Convergence of Cancer Mortality Rates Across U.S. States: The Role of Socioeconomic and Behavioral Risk Factors

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September 2025

K E Y W O R D S

Cancer Mortality; Convergence; Geographic Disparities; Cancer Prevention and Care; Cancer Risk Factors

A B S T R A C T

Background:
Geographic disparities in U.S. cancer mortality rates raise concerns about whether different states benefit equally from advances in best practices for cancer prevention, early detection, and care. This study assesses evidence consistent with U.S. states catching up to best practices after accounting for state-level differences in cancer risk factors.

Methods:
We analyze age-adjusted cancer mortality rates across 48 U.S. states and assess their convergence over the period from 1997 to 2021. Specifically, we examine whether states with initially higher mortality rates have experienced steeper declines in those rates over time, both with and without adjusting for state-level differences in cancer-related risk factors. We also investigate whether risk factors themselves have converged over time.

Results:
There is little evidence of unconditional convergence in cancer mortality across U.S. states. However, when controlling for risk factors such as smoking, obesity, share of manufacturing employment, and per capita GDP, convergence becomes apparent. Conditional on those risk factors being similar, if one state's mortality rate is higher than another's, then roughly half of the gap closes within 12 years. Persistent disparities in cancer-related risk factors largely explain the absence of unconditional convergence.

Conclusions:
The findings suggest convergence, though at a slow rate, toward best practices for cancer prevention and treatment across U.S. states. In addition to improving the dissemination of effective cancer control strategies, reducing disparities in state-level cancer mortality rates will require addressing ongoing socioeconomic and behavioral factors that influence cancer outcomes.

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This version: September 2025
Data and replication files are available at: https://github.com/ACOlivei/US-States-Cancer-Mortality

1. Introduction

Cancer mortality rates in the United States have declined since the 1990s. [1] However, demographic and geographic disparities persist, presenting a significant health challenge. [2-3] As best practices in cancer prevention, early detection, and treatment spread nationwide, one might expect these disparities to narrow. [4] This study evaluates whether cancer mortality rates across U.S. states have converged from 1997 to 2021, consistent with progress toward the widespread adoption of effective cancer control strategies. We also analyze factors that contribute to persistent differences in cancer mortality rates across states, despite the dissemination of knowledge and care. A better understanding of the factors that enhance or impede convergence can help guide policy efforts aimed at reducing differences in cancer outcomes across the country. [5,6]

2. Data and Sample

This study examines cancer mortality rates across the 48 contiguous U.S. states over six four-year periods, starting in 1997. The periods are 1997-2001, 2001-2005, …, up to 2017-2021. The sample includes 288 observations (48 states times 6 periods). The start date depends on state-level GDP data availability. Age-adjusted state-level cancer death rates are from the CDC Wonder database (ICD-10 codes C00-C97 from 1999 onward, and ICD-9 codes 140-208 for 1997-1998). State-level population data are sourced from the same dataset. State-level data on the percentages of obese individuals and everyday smokers come from the CDC Behavioral Risk Factor Data Portal. Real, or inflation-adjusted, state-level GDP data have been sourced from the Bureau of Economic Analysis and transformed on a per capita basis. State-level manufacturing employment data, expressed as a percentage of total employment, come from the Bureau of Labor Statistics Current Employment Statistics.

3. Measures

The primary outcome is the four-year change in the log of age-adjusted cancer mortality rates at the state level, calculated as the log death rate at the end of each period minus the log death rate at the beginning. For example, for the 1997–2001 period, the outcome is the log mortality rate in 2001 minus that in 1997. The change is explained using the initial mortality rate at the start of the period (e.g., 1997 for the 1997–2001 period), along with a set of state-level controls also measured at the beginning of each period. These include the log-transformed values of the percentage of everyday smokers, the percentage of the population classified as obese, the share of employment in manufacturing, and per capita real GDP. This approach is applied across all six periods.

4. Statistical analysis

The analysis seeks to determine whether states with higher initial cancer mortality rates catch up to those with lower rates. Our approach is common in the demographic literature examining convergence in mortality rates across regions over time. [7,8] We conduct ordinary least squares (OLS) regressions using pooled data from 48 states over six non-overlapping four-year periods. The dependent variable is the four-year change in the log of the cancer mortality rate; explanatory variables include the log of the initial mortality rate and a set of log-transformed state-level controls measured at the start of each period. These regressions include constants for each time period, which account for national changes over time.

