DemographicAnalysis.nbconvert

December 17, 2025

[1]:

```python
# 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]:

```python
df_od_age_group = pd.read_csv("../data/overdose_age_data_clean.csv")
```

[3]:

```python
df_od_age_group.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, crude         2       Sex
1  Deaths per 100,000 resident population, crude         2     Total
2  Deaths per 100,000 resident population, crude         2       Sex
3  Deaths per 100,000 resident population, crude         2     Total
4  Deaths per 100,000 resident population, crude         2     Total

   STUB_NAME_NUM   STUB_LABEL  STUB_LABEL_NUM  YEAR  YEAR_NUM       AGE  \
0              2         Male             2.1  2017        19  All ages
1              0  All persons             0.1  2006         8  All ages
2              2         Male             2.1  2016        18  All ages
```

```
3              0  All persons             0.1  1999         1  All ages
4              0  All persons             0.1  2000         2  All ages

   AGE_NUM  ESTIMATE  FLAG   sex age_group
0      1.1      29.0   NaN  Male       All
1      1.1      11.5   NaN   All       All
2      1.1      26.1   NaN  Male       All
3      1.1       6.0   NaN   All       All
4      1.1       6.2   NaN   All       All
```

[4]:

```
# filter for all drug overdose deaths
all_od_deaths = df_od_age_group[df_od_age_group["PANEL_NUM"] == 0]
# remove "All from age_group and sex since we want to look at distinct␣
 ↪age_groups and distinct sex
all_od_deaths = all_od_deaths[(all_od_deaths["age_group"] != "All") &␣
 ↪(all_od_deaths["sex"] != "All")]
all_od_deaths.head(5)
```

[4]:

```
                     INDICATOR                     PANEL  PANEL_NUM  \
228  Drug overdose death rates  All drug overdose deaths          0
229  Drug overdose death rates  All drug overdose deaths          0
230  Drug overdose death rates  All drug overdose deaths          0
231  Drug overdose death rates  All drug overdose deaths          0
232  Drug overdose death rates  All drug overdose deaths          0

                                              UNIT  UNIT_NUM    STUB_NAME  \
228  Deaths per 100,000 resident population, crude         2  Sex and age
229  Deaths per 100,000 resident population, crude         2  Sex and age
230  Deaths per 100,000 resident population, crude         2  Sex and age
231  Deaths per 100,000 resident population, crude         2  Sex and age
232  Deaths per 100,000 resident population, crude         2  Sex and age

     STUB_NAME_NUM            STUB_LABEL  STUB_LABEL_NUM  YEAR  YEAR_NUM  \
228              3  Male: Under 15 years            3.11  1999         1
229              3  Male: Under 15 years            3.11  2000         2
230              3  Male: Under 15 years            3.11  2001         3
231              3  Male: Under 15 years            3.11  2002         4
232              3  Male: Under 15 years            3.11  2003         5

                AGE  AGE_NUM  ESTIMATE  FLAG   sex       age_group
228  Under 15 years      1.2       0.1   NaN  Male  Under 15 years
229  Under 15 years      1.2       0.2   NaN  Male  Under 15 years
230  Under 15 years      1.2       0.2   NaN  Male  Under 15 years
231  Under 15 years      1.2       0.2   NaN  Male  Under 15 years
232  Under 15 years      1.2       0.2   NaN  Male  Under 15 years
```

[5]:

```
# get female and make deaths by year
male_female_ave = all_od_deaths[(all_od_deaths["sex"] == "Female") |␣
 ↪(all_od_deaths["sex"] == "Male")].groupby(["YEAR", "sex"]).mean("ESTIMATE").
 ↪reset_index()

