Supplemental Appendix

Medicaid Expansion and Incidence of Kidney Failure Among Nonelderly Adults

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Supplement Contents

Supplemental Appendix 1. Detailed Description of Kidney Failure Incidence Rate Calculations

Identification of Incident Patients

The date of incidence for each patient with treated kidney failure was defined as the earliest record of maintenance dialysis initiation (and the date maintenance dialysis began) or kidney transplantation (and date of transplantation) using the End Stage Renal Disease (ESRD) Medical Evidence Form (CMS 2728). Some sensitivity analyses restricted incident patients further (see Supplemental Table 6): only incident patients who were initiating maintenance dialysis (n=409,323); only incident patients with kidney failure due to diabetes (n=205,289; as determined by the primary cause of renal failure listed on CMS 2728: ICD-9 codes 25040 and 25041; ICD-10 codes E10.22, E10.29, E11.22, E11.29); and only incident patients with kidney failure due to hypertension (n=102,590; ICD-9 code 40391; ICD-10 code I12.9).

Assignment of Incident Patients to PUMAs

Patients' mailing addresses reported on the ESRD Medical Evidence Form (CMS 2728) were used to assign incident kidney failure patients to Public Use Microdata Areas (PUMAs). Patient addresses were geocoded and then geolocated within PUMAs using ArcGIS spatial mapping software, version 10.5.1 (ESRI). For addresses that could not be geocoded, such as P.O. Boxes, ZIP codes were crosswalked to ZIP Code Tabulation Areas (ZCTAs) which were subsequently crosswalked to PUMAs using the Missouri Census Data Center's Geographic Correspondence Engine (Geocorr 2014). Incident patients residing in ZCTAs that spanned PUMA boundaries were assigned to the PUMA in which the largest share of that ZCTA's population resided. The majority of incident patients (89.2%) were assigned to a PUMA based on their full mailing address, 6.1% were assigned on the basis of a one-to-one match with their ZIP code, 4.7% were assigned via a population-weighted match of their ZIP code, and 0.05% (188 patients) were dropped because they were unable to be geolocated within a PUMA (Supplemental Figure 1). In expansion states, 91.3% of incident patients in the pre-expansion period and 89.1% in the postexpansion period were assigned by geocoded address; 5.4% and 6.2%, respectively, were assigned by ZIP code exact match, 3.4% and 4.7%, respectively, were assigned by ZIP code with a population-weighted match; and <1% and <1% were unable to be geolocated. In non-expansion states, 90.4% and 87.7% were assigned to PUMAs by geocoded address in the pre- and postexpansion time periods, respectively; 5.5% and 6.6%, respectively, were assigned by ZIP code exact match; 4.0% and 5.7%, respectively, were assigned by ZIP code population-weighted match; and <1% and <1%, respectively, were unable to be geolocated.

Area-Level Incidence Rate Calculations and Exclusions

Kidney failure incidence rates were calculated at the PUMA-quarter cell level. There were 1,053,248 potential age-sex-race/ethnicity PUMA-quarter cells in the study period (2 age groups × 2 sex groups × 4 race/ethnicity groups × 4 quarters × 7 years × 2351 PUMAs). Of these, 633 cells (containing 659 incident patients in total) were excluded because there were no individuals in the given population observed in the ACS 1-year Public Use Microdata Sample (PUMS), though there were incident kidney failure patients that quarter. Another 23,555 cells had no incident patients and no individuals observed in the ACS PUMS data. In adjusted analyses, an additional 2,256 cells were excluded due to missing covariates, resulting in a final sample of 1,026,804 population-specific PUMA-quarter cells. In total, these exclusions eliminated 0.49% of incident patients and 0.21% of the United States nonelderly population.

PUMA-Level Characteristics

PUMA-level population characteristics were drawn from American Community Survey 1-year Subject Tables, published by the United States Census Bureau.[1] Items 1-3 were included in adjusted models as time-varying PUMA-level covariates. In exploratory analyses reported in Table 3, item 4 was used to

stratify PUMAs into those with above- and below-median uninsurance rates based on the PUMA's average uninsurance rate in 2012 and 2013, the time period before Medicaid expansion and most other provisions of the ACA occurred. The same strategy was used to stratify PUMAs by above- or below-median poverty rates in the pre-expansion period.

1. The percent of the nonelderly adult population ages 19-64 with annual household income below the federal poverty level (from ACS table S1701)
2. The unemployment rate for those ages 20-64 (from ACS table S2301)
3. The percent of the adult population with a high school degree or equivalency (from ACS table S1501)
4. The percent of the nonelderly adult population who were uninsured (from ACS table S2701)

In exploratory analyses reported in Table 3 we also stratified by PUMA metropolitan status. We used files developed by the United States Department of Agriculture Economic Research Service to classify PUMAs as metropolitan (urban) and non-metropolitan (rural).[2] Following ERS methodology, we classified PUMAs as urban if more than 50% of the 2010 population in that PUMA resided in a metropolitan area, using the 2013 Office of Management and Budget (OMB) metro delineation. Of the 2,351 PUMAs, 349 (14.8%) were classified as rural, while 2,002 were classified as urban (85.2%). The share of the study population residing in rural and urban PUMAs is reported in Table 1.

