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Article

Early Medicaid Expansion and Cancer Mortality

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Abstract

Background: Although Medicaid expansion is associated with decreased uninsured rates and earlier cancer diagnoses, no study has demonstrated an association between Medicaid expansion and cancer mortality. Our primary objective was to quantify the relationship between early Medicaid expansion and changes in cancer mortality rates. **Methods:** We obtained county-level data from the National Center for Health Statistics for adults aged 20-64 years who died from cancer from 2007 to 2009 (preexpansion) and 2012 to 2016 (postexpansion). We compared changes in cancer mortality rates in early Medicaid expansion states (CA, CT, DC, MN, NJ, and WA) vs nonexpansion states through a difference-in-differences analysis using hierarchical Bayesian regression. An exploratory analysis of cancer mortality changes associated with the larger-scale 2014 Medicaid expansions was also performed. **Results:** In adjusted difference-in-differences analyses, we observed a statistically significant decrease of 3.07 (95% credible interval = 2.19 to 3.95) cancer deaths per 100 000 in early expansion vs nonexpansion states, which translates to an estimated decrease of 5276 cancer deaths in the early expansion states during the study period. Expansion-associated decreases in cancer mortality were observed for pancreatic cancer. Exploratory analyses of the 2014 Medicaid expansions showed a decrease in pancreatic cancer mortality (−0.18 deaths per 100 000, 95% confidence interval = −0.32 to −0.05) in states that expanded Medicaid by 2014 compared with nonexpansion states. **Conclusions:** Early Medicaid expansion was associated with reduced cancer mortality rates, especially for pancreatic cancer, a cancer with short median survival where changes in prognosis would be most visible with limited follow-up.

Cancer is a leading cause of death in the United States, resulting in approximately 600 000 deaths per year (1). Although cancer mortality rates have improved over time, certain populations persistently have worse outcomes linked to poorer access to health care (1,2). The Affordable Care Act (ACA) provided states the opportunity to expand Medicaid to additional low-income individuals (3). To date, 39 states have elected to expand; however, California, Connecticut, Minnesota, New Jersey, Washington, and Washington DC had limited expansions earlier in 2010 or 2011 (4). The differential expansion status across states and the temporal nature of these expansions provide a natural experiment for examining potential impacts of Medicaid expansion (5).

Medicaid expansion is associated with decreased uninsured rates, improved cancer screening rates, and increased early-stage cancer diagnoses (6-16). Early data have also associated Medicaid expansion with increased overall survival for cancer patients, particularly among some patients with lung cancer (17,18). Medicaid expansion is associated with decreased overall mortality rates (19-21), but no published data have examined associations with cancer mortality rates. Our objective was to quantify cancer mortality changes associated with the early Medicaid expansions using state- and county-level mortality data .

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Methods

Study Sample

Age-adjusted cancer mortality data from the National Center for Health Statistics (NCHS) from 2002-2016 for individuals aged 20-64 years at time of death were obtained via SEER*Stat software (state-level data) and the CDC Wonder Compressed Mortality File (county-level data). County-level data from the CDC were limited to ages 25-64 years due to differences in calculating age-adjusted rates (15- to 19-year-olds and 20- to 24-year-olds were combined for age adjustments) (22,23). Despite the same source of data (NCHS), different software was used to obtain data given customizable year ranges in CDC Wonder not available in SEER*Stat (county-level data in SEER*Stat is restricted to prespecified year ranges: 2002-2004, 2005-2007, 2008-2011, 2012-2016) but otherwise streamlined data collection in SEER*Stat. NCHS cancer mortality data reflect all documented deaths from cancer in the United States, allowing population-level rather than individual-level estimates. Cause of death was based on the International Classification of Diseases, 10th Revision (ICD-10) codes from death certificates. Mortality rates and standard errors were obtained for all cancers combined, overall and by race, and for select cancer sites. The select sites for subgroup analyses were chosen based on those comprising the leading causes of cancer death in the United States (lung, prostate, female breast, colorectal, pancreas, and liver), which comprise over 50% of cancer deaths, and those with evidence-based screening recommendations (cervix, in addition to others mentioned above: female breast, colorectal, lung, and prostate) (1). The NCHS suppresses mortality rates when the number of events is less than 10; in such cases, mortality rates were imputed as part of the fully Bayesian specification and restricted such that the imputed rates would correspond to 0-9 deaths per county population (see the Supplementary Methods, available online). No mortality data were suppressed for the unadjusted analyses, which were aggregated by state Medicaid expansion status. We retrieved pre- and post-early expansion county-level covariate information (metropolitan residence status, percent unemployed, percent high school education, percent poverty, percent non-White, percent Black, percent Hispanic, percent elderly, and percent female) published by the United States Census Bureau and the US Department of Agriculture Economic Research Service (see the Supplementary Methods, available online for details) (24-27). County mortality and covariate data were merged by state and county names. Finally, Medicaid coverage rates by state before the expansions (2008) were obtained for qualitative comparisons (28).