To assess convergence in the control variables themselves, we run separate OLS regressions for each control, using the four-year change as the dependent variable and the initial value as the explanatory variable, again with period indicators. The statistical analysis uses a two-sided p-value of .05. All regressions were executed using the `reg` command in Stata 18.

5. Results

Figure 1 presents a boxplot of log cancer mortality across states from 1997 to 2021. Cancer mortality rates declined nationally – the median state-level rate fell by approximately 32%. However, the dispersion across states remained stable. The standard deviation of the log cancer mortality rate was 0.0870 in 1997 and 0.0967 in 2021, indicating no clear trend toward convergence. The first column of Table 1 confirms this pattern by regressing the 4-year change in state-level cancer mortality on the initial state-level mortality for the six periods from 1997 to 2021, while also controlling for period-specific effects (not reported in the table). A reduction in dispersion would be consistent with a negative coefficient for initial rates, implying that states with higher mortality would experience greater declines. The estimated coefficient on the initial rate is −0.035 (SE = 0.022, $p = 0.117$), suggesting only weak and statistically insignificant convergence as the gap in initial mortality closes by roughly 15% over two decades – an extremely slow pace. This result provides little evidence of unconditional convergence.

The next column shows how convergence findings change when controlling for factors affecting cancer mortality disparities across states, such as tobacco usage, obesity, the share of manufacturing workers, and per capita GDP. Tobacco and obesity are established cancer risk factors. [9,10] High occupational exposure to carcinogens in manufacturing and proximity to these activities may also increase cancer risk. [11] The connection between income and cancer death rates could relate to less affordable and less available care. [12] Estimates for these controls have expected signs: tobacco usage, obesity, and manufacturing share correlate positively with changes in cancer mortality, while real per capita GDP correlates negatively. Notably, the coefficient on initial mortality becomes substantially larger in magnitude and highly statistically significant (−0.223, SE = 0.035, $p < 0.001$), implying a much stronger convergence pattern. Figure 1A visually illustrates the improvement in the correlation between the 4-year change in state-level cancer mortality and the initial state-level mortality, after controlling for the risk factors. Conditional on these risk factors, nearly half of the mortality gap between two otherwise similar states closes within approximately 12 years. This evidence, albeit indirect, is consistent with the notion that the diffusion of cancer control best practices contributes to convergence, once differences in structural and behavioral risk factors are taken into account.

Table 2 illustrates one reason for the difference in cancer death rates' unconditional and conditional convergence across states. It presents estimates from regressing the four-year change on the initial value for each control, accounting for period-specific effects. Tobacco usage, the share of manufacturing, and real GDP have not converged over time. There is evidence of convergence in obesity trends; however, these trends have been rising. [13] In short, the fact that some important cancer risk factors have not equalized across states accounts for the persistence of cancer mortality dispersion. Still, conditional on considering these factors, state-level differences in cancer mortality rates have been narrowing.

6. Discussion

Cancer remains the second leading cause of death in the United States, and while national mortality rates have declined since the 1990s, geographic disparities persist. [1] This study explores the ongoing dispersion in cancer mortality rates across U.S. states. We analyze data from 1997 to 2021 for the 48 contiguous states at four-year intervals. This interval length is suitable for assessing convergence in cancer mortality rates, and the repeated cross-section across six distinct four-year periods provides enough observations to control for specific state factors that influence cancer mortality rates.

Three key findings emerge from the analysis. First, from 1997 to 2021, there was a lack of unconditional convergence in cancer mortality rates among states. Second, when accounting for differences in smoking prevalence, obesity, manufacturing employment, and per-capita GDP, a strong pattern of conditional convergence emerges. States with similar levels of these risk factors tend to converge toward comparable mortality rates. This finding provides evidence, although indirect, that advancements in cancer treatment are being adopted nationally and benefiting states with historically higher mortality rates. The estimated rate of convergence is slow, but previous studies have documented significant lags in the adoption of new therapies.