male_female_ave.head(5)
```

[5]:

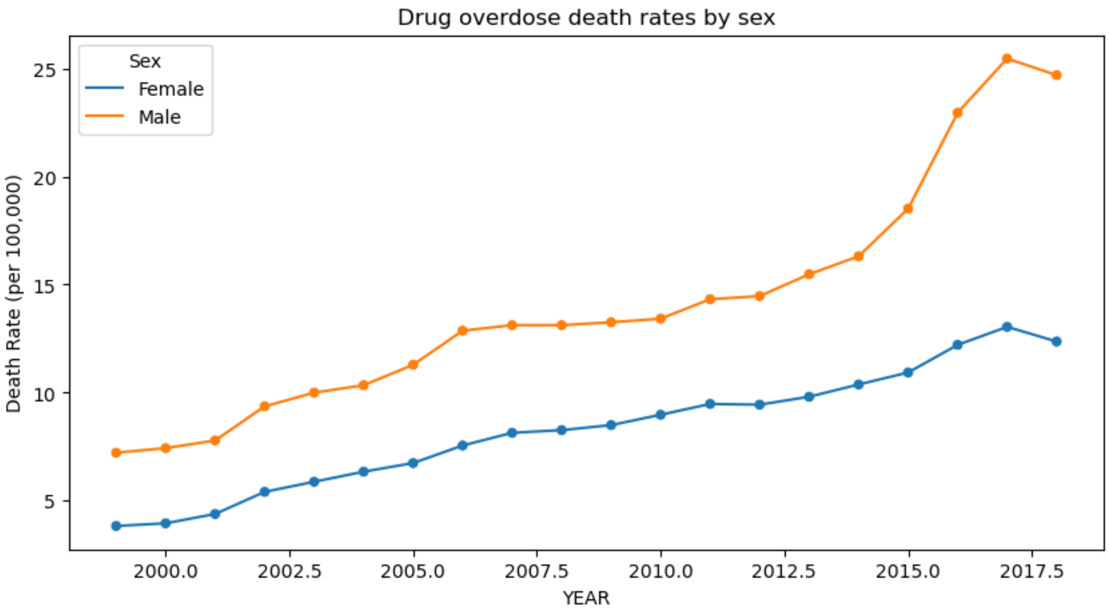
```
   YEAR     sex  PANEL_NUM  UNIT_NUM  STUB_NAME_NUM  STUB_LABEL_NUM  YEAR_NUM  \
0  1999  Female        0.0       2.0            3.0            3.25       1.0
1  1999    Male        0.0       2.0            3.0            3.15       1.0
2  2000  Female        0.0       2.0            3.0            3.25       2.0
3  2000    Male        0.0       2.0            3.0            3.15       2.0
4  2001  Female        0.0       2.0            3.0            3.25       3.0

   AGE_NUM  ESTIMATE  FLAG
0     1.59  3.833333   NaN
1     1.59  7.222222   NaN
2     1.59  3.955556   NaN
3     1.59  7.433333   NaN
4     1.59  4.388889   NaN
```

[6]:

```
# plot year vs estimated deaths for each sex

fig, ax = plt.subplots(figsize=(10, 5))
sns.scatterplot(data = male_female_ave, x='YEAR', y='ESTIMATE', hue='sex')
sns.lineplot(data = male_female_ave, x='YEAR', y='ESTIMATE', hue='sex')
# 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='Sex')


