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Premium subsidies, the mandate, and Medicaid expansion: Coverage effects of the Affordable Care Act

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ABSTRACT

Using premium subsidies for private coverage, an individual mandate, and Medicaid expansion, the Affordable Care Act (ACA) has increased insurance coverage. We provide the first comprehensive assessment of these provisions' effects, using the 2012–2015 American Community Survey and a triple-difference estimation strategy that exploits variation by income, geography, and time. Overall, our model explains 60% of the coverage gains in 2014–2015. We find that coverage was moderately responsive to price subsidies, with larger gains in state-based insurance exchanges than the federal exchange. The individual mandate's exemptions and penalties had little impact on coverage rates. The law increased Medicaid among individuals gaining eligibility under the ACA and among previously-eligible populations ("woodwork effect") even in non-expansion states, with no resulting reductions in private insurance. Overall, exchange premium subsidies produced 40% of the coverage gains explained by our ACA policy measures, and Medicaid the other 60%, of which 1/2 occurred among previously-eligible individuals.
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One of the most significant policy issues facing the United States over the past forty years has been the high number of those without health insurance. The percentage of uninsured Americans rose steadily from the 1980s through 2010, through both recessions and economic growth (DeNavas-Walt et al., 2013). A major policy focus during this era was intervening in insurance markets to expand coverage and offset this trend. This mostly happened using public insurance via Medicaid and the Children's Health Insurance Program, with little private sector intervention (Gruber and Levitt, 2000). This pattern of incremental public coverage expansion changed dramatically with the passage of the Affordable Care Act (ACA) in 2010.

The ACA enacted enormous expansions of both public and private insurance. The former was to take place through a nationwide expansion of Medicaid to all those with incomes below 138% of the Federal Poverty Level (FPL); however, the Supreme Court ruled in 2012 that states could refuse this expansion. The private insurance expansion takes place through sizeable income-based tax credits for those with incomes from 100–400% of FPL who are not eligible for Medicaid, to subsidize premiums for private insurance purchased on newly established insurance exchanges. Underlying the expansion are new insurance regulations that end discrimination on the basis of pre-existing conditions, coupled with an individual mandate that requires most Americans to obtain insurance (with several exemptions, most notably related to affordability). These principal pieces of the ACA took effect in January 2014.[1]

National data from multiple sources strongly support the notion that the ACA has reduced the uninsurance rate substantially beginning in 2014, reaching an historic low by 2015 (Cohen and Martinez, 2014; Smith and Medalia, 2015; Sommers et al., 2015a). This drop has generally been attributed to the ACA, but most analyses of the ACA to date have been largely descriptive (Cohen and Martinez, 2014; Long et al., 2014) or limited to a particular aspect of the ACA such as the Medicaid expansion (Black and Cohen, 2015; Kaestner

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[1] The earliest coverage expansion enacted under the ACA was the dependent coverage provision, which mandated that private insurers allow parents to cover their children on their insurance until age 26. This provision took effect September 2010. We do not examine this policy here, since it had essentially reached steady-state by 2012 and has already been examined thoroughly elsewhere (Antwi et al., 2013).

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et al., 2015; Wherry and Miller, 2016). No studies have disentangled the different coverage effects of the ACA's various provisions. Even as the 2016 election results cast uncertainty over the ACA's future, these issues remain critically important to understanding the potential impact of a partial or complete rollback of the law, as well as the potential consequences of future state or federal efforts to expand coverage.

In this paper, we provide the first comprehensive model that identifies the causal impact of the ACA's numerous provisions on insurance coverage. In doing so, we also offer an empirical template for future research on this wide-ranging law. We use data from the American Community Survey (ACS) for the two years before and two years after full ACA implementation. We estimate rich models that examine both the public coverage expansions and private coverage subsidies that are put in place by the ACA, as well as the individual mandate. Public insurance expansions are identified by state decisions about whether to take up the Medicaid expansions and by differential impacts of Medicaid expansions across income groups and family types. Private insurance subsidies are identified by the variation in effective subsidy rates by income group and area of the country. Mandate effects are identified by variation in the incidence of the penalty (related to the law's several mandate exemptions) and the magnitude of the penalty (tied to income and family structure). Our models allow us to control for fixed differences and trends by income group and geographic area.

Overall, we find that our policy parameterization can explain roughly 60% of the increase in insurance coverage from 2012–2013 to 2014–2015. The remaining 40% of coverage gains in 2016 does not appear to be mediated by the economic recovery, based on prior research by Blumberg, Garrett, and Holohan. A reasonable interpretation is therefore that as much as 40% of the ACA's coverage gains could be attributable to the combined effects of increased insurance purchase rates related to the new marketplace, increased value of coverage based on the law's essential benefits, community rating, and a generalized effect of the mandate not tied to its specific exemptions and penalty amounts. Any one of these policies in isolation could, in theory, be contributing up to 40% of the overall ACA effect, though more likely each is contributing a portion. Unfortunately, given the simultaneous implementation of these policy provisions, it is impossible to disentangle each of these components.

Within these ACA coverage changes, we have several key findings. The impact of tax credits to private insurance was fairly modest but grew over time, with each 10% increase in subsidy reducing the uninsured rate by roughly 0.5 percentage points in 2014 and 0.9 percentage points in 2015. Premium tax credits produced much larger effects in states operating state-based insurance exchanges, as opposed to using the federal exchange (healthcare.gov), suggesting potential benefits to local implementation of the law. All told, exchange insurance subsidies accounted for approximately 40% of the reduction in the uninsured rate attributable to our ACA policy parameters. In contrast, the mandate penalty had a negligible impact on coverage.

