WA                       10804.0       8209.0          2657.0
     WI                       11151.0       6514.0          4759.0
     WV                       15195.0       9003.0          6204.0
     WY                         158.0        186.0           139.0

[102 rows x 15 columns]
```

[30]:
```
# Flatten the pivot_table to join the Locality category in the observation type␣
 ↪header names
df_pivot.columns = [' '.join(col) for col in df_pivot.columns.values]
```

[31]:
```
df_pivot.columns
```

[31]:
```
Index(['Expected_Deaths All', 'Expected_Deaths Metropolitan',
       'Expected_Deaths Nonmetropolitan', 'Observed_Deaths All',
       'Observed_Deaths Metropolitan', 'Observed_Deaths Nonmetropolitan',
       'Percent_Potentially_Excess_Deaths All',
       'Percent_Potentially_Excess_Deaths Metropolitan',
       'Percent_Potentially_Excess_Deaths Nonmetropolitan', 'Population All',
       'Population Metropolitan', 'Population Nonmetropolitan',
       'Potentially_Excess_Deaths All',
       'Potentially_Excess_Deaths Metropolitan',
       'Potentially_Excess_Deaths Nonmetropolitan'],
      dtype='object')
```

[32]:
```
# Sort the Dataframe
df_pivot.sort_index(inplace=True)
df_pivot.query('Year == 2014')
```

[32]:
```
                Expected_Deaths All  Expected_Deaths Metropolitan  \
Year State_Code
2014 AK                      9618.0                        6178.0
     AL                     76163.0                       56636.0
     AR                     46043.0                       26386.0
     AZ                    102820.0                       97111.0
     CA                    540349.0                      524776.0
…                                …                            …
     VT                     10845.0                        3240.0
```

```
      WA                     106000.0                      93091.0
      WI                      90072.0                      63327.0
      WV                      32177.0                      19185.0
      WY                       8859.0                       2582.0

                Expected_Deaths Nonmetropolitan  Observed_Deaths All  \
Year State_Code
2014 AK                                3403.0              11037.0
     AL                               19527.0             105675.0
     AR                               19650.0              65784.0
     AZ                                5711.0             106986.0
     CA                               15576.0             548517.0
…                                       …                    …
     VT                                7608.0              12753.0
     WA                               12911.0             114786.0
     WI                               26742.0             102246.0
     WV                               12992.0              48615.0
     WY                                6249.0               8979.0

                Observed_Deaths Metropolitan  \
Year State_Code
2014 AK                              6852.0
     AL                             76464.0
     AR                             35679.0
     AZ                            101478.0
     CA                            531036.0
…                                      …
     VT                              3633.0
     WA                             99771.0
     WI                             72105.0
     WV                             29391.0
     WY                              2665.0

                Observed_Deaths Nonmetropolitan  \
Year State_Code
2014 AK                              4137.0
     AL                             29211.0
     AR                             30105.0
     AZ                              5508.0
     CA                             17481.0
…                                      …
     VT                              9120.0
     WA                             15015.0
     WI                             30141.0
     WV                             19224.0
     WY                              6291.0
```

```
                Percent_Potentially_Excess_Deaths All  \
Year State_Code
2014 AK                                         371.5
     AL                                         740.5
     AR                                         784.7
     AZ                                         206.8
     CA                                         137.5
…                                               …
     VT                                         429.3
     WA                                         234.6
     WI                                         289.6
     WV                                         886.9
     WY                                         101.0

                Percent_Potentially_Excess_Deaths Metropolitan  \
Year State_Code
2014 AK                                                  334.4
     AL                                                  694.4
     AR                                                  670.6
     AZ                                                  215.1
     CA                                                  133.3
…                                                        …
     VT                                                  382.1
     WA                                                  208.5
     WI                                                  291.7
     WV                                                  922.9
     WY                                                  199.5

                Percent_Potentially_Excess_Deaths Nonmetropolitan  \
Year State_Code
2014 AK                                                     474.6
     AL                                                     871.4
     AR                                                     936.5
     AZ                                                     220.7
     CA                                                     341.2
…                                                           …
     VT                                                     476.0
     WA                                                     459.2
     WI                                                     305.3
     WV                                                     832.1
     WY                                                     136.7

                Population All  Population Metropolitan  \
Year State_Code
2014 AK             15762231.0               10738815.0
     AL             98584620.0               75517581.0
     AR             60216000.0               37603665.0
```

```
     AZ             136871601.0             129924657.0
     CA             807586629.0             791482749.0
…                          …                       …
     VT              12437853.0               4445346.0
     WA             145078080.0             131183028.0
     WI             116532489.0              87141945.0
     WV              36632532.0              22733298.0
     WY              11971962.0               3531017.0

                Population Nonmetropolitan  Potentially_Excess_Deaths All  \
Year State_Code
2014 AK                          4844330.0                          1578.0
     AL                         23067039.0                         29520.0
     AR                         22612335.0                         19829.0
     AZ                          6946944.0                          6592.0
     CA                         16103880.0                         22127.0
…                                      …                          …
     VT                          7992507.0                          1920.0
     WA                         13895052.0                          9973.0
     WI                         29390544.0                         12357.0
     WV                         13899234.0                         16462.0
     WY                          8310732.0                           405.0

                Potentially_Excess_Deaths Metropolitan  \
Year State_Code
2014 AK                                        837.0
     AL                                      19852.0
     AR                                       9443.0
     AZ                                       6598.0
     CA                                      20498.0
…                                                …
     VT                                        436.0
     WA                                       7796.0
     WI                                       8896.0
     WV                                      10263.0
     WY                                        190.0

                Potentially_Excess_Deaths Nonmetropolitan
Year State_Code
2014 AK                                            797.0
     AL                                           9702.0
     AR                                          10455.0
     AZ                                            246.0
     CA                                           2036.0
…                                                    …
     VT                                           1547.0
     WA                                           2253.0
```

```
WI                                                  3600.0
WV                                                  6233.0
WY                                                   335.0