Supplemental Appendix 2. Regression Equations for Analyses: Primary Outcome (Kidney Failure Incidence)

Main Model

For each age group *a*, sex *j*, race/ethnicity *k*, PUMA *p*, state *s*, quarter *q*, year *t*, the model of the quarterly incidence rate of kidney failure per million population was given by

$$\begin{aligned} Incidence\_Rate_{ajkpsqt} &= \beta_0 + \beta_1\left(Expansion_{ps} \times [PostYear = 1]_q\right) \\ &+ \beta_2\left(Expansion_{ps} \times [PostYear = 2\ or\ 3]_q\right) \\ &+ \beta_3\left(Expansion_{ps} \times [PostYear = 4\ or\ 5]_q\right) + X_{pt} + \delta_p + \eta_q + \gamma_{qt} \\ &+ \varepsilon_{ajkpsqt} \end{aligned}$$

where X_{pt} is a vector of time-varying PUMA covariates, δ_p is a vector of PUMA fixed effects, η_q denotes season fixed effects, γ_{tq} denotes year-quarter fixed effects, and ε is an error term. The coefficients of interest are β_2 and β_3, the interactions between states' Medicaid expansion status and the time periods 2 & 3 years and 4 & 5 years after expansion occurred, respectively.

Age groups *a* were 19-44 and 45-64; sex groups *j* were male and female; race/ethnicity groups *k* were non-Hispanic White, non-Hispanic Black, Hispanic, and other. Time-varying PUMA covariates X_{pt} were the proportion of nonelderly adults with annual household income below the federal poverty level, the unemployment rate for nonelderly adults, and the proportion of the adult population who holds a high school degree or equivalency.

We used multivariable linear models with Huber-White robust standard errors clustered at the state level to account for state-level correlation and serial autocorrelation.[3–5] Models were weighted by the population of each PUMA cell.

Sensitivity Analyses

We conducted a number of sensitivity analyses, reported in Supplemental Tables 4, 5, 6, 7 and 8. Those with statistical models different than the main model (equation 1) are detailed below. Sensitivity analyses presented in Supplemental Table 6 restricted the incident patient population to those initiating maintenance dialysis, those with kidney failure due to diabetes, and those with kidney failure due to hypertension all used the main model (equation 1). The sensitivity analysis that excluded PUMAs in early expansion states (those states are denoted in Supplemental Table 1; sensitivity analysis is reported in Supplemental Table 7) also used the main model (equation 1). Additionally, we attempted to conduct a falsification test among adults age 70 and older but were unable to confirm parallel trends in incidence rates in expansion and non-expansion states prior to 2014.

Parallel Trends Assumption Testing (Supplemental Tables 4 & 5)

Our difference-in-difference specification assumes that, if Medicaid expansion had not occurred, the incidence of kidney failure would have trended similarly between Medicaid expansion and non-expansion states. Thus, the observed post-policy divergence is attributable to the ACA Medicaid expansions rather than pre-policy differences in trends. To confirm that pre-expansion incidence rates were parallel in expansion and non-expansion states, we tested the significance of the regression coefficient on an expansion-by-time indicator (β_1) for pre-2014 quarters.

$$Incidence\_Rate_{ajkpsqt} = \beta_0 + \beta_1\left(Expansion_{ps} \times Time_{tq}\right) + X_{pt} + \delta_p + \eta_q + \gamma_{qt} + \varepsilon_{ajkpsqt}$$

We also conducted event-study falsification tests for each quarter during the pre-period, using only data from pre-2014 quarters. We specified a difference-in-differences model with a single pseudo postexpansion time period. Using each quarter between (but not inclusive of) Q1 2012 and Q4 2013 as a falsified expansion time point, we tested the significance of the regression coefficient on the difference-in-difference term (β_1). For example, using 2012 Q3 as the falsified expansion time point, the pre-period would considered Q1 and Q2 2012, and the post-period Q3 2012 through Q4 2013.

$$Incidence\_Rate_{ajkpsqt} = \beta_0 + \beta_1\left(Expansion_{ps} \times FalsifiedPost_q\right) + X_{pt} + \delta_p + \eta_q + \gamma_{qt} + \varepsilon_{ajkpsqt}$$

Exclude Demographic & Time-Varying PUMA-Level Population Characteristics (Supplemental Table 7)

We excluded demographic and time-varying PUMA-level population characteristics from our model, including only geographic (PUMA) and time (year-quarter and season) fixed effects.

$$Incidence\_Rate_{psqt} = \beta_0 + \beta_1\left(Expansion_{ps} \times [PostYear = 1]_q\right) + \beta_2\left(Expansion_{ps} \times [PostYear = 2\ or\ 3]_q\right) + \beta_3\left(Expansion_{ps} \times [PostYear = 4\ or\ 5]_q\right) + \delta_p + \eta_q + \gamma_{qt} + \varepsilon_{psqt}$$

Exclude Time-Varying PUMA-Level Population Characteristics (Supplemental Table 7)

We excluded time-varying PUMA-level population characteristics from our model, adjusting only for age group, sex, and race/ethnicity, in addition to geographic and time fixed effects.

$$Incidence\_Rate_{ajkpsqt} = \beta_0 + \beta_1\left(Expansion_{ps} \times [PostYear = 1]_q\right) + \beta_2\left(Expansion_{ps} \times [PostYear = 2\ or\ 3]_q\right) + \beta_3\left(Expansion_{ps} \times [PostYear = 4\ or\ 5]_q\right) + \delta_p + \eta_q + \gamma_{qt} + \varepsilon_{ajkpsqt}$$

State-Level Analysis (Supplemental Table 7)

Rather than using PUMAs as the geographic unit of analysis, we collapsed our data to the state level and used time-varying state-level population characteristics (X_{st}) and state (δ_s) and time fixed effects.

