

Supplementary Online Content

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eReferences

This supplementary material has been provided by the authors to give readers additional information about their work.

eAppendix. Supplementary Methods and Results

Section 1. Definition of Expansion and Nonexpansion States and Post Period

Patients were designated as undergoing dialysis in an expansion state if they resided in an expansion state as of the time they initiated dialysis. The table below provides a list of expansion states, their date of Medicaid expansion, and whether they were also designated as an early expansion state for sensitivity analyses described in Section 4.

Expansion and Nonexpansion States and Date of Expansion

| States | Date of ACA Medicaid expansion |
|---|--------------------------------|
| Arkansas, Arizona, California, Colorado, Connecticut, Delaware*, D.C.*, Hawaii, Illinois, Iowa, Kentucky, Massachusetts*, Maryland, Minnesota, New Jersey, New Mexico, New York*, Nevada, North Dakota, Ohio, Oregon, Rhode Island, Vermont*, Washington, West Virginia | January 1, 2014 |
| Michigan | April 1, 2014 |
| New Hampshire | August 15, 2014 |
| Pennsylvania | January 1, 2015 |
| Indiana | February 1, 2015 |
| Alaska | September 1, 2015 |
| Montana | January 1, 2016 |
| Louisiana | July 1, 2016 |

Note: Nonexpansion states were as follows: Alabama, Florida, Georgia, Idaho, Kansas, Maine, Mississippi, Missouri, Nebraska, North Carolina, Oklahoma, South Carolina, South Dakota, Tennessee, Texas, Utah, Virginia, Wisconsin, and Wyoming.

* denotes early expansion states, as defined by Miller and Wherry, 2017¹

Section 2. Further Description of Outcomes and Study Population

The source of each outcome in the REMIS data, further exclusions (if any), and sample sizes are provided below.

| Outcome | Source in REMIS Data | Additional Exclusions | Sample Size |
|--|---------------------------------------|--|-------------|
| One-year mortality | Death Notification Form (CMS 2746) | Excluded patients initiating dialysis after January 1, 2016 and those who died within 90 days of initiation dialysis | 180,044 |
| Medicaid* | ESRD Medical Evidence Form (CMS 2728) | None | 236,246 |
| Uninsurance* | | | |
| Receipt of nephrology care prior to dialysis | | Excluded patients with missing values for this outcome | 204,959 |
| Presence of arteriovenous fistula or graft | | Excluded patients who did not initiate hemodialysis | 205,875 |

* To construct the medicaid and uninsured outcomes, we used the following hierarchy of insurance types in the Medical Evidence Form: dual Medicare-Medicaid, Medicare (including Medicare Advantage) without Medicaid coverage, Medicaid, Employer Group, VA and Other. We classified individuals as uninsured if their current medical coverage was marked as 'None'.

Section 3. Regression Specification

For each outcome Y , we estimated the following multivariate regression:

$$Y_{ism} = \alpha_0 + \alpha_1 + \alpha_m + \beta_1 \text{Expand}_{ism} + \beta_2 X_{is} + \varepsilon_{ism} \quad (1)$$

where i denotes individual, s denotes state of residence at the time a patient initiated dialysis, and m denotes the year and month when the patient initiated dialysis. Here α_s is a vector of state-level indicators, and α_m is a vector of indicator variables indicating the period (year-month) when a patient first initiated dialysis. Further, X_{is} is a vector of covariates and includes the following variables: age (in years), sex, race/ethnicity (non-Hispanic white, non-Hispanic black, Hispanic, other), primary cause of ESRD (diabetes, hypertension, other), comorbid conditions, current smoking, alcohol dependence, hemoglobin level (g/dl), serum albumin (g/dl), body mass index (kg/m²), and the proportion of persons living in the patient's Census Tract or ZIP Code with income below the federal poverty limit. The variable Expand_{ism} is an indicator variable that equals 1 if an individual initiated dialysis in an expansion state after that state expanded Medicaid, and equals 0 otherwise. β_1 is the main coefficient of interest and represents the adjusted mean difference between expansion and Nonexpansion states in the change in outcomes from the pre-expansion period to the post-expansion period.

Section 4. Parallel Trends Assumption

Our difference-in-difference specification assumes that, if Medicaid expansion had not occurred, the outcomes would have trended similarly across expansion and Nonexpansion states. Therefore, we attribute observed post-policy divergence in the outcomes to the impact of the ACA Medicaid expansions rather than a pre-policy difference in trends. We investigated this parallel trends assumption underlying our empirical model by estimating an equation similar to equation (1) using only pre-policy data. The model included an interaction between whether or not a state expanded Medicaid and a linear year-month specific time trend.

Section 5. Sensitivity Analyses

We explore the robustness of our mortality estimates to alternate specifications. The results of the sensitivity analyses are presented in eTable 2.

Accounting for Early Expansion

Although most states expanded Medicaid coverage on January 1st, 2014 or later, five states (DC, DE, NY, MA, and VT) that made substantial expansions of Medicaid coverage to nonelderly adults prior to 2014. We selected these states to be consistent with the

approach described in Miller and Wherry, 2017.¹ In eFigure 5, panels A-E, we present graphs of our main outcomes after dropping these early expansion states.

Alternative Approach to Handling Missing Data

In our study population, the rate of missing was 5% for body mass index (BMI), 14% for hemoglobin, 2% for area-level poverty, and 30% for serum albumin. Our first method to address the missing data for each variable was to assume that the data was missing at random, replacing the missing observation with the mean value for the non-missing observations, and including an indicator variable if the observation had a missing value. Although simple to implement, this approach suffers from the problem of introducing errors in the correlation between variables, thereby also potentially biasing the estimated coefficients. The problem is most severe for albumin for which about 30% of the observations have missing values. We therefore also used a multiple imputation approach to account for missing values of albumin. This approach leverages the potential correlation of albumin with other variables such as age, gender, and co-morbidities. Using these variables, we imputed a value for albumin and do this 20 times to generate 20 different estimates of imputed albumin. The STATA procedure combines the point estimates derived from all imputations to arrive at a single point estimate and associated confidence interval. In eTable 2, we explore the sensitivity of our mortality estimate to using multiple imputation for missing values for albumin.

Excluding Transitional Periods Around Medicaid Expansion

Patients who started dialysis in an expansion state prior to 2014 may have acquired Medicaid coverage through the expansion after 2014. We therefore examined the sensitivity of our mortality estimates after excluding all patients living in expansion states who initiated dialysis during the fifteen month period prior to expansion. Further, the health effects of Medicaid expansion may take time to materialize. Therefore, we conducted a second sensitivity analysis that excluded the six month period immediately following the implementation date in each expansion state.

Consideration of One-year Mortality Beginning on the 43rd day Following Initiation of Dialysis

Our primary outcome was one-year mortality beginning on the 91st day following initiation of dialysis. This approach is consistent with that used by the United States Renal Data System, because deaths in the early period following dialysis initiation are undercounted in the REMIS data.^{2,3} Given a recent paper that determined that undercounting of deaths are concentrated in the first 6 weeks following initiation,³ we examined the sensitivity of our estimates after defining one-year mortality beginning on the 43rd day following the initiation of dialysis.

Examining Mortality Amenable and Not Amenable to Health Care

Using data on the cause of death information provided in form CMS 2746, we classified deaths that were not amenable to healthcare as those due to a drug overdose, accident unrelated to treatment, or suicide. As with our primary outcome of all-cause mortality, we required the death to have occurred within 1 year following the 91st day after initiating

dialysis. Similarly, we constructed an indicator variable to measure mortality amenable to health care, by excluding deaths that were due to drug overdose, accident unrelated to treatment, or suicide.

