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MEDICAID AND MORTALITY:
NEW EVIDENCE FROM LINKED SURVEY AND ADMINISTRATIVE DATA

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Medicaid and Mortality: New Evidence from Linked Survey and Administrative Data
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ABSTRACT

We use large-scale federal survey data linked to administrative death records to investigate the relationship between Medicaid enrollment and mortality. Our analysis compares changes in mortality for near-elderly adults in states with and without Affordable Care Act Medicaid expansions. We identify adults most likely to benefit using survey information on socioeconomic and citizenship status, and public program participation. We find a 0.13 percentage point decline in annual mortality, a 9.3 percent reduction over the sample mean, associated with Medicaid expansion for this population. The effect is driven by a reduction in disease-related deaths and grows over time. We find no evidence of differential pre-treatment trends in outcomes and no effects among placebo groups.

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The Medicaid program is the largest health insurance provider for low income individuals in the United States. Established in 1965, Medicaid currently covers over 72 million enrollees and represents over $500 billion in government spending annually (Centers for Medicare & Medicaid Services, 2019a,b). However, despite the size and scope of this program, we know relatively little about whether Medicaid coverage actually improves the health of its beneficiaries. This is particularly true for low income adults who gained Medicaid eligibility under the Affordable Care Act (ACA), and who are the focus of nearly all of the ongoing policy debate surrounding the program. Studies of the health effects for this group tend to be inconclusive due to small sample sizes (Baicker et al., 2013; Finkelstein et al., 2012), or due to the lack of available data that links information on Medicaid eligibility to objective measures of health such as mortality (Black et al., 2019). The inconclusive nature of these results has led to skepticism among some researchers, policymakers, and members of the media as to whether Medicaid has any positive health impacts for this group.[1]

Understanding what types of public programs, if any, are effective at improving the health of low-income individuals is especially important given that they experience dramatically higher mortality rates and worse health outcomes on a number of dimensions than the general population. For example, the annual mortality rate for individuals ages 55 to 64 in households earning less than 138 percent of the Federal Poverty Level (FPL) is 1.6 percent, almost 2.3 times higher than the 0.7 percent rate experienced by higher-income individuals of the same age.[2] This low-income group also experiences higher risks of dying from diabetes (by 432%), cardiovascular disease (238%), and respiratory disease (213%) relative to those in higher income households; all of these diseases are believed to be at least somewhat amenable to drug therapy. These higher rates of death translate to dramatic differences in life expectancy across income groups. For example, Chetty et al. (2016) find that men at the bottom of the income distribution live on average nearly 15 years less, and women over 10 years less, than those at the top of the income distribution conditional on surviving to age 40. While data from nearly all countries show a positive correlation between income and health, this correlation is stronger in the United States than other high income countries (Semyonov et al., 2013).

Medicaid could play a crucial role in reducing these disparities if it improves access to effective medical care that beneficiaries would not otherwise receive, and recent research suggests this is likely to be the case. For example, Ghosh et al. (2019) find a substantial increase in prescription drug utilization under the ACA Medicaid expansions, including medications for the management of diabetes, treatments for HIV and Hepatitis C, and drug therapies for cardiovascular disease. These particular types of prescription drugs are among those demonstrated to reduce mortality.[3] Changes in access to these

[1]Flagged as an example of this by Sommers et al. (2017), Congressman Raul Labrador stated that "nobody dies because they don't have access to health care" during a discussion of Medicaid (Phillips, 2017). Also, Goodman-Bacon et al. (2017) provide a review of media discussion and some academic research suggesting that Medicaid may in fact be harmful to health.

[2]Authors' calculations using death rates from 2008 to 2013 derived from the publicly-available National Health Interview Survey Linked Mortality File (National Center for Health Statistics, 2019) for adults with incomes below 138% FPL and those with incomes 400% FPL or greater. We chose these two income cutoffs since adults with incomes below 138% FPL qualify for Medicaid in states that expanded their programs to include low-income adults under the ACA; also, adults with incomes below 400% FPL qualify for subsidies for private insurance coverage.

[3]Systematic reviews and meta-analyses of randomized, controlled trials find significant decreases in all-cause and cardiovascular mortality for adults who receive statins (Chou et al., 2016) and decreased all-cause mortality for Type 2 diabetics receiving glucose-lowering drugs (Zheng et al., 2018). In addition, systematic reviews of observational studies indicate decreased mortality among HIV-infected adults initiating anti-retroviral therapy (Chou et al., 2005), as well as

medications are likely to be particularly important for this population given their higher prevalence of chronic disease (Karaca-Mandic et al., 2017). Medicaid coverage may also affect health if it leads to earlier detection and treatment of life-threatening health conditions. Existing research has documented increased screening of treatable cancers such as breast and cervical cancer with expanded Medicaid coverage (Finkelstein et al., 2012; Sabik et al., 2018), as well as the detection of cancer both overall and at an early stage (Soni et al., 2018) and improved access to cancer surgery (Eguia et al., 2018). Furthermore, Medicaid coverage increases the number of hospitalizations, procedures performed in the hospital, and the number of emergency department visits for conditions that require immediate care (Duggan et al., 2019; Finkelstein et al., 2012; Taubman et al., 2014), all of which are likely to be associated with serious medical issues that require treatment. In addition to increasing the provision of these types of ostensibly high value services, Medicaid also increases the use of a variety of other types of medical care such as routine screening for chronic illnesses, outpatient physician visits, use of prescription drugs that aid in smoking cessation, and dental care which also have the potential to improve health over the longer term.[4]

In this paper, we provide new evidence of the impact of Medicaid on health by using administrative mortality data linked to large-scale, individual survey records. We use this novel dataset to examine the impact of a sizeable Medicaid eligibility expansion that occurred in some states as the result of the ACA. In 2014, the ACA expanded eligibility for the Medicaid program to include all adults in families with incomes under 138 percent of the Federal Poverty Level (FPL). Previously only pregnant women, adults with disabilities, and very low income parents tended to qualify for Medicaid coverage. Although intended to apply to all states, a 2012 Supreme Court decision made the Medicaid eligibility expansion optional. As a result, only 29 states and the District of Columbia expanded coverage in 2014, with 7 additional states electing to expand over the next several years. Despite non-universal adoption, the ACA Medicaid expansions still represent a historic expansion in insurance coverage. Approximately 13.6 million adults gained Medicaid coverage under the ACA (Medicaid and CHIP Payment and Access Commission, 2018); for comparison, Medicare enrolled about 19 million elderly beneficiaries after its creation in 1965 (Bureau of the Census, 1969). We take advantage of variation in state adoption of this large expansion in coverage to compare changes in mortality among individuals in expansion states and non-expansion states.

In contrast to prior research that relies on death certificate data with limited information on individual characteristics, our data include detailed survey measures collected from the 2008 to 2013 years of the American Community Survey (ACS). This large-scale national survey contains approximately 4 million respondents in each year and allows us to observe information on specific characteristics that determine Medicaid eligibility including income, citizenship status, and the receipt of other social assistance. With this information, we are able to identify individuals who were most likely to benefit from the ACA Medicaid eligibility expansions and, in this way, overcome the inherent limitations present in existing studies that rely only on aggregate death records. Following Black et al. (2019), we focus on those in this group who were between the ages of 55 and 64 in 2014, who are at greater risk of mortality, although we also present results for all non-elderly adults. We follow individuals in our sample over time

indirect evidence of decreased mortality linked to cured infection under antiviral treatment for Hepatitis C (Moyer, 2013).

[4] See Finkelstein et al. (2012); Nasseh and Vujicic (2017); Semyonov et al. (2013).

to examine changes in mortality associated with Medicaid expansion by linking them to the Census Numident file, which contains administrative records on the date of death for all individuals with Social Security Numbers (SSNs) who die in the United States. This file allows us to observe mortality rates for our sample through 2017, four years after the initial ACA Medicaid eligibility expansions. Despite the high-quality of the death information in the Census Numident file, it does not include cause of death information. In supplemental analyses, we further examine changes in mortality by the underlying cause of death using data from the Mortality Disparities in American Communities (MDAC) project, which links the 2008 year of the ACS to death certificate records using the National Death Index.

Our analysis shows that the ACA Medicaid expansions reduced mortality among this targeted group. Prior to the expansions, individuals in our sample residing in expansion and non-expansion states had very similar trends in both Medicaid coverage and mortality. At the time of the expansion, the trajectories of these two groups diverged significantly, with expansion state residents seeing increases in Medicaid coverage and decreases in the probability of being uninsured, and decreases in annual mortality rates. In the first year following the coverage expansion, the probability of mortality declined by about 0.09 percentage points, or 6.4 percent relative to the sample mean. The estimated impact of the expansions increases over time, suggesting that prolonged exposure to Medicaid results in increasing health improvements. By year 4, residents of expansion states have an annual mortality rate that is 0.2 percentage points lower than their non-expansion state counterparts. In our supplemental analysis using the MDAC data, we find evidence that healthcare amenable and internal causes of death were reduced by the expansions, but no evidence that deaths due to external causes, such as car accidents, fell. We also conduct several placebo tests to assess the validity of our analysis including examining the impact of the expansions on those age 65 or older in 2014 who did not gain Medicaid eligibility; examining the effect on individuals in higher income households who were less likely to be affected; and, restricting the analysis sample to the pre-ACA period. We find no relative change in coverage or mortality across expansion and non-expansion states among the elderly or in the pre-ACA period, settings in which no Medicaid expansion occurred. Among those in higher income households, we find small but statistically significant increases in Medicaid coverage and similarly small decreases in mortality, consistent with a causal impact of Medicaid on mortality.