$$Incidence\_Rate_{ajksqt} = \beta_0 + \beta_1\left(Expansion_s \times [PostYear = 1]_q\right) + \beta_2\left(Expansion_s \times [PostYear = 2\ or\ 3]_q\right) + \beta_3\left(Expansion_s \times [PostYear = 4\ or\ 5]_q\right) + X_{st} + \delta_s + \eta_q + \gamma_{qt} + \varepsilon_{ajksqt}$$

Negative Binomial Model (Supplemental Table 7)

We modeled the count of incident patients, rather than the incidence rate, using a generalized linear model with a log link and negative binomial distribution to account for zero-inflation of the outcome and

included each population cell size as a predictor. In this model, β_2 is effect estimate of interest and represents the marginal adjusted difference-in-differences estimate:

$$\begin{aligned}\log(\#\, incident_{ajkpsqt}) &= \log(\#at\ risk_{ajkpsqt}) + \beta_0 + \beta_1(Expansion_{ps} \times [PostYear = 1]_q) \\ &+ \beta_2(Expansion_{ps} \times [PostYear = 2\ or\ 3]_q) \\ &+ \beta_3(Expansion_{ps} \times [PostYear = 4\ or\ 5]_q) + X_{pt} + \delta_p + \eta_q + \gamma_{qt} \\ &+ \varepsilon_{ajkpsqt}\end{aligned}$$

Single Post-Expansion Time Period (Supplemental Table 8)
We respecified our statistical model to model the entire postexpansion period, rather than separating out the first transitional year. In this model, β_1 is effect estimate of interest.

$$\begin{aligned}Incidence\_Rate_{ajkpsqt} &= \beta_0 + \beta_1(Expansion_{ps} \times Post_q) + X_{pt} + \delta_p + \eta_q + \gamma_{qt} + \varepsilon_{ajkpsqt}\end{aligned}$$

Estimates for Each Year Post (Supplemental Table 8)
We respecified our model to separately estimate the effect for each year postexpansion, rather than the three time periods in the main model. In this model, we report β_1 though β_5 as effects of interest.

$$\begin{aligned}Incidence\_Rate_{ajkpsqt} &= \beta_0 + \beta_1(Expansion_{ps} \times [PostYear = 1]_q) \\ &+ \beta_2(Expansion_{ps} \times [PostYear = 2\ ]_q) \\ &+ \beta_3(Expansion_{ps} \times [PostYear = 3]_q) \\ &+ \beta_4(Expansion_{ps} \times [PostYear = 4\ ]_q) \\ &+ \beta_5(Expansion_{ps} \times [PostYear = 5]_q) + X_{pt} + \delta_p + \eta_q + \gamma_{qt} \\ &+ \varepsilon_{ajkpsqt}\end{aligned}$$

Supplemental Appendix 3. Regression Equations for Analyses: Secondary Outcome (Uninsurance)

Main Model

For each person *i* living in state *s*, during year *t*, the model of the uninsurance was given by

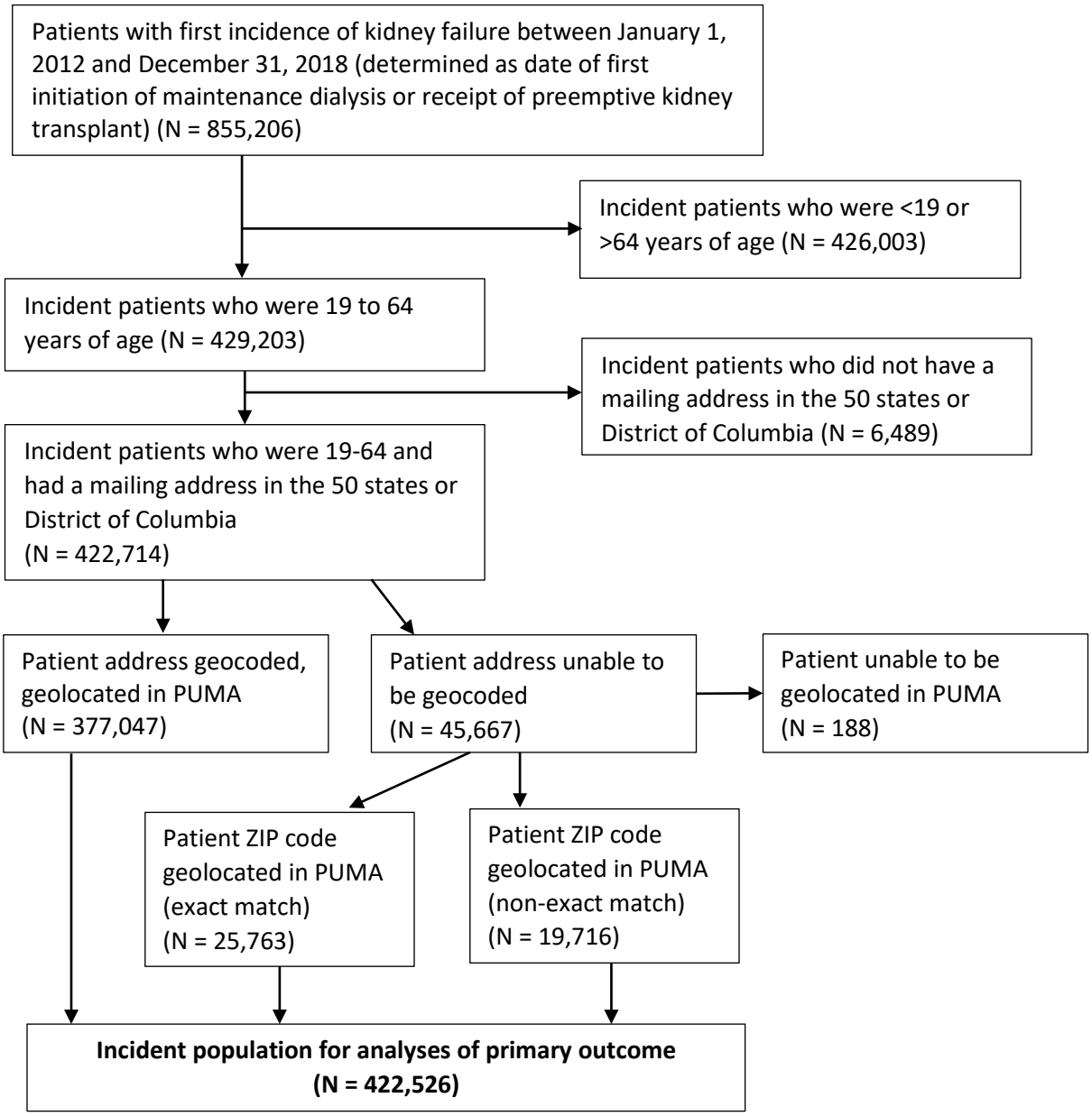
$$\begin{aligned} Uninsured_{ist} = \beta_0 &+ \beta_1(Expansion_s \times [PostYear = 1]_t) \\ &+ \beta_2(Expansion_s \times [PostYear = 2\ or\ 3]_t) \\ &+ \beta_3(Expansion_s \times [PostYear = 4\ or\ 5]_t) + X_i + \delta_s + \gamma_t + \varepsilon_{ist} \end{aligned}$$