Meanwhile, Medicaid accounted for the other 60% coverage change attributable to our ACA policy measures, via three distinct pathways. Medicaid expansion increased coverage among newly-eligible individuals by roughly 14 percentage points in 2015, which accounted for nearly 20% of the observed ACA effect on the uninsured rate. Another 10% came from the ACA's early expansions of Medicaid that occurred in 6 states between 2011–2013. Nearly 30% of the ACA policy impact on coverage in 2014–2015 came via the less discussed "woodwork effect" of increased insurance enrollment among those who were previously eligible for Medicaid before the ACA but not enrolled. This phenomenon was evident in all states, whether or not they had expanded Medicaid, and occurred for both adults and children. Finally, we find no evidence that the expansion of Medicaid led to offsetting reductions in private insurance.

Our paper proceeds as follows. Section 1 describes the ACA's main coverage provisions. Section 2 reviews the existing literature on how these policies may impact health insurance coverage. Section 3 describes our data and policy variables. Section 4 presents our empirical strategy. Section 5 presents our results. Section 6 discusses policy implications and concludes.

1. Background on the Affordable Care Act

The ACA represents the largest transformation of the U.S. health care system since the introduction of Medicare and Medicaid in the mid-1960s. While the legislation also addressed issues such as health care costs and quality of care, we focus on the coverage provisions of the ACA. There are three key provisions that form the law's "three legged stool":

The first is a federal overhaul of private insurance market regulation. Among other changes, the ACA guarantees the issue of insurance regardless of pre-existing conditions, bans medical underwriting, and eliminates annual or lifetime benefit limits. These provisions apply to the entire non-group insurance market, as well as to non-self-insured employers.

The second is the individual mandate. Under the ACA, legal residents of the U.S. are mandated to obtain insurance, subject to a number of exemptions, and those who do not are subject to a tax penalty. This penalty was modest in 2014, equal to the larger of $95 or 1% of income; it has grown more sizeable since, rising to the larger of $695 or 2.5% of income in 2016. Exemptions exist for those with incomes below the threshold for filing federal income taxes, low-income residents in states that have not expanded Medicaid under the ACA, and those who cannot find insurance on the exchange for less than 8% of income.

The third is comprised of policies to make health insurance more affordable. This includes a massive expansion of public insurance through a universal extension of Medicaid eligibility to all those below 138% of the federal poverty level.[2] Medicaid was previously categorically restricted: some groups (such as children and pregnant women) were typically eligible above this income level, others (such as disabled adults and low-income parents) were only eligible at much lower income levels, and the remaining low-income adults (so-called "childless adults") were not eligible at all in most states. This expansion had differential impacts by state, income, and family type. An additional element of variation in Medicaid eligibility was the result of a Supreme Court decision in 2012, which made the ACA's Medicaid expansions voluntary. As a result, only 24 states plus Washington D.C. expanded by January 2014; since then, another 7 states have expanded (Kaiser, 2015).

The other source of financial support for insurance was through the introduction of new tax credits for private insurance purchased through the exchanges. Individuals are eligible for tax credits if they are ineligible for Medicaid and have incomes between 100% and 400% of FPL. These credits cap the share of income that individuals must pay for coverage (at the "silver" level described below) at between 2% and 9.5% of income on a sliding scale basis. In addition, the ACA provides cost-sharing subsidies to enrollees with incomes below 250% of FPL.

The ACA included other provisions that are harder to quantify, but which might have significant effects. The first is the

[2] The statutory cutoff for Medicaid eligibility under the ACA is 133% of FPL, but requires that states disregard a portion of applicants' income equal to an additional 5% of FPL, producing an effective eligibility threshold of 138% of FPL. Also, note that Medicaid coverage is not available to individuals without either U.S. citizenship or legal permanent residency status for at least 5 years.

introduction of private insurance exchanges, which brought organized shopping to a fractured non-group insurance market. On these exchanges, individuals can compare options at four different "metal" levels based on the plans' actuarial value (the share of expected medical costs covered): 60% for bronze, 70% for silver, 80% for gold, and 90% for platinum. States had the option of establishing their own exchanges or using the federal exchange; 13 states plus Washington D.C. operated state-based exchanges in 2014–2015, though two states (Kentucky and Hawaii) have since reverted to the federal exchange.

The ACA includes an "employer mandate" as well. This is a charge levied on firms based on the share of their employees that are not offered affordable coverage who end up receiving exchange tax credits. However, this provision was delayed until 2015, and given the lack of information on employer offers of coverage in the ACS, we did not model that policy directly.

2. Literature review

Our paper focuses on three main policy levers: public expansions, private insurance subsidies, and an individual mandate. In this section we review the literature on the effects of these policies on health insurance coverage and what is known to date about the ACA's effects.

Previous research on public insurance expansions focuses on the sizeable expansions of Medicaid and the Children's Health Insurance program (CHIP) over the late 1980s-early 1990s, and again in the late 1990s-early 2000s (Gruber and Simon, 2008; Sommers et al., 2012a). The literature finds that take-up of these Medicaid and CHIP expansions was moderate, with roughly 25–35% of those who became newly-eligible for public insurance coverage choosing to enroll. One reason is that many of those made eligible for public insurance already had private insurance coverage. Complex application processes and informational barriers also contribute to low participation (Sommers et al., 2012b).