Data Analysis

A quasi-experimental design was used to reduce potential confounding through accounting for changes that may have happened in the absence of expansion (due to preexisting temporal trends as a result of factors such as improved treatments) (5). Difference-in-differences (DID) analyses compared changes in mortality rates from pre- (2007-2009) to post- (2012-2016) early expansion between early expansion states (CA, CT, DC, MN, NJ, and WA) and nonexpansion states (based on Medicaid expansion status on December 31, 2016) (5). States that expanded in 2014-2016 were excluded. The years 2010-2011 were treated as a washout or phase-in period given the dates of early expansion (April 2010-July 2011) (4). Data from 2002-2006 were not used in the primary DID analyses but were used to establish preexpansion mortality rate trends and in a sensitivity analysis. The parallel trends assumption was tested by comparing changes in cancer mortality rates between early expansion and nonexpansion states during the preexpansion period (see the Supplementary Methods and Supplementary Table 1, available online) (5). Analyses were performed for all cancers combined, by cancer site, and by race. Finally, we used a difference-in-difference-in-differences (DDD), or triple difference, approach to evaluate whether the effect was modified by race.

Unadjusted DID analyses were performed by calculating the DID estimate: $(\text{Rate}_{\text{early expansion, 2012-16}} - \text{Rate}_{\text{early expansion, 2007-09}}) - (\text{Rate}_{\text{nonexpansion, 2012-16}} - \text{Rate}_{\text{nonexpansion, 2007-09}})$ (see the Supplementary Methods, available online). P values were 2-sided, with P less than .05 considered statistically significant.

For adjusted DID analyses, we used a hierarchical Bayesian linear regression model accounting for state, county, and covariates (metropolitan residence status, percent unemployed, percent high school education, percent poverty, percent non-White, percent elderly, and percent female) (10,29). Details regarding the hierarchical Bayesian model, covariate selection, and assessments of the adequacy of draws from the posterior distribution are given in Supplementary Table 2 and Supplementary Figure 1 (available online). For the DDD analysis, the regression model was expanded to include expansion status by time period by race interaction variables. The marginal posterior distribution was used to obtain the DID estimate (the mean), 95% credible interval (95% CrI = 2.5 and 97.5 percentiles) and the 1-tailed probability Pr of the estimate being greater than 0 (or <0, for positive means) (30). Because Pr is 1-sided, Pr less than .025 is required for statistical significance. Data analysis was performed using R v3.6.2 and the R2jags and superdiag packages.

Sensitivity Analyses

Because the expansions were limited in most early expansion states (enrolling <50k) with the exception of California (enrolling >400k), 1 analysis compared California only with the states that did not expand early and another analysis excluded California (4). Due to potential impacts of the economic recession in 2008-2009, 1 analysis treated 2002-2007 as the preexpansion period. Additionally, the states that expanded Medicaid in 2014-2016, which were excluded from the primary analyses, were grouped with nonexpansion states to form a comparison group of states that did not expand Medicaid in 2010-2011. Finally, we conducted a sensitivity triple-differences analysis by county poverty level because Medicaid eligibility is income related .

Exploratory Analyses

The early Medicaid expansions were relatively small in scope relative to the 2014 expansions. Hence, exploratory (unadjusted) DID analyses were performed to compare mortality rates from 2011-2013 with 2015-2017 in states that expanded Medicaid in 2014 relative to nonexpansion states (additional follow-up time was available due to no county-level data restrictions); states that expanded Medicaid from 2015-2017 were excluded. These were not the primary analyses given the likely insufficient follow-up needed to detect mortality rate changes. Additionally, the changes in the uninsured rate for the state groups from

Table 1. Cancer mortality rates and characteristics by state Medicaid expansion status

Population characteristic	Early expansion states[a]		Nonexpansion states[b]	
	2007-2009	2012-2016	2007-2009	2012-2016
Population over time period, (No.)	111 219 801	194 609 695	204 680 111	361 309 898
No. of cancer deaths by cancer site and race subgroups				
All malignancies	89 673	149 440	200 902	348 028
Breast	9846	15 790	19 642	32 429
Cervix	1385	2381	3221	5763
Colorectal	7870	14 311	18 428	33 299
Liver	4882	10 212	8889	20 678
Lung	19 262	27 740	54 918	87 022
Pancreas	5635	10 085	11 284	21 963
Prostate	1558	2762	3324	6208
White	72 481	118 102	158 765	271 285
Black	9740	16 584	38 399	68 544
Other[c]	7452	14 754	3738	8199
County-level attributes weighted by county population, mean (SD)[d]				
Metropolitan, %	93.7 (24.4)	94.5 (22.7)	79.5 (40.4)	82.6 (37.9)
Unemployed, %	5.1 (1.4)	5.3 (1.8)	4.3 (1.2)	4.7 (1.1)
No high school education, %	20.0 (7.6)	14.3 (6.3)	20.5 (8.0)	13.2 (5.7)
Poverty, %	11.2 (3.6)	12.8 (4.2)	13.8 (5.5)	14.8 (5.2)
Non-White, %	22.9 (10.7)	25.7 (11.0)	21.8 (14.8)	23.9 (15.1)
Black,[e]%	8.1 (7.8)	9.4 (7.6)	16.6 (14.4)	18.1 (14.5)
Hispanic,[e]%	26.0 (16.4)	28.9 (17.0)	14.8 (17.5)	17.5 (18.4)
Elderly, %	15.0 (2.5)	14.2 (2.6)	16.3 (4.7)	15.1 (4.8)
Female, %	50.5 (1.0)	50.5 (0.9)	50.8 (1.4)	50.8 (1.4)

[a]Early Medicaid expansion states include CA, CT, DC, MN, NJ, and WA.

