Measuring the quality of mortality data in high-income settings

Amy Mann, Mathew Kiang, Monica Alexander

Toronto Data Science Workshop, January 14, 2026

Motivation

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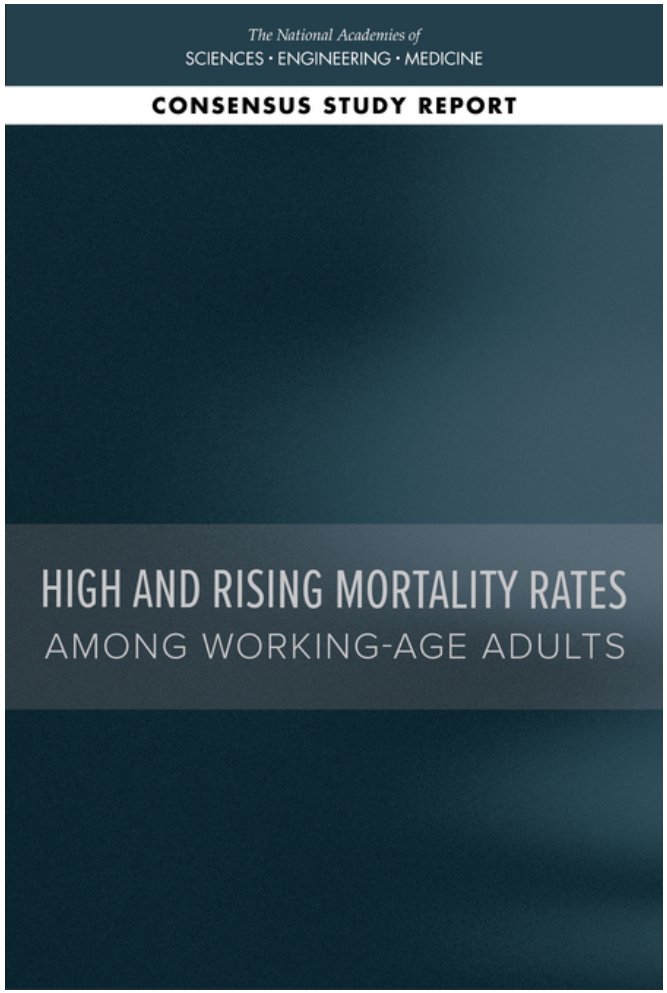

[NASEM; 2021]

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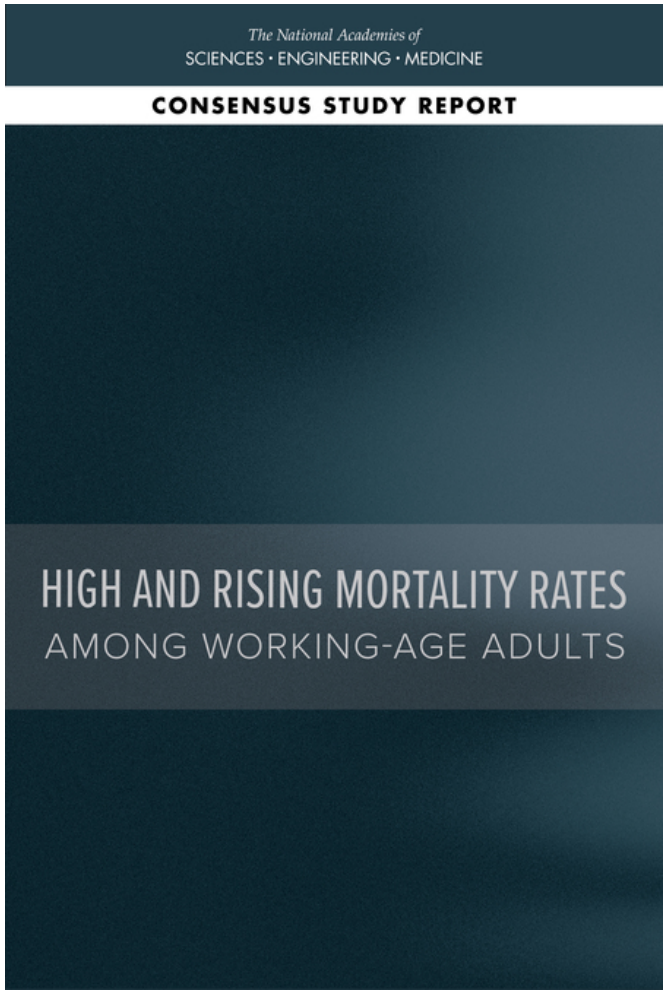

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- More than 5,000 papers have cited US CDC's vital statistics system in the last ten years

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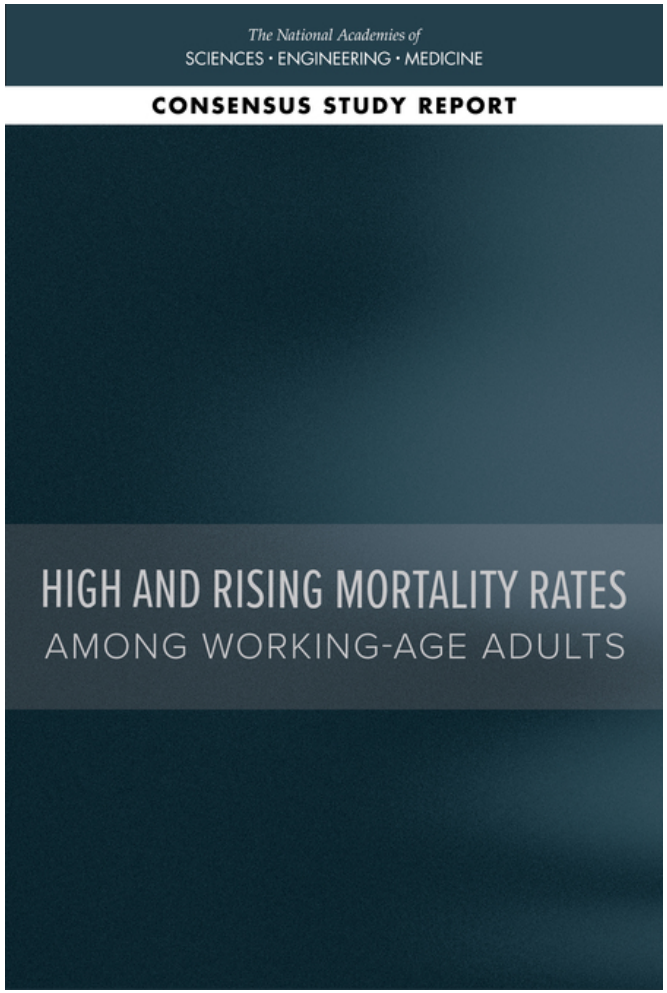

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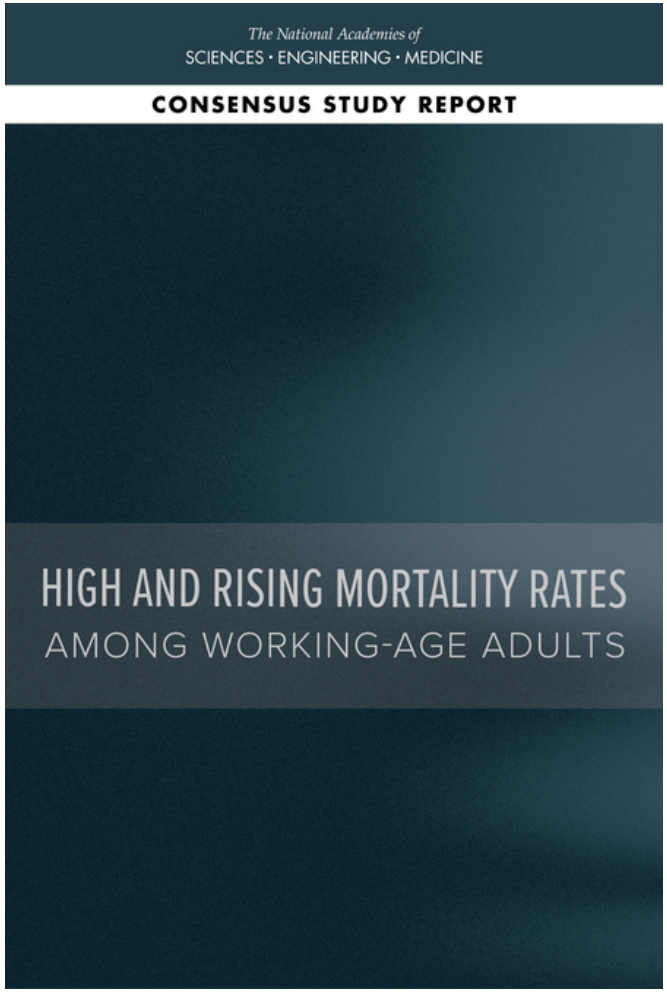

