OpioidAnalysis

December 17, 2025

[1]:

```
# Imports
import pandas as pd
import matplotlib.pyplot as plt
import seaborn as sns
import numpy as np
import os
import sys

os.makedirs('../figures', exist_ok = True)

# Define the relative path to the 'src' folder
module_path = os.path.abspath(os.path.join('..', 'src'))

# Add the path to sys.path
if module_path not in sys.path:
    sys.path.append(module_path)

import analysis_utils as utils
```

[2]:

```
# import race data
df_od_race = pd.read_csv("../data/overdose_race_data_clean.csv")
```

[3]:

```
df_od_race.head(5)
```

[3]:

```
                   INDICATOR                     PANEL  PANEL_NUM  \
0  Drug overdose death rates  All drug overdose deaths          0
1  Drug overdose death rates  All drug overdose deaths          0
2  Drug overdose death rates  All drug overdose deaths          0
3  Drug overdose death rates  All drug overdose deaths          0
4  Drug overdose death rates  All drug overdose deaths          0

                                                UNIT  UNIT_NUM STUB_NAME  \
0  Deaths per 100,000 resident population, age-ad…        1     Total
1  Deaths per 100,000 resident population, age-ad…        1     Total
2  Deaths per 100,000 resident population, age-ad…        1     Total
3  Deaths per 100,000 resident population, age-ad…        1     Total
4  Deaths per 100,000 resident population, age-ad…        1     Total
```

```
   STUB_NAME_NUM   STUB_LABEL  STUB_LABEL_NUM  YEAR  YEAR_NUM       AGE  \
0              0  All persons             0.1  1999         1  All ages
1              0  All persons             0.1  2000         2  All ages
2              0  All persons             0.1  2001         3  All ages
3              0  All persons             0.1  2002         4  All ages
4              0  All persons             0.1  2003         5  All ages

   AGE_NUM  ESTIMATE  FLAG  sex race_ethnicity
0      1.1       6.1   NaN  All            All
1      1.1       6.2   NaN  All            All
2      1.1       6.8   NaN  All            All
3      1.1       8.2   NaN  All            All
4      1.1       8.9   NaN  All            All
```

[4]:

```
#define drug overdose causes as a dictionary
d_death_cause = { 0 : "All overdose deaths", 1 : "Any opioid", 2 : "Natural and␣
 ↪semi-synthetic", 3 : "Methadone", 4 : "Other synthetic opioid", 5 : "Heroin"}
```

[5]:

```
# filter for all drug overdose deaths
all_opioid_deaths = df_od_race[df_od_race["PANEL_NUM"] == 1].copy()
all_opioid_deaths["death_cause"] = all_opioid_deaths['PANEL_NUM'].
 ↪map(d_death_cause)
# remove "All from age_group and sex since we want to look at distinct␣
 ↪age_groups and distinct sex
all_opioid_deaths = all_opioid_deaths[(all_opioid_deaths["race_ethnicity"] ==␣
 ↪"All") & (all_opioid_deaths["sex"] == "All")]

all_opioid_deaths.head(5)
```

[5]:

```
                      INDICATOR                                        PANEL  \
417  Drug overdose death rates  Drug overdose deaths involving any opioid
418  Drug overdose death rates  Drug overdose deaths involving any opioid
419  Drug overdose death rates  Drug overdose deaths involving any opioid
420  Drug overdose death rates  Drug overdose deaths involving any opioid
421  Drug overdose death rates  Drug overdose deaths involving any opioid

     PANEL_NUM                                              UNIT  UNIT_NUM  \
417          1  Deaths per 100,000 resident population, age-ad…         1
418          1  Deaths per 100,000 resident population, age-ad…         1
419          1  Deaths per 100,000 resident population, age-ad…         1
420          1  Deaths per 100,000 resident population, age-ad…         1
421          1  Deaths per 100,000 resident population, age-ad…         1

    STUB_NAME  STUB_NAME_NUM   STUB_LABEL  STUB_LABEL_NUM  YEAR  YEAR_NUM  \
417     Total              0  All persons             0.1  1999         1
418     Total              0  All persons             0.1  2000         2
```

```
419     Total              0  All persons             0.1  2001         3
420     Total              0  All persons             0.1  2002         4
421     Total              0  All persons             0.1  2003         5

          AGE  AGE_NUM  ESTIMATE  FLAG  sex race_ethnicity death_cause
417  All ages      1.1       2.9   NaN  All            All  Any opioid
418  All ages      1.1       3.0   NaN  All            All  Any opioid
419  All ages      1.1       3.3   NaN  All            All  Any opioid
420  All ages      1.1       4.1   NaN  All            All  Any opioid
421  All ages      1.1       4.5   NaN  All            All  Any opioid
```