where X_i is a vector of person-level covariates, δ_s is a vector of state fixed effects, γ_t denotes year fixed effects, and ε is an error term. The coefficients of interest are β_2 and β_3, the interactions between states' Medicaid expansion status and the time periods 2 & 3 years and 4 & 5 years after expansion occurred, respectively.

Person-level covariates were age in years; sex (male or female); race/ethnicity (non-Hispanic White, non-Hispanic Black, Hispanic, or other), an indicator for living in a household with annual income below the federal poverty level, and indicator for being unemployed, and an indicator for holding a high school degree or equivalency.

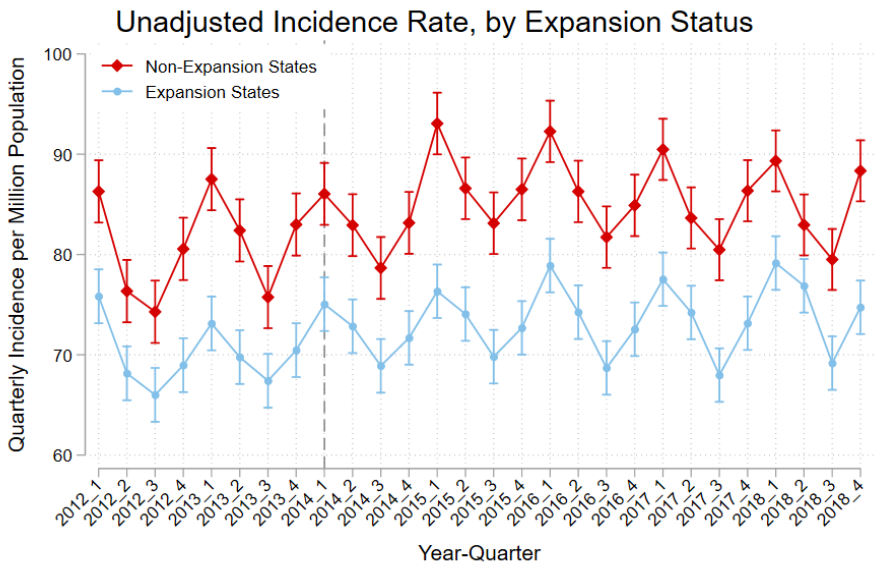
We used multivariable linear models with Huber-White robust standard errors clustered at the state level to account for state-level correlation and serial autocorrelation.[3–5] Models were weighted using replicate survey weights to account for the complex study design of the American Community Survey.[6]

Supplemental Figure 1. Study Population Flowchart – Incident Kidney Failure Cases

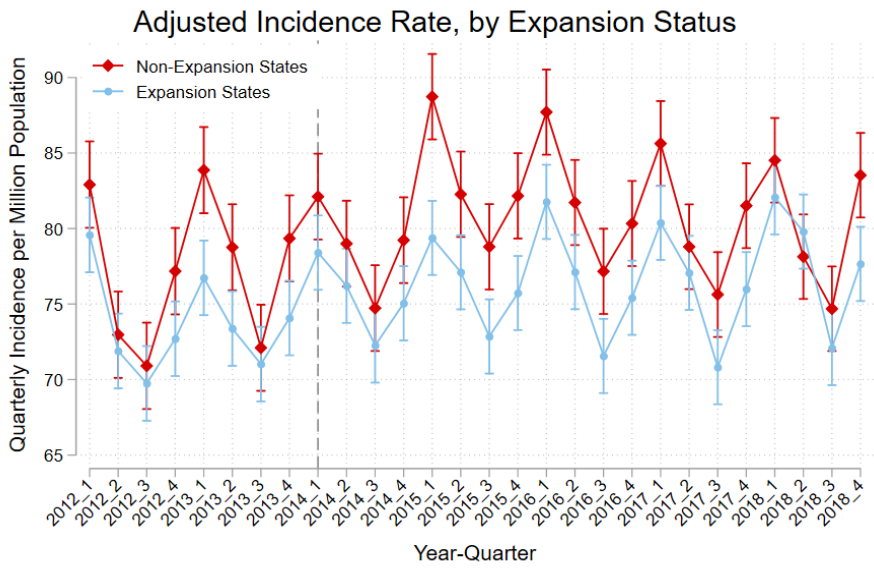


Supplemental Figure 2. Quarterly Kidney Failure Incidence per Million Population, by State Medicaid Expansion Status without Seasonality Adjustment

