Decomposing the US drug overdose crisis

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Over 1.3 million drug overdose deaths

Over 5x increase from 1999 to 2022

Only three year-over-year declines

Racial and ethnic inequities

Geographic variation

Different pharmacological drivers

Typical approaches have two issues

Issue 1: Double-counting deaths

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Issue 2: Unclear relationship between rates

Develop a more nuanced description of the US drug overdose crisis:

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1. What drove the *rise* in deaths from 1999 to 2022?

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1. What drove the *rise* in deaths from 1999 to 2022?
2. What drove the *decline* in deaths?

Methods

Data

- Restricted multiple cause of death data from NCHS, 1999-2024
- All 1.33 million drug deaths are classified into 1 of **15 mutually-exclusive drug groupings** (no double counting).
  - For example:
    - Methamphetamine alone vs fentanyl + methamphetamine
    - Cocaine alone vs fentanyl + cocaine
- SEER population denominators

Analytic approach

- Use a generalized Kitagawa decomposition to partition the **change** in the rate into substance- and geography-specific contributions (also age, sex, and race but not discussed)
- Uncertainty intervals generated via Monte Carlo simulation using a negative binomial distribution on deaths (B=5,000)

National rate change decomposed into...

Contribution of specific drug combinations

Contribution of specific drug combinations

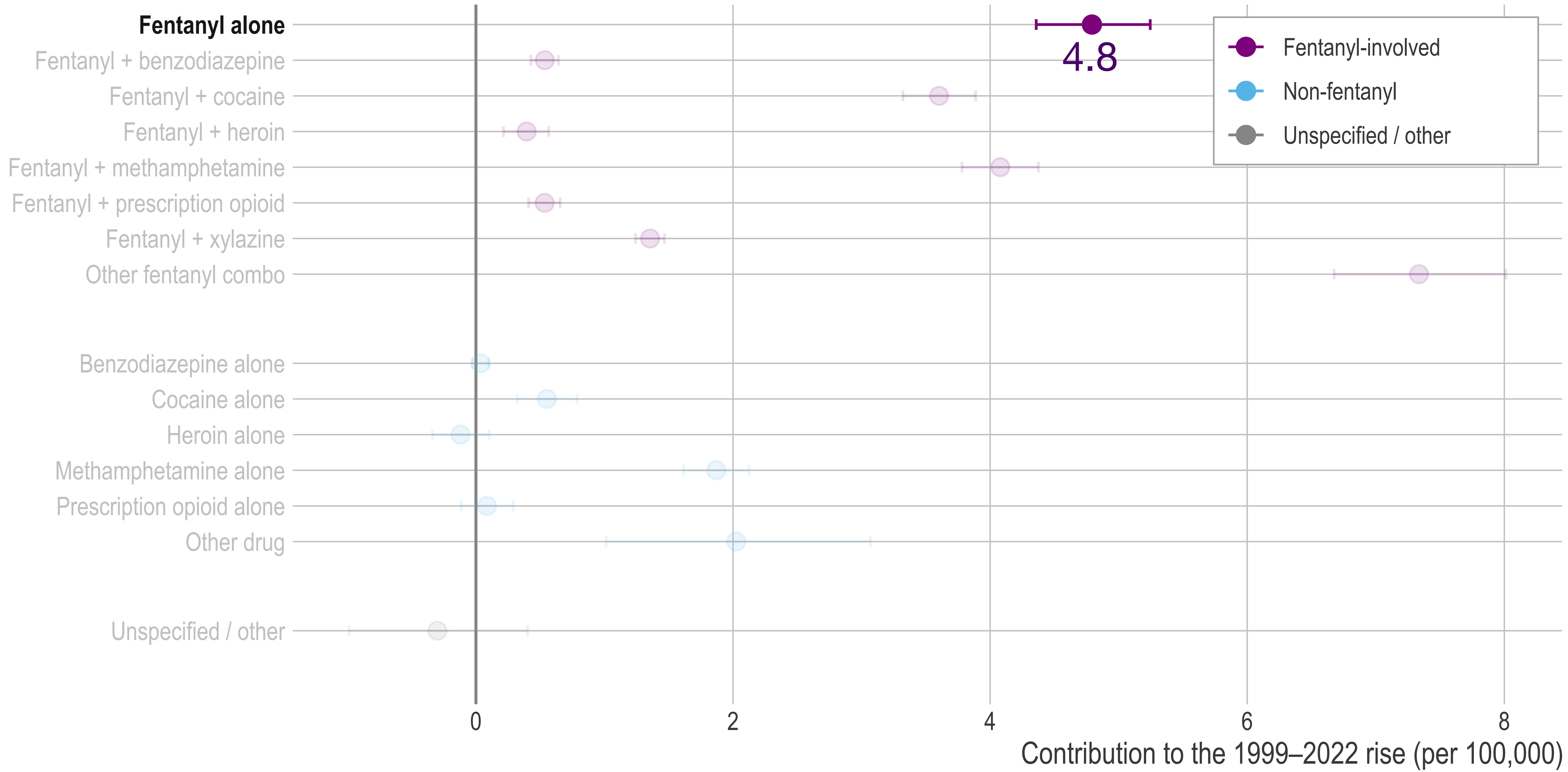
Or the contribution of each state

Or both (California)

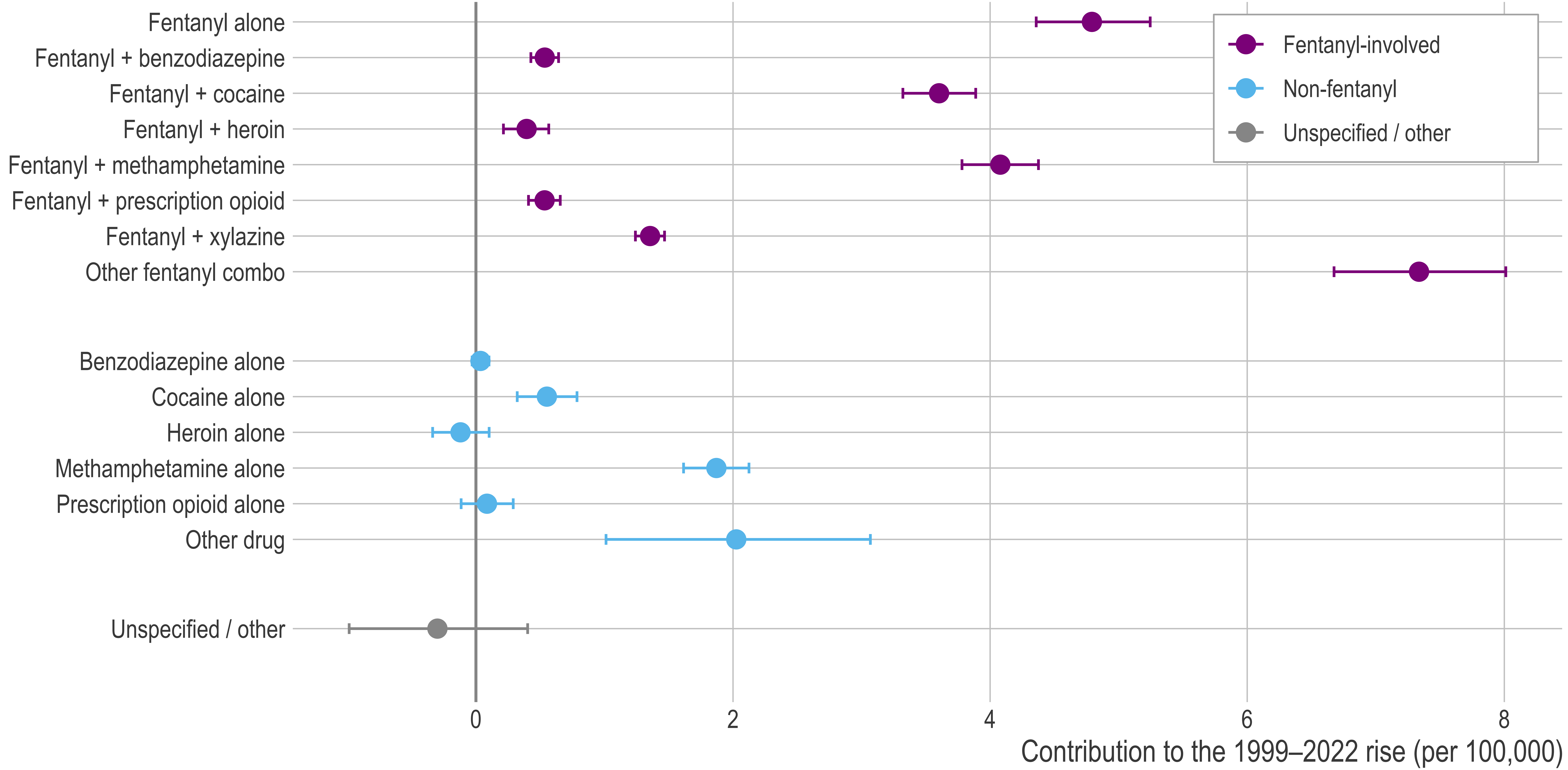
Results:
The rise

Increase of ~27 deaths per 100,000

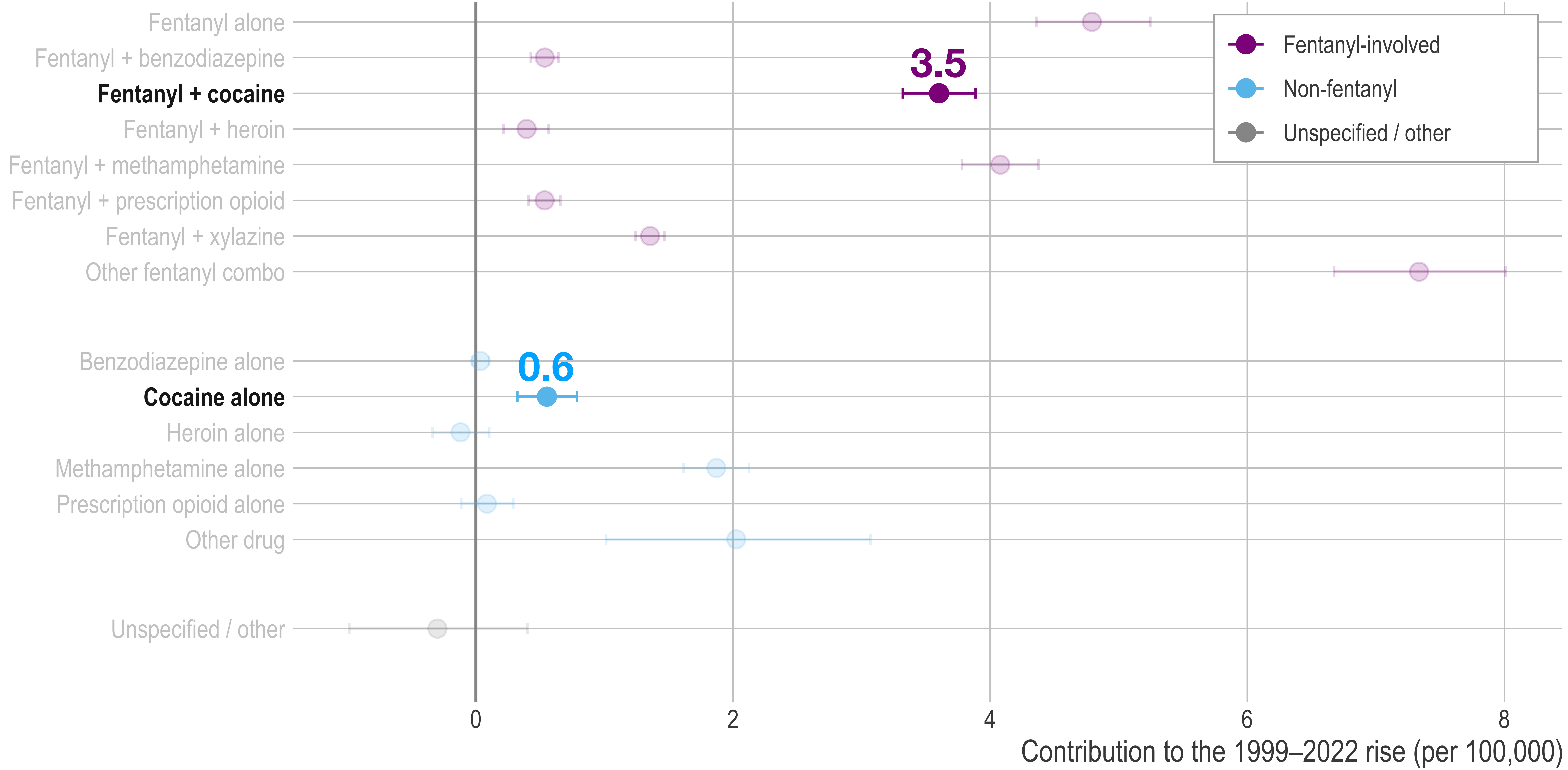
Fentanyl-alone largest (specified) contributor