[6]:
```python
# filter for all drug overdose deaths
synthetic_opioids = [3, 4]
synthetic_opioid_deaths = df_od_race[df_od_race["PANEL_NUM"].
 ↪isin(synthetic_opioids)].copy()
synthetic_opioid_deaths["death_cause"] = synthetic_opioid_deaths['PANEL_NUM'].
 ↪map(d_death_cause)
# include "All from race and sex
synthetic_opioid_deaths =␣
 ↪synthetic_opioid_deaths[(synthetic_opioid_deaths["race_ethnicity"] == "All")␣
 ↪& (synthetic_opioid_deaths["sex"] == "All")]

synthetic_opioid_deaths.head(5)
```

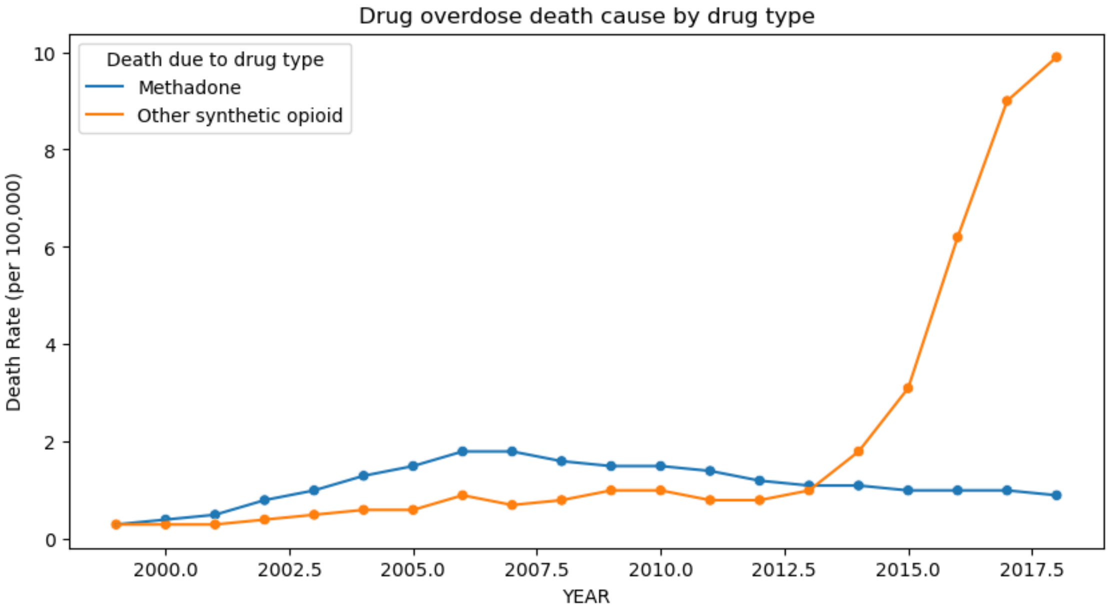
[6]:
```
                      INDICATOR                                     PANEL  \
1178  Drug overdose death rates  Drug overdose deaths involving methadone
1195  Drug overdose death rates  Drug overdose deaths involving methadone
1196  Drug overdose death rates  Drug overdose deaths involving methadone
1197  Drug overdose death rates  Drug overdose deaths involving methadone
1198  Drug overdose death rates  Drug overdose deaths involving methadone

      PANEL_NUM                                             UNIT  UNIT_NUM  \
1178          3  Deaths per 100,000 resident population, age-ad…           1
1195          3  Deaths per 100,000 resident population, age-ad…           1
1196          3  Deaths per 100,000 resident population, age-ad…           1
1197          3  Deaths per 100,000 resident population, age-ad…           1
1198          3  Deaths per 100,000 resident population, age-ad…           1

     STUB_NAME  STUB_NAME_NUM   STUB_LABEL  STUB_LABEL_NUM  YEAR  YEAR_NUM  \
1178     Total              0  All persons             0.1  2002         4
1195     Total              0  All persons             0.1  1999         1
1196     Total              0  All persons             0.1  2000         2
1197     Total              0  All persons             0.1  2001         3
1198     Total              0  All persons             0.1  2003         5

           AGE  AGE_NUM  ESTIMATE  FLAG  sex race_ethnicity death_cause
1178  All ages      1.1       0.8   NaN  All            All   Methadone
```

```
1195   All ages       1.1       0.3    NaN   All            All    Methadone
1196   All ages       1.1       0.4    NaN   All            All    Methadone
1197   All ages       1.1       0.5    NaN   All            All    Methadone
1198   All ages       1.1       1.0    NaN   All            All    Methadone
```