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- More than 5,000 papers have cited US CDC's vital statistics system in the last ten years
- Often taken for granted in high-income countries that mortality data is reliable
- Most data quality papers focus on low-income settings and national registries. We are interested in sub-national differences in data quality

Death certificate coding

Death certificate coding

U.S. STANDARD
CERTIFICATE OF DEATH

DECEDENT
PARENTS
INFORMANT
DISPOSITION
PRONOUNCING PHYSICIAN ONLY
CAUSE OF DEATH
CERTIFIER
REGISTRAR

[NAS; 2003]

Death certificate coding


U.S. STANDARD
CERTIFICATE OF DEATH

[NAS; 2003]

Disease or condition that led directly to the death

Intermediate cause of death

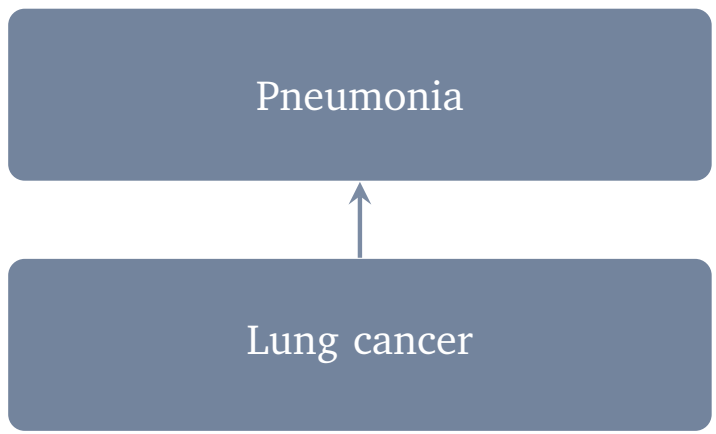
Underlying cause of death

Death certificate coding example

Death certificate coding example

Lung cancer

Death certificate coding example



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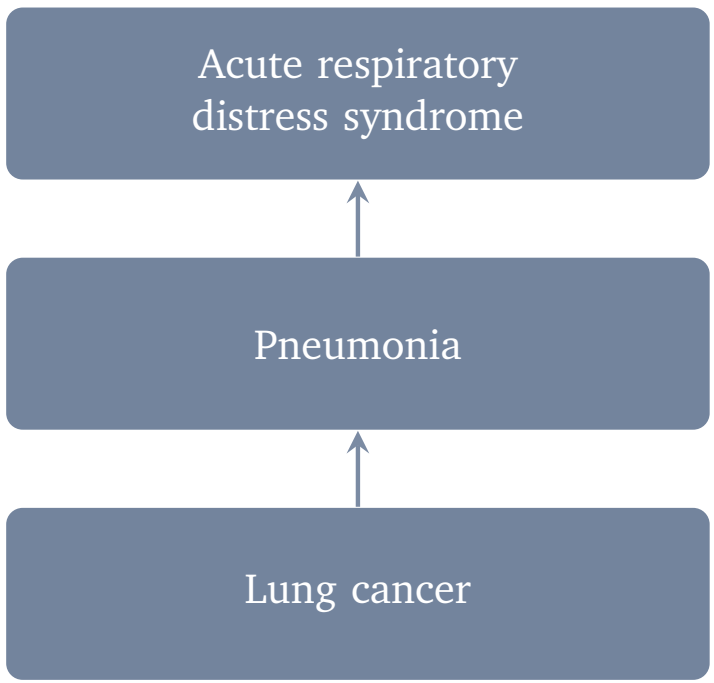

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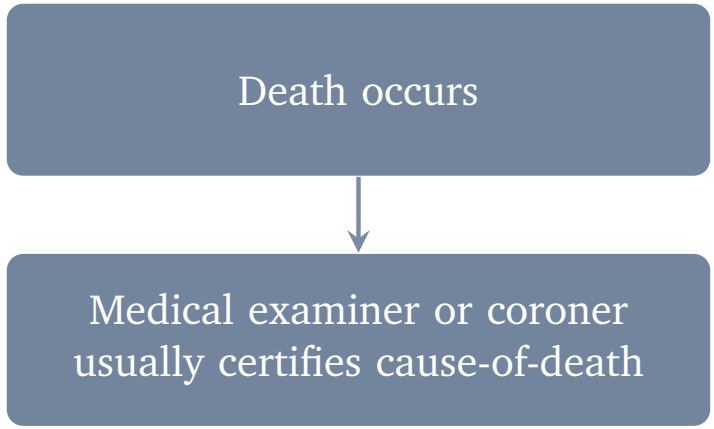

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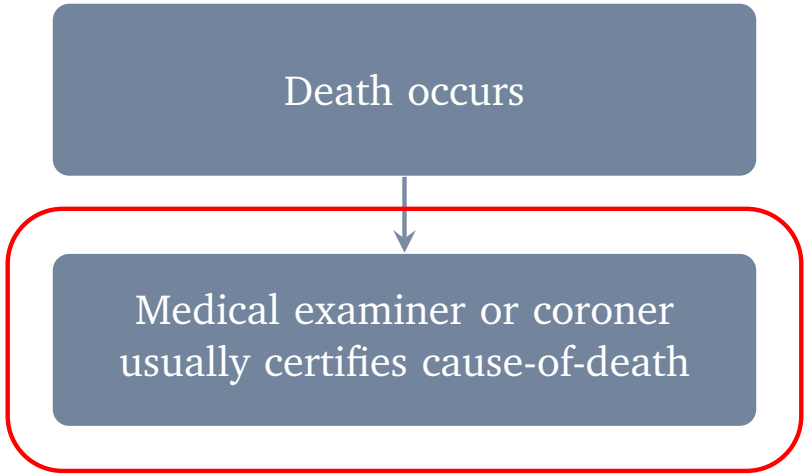

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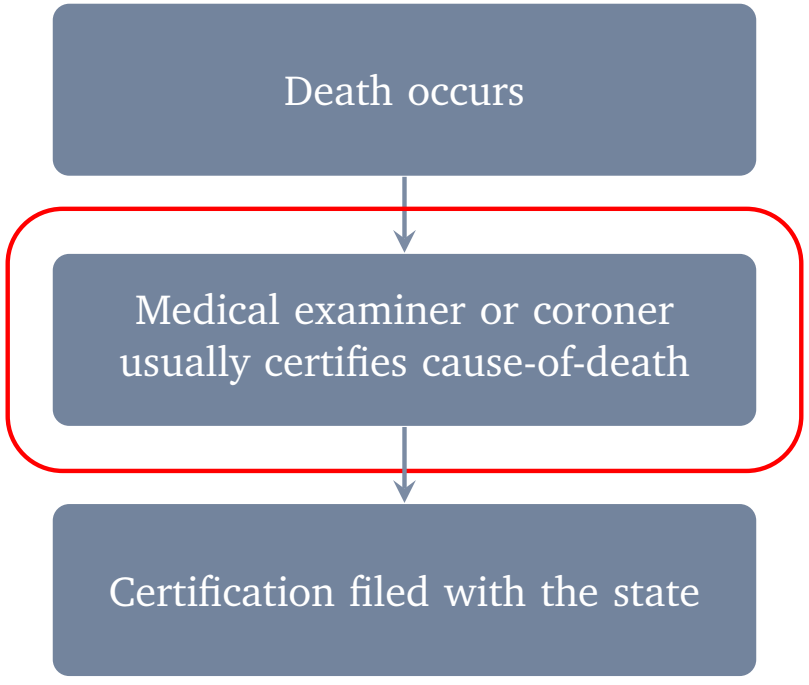