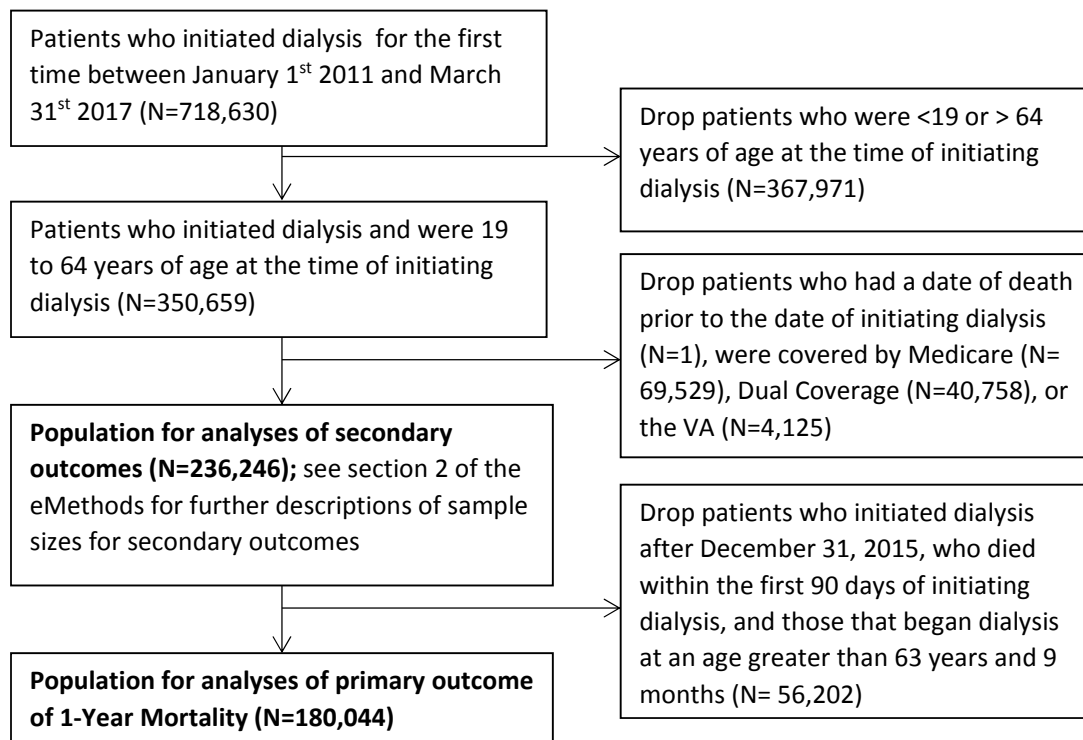
Assessing Changes in Clinical Severity Post-Expansion

It is also possible that the expansion of insurance could alter the timecourse of when patients with chronic kidney disease choose to initiate dialysis, which could change the composition of the study population over time. To investigate this, we examined differential changes in the number of patients, type of initial dialysis, and prevalence of comorbid conditions in expansion vs. nonexpansion states. Specifically, we constructed generated difference-in-difference estimates for the log of the number of incident patients, the proportion initiating peritoneal dialysis, the estimated glomerular filtration rate, and the prevalence of the seven comorbid conditions listed in Table 1 of the main paper.

Estimation of Difference-in-Differences for Persons with Medicare, VA and Dual Medicare-Medicaid Coverage

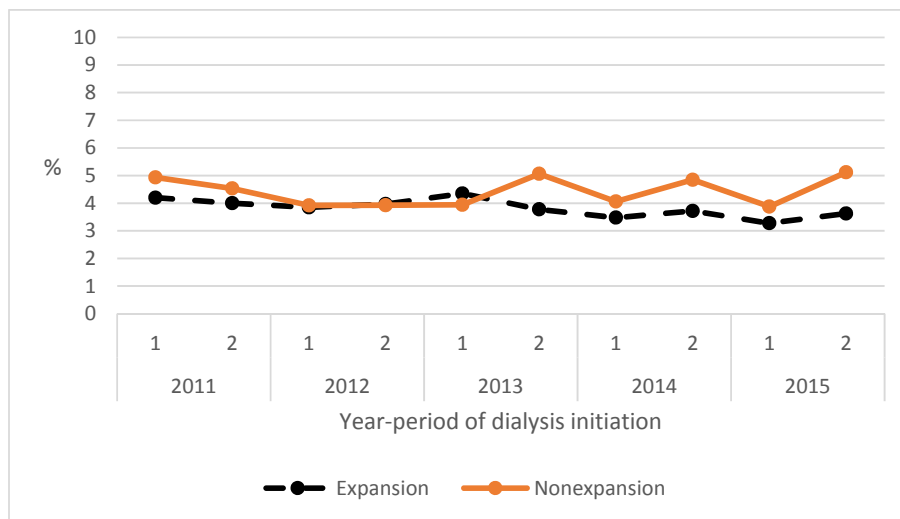
In our primary analysis, we excluded patients with Medicare, dual Medicare-Medicaid, or VA coverage, since the ACA's expansion did not change Medicaid eligibility for these patients. As a falsification test, we determined whether Medicaid expansion was associated with changes in outcomes for these populations. In one model, we combined Medicare (n=69,529) and VA (n=4,125) patients given the relatively small number in the latter group. The other model included patients with dual Medicare-Medicaid coverage (n=40,758). eTable 7 shows the difference-in-difference estimates and associated p-values for each of these sub-groups of patients. We find that Medicaid expansion was not associated with significant changes in mortality for these subgroups.

eFigure 1. Study Population Flowchart

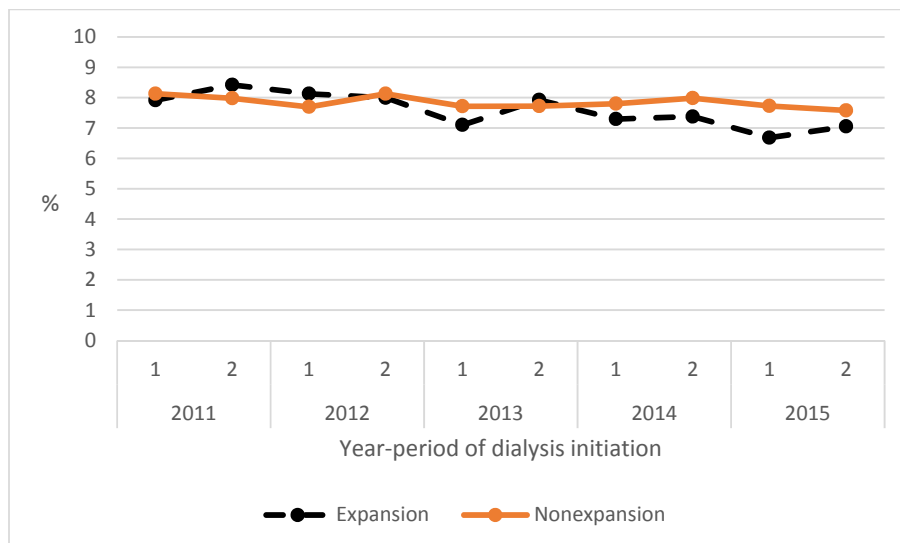


eFigure 2. Trends in One-Year Mortality in Expansion and Nonexpansion States, by Age, Race, and Area-Level Poverty