Some individuals, however, may have dropped their private coverage for free or heavily subsidized public insurance, a phenomenon known as "crowd out" (Cutler and Gruber, 1996). Estimates of the share enrolling in public insurance who would otherwise have private insurance vary. Some studies have found rates ranging from 20–60% (Gruber and Simon, 2008; Lo Sasso and Buchmueller, 2004), while others have found little to no crowd-out (Hamersma and Kim, 2013; Thorpe and Florence, 1998). In general, crowd-out has been found to be greater among expansions to higher-income groups (Kronick and Gilmer, 2002).

There has been much less work on the impact of private insurance subsidies. One well-cited study (Marquis and Long, 1995) used geographic variation in the price of individual insurance to assess the correlation with insurance coverage, estimating an elasticity of demand of −0.4. This is problematic, however, since other factors correlated with insurance demand may drive this price variation. There has been more work on tax policy and the demand for employer-sponsored insurance; see Gruber (2005) for a review. Massachusetts' 2006 health reform law, which featured premium subsidies and a state exchange, led to large reductions in the uninsured rate (Long et al., 2009). However, the state law's other features (including individual and employer mandates) complicate the interpretation of these findings, and previous research has not disentangled the effects of subsidies vs. these other provisions.

There is also less understanding of how the individual mandate impacts coverage and interacts with the ACA's other provisions. Again, the best evidence comes from Massachusetts, which introduced an individual mandate as part of its 2006 health reform. In addition to a general decline in the uninsured rate, prior research shows several spillover effects of the mandate. First, individuals who were already eligible for the state's Medicaid program but not yet enrolled significantly increased their take-up (Sonier et al., 2013). Second, despite generous non-employer insurance subsidies and a weak employer mandate, there was no erosion of employer-sponsored coverage – and some evidence that such coverage increased (Kolstad and Kowalski, 2012). This may reflect a response to the individual mandate, in which workers accept lower wages in return for employer coverage (Hackmann et al., 2015).

In terms of the ACA itself, a growing body of research has begun to document changes in coverage under the law. Several states opted to expand Medicaid under the ACA prior to 2014, and studies indicate small marginal changes in coverage with variable crowd-out – little among those with health problems, but significant among younger adults (Sommers et al., 2014). For the 2014 expansion, federal survey data (Cohen and Martinez, 2014; Smith and Medalia, 2015) and private data sources (Shartzer et al., 2015; Sommers et al., 2015a) all confirm a large drop in the uninsured rate, particularly among lower-income adults. A time-series analysis estimated nearly equal coverage gains in 2014 due to exchange insurance and Medicaid (Carman et al., 2015), though this study simply presented descriptive trends. Finally, several analyses describe moderate coverage gains in 2014 due to the Medicaid expansion (Courtemanche et al., 2016; Kaestner et al., 2015). To our knowledge, no research has yet developed an identification strategy to assess the ACA's coverage provisions simultaneously and disentangle their effects.[3]

3. Data and policy measurement

3.1. Data

Our primary source of data for this analysis is the 2012–2015 American Community Survey (ACS). The ACS, conducted by the United States Census Bureau, is the largest household survey in the country, with approximately 3 million individuals surveyed in the public-use file each year. Within-state geographical information is available in the ACS based on approximately 2350 "public use microdata areas" (PUMAs). PUMAs are mutually exclusive areas within states that are populated with at least 100,000 individuals; PUMA boundaries were redrawn after 2011 using the Decennial Census, which precludes us from using data prior to 2012. The ACS is one of the primary sources used by the federal government to evaluate health insurance coverage (Finegold and Gunja, 2014; Smith and Medalia, 2015).

Our study sample includes all non-elderly (age under 65) individuals residing in the U.S., other than in Massachusetts. We exclude the elderly from our analysis because the ACA's coverage expansions did not apply to individuals 65 and over. We excluded Massachusetts because the state's 2006 health reform law already included many ACA-like features; our results are essentially unchanged by this exclusion.

Our dependent variables of interest in the ACS are four measures of insurance coverage: no health insurance (uninsured), Medicaid, employer-sponsored insurance (ESI, including military and union coverage), and non-group private insurance. Together, these four categories are inclusive of 98% of non-elderly individuals in the survey, with the remainder insured by the VA or Medicare. Regarding Medicaid, the ACS's question asks about "Medicaid, Medical Assistance, or any kind of government-assistance plan for those

[3] Another strand of research examines effects of public insurance on labor supply, with conflicting findings (Baicker et al., 2014; Garthwaite et al., 2014). Early evidence on the ACA suggests that labor market effects have been minimal (Garrett and Kaestner, 2015; Gooptu et al., 2016; Moriya et al., 2016), and we do not focus on this issue here.

with low incomes or a disability." Thus, some respondents may answer "yes" to this question based on their receipt of government subsidized exchange coverage, while others may report this as non-group coverage (i.e., "Insurance purchased directly from an insurance company").[4]

3.2. Policy measures

The ACA marks an enormous policy change toward insurance coverage. Fortunately for research purposes, many of the changes embodied in the law vary substantially across individuals in a way that can be parameterized. Other factors are more uniform and difficult to separate from non-ACA conditions that may more generally impact insurance coverage.