[b]Nonexpansion states are those that had not implemented Medicaid expansion as of December 31, 2016; includes AL, FL, GA, ID, KS, ME, MS, MO, NE, NC, OK, SC, SD, TN, TX, UT, VA, WI, WY.

[c]The “other” race category includes all individuals not classified as White or Black and is largely composed of individuals of American Indian, Alaska Native, or Asian or Pacific Islander descent. Persons of Hispanic origin can be of any race.

[d]Attributes by state and time period were compared with a weighted linear model, including variables for expansion status, time period, and their interaction (note model design resembles difference-in-differences analysis). Counties attributes were statistically significantly different between early and not early Medicaid expansion states with P of .006 or less for percent metropolitan, percent unemployed, percent poverty, percent Black, percent Hispanic, percent elderly, and percent female. There was no difference between early and not early expansion states by percent without a high school education ($P = .77$) or percent non-White ($P = .51$). There was no difference in the pre- to post-early Medicaid expansion change in the attributes between the early and not early Medicaid expansion states ($P > .45$).

[e]County attributes are listed for informational purposes only; these variables were not included in the adjusted regression models. The variable percent Black was excluded because of high collinearity with percent non-White. The variable percent Hispanic was excluded due to a complex interplay between ethnicity and cancer outcomes; Hispanics have a lower cancer mortality rate than non-Hispanic Whites, but Hispanics are more likely to experience socioeconomic deprivation and thereby experience barriers to health care and subsequently poorer outcomes (29).

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2006 to 2017 were examined based on US Census Bureau estimates (31).

Results

There were 788 043 cancer deaths in 2007-2009 and 2012-2016 (Table 1). For the county-level analyses, 3715 county-year units were included in the analysis (see Supplementary Figure 2, available online, for the CONSORT diagram). Relative to nonexpansion states, early expansion states had lower percentages of impoverished, elderly, and Black residents and greater percentages of metropolitan and unemployed residents (Table 1). The changes in attributes over time were similar between state groups. Preexpansion Medicaid coverage rates [based on 2008 data (28)] were similar between state groups (Supplementary Table 3, available online).

Cancer mortality rates decreased in both early expansion (72.5 to 64.8 deaths per 100 000) and nonexpansion states (85.7 to 79.4 deaths per 100 000) from 2007-2009 to 2012-2016 (Table 2; Figure 1). In adjusted DID analyses, there was a decrease of 3.07 (95% CrI = 2.19 to 3.95, $Pr < .001$) deaths per 100 000 in early expansion relative to nonexpansion states. This translates to 5276 cancer deaths that were averted in early Medicaid expansion states in 2012-2016 (Supplementary Methods, available online).

There were qualitative decreases in adjusted cancer mortality rates in early expansion relative to nonexpansion states for each cancer site studied except colorectal, with statistically significant decreases for pancreatic cancer (adjusted estimate = −0.47, 95% CrI = −0.69 to −0.24, $Pr < .001$) (Table 2; Figure 1; Supplementary Figure 3, available online). There were also statistically significant adjusted early expansion–associated decreases in cervix and lung cancer mortality but non-statistically significant unadjusted DID estimates. Additionally, there were statistically significant early expansion–associated decreases in liver cancer mortality, but the parallel trends assumption was violated (Supplementary Table 1, available online). In our adjusted DDD analyses, there were no statistically significant differences in the expansion-associated changes in cancer mortality by race (Table 2).

In our sensitivity DID analyses, there were statistically significant expansion-associated decreases in overall cancer mortality and pancreatic cancer mortality across all sensitivity analyses (Supplementary Table 4, available online). Results for breast, cervix, and lung cancer mortality were inconsistent. In our sensitivity DDD analyses, for each percent increase in

Table 2. Changes in cancer mortality rates associated with early Medicaid expansion

	Mortality rate, No. per 100 000 population						Difference-in-differences			
	Early expansion states[a]			Nonexpansion states[b]			Unadjusted analysis		Adjusted analysis[c]	
Subgroup	2007-2009	2012-2016	Change (95% CI)	2007-2009	2012-2016	Change (95% CI)	Estimate (95% CI)	P[d]	Estimate (95% CrI)	Pr[e]
All malignancies	72.54	64.82	−7.72 (−8.13 to −7.31)	85.73	79.4	−6.33 (−6.66 to −6)	−1.38 (−1.91 to −0.86)	<.001	−3.07 (−3.95 to −2.19)	<.001
Breast[f]	16.01	14.22	−1.79 (−2.09 to −1.49)	16.96	15.37	−1.6 (−1.82 to −1.37)	−0.19 (−0.56 to 0.18)	.31	−0.19 (−0.71 to 0.16)	.19
Cervix	2.38	2.31	−0.07 (−0.22 to 0.07)	3	3.02	0.02 (−0.11 to 0.14)	−0.09 (−0.28 to 0.1)	.37	−0.32 (−0.66 to −0.01)	.02
Colorectal	6.41	6.37	−0.04 (−0.19 to 0.11)	7.92	7.82	−0.1 (−0.24 to 0.03)	0.06 (−0.14 to 0.26)	.54	0.01 (−0.24 to 0.27)	.46
Liver[f]	3.9	4.22	0.32 (0.21 to 0.43)	3.76	4.51	0.75 (0.68 to 0.83)	−0.43 (−0.57 to −0.3)	<.001	−0.46 (−0.71 to −0.22)	<.001
Lung	15.18	11.42	−3.76 (−3.94 to −3.59)	22.75	18.89	−3.86 (−4.02 to −3.7)	0.1 (−0.14 to 0.34)	.42	−0.36 (−0.79 to 0)	.02
Pancreas	4.47	4.22	−0.26 (−0.39 to −0.12)	4.72	4.87	0.14 (0.05 to 0.24)	−0.4 (−0.56 to −0.23)	<.001	−0.47 (−0.69 to −0.24)	<.001
Prostate	2.47	2.23	−0.24 (−0.37 to −0.11)	2.74	2.66	−0.08 (−0.18 to 0.02)	−0.16 (−0.32 to 0.01)	.06	−0.16 (−0.47 to 0.14)	.15
White[f]	72.79	65.13	−7.66 (−8.14 to −7.18)	82.31	77.02	−5.28 (−5.66 to −4.91)	−2.38 (−2.99 to −1.76)	<.001	−3.81 (−4.79 to −2.83)	<.001
Black[g]	105.03	91.06	−13.96 (−15.8 to −12.13)	113.86	99.92	−13.93 (−14.93 to −12.94)	−0.03 (−2.12 to 2.05)	.98	−0.58 (−3.03 to 0.76)	.26
Other[h]	50.35	47.81	−2.54 (−3.59 to −1.48)	47.45	46.92	−0.53 (−2.09 to 1.02)	−2 (−3.88 to −0.12)	.04	−0.47 (−2.51 to 0.24)	.21