ax.set_title('Drug overdose death rates by sex')
```

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

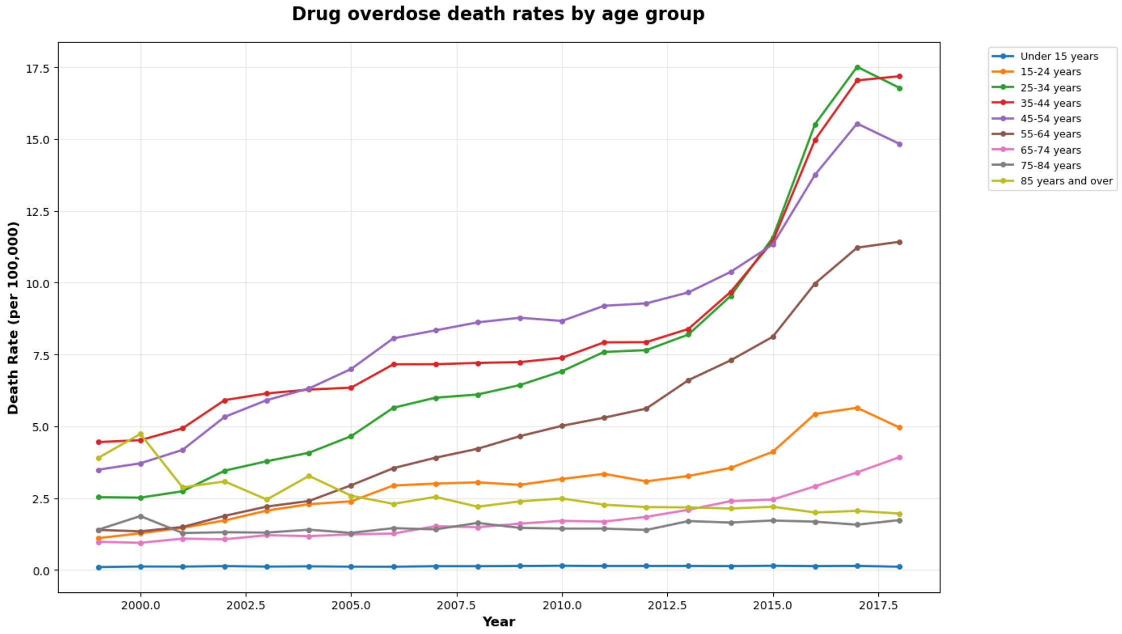
```
 Saved: figures/drug_overdose_death_rates_by_sex.png
```



[7]:

```
# filter data by age-group
#Trend by Age group

plt.figure(figsize=(14, 8))

df_od_age_group_distinct = df_od_age_group[df_od_age_group["age_group"] !=␣
 ↪"All"]
age_groups = df_od_age_group_distinct['age_group'].unique()

for age_grp in age_groups:
    age_trend = df_od_age_group_distinct[
        (df_od_age_group_distinct['age_group'] == age_grp)].
 ↪groupby('YEAR')['ESTIMATE'].mean().reset_index()

    if len(age_trend) > 0:
        plt.plot(age_trend['YEAR'], age_trend['ESTIMATE'],
                 marker='o', linewidth=2, label=age_grp, markersize=4)

plt.title('Drug overdose death rates by age group',
          fontsize=16, fontweight='bold', pad=20)
plt.xlabel('Year', fontsize=12, fontweight='bold')
plt.ylabel('Death Rate (per 100,000)', fontsize=12, fontweight='bold')
plt.legend(bbox_to_anchor=(1.05, 1), loc='upper left', fontsize=9)
plt.grid(True, alpha=0.3)
plt.tight_layout()

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

```
Saved: figures/drug_overdose_death_rates_by_age_group.png
```



```
[8]: # heatmap of rates by age x year
     # create heatmap_data for distinct age_groups, not "All", and for sex not "All"
     heatmap_data = all_od_deaths[(all_od_deaths["age_group"] != "All") &␣
      ↪(all_od_deaths["sex"] != "All")]

     heatmap_df = heatmap_data[['YEAR', 'sex', 'age_group', 'ESTIMATE']]
     heatmap_grouped = heatmap_df.groupby(['YEAR', 'sex', 'age_group']).
      ↪mean("ESTIMATE").reset_index()
     heatmap_grouped
```