Medicaid Eligibility. Our first policy measure is eligibility for Medicaid, which we combine with eligibility for the related Children's Health Insurance Program (CHIP). We decompose eligibility into three parts: eligibility prior to the ACA's Medicaid expansion (i.e., using 2010 income thresholds and criteria), eligibility under the so-called "early expansions" that occurred under the ACA between 2011–2013 in 6 states[5]; and new eligibility as a result of the 2014 Medicaid expansion. The first group is known as the "woodwork" (or "welcome mat") population that may newly take up Medicaid coverage due to increased awareness of coverage options under the ACA, the law's attempt to reduce administrative-related barriers to applying that have previously reduced enrollment (Aizer, 2007), and the individual mandate (Sommers and Epstein, 2011). In addition, the existence of Medicaid expansion may increase participation in this group as individuals know they are less likely to lose eligibility for small changes in income.

Our approach distinguishes between these categories of Medicaid eligibility because all three may have plausibly experienced coverage changes as a result of the ACA, but likely with heterogeneous take-up rates. Most analyses of Medicaid expansions prior to the ACA have ignored any potential woodwork effect, which in many cases was likely negligible given the lack of other systemic policy changes (such as the ACA's mandate and application streamlining). However, some analyses have identified similar spillover effects in previous expansions (Aizer and Grogger, 2003; Sonier et al., 2013). All measures of Medicaid eligibility are constructed using state rules based on age, income, disability, and parental status obtained from the Centers for Medicare and Medicaid Services (CMS) and the Kaiser Family Foundation.[6]

Fig. 1 depicts the percent of the sample eligible for Medicaid/CHIP, based on state expansion status for children (Panel A) and adults (Panel B). All children under the poverty line are eligible, regardless of state expansion decision. In the 200–300% FPL range, coverage is typically via CHIP and eligibility trails off – more steeply in non-expansion states (which have traditionally been less generous with coverage). For adults, expansion states offer eligibility to everyone with incomes up to 138% of FPL, while a minority of adults in non-expansion states meet both income and categorical criteria for eligibility. Even prior to the ACA expansion, eligibility standards for adults were more generous in expansion states than non-expansion states.

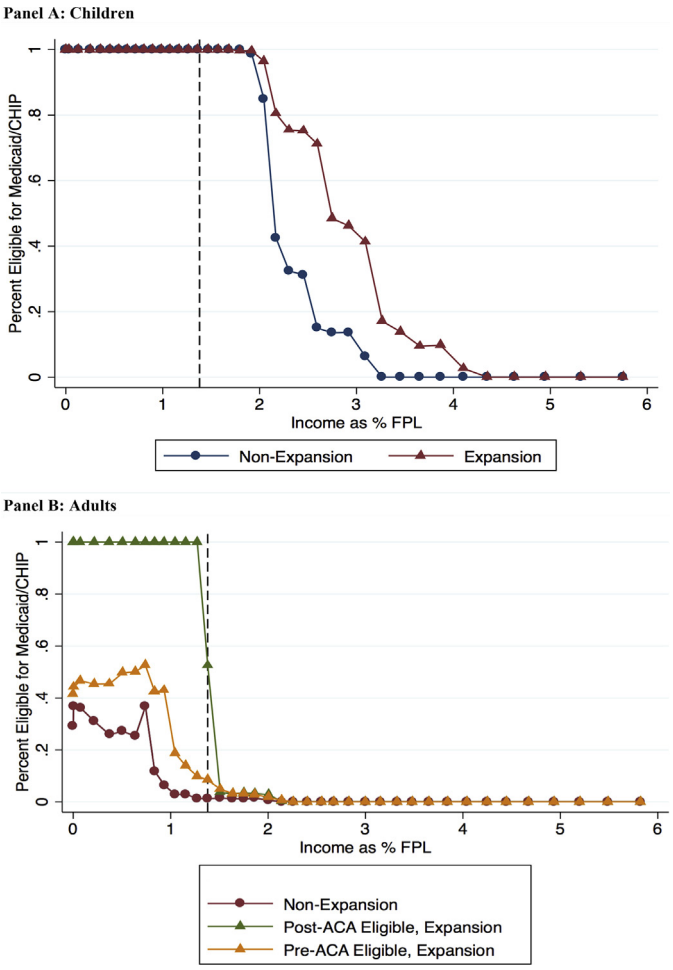

Fig. 1. Eligibility for Medicaid/CHIP by Income and State Medicaid Expansion Status. *Notes*: Top panel represents child eligibility and bottom panel represents adult eligibility. Dashed vertical line indicates 138% of the Federal Poverty Level (FPL).

Exchange Premium Subsidies. Our second policy measure is the subsidy rate for insurance purchased through the ACA's exchanges. Since exchange premiums are defined based on the family unit, our analysis models the premiums and subsidies using the notion of the health insurance unit (HIU) – defined as an adult, his/her spouse, and their dependent children in the household, excluding unrelated roommates or other adult relatives (such as grandparents). This corresponds to the family unit upon which premium subsidies and Medicaid eligibility is based, and we use the term "family" and HIU interchangeably below.