[a]Early Medicaid expansion states include CA, CT, DC, MN, NJ, and WA. CI = confidence interval, CrI = credible interval (Bayesian).

[b]Nonexpansion states are those that had not implemented Medicaid expansion as of December 31, 2016; includes AL, FL, GA, ID, KS, ME, MS, MO, NE, NC, OK, SC, SD, TN, TX, UT, VA, WI, and WY.

[c]Adjusted analyses (accounting for covariates) used a hierarchical Bayesian regression model that also included state and county effects.

[d]P = 2-tailed P value from Z test of the null hypothesis that the difference-in-differences estimate is equal to 0. See the Supplementary Methods (available online) for details.

[e]Pr = 1-tailed probability of Bayesian estimate being null. Because Pr is 1-sided, Pr less than .025 is required for statistical significance. See the Supplementary Methods (available online) for details.

[f]Several analyses did not satisfy tests of the parallel trends assumption, including analyses of breast, liver, and White cancer mortality rates, which should be interpreted with caution (see Supplementary Table 1, available online for detailed information).

[g]Triple difference (difference-in-difference-in-differences) comparison for White (reference) vs Blacks: unadjusted 2.34 (95% CI = 0.17 to 4.52, P = .034). Adjusted: 0.25 (95% CrI = −0.42 to 2.84, Pr = .37).

[h]Triple difference (difference-in-difference-in-differences) comparison for White (reference) vs others: unadjusted 0.37 (95% CI = −1.68 to 2.43, P = .72). Adjusted: 0.1 (95% CrI = −0.48 to 1.28, Pr = .41).