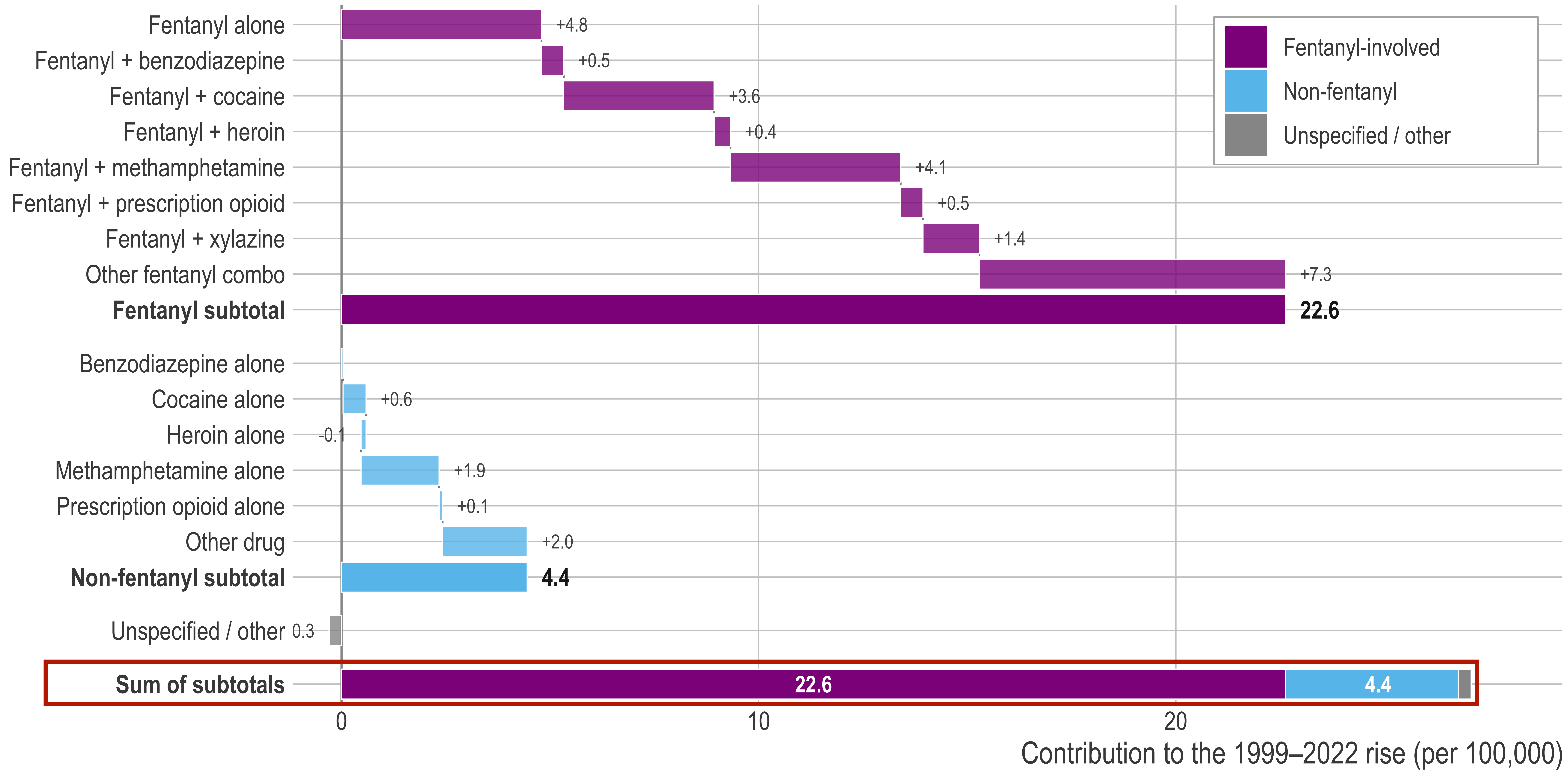
Substance-specific contributions vary widely