To construct the subsidy measure, we first calculate an unsubsidized premium for each HIU based on the ACA rating area they resided in. We directly matched premiums to individuals in cases where a single rating area mapped directly to a PUMA and used population-weighted premium averages in cases where multiple rating areas spanned a single PUMA. The HIU unsubsidized premium is the sum of the individual premiums for each of its members, with no more than three covered children included in the sum based on federal regulations. Individual premiums are based on the

[4] The ACS, while generally quite reliable at assessing health insurance coverage and used by the Census in its annual reports on insurance of the U.S. population, does produce overestimates of non-group coverage compared to other data sources (Mach and O'Hara, 2011). However, our study design effectively subtracts out any time-invariant over-reporting bias for this form of coverage in the survey.

[5] The early expansion states are CA, CT, DC, MN, NJ, and WA. See Sommers et al. (2013) for expansion details and timing.

[6] Medicaid and CHIP eligibility for children, parents, and childless adults was obtained for each state, as of 2013, from a pre-ACA survey of all 50 states conducted by the Kaiser Family Foundation (Heberlein et al., 2013), supplemented by information on the six states adopting the ACA's early-expansion option to expand prior to 2014 (Meng et al., 2012; Sommers et al., 2013). Information on disability-related eligibility is also from Kaiser (Kaiser, 2010); adult disability was identified in the ACS using their disability recode variable. 2014 eligibility was updated with information from CMS (2014). The ACS does not report pregnancy, so we do not attempt to model that pathway of eligibility here. We apply the ACA's statutory 5% income disregard to all MAGI-eligible groups (groups who income is totaled using the notion of Modified Gross Adjusted Income).

second-lowest-cost silver plan in the rating area, obtained from the Robert Wood Johnson Foundation. We use this plan for two reasons: (1) the silver tier is the most commonly purchased tier, selected by 65% of consumers in the first open enrollment period (ASPE, 2014); and (2) the second-lowest cost silver plan is the one to which the ACA's premium tax credits are pegged. All unsubsidized premiums are age-adjusted using state-specific age-rated premium curves obtained from CMS.

Then, we calculate the net subsidized premium for each family. Families with incomes outside of 100–400% of FPL and those eligible for Medicaid or CHIP are ineligible for subsidies. For the remainder of the sample, net premiums are calculated based on the ACA's subsidy schedule, which determines premium payments on a sliding scale percentage of income.[7] In addition to net premiums, we also calculate each HIU's *Percent Subsidy*, equal to 1 – (*Net Premium/Unsubsidized Premium*). While both are measures of premium subsidy generosity, they have important differences. The net premium only captures cost, while the percent subsidy incorporates both the cost of coverage and its effective value to the consumer; holding net premiums constant, the percent subsidy is higher for older adults and those living in areas with more expensive health insurance. *A priori*, we hypothesize consumers respond to both the cost and value of coverage. Thus, percent subsidy is our preferred parameter, but we test both and allow the data to indicate which is a better predictor of behavior.[8]

Fig. 2 shows the percent subsidy as a function of FPL and Medicaid expansion status. In non-expansion states, premium subsidies are available starting at 100% of FPL; in expansion states, where such families are eligible for Medicaid, subsidies begin at 138% of FPL.[9] Subsidy rates peak at about two-thirds for non-expansion states for those between 100–138% of FPL, and slightly over half for those just above 138% of FPL in expansion states. The subsidy rate then declines steadily but not quite linearly until going to zero above 400% of FPL. Overall, the variation in premium subsidies is a result of two factors – unsubsidized premiums and the ACA's income-based subsidy rules. While the former may vary across markets based on potentially endogenous factors including health care costs, PUMA fixed effects should address this concern, and it is only in combination with the ACA's tax credit schedule – which is plausibly exogenous – that we obtain variation used to identify the policy impact of the subsidies.[10]

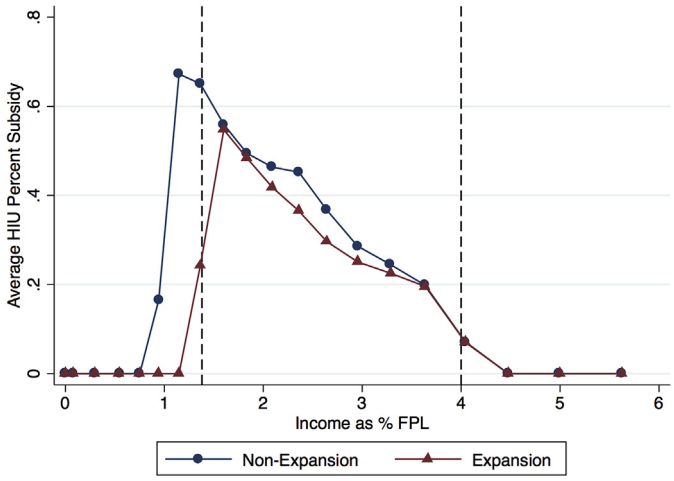

Fig. 2. Exchange percent subsidy in 2015 by Income and State Medicaid Expansion Status. *Notes*: Dashed vertical lines indicate 138% and 400% of the Federal Poverty Level (FPL).