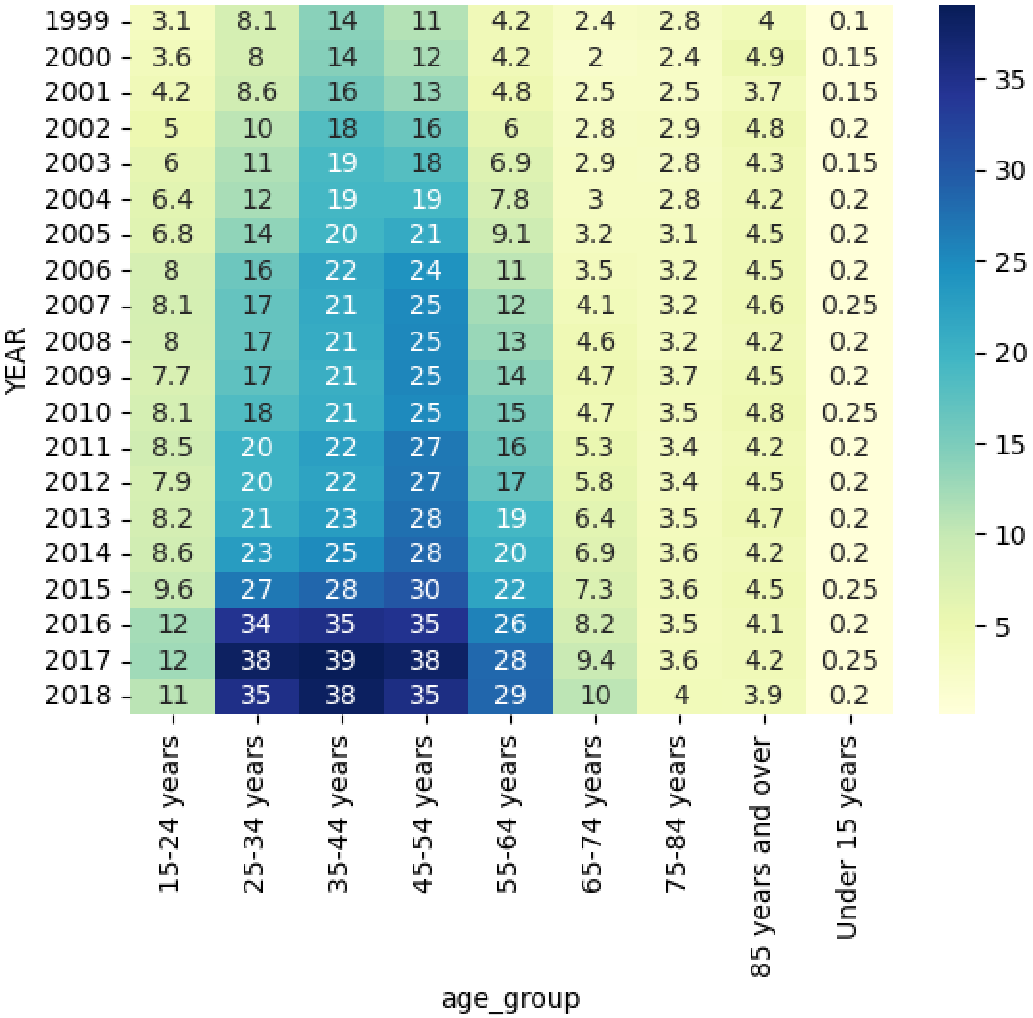
```
[8]:      YEAR     sex        age_group  ESTIMATE
     0    1999  Female      15-24 years       1.8
     1    1999  Female      25-34 years       4.6
     2    1999  Female      35-44 years       8.7
     3    1999  Female      45-54 years       7.2
```

```
4    1999  Female        55-64 years       3.5
..    …     …                 …        …
355  2018    Male        55-64 years      37.2
356  2018    Male        65-74 years      13.9
357  2018    Male        75-84 years       4.5
358  2018    Male  85 years and over       4.0
359  2018    Male     Under 15 years       0.2

[360 rows x 4 columns]
```