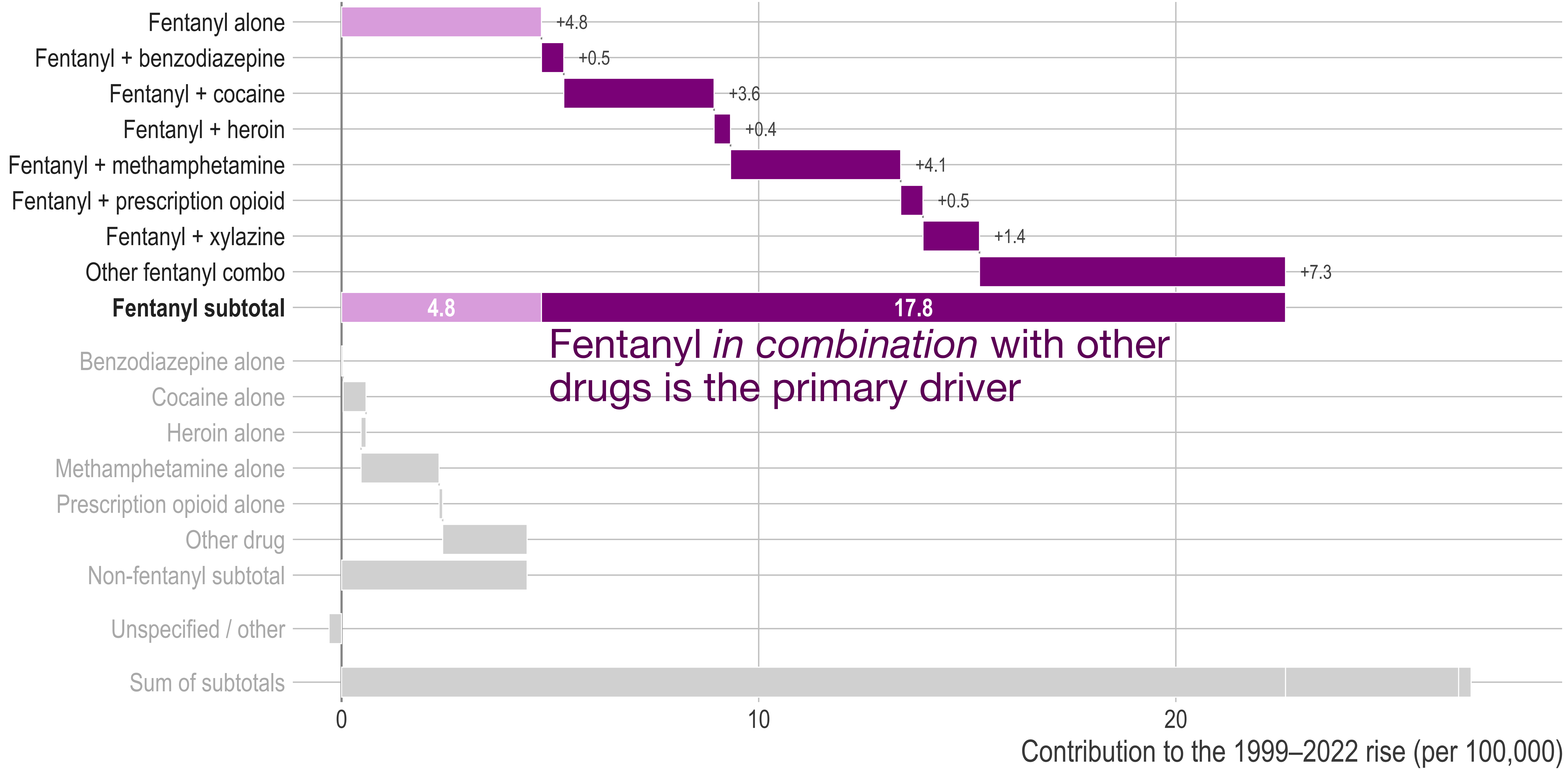
Fentanyl + cocaine ~6x higher



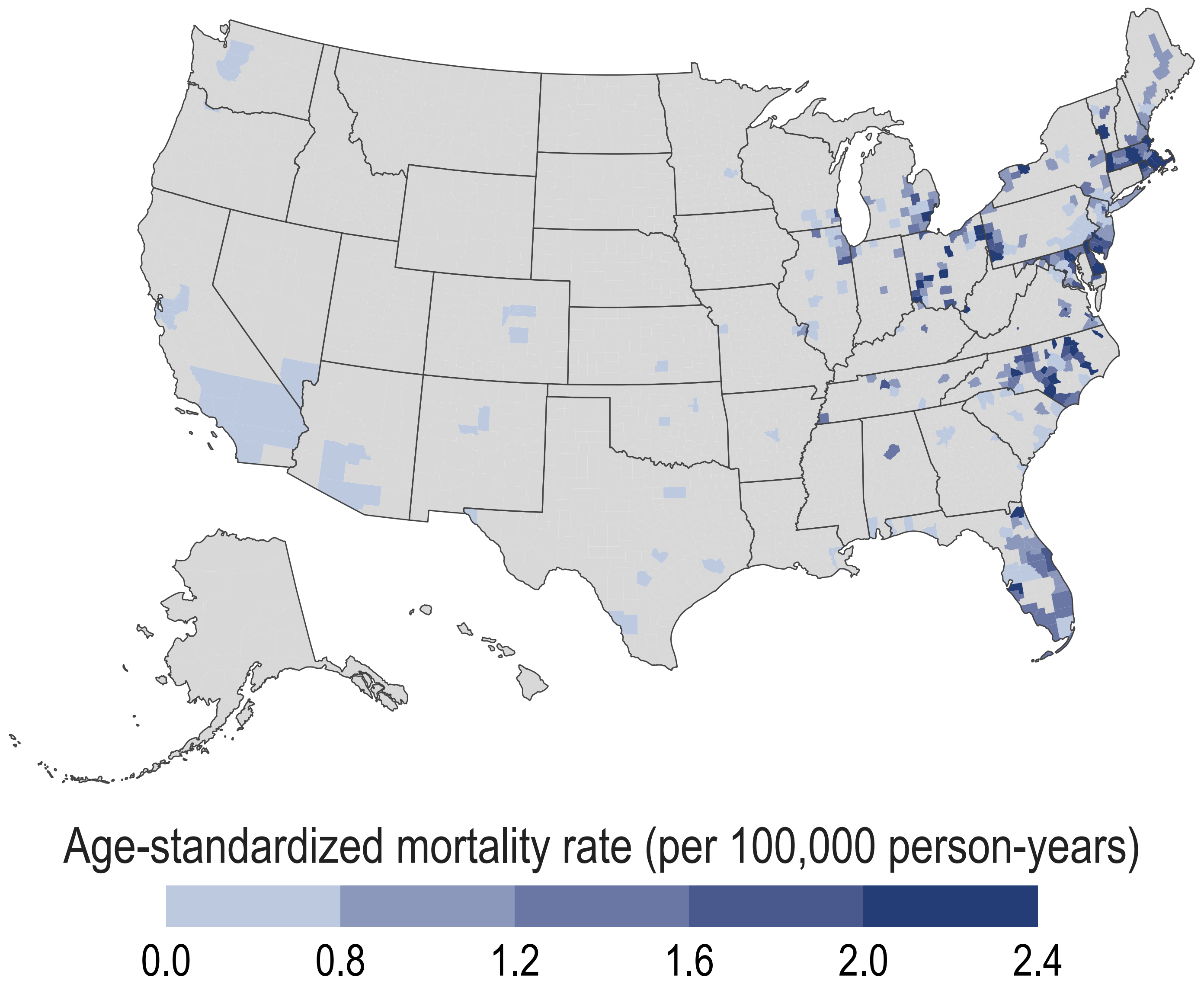
Fentanyl contributed 85% of the rise



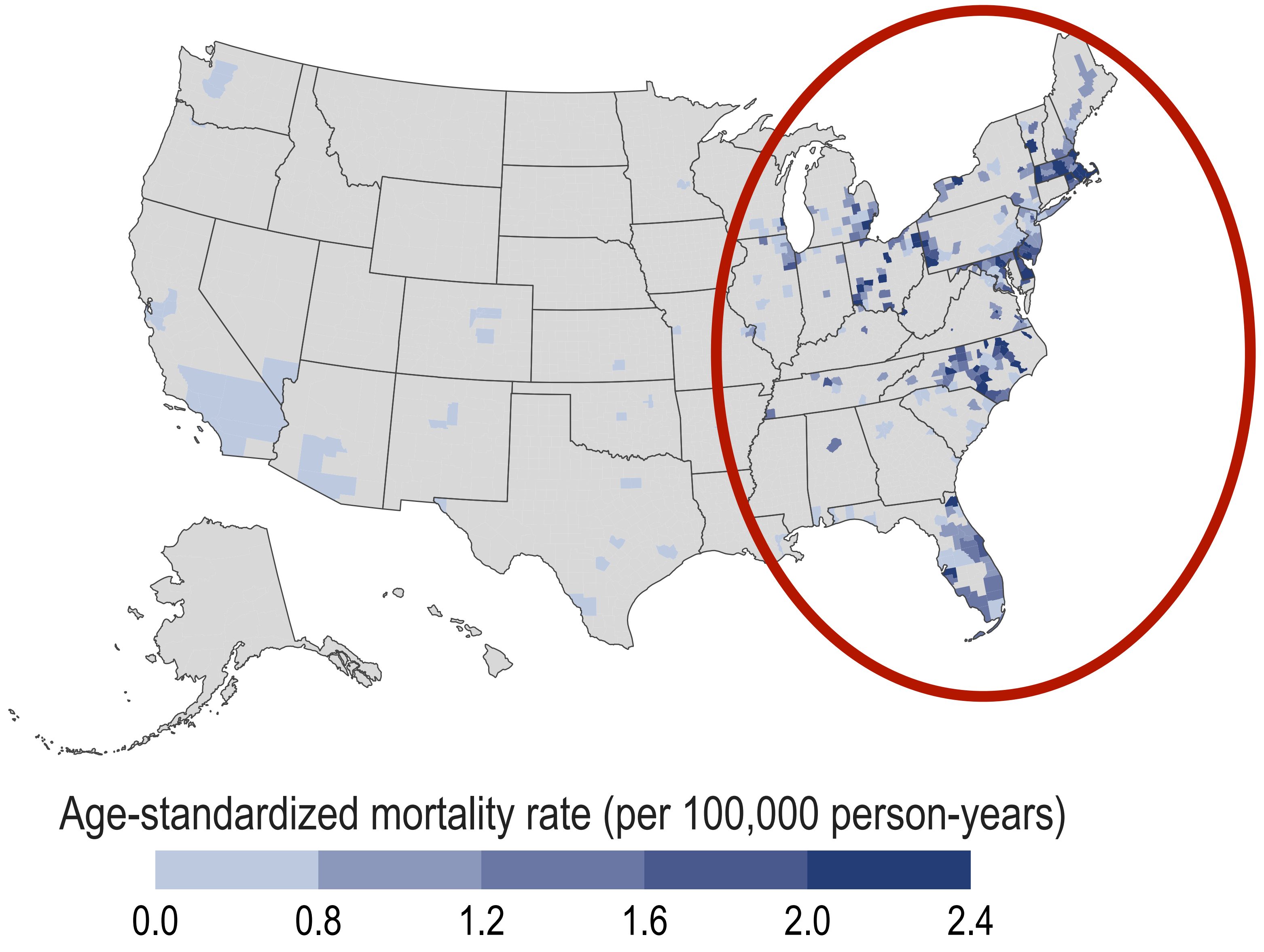
But only 25% of that was fentanyl alone



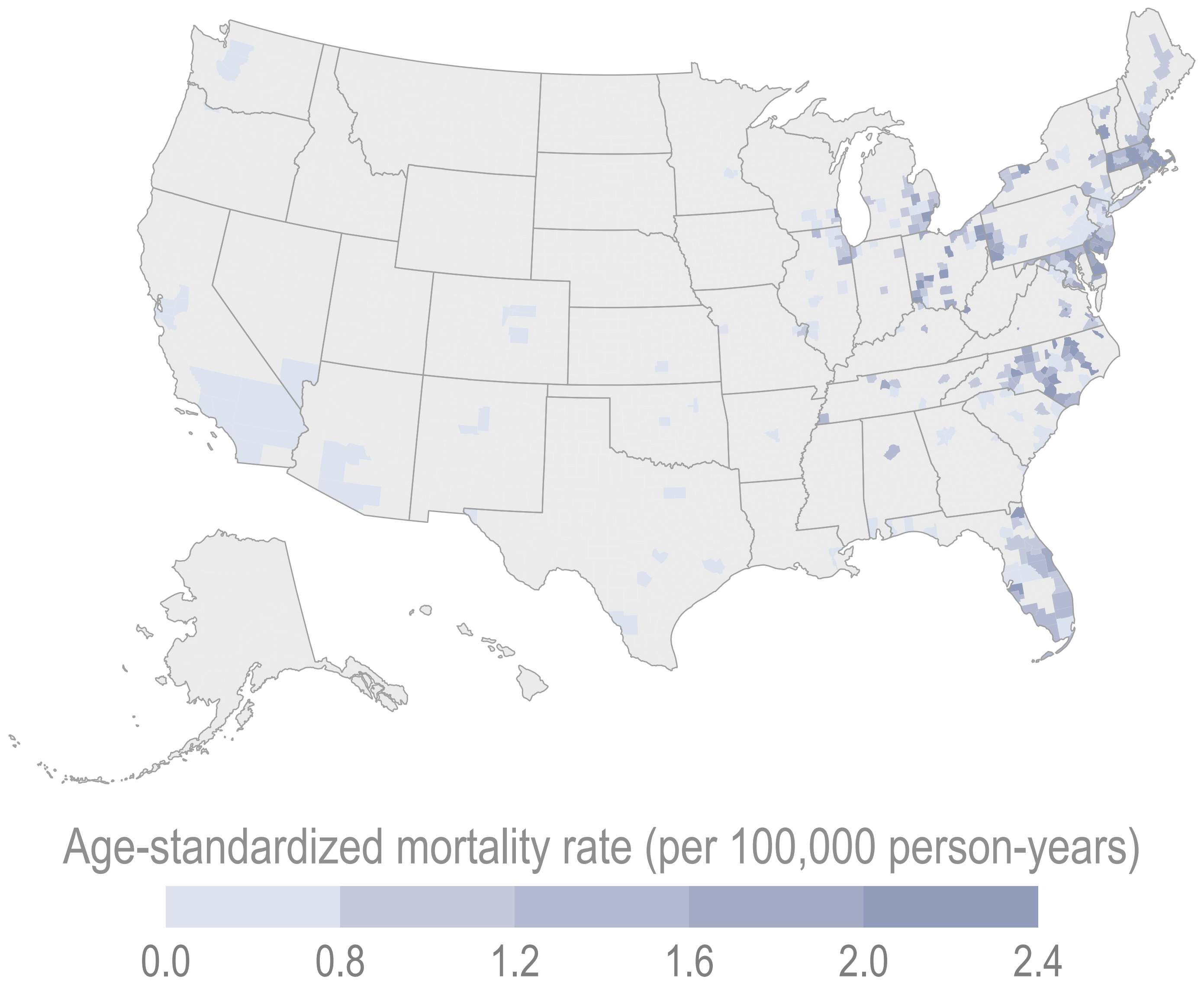