Our analysis provides new evidence that Medicaid coverage reduces mortality rates among low-income adults. Our estimates suggest that approximately 15,600 deaths would have been averted had the ACA expansions been adopted nationwide as originally intended by the ACA. This highlights an ongoing cost to non-adoption that should be relevant to both state policymakers and their constituents.

1 Background

Many studies have shown that Medicaid coverage increases access to and use of health care and reduces financial burden for low-income adults,[5] but evidence as to whether it improves their health remains limited. Studies that do examine health tend to rely on self-reported health measures from survey data. The evidence from these studies spans from estimated large or modest improvements in reported health associated with Medicaid expansion (Cawley et al., 2018; Simon et al., 2017; Sommers et al.,

[5]See, e.g., Abramowitz, 2018; Allen et al., 2017; Baicker et al., 2013; Brevoort et al., 2019; Buchmueller et al., 2016; Caswell and Waidmann, 2017; Courtemanche et al., 2017; Finkelstein et al., 2012; Gallagher et al., 2019; Ghosh et al., 2019; Hu et al., 2018; Miller and Wherry, 2017, 2019; Simon et al., 2017; Sommers et al., 2015, 2017.

2017), to no effects (Courtemanche et al., 2018a,b; Sommers et al., 2015; Wherry and Miller, 2016) or even small but marginally significant negative effects (Miller and Wherry, 2017).

One concern with self-reported health data is that it may not accurately measure changes in physical health. In the Oregon Health Insurance Experiment (OHIE), low-income adults selected by a lottery to apply for Medicaid coverage reported near immediate improvements in their health compared to the controls, despite experiencing no significant differences yet in their health care utilization (Finkelstein et al., 2012).[6] The researchers concluded that the change in reported health may at least partly capture a general sense of improved well-being, or "winning" effects resulting from individuals' lottery selection. There is also the risk that changes in self-reported health may reflect increasing awareness of health problems or interactions with the health care system, rather than actual changes in physical health. One example would be increased contact with health providers leading to new information about a previously undiagnosed illness and, as a consequence, a worsened self-perception of health. This could bias downwards estimates of the effect of public health insurance on health.[7] Finally, in general, the reliability of self-reported health measures for U.S. adults and their association with objective health measures are documented to be worse among lower socioeconomic status groups (Dowd and Zajacova, 2007, 2010; Zajacova and Dowd, 2011).

In addition to offering the first experimental evidence on the effects of expanded Medicaid, the Oregon Health Insurance Experiment (OHIE) covered new ground by collecting data on clinical health measures among its participants. The researchers did not observe significant effects on any of the collected measures, however, which were blood pressure, cholesterol, and blood sugar levels. Using administrative data, they also found no evidence that Medicaid coverage led to a reduction in mortality during the 16 months following coverage gain. Their estimate suggested a 16 percent reduction in mortality associated with acquiring Medicaid, but with a large confidence interval that could not rule out sizeable changes in either direction.[8]

As the data become available, researchers are beginning to evaluate the mortality effects of the ACA Medicaid expansions.[9] Two current studies use population-level mortality data to estimate changes in adult mortality in expansion states compared to non-expansion states. In contrast to Oregon, the ACA Medicaid expansions affected a much larger number of people (13.6 million vs. under 11,000) (Medicaid and CHIP Payment and Access Commission, 2018; Finkelstein et al., 2012). However, the authors rely on death certificate data without the information on individual income needed to identify the policy's target population. As a consequence, it can be difficult to detect effects at the population-

[6]The researchers found an improvement in self-reported health for the treatment group during their initial survey, which was conducted, on average, about one month after gaining coverage, that was about two-thirds of the size of their main effect estimated using survey data collected more than a year later.

[7]See Currie and Gruber (1995) for more discussion.

[8]Another relevant randomized social experiment provided Medicare to newly entitled Social Security Disability Insurance (SSDI) beneficiaries (as opposed to them being subject to a 2-year waiting period for coverage). The evaluation of this experiment found no reductions in mortality up to 3 years later but the sample sizes were too small to be able to detect effects (Weathers and Stegman, 2012).

[9]A separate but related literature has examined the relationship between public health insurance and child mortality using variation in exposure tied to the introduction of Medicaid and later expansions in public coverage under Medicaid and the Children's Health Insurance Program. For the most part, these studies have found significant declines in mortality associated with expanded coverage for infants and children both in the short-term (e.g. Currie and Gruber, 1996a,b; Goodman-Bacon, 2018b; Howell et al., 2010) and long-term (Brown et al., 2018; Goodman-Bacon, 2016; Wherry and Meyer, 2016).

level, particularly when Medicaid coverage is estimated to have increased by as little as 1 percentage point among all nonelderly adults (Black et al., 2019). The two studies examining the effects of the ACA Medicaid expansions in this manner reach different conclusions, detecting no (Black et al., 2019) and sizeable effects on adult mortality (a 3.6% reduction) (Borgschulte and Vogler, 2019).In addition, research on pre-ACA expansions in Medicaid that also relies on aggregated data finds larger effects on adult mortality;[10] Sommers et al. (2012) and Sommers (2017) find a 6 percent reduction in nonelderly adult mortality in pre-ACA Medicaid expansions in New York, Maine, and Arizona measured over a five-year period.The absence of conclusive evidence on whether Medicaid improves the objective health of adult beneficiaries is a major omission given that Medicaid is a public health program that aims to improve access to and use of efficacious health care.

All of these studies rely on changes in survival for the Medicaid eligible to translate into overall mortality effects observable at the population (or state) level. However, at least two studies suggest that a focus on subgroups most at risk for mortality may increase the likelihood of detecting effects. Swaminathan et al. (2018) examine the impact of the ACA Medicaid expansions on the one-year survival rate of patients with end stage renal disease initiating dialysis. The authors find a significant 8.5 percent reduction in mortality for individuals with this chronic condition, driven primarily by a decrease in deaths due to causes considered health care amenable. More recently, Khatana et al. (2019) find evidence of a decrease in rates of cardiovascular disease among adults ages 45-64 associated with state adoption of the ACA Medicaid expansions.

For this reason, it is likely that the primary impediment to analyzing the impact of Medicaid on mortality has been data availability. Data from death certificate records contain very little socioeconomic information on the decedent; in particular, they contain no information on the decedent's income, whether he or she previously had health insurance coverage, or other characteristics that might affect Medicaid eligibility. Without data that links information on individual Medicaid eligibility and mortality, researchers must rely on eligibility changes over larger population groups – for example, residents of certain states or counties – which contain many individuals who would not be affected by Medicaid policy. This decreases the power to detect changes in mortality of a plausible magnitude, leading some researchers to conclude that "it will be extremely challenging for a study [on the ACA Medicaid expansions] to reliably detect effects of insurance coverage on mortality unless these data can be linked at the individual level to large-sample panel data" (Black et al., 2019).

This finding of mortality effects for certain subgroups that may not be detectable in larger aggregations of data is consistent with existing work on the effects of Medicare on health. Card et al. (2004) and Finkelstein and McKnight (2008) find little evidence of an effect of Medicare on mortality using death certificate records. However, among those who are hospitalized and severely ill, Card et al. (2009) find a significant 1 percentage point (or 20 percent) reduction in mortality following admission that persists for at least 9 months following discharge. This analysis notably identifies these effects by comparing patients just below and above the Medicare-eligible age of 65 when admitted, which is just above the age range considered in our analyses.

It is also worth noting that, at the time of these studies, Medicare did not provide coverage for

[10] In addition, an analysis of the mortality effects of insurance expansion under Massachusetts's 2006 health reform by Sommers et al. (2014) finds a significant 2.9 percent reduction in all-cause mortality over four years of follow-up; among deaths from "heath-care amenable" conditions, the authors find a 4.5 percent decline.

prescription drugs. Recent papers studying the introduction of prescription drug coverage under the Medicare Part D program are finding evidence of mortality declines. Huh and Reif (2017) focus on those age 66 and find that insurance coverage for prescription drugs reduces mortality in this group by about 0.16 percentage points annually (about 9.6 percent). Dunn and Shapiro (2019) find slightly larger effects in an analysis that incorporates individuals with older ages. For both papers, reductions in mortality are driven by a decline in deaths due to cardiovascular disease. Using data for a subset of Medicare beneficiaries, Kaestner et al. (2017) find no significant effect on mortality but do document reductions in hospitalization admissions for heart disease, respiratory disease, and diabetes under the program. Importantly, sizeable increases in the use of prescription drugs that treat these particular diseases have been documented under the ACA Medicaid expansions (see Ghosh et al., 2019).