[51 rows x 15 columns]
```

0.8 Find outliers or anonmalies in the counts

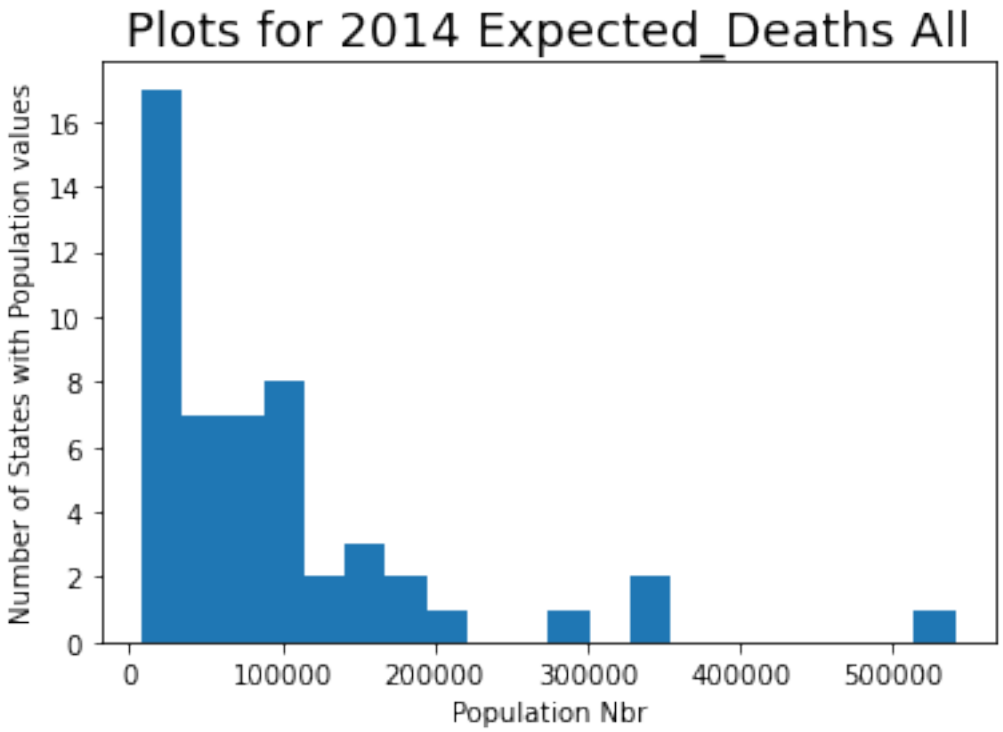
[34]:
```
# do not include the 0 State_code which is the totals row.
# Compute Mean for Expected_Deaths_All
df_pivot.iloc[0:51,2].mean()
```

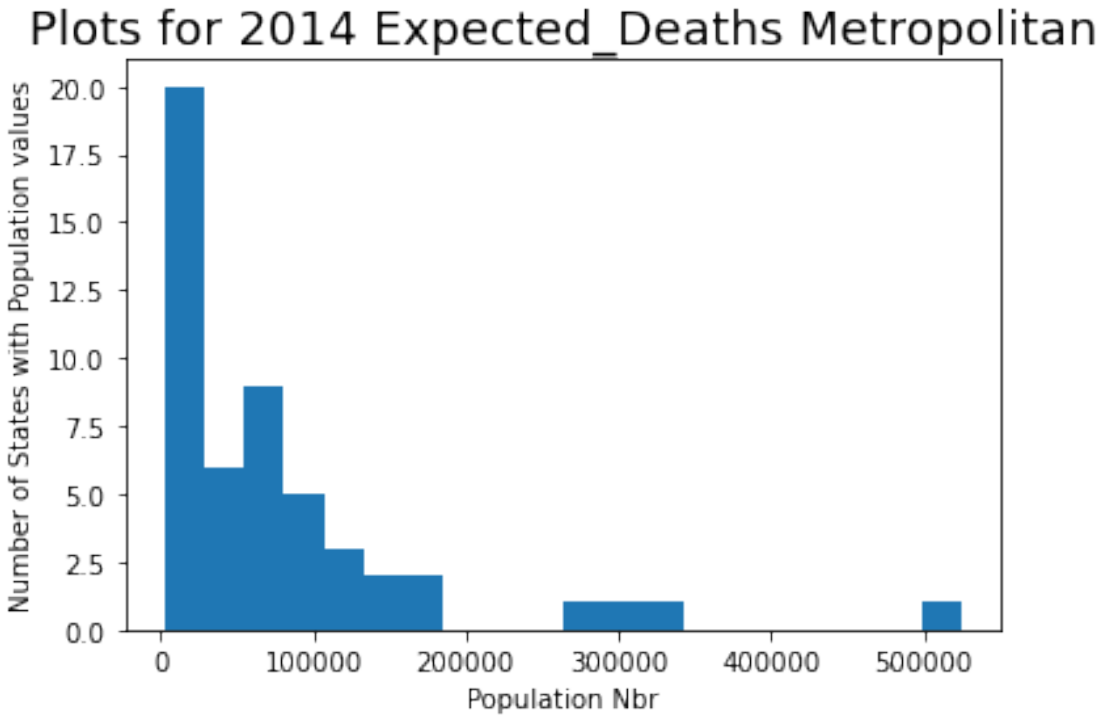
[34]:
```
15346.941176470587
```

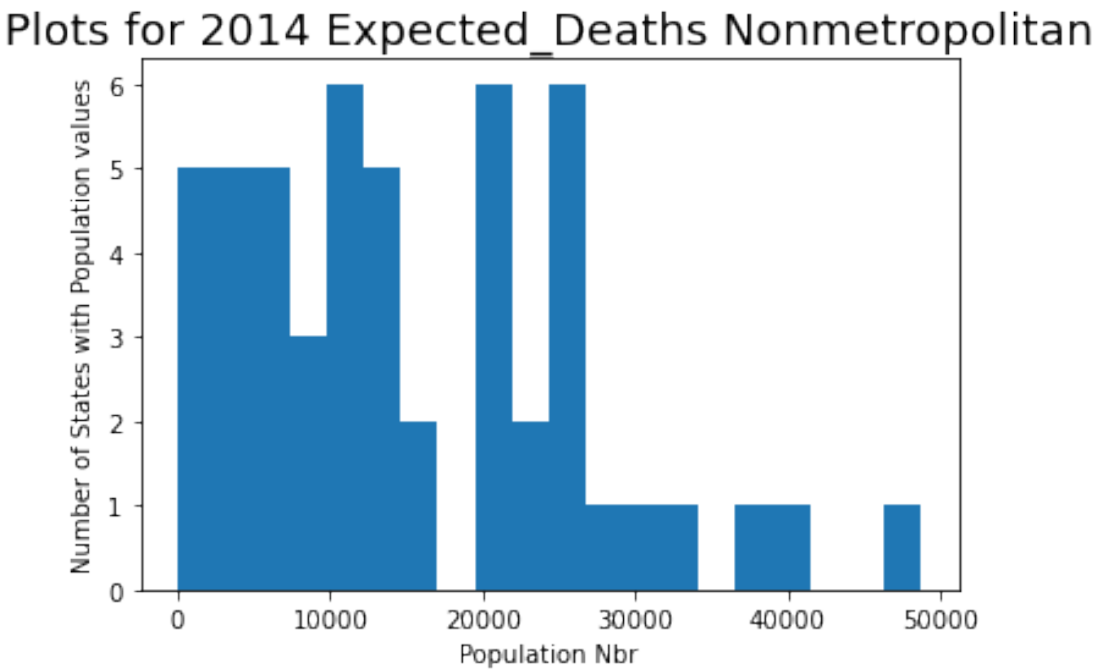
[35]:
```
df_pivot.iloc[52:,1].mean()
```

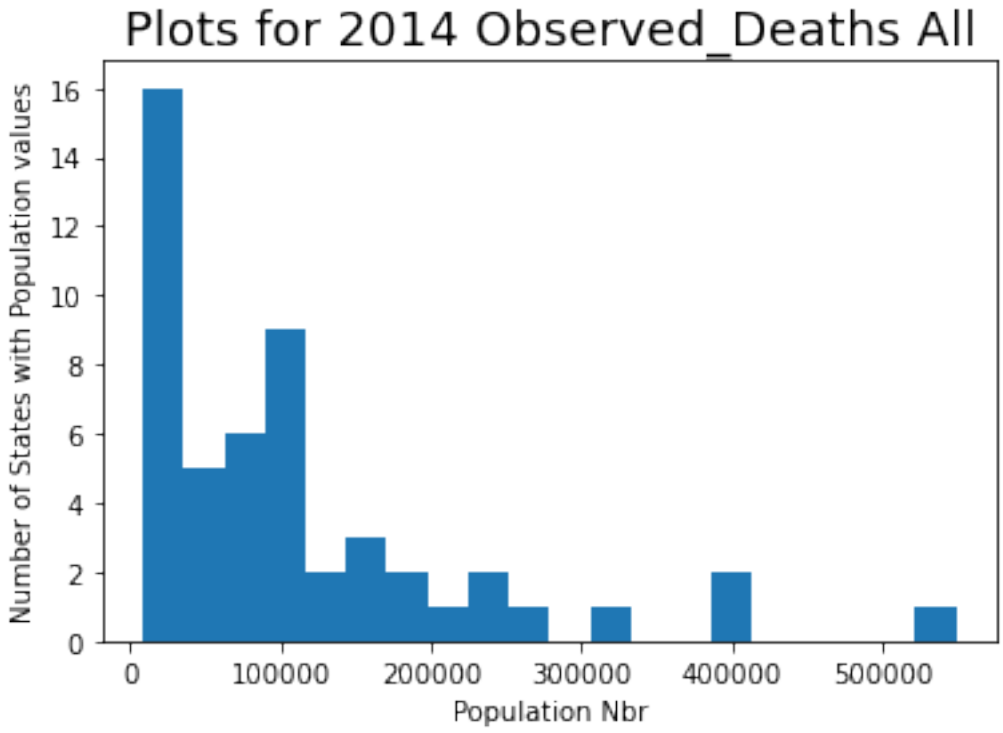
[35]:
```
81388.78
```

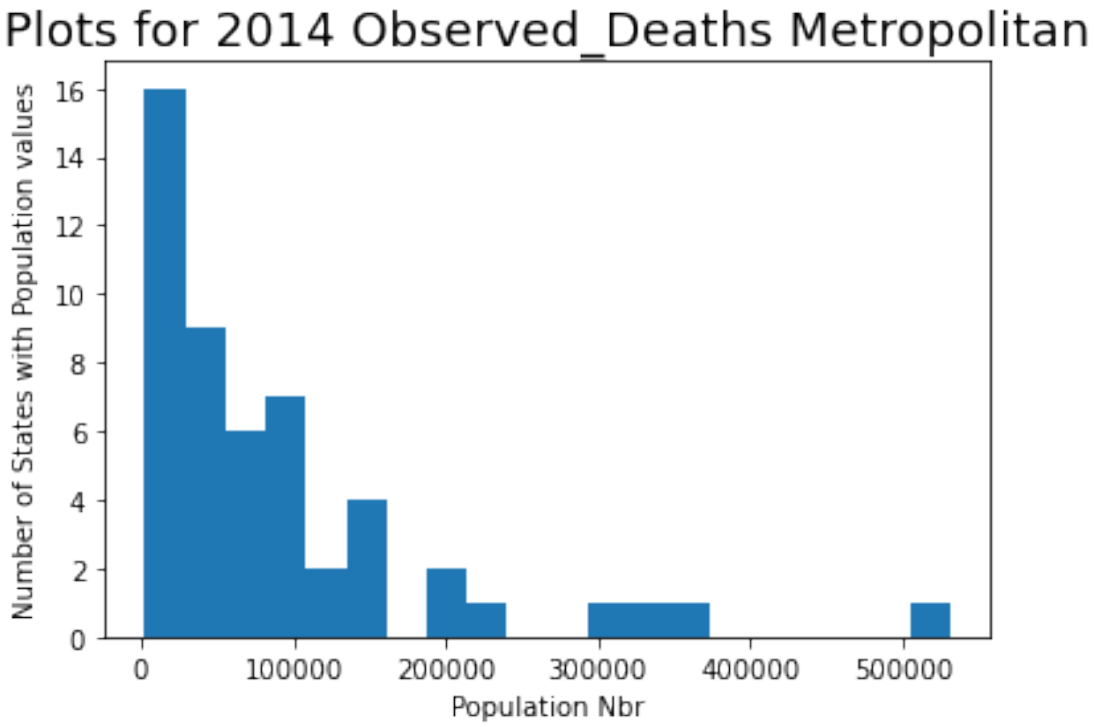
[36]:
```
# Create histograms to visually identify outliers or anomalies
 # Create histograms for each column in the pivot df
for x in df_pivot.columns:
    plt.title( "Plots for 2014 " +x, fontsize=18)
    plt.hist(df_pivot.iloc[0:51,0:][x], bins=20)
