In [ ]:
```
import pandas as pd
import numpy as np
import seaborn as sns
import matplotlib.pyplot as plt
import scipy.stats as stats
import datetime as dt
```

In [ ]:
```
STATES = ['CA', 'NM', 'NJ', 'NV']
KDE_BANDWIDTH = 0.4
NORMALIZATION_FACTOR = 10000
START_YEAR = 2022
START_MONTH = 5
START_DAY = 31
END_YEAR = 2022
END_MONTH = 12
END_DAY = 31
LOWER_INTERVAL_BOUND = dt.datetime(START_YEAR, START_MONTH, START_DAY)  # Datetime
UPPER_INTERVAL_BOUND = dt.datetime(END_YEAR, END_MONTH, END_DAY)        # Datetime
```

In [ ]:
```
def normalize(df, pop, nf=NORMALIZATION_FACTOR):
    """
    Returns a normalized version of the dataframe

    Args:
        df (Dataframe):
        pop (int): Population of the selected jurisdiction
        nf (int, optional): Normalization Factor. Defaults to NORMALIZATION_FACTOR.

    Returns:
        Dataframe:
    """
    return (df/pop) * nf
def stringify_distribution_moments(series, title='', print_on=True):
    series_expected = series.mean().round()
    series_variance = series.var().round(3)
    series_skewness = series.skew().round(3)
    series_kurtosis = series.kurtosis().round(3)
    s = "---- {} ----\nCenter: {}\nVariance: {}\nSkewness: {}\nKurtosis: {}".format
    if print_on:
        print(s)
    return s

def get_state_data(state_name):
    return get_state_cases_deaths_df(state_name), get_state_population(state_name)
def get_state_population(state_name):
    return pd.read_csv('data/{}_new_cases_deaths.csv'.format(state_name))['Populati
def get_state_cases_deaths_df(state_name):
    return wrangle(pd.read_csv('data/{}_new_cases_deaths.csv'.format(state_name)))
def wrangle(df):
    new_df = df.copy()
    new_df.drop(['Population'], axis=1, inplace=True)
    new_df.columns = ['Date', 'Cases', 'Deaths']
    new_df.set_index(new_df.columns[0], inplace=True)
    new_df.set_index(pd.to_datetime(new_df.index), inplace=True)
```

```
    return new_df
def get_weekly_statistic(df, statistic='sum'):
    if statistic == 'mean':
        return df.groupby(df.index.isocalendar().week, axis=0).mean().round()
    elif statistic == 'median':
        return df.groupby(df.index.isocalendar().week, axis=0).median().round()
    elif statistic == 'sum':
        return df.groupby(df.index.isocalendar().week, axis=0).sum().round()
```