[7]:

```
# plot year vs estimated deaths for each drug type

fig, ax = plt.subplots(figsize=(10, 5))
sns.scatterplot(data = synthetic_opioid_deaths, x='YEAR', y='ESTIMATE',␣
 ↪hue='death_cause')
sns.lineplot(data = synthetic_opioid_deaths, x='YEAR', y='ESTIMATE',␣
 ↪hue='death_cause')
# Add a legend and show the plot
ax.set_ylabel('Death Rate (per 100,000)')

# Get the current handles and labels
handles, labels = ax.get_legend_handles_labels()

# Create a dictionary to store unique labels and handles, which automatically␣
 ↪removes duplicates
# Using dict.fromkeys preserves the insertion order in Python 3.7+
unique_labels_handles = dict(zip(labels, handles))

# Extract the unique handles and labels
unique_handles = unique_labels_handles.values()
unique_labels = unique_labels_handles.keys()

# Apply the unique handles and labels to the legend
ax.legend(unique_handles, unique_labels, title='Death due to drug type')


ax.set_title('Drug overdose death cause by drug type')

fig.savefig('../figures/drug_overdose_death_cause_by_drug_type.png', dpi=300,␣
 ↪bbox_inches='tight')
print("  Saved: figures/drug_overdose_death_cause_by_drug_type.png")
```

```
 Saved: figures/drug_overdose_death_cause_by_drug_type.png
```



```
[8]: s_o_d = synthetic_opioid_deaths[["YEAR", "PANEL_NUM", "ESTIMATE",␣
      ↪"death_cause"]]
     a_o_d = all_opioid_deaths[["YEAR", "PANEL_NUM", "ESTIMATE", "death_cause"]]
```