    plt.xlabel('Population Nbr')
    plt.ylabel("Number of States with Population values")
    plt.show()
```

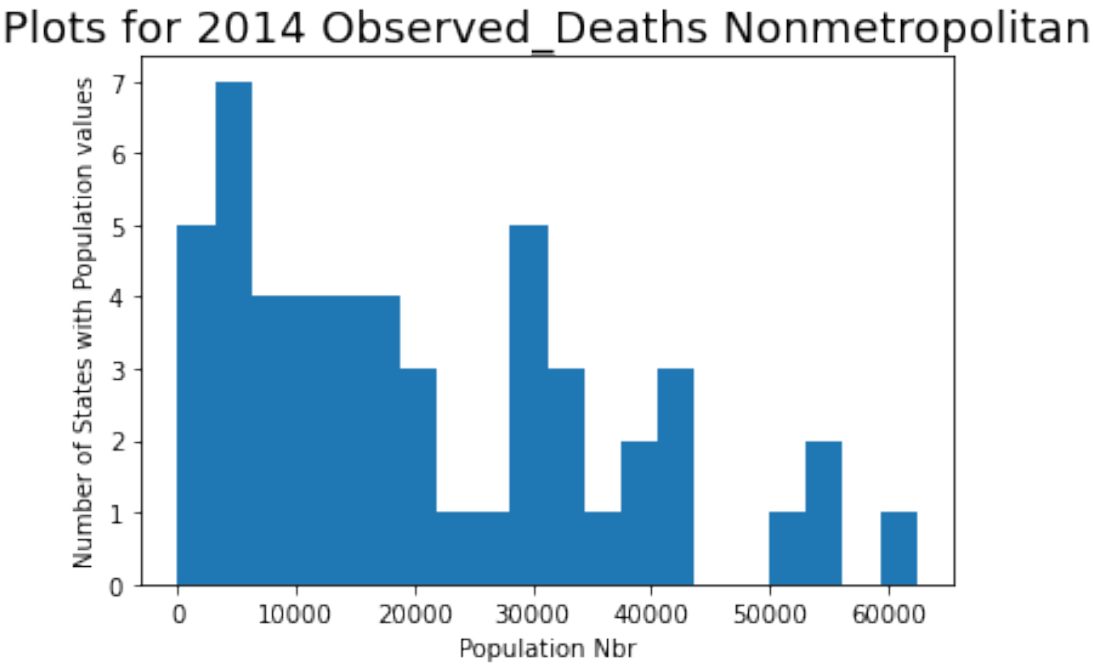

Plots for 2014 Expected_Deaths All
Number of States with Population values
0
2
4
6
8
10
12
14
16
0
100000
200000
300000
400000
500000
Population Nbr


Plots for 2014 Expected_Deaths Metropolitan
Number of States with Population values
0.0
2.5
5.0
7.5
10.0
12.5
15.0
17.5
20.0
0
100000
200000
300000
400000
500000
Population Nbr

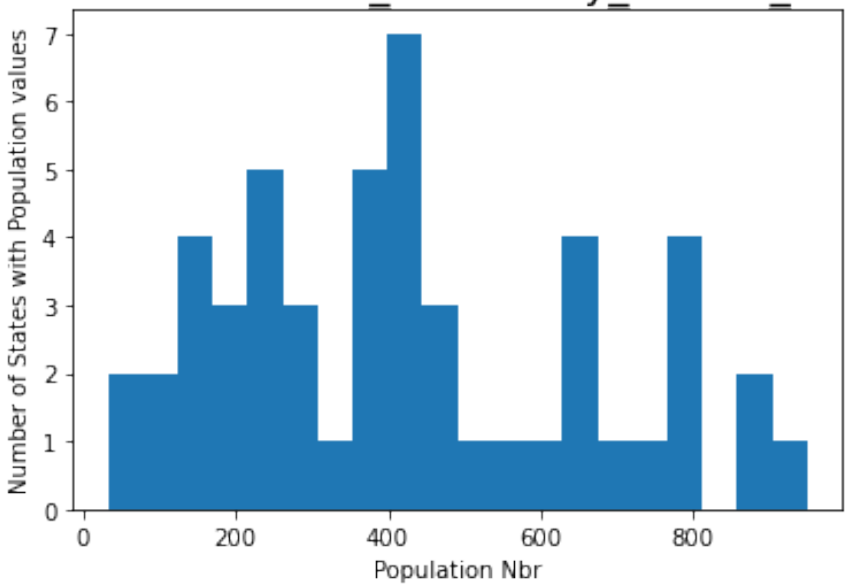

Plots for 2014 Expected_Deaths Nonmetropolitan
Number of States with Population values
0
1
2
3
4
5
6
0
10000
20000
30000
40000
50000
Population Nbr


Plots for 2014 Observed_Deaths All
Number of States with Population values
0
2
4
6
8
10
12
14
16
0
100000