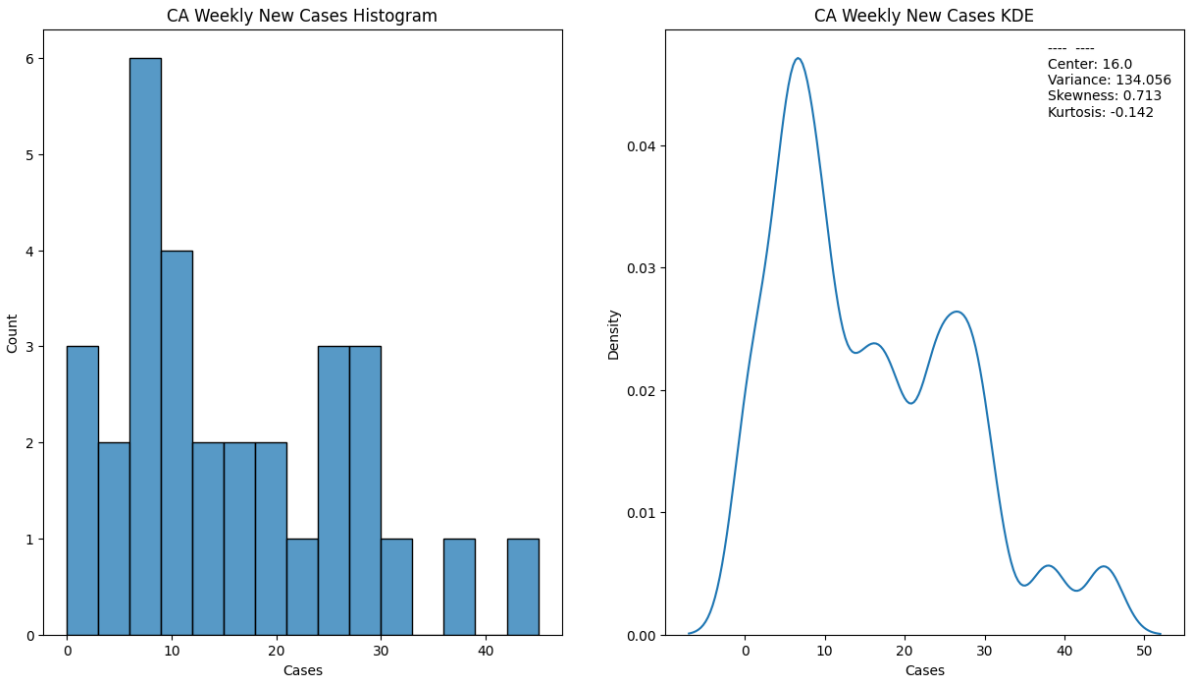
In [ ]:
```
state_1_df, state_1_pop = get_state_data(STATES[0])
state_2_df, state_2_pop = get_state_data(STATES[1])
state_3_df, state_3_pop = get_state_data(STATES[2])
state_4_df, state_4_pop = get_state_data(STATES[3])
state_1_df = normalize(state_1_df, state_1_pop)
state_2_df = normalize(state_2_df, state_2_pop)
state_3_df = normalize(state_3_df, state_3_pop)
state_4_df = normalize(state_4_df, state_4_pop)
```

In [ ]:
```
state_1_weekly_df = get_weekly_statistic(state_1_df)
state_2_weekly_df = get_weekly_statistic(state_2_df)
state_3_weekly_df = get_weekly_statistic(state_3_df)
state_4_weekly_df = get_weekly_statistic(state_4_df)
```

In [ ]:
```
from matplotlib.offsetbox import AnchoredText

fig, ax = plt.subplots(1, 2, figsize=(15, 8))
state_1_weekly_cases_hist = sns.histplot(data=state_1_weekly_df.Cases, bins=15, ax=
state_1_weekly_cases_kde = sns.kdeplot(data=state_1_weekly_df.Cases, bw_adjust=KDE_
ax[0].set_title('{} Weekly New Cases Histogram'.format(STATES[0]))
ax[1].set_title('{} Weekly New Cases KDE'.format(STATES[0]))
anc = AnchoredText(stringify_distribution_moments(state_1_weekly_df.Cases, print_on
ax[1].add_artist(anc)
```