Mandate. Our third policy measure is the tax penalty associated with the individual mandate. Fundamentally, the existence of the mandate is a time series change that cannot be separately identified in our model. To the extent that the mandate creates a generalized "taste for compliance" (Saltzman et al., 2015), our model is unable to capture that effect. However, in principle, the mandate does not impact those who are exempted, and due to non-linearities in the mandate penalty, families may be exposed to different levels of tax penalties for forgoing health insurance. We therefore construct a measure representing each family's tax penalty in dollars due to the mandate. The penalty is equal to $0 for families exempt due to any of the following (with the percentage of the sample affected by each exemption in 2014 listed in parentheses): (1) family income below the federal tax-filing threshold[11] (20.7%); (2) family income below 138% of FPL in a state that elected not to expand Medicaid (5.5%); (3) Native Americans (0.6%); or (4) no affordable coverage available, defined as the lowest-cost option having a premium greater than 8% of family income (10.2%).[12] For the roughly 64% of our sample subject to the mandate, the family-level mandate penalty is calculated per ACA criteria: the greater of $95 per uninsured adult (half that per child) or 1% of taxable income in 2014, and $325 per adult or 2% of taxable income in 2015.[13]

Fig. 3 shows the average mandate penalty per family in 2015, by income and Medicaid expansion status, while Appendix Fig. 1

[7] Premium tax credits are pegged to the following thresholds: 2% of income for individuals with incomes up to 133% of FPL; 3–4% of income for individuals with incomes between 133–150% of FPL; 4.0–6.3% of income for individuals with incomes between 150–200% of FPL; 6.3–8.05% of income for individuals with incomes between 200–250% of FPL; 8.05–9.5% of income for individuals with incomes between 250–300% of FPL; and 9.5% of income for individuals with incomes between 350–400% of FPL.

[8] Yet a third measure of premium subsidy is also possible, taking into account the ACA's cost-sharing reductions (CSR) for individuals with incomes from 100–250% FPL who are eligible for exchange subsidies. In an alternative analysis, we created a premium subsidy measure that takes this into account by inflating the value of coverage (the unsubsidized premium) based on the CSR's legislative increase in actuarial value. Silver plans have an actuarial value of 70%, but the CSR increases this to 94% for those with incomes 100–150% FPL, 87% for incomes 150–200% FPL, and 73% for incomes 200–250% FPL. The resulting measure therefore reflects a higher percent subsidy for those who would receive CSRs, and is equal to our original premium-based measure for those ineligible to receive CSRs. Overall, the CSR's increase the mean subsidy rate from 16% to 17%, and the results of the model using this variable are quite similar to our primary specification.

[9] Legal permanent residents are not eligible for Medicaid until after a five-year waiting period, but premium tax credits are available under the ACA for those with incomes under 138%. The ACS does not enable us to distinguish between legal and undocumented immigrants, though it does self-reported citizenship. We test the robustness of our results by excluding non-citizens from our sample, and the results are quite similar.

[10] Another important component of the ACA is community rating of premiums. The main effect of community rating is difficult to capture as it is essentially a time series effect. One could compute the "effective" subsidy to include the implicit subsidy of community rating, but since we do not observe health status, we cannot include implicit subsidization of the sick in such a calculation. But we do include the implicit subsidies from compressed age rating, since our existing subsidy variable is largest within a given income band for the most expensive (i.e., oldest) group.

[11] In 2014, the tax-filing thresholds were $10,150 for single non-elderly individuals; $20,300 for married couples filing jointly; and $13,050 for 'heads of household' (i.e., multi-individual HIUs without a married couple).

[12] The last exemption was based on the lowest-cost bronze-level plan in each rating area. Healthcare.gov provides county-level bronze premium data for states on the federal exchange, which are not available in the data source we use for our silver-level premiums. Thus, for the 16 states using state-based exchanges, we imputed the lowest-cost bronze premiums for each rating area using a regression model to predict the ratio of second-lowest-cost silver plan to lowest-cost bronze plan as a function of the following variables: number of silver plans, ratio of maximum to minimum silver premium, ratio of maximum to second-lowest silver premium, ratio of median to second-lowest silver premium, ratio of second-lowest to minimum silver premium, and PUMA-level demographic measures from the ACS for age, sex, race, citizenship, education, disability, parental status, marital status, and household size.

[13] The mandate penalty is additionally capped at the national average premium for bronze-level health plans offered by the health insurance exchanges, and those

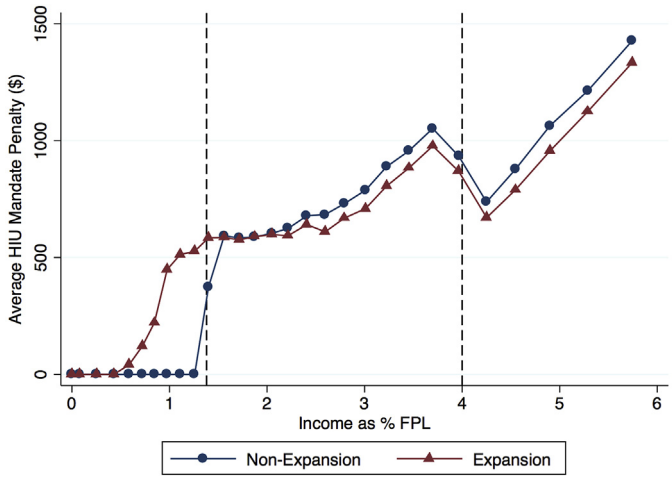

Fig. 3. Individual mandate penalty in 2015 by Income And State Medicaid Expansion Status. *Notes*: Dashed vertical lines indicate 138% and 400% of the Federal Poverty Level (FPL).

depicts the percentage of families subject to any mandate penalty. No one below 138% of FPL in non-expansion states is subject to the mandate, while in expansion states, the mandate takes effect at the tax-filing threshold. Between 138% and 400% of FPL, most families are subject to the mandate, with the penalty increasing with income. Near and above the 400% FPL subsidy cutoff, substantial portions of families are exempt based on the affordability criterion. At higher incomes, most families are subject to the mandate and the average penalty approaches $1500 per family.