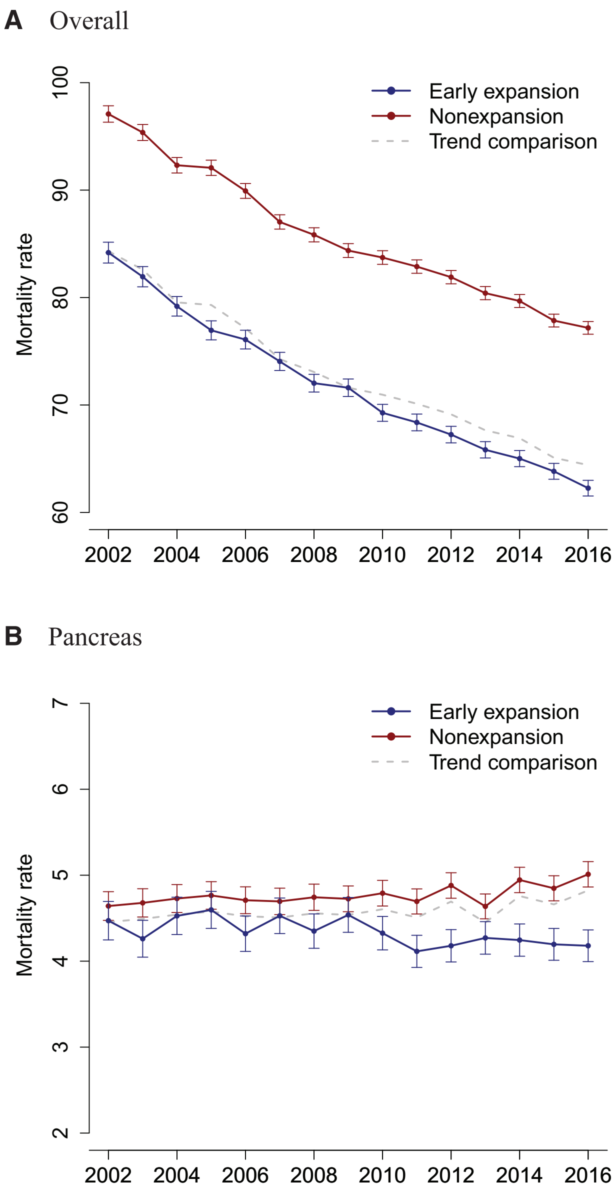

Figure 1. Temporal trends in overall (**A**) and pancreatic (**B**) cancer mortality rates by state early Medicaid expansion status. The year-to-year change in overall and pancreatic cancer mortality rates was similar in early Medicaid expansion and nonexpansion states from 2002-2009 (with the exception of 2005 in the overall cancer mortality rate analysis). However, the trends diverged beginning in 2010, when the first early Medicaid expansions occurred. The **dashed line** for "trend comparison," for easier visual comparison of temporal trends, is equal to the trends of the nonexpansion states translated down such that the comparison mortality rates at the end of the preexpansion study period (2009) are equal to the rate in the early expansion group. Mortality rate is the age-adjusted deaths per 100 000 population. **Error bars** denote 95% confidence intervals.

residents living in poverty, there were expansion-associated decreases in cancer mortality overall and across most subgroups, though most decreases were not statistically significant (Supplementary Table 4, available online).

In exploratory analyses, the decrease in uninsured rates in early expansion vs nonexpansion states was small, from 2007 to 2013 (−0.39 percentage points [%]) (Figure 2; Table 3), but much larger from 2013 to 2016 (−3.20%), which translates to a net 1.76 million individuals gaining insurance coverage from

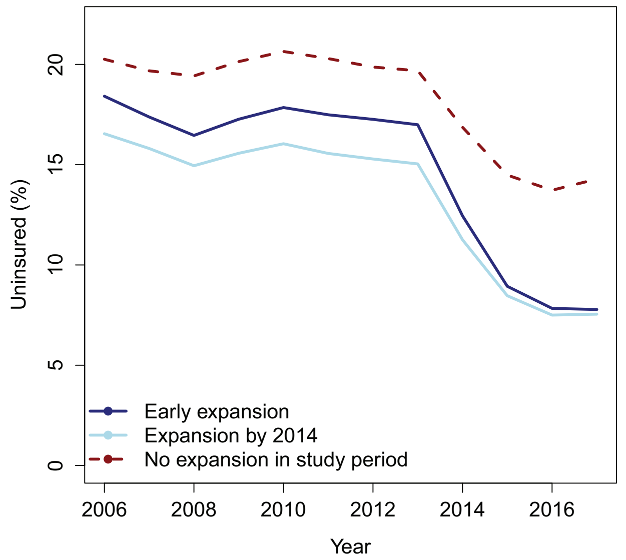

Figure 2. Temporal trends in the uninsured rate by state Medicaid expansion status. There was generally a slowly decreasing uninsured rate in early Medicaid expansion states until 2013, with a smaller gap of the uninsured rate between early and not early expansion states in 2013 compared with the gap in 2006. The elevated uninsured rates in 2009 and 2010 may be secondary to the great recession. Beginning in 2014, with the initiation of the larger scale Medicaid expansions, early Medicaid expansion states had a larger decrease in the uninsured rate than the other groups of states, including the group of all states that expanded in 2014.

2013 to 2017 in early expansion states. In contrast, there was a smaller decrease (1.58%) in the uninsured rate from 2013 to 2017 in states that expanded by 2014 vs nonexpansion states. In analyses examining the 2014 Medicaid expansions, there was no decrease in the overall cancer mortality rate in states that expanded by 2014 vs nonexpansion states, though there was a statistically significant decrease for pancreatic cancer (−0.18 deaths per 100 000, 95% confidence interval = −0.32 to −0.05, P = .009) (Table 4; Figure 3; Supplementary Figure 4, available online). The parallel trends assumption was not met for many other analyses (Supplementary Tables 5 and 6, available online).

Discussion

These nationwide data demonstrate decreased cancer mortality rates, overall and for pancreatic cancer, in states that expanded Medicaid early vs nonexpansion states. Evidence for expansion-associated mortality changes for other cancer sites was limited. Although exploratory analyses of the 2014 Medicaid expansions found no statistically significant association with cancer mortality overall, there were expansion-associated decreases for pancreatic cancer. However, because most patients diagnosed with cancer live beyond 5 years, these early data with limited follow-up likely do not fully capture ACA-associated changes in cancer mortality (32).

Early expansion states combined only enrolled approximately 500 000 individuals from 2010 to 2012 compared with the millions gaining coverage due to the main Medicaid expansions occurring in 2014 (4). It is unlikely that the estimated number of cancer deaths prevented arose strictly from the approximately 500 000 individuals gaining coverage under the 2010-2011 expansions. However, our exploratory analyses showed that early expansion states had the largest declines in the uninsured

Table 3. Changes in the uninsured rate associated with the early and 2014 Medicaid expansions

Years compared	State group	% Uninsured		Pre- to postexpansion change		Difference-in-differences	
		Preexpansion	Postexpansion	Percentage point	No. insured by expansion[a]	Percentage point	No. insured attributed to expansion[b]
Early Medicaid expansion[c]							
2007 vs 2013[e]	Early expansion	17.38	16.99	−0.39	209 451	−0.39	211 662
	Nonexpansion	19.68	19.69	0.00	NA	Reference	NA
2007 vs 2012-2016[f]	Early expansion	17.38	12.68	−4.70	2 581 120	−1.92	1 055 706
	Nonexpansion	19.68	16.9	−2.78	NA	Reference	NA
2007 vs 2016[g]	Early expansion	17.38	7.83	−9.54	5 238 685	−3.59	1 970 024
	Nonexpansion	19.68	13.73	−5.95	NA	Reference	NA
2013 vs 2016[h]	Early expansion	16.99	7.83	−9.16	5 027 054	−3.2	1 756 159
	Nonexpansion	19.69	13.73	−5.96	NA	Reference	NA
2014 Medicaid expansion[d]							
2013 vs 2016[h]	Expansion by 2014	15.04	7.5	−7.54	10 770 387	−1.58	2 255 886
	Nonexpansion	19.69	13.73	−5.96	NA	Reference	NA

[a]This value represents the estimated number of newly insured individuals in the group of states over the study period (calculated as percentage point increase * expansion state population in final year of comparison). NA = not applicable.