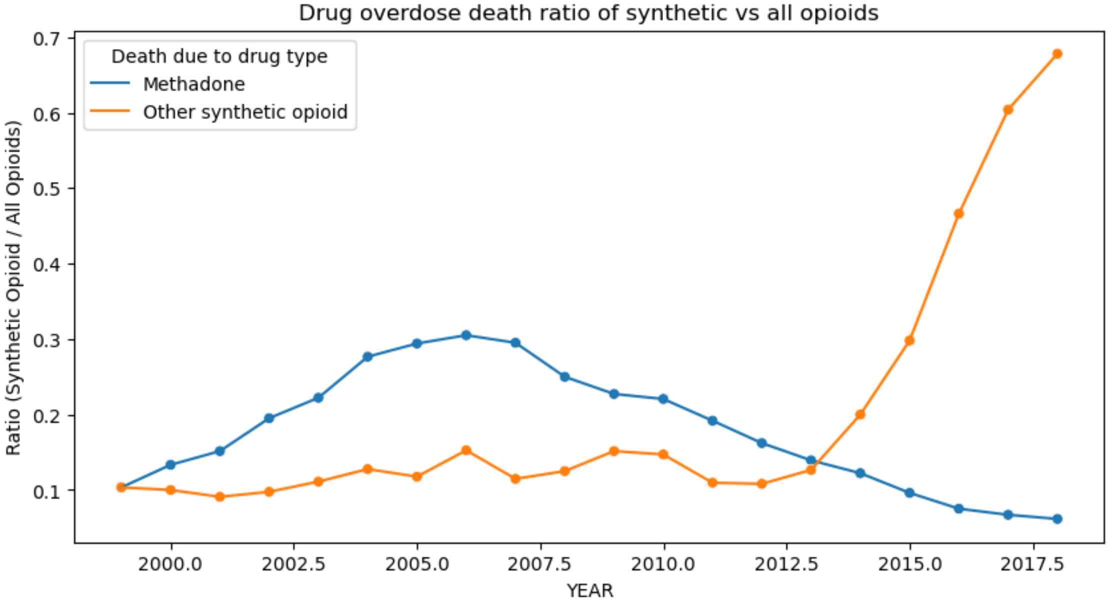
```
[9]: combined_df = pd.merge(s_o_d, a_o_d, on = ["YEAR"], how = 'inner',␣
      ↪suffixes=('_left', '_right'), sort=True)
     combined_df["ratio"] = combined_df["ESTIMATE_left"] /␣
      ↪combined_df["ESTIMATE_right"]
     combined_df.head(5)
```

```
[9]:    YEAR  PANEL_NUM_left  ESTIMATE_left        death_cause_left  \
     0  1999               3            0.3               Methadone
     1  1999               4            0.3  Other synthetic opioid
     2  2000               3            0.4               Methadone
     3  2000               4            0.3  Other synthetic opioid
     4  2001               3            0.5               Methadone

        PANEL_NUM_right  ESTIMATE_right death_cause_right     ratio
     0                1             2.9        Any opioid  0.103448
     1                1             2.9        Any opioid  0.103448
     2                1             3.0        Any opioid  0.133333
     3                1             3.0        Any opioid  0.100000
     4                1             3.3        Any opioid  0.151515
```

```
[10]: # plot year vs ratio for each drug type
```

```python
fig, ax = plt.subplots(figsize=(10, 5))
sns.scatterplot(data = combined_df, x='YEAR', y='ratio', hue='death_cause_left')
sns.lineplot(data = combined_df, x='YEAR', y='ratio', hue='death_cause_left')
# Add a legend and show the plot
ax.set_ylabel('Ratio (Synthetic Opioid / All Opioids)')

# Get the current handles and labels
handles, labels = ax.get_legend_handles_labels()

# Create a dictionary to store unique labels and handles, which automatically removes duplicates
# Using dict.fromkeys preserves the insertion order in Python 3.7+
unique_labels_handles = dict(zip(labels, handles))

# Extract the unique handles and labels
unique_handles = unique_labels_handles.values()
unique_labels = unique_labels_handles.keys()

# Apply the unique handles and labels to the legend
ax.legend(unique_handles, unique_labels, title='Death due to drug type')


ax.set_title('Drug overdose death ratio of synthetic vs all opioids')

fig.savefig('../figures/drug_overdose_death_ratio_opioids.png', dpi=300, bbox_inches='tight')
print("  Saved: figures/drug_overdose_death_ratio_opioids.png")
```

```
Saved: figures/drug_overdose_death_ratio_opioids.png
```