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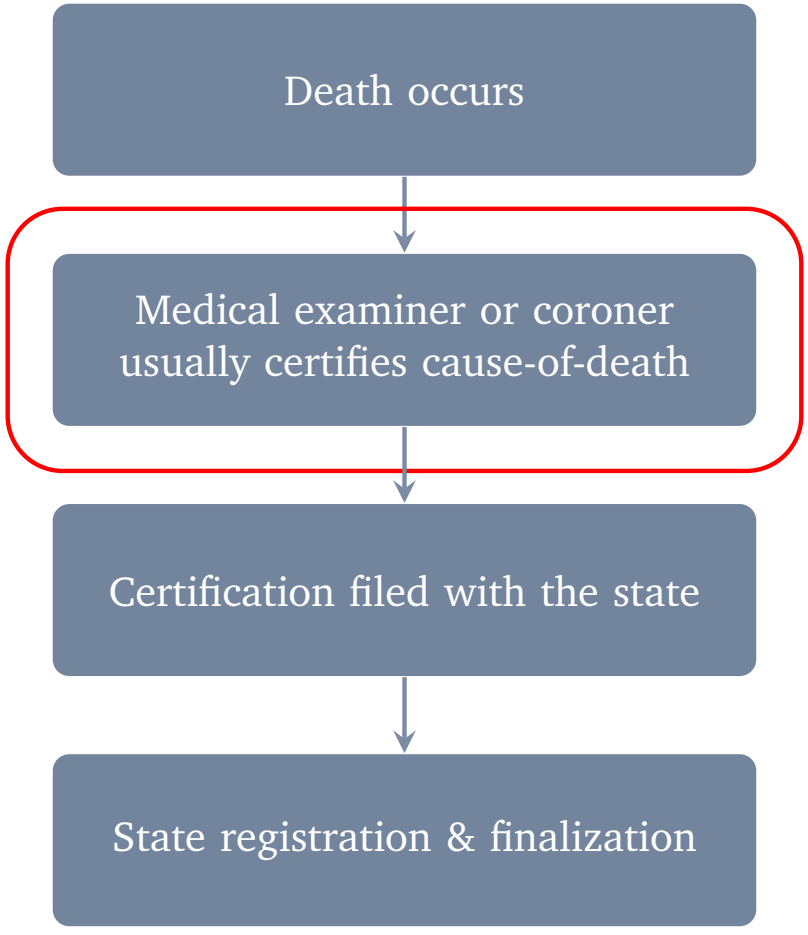

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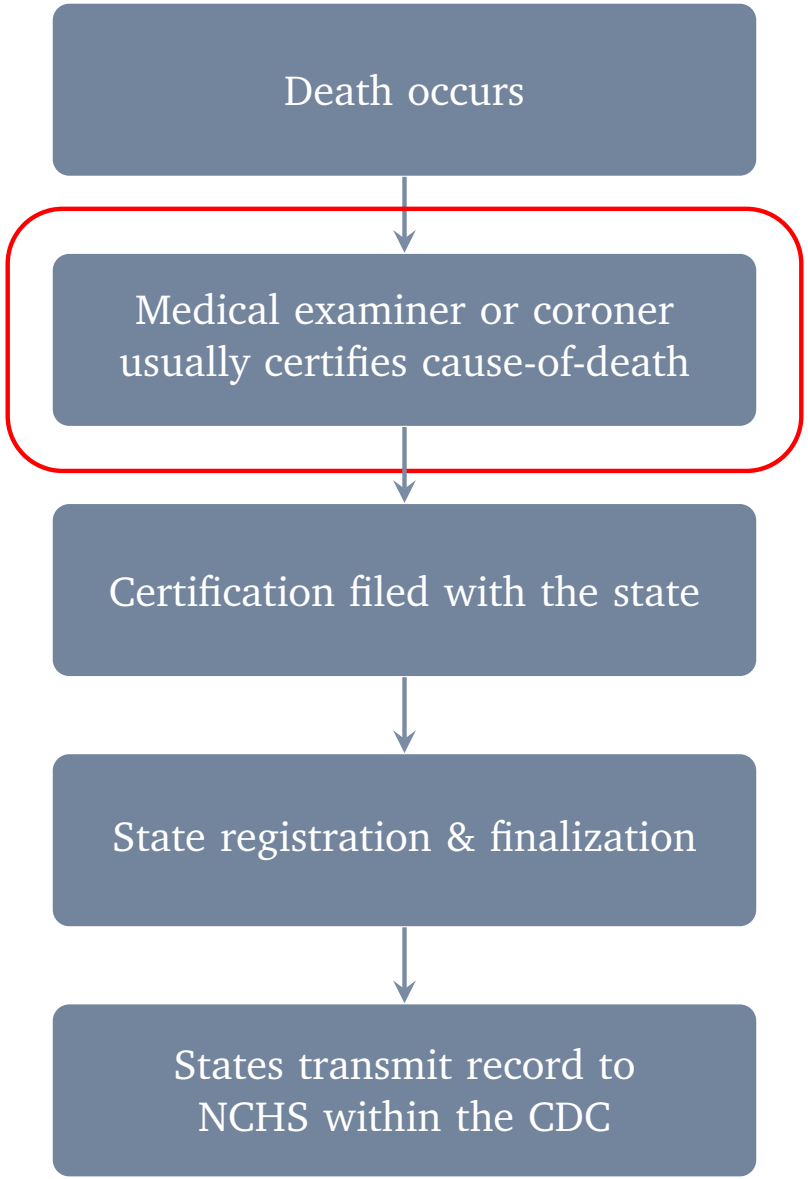

Data quality problems

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In the paper, we look at 3 aspects of data quality and then apply these metrics to the US at a county-level.

Methods

Proportion of garbage codes

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- Lozano et al, 2012 show that re-distributing garbage codes changes the top 10 leading causes of death worldwide.
- In 2023, about 10% of deaths in the United States were garbage coded.

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- Another way to think about this is that we are interested in the diversity within each cause of death category.

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- Here, $w_{k,t}(d \mid c)$ is the within-cause distribution of ICD-10 codes in county set k, and $s_t(c)$ is the national share of cause group c.
- $p^*_{k,t}(d)$ represents the probability that a death in county set k would be coded as ICD-10 code d, *if the county had the national cause-of-death mix*.

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We then measure how spread out this standardized ICD-10 distribution is using Shannon entropy.

$$H_{k,t} = -\sum_d p^*_{k,t}(d) \log p^*_{k,t}(d)$$

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- We rescale entropy to a 0-100 score to obtain the level of detail.

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$h_i :=$ normalized Shannon entropy for record i

$K_g =$ candidate underlying causes of death

$p_i(k) =$ probability candidate k is the true cause of death

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$$\text{RI} := 1 - \frac{\sum_{i \in G_{c,t}} h_i}{N_{c,t}} \in [0, 1]$$

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- For example, $z_{\text{avg}} = 1$ means the county set has, on average, one standard deviation better data quality than the mean