Cocaine + fentanyl mortality rate

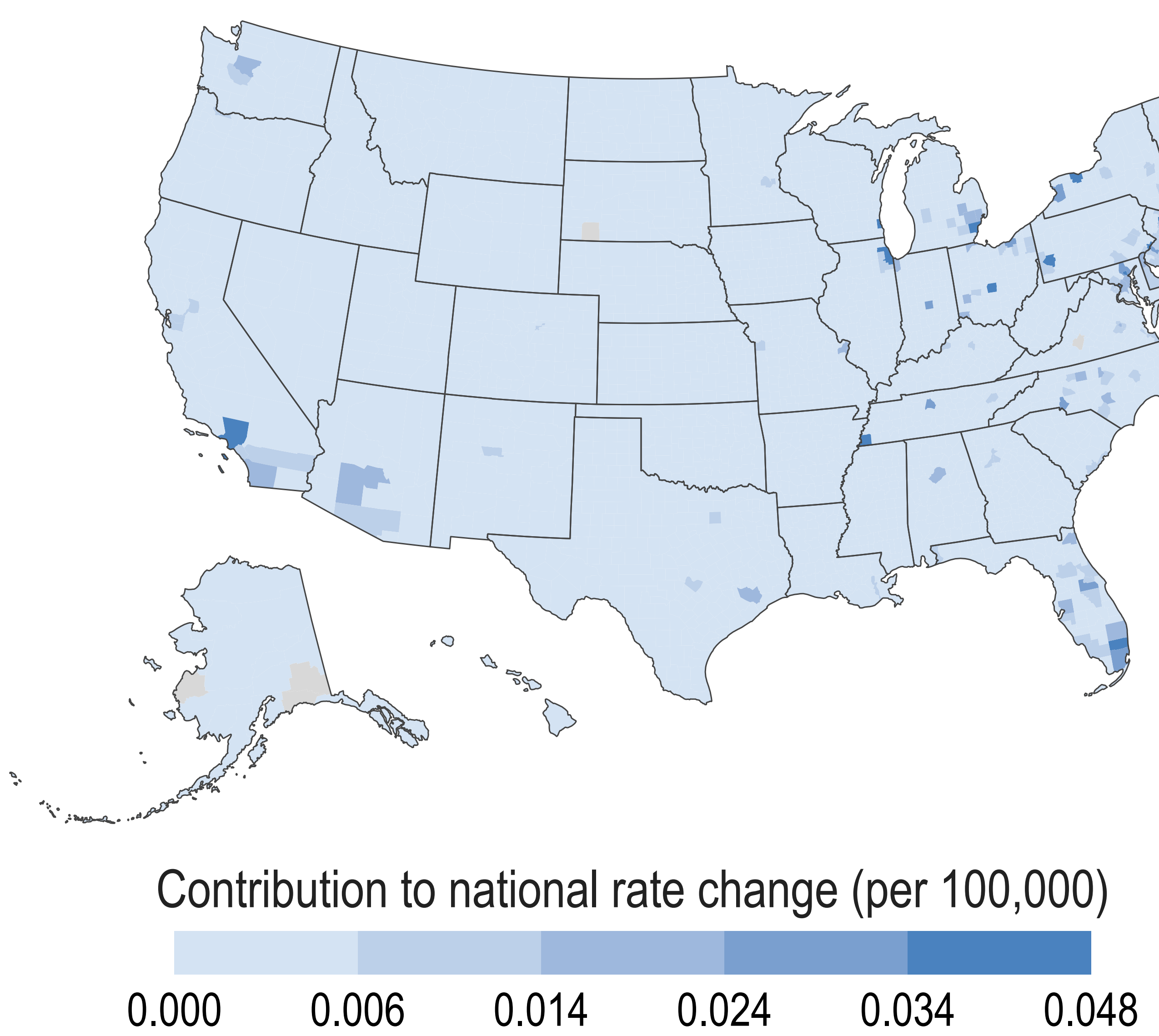


When looking at rates, eastern US problem

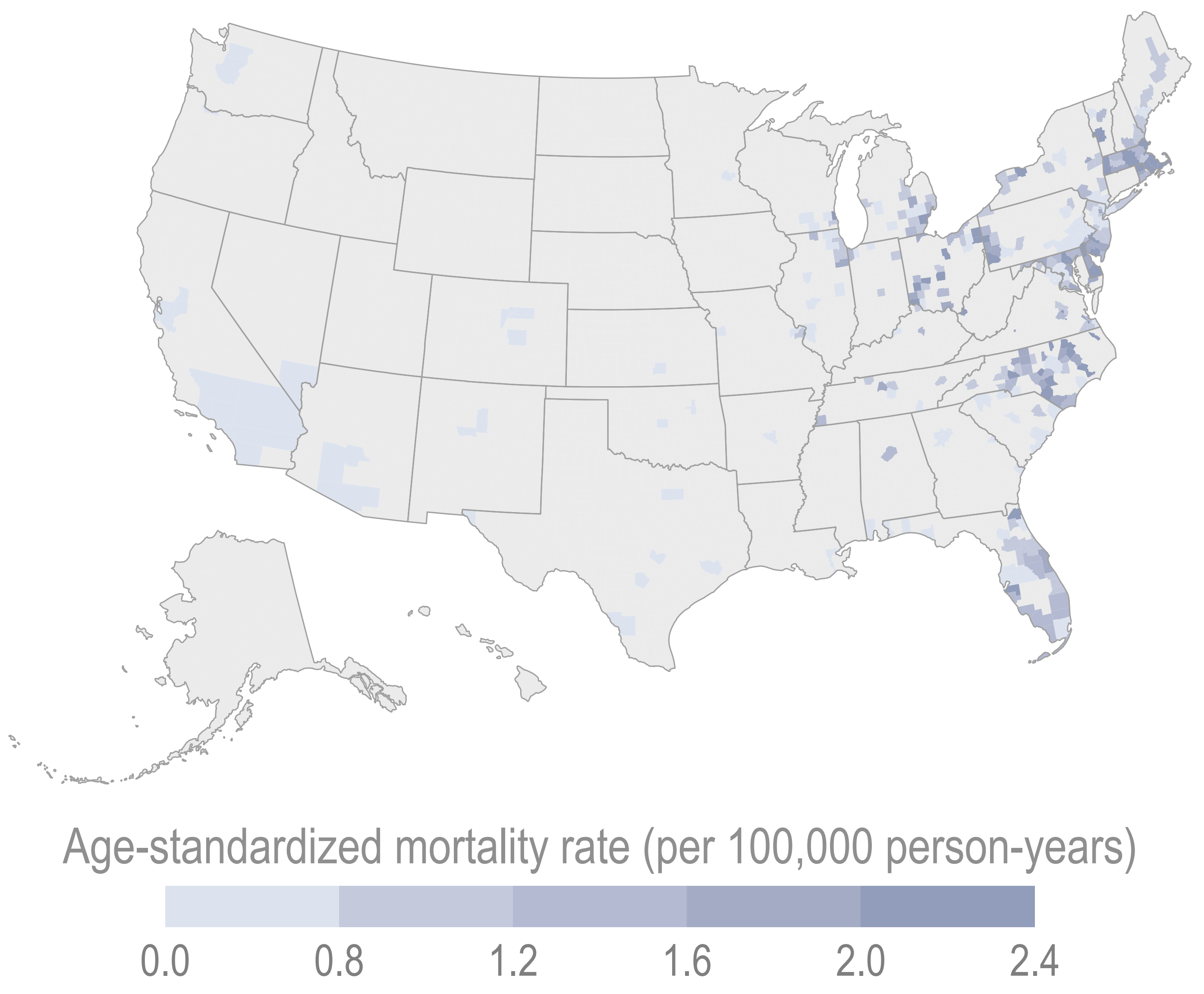


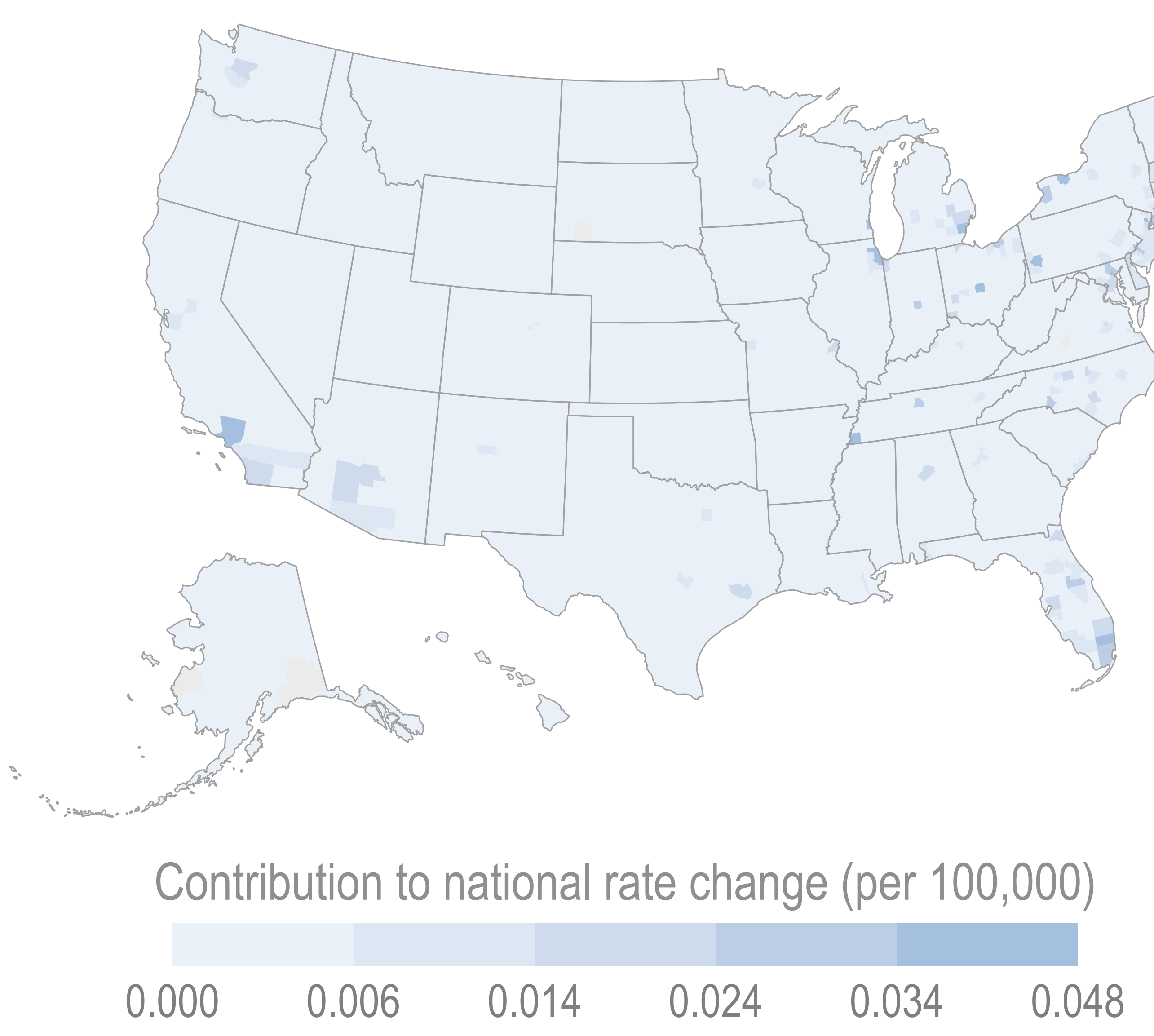
But burden is geographically distributed