[11]:

```
# filter for all drug overdose deaths by race
all_opioid_deaths_by_race = df_od_race[df_od_race["PANEL_NUM"] == 1].copy()
all_opioid_deaths_by_race["death_cause"] =␣
 ↪all_opioid_deaths_by_race['PANEL_NUM'].map(d_death_cause)

all_opioid_deaths_by_race =␣
 ↪all_opioid_deaths_by_race[all_opioid_deaths_by_race["race_ethnicity"] !=␣
 ↪"All"]
all_opioid_deaths_by_race =␣
 ↪all_opioid_deaths_by_race[~all_opioid_deaths_by_race["race_ethnicity"].str.
 ↪contains("Not", case=False)]

all_opioid_deaths_by_race.head(5)
```

[11]:

```
                      INDICATOR                                    PANEL  \
474  Drug overdose death rates  Drug overdose deaths involving any opioid
475  Drug overdose death rates  Drug overdose deaths involving any opioid
476  Drug overdose death rates  Drug overdose deaths involving any opioid
477  Drug overdose death rates  Drug overdose deaths involving any opioid
478  Drug overdose death rates  Drug overdose deaths involving any opioid

     PANEL_NUM                                          UNIT  UNIT_NUM  \
474          1  Deaths per 100,000 resident population, age-ad…         1
475          1  Deaths per 100,000 resident population, age-ad…         1
476          1  Deaths per 100,000 resident population, age-ad…         1
477          1  Deaths per 100,000 resident population, age-ad…         1
478          1  Deaths per 100,000 resident population, age-ad…         1

        STUB_NAME  STUB_NAME_NUM   STUB_LABEL  STUB_LABEL_NUM  YEAR  YEAR_NUM  \
474  Sex and race              4  Male: White             4.1  1999         1
475  Sex and race              4  Male: White             4.1  2000         2
476  Sex and race              4  Male: White             4.1  2001         3
477  Sex and race              4  Male: White             4.1  2002         4
478  Sex and race              4  Male: White             4.1  2003         5

          AGE  AGE_NUM  ESTIMATE  FLAG   sex race_ethnicity death_cause
474  All ages      1.1       4.4   NaN  Male          White  Any opioid
475  All ages      1.1       4.5   NaN  Male          White  Any opioid
476  All ages      1.1       5.0   NaN  Male          White  Any opioid
477  All ages      1.1       6.1   NaN  Male          White  Any opioid
478  All ages      1.1       6.7   NaN  Male          White  Any opioid
```

[12]:

```
# filter for synthetic opioid deaths by race
```

```
synthetic_opioid_deaths_by_race = df_od_race[df_od_race["PANEL_NUM"].
 ↪isin(synthetic_opioids)].copy()
synthetic_opioid_deaths_by_race["death_cause"] =␣
 ↪synthetic_opioid_deaths_by_race['PANEL_NUM'].map(d_death_cause)
# include "All from race and sex
synthetic_opioid_deaths_by_race =␣
 ↪synthetic_opioid_deaths_by_race[(synthetic_opioid_deaths_by_race["race_ethnicity"]␣
 ↪!= "All")]
synthetic_opioid_deaths_by_race =␣
 ↪synthetic_opioid_deaths_by_race[~synthetic_opioid_deaths_by_race["race_ethnicity"].
 ↪str.contains("Not", case=False)]

synthetic_opioid_deaths_by_race.head(5)
```

```
[12]:                 INDICATOR                                     PANEL  \
      1251  Drug overdose death rates  Drug overdose deaths involving methadone
      1252  Drug overdose death rates  Drug overdose deaths involving methadone
      1253  Drug overdose death rates  Drug overdose deaths involving methadone
      1254  Drug overdose death rates  Drug overdose deaths involving methadone
      1255  Drug overdose death rates  Drug overdose deaths involving methadone

            PANEL_NUM                                               UNIT  UNIT_NUM  \
      1251          3  Deaths per 100,000 resident population, age-ad…         1
      1252          3  Deaths per 100,000 resident population, age-ad…         1
      1253          3  Deaths per 100,000 resident population, age-ad…         1
      1254          3  Deaths per 100,000 resident population, age-ad…         1
      1255          3  Deaths per 100,000 resident population, age-ad…         1

               STUB_NAME  STUB_NAME_NUM   STUB_LABEL  STUB_LABEL_NUM  YEAR  \
      1251  Sex and race              4  Male: White             4.1  1999
      1252  Sex and race              4  Male: White             4.1  2000
      1253  Sex and race              4  Male: White             4.1  2001
      1254  Sex and race              4  Male: White             4.1  2002
      1255  Sex and race              4  Male: White             4.1  2003

            YEAR_NUM       AGE  AGE_NUM  ESTIMATE  FLAG   sex race_ethnicity  \
      1251         1  All ages      1.1       0.4   NaN  Male          White
      1252         2  All ages      1.1       0.5   NaN  Male          White
      1253         3  All ages      1.1       0.7   NaN  Male          White
      1254         4  All ages      1.1       1.2   NaN  Male          White
      1255         5  All ages      1.1       1.6   NaN  Male          White

           death_cause
      1251   Methadone
      1252   Methadone
      1253   Methadone
      1254   Methadone
```

```
1255    Methadone
```