Results

Aggregate data quality index

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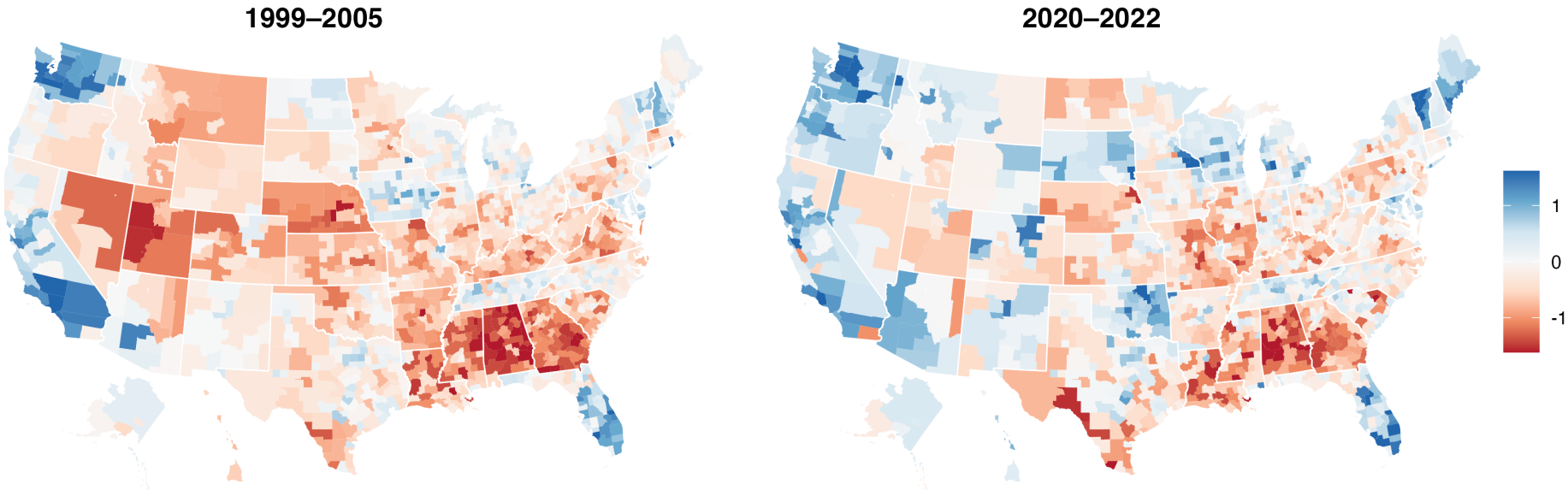

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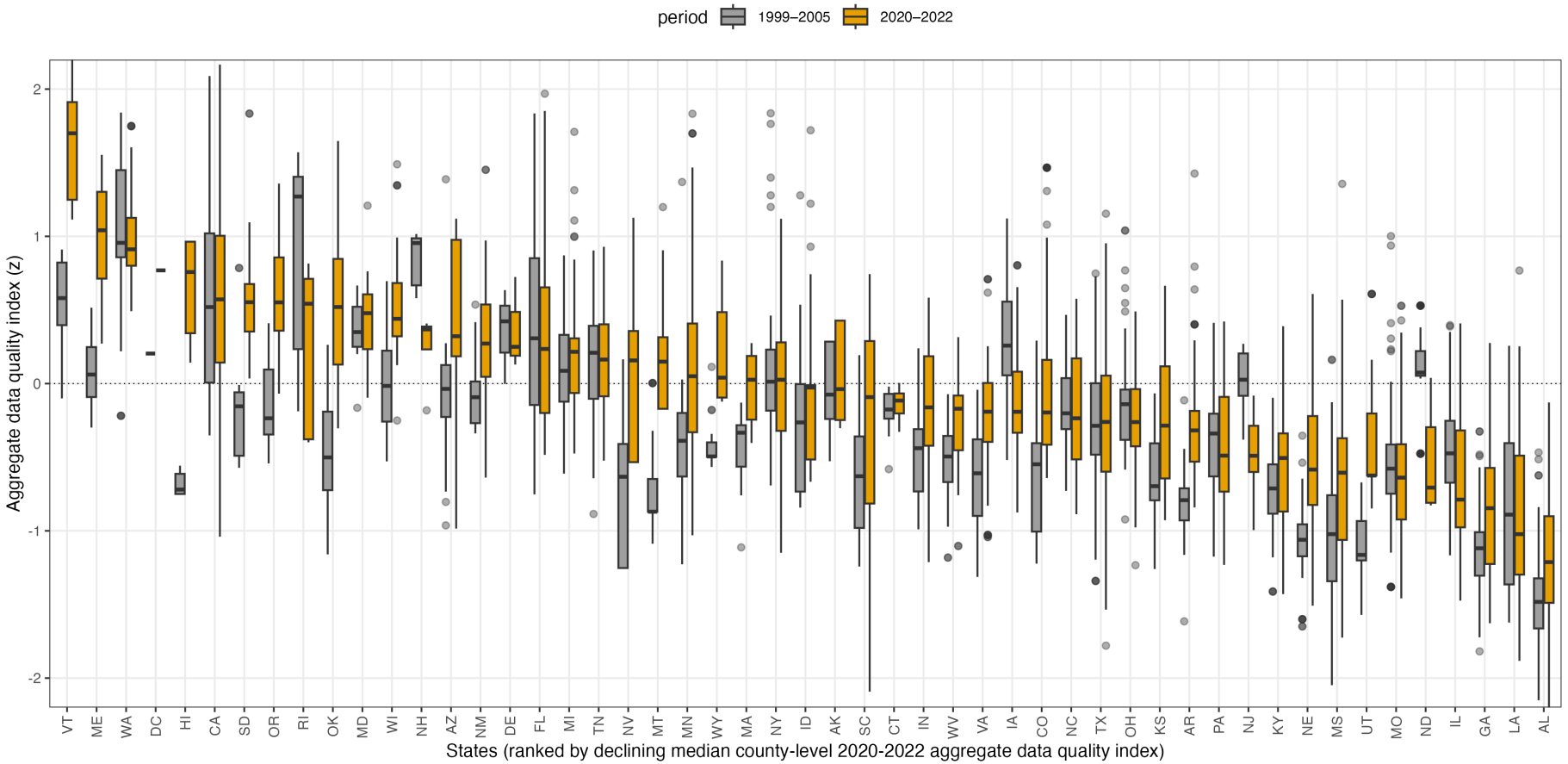

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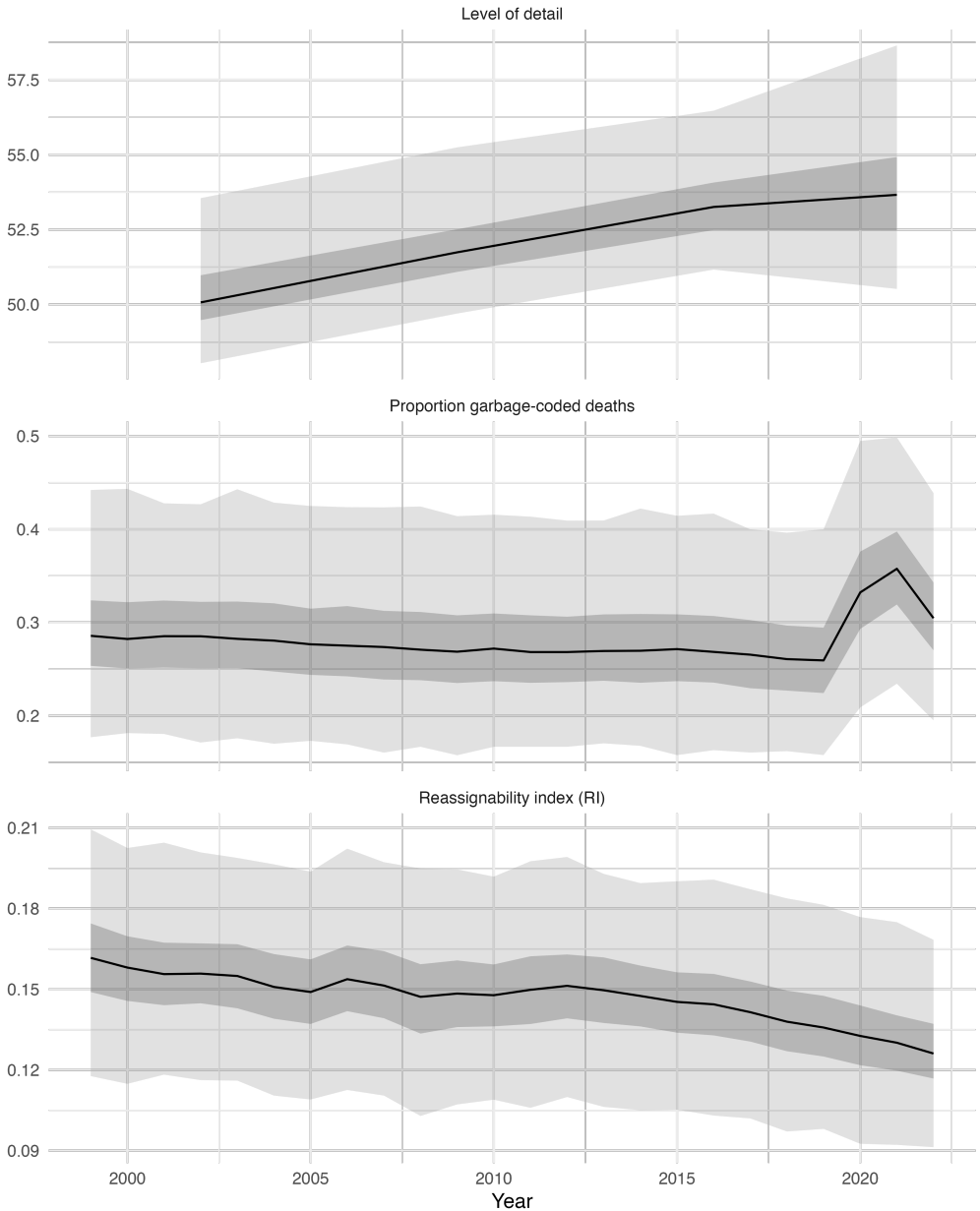
- Correlation with median county income is 0.31 in 1999-2005 and 0.37 in 2020-2022
- Per-capita public health spending correlation is 0.17 in 1999-2005 and 0.14 in 2020-2022
- Association with reporting type is 0.33 in 1999-2005 and 0.34 in 2020-2022