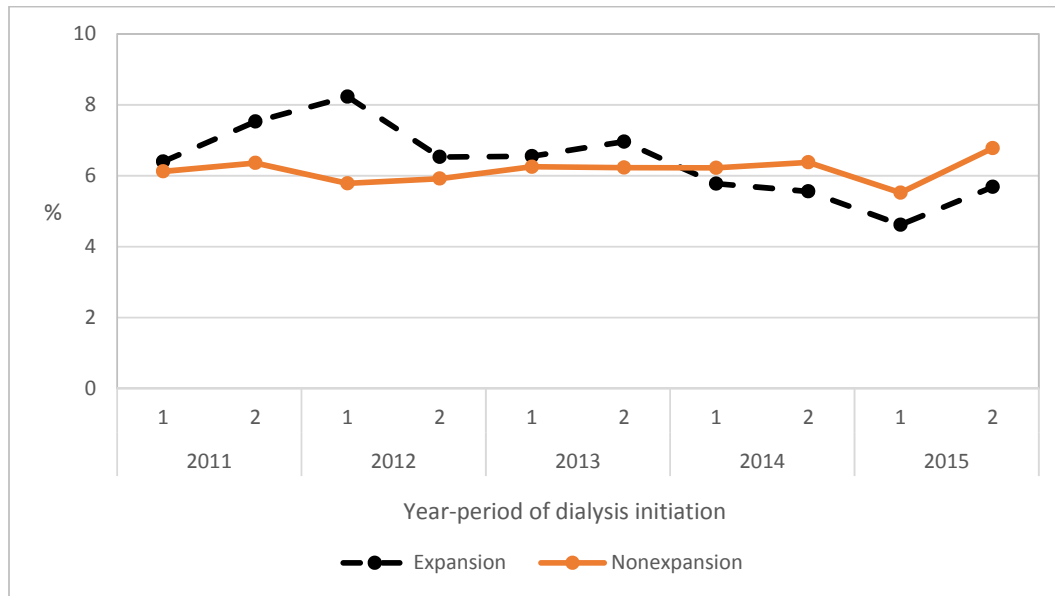
Panel A. Persons aged 19-44 years



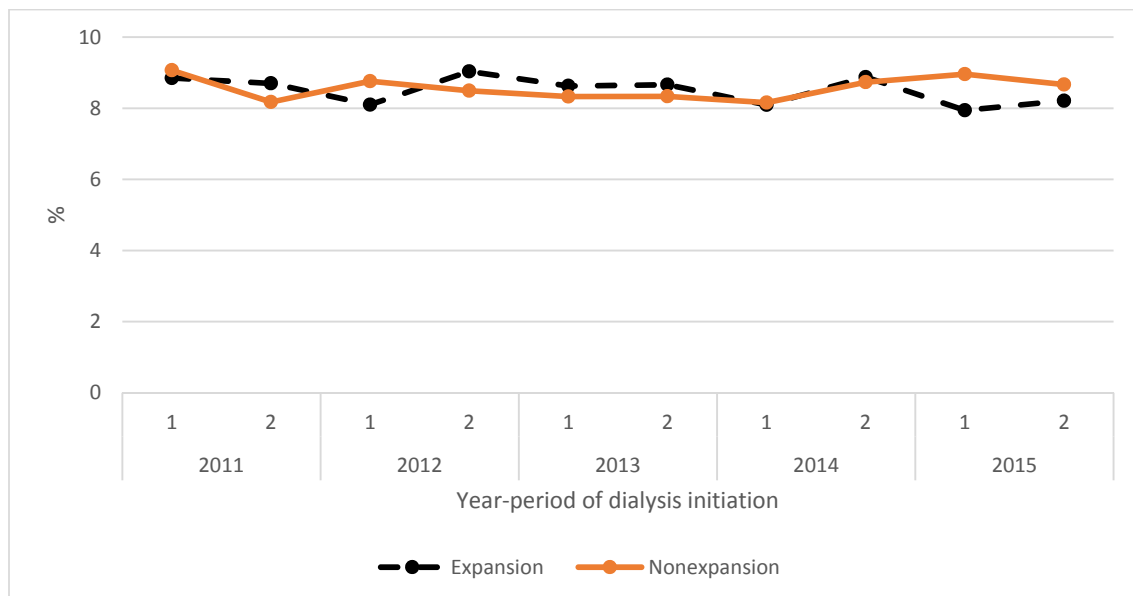
Panel B. Persons aged 45-64 years



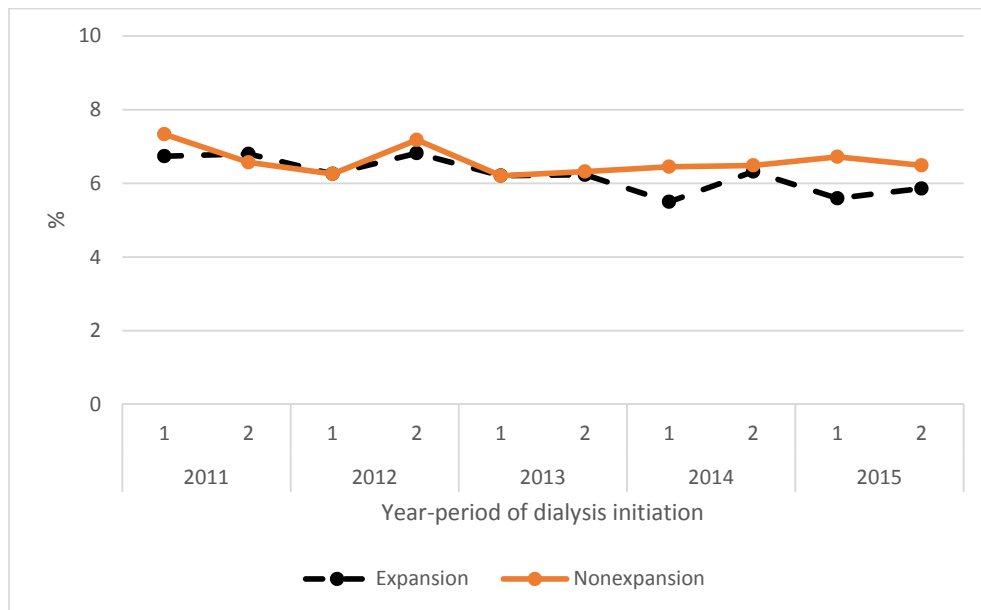
Panel C. Non-Hispanic black patients



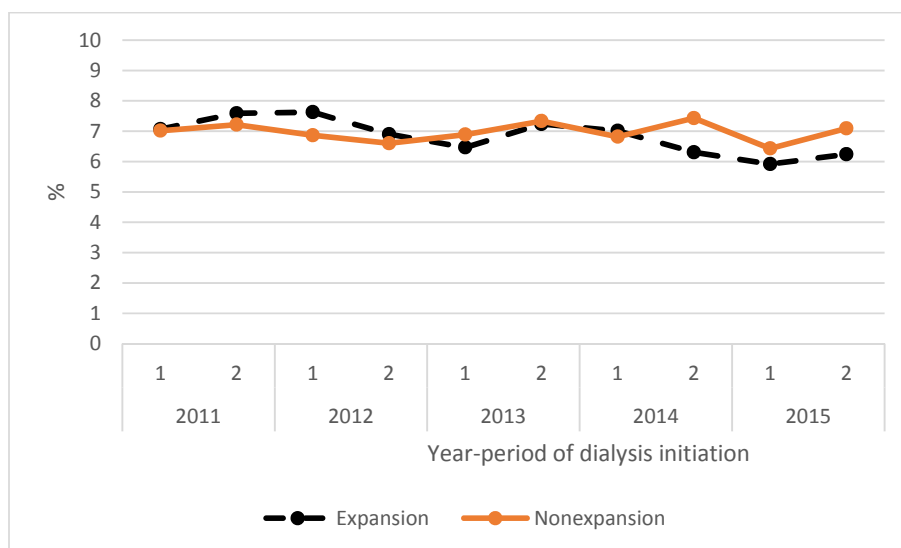
Panel D. Non-Hispanic white patients



Panel E. Persons living in areas with poverty rates below the sample median



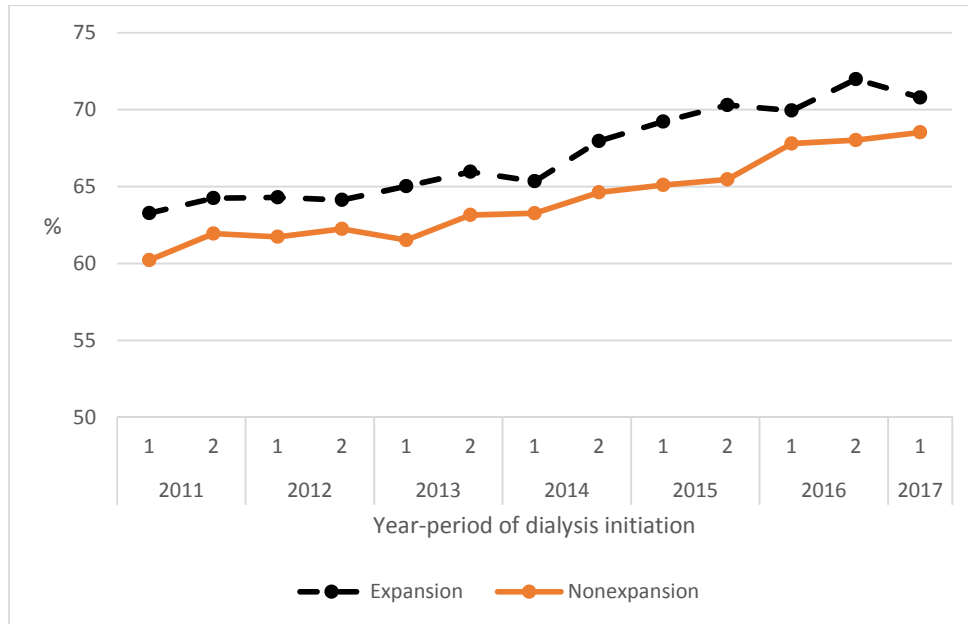
Panel F. Persons living in areas with poverty rates above the sample median



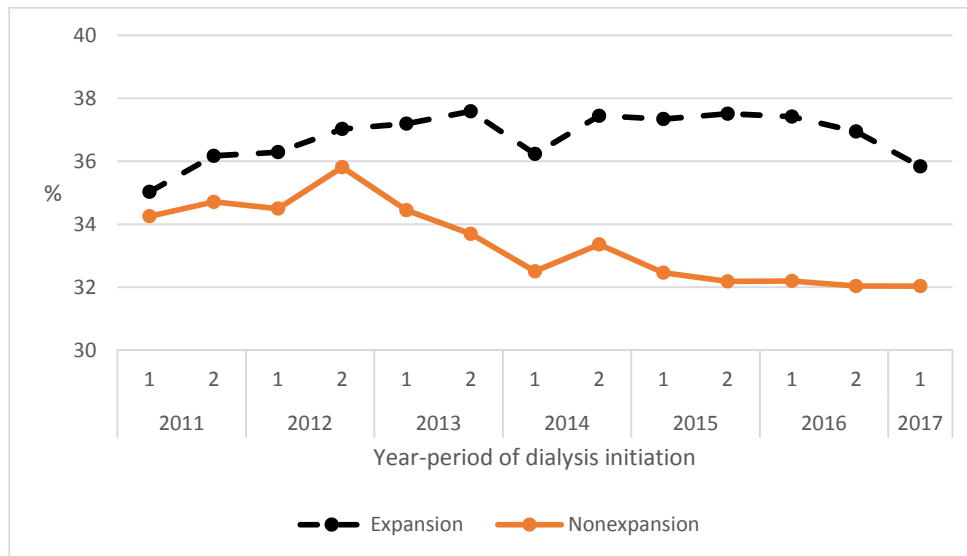