2 Data and Outcomes

To conduct our analysis, we use data from two sources. First, we select respondents from the 2008 to 2013 waves of the American Community Survey who, based on their pre-ACA characteristics, were likely to benefit from the ACA Medicaid expansions. We include only individuals who either are in households with income at or under 138 percent of the FPL or who have less than a high school degree. Since we only have information on income captured at one point in time, the latter criterion is used to identify individuals who are of low socioeconomic status but might not meet the income cutoff at the time of the ACS interview. We exclude non-citizens, many of whom are not eligible for Medicaid, and those receiving Supplemental Security Income (SSI), who are likely to be Medicaid eligible even without the expansions.[11] We restrict our primary analysis to individuals who were age 55 to 64 in 2014. This higher age group has relatively high mortality rates, and is also consistent with the sample criteria used in Black et al. (2019). We present results for all non-elderly adults in a supplementary analysis. We also exclude residents of 4 states and DC that expanded Medicaid to low-income adults prior to 2014.[12] There are approximately 566,000 respondents who meet our sample criteria.[13]

Descriptive statistics for the sample by state Medicaid expansion status are reported in Table A1. The average age of the respondents in the two groups is similar. However, individuals in expansion states are slightly better off with higher average income (147% of the FPL vs 140%) and educational attainment (45.3% with less than high school education vs 46.8%), as well as lower baseline rates of coverage (32.6% uninsured vs 37.3%), than individuals in non-expansion states. In addition, individuals in expansion states are more likely to be white or Hispanic, while a higher share of those in non-expansion states are black.

These data are linked to the Census Numident file. The Census Numident file is derived from the Social Security Administration (SSA) Numerical Identification file, which includes information on date and county of birth and date of death (if it has occurred) for individuals with a Social Security Number (SSN). These data have been used in, e.g., Brown et al. (2018); Chetty et al. (2011, 2016); Dobbie and Song (2015); Sullivan and von Wachter (2009), and other research relying on death information from

[11] SSI recipients are automatically eligible for Medicaid coverage in most states.

[12] DE, MA, NY, and VT all expanded coverage to individuals with incomes at least to the poverty line prior to the ACA; DC received approval to implement its ACA Medicaid expansion early with enrollment starting in 2011.

[13] Note that Census disclosure rules prohibit the disclosure of exact sample sizes and require rounding. All sample sizes reported in this paper are therefore rounded according to these rules.

tax records. Total deaths reported in the SSA file by age and year closely track the numbers reported by the National Center for Health Statistics (Chetty et al., 2016). In addition to this death information from the SSA, the Census Bureau also has information on date of death from the National Death Index (NDI) for some individuals and years, which it incorporates into its date of death measure when available.[14] The Census Bureau receives the SSA Numident file each year and formats this information so that there is a single record per individual reflecting the most accurate and up-to-date information at that point in time. We use the most recently available version of the Census Numident, which captures date of death through the second quarter of 2018. Because we observe only a partial year in 2018, we limit our analyses to deaths occurring in 2017 and earlier.

The Census Numident and ACS data are linked via the Census Bureau's Personal Identification Validation System (PVS). This system assigns individuals in each dataset a protected identification key (PIK), an anonymized identifier that allows Census to track individuals across datasets. Approximately 94 percent of all ACS respondents are successfully assigned a PIK using available information on name, address, and date of birth, with a slightly higher match rates for citizens (95 percent) (Wagner and Layne, 2014). The assignment of a PIK allows respondents in the ACS to be matched to the Census Numident file. PIKS for the Census Numident file are assigned using social security numbers (SSNs). Since our analysis is restricted to older citizens, and since nearly all American citizens have SSNs assigned by the time they reach adulthood (see Bernstein et al., 2018), we expect to have nearly full coverage of deaths in the Numident file.

Once these data are linked, we observe the vital status of each individual during the year they respond to the ACS and then each subsequent year. For example, an individual who responds to the 2008 ACS has his or her vital status observed in 2008 and each subsequent year through 2017, whereas an individual who responds to the 2013 ACS has his or her vital status observed in 2013 through 2017. We construct our outcome measure to represent mortality during each calendar year. If the individual is alive in a given year, the outcome variable takes a value of 0; if that individual died in that year it takes a value of 1. Once an individual has died, he or she is removed from the sample for subsequent years. In this way, we will be able to measure changes in the annual probability of death among individuals who were alive at the beginning of the year.

Annual mortality is about 1.4 percent for our sample on average across all years, and approximately 1.3 percent among respondents in expansion states during the year just prior to expansion.[15] Note that because we have a fixed sample that ages in each period, mortality rates increase over time (i.e., our sample is oldest in the last year, 2017).

While our data offer the opportunity to link mortality and economic variables at the individual level, there are also several important limitations. First, we observe the economic characteristics of individuals (income and educational attainment, receipt of social services, and citizenship status) at the time they respond to the ACS, between 2008 and 2013. These are time-varying characteristics and may not accurately reflect economic characteristics at the time of the Medicaid expansions for some members of our sample. For example, an individual in a low-income household in 2008 may be in a higher-income household by 2014, at the time the expansions occurred. Similarly, individuals may

[14] The NDI collects detailed information on deaths from state vital statistics offices. Respondents to the 2008 ACS were linked to the NDI for the years 2008-2015, as part of the Mortality Disparities in American Communities project.

[15] These annual averages are calculated excluding mortality rates for individuals during their year of ACS interview.

migrate to different states between the time they responded to the ACS and the time the expansions occurred, resulting in our misclassification of whether that individual was exposed to the eligibility expansion.[16] In general, we expect that this type of misclassification will bias our estimates towards zero.

A second limitation is that our data do not include information on the cause of death. The death information in the Census Numident is derived primarily from the Social Security Administration death records, which contain only date of death. We therefore supplement our main analysis with an exploration of data from the 2008 year of the ACS, which was linked to death certificate records from 2008 to 2015 as part of the Mortality Disparities in American Communities (MDAC) project. While this drastically reduces both the sample size and follow-up period, it does allow us to investigate changes in mortality based on the underlying cause of death as reported on the death certificate.

3 Empirical Strategy

Our empirical strategy looks at changes in annual mortality in the expansion states relative to the non-expansion states before and after the implementation of the ACA Medicaid expansions. We estimate this using an event-study model that allows us to assess the evolution of relative outcomes while controlling for fixed differences across states and national trends over time. We estimate:

$$Died_{isjt} = Expansion_s \times \sum_{\substack{y=-6 \\ y\neq -1}}^{3} \beta_y I(t - t_s^* = y) + \beta_t + \beta_s + \beta_j + \gamma \mathbf{I}(j = t) + \epsilon_{isjt}. \tag{1}$$

As described earlier, our data is constructed at the individual (i) by year (t) level. Each individual responds to the ACS during a survey wave (j) and reports their state of residence (s) at that time. The dependent variable $Died_{isjt}$ denotes death during each year t among individuals who were alive at the beginning of year t. We only observe mortality for part of the year in the year the individual is surveyed (j), since that individual had to be alive in order to complete the survey. To account for this, we include an indicator variable that year t is the year that the individual responded to the ACS (i.e., that $j = t$).[17] In this equation, β_s denotes state fixed effects and β_j denotes fixed effects associated with survey wave. β_t denotes calendar year fixed effects, which will account for general trends in mortality for all individuals in our sample including their gradual aging over time.[18]

The variable $Expansion_s$ equals 1 if, at the time they responded to the ACS, individual i was living in a state that opted to expand Medicaid eligibility between 2014 and 2017, and zero otherwise. Indicator variables $I(t - t_s^* = y)$ measure the time relative to the implementation year, t_s^*, of the expansion in that state, and are zero in all periods for non-expansion states.[19] While most states expanded in the beginning of 2014, some states expanded later in the year or in subsequent years. If a state expanded on or after July 1 of a given year, we code it as having expanded in the subsequent

[16] Note that it does not appear that migration decisions are correlated with a state's decision to expand Medicaid, see Goodman (2017).

[17] If we drop the observations for which we observe less than a full year of mortality our results are unchanged. Note that we do not have information on the date of the ACS interview.

[18] Results are also virtually identical in a model that includes controls for gender, race, and single year of age.

[19] We group together $y \leq -6$ into a single indicator variable interacted with expansion status since we only observe $y < -6$ for late expander states.

year.[20] The omitted category is $y = -1$, the year prior to the expansion. Therefore, each estimate of β_y provides the change in outcomes in expansion states relative to non-expansion states during year y, as measured from the year immediately prior to expansion. If expansion and non-expansion states were trending similarly prior to the ACA, we would expect that indicators associated with event times $y = -6$ to $y = -2$ would be small and not statistically significant. We estimate equation (1) with a linear probability model and report heteroskedasticity-robust standard errors that are clustered at the state level. All analyses use ACS survey weights.

In addition to the event study analyses, we also present difference-in-differences estimates as a summary of the effect across all post-expansion years. These are estimated using the same equation except the event study coefficients are replaced with a single variable indicating the individual i was in an Expansion state after the expansion had occurred ($Expansion_s \times Post_t$).