Data quality over time



Level of detail

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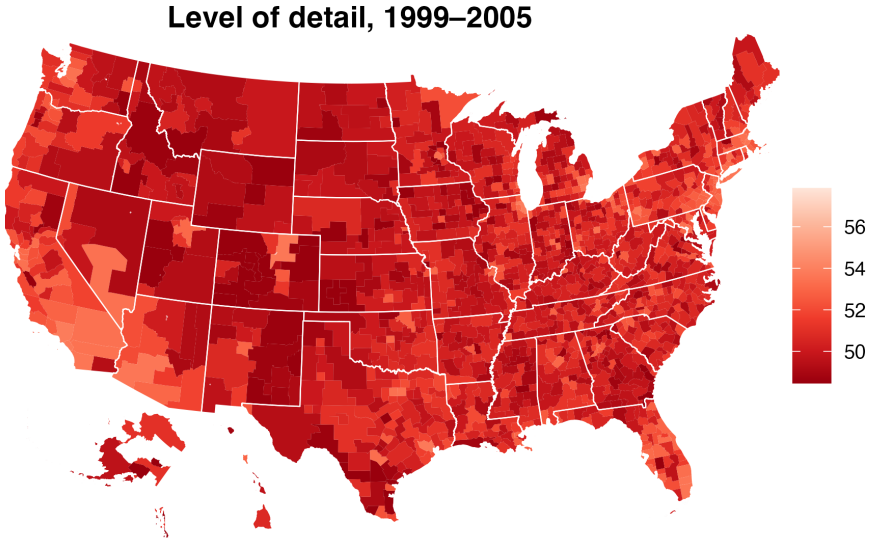
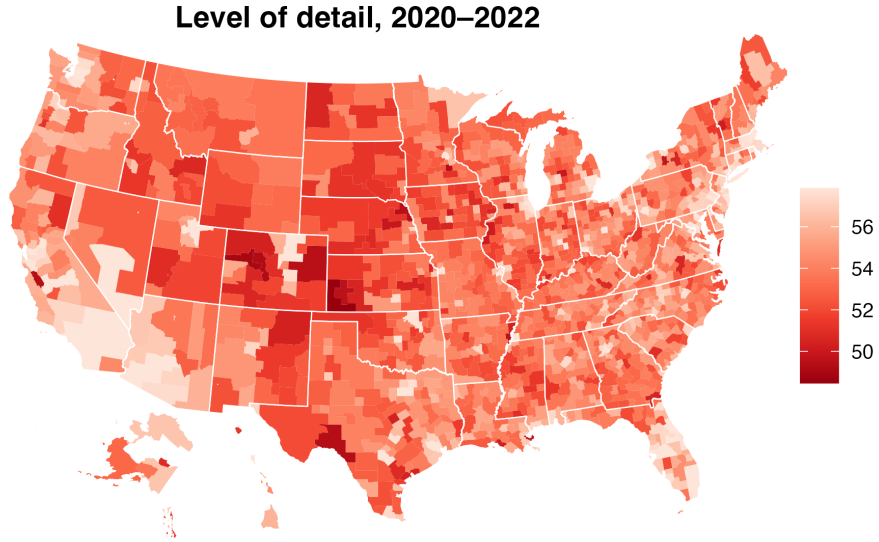
B





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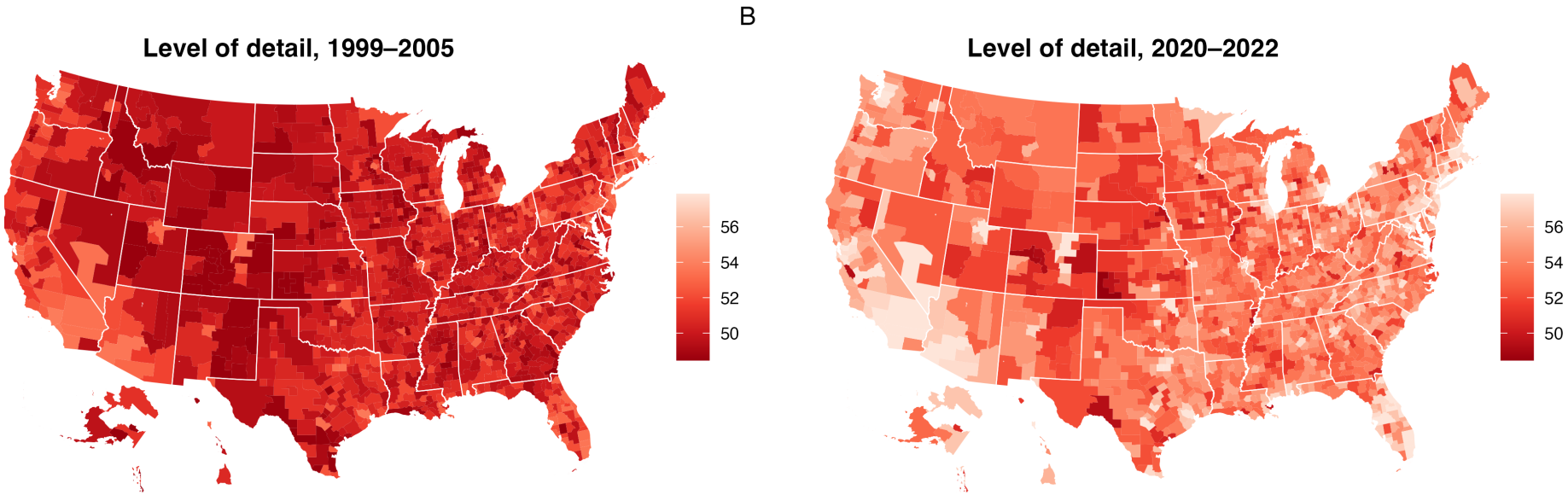

- Increased from 1999-2022; unclear to what extent it is driven by increasing diversity in cause of death in general (the underlying cause mixture is controlled for by period, not globally) or by improved specificity in coding

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- Higher level of detail associated with higher median county income ($\rho = 0.23$ in 1999-2005; 0.26 in 2020-2022),
- Higher level of detail with death investigation system type ($\rho = 0.24$ in 1999-2005; 0.27 in 2020-2022).
- Small association between detail and per-capita public health spending ($\rho = 0.08$ in 1999-2005; 0.05 in 2020-2022).