Note: Expansion states restricted to those that expanded January 1, 2014. The data points labeled '1' and '2' on the X-axis correspond to half-yearly periods.

eFigure 3. Trends in Nephrology Care by State Medicaid Expansion Status

Panel A. Receipt of nephrology care prior to dialysis



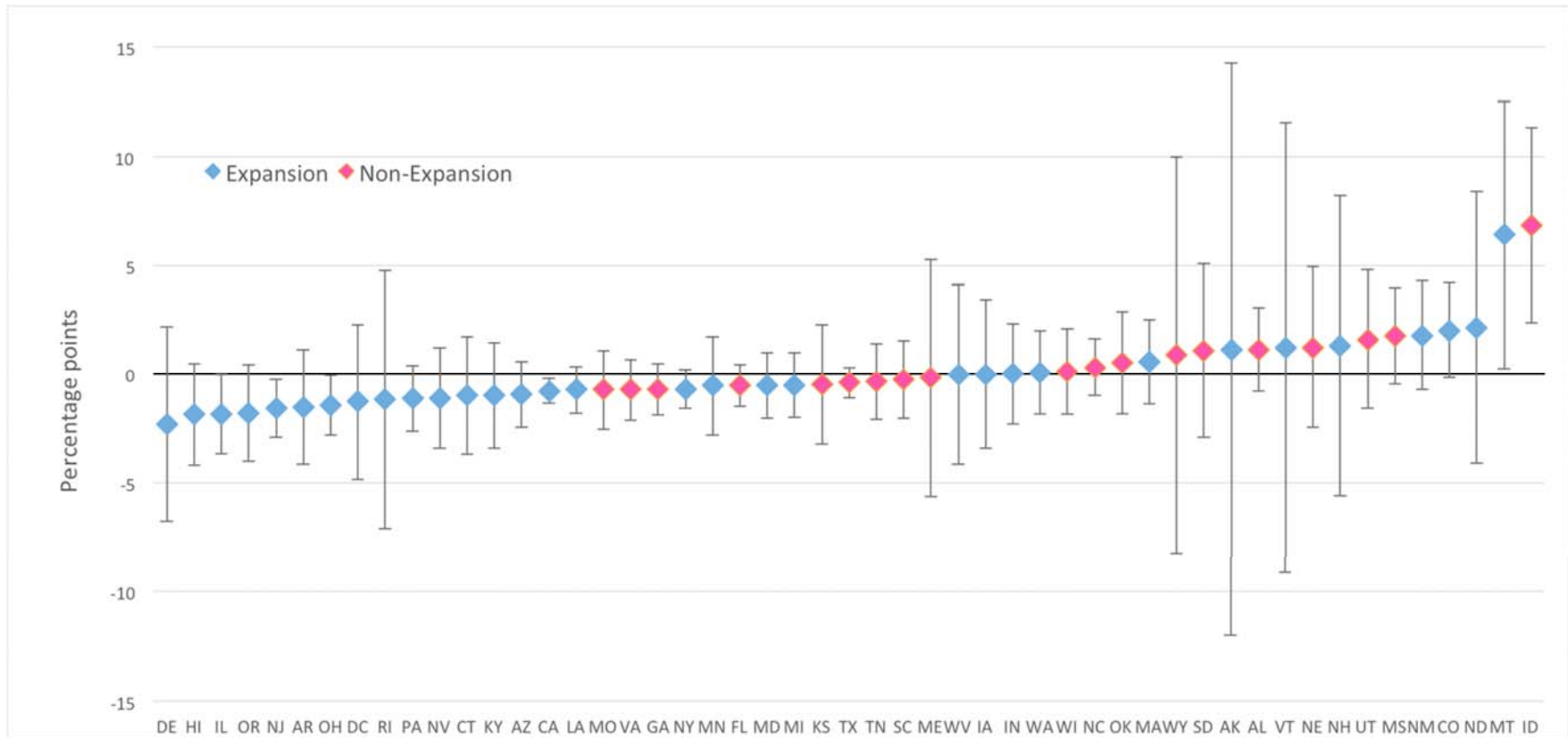
Panel B. Presence of an arteriovenous fistula or graft at initiation of hemodialysis



Note: Axis extends from 50% to 75% for Panel A and 30% to 40% for Panel B. Expansion states restricted to those that expanded January 1, 2014. The period labeled '1' for 2017 refers to data in the first quarter of 2017. All other periods are half-yearly.