[9]:

```python
# Pivot the data into a matrix format (months as rows, years as columns)
heatmap_matrix = heatmap_grouped.pivot_table(index="YEAR", columns="age_group",␣
 ↪values="ESTIMATE")
ax = sns.heatmap(heatmap_matrix, annot=True, cmap="YlGnBu")

# Get the Figure object and save it
fig = ax.get_figure()

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

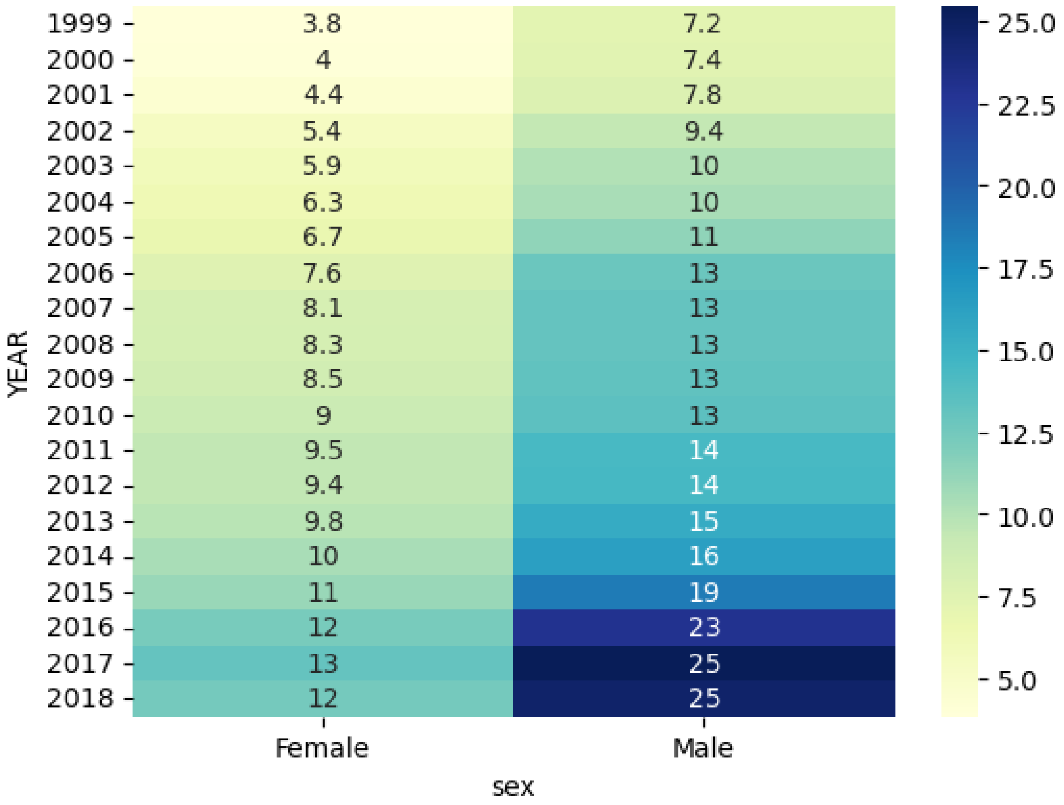
```
 Saved: figures/heatmap_by_age_group.png
```



[10]:

```python
# Pivot the data into a matrix format (months as rows, years as columns)
heatmap_matrix = heatmap_grouped.pivot_table(index="YEAR", columns="sex", values="ESTIMATE")
ax = sns.heatmap(heatmap_matrix, annot=True, cmap="YlGnBu")

# Get the Figure object and save it
fig = ax.get_figure()

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

```
 Saved: figures/heatmap_by_sex.png
```



```
[11]: # compute rate of change
      heatmap_data_m = heatmap_data[heatmap_data["sex"] == "Male"]
      df_age_rate_of_change_m = utils.compute_rate_change(heatmap_data_m, 1999, 2018,␣
       ↪group_col="age_group")
      df_age_rate_of_change_m
```

```
[11]:            age_group  start_rate  end_rate  absolute_change  percent_change
      0     Under 15 years         0.1       0.2              0.1      100.000000
      1        15-24 years         4.5      14.3              9.8      217.777778
      2        25-34 years        11.5      49.6             38.1      331.304348
      3        35-44 years        19.2      52.4             33.2      172.916667
      4        45-54 years        15.2      46.1             30.9      203.289474
      5        55-64 years         4.9      37.2             32.3      659.183673
      6        65-74 years         2.7      13.9             11.2      414.814815
      7        75-84 years         2.5       4.5              2.0       80.000000
      8  85 years and over         4.4       4.0             -0.4       -9.090909
```

```
[12]: # compute rate of change
      heatmap_data_f = heatmap_data[heatmap_data["sex"] == "Female"]
      df_age_rate_of_change_f = utils.compute_rate_change(heatmap_data_f, 1999, 2018,␣
       ↪group_col="age_group")
```

```
df_age_rate_of_change_f
```