Panel A



Panel B



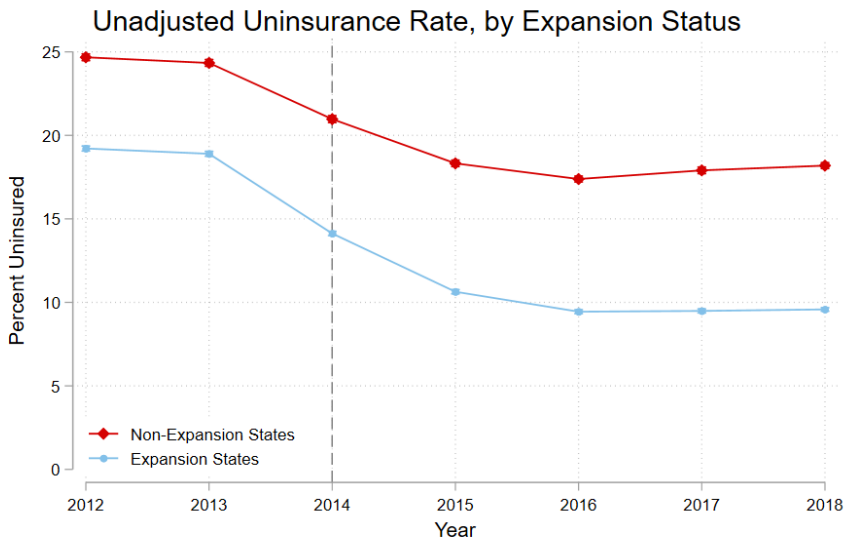
States that expanded their Medicaid programs after January 1, 2014 (time point denoted with a vertical dashed line) are excluded (see Supplemental Table 1).

Incidence rates presented in Panel A are unadjusted. Incidence rates presented in Panel B are adjusted for age group, sex, and race/ethnicity.

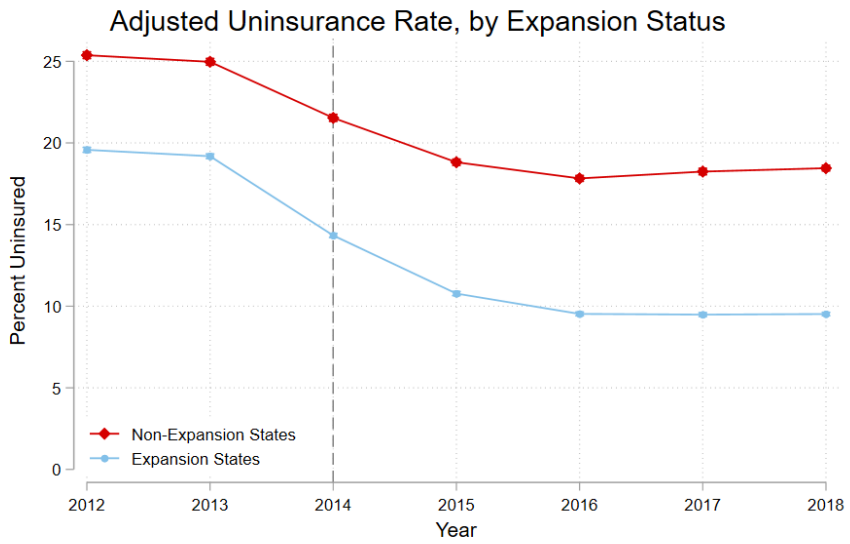
Vertical bars provide 95% confidence intervals.

Supplemental Figure 3. Annual Uninsurance Rate, by State Medicaid Expansion Status

Panel A



Panel B



States that expanded their Medicaid programs after January 1, 2014 (time point denoted with a vertical dashed line) are excluded (see Supplemental Table 1).

Uninsurance rates presented in Panel A are unadjusted. Uninsurance rates presented in Panel B are adjusted for age, sex, and race/ethnicity. Vertical bars provide 95% confidence intervals, which are derived using replicate survey weights, but are too small to be visible.

Supplemental Table 1. Definition of Expansion and Non-Expansion States and Post Period

State(s)[7]	Date of ACA Medicaid Expansion	Time Period Considered Expanded for Kidney Failure Incidence Analysis	Time Period Considered Expanded for Uninsurance Analysis
Arizona, Arkansas, California, Colorado, Connecticut, Delaware*, D.C.*, Hawaii, Illinois, Iowa, Kentucky, Maryland, Massachusetts*, Minnesota, Nevada, New Jersey, New Mexico, New York*, North Dakota, Ohio, Oregon, Rhode Island, Vermont*, Washington, West Virginia	January 1, 2014	Q1 2014 forward	2014 forward
Michigan	April 1, 2014	Q2 2014 forward	2015 forward
New Hampshire	August 15, 2014	Q4 2014 forward	2015 forward
Pennsylvania	January 1, 2015	Q1 2015 forward	2015 forward
Indiana	February 1, 2015	Q2 2015 forward	2016 forward
Alaska	September 1, 2015	Q4 2015 forward	2016 forward
Montana	January 1, 2016	Q1 2016 forward	2016 forward
Louisiana	July 1, 2016	Q3 2016 forward	2017 forward

For analysis of the primary outcome (incidence of kidney failure) PUMAs were considered expanded if they were located in a state that expanded its Medicaid program and the expansion was in effect for the entire quarter.