4. Empirical strategy

Our overall empirical strategy consists of a longitudinal design that uses geographical and income-based variation in the ACA policy levers to identify changes in coverage over time, adjusting for time, geography, and income. We use the 2012–2013 period to control for geographic and income group differences that might be correlated with our outcomes of interest. Essentially, this allows us to do a difference-in-difference-in-difference (DDD) model across PUMAs, income groups, and time. Our model also separately identifies the policy effects in 2014 vs. 2015 since the policies themselves evolved over time.

We have 8 policy parameters – two versions each (2014 and 2015) of the mandate penalty, new Medicaid eligibility based on state expansion decisions, and premium subsidy rate; and then single measures of pre-ACA Medicaid eligibility and early expansion eligibility (since neither policy changed between 2014 and 2015). We model the direct effects of these policies in all four years of the study (which includes 2 years of the pre-ACA baseline) and the DDD estimates by interacting each term with post-ACA year fixed effects:

$$
\begin{aligned}
\%Uninsured ijt = {} & \beta_0 + \beta_1\, PercentSubsidy2014_{ij} \\
& + \beta_2\, PercentSubsidy2015_{ij} + \beta_3 MandatePenalty2014_{ij} \\
& + \beta_4 MandatePenalty2015_{ij} + \beta_5 McaidEligiblePreACA_{ij} \\
& + \beta_6 McaidEarlyExpansionEligible_{ij} + \beta_7 McaidNewlyEligible2014_{ij} \\
& + \beta_8 McaidNewlyEligible2015_{ij} \\
& + \beta_9 PercentSubsidy2014_{ij} * Yr2014_t \\
& + \beta_{10} MandatePenalty2014_{ij} * Yr2014_t \\
& + \beta_{11} McaidEligiblePreACA_{ij} * Yr2014_t \\
& + \beta_{12} McaidEarlyExpansionEligible_{ij} * Yr2014_t \\
& + \beta_{13} McaidNewlyEligible2014_{ij} * Yr2014_t \\
& + \beta_{14} PercentSubsidy2015_{ij} * Yr2015_t \\
& + \beta_{15} MandatePenalty2015_{ij} * Yr2015_t \\
& + \beta_{16} McaidEligiblePreACA_{ij} * Yr2015_t \\
& + \beta_{17} McaidEarlyExpansionEligibleij * Yr2015_t \\
& + \beta_{18} McaidNewlyEligible2015_{ij} * Yr2015_t \\
& + \Omega\, Area_j * HIU\_Type_i + \partial\, Year_t * HIU\_Type_i \\
& + \mu\, Income_i * HIU\_Type_i + \pi\, AreaUnemploymentRate_{jt} \\
& + \beta_x X_{ijt} + \varepsilon_{ijt} \qquad (1)
\end{aligned}
$$

Subscript *i* indexes the family (HIU), which is the unit of observation; *j* indexes the geographical area; and *t* indexes time (year). The dependent variable is the percent of each HIU without insurance at the time of the survey; for single adults, this is a binary variable, for families with multiple members this is a continuous fraction ranging from 0 to 1. β_1 through β_8 capture the baseline (pre-ACA) direct effects of the PUMA-income policy variables. The coefficients of interest are β_9 through β_{13}, which measure the impact of the ACA policy variables in 2014, and β_{14} through β_{18}, which measure the policy impacts in 2015.[14]

Ω is a vector of area fixed effects (either PUMA or state, depending on the model), ∂ is a vector of year fixed effects, and μ is a vector of fixed effects for different income groups; all three fixed effects were interacted with HIU type (single adults, adult couples, and families with children), since each group has its own coverage trends and policy responses. X_{ijt} is a vector of the demographics based on the adult(s) in the family: race/ethnicity, marital status, citizenship, age, educational attainment, and number of children. Finally, the model adjusts for annual county-level unemployment rates from the Bureau of Labor Statistics.

Even with the DDD model, Eq. (1) raises several identification concerns. Primary among these is state- or PUMA-level differences in the income distribution that may be related to both premiums and Medicaid expansion, as well as omitted factors correlated with both family income and tastes for insurance. Another flaw is that the mapping of survey-reported income onto ACA-related eligibility is imprecise, creating measurement error biased toward the null.

We address many of these concerns through the use of a "simulated" measure of eligibility (Currie and Gruber, 1996a,b; Cutler and Gruber, 1996). For this measure, we first group all families into 12 income bands.[15] For each income band, we randomly select from the national sample up to 200 families of each of three types –

with only short periods without insurance (less than 3 months per year) are also exempt from the fine.

[14] A simpler alternative is to run two separate models: one for 2012–2014, and the other for 2012–2015 that omits 2014 as a washout period. The overall results of these separate models are essentially identical to the single model specified here.