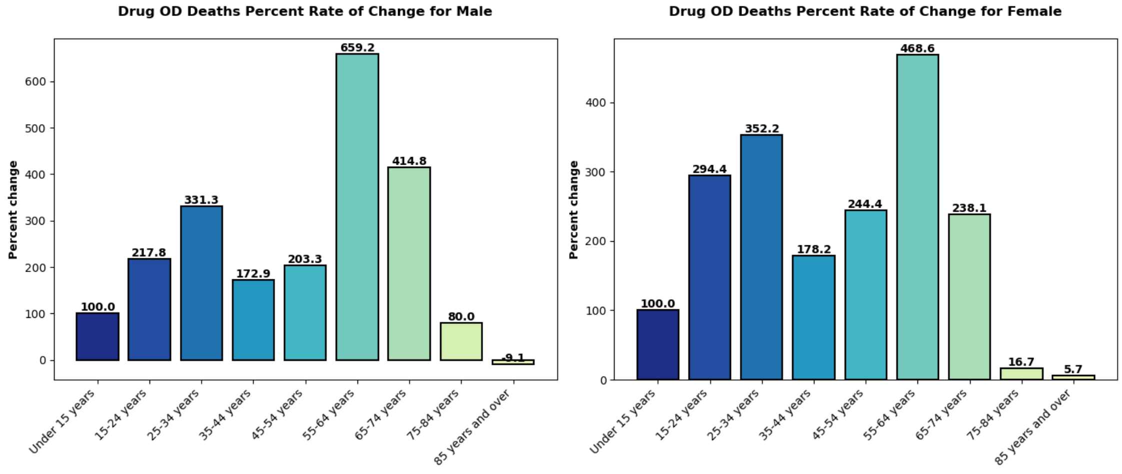
[12]:

```
          age_group  start_rate  end_rate  absolute_change  percent_change
0    Under 15 years         0.1       0.2              0.1      100.000000
1       15-24 years         1.8       7.1              5.3      294.444444
2       25-34 years         4.6      20.8             16.2      352.173913
3       35-44 years         8.7      24.2             15.5      178.160920
4       45-54 years         7.2      24.8             17.6      244.444444
5       55-64 years         3.5      19.9             16.4      468.571429
6       65-74 years         2.1       7.1              5.0      238.095238
7       75-84 years         3.0       3.5              0.5       16.666667
8  85 years and over        3.5       3.7              0.2        5.714286
```