4 Results

4.1 Impact of ACA Expansions on Medicaid Eligibility and Enrollment

We first estimate the impact of the ACA Medicaid expansions on Medicaid eligibility and coverage for individuals similar to those in our sample. We consider changes in eligibility for Medicaid in addition to enrollment changes since eligible individuals are "conditionally covered" by the program, in the sense that they may choose to remain uninsured and enroll only when they become ill. This concept of conditional coverage was first discussed by Cutler and Gruber (1996) in their study of historic Medicaid expansions for pregnant women and children; it may be even more relevant in our context, however, given another change under the ACA designed to provide a new pathway for the uninsured to gain immediate access to Medicaid-funded services. For the first time, the federal government required states to implement presumptive eligibility programs under their Medicaid programs. Specifically, the ACA granted hospitals the ability to make presumptive eligibility determinations for Medicaid for certain groups covered in their state, including the non-elderly ACA expansion population (Caucci, 2014).[21] This means that if patients appear to have incomes low enough to qualify for Medicaid, hospitals may grant temporary Medicaid enrollment. Recipients of this temporary enrollment status may immediately receive health services and providers are guaranteed reimbursement for those services. In addition to presumptive eligibility programs, federal law directs states to provide retroactive coverage for new enrollees by covering medical bills incurred up to 3 months prior to their application date if they met the eligibility criteria during that time.[22] By not requiring an individual to first enroll in Medicaid prior to receiving Medicaid-funded care, these policies reinforce the notion that all eligible individuals are effectively covered by the program even if not actually enrolled.

Since we only observe our sample in the ACS during the pre-expansion years, we do not have

[20]In our analyses, states that expanded Medicaid in 2014 are AR, AZ, CA, CO, CT, HI, IL, IA, KY, MD, MI, MN, NJ, NM, NV, ND, OH, OR, RI, WA, and WV. Michigan implemented their expansion in April 2014 with the remainder of states expanding in January 2014. States that we considered to have 2015 expansions are NH (implemented August 15, 2014), PA (January 1, 2015), and IN (February 1, 2015). We consider AK (September 1, 2015) and MT (January 1, 2016) to be 2016 expansion states and LA (July 1, 2016) to be a 2017 expansion state.

[21]Previously presumptive eligibility programs were optional for states and limited to pregnant women and children. States also had discretion over what types of providers could grant presumptive eligibility for these groups.

[22]A handful of states (AR, IA, IN, NH) had federal waivers to waive retroactive coverage for the expansion population, or other existing Medicaid eligibility groups, during our study period (Musumeci and Rudowitz, 2017).

information on their economic characteristics or coverage decisions during the post-expansion period. However, we are able to estimate model (1) using respondents in the 2008 to 2017 waves of the ACS who were age 55 to 64 in 2014, and otherwise meet the same sample restrictions as in our main analyses. While this analysis does not completely mirror that used to study mortality, it allows us to provide an estimate of the changes in eligibility and coverage similar to those likely experienced by our sample.[23] We impute income eligibility for Medicaid using information on family structure and income and state-specific eligibility criteria over this time period.[24] In addition to changes in Medicaid eligibility, we also examine changes in Medicaid coverage and overall insurance status using respondent reports about current health insurance coverage at the time of the ACS survey.

The results are presented in Figure 1 and in the first three columns of Table 1. We find a large increase in Medicaid eligibility associated with the ACA Medicaid expansions with gains of between 41 and 46 percentage points during each post-expansion year, as compared to the year just prior to expansion. Consistent with many other studies of this policy,[25] we also find significant increases in Medicaid coverage and decreases in uninsurance associated with the decision to expand Medicaid eligibility. Reported Medicaid coverage increases by 7.3 percentage points in the first year and by 9.9 percentage points four years after the expansion relative to the year prior to expansion, while uninsurance decreases by 3.8 percentage points in the first year and 3.9 percentage points four years after the expansion. The estimates for years 2 and 3 are larger than those for year 4, which likely reflects the increasing share of the sample that is aging into Medicare over the study period.

It is important to note that the increases in Medicaid coverage observed in the survey data are most likely smaller than total enrollment changes for several reasons. First, Medicaid coverage is notoriously underreported in survey data. Boudreaux et al. (2015) link the 2009 ACS to administrative data on Medicaid and Children Health Insurance Program (CHIP) enrollment and find that 23 percent of Medicaid/CHIP enrollees do not report this source of coverage. Rates of underreporting are higher for adults and minority groups; in addition, these groups are more likely to report no insurance coverage than other sources of coverage. Second, by asking about coverage only at the time of the survey, the ACS does not capture information on Medicaid coverage for individuals enrolled in Medicaid during other times during the year. Given that there is tremendous churn among adults in the Medicaid program,[26] these estimates, therefore, likely underrepresent the total share of adults gaining any Medicaid coverage during each year.

We conducted our own analysis of underreporting for individuals meeting our sample criteria using data available from the 2008 to 2012 National Health Interview Survey (NHIS) for respondents linked to administrative data on Medicaid enrollment.[27] We found that while 14.3 percent of the sample reported

[23] There is one additional difference in the setup of this analysis. To avoid having multiple samples disclosed from the restricted-use data, we use the public-use ACS files for this "first-stage" analysis. The public-use file is a two-thirds random sample of the restricted-use file and will therefore result in nearly identical results, but with slightly larger confidence intervals.

[24] We consider eligibility for low-income parents under Medicaid Section 1931 criteria in each state, as well as expanded eligibility for parents and childless adults under waiver programs that offered comparable coverage to the ACA Medicaid expansions. Please see Appendix Section B for additional details about the eligibility imputation.

[25] E.g., Buchmueller et al. (2016); Cawley et al. (2018); Courtemanche et al. (2017); Miller and Wherry (2017, 2019); Sommers et al. (2015)

[26] See, for example, analyses in Sommers (2009) and Collins et al. (2018).

[27] These data are available from the National Center for Health Statistics for NHIS respondents who consent to the linkage. Due to an unfortunately timed change in the way CMS collects enrollee-level Medicaid administrative records,

being enrolled in Medicaid at the time they completed the survey, 19.3 percent were enrolled at some point during that year according to the CMS administrative records; this suggests an undercount based on survey data of approximately 35 percent.

Because this analysis is based on the reporting behavior of Medicaid enrollees prior to the ACA, it may not necessarily reflect the degree of underreporting among those gaining Medicaid coverage under the ACA expansions. Therefore, we also estimate by how much we might be undercounting the change in total Medicaid enrollment under the ACA by comparing the "first stage" we obtain from the ACS with a "first stage" obtained from different CMS administrative data reports on total Medicaid enrollment during the study period. The two different administrative sources used for this analysis offer different definitions of enrollment and have different information in terms of the years and states available, as well as the ages for which information on enrollment is collected. Depending on the data source used, we find estimates of undercount ranging from somewhat smaller (18%) to considerably larger (exceeding 100%) than the estimate arrived at with the NHIS-CMS linked data. Since the NHIS-CMS data analysis allowed us to create an analytic sample most similar to that used in this paper, we apply the 35 percent undercount estimates when discussing treatment effects in the section that follows. Additional details on the analysis of underreporting in the NHIS-CMS data, as well as the analyses involving the CMS data reports may be found in Appendix Section C.

4.2 Impact of ACA Expansions on Mortality

Our estimates of equation (1) are presented in Figure 2 and in the fourth column of Table 1. Prior to the ACA expansion, mortality rates trended similar across the two groups: pre-expansion event study coefficients are close to zero and not statistically significant. Starting in the first year of the expansion, we observe mortality rates decrease significantly among respondents in expansion states relative to non-expansion states. The coefficient estimated in the first year following the expansion indicates that the probability of dying in this year declined by about 0.09 percentage points. In years 2 and 3, we find reductions in the probability of about 0.1 percentage points and, in year 4, a reduction of about 0.2 percentage points. All estimates are statistically significant.

In the difference-in-differences model, we estimate an average reduction in mortality of about 0.13 percentage points (top panel of Table 1).[28] We can combine this estimate with the estimates of the first stage to provide information on the treatment effect of Medicaid coverage on the group that actually enrolled.[29] Our analysis of the ACS suggested that Medicaid enrollment increased by about 10.1 percentage points in our sample. However, as noted above, we estimate that survey measures are likely to underreport actual take-up by about 35 percent (see Appendix Section C). Incorporating this underreport into our first stage estimates indicates that the true first stage is likely closer to 15.5

data are unavailable for most states after 2012.

[28] If we average the post-expansion event study indicators, rather than estimating a two way fixed effects difference-in-differences coefficient, the estimate is nearly identical. This suggests that any potential bias introduced in the DID estimate from using earlier implementation states as controls for later implementation states during their post-period if there are time-varying treatment effects is likely small (see Goodman-Bacon, 2018a).

[29] One can further scale up this estimate to arrive at the local average treatment effect of gaining any coverage by incorporating estimated crowd out. However, for the interpretation to be valid it must be the case that Medicaid coverage is equivalent to the private coverage purchased when Medicaid is unavailable. This is unlikely to be the case; for example, beneficiaries who switch to Medicaid from private insurance typically will not pay a premium and have minimal cost sharing, and could thus potentially benefit financially. For this reason, we focus on the treatment effect of Medicaid in this discussion.

percent (i.e., $\frac{0.101}{(1-0.35)}$). Our estimates therefore suggest that the treatment effect of Medicaid coverage on mortality is about a 0.8 percentage point ($= \frac{0.13}{0.155}$) reduction.