For analysis of the secondary outcome (uninsurance rates), states were considered expanded if the state expanded its Medicaid program and the expansion was in effect for the entire calendar year.

States that did not expand Medicaid during the study period: Alabama, Florida, Georgia, Idaho, Kansas, Maine†, Mississippi, Missouri, Nebraska, North Carolina, Oklahoma, South Carolina, South Dakota, Tennessee, Texas, Utah, Virginia, Wisconsin, Wyoming

* denotes early expansion states, as defined by Miller and Wherry, 2017[8]

† Maine implemented Medicaid expansion on January 10, 2019, but provided eligible enrollees retroactive coverage to July 2018. For purposes of this analysis, Maine is considered a non-expansion state for the duration of the study period.

Supplemental Table 2. Sample Size for Kidney Failure Incidence Rate Calculations by Years Postexpansion and Racial/Ethnic Group

Years Post-Expansion[a]	Group	Incident Patients (Numerator)		At-Risk Patients (Denominator)	
		Expansion States	Non-Expansion States	Expansion States	Non-Expansion States
0	**Total**	**75,891**	**47,210**	**264,063,168**	**145,917,712**
	Non-Hispanic White	35,469	18,745	170,133,272	90,605,650
	Non-Hispanic Black	22,128	19,606	28,312,115	23,861,338
	Hispanic	12,490	7,344	41,067,318	23,527,442
	Other	5,804	1,515	24,550,456	7,923,286
1	**Total**	**35,330**	**24,484**	**120,867,200**	**73,875,584**
	Non-Hispanic White	16,218	9,933	75,467,875	45,171,145
	Non-Hispanic Black	9,646	9,888	12,454,106	12,229,407
	Hispanic	6,550	3,845	20,674,009	12,264,167
	Other	2,916	818	12,271,211	4,210,869
2	**Total**	**35,941**	**26,073**	**121,205,376**	**74,511,472**
	Non-Hispanic White	16,840	10,678	74,956,275	45,126,285
	Non-Hispanic Black	9,447	10,084	12,516,470	12,362,958
	Hispanic	6,668	4,425	21,112,089	12,616,442
	Other	2,986	886	12,620,541	4,405,784
3	**Total**	**35,349**	**25,895**	**119,574,776**	**74,872,112**
	Non-Hispanic White	16,532	10,995	73,500,720	45,041,512
	Non-Hispanic Black	8,811	9,786	12,030,318	12,400,607
	Hispanic	6,867	4,238	21,271,845	12,884,155
	Other	3,139	876	12,771,895	4,545,842
4	**Total**	**33,984**	**25,735**	**116,450,016**	**75,456,136**
	Non-Hispanic White	15,690	10,846	70,492,783	44,858,311
	Non-Hispanic Black	8,207	9,833	11,473,887	12,503,913
	Hispanic	6,920	4,202	21,523,483	13,328,352
	Other	3,167	854	12,959,859	4,765,560
5	**Total**	**30,838**	**25,796**	**103,024,656**	**75,813,120**
	Non-Hispanic White	13,493	11,213	59,967,366	44,744,075
	Non-Hispanic Black	7,032	9,533	10,012,040	12,572,978
	Hispanic	7,098	4,164	20,777,894	13,633,162
	Other	3,215	886	12,267,360	4,862,906

[a] The postexpansion period for each state was defined based on its own implementation date (see Supplemental Table 1).

Please note that groups might not add precisely to the total due to rounding to the nearest person-year.

Supplemental Table 3. Changes in Uninsurance Among Nonelderly Adults Following the ACA Medicaid Expansion, Stratified Analyses