200000
300000
400000
500000
Population Nbr

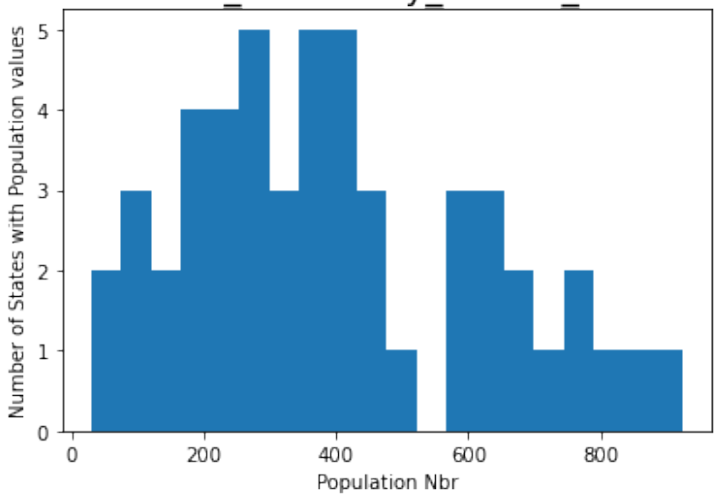

Plots for 2014 Observed_Deaths Metropolitan
Number of States with Population values
0
2
4
6
8
10
12
14
16
0
100000
200000
300000
400000
500000
Population Nbr

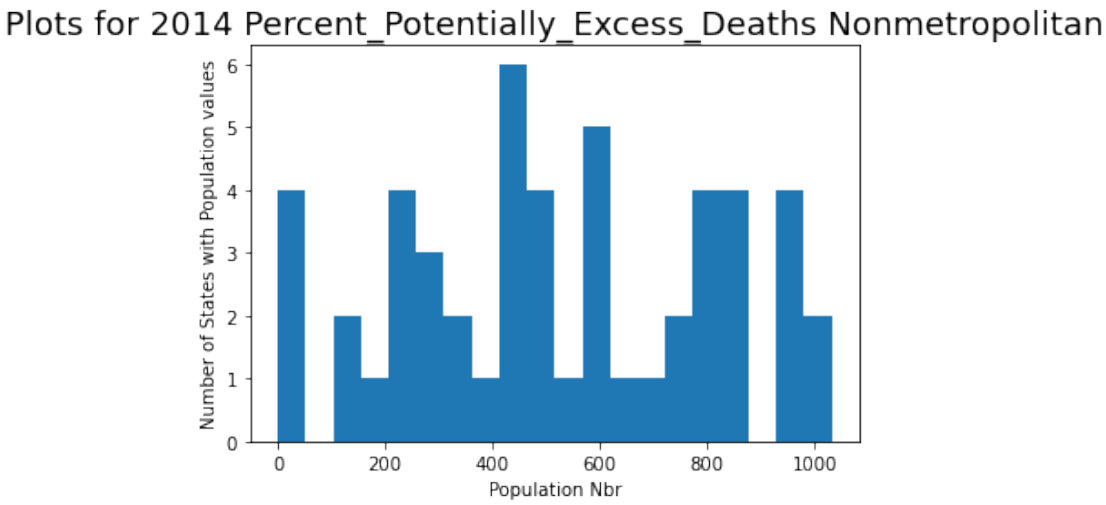

Plots for 2014 Observed_Deaths Nonmetropolitan
Number of States with Population values
0
1
2
3
4
5
6
7
0
10000
20000
30000
40000
50000
60000
Population Nbr

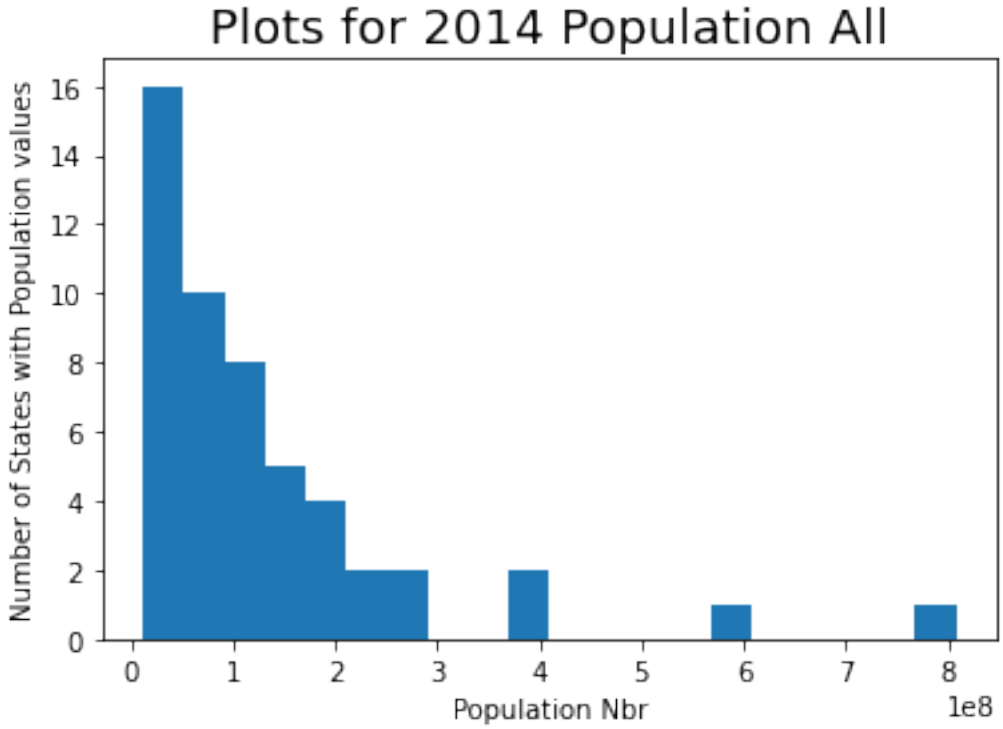
Plots for 2014 Percent_Potentially_Excess_Deaths All

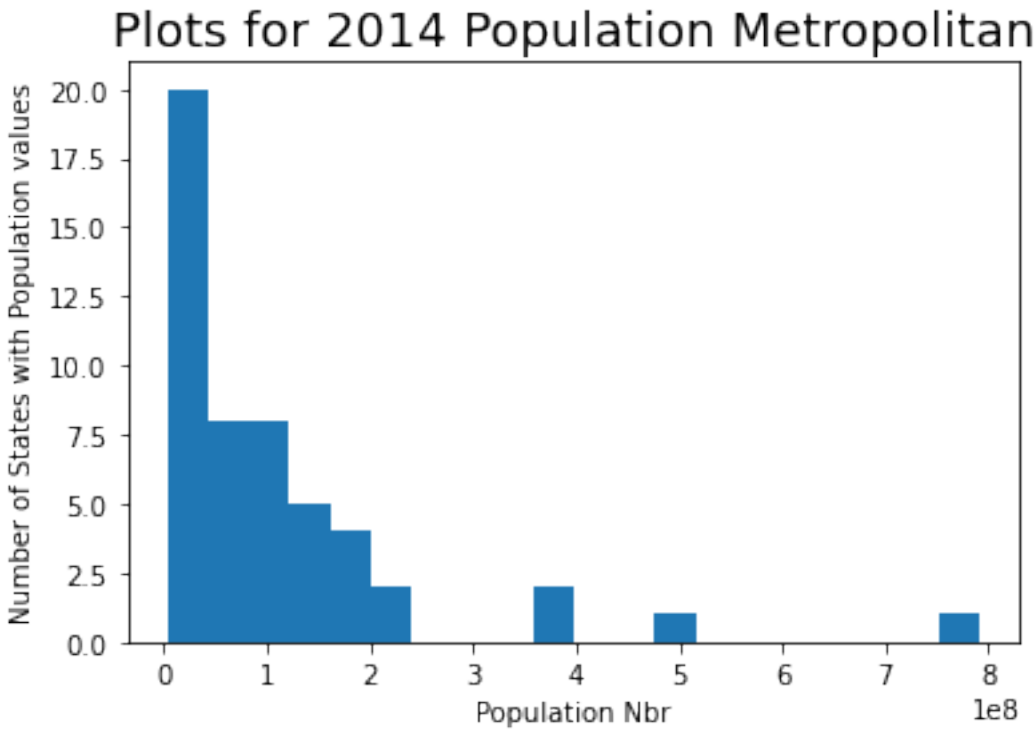


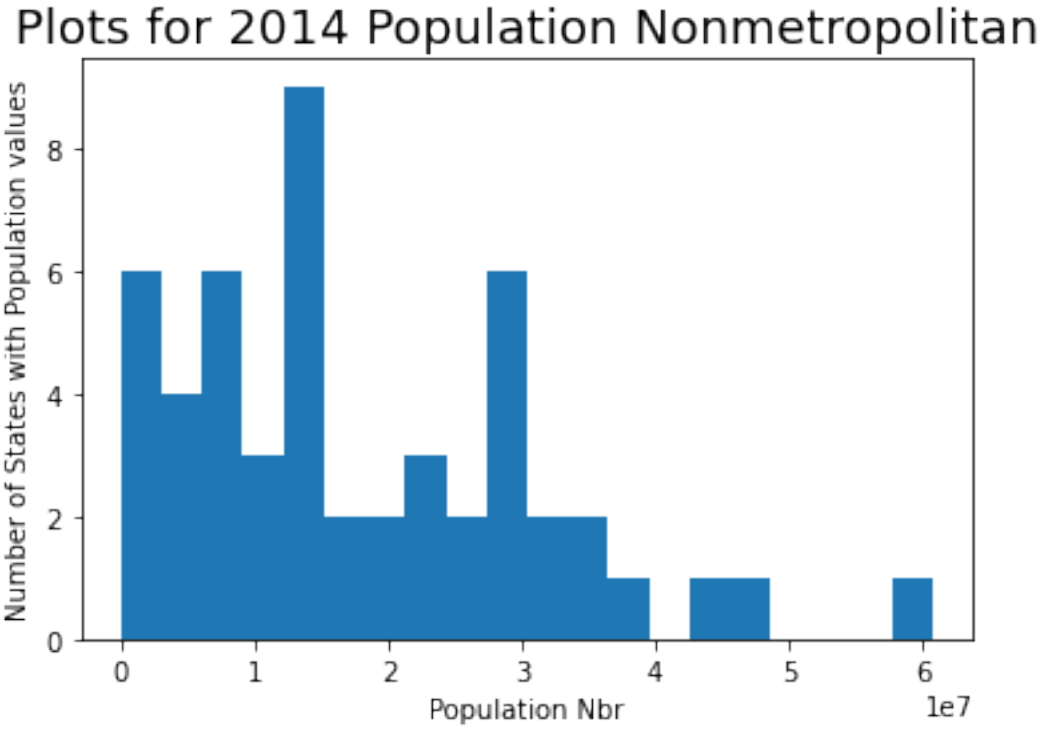
Plots for 2014 Percent_Potentially_Excess_Deaths Metropolitan

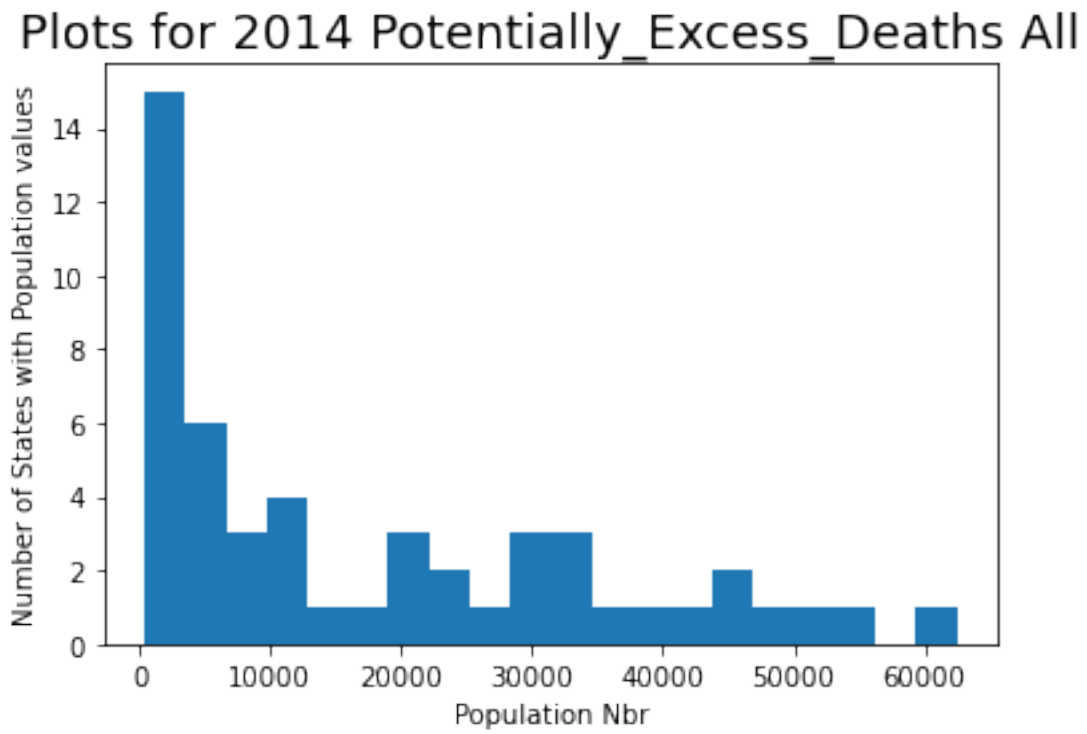


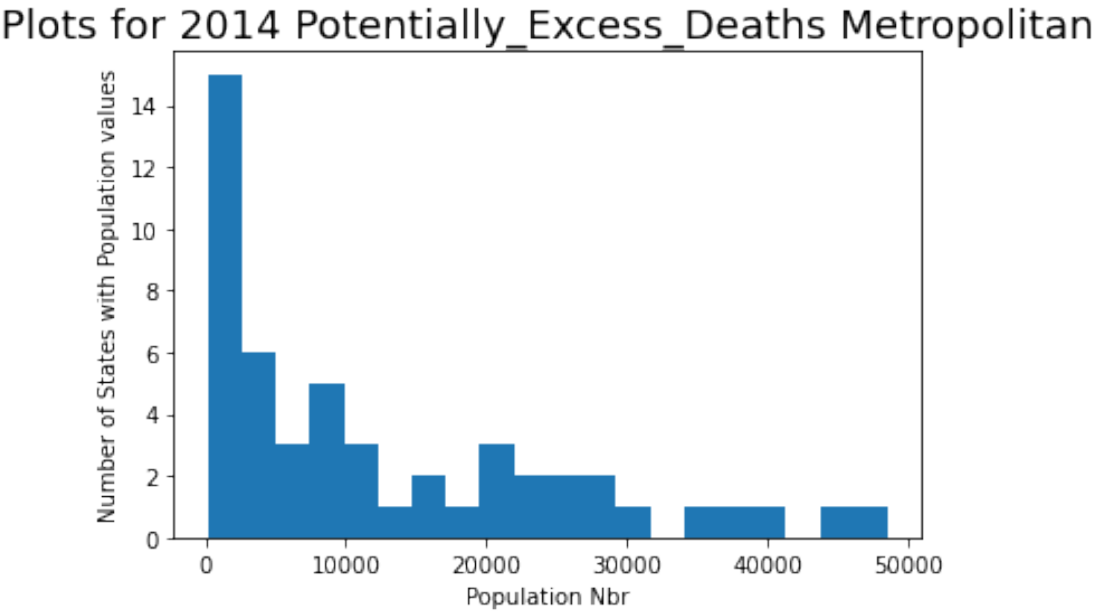