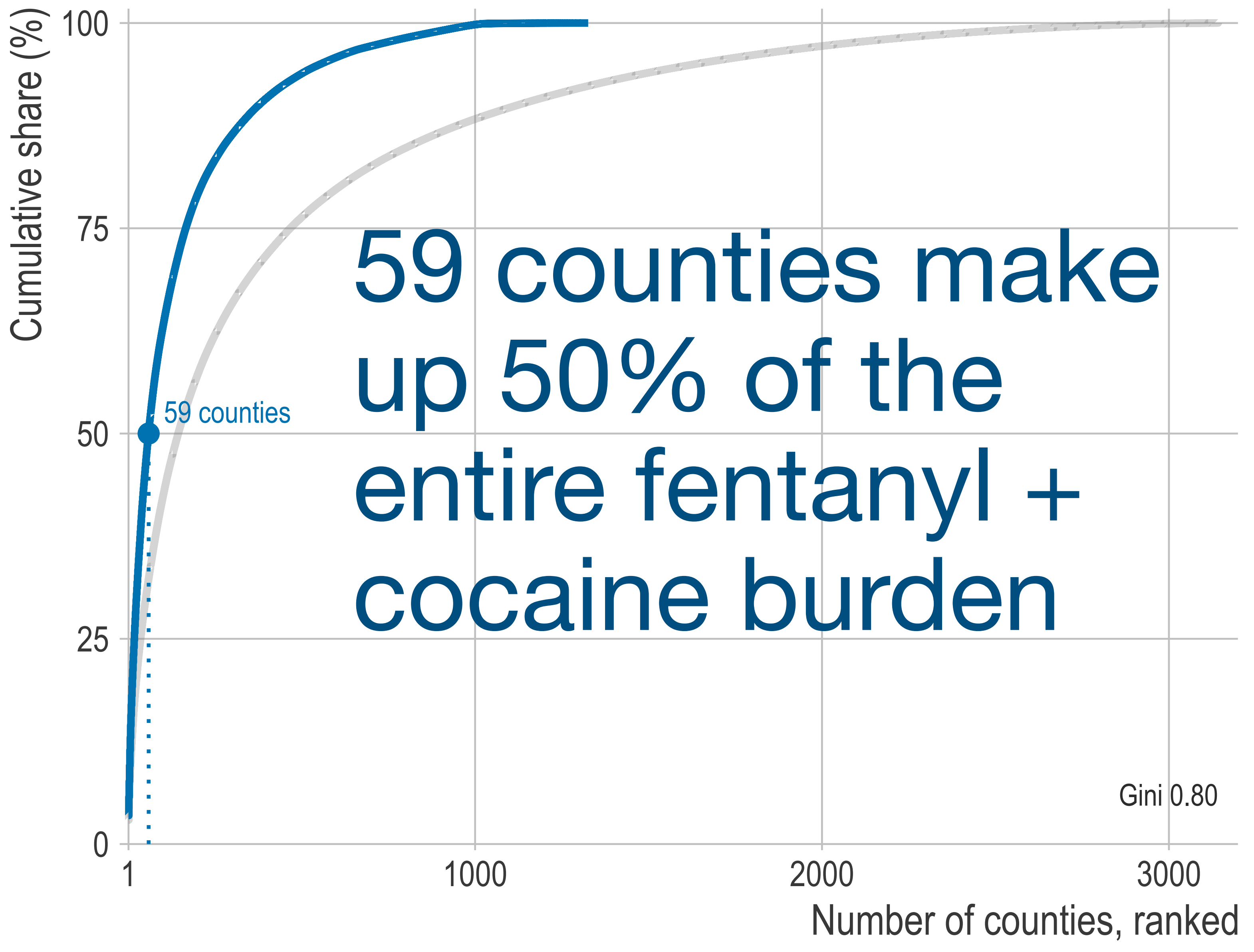




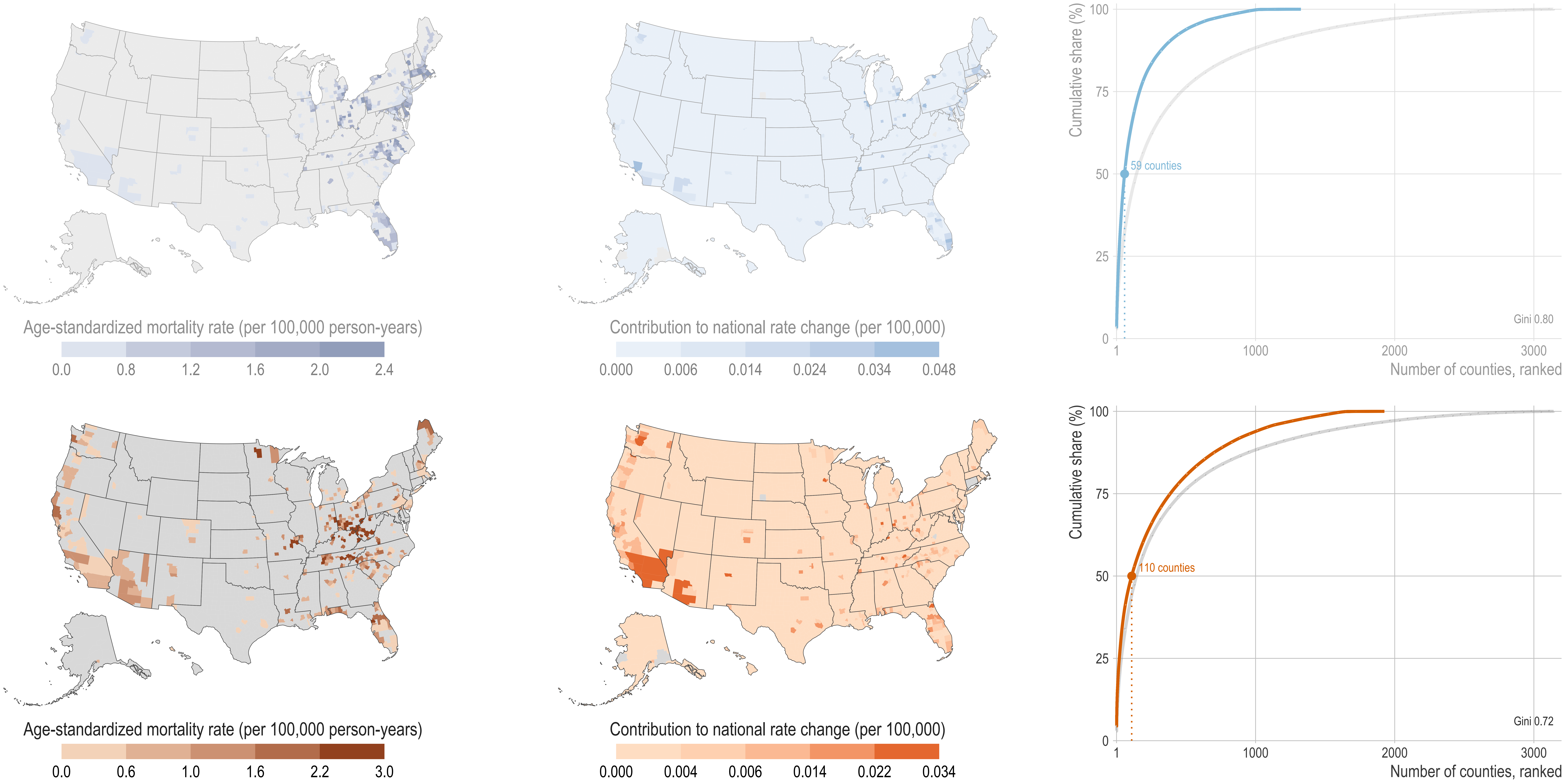
And highly concentrated



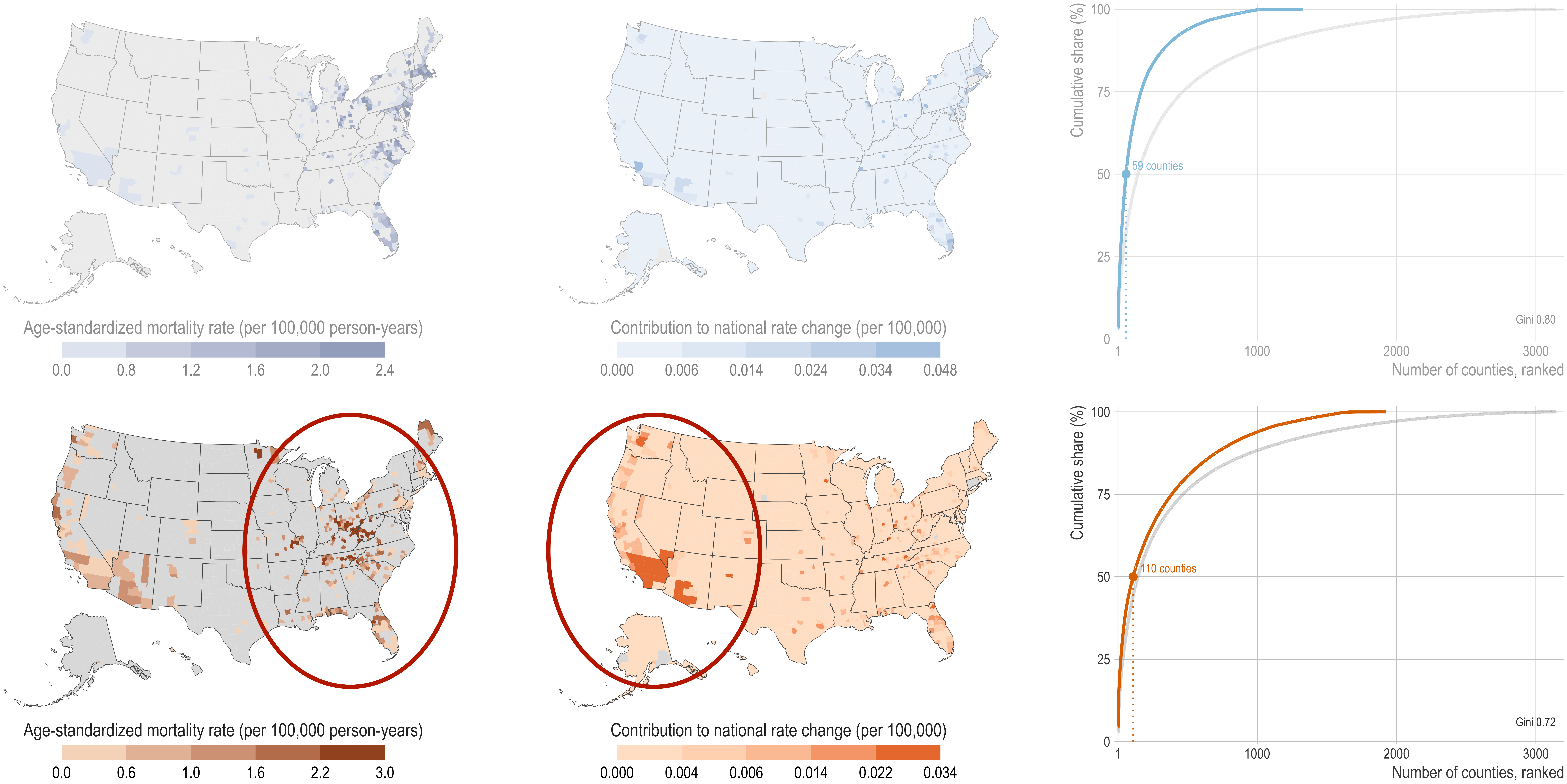




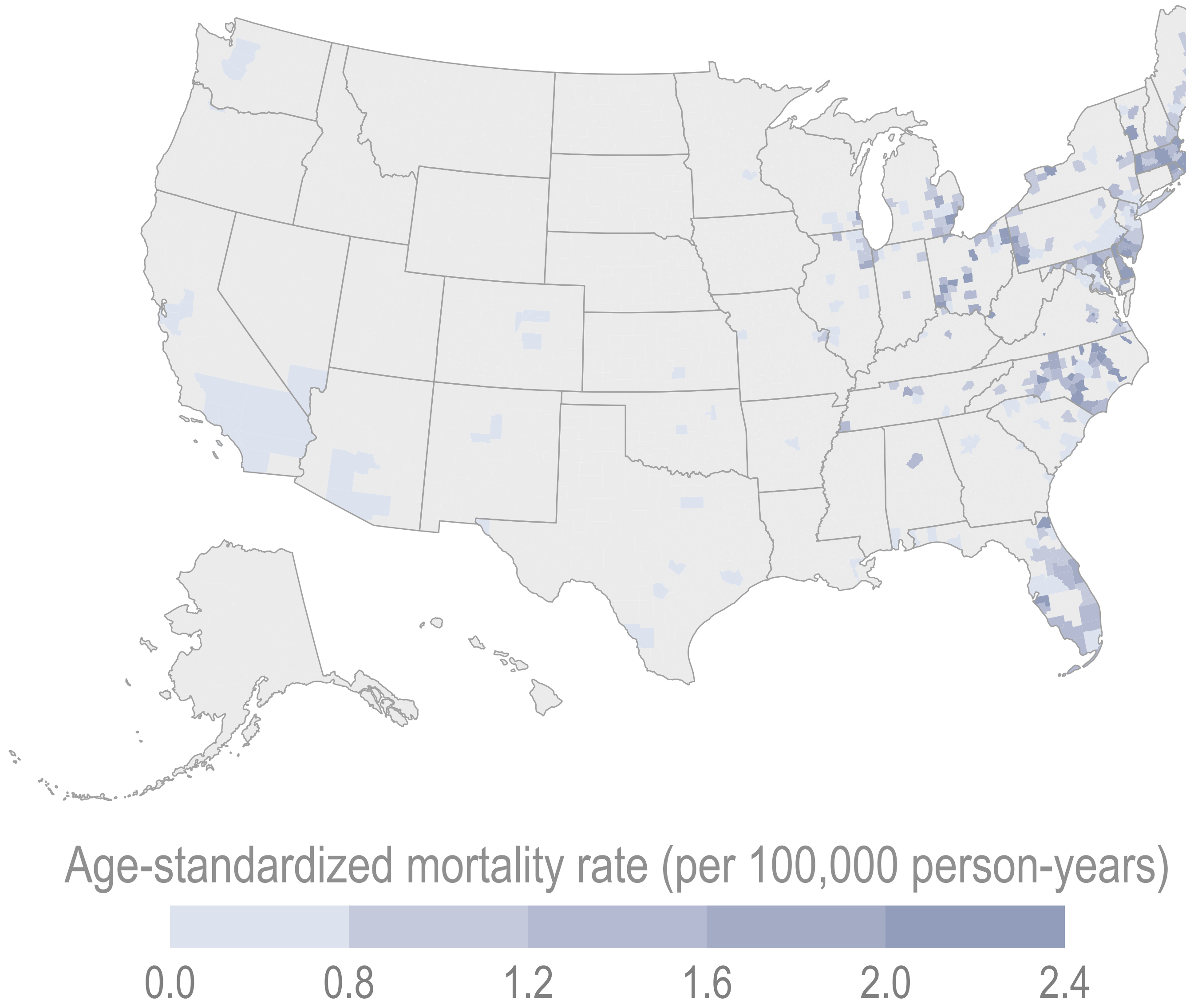
Methamphetamine + fentanyl burden

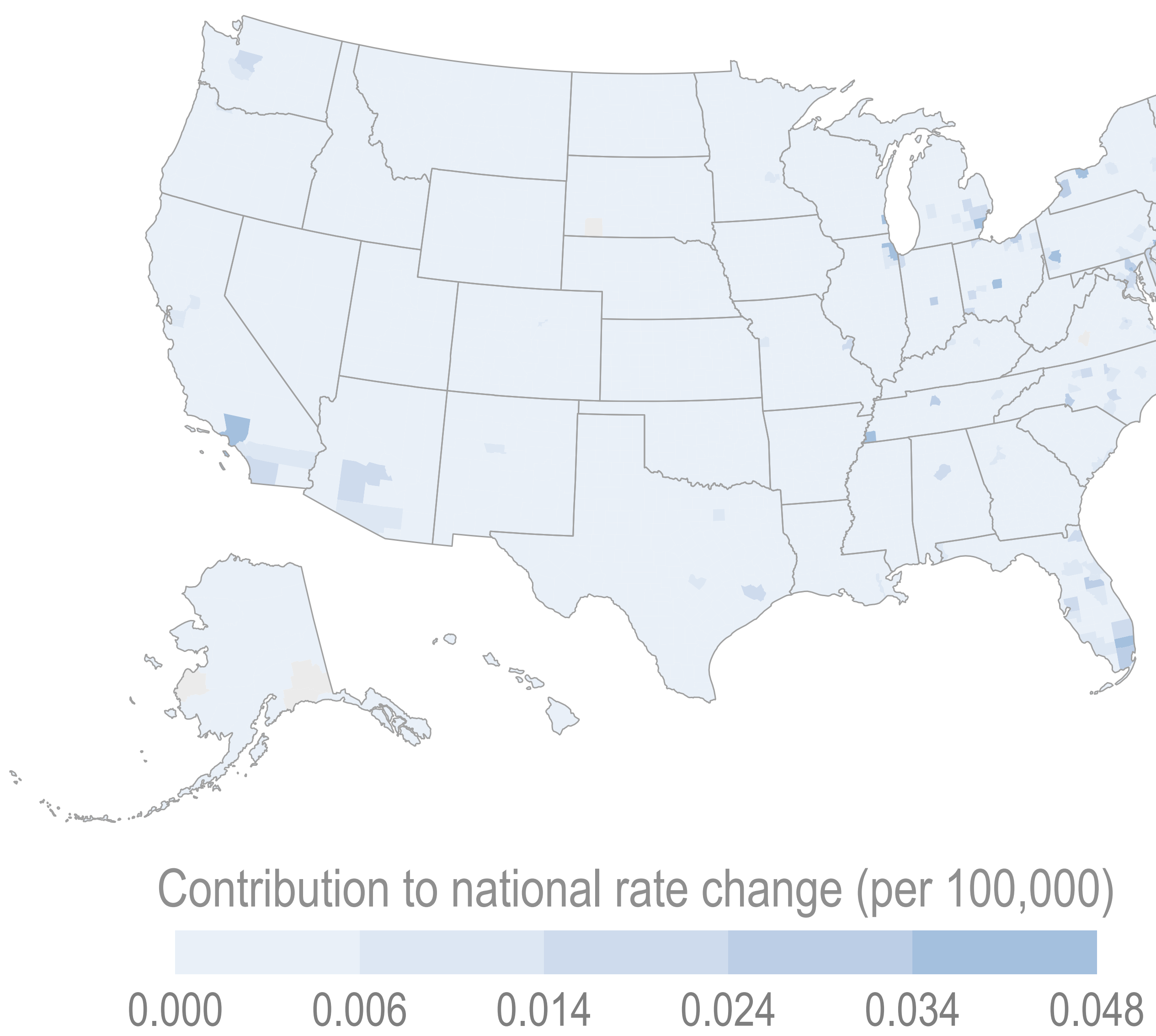


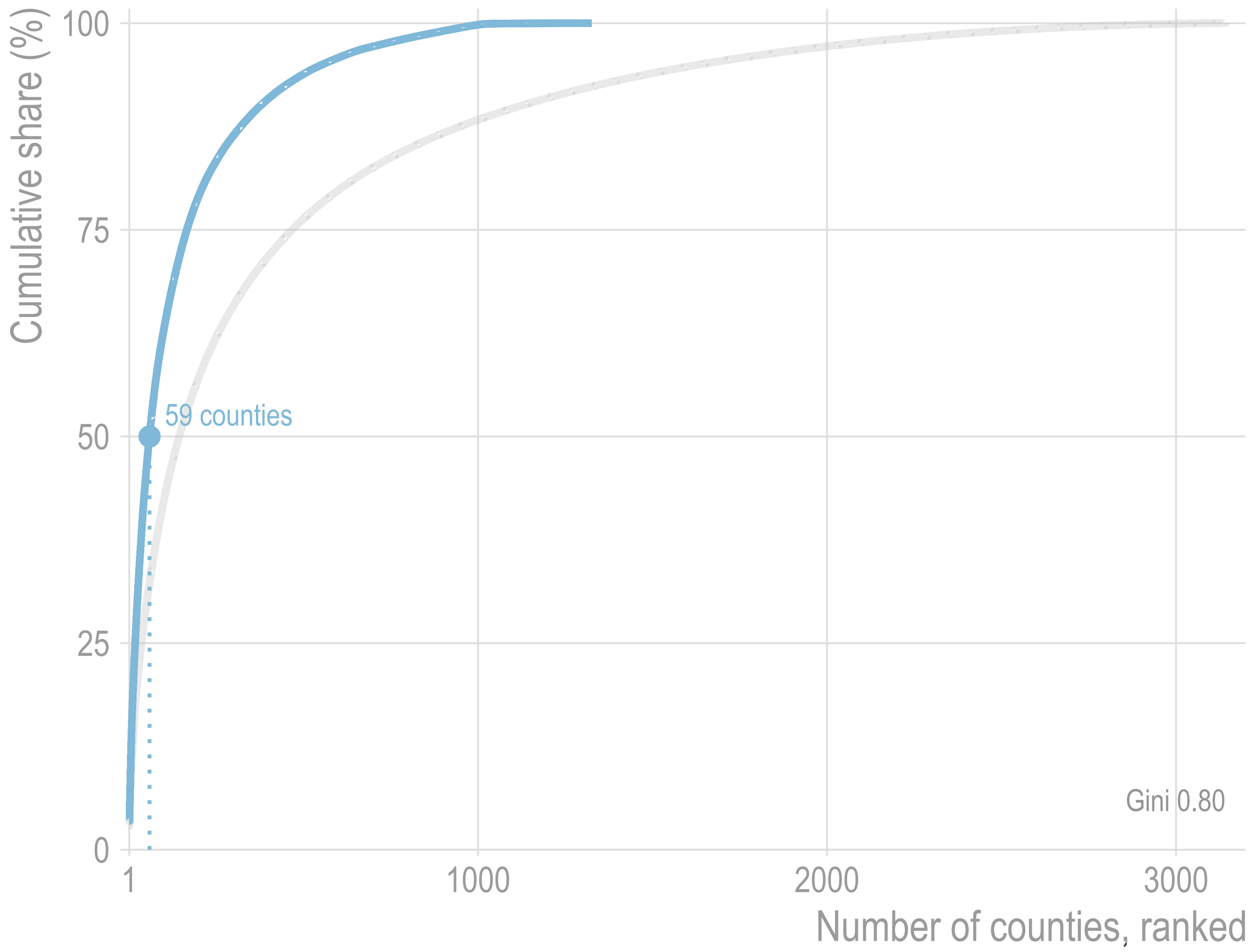
Reversed — rates in east but burden in west