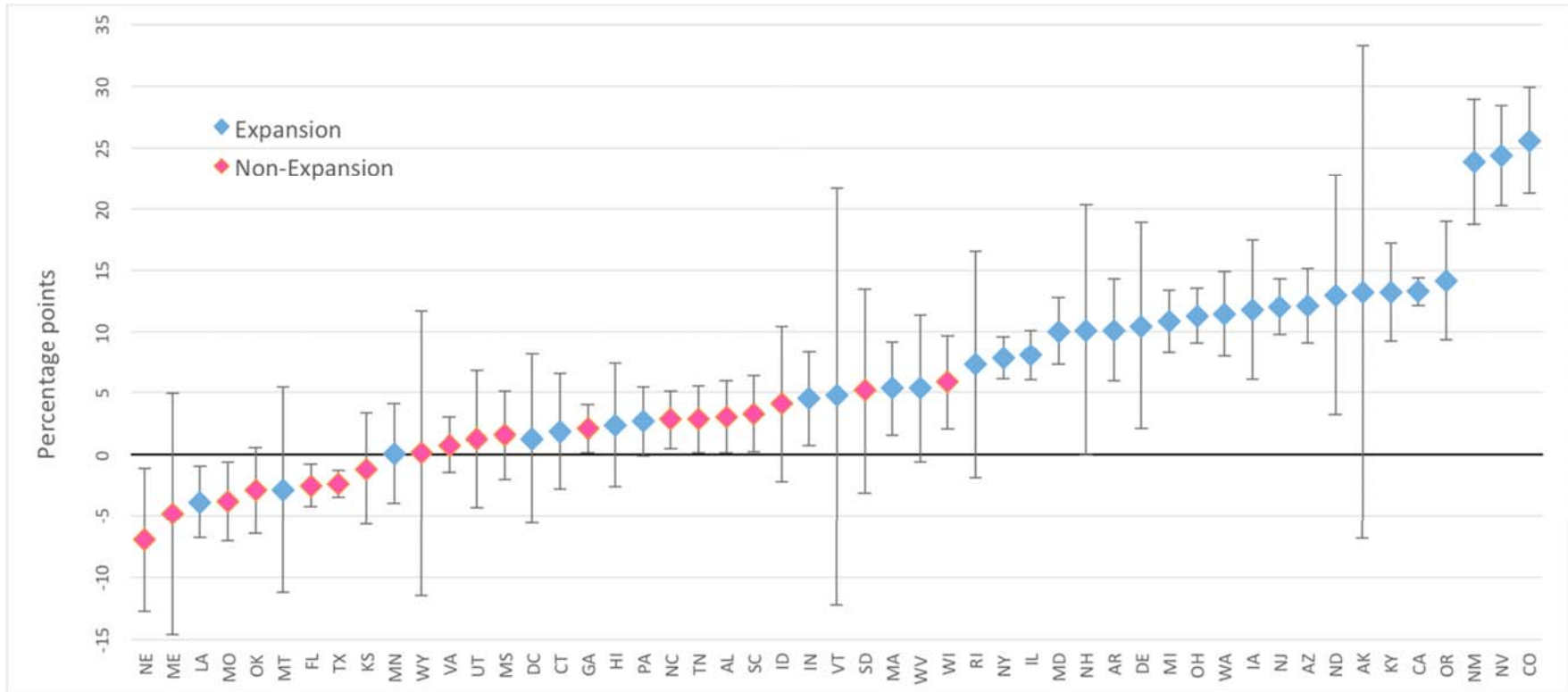
eFigure 4. State-Level Changes in 1-Year Mortality and Medicaid Coverage

Panel A. 1-Year Mortality



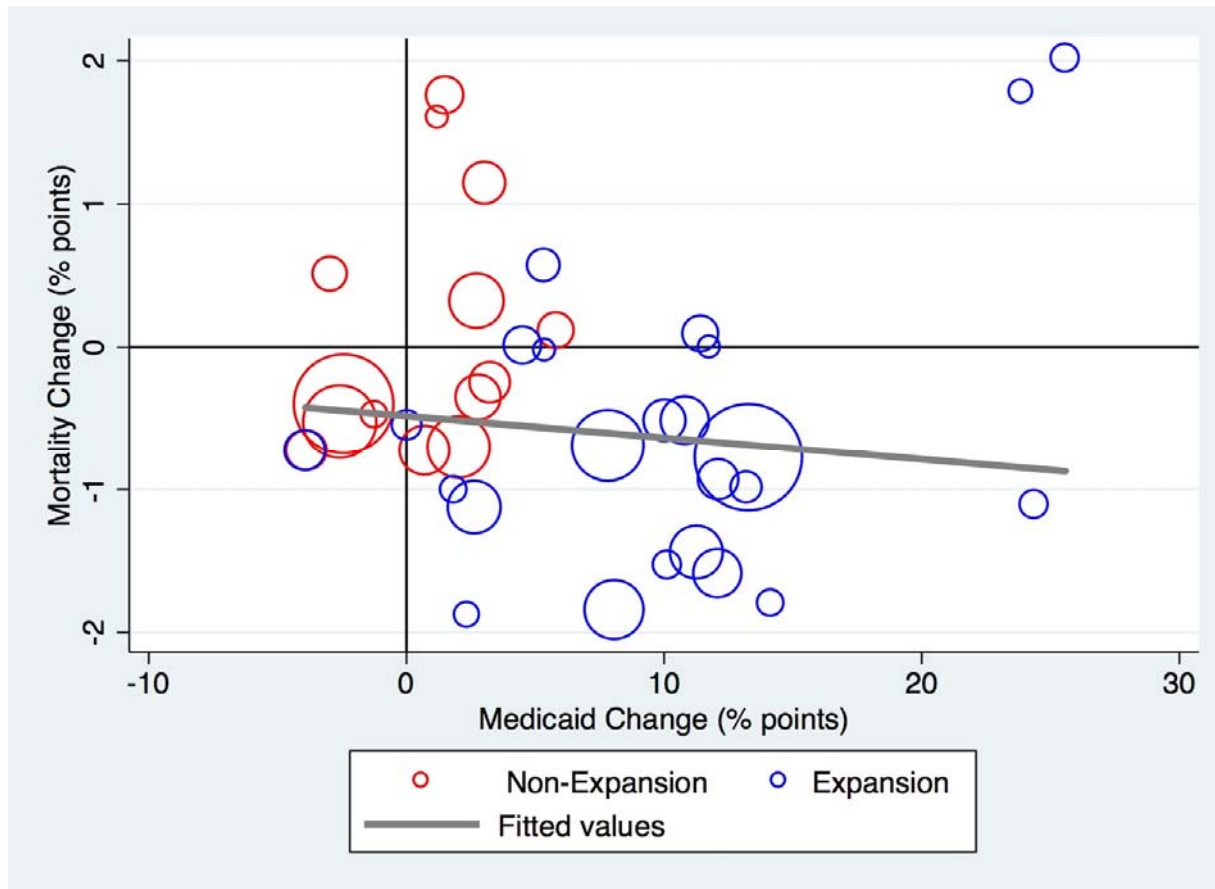
Note: The estimates (with 95% CIs) indicate the adjusted change between the pre-expansion and post-expansion periods. For non-expansion states, the post-expansion period is defined as the period following December 31, 2013.

Panel B. Medicaid Coverage



Note: The estimates (with 95% CIs) indicate the adjusted change between the pre-expansion and post-expansion periods. For non-expansion states, the post-expansion period is defined as the period following December 31, 2013.