Out[ ]:
```
<matplotlib.offsetbox.AnchoredText at 0x256981e4390>
```



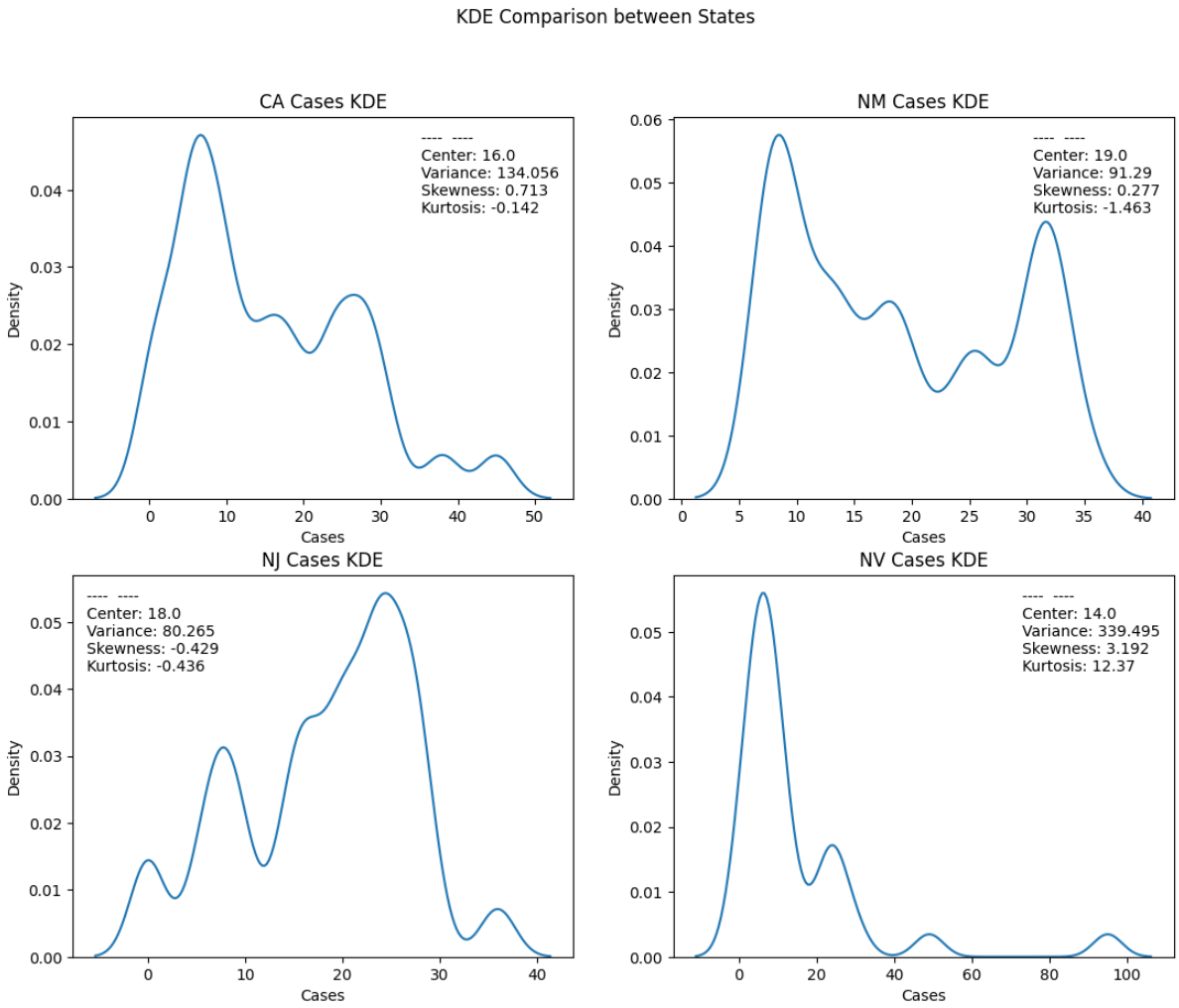
In [ ]:
```
dm = stringify_distribution_moments(state_1_weekly_df.Cases, title='CA Cases')
```

```
---- CA Cases ----
Center: 16.0
Variance: 134.056
Skewness: 0.713
Kurtosis: -0.142
```