[13]:
```
s_o_d_race = synthetic_opioid_deaths_by_race[["YEAR", "PANEL_NUM", "ESTIMATE",␣
 ↪"race_ethnicity", "sex", "death_cause"]]
a_o_d_race = all_opioid_deaths_by_race[["YEAR", "PANEL_NUM", "ESTIMATE",␣
 ↪"race_ethnicity", "sex", "death_cause"]]
```

[14]:
```
combined_df_race = pd.merge(s_o_d_race, a_o_d_race, on = ["YEAR",␣
 ↪"race_ethnicity", "sex"], how = 'inner', suffixes=('_left', '_right'),␣
 ↪sort=True)
combined_df_race.head(5)
```

[14]:
```
   YEAR  PANEL_NUM_left  ESTIMATE_left                  race_ethnicity     sex  \
0  1999               3            0.2       Black or African American  Female
1  1999               3            0.2       Black or African American    Male
2  1999               3            0.4  Hispanic or Latino: All races    Male
3  1999               4            0.2  Hispanic or Latino: All races    Male
4  1999               3            0.2                           White  Female

         death_cause_left  PANEL_NUM_right  ESTIMATE_right death_cause_right
0               Methadone                1             1.5        Any opioid
1               Methadone                1             5.7        Any opioid
2               Methadone                1             5.8        Any opioid
3  Other synthetic opioid                1             5.8        Any opioid
4               Methadone                1             1.5        Any opioid
```

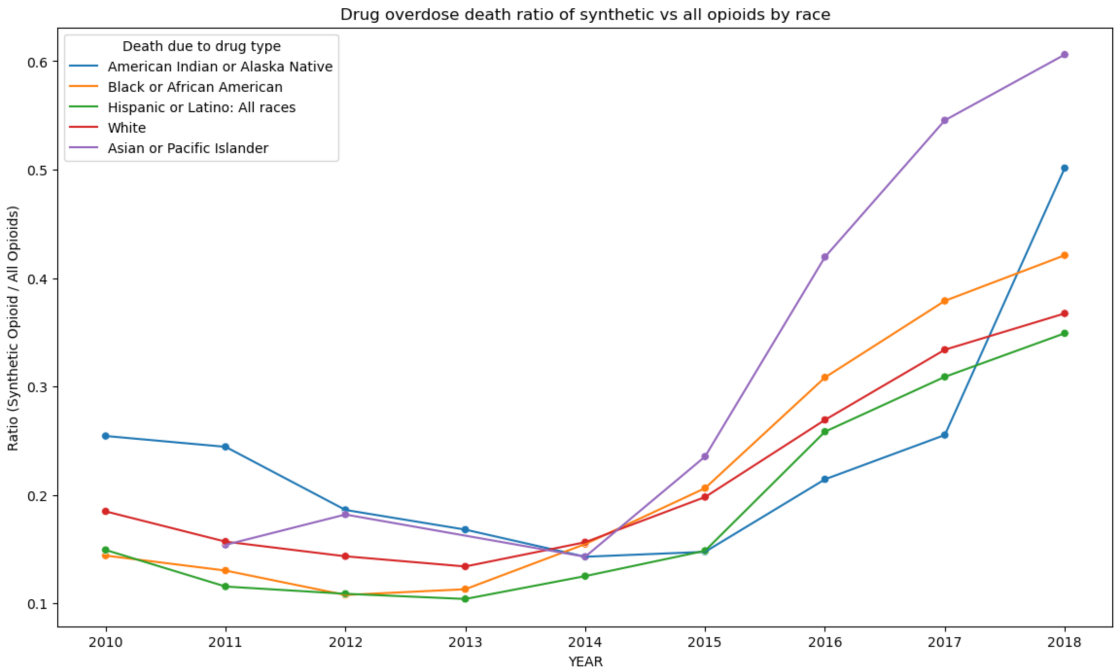
[15]:
```
combined_df_merged = combined_df_race.groupby(["YEAR", "race_ethnicity"]).
 ↪sum(["ESTIMATE_left", "ESTIMATE_right"]).reset_index()
combined_df_merged["ratio"] = combined_df_merged["ESTIMATE_left"] /␣
 ↪combined_df_merged["ESTIMATE_right"]
combined_df_merged = combined_df_merged[(combined_df_merged["YEAR"] >= 2010) &␣
 ↪(combined_df_merged["YEAR"] <= 2018)]
combined_df_merged.head(5)
```