[14-15]. Third, the persistence of geographic disparities is largely driven by the lack of convergence in these underlying risk factors themselves, reinforcing a pattern of divergence in health outcomes where these conditions remain uneven.

One important limitation of this study is the omission of other factors influencing cancer mortality across states, which could bias the estimated rate of convergence. While the analysis could include additional covariates, such as the share of Black population, the share of college-educated individuals, the poverty rate, the share of rural population, and healthcare output per capita, their inclusion did not affect our findings. Specifically, these additional state-level variables do not significantly alter the estimated rate of conditional convergence (see Appendix), although we cannot rule out that other omitted variables might.

7. Conclusion

Geographic disparities in cancer mortality across the U.S. persist, raising the important question of whether all states are effectively leveraging advancements in best practices for cancer prevention, early detection, and care. [6] This study finds that states with similar levels of tobacco use, obesity, manufacturing employment, and per-capita GDP tend to converge to the same cancer mortality rate – suggesting that progress is reaching lagging states. However, broader convergence remains hindered by persistent differences in these underlying risk factors, many of which show little evidence of narrowing. Efforts to reduce cancer mortality disparities must therefore prioritize targeted strategies to close gaps in the underlying social and behavioral drivers of cancer risk across states.

Financial disclosure
No funding was received for this study.

Declaration of competing interest
The author reports no conflict of interest.

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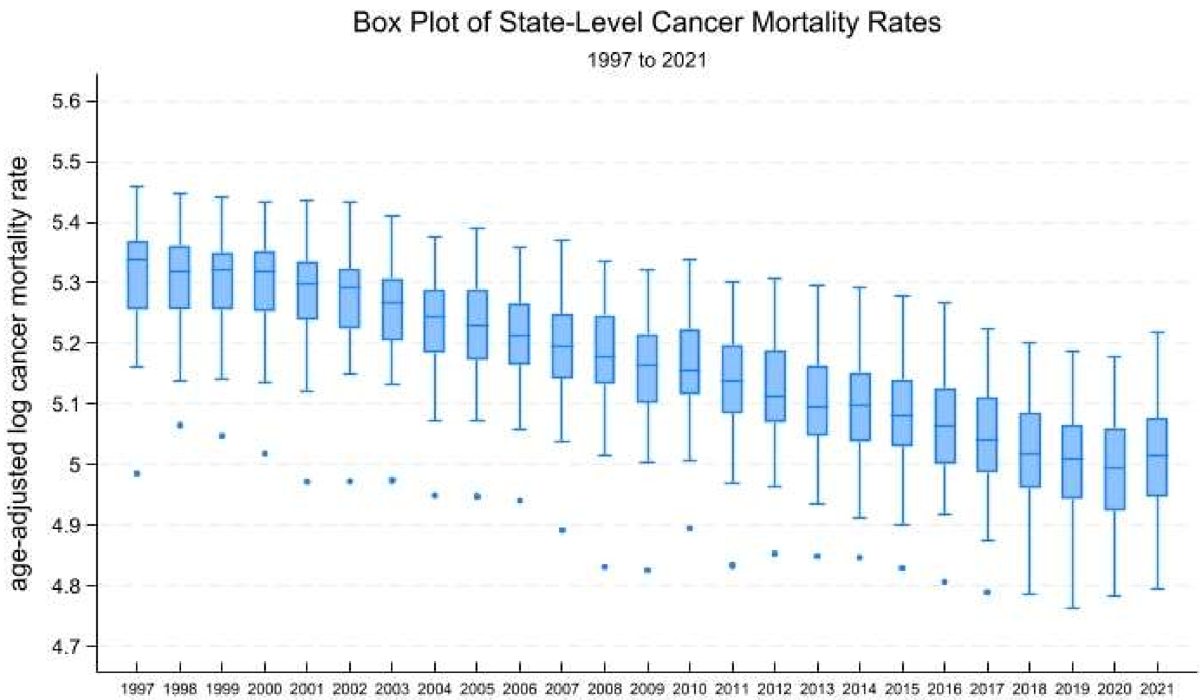

Figure 1. Box plot distribution of age-adjusted log cancer death rates for the 48 contiguous US states (excluding DC) from 1997 to 2021. Each box displays the median log cancer mortality rate for a specific year (represented by the line in the box), while the upper and lower ends of the box indicate the 75th and 25th percentiles, respectively. The whiskers represent the upper and lower adjacent values, defined as the third quartile plus 1.5 times the interquartile range (upper adjacent value) and the first quartile minus 1.5 times the interquartile range (lower adjacent value). Dots represent values outside of the range spanned by the box and whiskers.