In [ ]:
```
fig, ax = plt.subplots(2, 2, figsize=(13, 10))

fig.suptitle('KDE Comparison between States')
state_1_weekly_cases_kde = sns.kdeplot(data=state_1_weekly_df.Cases, bw_adjust=KDE_
state_2_weekly_cases_kde = sns.kdeplot(data=state_2_weekly_df.Cases, bw_adjust=KDE_
state_3_weekly_cases_kde = sns.kdeplot(data=state_3_weekly_df.Cases, bw_adjust=KDE_
state_4_weekly_cases_kde = sns.kdeplot(data=state_4_weekly_df.Cases, bw_adjust=KDE_
ax[0,0].set_title('{} Cases KDE'.format(STATES[0]))
ax[0,1].set_title('{} Cases KDE'.format(STATES[1]))
ax[1,0].set_title('{} Cases KDE'.format(STATES[2]))
ax[1,1].set_title('{} Cases KDE'.format(STATES[3]))
anc = AnchoredText(stringify_distribution_moments(state_1_weekly_df.Cases, print_on
ax[0,0].add_artist(anc)
anc = AnchoredText(stringify_distribution_moments(state_2_weekly_df.Cases, print_on
ax[0,1].add_artist(anc)
anc = AnchoredText(stringify_distribution_moments(state_3_weekly_df.Cases, print_on
ax[1,0].add_artist(anc)
anc = AnchoredText(stringify_distribution_moments(state_4_weekly_df.Cases, print_on
ax[1,1].add_artist(anc)
```

Out[ ]:
```
<matplotlib.offsetbox.AnchoredText at 0x25698340550>
```



Comment about the difference between distributions

Comparing the four distributions along side each other, we can see that there are consistency about some new cases rate, for california for example, after normalization, we can see that we have two spikes around 10 & 25 cases per the normalization factor for each week. the patter repeats for New Mexico, we can see that it also have a 2 spike distribution around 10 & 32. Both CA and NM have a positive skewness and a negative kurtosis. The pattern is alittle bit off for both New Jersey and Nevada, as they only have one main spike with the difference being the variance, as NV has a remarkable variance in values and positive skewness and kurtosis, while NJ has a negative skewness and kurtosis. Most of the centers of the distributions are close to each other, with Nevada being the lowest with 14 new cases per normalization factor per week, and the rest of the states 16, 19 and 18 for CA, NM, and NJ respectively.

In [ ]:
```
enrichment_df = pd.read_csv('data/enrichment.csv')
enrichment_df[enrichment_df.columns[3:]] = enrichment_df[enrichment_df.columns[3:]]
enrichment_df = enrichment_df[enrichment_df['Sex'] == 'T']
enrichment_df = enrichment_df.drop(['Sex', 'StateFIPS'], axis=1)
enrichment_df = enrichment_df.set_index(enrichment_df['State']).drop('State', axis=
enrichment_df = enrichment_df.sort_index()
```

```
enrichment_youth_df = enrichment_df[enrichment_df.columns[:8]]
enrichment_senior_df = enrichment_df[enrichment_df.columns[8:]]
enrichment_youth_df = enrichment_youth_df.aggregate(np.sum, axis=1)
enrichment_senior_df = enrichment_senior_df.aggregate(np.sum, axis=1)
enrichment_df.head(3)
```

Out[ ]:

State	Under 5 years	5 to 9 years	10 to 14 years	15 to 19 years	20 to 24 years	25 to 29 years	30 to 34 years	35 to 39 years	40 to 44 years	45 to 49 years	50 to 54 years	55 to 59 years	60 to 64 years	6 y
AK	6.3	7.1	7.2	6.9	6.3	7.5	7.9	7.5	6.6	5.5	5.8	5.9	6.4	
AL	5.8	5.9	6.7	6.7	6.4	6.2	6.3	6.2	6.5	6.0	6.3	6.6	6.8	
AR	5.9	6.5	6.8	6.8	6.6	6.1	6.6	6.5	6.2	5.8	6.0	6.5	6.3	

In [ ]:
```
covid_df = pd.read_csv('data/covid_confirmed_usafacts.csv')
covid_df = covid_df[covid_df['countyFIPS'] != 0]
covid_df = covid_df.drop(['countyFIPS', 'County Name', 'StateFIPS'], axis=1)
covid_df = covid_df.groupby('State').sum()
covid_df = covid_df.transpose()
covid_df.index = pd.to_datetime(covid_df.index)
covid_df = covid_df.loc[LOWER_INTERVAL_BOUND:UPPER_INTERVAL_BOUND]
covid_df = covid_df.diff(axis=0)
covid_df = covid_df.drop(covid_df.index[0])
covid_df = covid_df.transpose()
covid_df = covid_df.sort_index()
covid_df = covid_df.groupby(covid_df.columns.isocalendar().week, axis=1).sum()
covid_df.head(3)
```