[15]:
```
    YEAR                     race_ethnicity  PANEL_NUM_left  ESTIMATE_left  \
39  2010  American Indian or Alaska Native              10            4.5
40  2010         Black or African American              14            1.9
41  2010     Hispanic or Latino: All races              14            1.7
42  2010                             White              14            5.8
43  2011  American Indian or Alaska Native               6            3.2

    PANEL_NUM_right  ESTIMATE_right     ratio
39                3            17.7  0.254237
40                4            13.2  0.143939
41                4            11.4  0.149123
42                4            31.4  0.184713
43                2            13.1  0.244275
```

[16]:

```
# plot year vs ratio for each race

fig, ax = plt.subplots(figsize=(14, 8))
sns.scatterplot(data = combined_df_merged, x='YEAR', y='ratio',␣
 ↪hue='race_ethnicity')
sns.lineplot(data = combined_df_merged, x='YEAR', y='ratio',␣
 ↪hue='race_ethnicity')
# Add a legend and show the plot
ax.set_ylabel('Ratio (Synthetic Opioid / All Opioids)')

# Get the current handles and labels
handles, labels = ax.get_legend_handles_labels()

# Create a dictionary to store unique labels and handles, which automatically␣
 ↪removes duplicates
# Using dict.fromkeys preserves the insertion order in Python 3.7+
unique_labels_handles = dict(zip(labels, handles))

# Extract the unique handles and labels
unique_handles = unique_labels_handles.values()
unique_labels = unique_labels_handles.keys()

# Apply the unique handles and labels to the legend
ax.legend(unique_handles, unique_labels, title='Death due to drug type')



ax.set_title('Drug overdose death ratio of synthetic vs all opioids by race')

fig.savefig('../figures/drug_overdose_death_ratio_opioids_by_race.png',␣
 ↪dpi=300, bbox_inches='tight')
print("  Saved: figures/drug_overdose_death_ratio_opioids_by_race.png")
```

```
 Saved: figures/drug_overdose_death_ratio_opioids_by_race.png
```



```
[17]: # Calculate the highest proportion shift by race
      highest_proportion_shift = combined_df_merged.sort_values(by = "ratio",␣
        ↪ascending=False).head(1)
      highest_proportion_shift

      print(f"The race with the highest proportion shift is␣
        ↪'{highest_proportion_shift["race_ethnicity"].iloc[0]}' in␣
        ↪{highest_proportion_shift["YEAR"].iloc[0]}")
```

```
The race with the highest proportion shift is 'Asian or Pacific Islander' in
2018
```

```
[ ]:
```