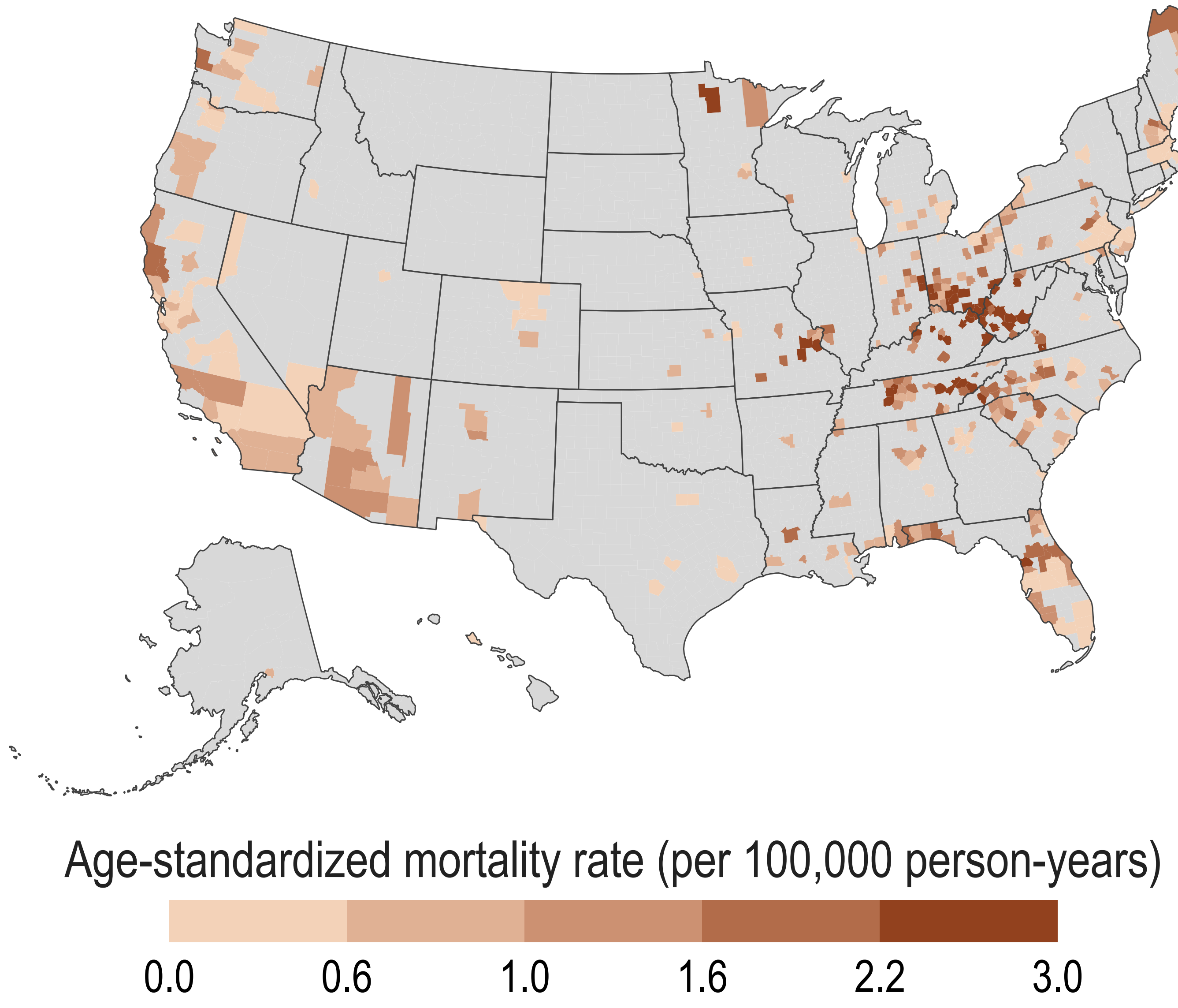


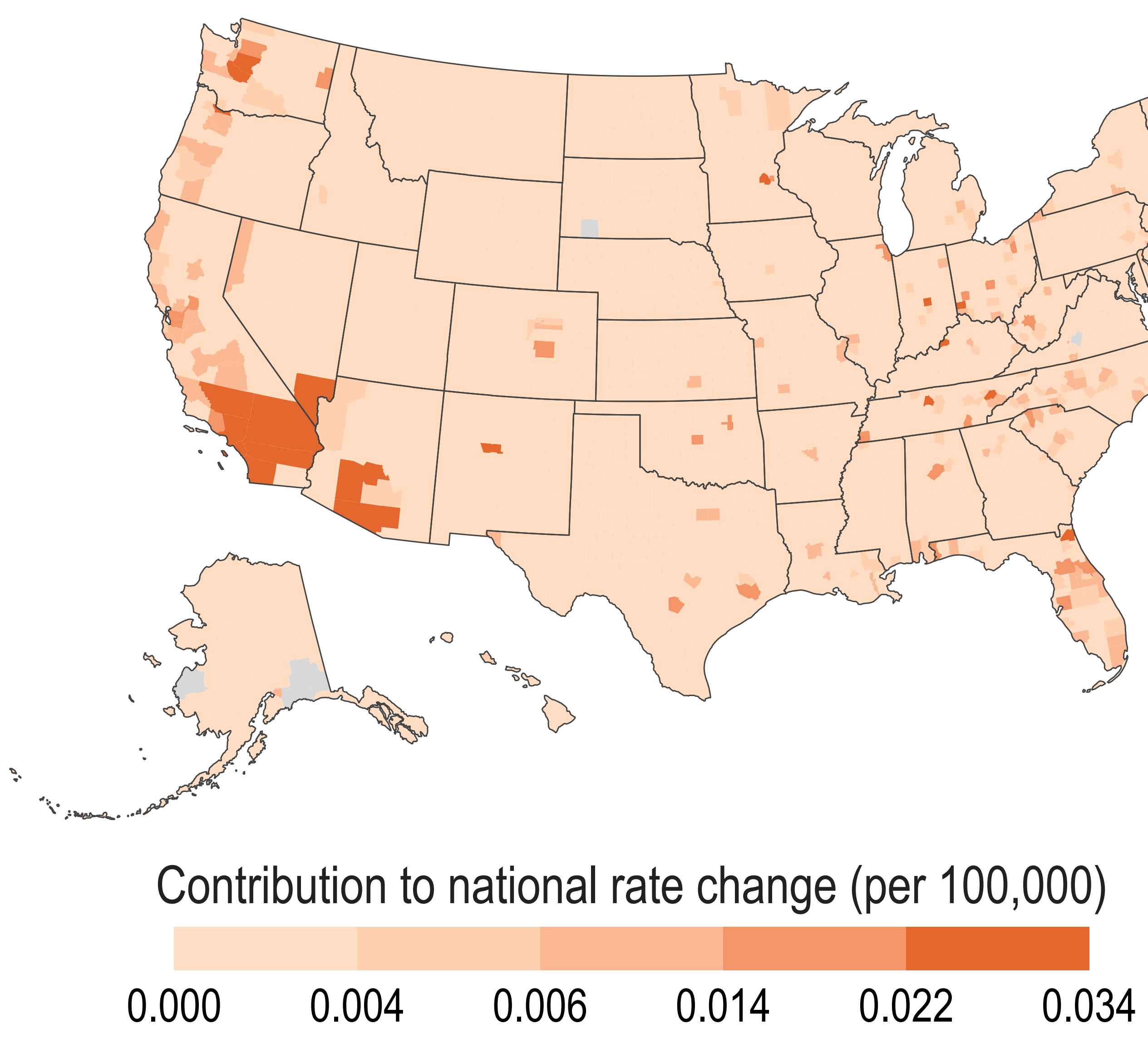
Burden is less concentrated

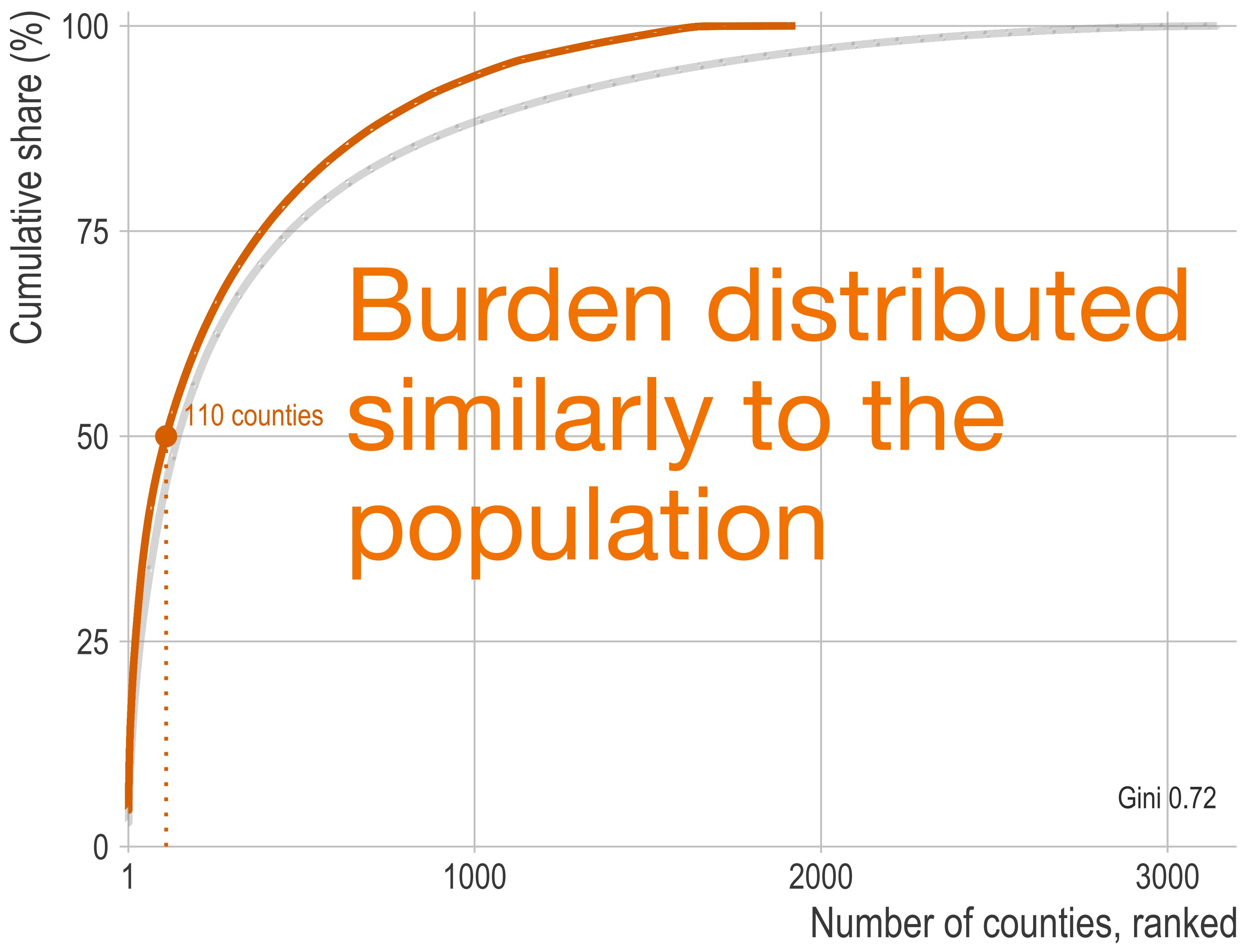








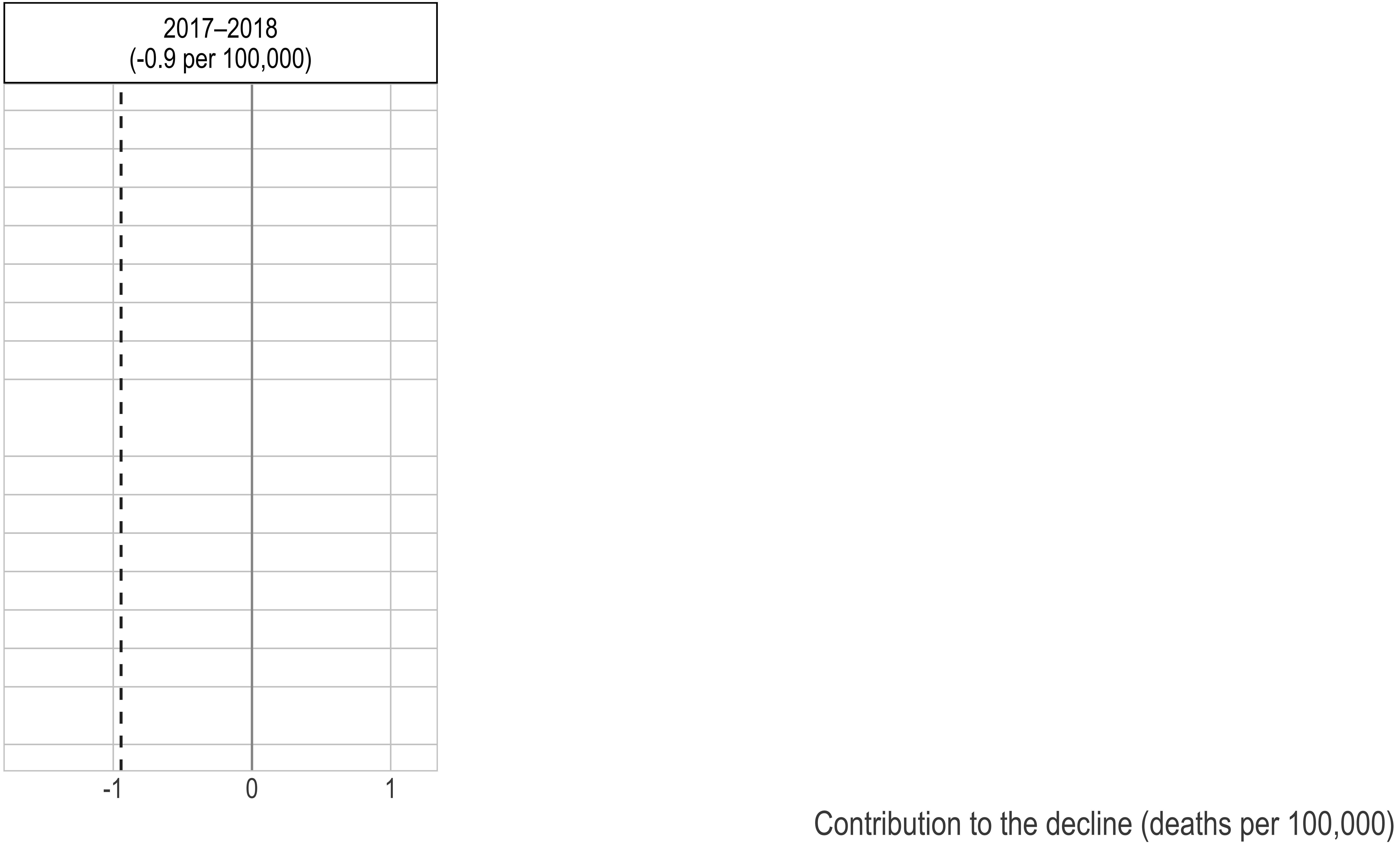




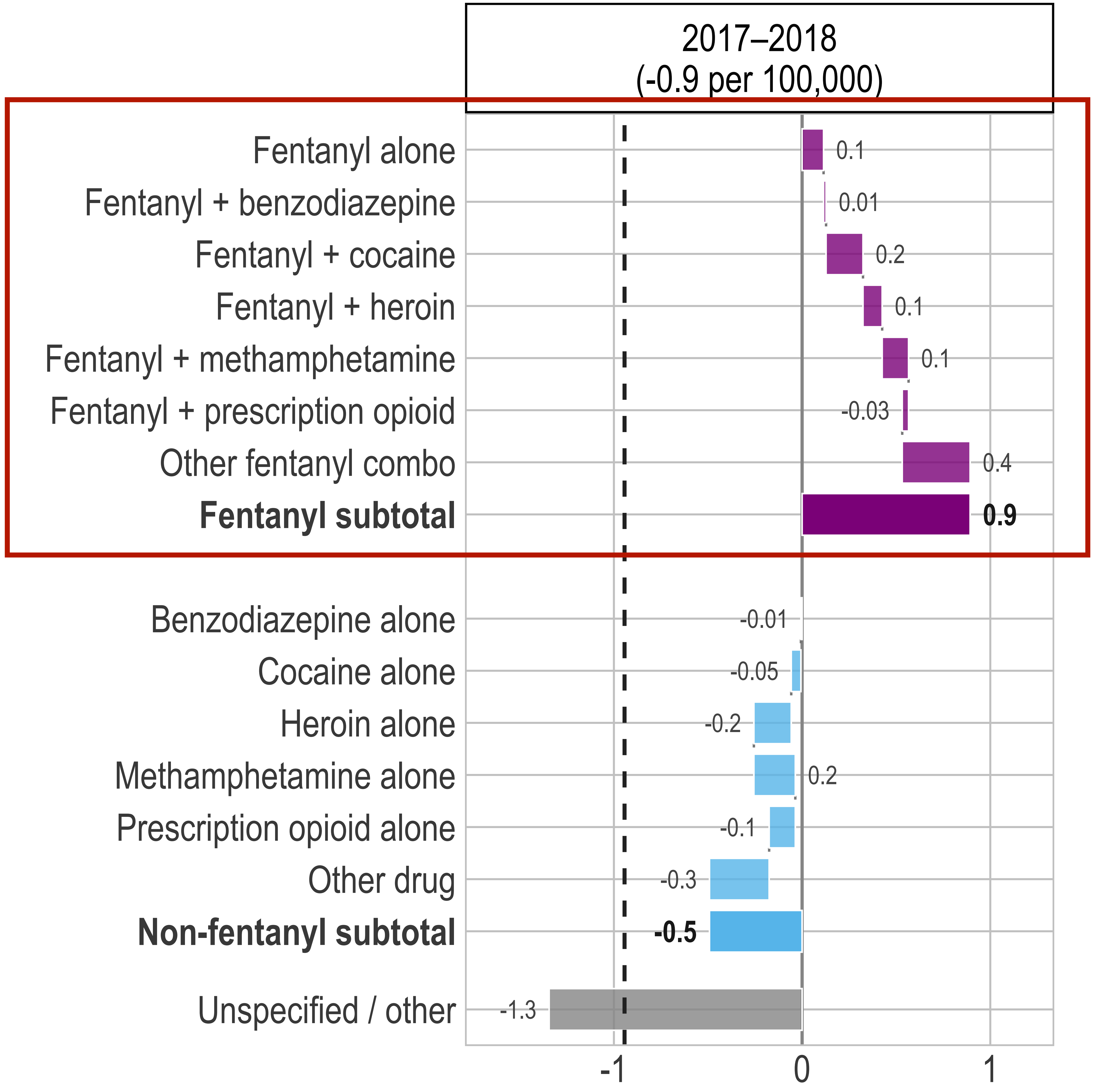
Results:
The declines

Three declines over 26 year period

Drop of ~1 per 100,000 in 2018



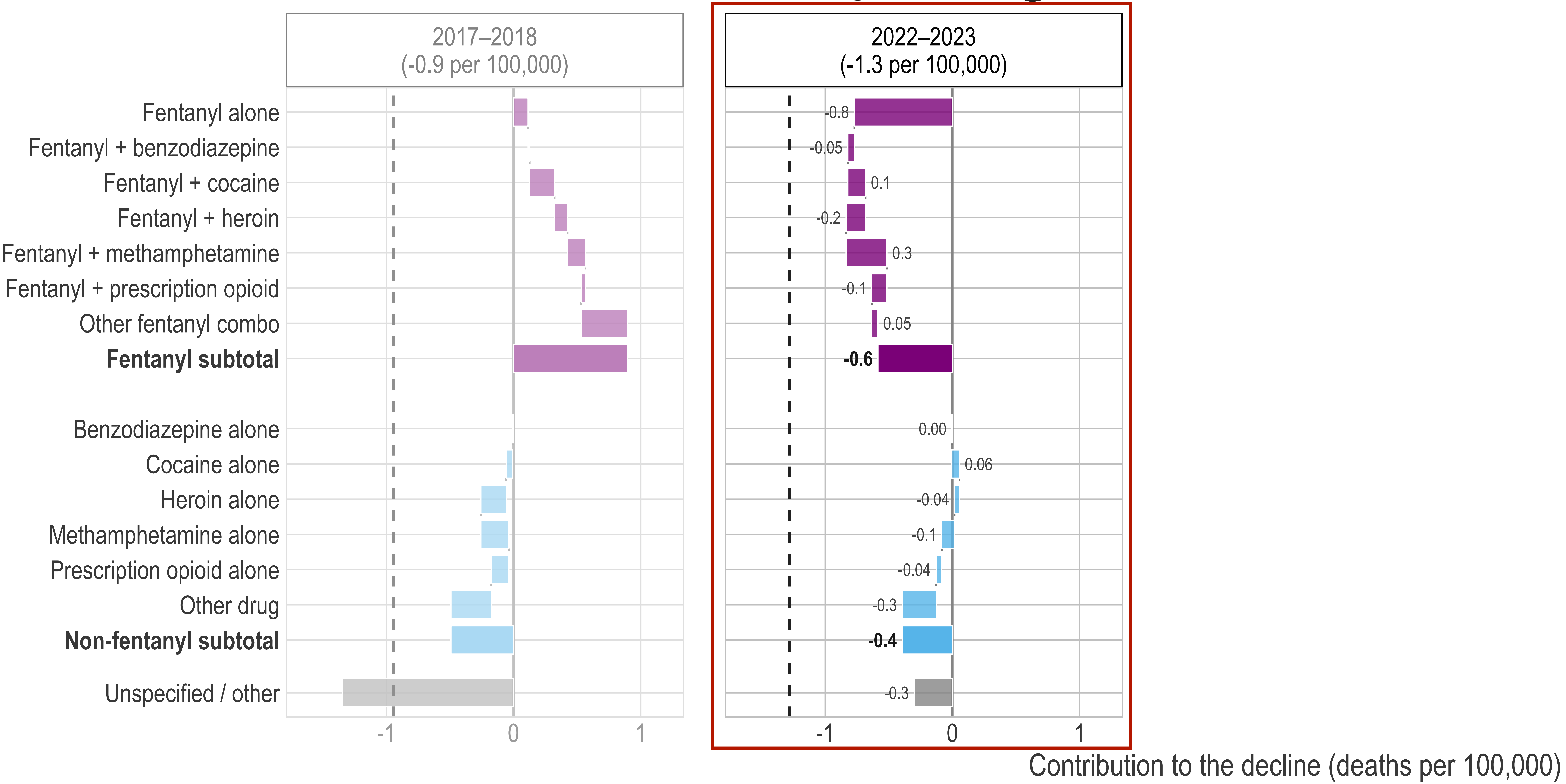
Fentanyl was *increasing* during this time



Contribution to the decline (deaths per 100,000)

Decrease was unspecified and non-fentanyl

In the 2023 decline, everything decreased*



*with exceptions

In 2024, only fentanyl decreased (but a lot)

Decreases are getting geographically diffuse

In 2018, five states made up entire decrease

In 2023, ten states

In 2024, every state contributed to decrease

Conclusion

- **Fentanyl accounted for 85%** of the increase in drug deaths from 1999-2022.
- **Fentanyl *in combination*** accounted for 75% of that rise.
- Different combinations have **different geographic patterns**.
- Declines have become increasingly **driven by fentanyl**.
- Declines have become more **geographically diffuse**.

- Decompositions can provide an alternative perspective on the burden of drug deaths.

Thank you

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Extra slides

Racial and ethnic inequities

Geographic variation

Example of geographic decomposition

Burden ≠ population

Kitagawa Decomposition

$$R_t = \sum_a \pi_{t,a} \cdot m_{t,a}$$

Kitagawa Decomposition

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- **Crude mortality rate** at time *t*

Kitagawa Decomposition

$$\boxed{R_t} = \sum_a \boxed{\pi_{t,a}} \cdot m_{t,a}$$

- **Crude mortality rate** at time *t*
- **Proportion of the population** at time *t* in age group *a*

Kitagawa Decomposition

$$\boxed{R_t} = \sum_a \boxed{\pi_{t,a}} \cdot \boxed{m_{t,a}}$$