[b]This value represents the estimated number of newly insured individuals in the group of expansion states that can be attributed to the Medicaid expansions (calculated as DID/100 * expansion state population in final year of comparison).

[c]Early expansion states include CA, CT, DC, MN, NJ, and WA; not early expansion includes all other states.

Nonexpansion states are those that had not implemented Medicaid expansion as of December 31, 2016; includes AL, FL, GA, ID, KS, ME, MS, MO, NE, NC, OK, SC, SD, TN, TX, UT, VA, WI, and WY.

[d]2014 Medicaid expansion states include AZ, AR, CA, CO, CT, DE, DC, HI, IL, IA, KY, MA, MD, MI, MN, NV, NH, NJ, NM, NY, ND, OH, OR, RI, VT, WA, and WV; states that expanded in 2015-16 (AK, IN LA, MT, and PA) were excluded from these analyses.

[e]This year comparison estimates the insurance coverage gains from early Medicaid expansion alone (before the enactment of other ACA components and the larger Medicaid expansions in 2014).

[f]This year comparison estimates the insurance coverage gains for the early expansion states over the study period of the present analysis, averaged over all post early-expansion years.

[g]This year comparison estimates the insurance coverage gains for the early expansion states over the study period of the present analysis, based solely on the coverage rates at the end of the study period.

[h]This year comparison estimates the insurance coverage gains for the 2014 expansions.

rate after 2014, even when compared with states that expanded Medicaid in 2014. These insurance coverage changes likely contribute to the observed mortality rate changes through 2016. Interestingly, others have shown that states that expanded Medicaid early had expansion-associated improvements in cancer screening rates and overall cancer survival after 2014 in contrast to no statistically significant expansion-associated changes for states that expanded in 2014 (18,33). Reasons for the greater changes in early expansion states are uncertain, though they may be related to the states being better equipped to provide coverage for their needy residents due to prior expansions or other underlying health system differences (4).

Cancer mortality has decreased over time for the past several decades, approximately 2% per year recently (1), or 7.4% (6.33/85.73) from 2007-2009 to 2012-2016 based on our nonexpansion state data. The decrease of 3 deaths per 100 000 attributed to early Medicaid expansion translates to a decrease in cancer mortality by 4.2% over the study period (ie, 3.07/72.5, the preexpansion rate), potentially accelerating the improvements over time by 50% (ie, 4.2/7.4, the expected improvement without expansion). Of note, despite persistently lower cancer mortality rates occurring in Medicaid expansion states throughout the study period, there was an early expansion-associated decrease in cancer mortality, which may lead to further state-based disparities in cancer outcomes if nonexpansion states do not adopt the expansions (34–36).

When analyzing the 2014 Medicaid expansions with limited follow-up, there was a statistically significant expansion-associated decrease in pancreatic cancer mortality. Because cancers with shorter median survival times, such as pancreatic cancer, may be expected to be the first to demonstrate any policy-related changes in cancer mortality, this result provides additional support of our primary findings (1). Similarly, Han et al. (11) identified 2014 Medicaid expansion-related increases in early-stage cancer diagnoses for pancreatic cancer (but, interestingly, not for any of the other sites included in this analysis), likely suggesting that more patients with pancreatic cancer had curable disease or at least would be able to undergo therapy with curative intent after the expansions. However, we found no detectable expansion-associated decrease in overall cancer mortality (non-statistically significant DID estimate favoring nonexpansion states). It is unclear whether the lack of an overall effect is due to inadequate follow-up or whether there was minimal impact on cancer mortality. Data with additional follow-up will be needed to clarify the trends.

Cancer mortality rates for Black individuals and for lung and prostate cancers declined more in nonexpansion than in 2014 Medicaid expansion states. However, these estimates are unreliable given the failed parallel trends assumption, which nonparallel trends contributed to the mortality “increases” (Supplementary Table 5, available online). Although the reasons for the differential changes are unclear, the lung cancer mortality trends may be related to decreasing incidence of smoking-related cancer diagnoses, especially because nonexpansion states, which historically had the highest rates of smoking, have had the largest absolute reductions in smoking rates (Supplementary Table 6, available online) (37–39).