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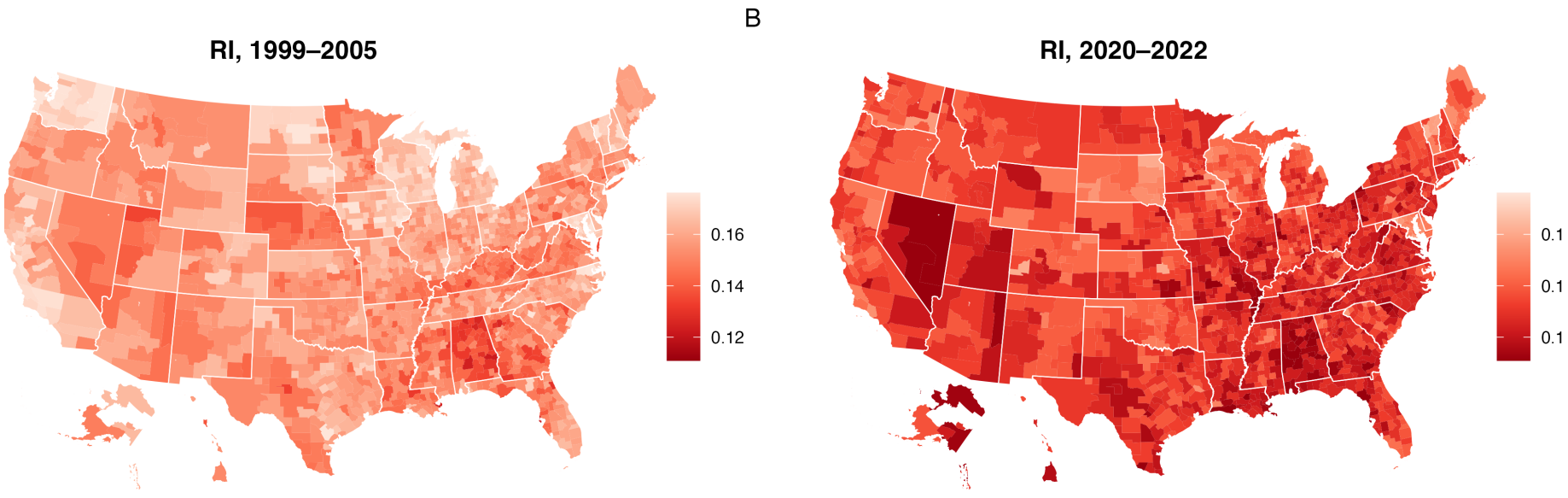

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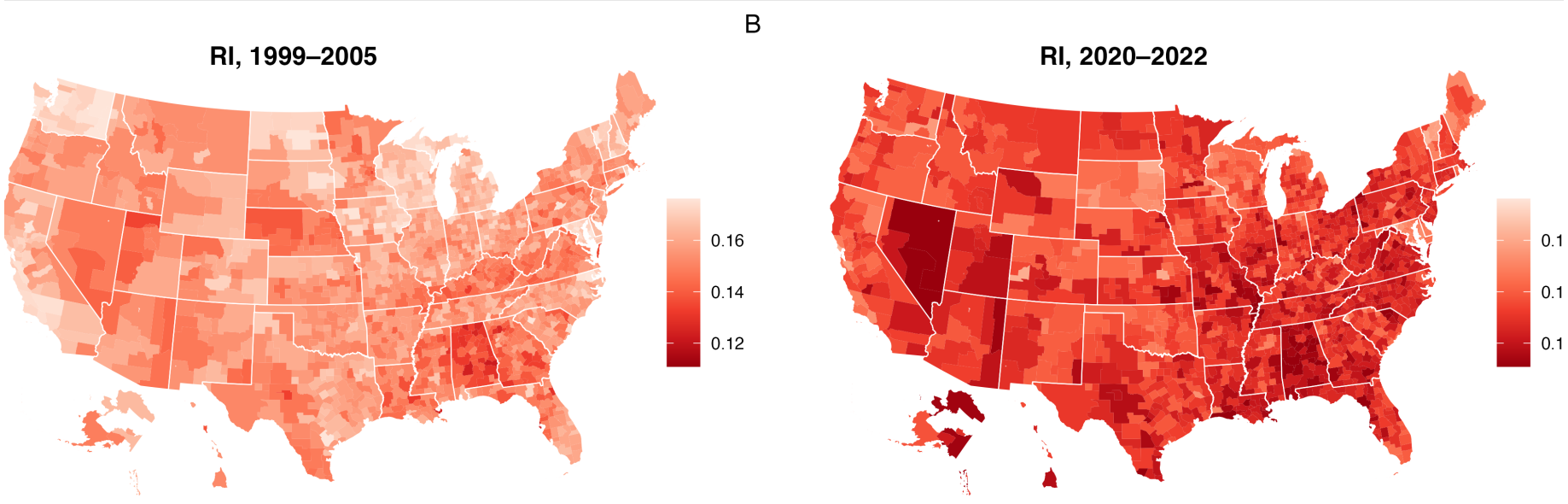

- Positively correlated with mean county income ($\rho = 0.14$ in 1999-2005; 0.13 in 2020-2022) and with per-capita public health spending ($\rho = 0.09$ in 1999-2005; 0.08 in 2020-2022)

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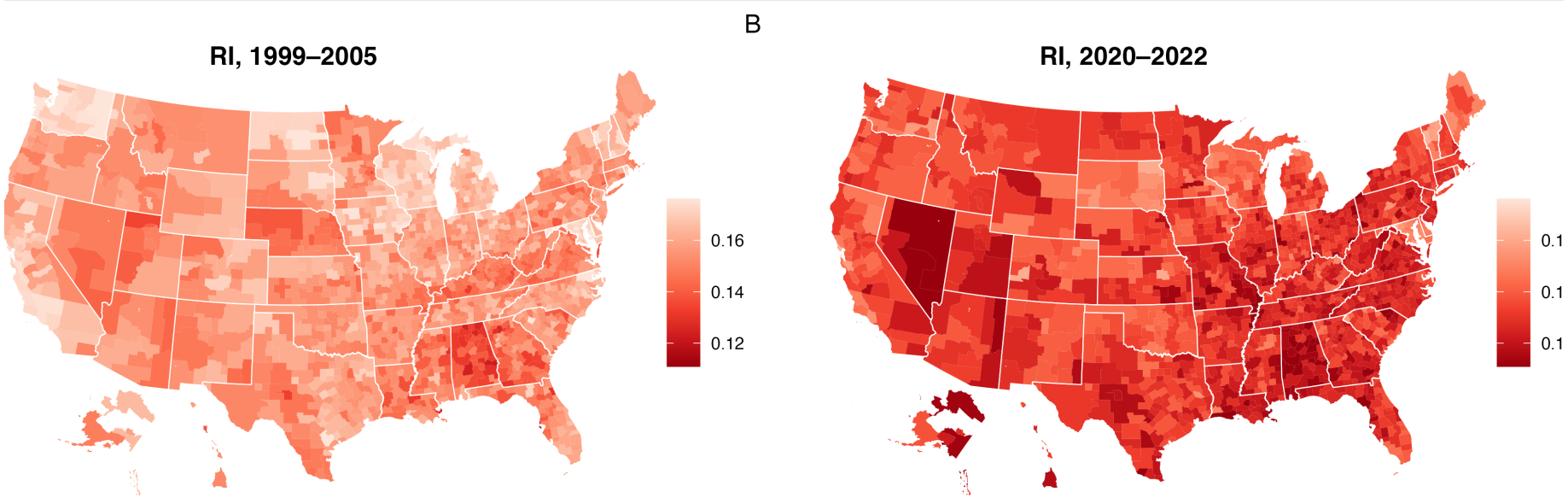

- Positively correlated with mean county income ($\rho = 0.14$ in 1999-2005; 0.13 in 2020-2022) and with per-capita public health spending ($\rho = 0.09$ in 1999-2005; 0.08 in 2020-2022)

- Small differences by reporting type ($\rho = 0.11$ in 1999-2005; 0.06 in 2020-2022).