Plots for 2014 Percent_Potentially_Excess_Deaths Nonmetropolitan
Number of States with Population values
Population Nbr
0
1
2
3
4
5
6
0
200
400
600
800
1000

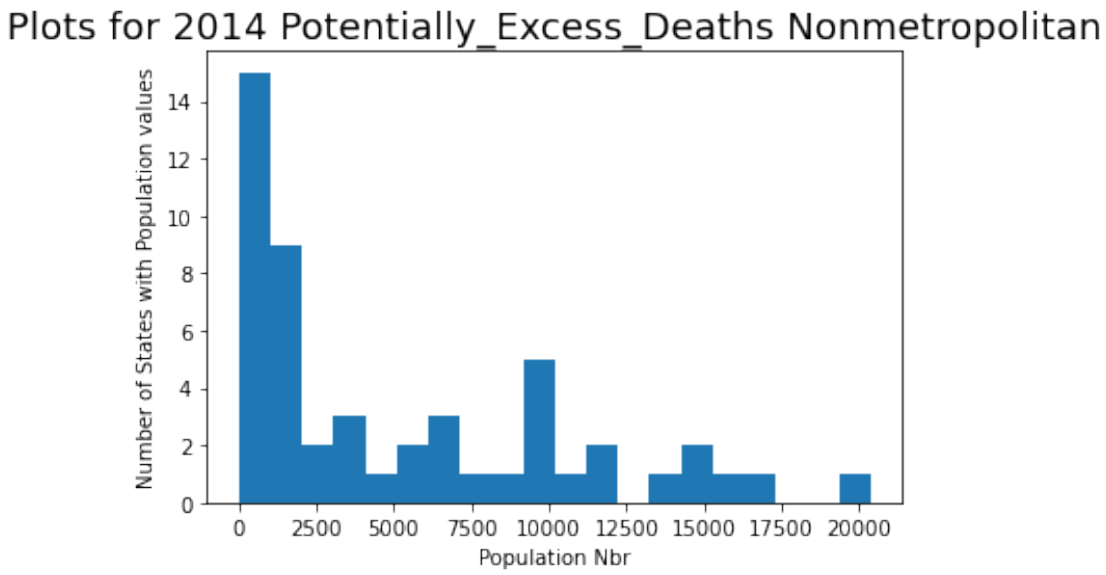

Plots for 2014 Population All
Number of States with Population values
Population Nbr
1e8
0
2
4
6
8
10
12
14
16
0
1
2
3
4
5
6
7
8


Plots for 2014 Population Metropolitan
Number of States with Population values
20.0
17.5
15.0
12.5
10.0
7.5
5.0
2.5
0.0
0
1
2
3
4
5
6
7
8
Population Nbr
1e8


Plots for 2014 Population Nonmetropolitan
Number of States with Population values
8
6
4
2
0
0
1
2
3
4
5
6
Population Nbr
1e7


Plots for 2014 Potentially_Excess_Deaths All
Number of States with Population values
0
2
4
6
8
10
12
14
0
10000
20000
30000
40000
50000
60000
Population Nbr


Plots for 2014 Potentially_Excess_Deaths Metropolitan
Number of States with Population values
0
2
4
6
8
10
12
14
0
10000
20000
30000
40000
50000
Population Nbr



0.9 Compute zscores to find outliers

[ ]:
```
from scipy import stats
```

[38]:
```
# Computer zscores for year 2014 "Expected Deaths All"
df_2014 = df_pivot.query('Year == 2014')
df_2014
```

[38]:

Year	State_Code	Expected_Deaths All	Expected_Deaths Metropolitan	\
2014	AK	9618.0	6178.0	
	AL	76163.0	56636.0	
	AR	46043.0	26386.0	
	AZ	102820.0	97111.0	
	CA	540349.0	524776.0	
…		…	…	
	VT	10845.0	3240.0	
	WA	106000.0	93091.0	
	WI	90072.0	63327.0	
	WV	32177.0	19185.0	
	WY	8859.0	2582.0	

Year	State_Code	Expected_Deaths Nonmetropolitan	Observed_Deaths All	\
2014	AK	3403.0	11037.0	
	AL	19527.0	105675.0	
	AR	19650.0	65784.0	