Table 1. Estimates of Conditional and Unconditional Convergence in Cancer Mortality Rates

The dependent variable is the 4-year change in the state-level log cancer mortality rate for the periods 1997-2001, 2001-2005, 2005-2009, 2009-2013, 2013-2017, and 2017-2021.

	(1) Without Cancer Risk Factors	(2) With Cancer Risk Factors
Initial Cancer Mortality Rate	-0.0355	**-0.2237**
	SE = 0.0222, |p| = 0.117	SE = 0.0350, |p| < 0.001
Initial Tobacco Use		**0.0735**
		SE = 0.0167, |p| < 0.001
Initial Obesity		**0.0541**
		SE = 0.0154, |p| = 0.001
Initial Share of Manufacturing		**0.0113**
		SE = 0.0029, |p| < 0.001
Initial Per-Capita GDP		**-0.0245**
		SE = 0.0079, |p| = 0.003
Number of Observations	288	288
R-squared	0.217	0.380

Note: SE = standard errors. Standard errors are clustered at the state level. Indicator variables (not reported) for each of the six periods considered are included in the analysis. Estimates in bold indicate that the 95 percent confidence interval does not include zero. All explanatory variables are expressed in logs. For example, in column (2), the value of -0.2237 means that a one percentage point higher initial cancer mortality rate lowers the following 4-year change in mortality rate by 0.2237 of one percentage point.

Table 2. Estimates of Unconditional Convergence in Cancer Risk Factors

The dependent variable is the 4-year change in each specific cancer socio-economic risk factor, for the periods 1997-2001, 2001-2005, 2005-2009, 2009-2013, 2013-2017, and 2017-2021.

	(1) Change in Tobacco Use	(2) Change in Obesity	(3) Change in Manuf. Share	(4) Change in Per-Capita GDP
Initial Tobacco Use	0.0262			
	SE = 0.0184, |p|=0.162			
Initial Obesity		**-0.1288**		
		SE = 0.0268, |p|<0.001		
Initial Share of Manufacturing			-0.0060	
			SE = 0.0131, |p|=0.65	
Initial Per-Capita GDP				-0.0255
				SE = 0.0109, |p|=0.189
Number of Observations	287	287	288	288
R-squared	0.581	0.599	0.652	0.359

Note: SE = standard errors. Standard errors are clustered at the state level. Indicator variables (not reported) for each of the six periods considered are included in the analysis. Estimates in bold indicate that the 95 percent confidence interval does not include zero. All explanatory variables are expressed in logs. For example, in column (3), the value of -0.0060 means that a one percentage point higher initial share of manufacturing lowers the following 4-year change in the manufacturing share by 0.0060 of one percentage point.

Appendix

Relationship Between 4-year Change in Log Cancer Mortality Rate
and Initial Log Cancer Mortality Rate