Out[ ]:

State	week 22	23	24	25	26	27	28	29	30	31	...	
AK	0.0	3248.0	1984.0	2316.0	2535.0	1949.0	2286.0	2249.0	2263.0	1765.0	...	5
AL	2066.0	8332.0	9620.0	11287.0	12783.0	14633.0	16649.0	17366.0	16712.0	12047.0	...	29
AR	1762.0	3837.0	4696.0	5442.0	6958.0	8037.0	9272.0	8870.0	7889.0	6858.0	...	17

3 rows × 31 columns

In [ ]:
```
states_pop = pd.read_csv('data/covid_county_population_usafacts.csv')
states_pop = states_pop[states_pop['countyFIPS'] != 0].drop(['countyFIPS', 'County
states_pop.head(3)
```

Out[ ]:

State	population
AK	731545
AL	4903185
AR	3017804

In [ ]:
```
covid_mean_df = covid_df.mean(axis=1).round()
covid_mean_normalized_df = covid_mean_df.divide(states_pop['population']) * NORMALI
covid_mean_normalized_df = covid_mean_normalized_df.round()
covid_mean_normalized_df.head(3)
```

Out[ ]:
```
State
AK    15.0
AL    17.0
AR    15.0
dtype: float64
```

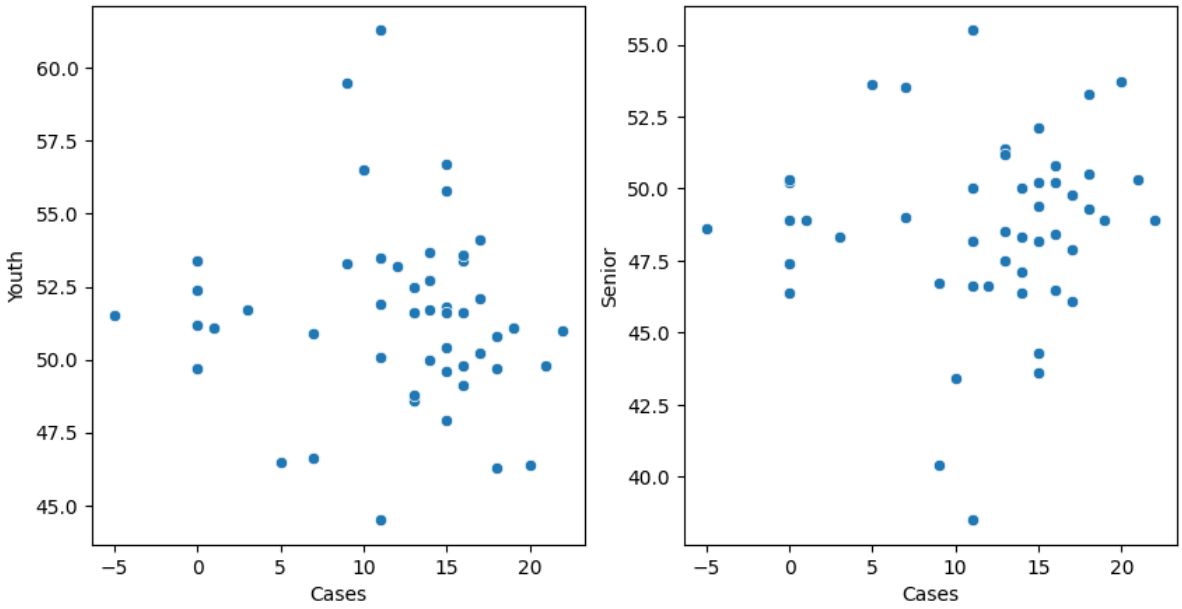
In [ ]:
```
covid_enrich_df = {'Cases': covid_mean_normalized_df, 'Youth':enrichment_youth_df,
covid_enrich_df = pd.concat(covid_enrich_df, axis=1).dropna()
covid_enrich_df.head(3)
```