It is important to note that even this re-scaled first stage only considers the immediate, or short-term, effects of Medicaid coverage on mortality. To the extent that there are longer-term effects on health, it is not clear that the average annual change in coverage is the correct first stage. For instance, individuals who gained coverage in 2014 but not later years may still experience health benefits that translate into reduced mortality in subsequent years. This is particularly relevant for the age group we study, as part of the sample ages in to Medicare over our analysis period. These individuals might still experience reduced mortality after enrollment in Medicare due to long-run health gains from receiving Medicaid at ages 62 to 64. Results in recent work examining the long-term effects of public insurance expansions for children document health improvements that manifest years later.[30] A more appropriate first stage, if the data were available, might be the change in the proportion of the sample with any exposure to Medicaid at the time of each post-expansion year, which will necessarily be larger than the estimates presented here.

4.3 Placebo Tests and Additional Analyses

To assess the validity of our empirical approach, we conduct several "placebo" tests. In these tests, we investigate whether we observe effects of the Medicaid expansions in populations that we expect to be unaffected or less affected by the policy change.

Our first placebo tests uses individuals who were age 65 and older at the time of the ACA expansions. These individuals had near universal coverage through the Medicare program and should not have been directly affected by the coverage expansions.[31] To conduct this test, we estimate equation (1) but use a sample of individuals who were 65 years old or older in 2014. The results are presented in the first panel of Figure 3. As predicted, we observe no effect of the Medicaid expansions on Medicaid coverage for this group (panel a). We also see no effect of the ACA on mortality rates for this group.

A second placebo tests shifts our analysis sample back in time to the pre-ACA period. This test can assess whether any elements of our sample construction, such as drawing the ACS sample only in the pre-expansion period, might lead to spurious results. We construct the data in the same fashion as our main analysis, but use mortality data from 2004 to 2013 for ACS respondents from 2004 to 2009 (rather than mortality data from 2008 to 2017 for 2008-2013 ACS respondents). We construct a variable indicating that a state expanded that corresponds to $Expansion_s$ in equation (1), but behaves as if the expansions occurred in 2010 rather than 2014, with states expanding t years after 2014 treated as if they expanded in 2010+t. The results of this placebo test using the pre-ACA period is presented in the second row of Figure 3.[32] As expected, we find no effect on Medicaid coverage or mortality in expansion states during this pre-ACA period.

[30] Boudreaux et al. (2016) and Goodman-Bacon (2016) document better later life adult health among children who gained exposure to Medicaid under its rollout in the 1960s. Brown et al. (2018); Currie et al. (2008); Miller and Wherry (2018); Thompson (2017); Wherry and Meyer (2016) and Wherry et al. (2017) find evidence of better long-term health for children benefiting from later expansions in Medicaid and CHIP.

[31] Prior work has documented some spillover effects on the health care utilization of this population under pre-ACA state Medicaid expansions, but analyses of the ACA Medicaid expansions have found no evidence of such spillovers and are able to rule out very small effects (Carey et al., 2018).

[32] Since the ACS only began collecting data on health insurance in 2008, the analysis for Medicaid coverage is limited to the 2008-2013 years.

Finally, we examine individuals age 55 to 64 in households earning 400% FPL or greater at the time of the ACS interview. This group should be less affected than our main sample of low income or low education respondents. However, they may still gain Medicaid coverage under the expansions due to changes in income over time, or if their income is reported with error. As seen in the third row of Figure 3, we do find small but statistically significant increases in Medicaid enrollment corresponding with the expansions among this group. We also see small but, for some years, statistically significant reductions in mortality for this group. However, these mortality reductions are quite small, between 15 and 20% of the size observed in our primary sample. The sample for the higher income group is also nearly three times as large as our main sample, resulting in much tighter confidence intervals. Taken together, all three placebo tests support our empirical design.

In addition to these placebo tests, we also conduct several additional analyses to further understand the impact of the Medicaid expansions. First, we examine changes in death rates by the underlying cause of death using the MDAC. These analyses rely on a much smaller sample and shorter follow-up period, and so we consider this analysis to be exploratory in nature. We examine deaths due to non-disease related (i.e. "external") and disease-related (i.e. "internal") causes separately. A subset of deaths caused by internal factors are considered to be "health care amenable" (Nolte and McKee, 2003), which we also examine separately. These results are presented in Table A2. We observe similar patterns for internal mortality and health care amenable mortality as we do in our main results, with relative decreases beginning in the first year after the expansions occur. Individual year effects are not statistically significant for health care amenable mortality, and are significant at the $p < 0.10$ level for deaths from internal causes; however, we find highly significant reductions in deaths related to internal causes and marginally ($p < 0.10$) significant reductions in deaths from health care amenable causes under the difference-in-differences model. In contrast, mortality from external causes, which may be less affected by insurance coverage, does not appear to decrease after the expansions. The point estimates on the individual year effects are not statistically significant and the estimate on the pooled year effect is only significant at the 10% level. The estimate is also positive, although we note that there is a slight upward pre-trend in these deaths in the expansion states relative to non-expansion states.

We further probe cause of death analysis by conducting an analysis using the ICD code groupings by body region. We emphasize that this exercise is meant to be exploratory only with the hope that it will provide guidance for future work should better data become available. The results are reported in Table A3. For most diseases, we observe negative coefficients; the largest negative point estimates are observed for deaths related to neoplasms (cancer), endocrine and metabolic diseases (primarily diabetes), cardiovascular disease, and respiratory diseases. Two of these (cardiovascular and endocrine/metabolic) are marginally significant at the 10% level. We also see a small negative but statistically significant impact on diseases related to the skin and subcutaneous tissue. However, this significant effect would not survive a correction for the many tests conducted.

A second additional analysis uses our main data source but examines changes in mortality for different populations. Our main analysis is limited to individuals age 55 to 64 at the time of the Medicaid expansions, a group with higher mortality rates that has been the focus of other work on this topic (e.g. Black et al., 2019). In column (1) of Table A4, we also estimate the impact of Medicaid expansion on mortality for individuals who meet our sample inclusion criteria but are age 19 to 64 in 2014. As with the 55-64 year old group, we find that mortality rates trended very similarly in the two groups of states prior to the expansions, with the event study coefficients for the pre-expansion years very close to zero (except for $y = -6$). Beginning in the first year of expansion, we see relative declines in mortality in the expansion states, although the estimates are much smaller in magnitude than those observed for the 55-64 age group and only statistically significant in the second year following implementation. In that year, we find a reduction in the probability of death of about 0.02 percentage points. Interestingly, when combined with the first stage for this group (a 13.4 percentage point gain in Medicaid coverage; these results available from the authors), the associated treatment effect is very close to that reported in the Oregon Health Insurance Experiment (although not statistically significant): about a 0.15 percentage point reduction in the probability of mortality, compared to their estimate of 0.13 percentage points (LATE estimate in Table IX in Finkelstein et al., 2012).

Another additional analysis limits the main sample of 55 to 64 year olds to approximately a 30 percent subset who reported being uninsured at the time of the survey. These results are presented in the second column of Table A4. As this group is somewhat younger, the mean annual mortality rate is slightly lower than in the overall sample, at 1.1% mortality per year. This subsample also has fewer observations – 180,000 individuals (or 1.3 million individual by year observations) – resulting in wider confidence intervals. Nevertheless, we observe the same pattern of no pre-ACA changes and a relative decrease in mortality beginning at the time of expansion. The point estimates indicate somewhat larger decreases in mortality for this group of 0.15 percentage points (or 13.6% of the sample mean) compared to the reduction in the main sample of 0.13 percentage points (or 9.3% of the sample mean).

5 Interpreting the Estimates and Comparisons to Past Work

The above results present consistent evidence of a decrease in all-cause mortality among low socioeconomic status, older adults under the ACA Medicaid expansions. Our point estimate indicates an average decrease in annual mortality of 0.13 percentage points during the four-year post period, or a treatment effect of Medicaid coverage among those who enroll of 0.8 percentage points. To interpret the magnitude of this estimate, we must consider the mortality rate in the absence of Medicaid expansion. The average annual mortality rate in our sample is about 1.4 percentage points. However, baseline mortality among those who actually enrolled in Medicaid (i.e., the "compliers," see Imbens and Angrist, 1994) is potentially much higher. This will be the case if those in worse health are more likely to enroll in Medicaid. The literature indicates that such adverse selection does tend to occur (e.g. Kenney et al., 2012; Marton and Yelowitz, 2015); this may also be exacerbated by policies designed to provide immediate coverage to those in need, as discussed earlier (i.e. presumptive eligibility and retroactive coverage). Data from the 2014 National Health Interview survey linked mortality files indicate that Medicaid enrollees in the 55-64 age range have a 2.3 percentage point chance of of dying in the following year.[33] We may therefore expect the mean mortality rate among the compliers to fall somewhere in the 1.4 to 2.3 percent range. Combined with our estimated treatment effect of an 0.8 percentage point reduction in mortality, this indicates that Medicaid reduces mortality by between 35%

[33]Note that this is similar to the 2.3 percentage point probability of dying observed in the Oregon Health Insurance Experiment control group for participants in this age group over the approximately 16 month period over which deaths were observed (as calculated by the authors from the public-use replication kit, see Table A5).

and 57%. Naturally, the uncertainty about both the size of the first stage and the baseline mean among the compliers results in a fairly large range of possible treatment effects. For this reason, we believe the focus should be primarily on the reduced-form estimates of the change in mortality for our overall sample, which was selected based on their likely eligibility for Medicaid, rather than these "back of the envelope" treatment effect calculations.