Panel C. Relationship Between Post-Expansion Changes in Medicaid Coverage and Changes in Mortality

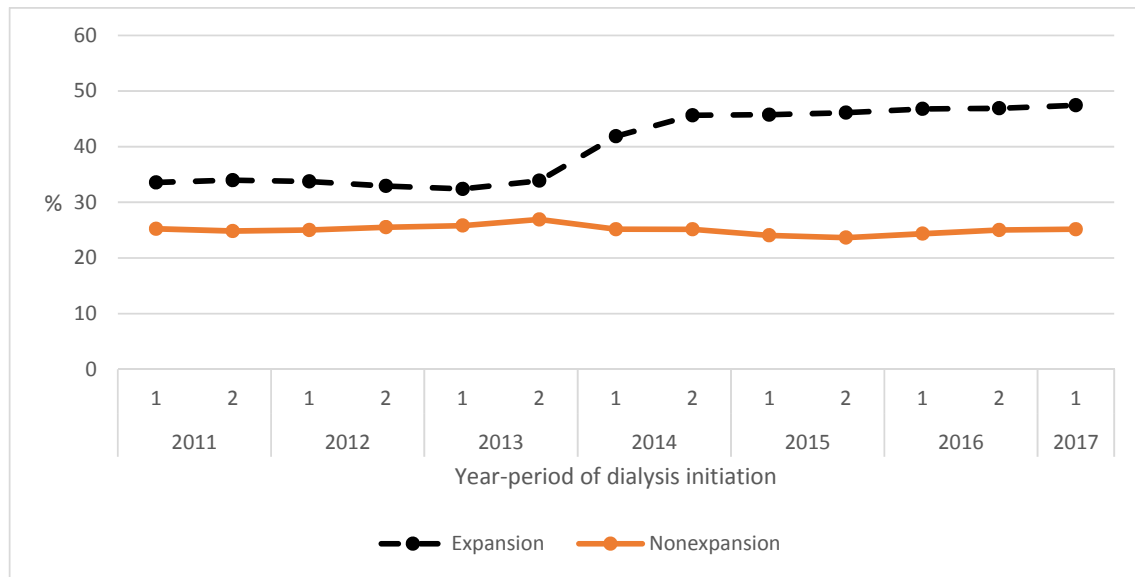


Notes: The estimates indicate the adjusted change between the pre-expansion and post-expansion periods. For non-expansion states, the post-expansion period is defined as the period following December 31, 2013. Each circle represents a state, with the size of the circle proportional to the sample size in the state. States with <1000 patients (n=12) are excluded.

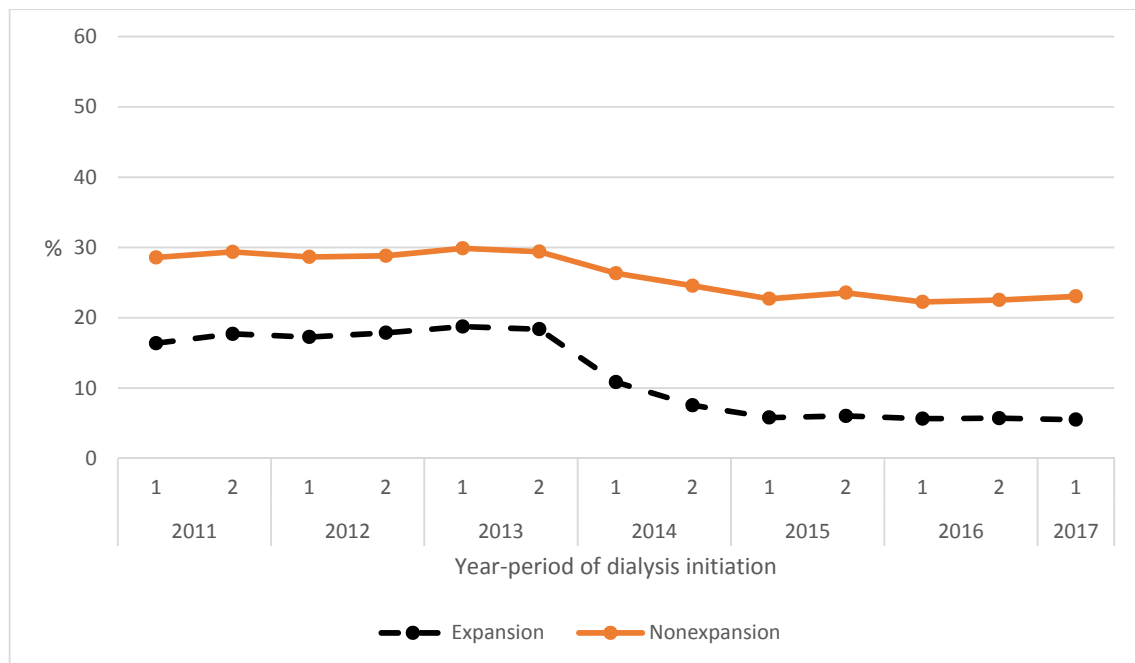
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eFigure 5. Trends in Insurance Coverage, Access to Nephrologist, Presence of an Arteriovenous Fistula or Graft, and Mortality After Excluding Early Expansion States