Proportion of garbage codes

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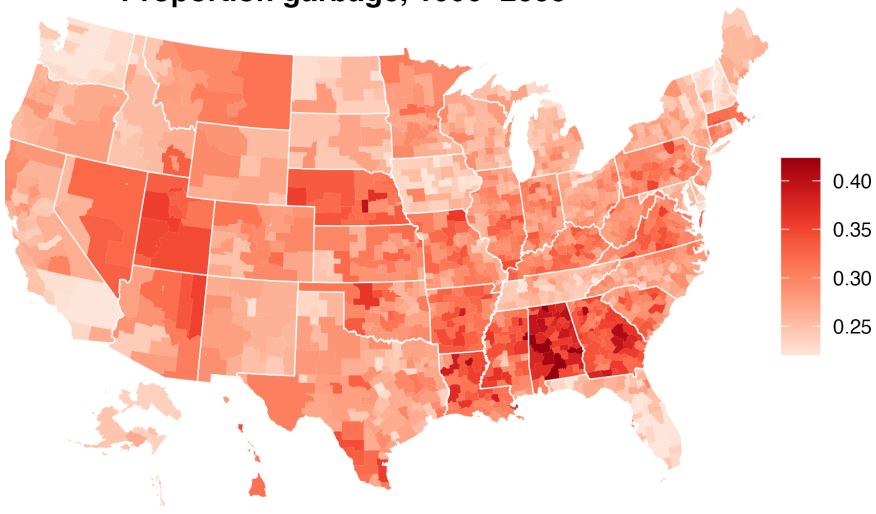

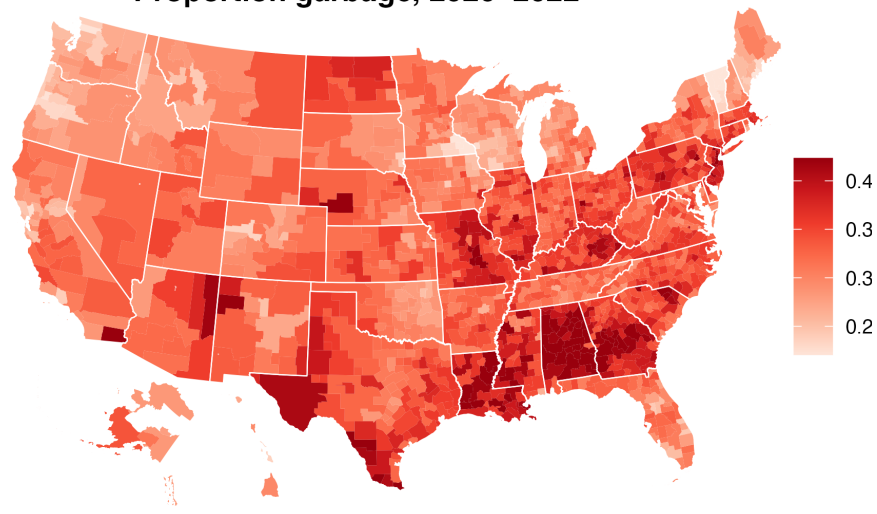

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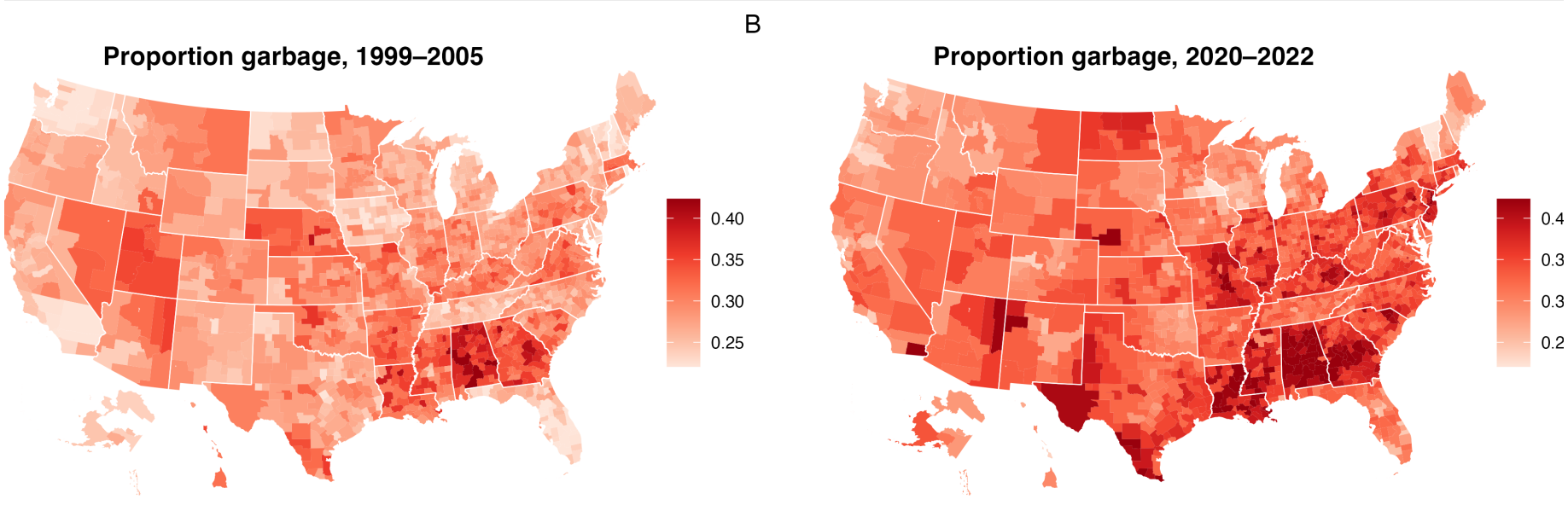

- Decreased from 1999-2019 and increased during the COVID-19 pandemic
- The proportion of garbage-coded deaths was lower in higher-income counties (ρ = -0.25 in 1999-2005; -0.29 in 2020-2022)

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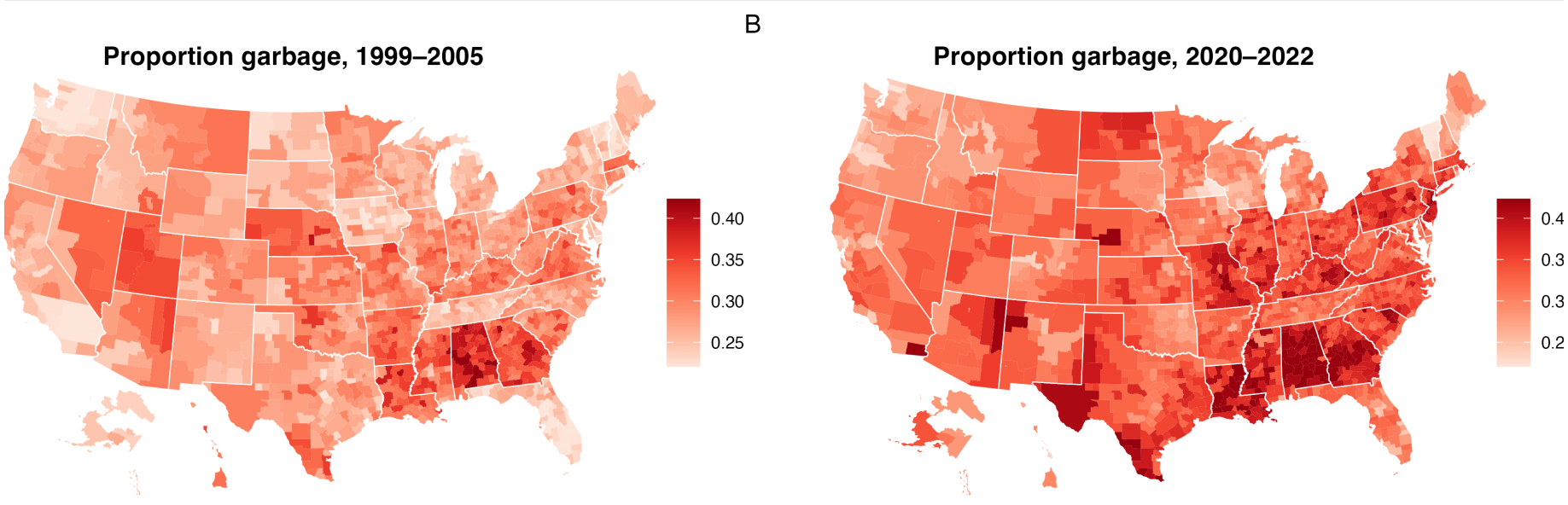

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- The proportion of garbage-coded deaths was lower in higher-income counties (ρ = -0.25 in 1999-2005; -0.29 in 2020-2022)
- Lower in counties using medical examiners (ρ =-0.31 in 1999-2005; -0.34 in 2020-2022) and associated with per-capita public health spending (ρ = -0.21 in 1999-2005; -0.15 in 2020-2022)

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- Correlation between lower aggregate data quality index and COVID-19 underreporting is 0.33

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- Low RI suggests incomplete or generic MCOD reporting and is likely most affected by jurisdictional differences in death certificate coding practises
- The strong state-specific effects on data quality is something to be optimistic about

Thank you!