There are several potential reasons for the decreased mortality following early Medicaid expansion. One important factor likely includes more people being cured of the disease (or at

Table 4. Changes in cancer mortality rates associated with Medicaid expansions occurring in 2014

	Mortality rate, No. per 100 000 population						Difference-in-differences	
	States expanding Medicaid by 2014[a]			Nonexpansion states[b]			Unadjusted analysis	
Subgroup	2011-2013	2015-2017	Change (95% CI)	2011-2013	2015-2017	Change (95% CI)	Estimate (95% CI)	P[c]
All malignancies	73.45	68.63	−4.82 (−5.08 to −4.56)	81.73	76.75	−4.97 (−5.3 to −4.64)	0.15 (−0.26 to 0.57)	.47
Breast	14.98	14.04	−0.94 (−1.14 to −0.75)	15.92	15.04	−0.88 (−1.12 to −0.64)	−0.06 (−0.38 to 0.25)	.69
Cervix[d]	2.51	2.35	−0.16 (−0.25 to −0.07)	2.94	3	0.06 (−0.08 to 0.2)	−0.22 (−0.39 to −0.05)	.01
Colorectal[d]	6.77	6.8	0.03 (−0.07 to 0.12)	7.82	7.94	0.13 (−0.02 to 0.27)	−0.1 (−0.28 to 0.07)	.25
Liver[d]	4.06	3.85	−0.2 (−0.27 to −0.13)	4.46	4.44	−0.02 (−0.11 to 0.06)	−0.18 (−0.29 to −0.07)	.001
Lung[d]	16.58	14.01	−2.58 (−2.7 to −2.45)	20.37	17.16	−3.21 (−3.37 to −3.04)	0.63 (0.42 to 0.84)	<.001
Pancreas	4.53	4.52	−0.01 (−0.1 to 0.08)	4.74	4.91	0.17 (0.07 to 0.27)	−0.18 (−0.32 to −0.05)	.009
Prostate[d]	2.3	2.37	0.07 (−0.01 to 0.15)	2.67	2.59	−0.08 (−0.18 to 0.02)	0.15 (0.02 to 0.27)	.02
White[d]	73.33	68.6	−4.73 (−5.04 to −4.41)	78.99	74.75	−4.24 (−4.63 to −3.84)	−0.49 (−1 to 0.01)	.06
Black[d]	96.82	88.86	−7.96 (−8.92 to −6.99)	104.74	94.85	−9.89 (−10.86 to −8.93)	1.93 (0.57 to 3.29)	.006
Other	47.79	46.81	−0.98 (−1.77 to −0.2)	46.81	46.89	0.08 (−1.53 to 1.69)	−1.06 (−2.86 to 0.73)	.25

[a]The 2014 expansion states included AZ, AR, CA, CO, CT, DE, DC, HI, IL, IA, KY, MA, MD, MI, MN, NV, NH, NJ, NM, NY, ND, OH, OR, RI, VT, WA, and WV. CI = confidence interval.

[h]Nonexpansion states are those that had not implemented Medicaid expansion as of December 31, 2017; includes AL, FL, GA, ID, KS, ME, MS, MO, NE, NC, OK, SC, SD, TN, TX, UT, VA, WI, and WY. States that expanded in 2015-17 (AK, IN LA, MT, and PA) were excluded.

[c]P = 2-tailed P value from Z test of the null hypothesis that the difference-in-differences estimate is equal to 0. See the Supplementary Methods (available online) for details.

[d]Analyses that failed formal testing of the parallel trends assumption included analyses of cervix, colorectal, liver, lung, prostate, White, and Black mortality rates, which should be interpreted with caution (see Supplementary Table 5, available online for details).

least living substantially longer) through improved access leading to earlier detection and receipt of lifesaving therapy. A number of studies support the concept that Medicaid expansion leads to an increased proportion of diagnoses of localized vs advanced cancers (10,11,15), although not all were statistically significant (7). One potential reason for these improvements may be expansion-associated increases in screening (8,12–14,16,33), though studies provide mixed results regarding whether the increases in early-stage cancers occur among cancers amenable to screening, and our data did not show mortality changes in cancer sites where screening is routinely available (10,11,15). Increased access to care could also result in increased early incidental detections (eg, during imaging done for other reasons) or in decreased delays in presentation for symptoms that lead to a workup revealing malignancy (eg, due to worry about medical bills). Consistent with this hypothesis, others have shown expansion-associated improvements in stage at diagnosis in cancers for which no screening programs exist (7,11). Additionally, studies have shown ACA-associated decreases in cost-related barriers to medical care among cancer patients (40,41), and financial toxicity is an independent predictor of cancer mortality (42). Finally, Medicaid expansion is associated with increased access to surgery and decreased time to treatment initiation for some cancers, though data show mixed results (43–50). Given the associations of stage at diagnosis, financial toxicity, and treatment receipt with cancer outcomes, Medicaid expansion-related improvements in 1 or more of these factors may increase survival times and lead to more patients who achieve durable remissions, hence improving the cancer mortality rate.

It is improbable that Medicaid expansion would have decreased the number of malignancies within this short study period, especially because improvements in cancer screening may not appear until several years following Medicaid expansion (33). In contrast, recent data suggest Medicaid expansion is associated with more (primarily localized) cancer diagnoses (10). Cancer incidence may not have decreased due to Medicaid expansion; however, comorbid conditions, which worsen cancer prognosis, may have decreased with improved health-care access (51,52).