[13]:

```
fig, (ax1, ax2) = plt.subplots(1, 2, figsize=(14, 6))

attr_name = 'percent_change'
attr_label = 'Percent change'
title_label = 'Drug OD Deaths Percent Rate of Change for '

dataset = df_age_rate_of_change_m
sex_label = "Male"

if len(dataset) > 0:
    n_colors = len(dataset)
    colors = sns.color_palette("YlGnBu_r", n_colors)
    bars = ax1.bar(dataset['age_group'], dataset[attr_name],
                   color=colors, edgecolor='black', linewidth=1.5)
    ax1.set_xticks(range(len(dataset)), dataset['age_group'],
               rotation=45, ha='right', fontsize=10)

    ax1.set_title(title_label+sex_label,
              fontsize=12, fontweight='bold', pad=20)
    ax1.set_ylabel(attr_label,
               fontsize=10, fontweight='bold')
    for i, bar in enumerate(bars):
        height = bar.get_height()
        ax1.text(bar.get_x() + bar.get_width()/2., height,
                 f'{height:.1f}', ha='center', va='bottom', fontsize=10,
                 fontweight='bold')

dataset = df_age_rate_of_change_f
sex_label = "Female"

if len(dataset) > 0:

    n_colors = len(dataset)
    colors = sns.color_palette("YlGnBu_r", n_colors)
    bars = ax2.bar(dataset['age_group'], dataset[attr_name],
                   color=colors, edgecolor='black', linewidth=1.5)
    ax2.set_xticks(range(len(dataset)), dataset['age_group'],
              rotation=45, ha='right', fontsize=10)

    ax2.set_title(title_label+sex_label,
             fontsize=12, fontweight='bold', pad=20)
    ax2.set_ylabel(attr_label,
              fontsize=10, fontweight='bold')
    for i, bar in enumerate(bars):
        height = bar.get_height()
        ax2.text(bar.get_x() + bar.get_width()/2., height,
                f'{height:.1f}', ha='center', va='bottom', fontsize=10,
                fontweight='bold')

plt.tight_layout()
# Display the plots

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

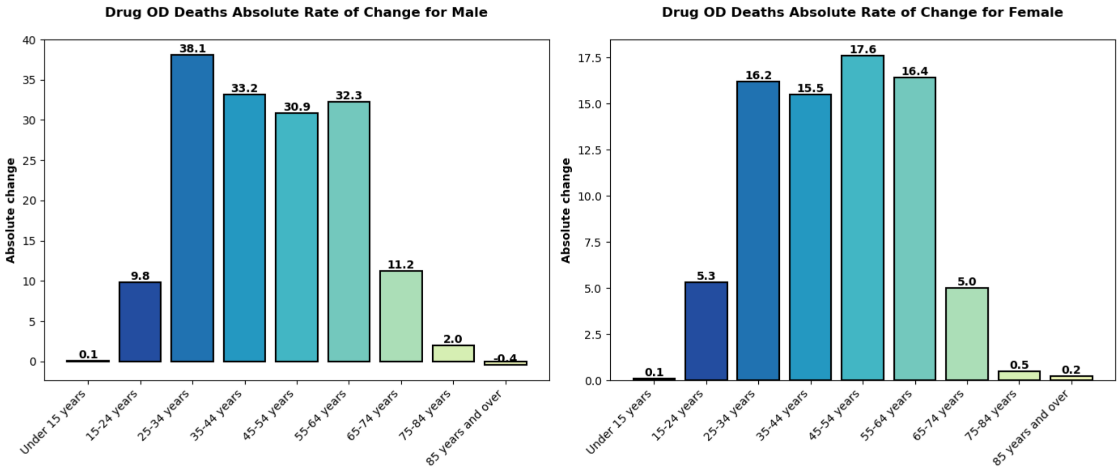
```
 Saved: figures/drug_overdose_deaths_percent_change_by_sex.png
```



[14]:
```
fig, (ax1, ax2) = plt.subplots(1, 2, figsize=(14, 6))

attr_name = 'absolute_change'
attr_label = 'Absolute change'
title_label = 'Drug OD Deaths Absolute Rate of Change for '

dataset = df_age_rate_of_change_m
```

```
sex_label = "Male"

if len(dataset) > 0:
    n_colors = len(dataset)
    colors = sns.color_palette("YlGnBu_r", n_colors)
    bars = ax1.bar(dataset['age_group'], dataset[attr_name],
                   color=colors, edgecolor='black', linewidth=1.5)
    ax1.set_xticks(range(len(dataset)), dataset['age_group'],
               rotation=45, ha='right', fontsize=10)

    ax1.set_title(title_label+sex_label,
              fontsize=12, fontweight='bold', pad=20)
    ax1.set_ylabel(attr_label,
               fontsize=10, fontweight='bold')
    for i, bar in enumerate(bars):
        height = bar.get_height()
        ax1.text(bar.get_x() + bar.get_width()/2., height,
                 f'{height:.1f}', ha='center', va='bottom', fontsize=10,
                 fontweight='bold')

dataset = df_age_rate_of_change_f
sex_label = "Female"

if len(dataset) > 0:

    n_colors = len(dataset)
    colors = sns.color_palette("YlGnBu_r", n_colors)
    bars = ax2.bar(dataset['age_group'], dataset[attr_name],
                   color=colors, edgecolor='black', linewidth=1.5)
    ax2.set_xticks(range(len(dataset)), dataset['age_group'],
               rotation=45, ha='right', fontsize=10)

    ax2.set_title(title_label+sex_label,
              fontsize=12, fontweight='bold', pad=20)
    ax2.set_ylabel(attr_label,
               fontsize=10, fontweight='bold')
    for i, bar in enumerate(bars):
        height = bar.get_height()
        ax2.text(bar.get_x() + bar.get_width()/2., height,
                 f'{height:.1f}', ha='center', va='bottom', fontsize=10,
                 fontweight='bold')

plt.tight_layout()

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

```
Saved: figures/drug_overdose_deaths_absolute_change_by_sex.png
```



[15]:
```python
# Male groups with largest percent change
attr_name = 'percent_change'
dataset = df_age_rate_of_change_m
threshold = 200

dataset_sorted = dataset.sort_values(by = attr_name, ascending=False)
dataset_sorted_subset = dataset_sorted[dataset_sorted[attr_name] > threshold]
dataset_sorted_subset = dataset_sorted_subset[["age_group", attr_name]]
print(f"Top age groups for males experiencing the greater than {threshold}␣
 ↪percent change:")
dataset_sorted_subset.head(10)
```

```
Top age groups for males experiencing the greater than 200 percent change:
```

[15]:
```
     age_group  percent_change
5  55-64 years      659.183673
6  65-74 years      414.814815
2  25-34 years      331.304348
1  15-24 years      217.777778
4  45-54 years      203.289474
```

[16]:
```python
# Male groups with largest change
attr_name = 'absolute_change'
dataset = df_age_rate_of_change_m
threshold = 10

dataset_sorted = dataset.sort_values(by = attr_name, ascending=False)
dataset_sorted_subset = dataset_sorted[dataset_sorted[attr_name] > threshold]
dataset_sorted_subset = dataset_sorted_subset[["age_group", attr_name]]
```

```
print("Top age groups for males experiencing the largest absolute change:")
dataset_sorted_subset.head(10)
```

```
Top age groups for males experiencing the largest absolute change:
```

[16]:

```
     age_group  absolute_change
2  25-34 years             38.1
3  35-44 years             33.2
5  55-64 years             32.3
4  45-54 years             30.9
6  65-74 years             11.2
```

[17]:

```
# Female groups with largest change
attr_name = 'percent_change'
dataset = df_age_rate_of_change_f
threshold = 200

dataset_sorted = dataset.sort_values(by = attr_name, ascending=False)
dataset_sorted_subset = dataset_sorted[dataset_sorted[attr_name] > threshold]
dataset_sorted_subset = dataset_sorted_subset[["age_group", attr_name]]
print(f"Top age groups for females experiencing the greater than {threshold}␣
 ↪percent change:")
dataset_sorted_subset.head(10)
```

```
Top age groups for females experiencing the greater than 200 percent change:
```

[17]:

```
     age_group  percent_change
5  55-64 years      468.571429
2  25-34 years      352.173913
1  15-24 years      294.444444
4  45-54 years      244.444444
6  65-74 years      238.095238
```

[18]:

```
# Female groups with largest change
attr_name = 'absolute_change'
dataset = df_age_rate_of_change_f
threshold = 10

dataset_sorted = dataset.sort_values(by = attr_name, ascending=False)
dataset_sorted_subset = dataset_sorted[dataset_sorted[attr_name] > threshold]
dataset_sorted_subset = dataset_sorted_subset[["age_group", attr_name]]
print("Top age groups for females experiencing the largest absolute change:")
dataset_sorted_subset.head(10)
```

```
Top age groups for females experiencing the largest absolute change:
```

```
[18]:       age_group  absolute_change
      4  45-54 years             17.6
      5  55-64 years             16.4
      2  25-34 years             16.2
      3  35-44 years             15.5
```

```
[ ]:
```