- **Crude mortality rate** at time *t*
- **Proportion of the population** at time *t* in age group *a*
- **Age-specific mortality rate** at time *t* in age group *a*

Kitagawa Decomposition

$$R_2 - R_1 = \sum_a \frac{m_{1,a} + m_{2,a}}{2}(\pi_{2,a} - \pi_{1,a}) + \sum_a \frac{\pi_{1,a} + \pi_{2,a}}{2}(m_{2,a} - m_{1,a})$$

Kitagawa Decomposition

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How much is the **change in the rates**

Kitagawa Decomposition

$$\boxed{R_2 - R_1} = \underbrace{\boxed{\sum_a \frac{m_{1,a} + m_{2,a}}{2}(\pi_{2,a} - \pi_{1,a})}}_{\text{composition}} + \sum_a \frac{\pi_{1,a} + \pi_{2,a}}{2}(m_{2,a} - m_{1,a})$$

How much is the **change in the rates** attributable to differences in the **population composition**

Kitagawa Decomposition

$$\boxed{R_2 - R_1} = \underbrace{\boxed{\sum_a \frac{m_{1,a} + m_{2,a}}{2}(\pi_{2,a} - \pi_{1,a})}}_{\text{composition}} + \underbrace{\boxed{\sum_a \frac{\pi_{1,a} + \pi_{2,a}}{2}(m_{2,a} - m_{1,a})}}_{\text{rate}}$$

How much is the **change in the rates** attributable to differences in the **population composition** and how much in differences in **mortality**?

Kitagawa Decomposition

$$R_2 - R_1 = \underbrace{\sum_a \frac{m_{1,a} + m_{2,a}}{2}(\pi_{2,a} - \pi_{1,a})}_{\text{composition}} + \underbrace{\sum_a \frac{\pi_{1,a} + \pi_{2,a}}{2}(m_{2,a} - m_{1,a})}_{\text{rate}}$$

- Generalized to the age-standardized national rate change:
  - substance-specific (e.g., fentanyl + cocaine) component
  - geography-specific component
  - (also race-, sex-, and age-specific but not discussed here)

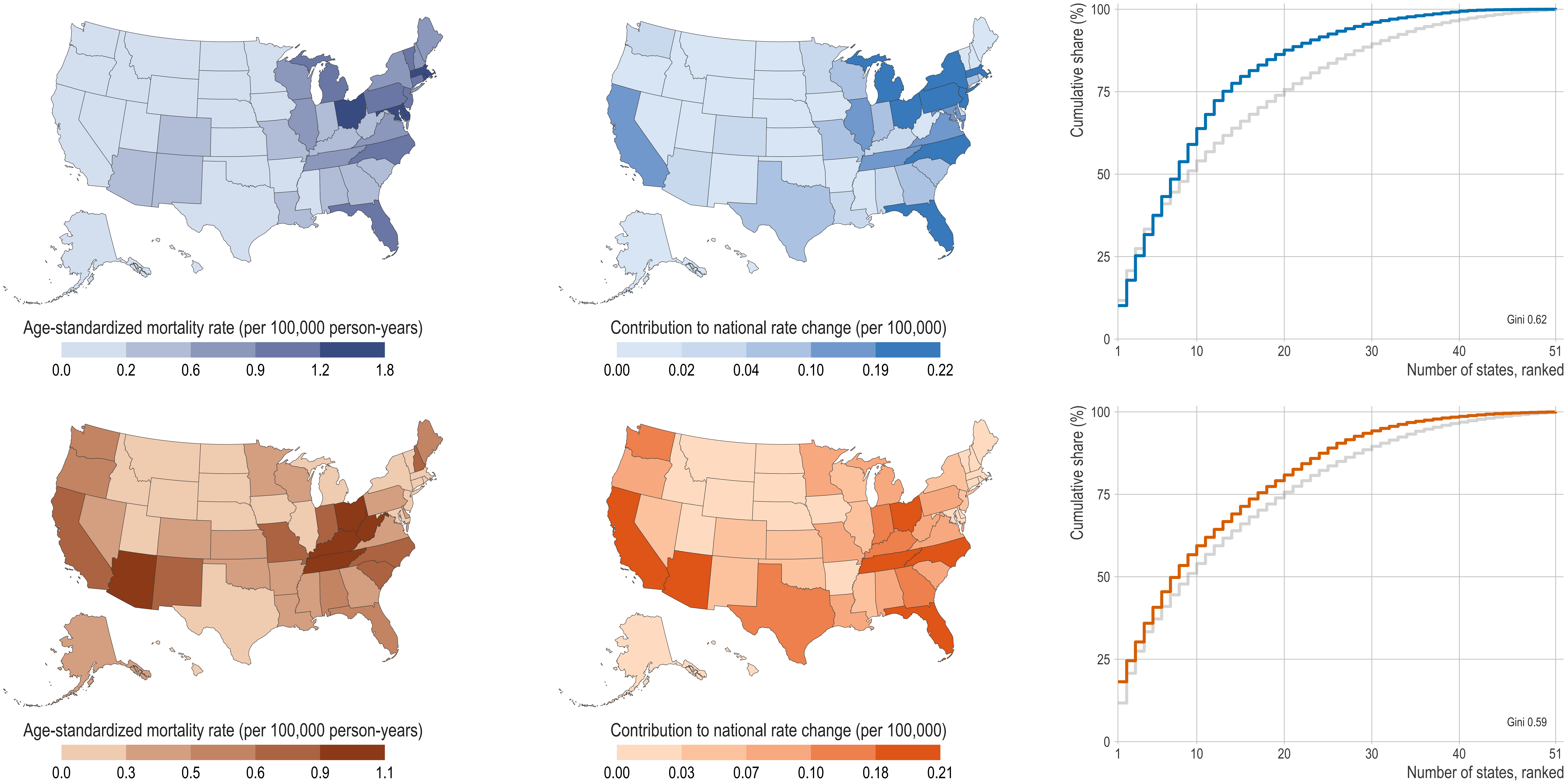
Kitagawa Decomposition

$$R_2 - R_1 = \underbrace{\sum_a \frac{m_{1,a} + m_{2,a}}{2}(\pi_{2,a} - \pi_{1,a})}_{\text{composition}} + \underbrace{\sum_a \frac{\pi_{1,a} + \pi_{2,a}}{2}(m_{2,a} - m_{1,a})}_{\text{rate}}$$