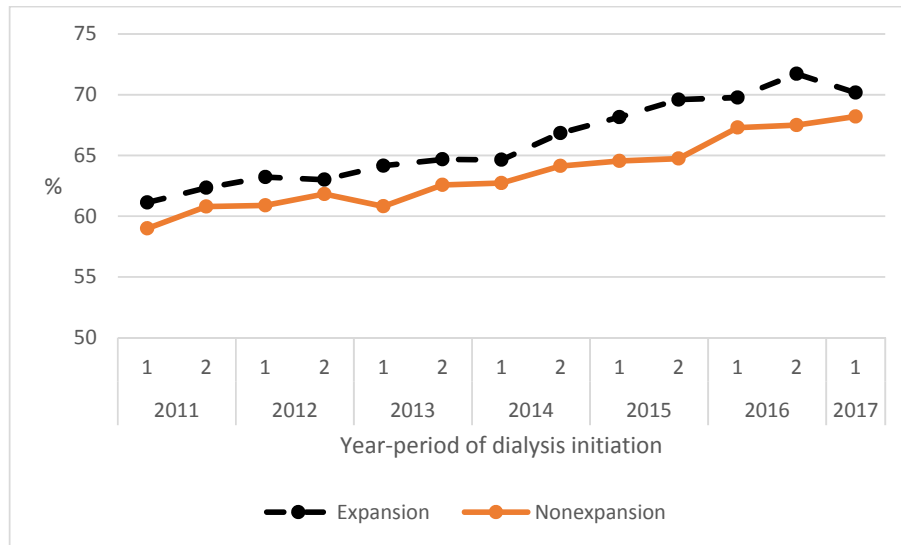
Panel A. Medicaid coverage



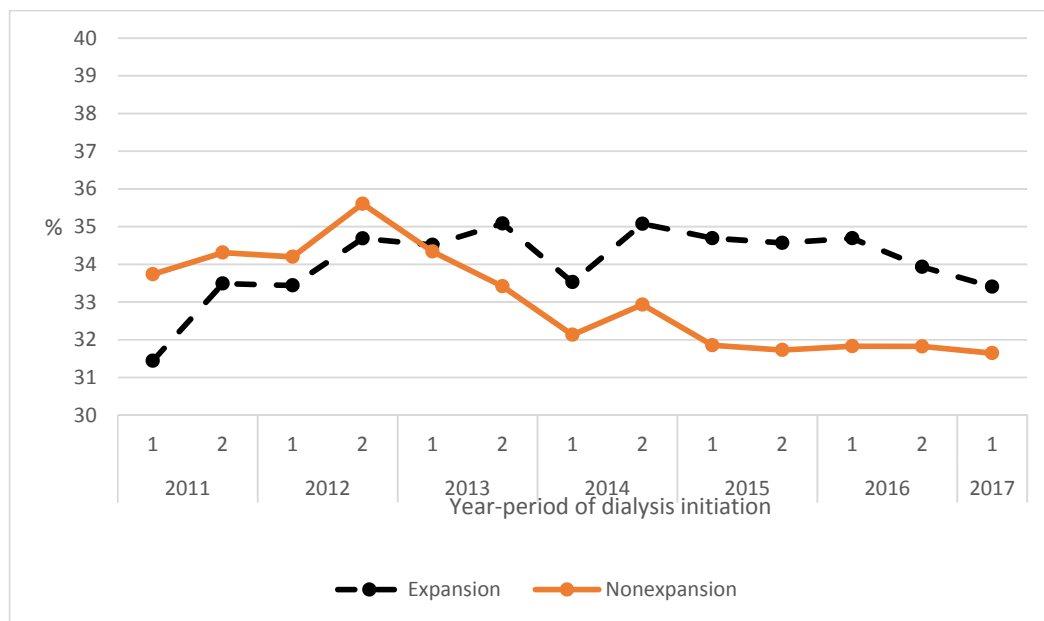
Panel B. Uninsurance



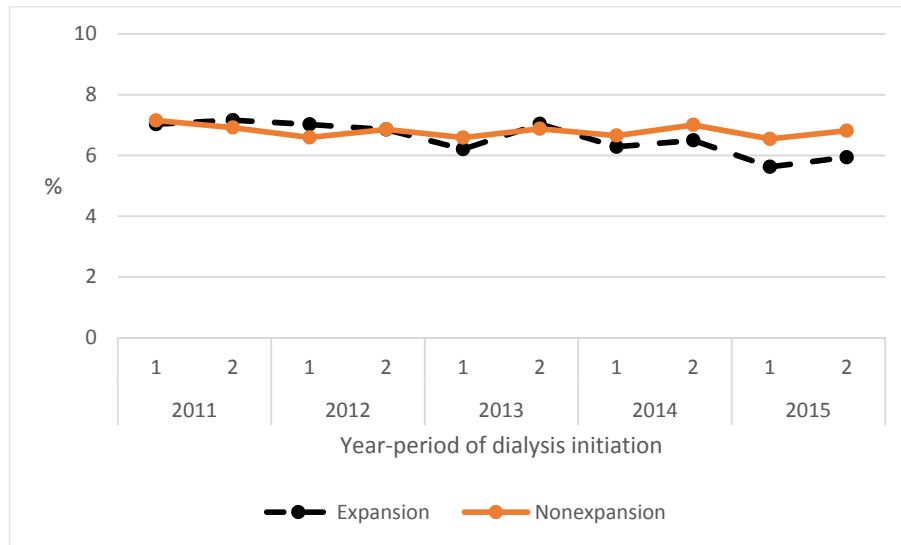
Panel C. Receipt of nephrology care prior to dialysis



Panel D. Presence of an arteriovenous fistula or graft at initiation of hemodialysis

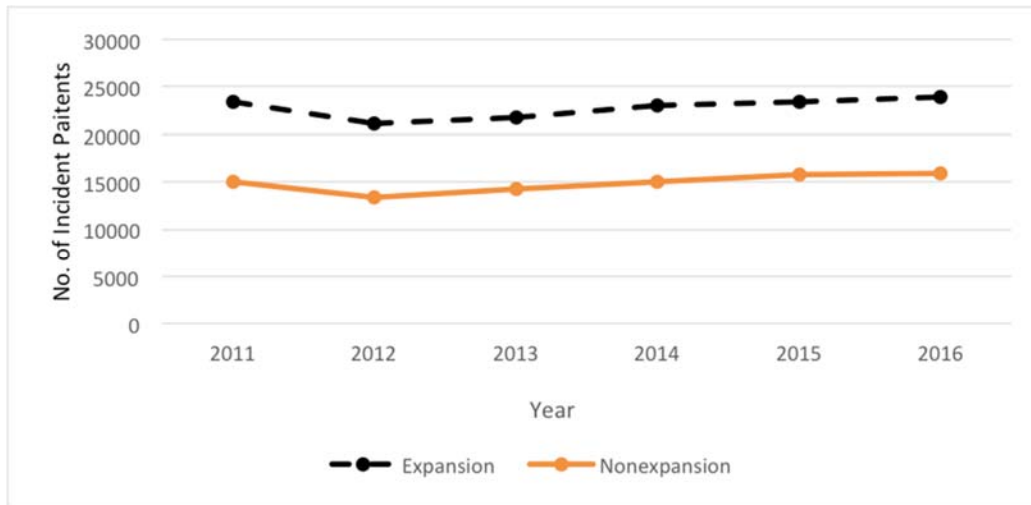


Panel E. One-year mortality



Note: The range of the Y axes vary by measure. Expansion states restricted to those that expanded January 1, 2014. The data points corresponding to period 1 in 2017 refers to data in the first quarter of 2017. All other periods are half-yearly.

eFigure 6. Annual Number of Patients Initiating Dialysis in Expansion and Nonexpansion States



eTable 1. Number of Patients in the Study Population, by State

| State | Number of Patients |
|---------------------|---------------------------|
| Alaska AK | 363 |
| Alabama AL | 4,255 |
| Arkansas AR | 2,247 |
| Arizona AZ | 4,934 |
| California CA | 34,595 |
| Colorado CO | 2,179 |
| Connecticut CT | 1,963 |
| Washington, D.C. DC | 961 |
| Delaware DE | 627 |
| Florida FL | 13,599 |
| Georgia GA | 9,796 |
| Hawaii HI | 1,847 |
| Iowa IA | 1,261 |
| Idaho ID | 717 |
| Illinois IL | 10,293 |
| Indiana IN | 4,212 |
| Kansas KS | 1,621 |
| Kentucky KY | 2,784 |
| Louisiana LA | 4,851 |
| Massachusetts MA | 3,067 |
| Maryland MD | 5,034 |
| Maine ME | 450 |
| Michigan MI | 6,855 |
| Minnesota | 2,563 |
| Missouri MO | 4,038 |
| Mississippi MS | 3,417 |
| Montana MT | 478 |
| North Carolina NC | 7,553 |
| North Dakota | 394 |
| Nebraska NE | 943 |
| New Hampshire NH | 399 |
| New Jersey NJ | 6,774 |
| New Mexico NM | 1,621 |
| Nevada NV | 2,234 |
| New York NY | 15,043 |
| Ohio OH | 8,477 |
| Oklahoma OK | 2,779 |
| Oregon OR | 1,906 |
| Pennsylvania PA | 8,124 |
| Rhode Island RI | 484 |
| South Carolina SC | 4,140 |
| South Dakota SD | 596 |
| Tennessee TN | 5,091 |
| Texas TX | 24,857 |
| Utah UT | 1,062 |
| Virginia VA | 6,179 |
| Vermont VT | 157 |
| Washington WA | 3,860 |
| Wisconsin WI | 3,032 |
| West Virginia WV | 1,304 |
| Wyoming WY | 230 |

eTable 2. Sensitivity Analyses of Changes in Insurance Coverage, Access to Nephrologist, Presence of an Arteriovenous Fistula or Graft, and 1-Year Mortality Following Medicaid Expansion