```
     AZ                                   5711.0             106986.0
     CA                                  15576.0             548517.0
…                                          …                   …
     VT                                   7608.0              12753.0
     WA                                  12911.0             114786.0
     WI                                  26742.0             102246.0
     WV                                  12992.0              48615.0
     WY                                   6249.0               8979.0

                Observed_Deaths Metropolitan  \
Year State_Code
2014 AK                              6852.0
     AL                             76464.0
     AR                             35679.0
     AZ                            101478.0
     CA                            531036.0
…                                     …
     VT                              3633.0
     WA                             99771.0
     WI                             72105.0
     WV                             29391.0
     WY                              2665.0

                Observed_Deaths Nonmetropolitan  \
Year State_Code
2014 AK                              4137.0
     AL                             29211.0
     AR                             30105.0
     AZ                              5508.0
     CA                             17481.0
…                                     …
     VT                              9120.0
     WA                             15015.0
     WI                             30141.0
     WV                             19224.0
     WY                              6291.0

                Percent_Potentially_Excess_Deaths All  \
Year State_Code
2014 AK                                          371.5
     AL                                          740.5
     AR                                          784.7
     AZ                                          206.8
     CA                                          137.5
…                                                  …
     VT                                          429.3
     WA                                          234.6
```

```
     WI                                          289.6
     WV                                          886.9
     WY                                          101.0

                Percent_Potentially_Excess_Deaths Metropolitan  \
Year State_Code
2014 AK                                                  334.4
     AL                                                  694.4
     AR                                                  670.6
     AZ                                                  215.1
     CA                                                  133.3
…                                                        …
     VT                                                  382.1
     WA                                                  208.5
     WI                                                  291.7
     WV                                                  922.9
     WY                                                  199.5

                Percent_Potentially_Excess_Deaths Nonmetropolitan  \
Year State_Code
2014 AK                                                     474.6
     AL                                                     871.4
     AR                                                     936.5
     AZ                                                     220.7
     CA                                                     341.2
…                                                           …
     VT                                                     476.0
     WA                                                     459.2
     WI                                                     305.3
     WV                                                     832.1
     WY                                                     136.7

                Population All  Population Metropolitan  \
Year State_Code
2014 AK             15762231.0              10738815.0
     AL             98584620.0              75517581.0
     AR             60216000.0              37603665.0
     AZ            136871601.0             129924657.0
     CA            807586629.0             791482749.0
…                        …                       …
     VT             12437853.0               4445346.0
     WA            145078080.0             131183028.0
     WI            116532489.0              87141945.0
     WV             36632532.0              22733298.0
     WY             11971962.0               3531017.0

                Population Nonmetropolitan  Potentially_Excess_Deaths All  \
```

```
Year State_Code
2014 AK                              4844330.0                              1578.0
     AL                             23067039.0                             29520.0
     AR                             22612335.0                             19829.0
     AZ                              6946944.0                              6592.0
     CA                             16103880.0                             22127.0
…                                          …                                    …
     VT                              7992507.0                              1920.0
     WA                             13895052.0                              9973.0
     WI                             29390544.0                             12357.0
     WV                             13899234.0                             16462.0
     WY                              8310732.0                               405.0

                Potentially_Excess_Deaths Metropolitan  \
Year State_Code
2014 AK                                          837.0
     AL                                        19852.0
     AR                                         9443.0
     AZ                                         6598.0
     CA                                        20498.0
…                                                  …
     VT                                          436.0
     WA                                         7796.0
     WI                                         8896.0
     WV                                        10263.0
     WY                                          190.0

                Potentially_Excess_Deaths Nonmetropolitan
Year State_Code
2014 AK                                            797.0
     AL                                           9702.0
     AR                                          10455.0
     AZ                                            246.0
     CA                                           2036.0
…                                                    …
     VT                                           1547.0
     WA                                           2253.0
     WI                                           3600.0
     WV                                           6233.0
     WY                                            335.0

[51 rows x 15 columns]
```

[43]:
```
# Print zcores
zscore_2014 = stats.zscore(df_2014.iloc[:,1])
zscore_2014
```

[43]:
```
array([-0.74821394, -0.22669078, -0.53934835,  0.19165023,  4.61190481,
       -0.13867121, -0.26067484, -0.72669483, -0.65440634,  2.57466941,
        0.3620977 , -0.63497506, -0.54483665, -0.65201877,  0.88114028,
       -0.04113238, -0.52921928, -0.41762378, -0.22668044,  0.24624386,
        0.08373427, -0.67304176,  0.47912982, -0.18773519, -0.11117801,
       -0.60910458, -0.75428105,  0.36402016, -0.76332487, -0.64368812,
       -0.67370325,  0.604813  , -0.59181281, -0.41980463,  2.01882109,
        0.67312222, -0.43971136, -0.28204925,  1.06229563, -0.64110418,
       -0.14810778, -0.75133535, -0.02919455,  2.33635715, -0.51047016,
        0.26600588, -0.77858049,  0.15010036, -0.15753402, -0.61377636,
       -0.78538144])
```

[44]:
```
# Display zscores GT than 3 or less than -3

bad_list = []
bad_list = [x for x in zscore_2014 if x > 3 or x < -3]
print(bad_list)
```

```
[4.611904813199927]
```

[ ]:
```
# The zscore shows California with a zscore over 3 for Expected Deaths All 2014.
# Calculate 2015 zscore for comparison
```

[45]:
```
# Computer zscores for year 2015 "Expected Deaths All"
df_2015 = df_pivot.query('Year == 2015')
df_2015
```

[45]:

Year	State_Code	Expected_Deaths All	Expected_Deaths Metropolitan	\
2015	AK	9699.0	6239.0	
	AL	76859.0	57272.0	
	AR	46424.0	26799.0	
	AZ	105356.0	99602.0	
	CA	550846.0	535135.0	
…		…	…	
	VT	10940.0	3282.0	
	WA	108307.0	95175.0	
	WI	91150.0	64206.0	
	WV	32212.0	19219.0	
	WY	8940.0	2639.0	

Year	State_Code	Expected_Deaths Nonmetropolitan	Observed_Deaths All	\
2015	AK	3354.0	11043.0	
	AL	19587.0	105708.0	
	AR	19627.0	67029.0	
	AZ	5755.0	109086.0	

```
      CA                                  15710.0             555861.0
…                                           …                   …
      VT                                   7660.0              12972.0
      WA                                  13128.0             117654.0
      WI                                  26942.0             102003.0
      WV                                  12993.0              47406.0
      WY                                   6303.0               8700.0

                 Observed_Deaths Metropolitan  \
Year State_Code
2015 AK                               7077.0
     AL                              77061.0
     AR                              37557.0
     AZ                             103224.0
     CA                             538362.0
…                                       …
     VT                               3705.0
     WA                             101973.0
     WI                              70308.0
     WV                              28209.0
     WY                               2676.0

                 Observed_Deaths Nonmetropolitan  \
Year State_Code
2015 AK                               3921.0
     AL                              28647.0
     AR                              29472.0
     AZ                               5862.0
     CA                              17499.0
…                                       …
     VT                               9267.0
     WA                              15681.0
     WI                              31695.0
     WV                              19197.0
     WY                               6024.0

                 Percent_Potentially_Excess_Deaths All  \
Year State_Code
2015 AK                                          333.6
     AL                                          718.9
     AR                                          810.4
     AZ                                          192.2
     CA                                          127.4
…                                                    …
     VT                                          395.2
     WA                                          219.9
     WI                                          275.9
```

```
     WV                                          825.4
     WY                                           53.1

                Percent_Potentially_Excess_Deaths Metropolitan  \
Year State_Code
2015 AK                                                  356.2
     AL                                                  666.9
     AR                                                  757.0
     AZ                                                  185.3
     CA                                                  124.6
…                                                        …
     VT                                                  333.5
     WA                                                  189.1
     WI                                                  230.0
     WV                                                  801.8
     WY                                                  177.1