This study's strengths include use of a national mortality database and quasi-experimental design. However, there are also a number of limitations. The study was observational; hence, we are unable to determine causal pathways. Due to the ecological study design, there is the risk of ecological fallacy (53,54). Individual-level inferences cannot be drawn from these data; we do not know if the cancer deaths that were averted in early Medicaid expansion states occurred among individuals who gained coverage under the Medicaid expansions. Rather, these data suggest that regions that implemented early Medicaid expansion saw fewer cancer deaths, which may be attributable to the policy (53,54). Furthermore, due to the county-level nature of the data, we could not stratify by and/or account for individual-level socioeconomic factors except race. Although we focused on adults younger than 65 years, the adults potentially Medicaid-eligible under the expansions, most cancer deaths occur in elderly adults; however, it is possible that, as cohorts age, individuals older than 65 years may see benefits of the expansions if they gained insurance and greater access to health (eg, screening) before age 65 years (1). DID assumptions are based on assumptions that may not be fulfilled, specifically that 2 comparison groups (early Medicaid expansion states vs other states) have "parallel trends," though testing of trends limited to the preexpansion period was performed (see the Supplementary Methods, available online, for additional discussion of limitations), and "common shocks," where non-policy factors are required to affect each group similarly (5). Such a factor may include the great recession, though a sensitivity analysis using 2002-2007 as the preexpansion period gave similar results. Furthermore, there is no perfect comparison group for the early expansion states; nonexpansion states are a heterogeneous group based on geography as well as

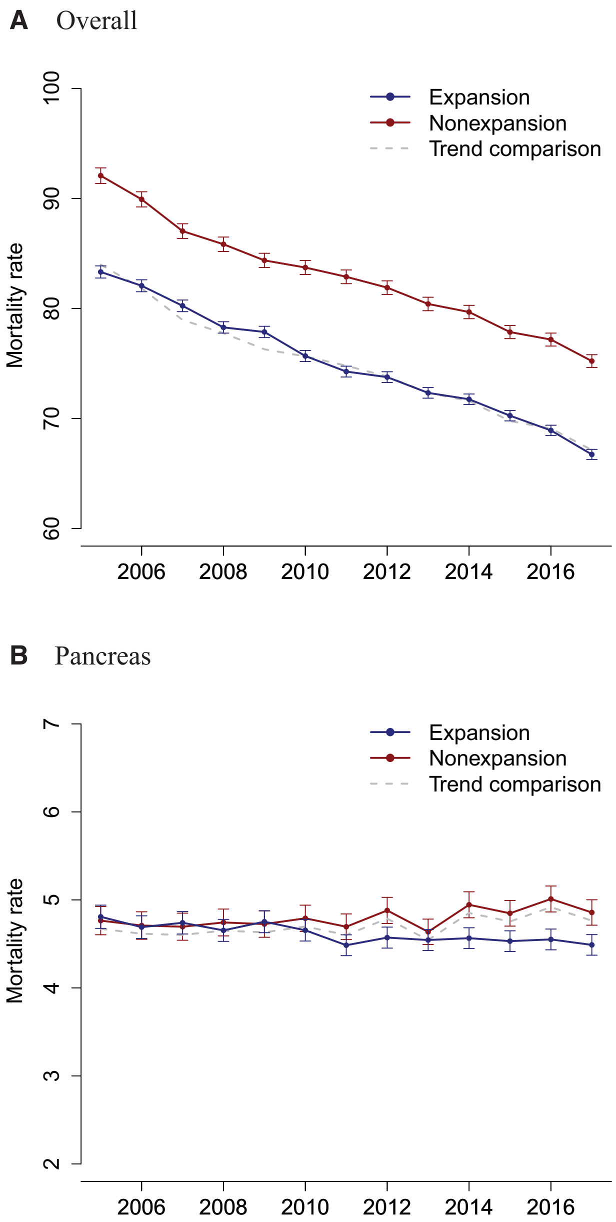

Figure 3. Temporal trends in overall (**A**) and pancreatic (**B**) cancer mortality rates by 2014 state Medicaid expansion status. The trends in cancer mortality rates for all cancers combined changed similarly over time for Medicaid expansion and nonexpansion states, with the exception of 2009. The trends in pancreatic cancer mortality rates were similar in Medicaid expansion and nonexpansion states until around 2013, when the trends began to diverge, consistent with the timing of the 2014 Medicaid expansions. The **dashed line** for "trend comparison," for easier visual comparison of temporal trends, is equal to the trends of the nonexpansion states translated up or down such that the comparison mortality rates at the end of the preexpansion study period (2013) are equal to the rate in the 2014 expansion group. Mortality rate is the age-adjusted deaths per 100 000 population. **Error bars** denote 95% confidence intervals.

expansion status, because many states expanded later (after 2016) whereas others never expanded Medicaid. However, sensitivity analyses with different early expansion and comparison groupings supported the main findings. Finally, a major limitation of the study revolves around the early Medicaid expansions themselves. Early expansion states expanded at different times, had heterogeneous Medicaid eligibility criteria, including varying criteria by county in California and variable usage of Section 1115 waivers, and enacted further Medicaid eligibility expansions in 2014 (4). Hence, the relative contribution of coverage gains in 2010-2011 toward the present findings is unclear compared with the much larger Medicaid coverage gains in 2014, state-specific programs, and other possible underlying factors in early expansion states.

In conclusion, early Medicaid expansion was associated with decreased cancer mortality rates. Although these early data suggest benefits of policies designed to increase health-care access, further follow-up is needed.

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Data Availability

The datasets analyzed during this study are subsets of national databases, which are available online (22–28,31). Note that a waiver/application is a prerequisite to using SEER*Stat software and accessing the associated data .

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