| | Unadjusted | Drop Early Expansion | Drop 6 months post-expansion | Drop 15 months pre-expansion and 6 months post-expansion | Multiple imputation for albumin | Define one-year mortality beginning with the 43 rd day following dialysis initiation |
|--|---|------------------------|------------------------------|--|---------------------------------|---|
| | Difference-in-Difference Estimate, percentage points (95% CI) | | | | | |
| Medicaid | 10.9 (8.1 to 13.8) | 10.9 (7.9 to 13.8) | 10.7 (7.9 to 13.5) | 10.4 (7.7 to 13.2) | 10.5 (7.6 to 13.3) | NA |
| Uninsured | -4.0 (-5.8 to -2.1) | -5.0 (-6.5 to -3.5) | -4.0 (-6.0 to -2.1) | -4.0 (-5.9 to -2.1) | -4.1 (-6.0 to -2.3) | NA |
| Predialysis nephrology care | 0.8 (-0.5 to 2.1) | 1.3 (0.2 to 2.4) | 1.0 (-0.3 to 2.3) | 1.2 (-0.05 to 2.6) | 1.0 (-0.1 to 2.2) | NA |
| Arteriovenous fistula or graft present | 2.4 (0.6 to 4.2) | 2.4 (0.6 to 4.2) | 2.4 (0.7 to 4.1) | 3.2 (1.1 to 5.5) | 2.3 (0.6 to 4.0) | NA |
| One-year mortality | -0.5 (-0.9 to -0.2) | -0.6 (-1.0 to -0.2) | -0.7 (-1.1 to -0.3) | -0.7 (-1.3 to -0.1) | -0.6 (-0.9 to -0.2) | -0.6 (-1.3 to -0.01) |

eTable 3. Changes in Insurance Coverage and Nephrology Care Following Medicaid Expansion, by Age, Race and Ethnicity, and Poverty

| Characteristic | Medicaid Coverage | | Uninsurance | | Predialysis nephrology care | | Presence of arteriovenous fistula or graft | |
|--|----------------------------|-------------------------|----------------------------|-------------------------|-----------------------------|-------------------------|--|-------------------------|
| | Percentage points (95% CI) | P-value for Interaction | Percentage points (95% CI) | P-value for Interaction | Percentage points (95%CI) | P-value for Interaction | Percentage points (95% CI) | P-value for Interaction |
| Age, y | | | | | | | | |
| 19-44 | 11.0 (7.9 to 14.1) | 0.85 | -6.4 (-9.1 to -3.7) | 0.002 | 1.8 (0.1 to 3.5) | 0.77 | 2.1 (-0.2 to 4.4) | 0.08 |
| 45-64 | 10.0 (7.1 to 12.9) | Ref. | -3.3 (-5.1 to -1.6) | Ref. | 1.0 (-0.2 to 2.2) | Ref. | 2.9 (1.0 to 4.9) | Ref. |
| Race/Ethnicity | | | | | | | | |
| White | 7.6 (5.4 to 9.9) | Ref. | -3.3 (-5.4 to -1.3) | Ref. | 1.2 (-0.4 to 3.0) | Ref. | 2.1 (-0.0 to 4.1) | Ref. |
| Black | 10.2 (7.3 to 13.0) | 0.06 | -5.4 (-7.8 to -2.9) | 0.06 | 2.4 (1.0 to 3.7) | 0.44 | 2.9 1.1 to 4.7) | 0.42 |
| Hispanic | 18.5 (13.2 to 23.7) | <0.001 | -6.5 (-9.9 to -3.1) | 0.06 | -0.5 (-2.1 to 1.2) | 0.18 | 3.9 (1.1 to 6.7) | 0.15 |
| Area-level Poverty | | | | | | | | |
| Less than median (16.3 %) | 9.1 (6.6 to 11.6) | 0.003 | -3.0 (-5.1 to -1.0) | 0.004 | 0.8 (-0.5 to 2.1) | 0.27 | 3.0 (0.7 to 5.2) | 0.95 |
| Greater than or equal to median (16.3 %) | 11.9 (8.6 to 15.2) | Ref. | -5.5 (-7.7 to -3.3) | Ref. | 1.7 (0.4 to 3.1) | Ref. | 2.5 (0.6 to 4.3) | Ref. |

eTable 4. Parallel Trends Assumption

| | Estimate | 95% CI |
|--|----------|-------------------|
| Medicaid | -0.0006 | -0.001 to 0.0003 |
| Uninsured | 0.0002 | -0.0006 to 0.0009 |
| Prior nephrology care | 0.0001 | -0.0004 to 0.0006 |
| Arteriovenous fistula or graft present | 0.0009 | -0.0002 to 0.002 |
| 1-year mortality | -0.0002 | -0.0006 to 0.0002 |

Notes: Estimate is the regression coefficient on an interaction term between an indicator variable for whether a state expanded Medicaid and a linear time trend. Data limited to pre-expansion period.

eTable 5. Changes in Health Care Amenable and Not Health Care Amenable Mortality Following Medicaid Expansion

| One-year mortality, beginning with the 91 st day following dialysis initiation | |
|---|---|
| | Difference-in-difference estimate Percentage points (95% CI) |
| Health care amenable | -0.6 (-1.1 to -0.1) |
| Not health care amenable | -0.04 (-0.2 to 0.09) |

eTable 6. Changes in the Number of Incident Patients, Proportion Initiating Peritoneal Dialysis, Glomerular Filtration Rate, and Prevalence of Comorbidities Following Medicaid Expansion

| | Difference-in-differences | 95 % CI |
|--|---------------------------|----------------|
| Logarithm of monthly number of incident patients | -0.36 | -1.1 to 0.3 |
| Peritoneal dialysis, % points | 0.8 | -0.3 to 1.9 |
| Estimated glomerular filtration rate (mL/min) | -0.13 | -0.22 to -0.03 |
| Congestive heart failure, % points | -0.4 | -1.0 to 0.2 |
| Atherosclerotic heart disease, % points | 0.1 | - 0.7 to 1.0 |
| Other cardiac disease, % points | 0.8 | 0.1 to 1.5 |
| Hypertension, % points | 0.3 | -0.5 to 1.0 |
| Diabetes, % points | 0.06 | -0.2 to 0.2 |
| Diabetic retinopathy, % points | 0.8 | 0.2 to 1.4 |
| Cancer, % points | 0.07 | -0.2 to 0.3 |

Notes: Baseline rate of logarithm of monthly incident patients in expansion and nonexpansion states were 4.65 and 4.66 respectively. Corresponding numbers for eGFR are 9.56 and 9.40. Estimated glomerular filtration rate is calculated using the Isotope Dilution Mass Spectrometry-traceable Modification of Diet in Renal Disease Study Equation.

eTable 7. Changes in One-Year Mortality and Nephrology Care Following Medicaid Expansion, Among Patients With Medicare/VA, Dual Medicare-Medicaid Coverage

| | Medicare/VA | Dual Medicare-Medicaid |
|--|-----------------------------------|----------------------------|
| | Difference-in-Difference Estimate | |
| | Percentage Points (95% CI) | Percentage Points (95% CI) |
| Prior Nephrology Care | 0.9 (-0.4 to 2.1) | 0.3 (-1.6 to 2.1) |
| Presence of arteriovenous fistula or graft | 1.3 (-0.3 to 3.1) | 2.2 (-0.7 to 5.2) |
| 1-year Mortality | -0.3 (-1.3 to 0.7) | 0.1 (-1.1 to 1.2) |

Notes: Coefficient presented is β_1 from equation (1). The regression includes the same set of covariates as that included in our main model (Table 2). In addition, since the Medicare/VA column combines data from both the Medicare and VA patients, this specification also includes an indicator variable for VA coverage.

eReferences

1. Miller S, Wherry LR. Health and access to care during the first 2 years of the ACA Medicaid expansions. *N Engl J Med* 2017;376:947-56.
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3. Foley RN, Chen SC, Solid CA, Gilbertson DT, Collins AJ. Early mortality in patients starting dialysis appears to go unregistered. *Kidney international*. 2014 Jan 1;86(2):392-398.