Nevertheless, we further assess the plausibility of our estimates by comparing the treatment effect estimate to that reported in the OHIE. We use the public-use replication kit to examine the effect of the experiment on participants who were ages 55-64 at the time of the experiment to derive estimates comparable to those presented here. Among this group, receiving Medicaid reduced the probability of mortality over a 16 month period by about 1.6 percentage points, or a decline of 70% relative to the control mean; this estimate is associated with a p-value of 0.128 (reported in Table A5). We scale this effect by 12/16th to arrive an annual effect of Medicaid on mortality of about 1.2 percentage points. This is comparable, but larger, than the 0.8 percentage point treatment effect estimated here.

Our estimated change in mortality for our sample translates into sizeable gains in terms of the number of lives saved under Medicaid expansion. Since there are about 3.7 million individuals who meet our sample criteria living in expansion states,[34] our results indicate that approximately 4,800 fewer deaths occurred per year among this population, or roughly 19,200 fewer deaths over the first four years alone. Or, put differently, as there are approximately 3 million individuals meeting this sample criteria in non-expansion states, failure to expand in these states likely resulted in 15,600 additional deaths over this four year period that could have been avoided if the states had opted to expand coverage.[35]

6 Conclusion

There is robust evidence that Medicaid increases the use of health care, including types of care that are well-established as efficacious such as prescription drugs and screening and early detection of cancers that are responsive to treatment.[36] Given this, it may seem obvious that Medicaid would improve objective measures of health. However, due to data constraints, this relationship has been difficult to demonstrate empirically, leading to widespread skepticism that Medicaid has any salutary effect on health whatsoever. Our paper overcomes documented data challenges by taking advantage of large-scare federal survey data that has been linked to administrative records on mortality. Using these data, we show that the Medicaid expansions substantially reduced mortality rates among those who stood to benefit the most.

[34] Authors' calculation using the public-use ACS.

[35] This relies on the assumption that effects of expansion in the non-expansion states would be similar to those observed in the expansion states.

[36] (E.g. Finkelstein et al., 2012; Ghosh et al., 2019; Soni et al., 2018).

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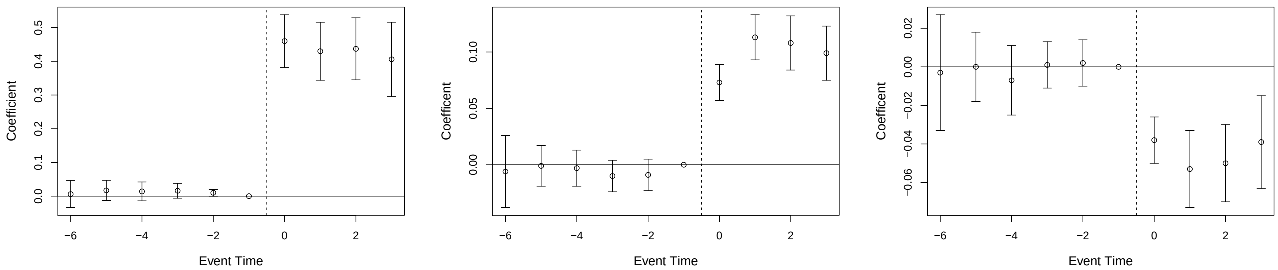
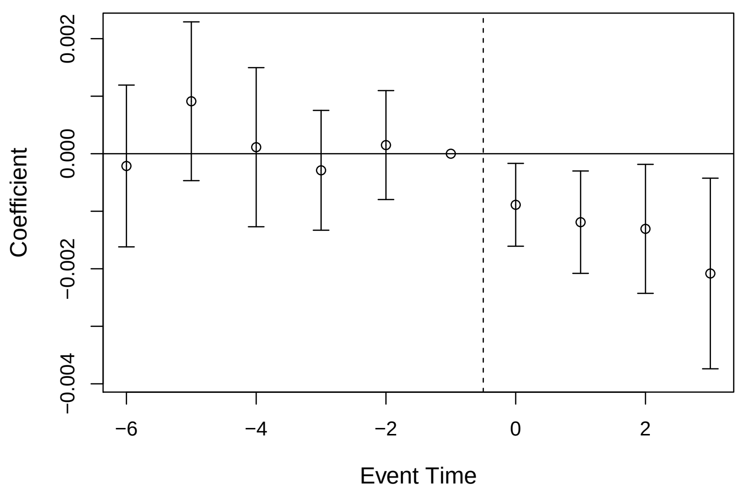
Figure 1: Effect of the ACA Medicaid Expansions on Eligibility and Coverage



(a) Medicaid Eligibility (b) Medicaid Coverage (c) Uninsured

Note: These figures report coefficients from the estimation of equation (1) for the outcomes of Medicaid eligibility, Medicaid coverage, and uninsurance in the 2008-2017 American Community Survey. The coefficients represent the change in outcomes for expansion states relative to non-expansion states in the six years before and four years after expansion, as compared to the year immediately prior to the expansion. The sample is defined as U.S. citizens ages 55-64 in 2014 who are not SSI recipients and who have either less than a high school degree or household income below 138% FPL. See Appendix Section B for detailed information on Medicaid eligibility determination.

Figure 2: Effect of the ACA Medicaid Expansions on Annual Mortality



Note: This figure reports coefficients from the estimation of Equation 1 for annual mortality. The coefficients represent the change in mortality for expansion states relative to non-expansion states in the six years before and four years after expansion, as compared to the year immediately prior to the expansion. The sample is defined as U.S. citizens ages 55-64 in 2014 observed in the 2008-2013 American Community Survey who are not SSI recipients and who have either less than a high school degree or household income below 138% FPL.

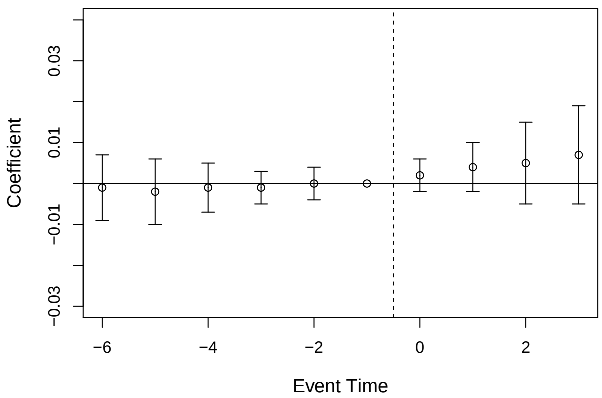
Table 1: Impact of the ACA Expansions on Coverage and Mortality: Difference-in-Differences Estimates

	Medicaid Eligibility	Medicaid Coverage	Any Insurance Coverage	Died in Year Main Sample
Difference-in-Differences Model:				
Expansion × Post	0.428 (0.05)***	0.101 (0.012)***	-0.044 (0.010)***	-0.001320 (0.000497)**
Event Study Model:				
Year 3	0.406 (0.055)***	0.099 (0.120)***	-0.039 (0.012)***	-0.002082 (0.0008284)**
Year 2	0.437 (0.046)***	0.108 (0.012)***	-0.050 (0.010)***	-0.001306 (0.0005606)**
Year 1	0.430 (0.043)***	0.113 (0.010)***	-0.053 (0.011)***	-0.001190 (0.0004449)***
Year 0	0.460 (0.039)***	0.073 (0.008)***	-0.038 (0.006)***	-0.000888 (0.0003600)**
Year -1 (Omitted)	0	0	0	0
Year -2	0.010 (0.005)*	-0.009 (0.007)	0.002 (0.006)	0.0001502 (0.0004735)
Year -3	0.016 (0.011)	-0.010 (0.007)	0.001 (0.006)	-0.0002885 (0.0005306)
Year -4	0.014 (0.014)	-0.003 (0.008)	-0.007 (0.009)	0.0001134 (0.0006915)
Year -5	0.017 (0.015)	-0.001 (0.009)	0.000 (0.009)	0.0009119 (0.0006901)
Year -6	0.006 (0.020)	-0.006 (0.016)	-0.003 (0.015)	-0.0002132 (0.0007031)
N (Individuals x Year)	714673	714673	714673	4030000
N (Individuals)	714673	714673	714673	566000

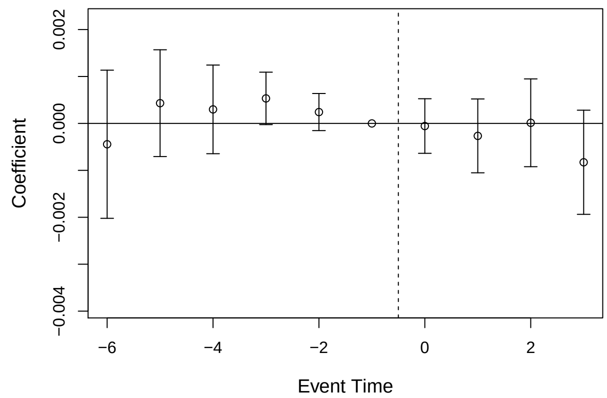
Note: This table displays the event study coefficient estimates of equation (1). Columns 1-4 show results for the main sample, citizens age 55 to 64 in 2014 who do not receive SSI and are either in low income households or have less than a high school degree education. Column 5 shows a placebo test using all individuals age 65 and older in 2014. For models based on restricted-use data, sample sizes are rounded following Census disclosure rules. See text for more details. Significance levels: *=10%, **=5%, ***=1%.