Without Risk Factors Controls | With Risk Factors Controls

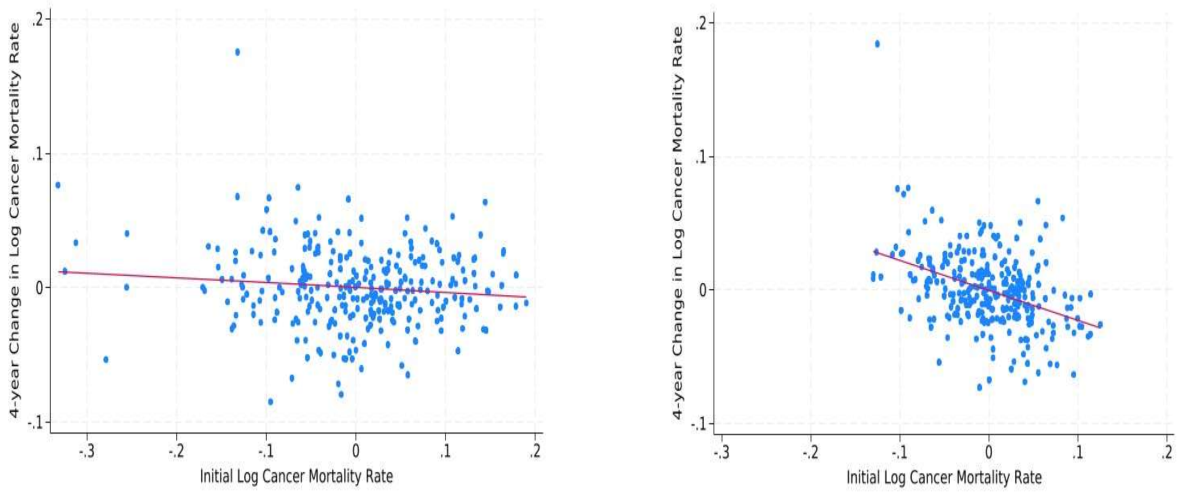

Figure 1A. The plots show the relationship between the 4-year change in log cancer mortality rate and the initial log cancer mortality rate without controlling (left panel) and controlling for (right panel) cancer risk factors. Specifically, the plots consider the portion of the 4-year change in log cancer mortality rate and the initial log cancer mortality rate that is not explained by time indicators (left panel), and by time indicators plus the four cancer risk factors included in the regression in column (2) of Table 1 (right panel). The slope of the fitted line (red line) in both plots corresponds to the estimated regression coefficient for the initial log cancer mortality rate reported in Table 1, columns (1) and (2), respectively. That is, the slope of the fitted line in the left panel is -0.0355, while it is -0.2237 in the right panel.

Table 3. Estimates of Conditional Convergence in Cancer Mortality Rates with Additional Controls

The dependent variable is the 4-year change in the state-level log cancer mortality rate for the periods 1997-2001, 2001-2005, 2005-2009, 2009-2013, 2013-2017, and 2017-2021.

	(1) Baseline	(2) With Additional Controls
Initial Cancer Mortality Rate	**-0.2237**	**-0.2087**
	SE = 0.0350, |p| < 0.001	SE = 0.0368, |p| < 0.001
Initial Tobacco Use	**0.0735**	**0.0596**
	SE = 0.0167, |p| < 0.001	SE = 0.0190, |p| = 0.003
Initial Obesity	**0.0541**	**0.0413**
	SE = 0.0154, |p| = 0.001	SE = 0.0205, |p| = 0.05
Initial Share of Manufacturing	**0.0113**	**0.0097**
	SE = 0.0029, |p| < 0.001	SE = 0.0029, |p| = 0.002
Initial Per-Capita GDP	**-0.0245**	-0.0152
	SE = 0.0079, |p| = 0.003	SE = 0.0124, |p| = 0.227
Initial Black Population Share		0.0001
		SE = 0.0020, |p| = 0.971
Initial College Share		-0.0199
		SE = 0.0171, |p| = 0.250
Initial Poverty Rate		-0.0085
		SE = 0.0109, |p| = 0.441
Rural Population in 2010 Census		0.0046
		SE = 0.0032, |p| = 0.159
Initial Per-Capita Health Care GDP		-0.0015
		SE = 0.0077, |p| = 0.851
Number of Observations	288	288
R-squared	0.380	0.388

Note: SE = standard errors. Standard errors are clustered at the state level. Indicator variables (not reported) for each of the six periods considered are included in the analysis. Estimates in bold indicate that the 95 percent confidence interval does not include zero. Column (1) in the table replicates results reported in Table 1. Column (2) adds additional socio-economic cancer risk factors. All explanatory variables are expressed in logs. For example, in column (1), the value of -0.2237 means that a one percentage point higher initial cancer mortality rate lowers the following 4-year change in mortality rate by 0.2237 of one percentage point. The shares of the Black population and those with a college degree come from the CDC Wonder database. The source for the poverty rate is the U.S. Census Bureau. The percentage of rural population is based on the 2010 Census, and as such, it remains invariant over time. State-level GDP data for the health care industry (expressed in constant dollars) have been sourced from the Bureau of Economic Analysis and transformed on a per capita basis.