Characteristic	Pre-2014 Mean Adjusted Uninsurance Rate[a]	Absolute Adjusted Difference-in-Differences Estimate (95% CI)		Relative Adjusted Difference-in-Differences Estimate (95% CI)[b]	
		2 & 3 Years Post	4 & 5 Years Post	2 & 3 Years Post	4 & 5 Years Post
Overall	21.01	-2.29 (-2.44 to -2.14)	-2.81 (-2.95 to -2.66)	-12.39% (-13.19% to -11.59%)	-15.20% (-15.99% to -14.40%)
Age group, years					
19-44	24.92	-2.73 (-2.95 to -2.51)	-3.18 (-3.41 to -2.96)	-12.40% (-13.4% to -11.41%)	-14.44% (-15.47% to -13.42%)
45-64	15.81	-1.74 (-1.91 to -1.57)	-2.30 (-2.47 to -2.13)	-12.57% (-13.79% to -11.35%)	-16.64% (-17.87% to -15.41%)
Sex					
Male	23.38	-2.62 (-2.82 to -2.43)	-3.38 (-3.59 to -3.17)	-12.56% (-13.47% to -11.65%)	-16.16% (-17.16% to -15.15%)
Female	18.67	-1.95 (-2.14 to -1.77)	-2.24 (-2.42 to -2.06)	-12.15% (-13.32% to -10.98%)	-13.94% (-15.08% to -12.80%)
Race/Ethnicity					
Non-Hispanic White	14.92	-1.84 (-1.99 to -1.69)	-2.00 (-2.17 to -1.83)	-13.81% (-14.93% to -12.69%)	-15.00% (-16.27% to -13.73%)
Non-Hispanic Black	25.69	-3.05 (-3.43 to -2.66)	-2.73 (-3.15 to -2.30)	-13.35% (-15.04% to -11.66%)	-11.94% (-13.79% to -10.09%)
Hispanic	40.86	-3.95 (-4.46 to -3.43)	-4.91 (-5.44 to -4.38)	-10.72% (-12.12% to -9.33%)	-13.34% (-14.77% to -11.91%)
Area-level poverty rate[c]					
Below median (14.1%)	16.02	-0.93 (-1.13 to -0.73)	-1.35 (-1.54 to -1.15)	-6.52% (-7.95% to -5.10%)	-9.47% (-10.85% to -8.09%)
At or above median	26.32	-4.22 (-4.44 to -4.00)	-5.01 (-5.25 to -4.76)	-17.97% (-18.91% to -17.03%)	-21.31% (-22.36% to -20.26%)
Area-level uninsurance rate[c]					
Below median (19.6%)	13.82	-1.56 (-1.76 to -1.35)	-1.73 (-1.94 to -1.52)	-11.73% (-13.28% to -10.18%)	-13.05% (-14.65% to -11.45%)
At or above median	28.23	-5.35 (-5.58 to -5.12)	-6.44 (-6.70 to -6.19)	-20.15% (-21.03% to -19.27%)	-24.28% (-25.23% to -23.32%)
Area-level metropolitan status[d]					
Urban	20.66	-2.06 (-2.22 to -1.90)	-2.60 (-2.76 to -2.43)	-11.29% (-12.18% to -10.41%)	-14.26% (-15.17% to -13.35%)
Rural	23.16	-3.69 (-4.07 to -3.31)	-4.12 (-4.55 to -3.69)	-18.20% (-20.08% to -16.32%)	-20.33% (-22.45% to -18.21%)

Models are adjusted for age, sex, and race/ethnicity, having household income below the federal poverty level, unemployment status, and high school graduate attainment status, in addition to fixed effects for year and state. Estimates and 95% CIs are derived from models with replicate survey weights and Huber-White robust standard errors clustered at the state level. Stratified analyses for sex and race/ethnicity do not adjust for the stratified covariate; age-group stratified analyses still adjust for age.

[a] Mean uninsurance rate pre-2014 is adjusted for same covariates as models.
[b] Difference-in-differences estimate relative to adjusted pre-expansion uninsurance rate in Medicaid expansion states.
[c] Stratification by median PUMA-level poverty and uninsurance rates pre-expansion (2012 and 2013).
[d] Urban-designated PUMAs those with over 50% of their 2010 population residing in metropolitan areas.

Supplemental Table 4. Parallel Trends Assumption Test – Time Trend

	Kidney Failure Incidence Rate Time Trend	
	Estimate	**95% Confidence Interval**
Full Sample (Main Analysis)	-0.31	(-0.76 to 0.14)

Estimate is the regression coefficient on an interaction term between an indicator variable for whether a PUMA was located in a Medicaid expansion state and a linear time trend. Data limited to the pre-expansion period. Model is adjusted for age, sex, and race/ethnicity distribution, poverty rate, unemployment rate, and high school graduate attainment rate, in addition to fixed effects for season, year-quarter, and PUMA. Estimates and 95% CIs are derived from models weighted by PUMA cell population. Incidence rate is per million population per quarter.

Supplemental Table 5. Parallel Trends Assumption Test – Event Study Falsification

	Kidney Failure Incidence Difference-in-Difference Estimate	
Falsified Expansion Time Point	**Estimate**	**95% Confidence Interval**
2012 Q2	-0.17	(-2.83 to 2.49)
2012 Q3	-1.73	(-3.57 to 0.10)
2012 Q4	-2.35	(-4.22 to -0.49)
2013 Q1	-1.97	(-4.05 to 0.12)
2013 Q2	-0.48	(-2.41 to 1.44)
2013 Q3	0.45	(-1.98 to 2.88)

Estimate is the regression coefficient on an interaction term between an indicator variable for whether a PUMA was located in a Medicaid expansion state and an indicator for a falsified post-period. Data limited to the pre-expansion period. Models are adjusted for age, sex, and race/ethnicity distribution, poverty rate, unemployment rate, and high school graduate attainment rate, in addition to fixed effects for season, year-quarter, and PUMA. Estimates and 95% CIs are derived from models weighted by PUMA cell population with Huber-White robust standard errors clustered at the state level.

Supplemental Table 6. Sensitivity Analyses of Changes in Kidney Failure Incidence Among Nonelderly Adults Following the ACA Medicaid Expansion – Specific Incident Patient Populations

Subgroup Analysis	Mean Adjusted Incidence Rate	Absolute Adjusted Difference-in-Differences Estimate (95% CI)		Relative Adjusted Difference-in-Differences Estimate (95% CI)[a]	
		2 & 3 Years Post	4 & 5 Years Post	2 & 3 Years Post	4 & 5 Years Post
Main Model	77.13	-2.20 (-3.89 to -0.51)	-0.56 (-2.71 to 1.58)	-3.07% (-5.43% to -0.72%)	-0.79% (-3.78% to 2.21%)
Incident Dialysis Patients Only	74.71	-2.21 (-3.67 to -0.75)	-0.65 (-2.74 to 1.45)	-3.20% (-5.31% to -1.09%)	-0.93% (-3.97% to 2.10%)
Primary Cause of Kidney Failure					
Diabetes	37.49	-0.75 (-1.76 to 0.26)	0.44 (-1.34 to 2.23)	-2.20% (-5.19% to 0.78%)	1.30% (-3.95% to 6.56%)
Hypertension	18.69	-0.44 (-1.27 to 0.38)	-0.18 (-1.27 to 0.91)	-2.66% (-7.59% to 2.27%)	-1.08% (-7.58% to 5.42%)

Incidence rates are per quarter (3 months) per million population.