                Percent_Potentially_Excess_Deaths Nonmetropolitan  \
Year State_Code
2015 AK                                                    445.9
     AL                                                    861.4
     AR                                                    893.8
     AZ                                                    363.9
     CA                                                    302.1
…                                                          …
     VT                                                    457.8
     WA                                                    458.4
     WI                                                    393.3
     WV                                                    863.6
     WY                                                     97.1

                Population All  Population Metropolitan  \
Year State_Code
2015 AK             15752025.0               10730610.0
     AL             98453697.0               75538374.0
     AR             60298329.0               37830675.0
     AZ            138245184.0              131349090.0
     CA            812037297.0              795993207.0
…                        …                        …
     VT             12369387.0                4445340.0
     WA            146927250.0              132955461.0
     WI            116414547.0               87214530.0
     WV             36394473.0               22640328.0
     WY             11976111.0                3679551.0

                Population Nonmetropolitan  Potentially_Excess_Deaths All  \
Year State_Code
```

```
2015 AK                          4667820.0                          1537.0
     AL                         22915323.0                         28849.0
     AR                         22467654.0                         20624.0
     AZ                          6896094.0                          6485.0
     CA                         16044090.0                         21109.0
…                                      …                                …
     VT                          7924047.0                          2070.0
     WA                         13971789.0                         10804.0
     WI                         29200017.0                         11151.0
     WV                         13754145.0                         15195.0
     WY                          8296560.0                           158.0

                Potentially_Excess_Deaths Metropolitan  \
Year State_Code
2015 AK                                        1015.0
     AL                                       19793.0
     AR                                       10758.0
     AZ                                        6083.0
     CA                                       19663.0
…                                                 …
     VT                                        467.0
     WA                                       8209.0
     WI                                       6514.0
     WV                                       9003.0
     WY                                        186.0

                Potentially_Excess_Deaths Nonmetropolitan
Year State_Code
2015 AK                                           661.0
     AL                                          9069.0
     AR                                          9927.0
     AZ                                           505.0
     CA                                          1961.0
…                                                    …
     VT                                          1655.0
     WA                                          2657.0
     WI                                          4759.0
     WV                                          6204.0
     WY                                           139.0

[51 rows x 15 columns]
```

[63]:
```
# Print zcores
zscore_2015 = stats.zscore(df_2015['Expected_Deaths All'])
zscore_2015
```

[63]:
```
array([-8.27748071e-01, -1.78609409e-01, -4.72780570e-01,  9.68299073e-02,
        4.40273793e+00, -1.62525925e-01, -3.68479568e-01, -8.40477607e-01,
       -7.70585980e-01,  2.44785047e+00,  4.79721196e-01, -7.09393352e-01,
       -4.55488892e-01, -6.84968495e-01,  9.22954544e-01,  4.10983182e-02,
       -5.10998174e-01, -2.51487692e-01, -2.54097392e-01,  1.00647801e-01,
       -4.40068921e-02, -6.87230235e-01,  6.15203278e-01, -1.18895611e-01,
       -3.84651178e-03, -4.86669972e-01, -7.54096543e-01,  5.74443634e-01,
       -8.18971747e-01, -6.53980726e-01, -7.01863885e-01,  4.17127063e-01,
       -6.07305762e-01, -4.95726597e-01,  1.98388450e+00,  8.61887569e-01,
       -3.61694348e-01, -2.93706836e-01,  1.10275320e+00, -7.60079522e-01,
       -1.57064887e-01, -7.95716422e-01,  7.80593999e-02,  2.57396663e+00,
       -5.90246058e-01,  2.95689032e-01, -8.15753118e-01,  1.25352960e-01,
       -4.04789646e-02, -6.10147435e-01, -8.35084227e-01])
```

[65]:
```
# Display zscores GT than 3 or less than -3

bad_list = []
bad_list = [x for x in zscore_2015 if x > 3 or x > -3]
print(bad_list)
```

```
[-0.8277480711228766, -0.1786094086790072, -0.4727805699577321,
0.09682990733741546, 4.402737928959205, -0.1625259254403741,
-0.3684795677773897, -0.8404776068351841, -0.7705859798528789,
2.4478504677433035, 0.47972119640905697, -0.7093933522183921,
-0.4554888923652354, -0.6849684951606843, 0.9229545442900653,
0.04109831818239237, -0.5109981737591476, -0.2514876921040634,
-0.2540973919084089, 0.10064780149562463, -0.04400689210376413,
-0.687230234991117, 0.6152032784739128, -0.11889561093364948,
-0.003846511781335936, -0.4866699722497488, -0.7540965433113477,
0.5744436337519682, -0.818971747336411, -0.653980726372789, -0.7018638850051138,
0.4171270633240882, -0.607305762094328, -0.49572659712631084, 1.983884504749995,
0.8618875688683802, -0.36169434828609137, -0.2937068356054753,
1.1027531952546403, -0.7600795217516805, -0.15706488696091034,
-0.7957164224132431, 0.07805939985578958, 2.5739666271770085,
-0.590246057817773, 0.29568903242854366, -0.8157531175777182,
0.12535295964342885, -0.04047896459048223, -0.6101474352146152,
-0.8350842272395368]
```

[72]:
```
# Check zscores for other features
zscore_2015 = stats.zscore(df_2015['Observed_Deaths All'])
zscore_2015
```

[72]:
```
array([-8.90443170e-01, -4.82799333e-02, -3.92377877e-01, -1.82284104e-02,
        3.95639241e+00, -3.42309798e-01, -4.71082976e-01, -8.90149594e-01,
       -8.22947343e-01,  2.57599733e+00,  5.88780326e-01, -7.88785754e-01,
       -4.74258936e-01, -7.59294695e-01,  1.09343774e+00,  1.91545098e-01,
       -5.31559664e-01, -4.06736420e-02, -1.13613972e-01, -1.28105959e-03,
```

```
       -7.79845026e-02, -7.20035556e-01,  7.76348801e-01, -2.00272316e-01,
        1.29413707e-01, -3.93285294e-01, -8.12832310e-01,  7.05410126e-01,
       -8.84358137e-01, -7.11708669e-01, -7.57800125e-01,  3.03584434e-01,
       -6.84139199e-01, -5.54084962e-01,  1.85721614e+00,  1.17136886e+00,
       -2.53329534e-01, -3.32781917e-01,  1.28556999e+00, -8.17823105e-01,
       -9.11420521e-02, -8.60391647e-01,  3.14473441e-01,  2.59177037e+00,
       -7.27935424e-01,  2.98647017e-01, -8.73282310e-01,  5.79946352e-02,
       -8.12405290e-02, -5.66948935e-01, -9.11287077e-01])
```

[73]:
```
# Check summary statistics of Cancer - Expected Deaths All 2015
df_2015['Expected_Deaths All'].describe()
```

[73]:
```
count        51.000000
mean      95337.960784
std      104489.655432
min        8382.000000
25%       26074.000000
50%       69049.000000
75%      107029.000000
max      550846.000000
Name: Expected_Deaths All, dtype: float64
```

[74]:
```
# Check summary statistics of Cancer - Expected Deaths All 2014
df_2014['Expected_Deaths All'].describe()
```

[74]:
```
count        51.000000
mean      93917.647059
std      102559.209756
min        8260.000000
25%       25696.000000
50%       68254.000000
75%      105117.000000
max      540349.000000
Name: Expected_Deaths All, dtype: float64
```

[ ]:
```

```