Figure 3: Placebo Tests

Age 65+ in 2014

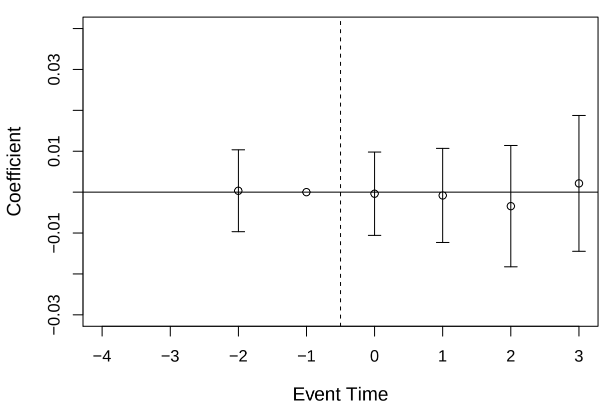


(a) Medicaid Coverage

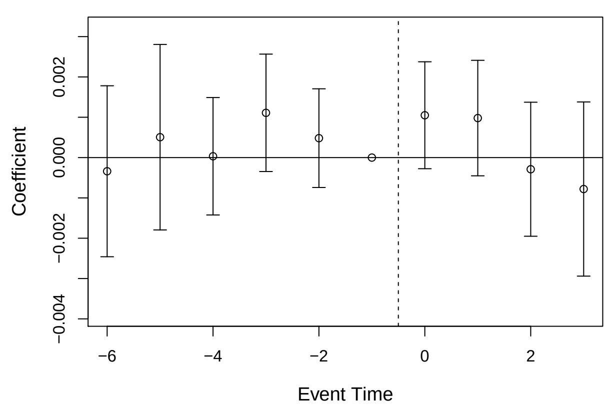


(b) Annual Mortality

Pre-ACA Years

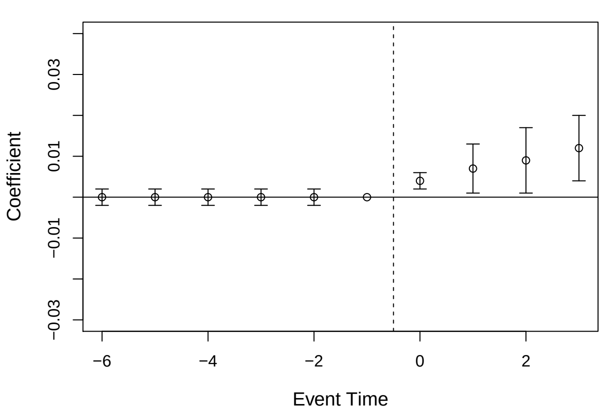


(c) Medicaid Coverage

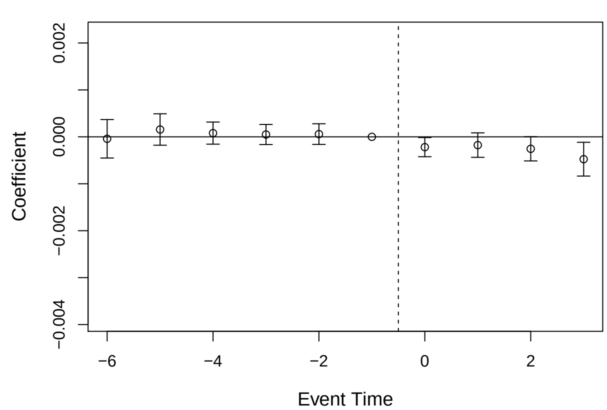


(d) Annual Mortality

Income 400%FPL +



(e) Medicaid Coverage



(f) Annual Mortality

Note: These figures plot coefficients from equation (1) for those age 65 and older in 2014 who would not have been affected by the Medicaid expansion due to their eligibility for the Medicare program (Row 1) and for those in higher income households who were likely less affected (Row 3). Row 2 plots the coefficients from (1) but uses pre-ACA years as a placebo test (see text for details).

Medicaid and Mortality: New Evidence from Linked Survey and Administrative Data

Appendix

Sarah Miller Sean Altekruse Norman Johnson Laura R. Wherry

A Additional Results

We present additional tables discussed in the main text in this section in Tables A1-A4. See the main text for further discussion of these results.

B First Stage Eligibility Estimates

To estimate the change in Medicaid eligibility associated with the ACA Medicaid expansions, we use the 2008-2017 ACS downloaded from IPUMS USA (Ruggles et al., 2019) and impute eligibility for our sample using state eligibility rules for each year. We consider eligibility for low-income parents under Medicaid Section 1931 criteria in each state, as well as expanded eligibility for parents and childless adults under waiver programs that offered comparable coverage to the ACA Medicaid expansions. We do not consider expanded programs that cover a more limited set of services and follow documentation from the Kaiser Family Foundation (KFF) to make this determination.

Information on state eligibility thresholds for coverage for adults were compiled from the sources listed in Table A6. The notes column in the table provides a record of any decisions made in applying the eligibility rules or to reconcile inconsistencies across different sources. KFF documentation on eligibility thresholds over time, which were used as our primary source, take into account state rules on earnings disregards when applicable. We defined the family unit for eligibility determination using the health insurance unit definition prepared by the State Health Access State Assistance Center, see details in State Health Access Data Assistance Center (2012). Following Medicaid rules for countable income (Centers for Medicare & Medicaid Services, 2016), we did not include family income from the Temporary Assistance for Needy Families or SSI programs in the calculation of total family income.

C Evaluating Survey Undercount of Medicaid Enrollment

To explore the extent to which survey measures undercount the number of individuals in our sample who were enrolled in Medicaid at any point during the survey year, we undertake several different analyses. Survey measures may undercount yearly enrollment because of respondents misreporting coverage or because a respondent correctly reports non-enrollment at the time of the survey but enrolls at a different point during the year. To examine this type of undercount, we take advantage of linked survey and administrative data on Medicaid coverage through the National Health Interview Survey via the public use NCHS-CMS Medicaid Feasibility Files. For each eligible respondent in the NHIS, these feasibility files state whether the respondent is present in the CMS MAX Person Summary (PS) file in each year.[37] All Medicaid enrollees are included in the PS file if they were enrolled at any point

[37]Respondents were eligible for linkage if they were age 18 or older at the time of the survey and if they consented to have their administrative data linked.

during that year, even if they were enrolled for only a partial year. We can therefore compare presence in the PS file to self-reported Medicaid coverage in the NHIS for individuals meeting our sample criteria (i.e., citizens, not receiving SSI, age 55 to 64 in 2014 and either in households earning under 138% FPL or having less than a high school education).

Ideally we would perform this calculation during the 2014 to 2017 years. However, a change in the way CMS collected administrative data from state Medicaid offices occurred in 2013 and resulted in far fewer states providing the necessary administrative data for linkages. Since the public use NHIS file does not contain state identifiers, we limit our analysis to years in our sample period during which all states were available, i.e. the 2008 to 2012 waves of the NHIS.

Our results are presented in Table A7. We see that while that 14.3 percent of NHIS respondents meeting our sample criteria reported being enrolled in Medicaid when asked as part of the survey, 19.3 percent were found to be enrolled at some point during the year in the administrative records. Enrollment would therefore be undercounted by approximately 35 percent ($\frac{19.3}{14.3} \approx 1.35$) relying on survey data alone, motivating our re-scaling of the survey first stage estimates.

We also supplement this analysis by using administrative enrollment data published in two sets of CMS reports. We calculate the difference-in-differences estimate from each set of reports and compare it to an estimate derived from survey reports for a similar population in the ACS. The first set of reports come from administrative enrollment data published by CMS and compiled by the Kaiser Family Foundation (KFF). Beginning in July 2013, CMS has published monthly total enrollment numbers in their Medicaid and CHIP Application, Eligibility Determination, and Enrollment Data reports. The KFF has compiled these monthly reports and calculated pre-ACA average monthly Medicaid/CHIP enrollment during the period July-September 2013, as well as average Medicaid/CHIP monthly enrollment for each month during the post-expansion period (Kaiser Family Foundation, 2019c). These totals refer to the total number of unduplicated individuals enrolled in Medicaid and CHIP.

We combine these administrative totals with state population estimates from each year of the ACS to create enrollment rates. Using the average monthly enrollment rates for 2013 and the monthly enrollment rates for 2014-2017, we then estimate a difference-in-differences model that includes state, year, and month fixed effects. We follow the same definition and timing of Medicaid expansion, as well as exclude the 5 early expander states, as in our main mortality data analyses. We use population weights and cluster the standard errors at the state level. We then compare these estimates to those acquired using only ACS survey data over the same period.

The results are reported in Table A8. The estimates using CMS data show a larger rate of Medicaid participation at baseline and a larger increase in participation under the ACA Medicaid expansions when compared to the estimates using ACS data. The change associated with Medicaid expansion is 23% larger when estimated with the administrative data.