Models are adjusted for age, sex, and race/ethnicity distribution, poverty rate, unemployment rate, and high school graduate attainment rate, in addition to fixed effects for season, year-quarter, and PUMA. Estimates and 95% CIs are derived from models weighted by PUMA cell population with Huber-White robust standard errors clustered at the state level.

[a] Difference-in-differences estimate relative to pre-expansion incidence rate in PUMAs in Medicaid expansion states

Supplemental Table 7. Sensitivity Analyses of Changes in Kidney Failure Incidence Among Nonelderly Adults Following the ACA Medicaid Expansion – Alternative Model Specifications

Sensitivity Analysis	Mean Adjusted Incidence Rate	Absolute Adjusted Difference-in-Differences Estimate (95% CI)		Relative Adjusted Difference-in-Differences Estimate (95% CI)[a]	
		2 & 3 Years Post	4 & 5 Years Post	2 & 3 Years Post	4 & 5 Years Post
Main Model	77.13	-2.20 (-3.89 to -0.51)	-0.56 (-2.71 to 1.58)	-3.07% (-5.43% to -0.72%)	-0.79% (-3.78% to 2.21%)
Only Time & PUMA Fixed Effects	77.23	-2.44 (-4.11 to -0.77)	-1.45 (-3.65 to 0.75)	-3.40% (-5.73% to -1.07%)	-2.02% (-5.09% to 1.05%)
Only Time & PUMA Fixed Effects & Demographics (no PUMA-level covariates)	77.23	-2.13 (-3.86 to -0.41)	-0.50 (-2.69 to 1.69)	-2.97% (-5.38% to -0.57%)	-0.69% (-3.75% to 2.36%)
Main Model, Excluding Early Expansion States	78.15	-2.20 (-3.96 to -0.44)	-0.52 (-2.87 to 1.82)	-3.02% (-5.43% to -0.61%)	-0.72% (-3.93% to 2.50%)
State Level Analysis	77.35	-1.49 (-2.81 to -0.16)	0.44 (-1.57 to 2.45)	-2.07% (-3.92% to -0.23%)	0.61% (-2.19% to 3.41%)
Negative Binomial Model	76.46	---	---	Marginal DiD Estimates -3.33% (-5.68% to -0.98%)	-1.95% (-4.86% to 0.96%)

Incidence rates are per quarter (3 months) per million population.

Estimates and 95% CIs are derived from models weighted by PUMA (or state, for the state level analysis) cell population with Huber-White robust standard errors clustered at the state level. All models except for the "no PUMA-level covariates model" are also adjusted for time-varying PUMA-level poverty rates, unemployment rates, and high school graduate attainment rates (or time-varying state-level covariates for the state level analysis).

All models are adjusted for age, sex, and race/ethnicity distribution, in addition to fixed effects for season, year-quarter, and PUMA (or state, for the state-level analysis).

[a] Difference-in-differences estimate relative to pre-expansion incidence rate in PUMAs in Medicaid expansion states for models except for the negative binomial model; the negative binomial model coefficient provides the marginal difference-in-differences (DiD) estimate.

Supplemental Table 8. Sensitivity Analyses of Changes in Kidney Failure Incidence Among Nonelderly Adults Following the ACA Medicaid Expansion – Alternative Post-Period Model Specifications

Sensitivity Analysis	Mean Adjusted Incidence Rate	Absolute Adjusted Difference-in-Differences Estimate (95% CI)		Relative Adjusted Difference-in-Differences Estimate (95% CI)[a]	
Main Model	77.13	**2 & 3 Years Post**	**4 & 5 Years Post**	**2 & 3 Years Post**	**4 & 5 Years Post**
		-2.20 (-3.89 to -0.51)	-0.56 (-2.71 to 1.58)	-3.07% (-5.43% to -0.72%)	-0.79% (-3.78% to 2.21%)
Alternative Model: Single Postexpansion Time Period	77.13	-1.28 (-2.75 to 0.19)		-1.79% (-3.83% to 0.26%)	
Alternative Model: Each Postexpansion Year Modeled Separately	77.13				
1 year post		-0.75 (-2.08 to 0.57)		-1.05% (-2.89% to 0.80%)	
2 year post		-2.52 (-4.45 to -0.59)		-3.52% (-6.20% to -0.83%)	
3 year post		-1.91 (-3.54 to -0.28)		-2.66% (-4.94% to -0.38%)	
4 year post		-1.36 (-3.47 to 0.74)		-1.90% (-4.83% to 1.03%)	
5 year post		0.62 (-1.90 to 3.14)		0.86% (-2.65% to 4.38%)	

Incidence rates are per quarter (3 months) per million population.

Models are adjusted for age, sex, and race/ethnicity distribution, poverty rate, unemployment rate, and high school graduate attainment rate, in addition to fixed effects for season, year-quarter, and PUMA. Estimates and 95% CIs are derived from models weighted by PUMA cell population with Huber-White robust standard errors clustered at the state level.

[a] Difference-in-differences estimate relative to pre-expansion incidence rate in PUMAs in Medicaid expansion states.

Supplemental Appendix 4. Online-Only Supplement References

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