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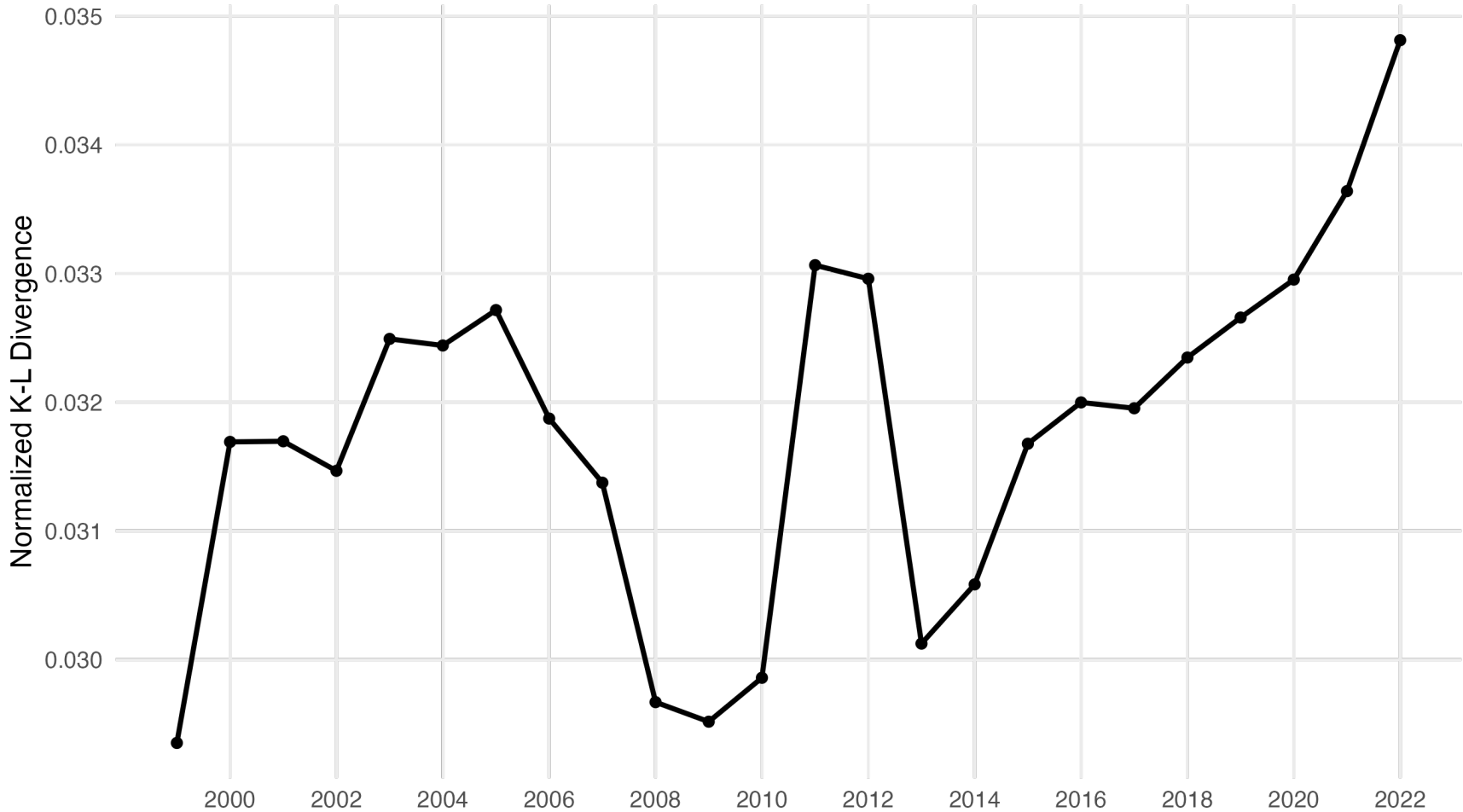
Supported by Data Sciences Institute

Supplementary Material

Why is it getting harder to re-assign garbage codes?



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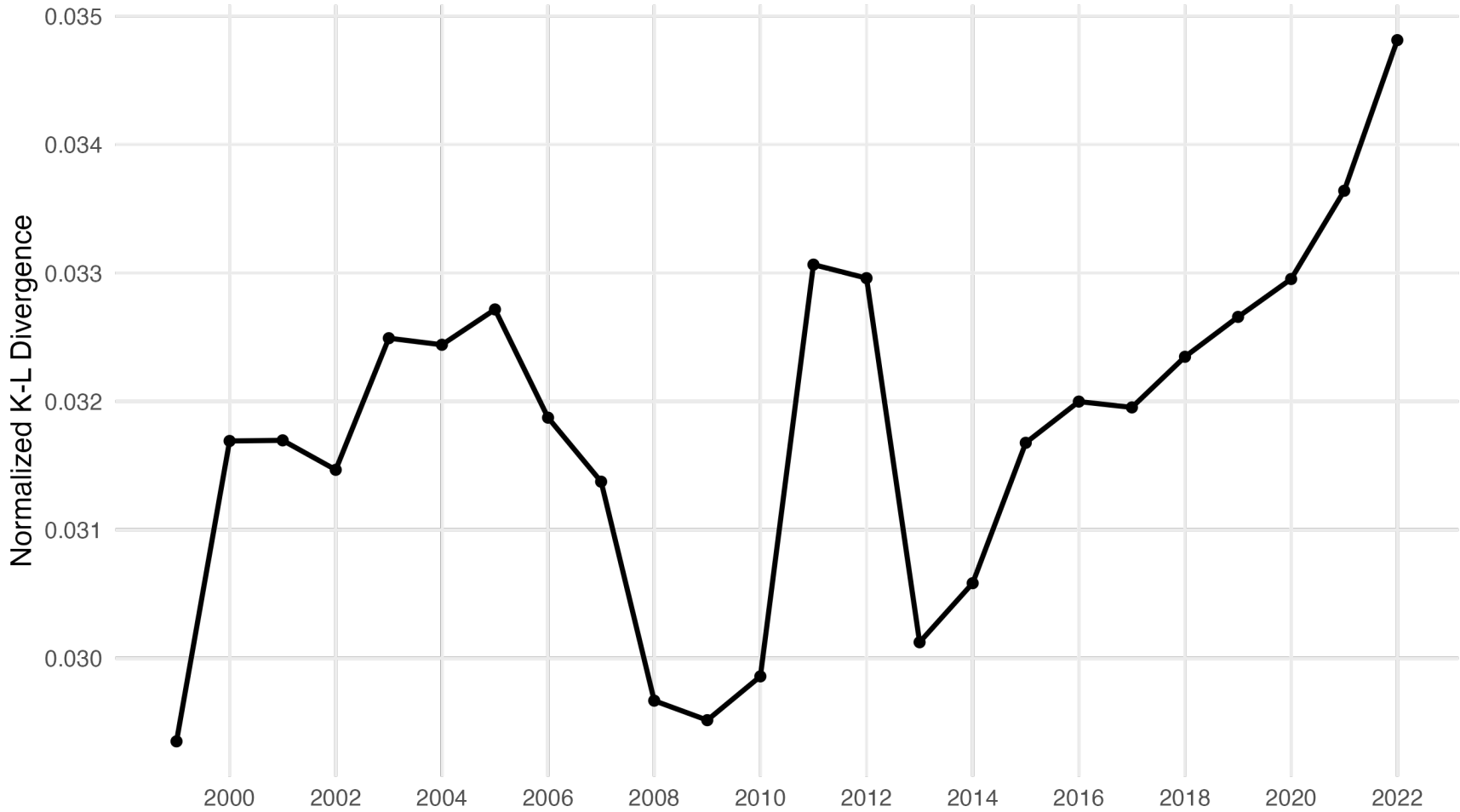

It's probably not because death certificates are becoming less descriptive.