The second analysis uses the MAX validation reports, which report the total number of Medicaid enrollees by state as well as the percent of enrollees in the 45 to 64 age range. These data have two advantages over the KFF monthly reports: they report the total number of individuals ever enrolled during the year and they are available for a population closer in age to the group examined in the main study. However, there are two major disadvantages to these reports: they are only available through 2014, and only for 16 states.[38] Using these data, and the corresponding sample from the ACS, we conduct a similar comparison. These results are reported in columns 3 and 4 of Table A8. For this age group and set of states, we find a dramatically larger effect of the ACA expansions using the enrollment rates based on the administrative data – about an 8.6 percentage point increase in enrollment – compared to those derived from the ACS – an increase of only 2.6 percentage points.

[38]These states are CA, GA, ID, IA, LA, MI, MN, MS, MO, NJ, PA, SD, TN, UT, WV, and WY.

Table A1: Descriptive Statistics of Main Sample by State Expansion Status

	Expansion State	Non-expansion State
% White	70.9	68.7
% Black	14.9	24.2
% Hispanic	15.3	12.2
% Uninsured	32.6	37.3
% Medicaid	20.5	16.2
% Less than High School Education	45.3	46.8
Average Age in 2014	55.8	55.9
Average Income relative to FPL	1.47	1.40
N	231,200	190,448

Note: This table displays weighted means for residents in expansion and non-expansion states meeting the sample criteria described in the text. These statistics were calculated using publicly-available 2008-2013 ACS data rather than the restricted version used in the main analysis.

Table A2: Impact of the ACA Expansions on Coverage and Mortality: Cause of Death

	Deaths from Internal Causes	Deaths from Health Care Amenable Causes	Deaths from External Causes
Difference-in-Differences Model:			
Expansion × Post	-0.002351 (0.006754)***	-0.0009907 (0.0005043)*	0.0003831 (0.0001998)*
Event Study Model:			
Year 1	-0.002207 (0.001262)*	-0.0004100 (0.0008170)	0.0000954 (0.0003947)
Year 0	-0.002090 (0.001081)*	-0.001029 (0.0007480)	0.0002501 (0.0003154)
Year -1 (Omitted)	0	0	0
Year -2	-0.0005340 (0.0008272)	0.0006530 (0.0005310)	-0.0000658 (0.0003380)
Year -3	0.0008772 (0.001038)	0.0001387 (0.0007171)	-0.0000658 (0.0004400)
Year -4	-0.0004416 (0.001118)	-0.0000797 (0.0008195)	-0.0003190 (0.0003844)
Year -5	0.0007490 (0.0009490)	0.0004741 (0.0007390)	-0.0002190 (0.0003696)
Year -6	0.0007098 (0.001062)	0.0002333 (0.0006164)	-0.0006014 (0.0003489)
N (Individuals x Year)	683000	683000	683000
N (Individuals)	88500	88500	88500

Note: This table displays the event study coefficient estimates of equation (1) using the MDAC. Sample sizes are rounded following Census disclosure rules. See text for more details. DRB Disclosure Approval #: CBDRB-FY19-310. Significance levels: *=10%, **=5%, ***=1%.

Table A3: Impact of the ACA Expansions on Mortality: Impact by ICD Grouping

	Infectious Disease	Neoplasms	Diseases of the blood and blood-forming organs	Endocrine, nutritional and metabolic diseases	Mental/Behavioral
Expansion × Post	-0.0000671 (0.0001273)	-0.0005512 (0.0004556)	0.0000337 (0.0000345)	-0.0004314 (0.0002277)*	-0.0000465 (0.0001100)
Mean	0.004121	0.02718	0.0002675	0.005279	0.001676
	Nervous System	Circulatory System	Respiratory	Digestive	Skin and Sub-cutaneous Tissue
Expansion × Post	-0.0000131 (0.00011.62)	-0.0008861 (0.0004804)*	-0.0003801 (0.0002758)	-0.0000046 (0.000243)	-0.00002550 (0.0000119)**
Mean	0.002392	0.02504	0.008223	0.006589	0.00008866
	Musculoskeletal system	Genitourinary system	Other		
Expansion × Post	0.0001148 (0.0000706)	-0.0001297 (0.0001101)	0.0003175 (0.0001910)		
Mean	0.0004495	0.002094	0.07006		

Note: This table displays the difference-in-differences coefficient estimates using the MDAC. Each entry is the result from a different regression. Rates are reported under coefficient estimates. Sample sizes are rounded following Census disclosure rules. DRB Approval Number: CBDRB-FY19-400. See text for more details. Significance levels: *=10%, **=5%, ***=1%.

Table A4: Impact of the ACA Expansions on Coverage and Mortality: Additional ACS Analyses

	Died in Year Ages 19-64	Died in Year, Uninsured at Time of ACS
Difference-in-Differences Model:		
Expansion × Post	-0.0001900 (0.0001680)	-0.001500 (0.0006590)**
Event Study Model:		
Year 3	-0.0003183 (0.0002191)	-0.002517 (0.0008802)**
Year 2	-0.0001270 (0.0001702)	-0.001425 (0.0009531)
Year 1	-0.0002309 (0.0001124)**	-0.001437 (0.0006387)**
Year 0	-0.0001541 (0.0001034)	-0.0008643 (0.0008343)
Year -1 (Omitted)	0	0
Year -2	-0.0000201 (0.0001146)	0.0001791 (0.0008579)
Year -3	0.0000318 (0.0001471)	-0.0005425 (0.0007373)
Year -4	-0.0000049 (0.0001663)	0.0001925 (0.0009295)
Year -5	0.0000138 (0.0001890)	0.001409 (0.001057)
Year -6	-0.0002170 (0.0002160)	0.0001959 (0.001126)
N (Individuals x Year)	23630000	1280000
N (Individuals)	3160000	180000

Note: This table displays the event study coefficient estimates of equation (1) using the ACS. Sample sizes are rounded following Census disclosure rules. See text for more details. DRB Disclosure Approval #: CBDRB-FY19-310. Significance levels: *=10%, **=5%, ***=1%.

Table A5: Results from the Oregon Health Insurance Experiment for participants age 55-64 in 2008

	Control Group Mean	Reduced Form	2SLS	p-value
Alive	0.977	0.0042	0.016	0.128
N	6550 (Control)	4240 (Treatment)		

This table uses the public-use replication kit of the Oregon Health Insurance Experiment to estimate the impact of Medicaid on individuals who were between the ages of 55 and 64 at the time of the experiment. The data and code were downloaded from https://www.nber.org/oregon/4.data.html.

Table A6: Sources for Parent and Adult Medicaid Eligibility Rules by Year

Year	Sources	Notes
2008-2010	Adults: NGA Center for Best Practices (2010), Table 9	We follow the criteria reported in Heberlein et al. (2011), Table 4 to determine whether programs described in NGA Center for Best Practices (2010) meet the full coverage criteria. We turned to additional sources to reconcile other differences with the program details reported in Kaiser Family Foundation (2019a). Specifically, we added a program for AZ following National Conference of State Legislatures (2009), a DC program based on Meyer et al. (2010), and altered HI and VT program details using Indiana Legislative Services Agency (2011).
2011-2017	Adults: Kaiser Family Foundation (2019a)	We consider eligibility rules to be in place as of the date of the relevant KFF survey. To be consistent with our definition of implementation of the ACA Medicaid eligibility expansions, we consider the expansion in Indiana to take place in 2015.
2008-2017	Parents: Kaiser Family Foundation (2019b)	We consider eligibility rules to be in place as of the date of the relevant KFF survey with the exception of the December 2009 survey for parents eligibility, which we apply to the 2010 year. To be consistent with our definition of implementation of the ACA Medicaid eligibility expansions, we consider the expansion in Indiana to take place in 2015.

Table A7: Undercount Estimates from the NHIS-CMS Linked Feasibility Files

% Reported Enrolled in Survey	0.143 (0.008)
% Reported Enrolled in Administrative Data	0.193 (0.009)
N	2,267

Note: This table displays the fraction of NHIS respondents meeting sample inclusion criteria who reported being enrolled in Medicaid in the NHIS (first row) versus those who were shown to be enrolled in Medicaid in the CMS administrative data (second row). Standard errors are in parentheses.

Table A8: Comparison of Medicaid Coverage Estimates: CMS vs. ACS

	All Ages and States, 2013-2017		Age 44-64, 17 States, 2012-2014	
	Enrollment Based on CMS Enrollment Reports	Enrollment Based on ACS Data	Enrollment Based on MAX Validation Reports	Enrollment Based on ACS Data
Expansion x Post	0.0382***	0.0309***	0.0862***	0.0258***
	(0.0093)	(0.0049)	(0.0248)	(0.0065)
Baseline Mean in Expansion States	0.197	0.172	0.120	0.108
Number of Observations	2,103	14,323,891	48	2,423,253

Note: The first two columns in this table display the difference-in-differences estimates for analyses using monthly enrollment rates constructed from CMS enrollment reports and self-reported enrollment from the ACS for all ages, respectively, for the years 2013-2017. All regressions include state and year fixed effects and the regression with CMS data also includes month dummies. The second two columns display the DID estimates for analyses using total number of adults ages 45-64 ever enrolled in each year during 2012-2014 from the MAX validation reports from 16 states, as well as the estimates derived from a comparison ACS sample for those years. The regressions include state and year fixed effects. For all regressions, robust standard errors are clustered by state. The regressions with administrative data use state population estimates as weights, while the analyses with ACS data use survey weights. See text in Appendix Section C for more details on the data. Significance levels: *=10%, **=5%, ***=1%.