Out[ ]:

State	Cases	Youth	Senior
AK	15.0	56.7	43.6
AL	17.0	50.2	49.8
AR	15.0	51.8	48.2

In [ ]:
```
fig, ax = plt.subplots(1, 2, figsize=(10, 5))
sns.scatterplot(x=covid_enrich_df.Cases, y=covid_enrich_df.Youth, ax=ax[0])
sns.scatterplot(x=covid_enrich_df.Cases, y=covid_enrich_df.Senior, ax=ax[1])
```

Out[ ]:
```
<Axes: xlabel='Cases', ylabel='Senior'>
```



Correlation Analysis

The anaylis is trying to figure out if a correlation is happening between the percentages of age groups in every state and the number of new covid cases.

Assumptions

Youth are considered citizens of ages from 0 to 40 years old, while senior citizens are considered 40< years old. The enrichment data is in a percentage format, a little bit of wrangling and aggregations with rounding take place, therefore the percentages may be off with an acceptable ~0.3 percent.

Procedure

- Covid data for all states has been collected as a dataframe, wrangling and aggregations take place, weekly statistics is used for new cases, and the mean of weeks 22 through 52 of the year 2022 is considered the center value for new cases for each state.
- Enrichment data is cleaned and sorted to align with covid data, irrelevant records were dropped, like counties data, and gender statistics.
- Enrichment data doesn't require normalization, however covid data is normalized by using every state population from the population dataset, after aggregating and sorting, the populations are used in addition to the NORMALIZATION FACTOR to normalized the new covid cases dataframe.
- Enrichment data is then separated into only two age groups, labeled Youth and Senior, these groups are the aggregation result of multiple age groups that were included in the data set.

- A scatter plot is used to plot the data points of new cases against the percentages of the two age groups as seen above.

Findings

- A weak negative correlation between the youth population percentage increase and new cases increase, meaning on average, as youth percentage increase in a population, the new cases slightly decrease.
- A weak positive correlation between the senior population percentage increase and new cases increase, meaning on average, as senior percentage increase in a population, the new cases slightly increase.

Hypothesis Testing

Hypothesis #1:

- Hypothesis:
  - **Null Hypothesis H0** - Youth dominated states have similar new cases rate as the entire country
  - **Alternative Hypothesis H1** - Youth dominated states have different new cases rate from the entire country

In [ ]:
```
states_mean = covid_enrich_df.Cases.mean().round()
covid_youth_dom = covid_enrich_df[covid_enrich_df['Youth'] > 50].drop(['Youth', 'Se
```

In [ ]:
```
stats.ttest_1samp(a= covid_youth_dom.Cases, popmean= states_mean)
```

Out[ ]:
```
TtestResult(statistic=-0.2666632804877797, pvalue=0.7912932917146352, df=35)
```

- Results shows
  - The test statistic "t" is equal to -0.2667
  - The PValue is 0.791 (>0.05)
  - A high PValue shows that there is no significant difference between the population mean and the youth new cases mean

We should reject the Alternative Hypothesis H1

Hypothesis #2:

- Hypothesis:
  - **Null Hypothesis H0** - Seniors dominated states have similar new cases rate as the entire country
  - **Alternative Hypothesis H1** - Seniors dominated states have different new cases rate from the entire country

In [ ]:
```
covid_seniors_dom = covid_enrich_df[covid_enrich_df['Senior'] > 50].drop(['Youth',
```

In [ ]:
```
stats.ttest_1samp(a= covid_seniors_dom.Cases, popmean= states_mean)
```

Out[ ]:
```
TtestResult(statistic=0.3084755732133888, pvalue=0.7622627914598168, df=14)
```

- Results shows
  - The test statistic "t" is equal to 0.3084
  - The PValue is 0.7622 (>0.05)
  - A high PValue shows that there is no significant difference between the population mean and the senior new cases mean

We should reject the Alternative Hypothesis H1

Hypothesis #3:

- Hypothesis:
  - **Null Hypothesis H0** - Male youth dominated states have similar new cases rate as the entire country
  - **Alternative Hypothesis H1** - Male youth dominated states have different new cases rate from the entire country

In [ ]:
```
enrichment_df = pd.read_csv('data/enrichment.csv')
enrichment_df[enrichment_df.columns[3:]] = enrichment_df[enrichment_df.columns[3:]]
enrichment_df = enrichment_df.drop(['StateFIPS'], axis=1)
enrichment_df = enrichment_df.set_index(['State', 'Sex'])
enrichment_df = enrichment_df.sort_index()
enrichment_youth_df = enrichment_df[enrichment_df.columns[:8]].dropna(axis=0)
enrichment_senior_df = enrichment_df[enrichment_df.columns[8:]]
enrichment_youth_df = enrichment_youth_df.aggregate(np.sum, axis=1)
enrichment_senior_df = enrichment_senior_df.aggregate(np.sum, axis=1)
enrichment_male_youth_df = enrichment_youth_df.loc[enrichment_youth_df.index.get_le
enrichment_female_youth_df = enrichment_youth_df.loc[enrichment_youth_df.index.get_
truth = enrichment_male_youth_df[enrichment_male_youth_df[enrichment_male_youth_df.
valid_states = covid_enrich_df.index.intersection(truth['State'])
enrichment_male_youth_df = covid_enrich_df.loc[valid_states]
```

Out[ ]:

State	Cases	Youth	Senior
AK	15.0	56.7	43.6
AL	17.0	50.2	49.8
AR	15.0	51.8	48.2
AZ	15.0	51.6	48.2
CA	16.0	53.4	46.5
CO	16.0	53.6	46.5
CT	13.0	48.6	51.4
DC	9.0	59.5	40.4
DE	15.0	47.9	52.1
FL	18.0	46.3	53.3
GA	9.0	53.3	46.7
HI	21.0	49.8	50.3
IA	11.0	51.9	48.2
ID	11.0	53.5	46.6
IL	-5.0	51.5	48.6
IN	0.0	52.4	47.4
KS	14.0	53.7	46.4
KY	22.0	51.0	48.9
LA	14.0	52.7	47.1
MA	11.0	50.1	50.0
MD	7.0	50.9	49.0
ME	11.0	44.5	55.5
MI	15.0	49.6	50.2
MN	3.0	51.7	48.3
MO	1.0	51.1	48.9
MS	17.0	52.1	47.9
MT	14.0	50.0	50.0
NC	18.0	50.8	49.3
ND	15.0	55.8	44.3
NE	0.0	53.4	46.4
NH	5.0	46.5	53.6
NJ	18.0	49.7	50.5

State	Cases	Youth	Senior
NM	19.0	51.1	48.9
NV	14.0	51.7	48.3
NY	17.0	50.2	49.8
OH	15.0	50.4	49.4
OK	17.0	54.1	46.1
OR	0.0	49.7	50.2
PA	13.0	48.8	51.2
RI	16.0	49.1	50.8
SC	0.0	49.7	50.3
SD	12.0	53.2	46.6
TN	0.0	51.2	48.9
TX	10.0	56.5	43.4
UT	11.0	61.3	38.5
VA	16.0	51.6	48.4
VT	7.0	46.6	53.5
WA	13.0	52.5	47.5
WI	16.0	49.8	50.2
WV	20.0	46.4	53.7
WY	13.0	51.6	48.5

In [ ]:
```
stats.ttest_1samp(a= enrichment_male_youth_df.Cases, popmean= states_mean)
```

Out[ ]:
```
TtestResult(statistic=-0.04425948747093246, pvalue=0.964873853418412, df=50)
```

- Results shows
  - The test statistic "t" is equal to -0.0442
  - The PValue is 0.9648 (>0.05)
  - A high PValue shows that there is no significant difference between the population mean and the male dominated youth states new cases mean

We should reject the Alternative Hypothesis H1