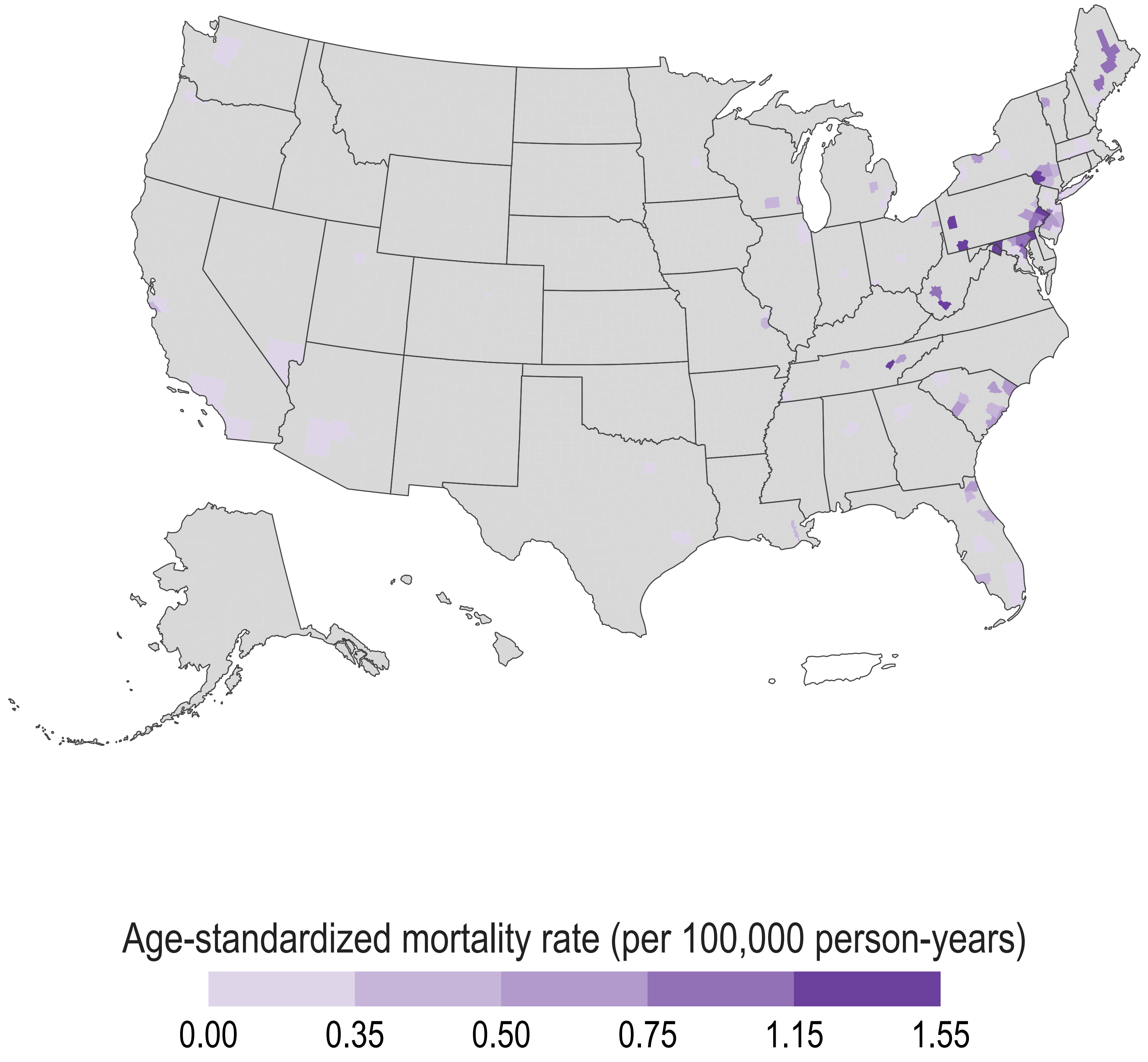
- Decomposition is **exact** so uncertainty is only via negative binomial
- Results only show the <u>rate</u> component

Fentanyl + methamphetamine 2x higher

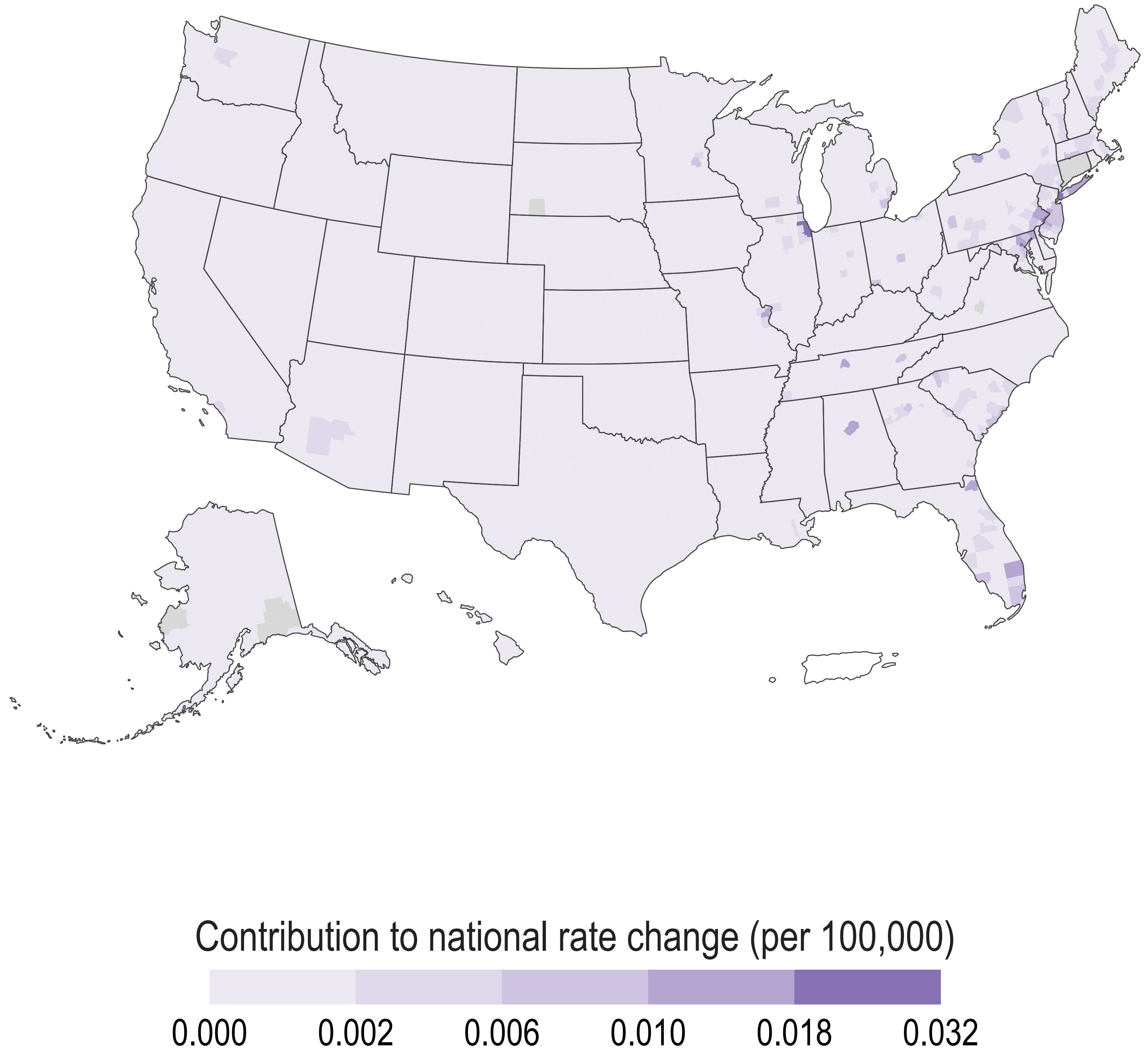
State-level comparison



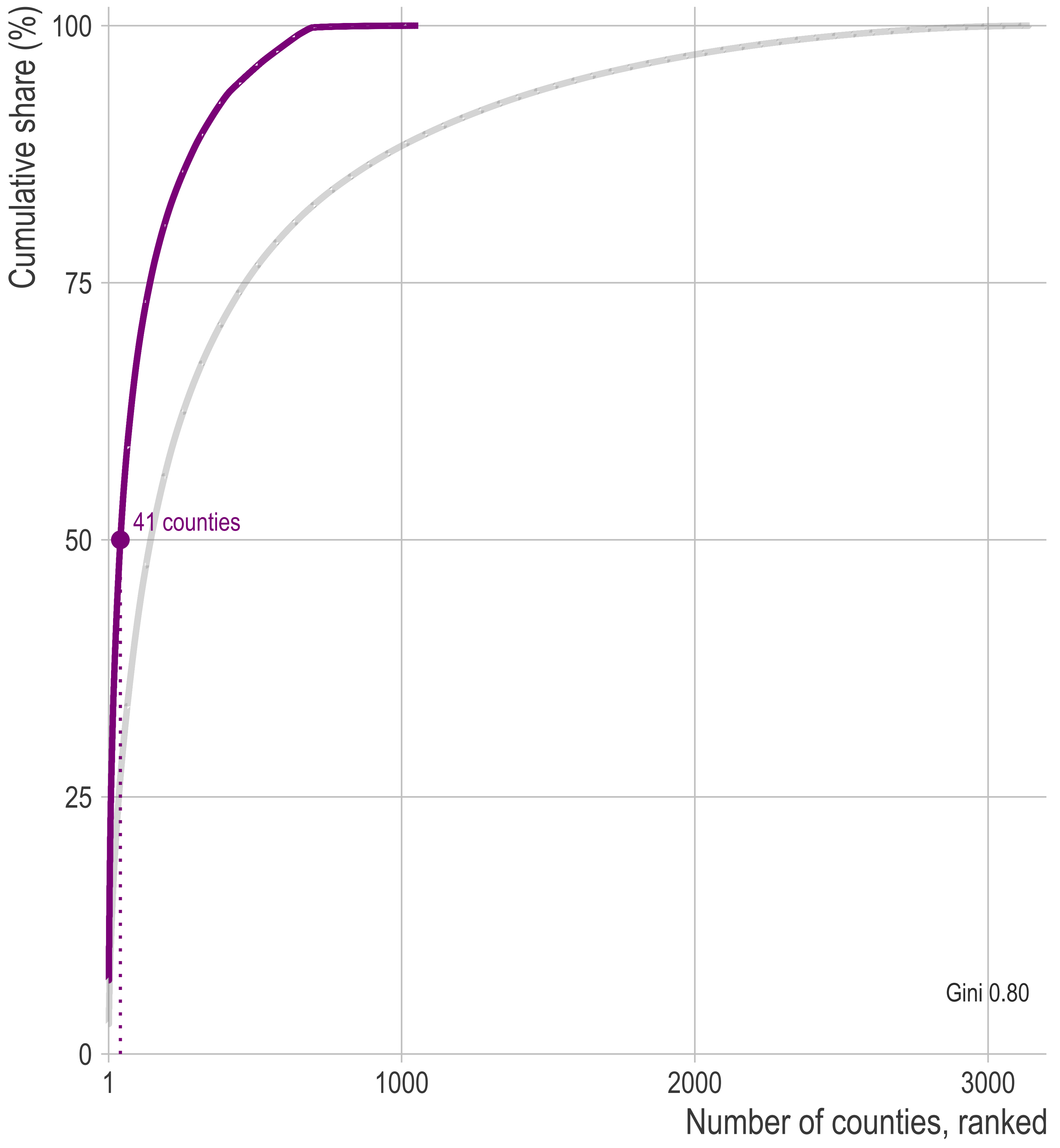
Xylazine



Age-standardized mortality rate (per 100,000 person-years)
0.00
0.35
0.50
0.75
1.15
1.55



Contribution to national rate change (per 100,000)
0.000
0.002
0.006
0.010
0.018
0.032



Cumulative share (%)
100
75
50
25
0
41 counties
Gini 0.80
1
1000
2000
3000
Number of counties, ranked