[15] The income bands were: 0–50% FPL, 50–100% FPL, 100–138% FPL, 138–200% FPL, 200–250% FPL, 250–300% FPL, 300–350% FPL, 350–400% FPL, 400–500% FPL, 500–600% FPL, 600–800% FPL, and greater than 800% FPL. Tweaking these to stagger them across the ACA's key income thresholds (e.g., using 100–150% FPL and 350–450% FPL instead) produces similar results in our regression models. In all models, we recoded negative incomes as $0, and incomes above the 99th percentile were top-coded as the 99th percentile.

single adults, adult couples,[16] and families with children – such that the total number of individuals sampled per group is approximately 200. We then assign this same sample to each PUMA in our dataset and estimate the value of our policy variables for that family type-PUMA-income group cell.

The resulting measure computes, for example, the average subsidy for a representative set of single adults from 150–200% of FPL, in each PUMA in the nation. Critically, this approach allows us to capture the variation in subsidies by income group and PUMA, but to also rigorously control for any direct influences of income and PUMA by putting in a full set of 12 income category dummies and PUMA dummies. That is, the only variation that identifies this model is interactions of PUMA, income, and year, and not direct effects of any of these factors.[17]

This approach mitigates several potential sources of bias. First, it eliminates any endogeneity based on state-level differences in income distributions. Some states have poorer populations or worsening economic conditions over time, which may affect premiums as well as the share of the population eligible for Medicaid; using a standardized population in all states removes any bias from this source. Second, this approach reduces concerns about the measurement of survey income, since we are longer reliant on precise family-level estimates of premium subsidies and other measures; instead, we use an aggregate measure of the ACA's policy features for families within a given income band. Third, it reduces the potential for individual-level endogeneity of income in response to ACA policies. We assign families to fairly broad income bands using their actual income, but then use the simulated measure for the whole income band to assess policy impact. In other words, the model assumes that income *group* is not endogenous, even if a family's specific income within that group may be. Fortunately, other work on the ACA suggests that employment responses to the law have been minimal on both the intensive and extensive margins (Gooptu et al., 2016; Kaestner et al., 2015; Moriya et al., 2016).

These simulated policy measures can serve as instruments for each family's actual premium subsidy, mandate penalty, and Medicaid eligibility as described in Eq. (1). The first-stage regression for such a 2SLS estimate is close to one for each policy measure (see Appendix Table 2), so that IV and reduced form estimation yield almost identical answers. Thus, for most analyses we focus on a reduced form model identical to Eq. (1), except that for each of the policy variables and interaction terms (β_1 through β_{18}) we use simulated policy measures as the independent variables of interest. For brevity, we do not re-state this equation, but this and the full 2SLS equation are described in Appendix A.

Our primary model focuses on the percentage of each HIU that is uninsured. In all models, we use ACS survey weights aggregated at the HIU-level and robust standard errors clustered at the level of the PUMA.

5. Results

5.1. Summary statistics and coverage trends

Table 1 presents summary statistics for our sample in 2014 and 2015. Nearly one-quarter of the population was Medicaid eligible before the ACA, 2% gained eligibility under the ACA's early expansions, while approximately 5% became eligible in 2014. Overall, nearly two-thirds of the sample was subject to the mandate, and the size of the average mandate penalty more than doubled from 2014 to 2015 ($458 to $956). The mean unsubsidized premium was slightly more than $8000 in both years. The subsidy rate was approximately 16% in both 2014 and 2015.

Table 1
Summary statistics of simulated policy variables in 2014 and 2015.

	2014	2015
Medicaid eligibility		
Percent previously eligible[a]	23.0% (31.9%)	22.7% (31.7%)
Percent eligible under ACA early expansion	2.0% (11.1%)	1.9% (10.9%)
Percent newly eligible in 2014	4.5% (18.2%)	5.5% (19.7%)
Individual mandate		
Family mandate penalty	$458 ($632)	$956 ($1210)
Subject to mandate penalty	63.7% (41.0%)	64.5% (40.5%)
Exchange premiums		
Unsubsidized family premium	$8023 ($3282)	$8114 ($3298)
Net subsidized family premium	$6631 ($3488)	$6715 ($3519)
Percent subsidy	16.2% (24.4%)	16.1% (24.3%)

Notes: Table presents weighted means, with standard deviations in parentheses, for the population 0 to 64 years old. All measures are assessed at the level of the Health Insurance Unit and use ACS survey weights, excluding the state of Massachusetts.
[a] Based on state eligibility criteria as of 2013.

Table 2
Time series change in insurance outcomes by family type (2012–2015).

	2012	2013	2014	2015
Overall				
Uninsured	17.5%	17.3%	14.0%	11.4%
Medicaid	18.3%	18.5%	20.0%	21.6%
Employer sponsored insurance	58.4%	58.1%	58.7%	59.1%
Non-group private	8.9%	8.6%	9.7%	10.7%
Single adults				
Uninsured	31.2%	30.3%	24.6%	20.0%
Medicaid	13.4%	13.7%	16.3%	18.7%
Employer sponsored insurance	47.5%	47.8%	49.1%	50.3%
Non-group private	8.7%	8.6%	10.4%	11.8%
Adult couples				
Uninsured	11.7%	11.8%	9.0%	7.1%
Medicaid	3.7%	3.9%	5.0%	5.8%
Employer sponsored insurance	75.1%	74.6%	74.6%	74.8%
Non-group private	11.5%	11.4%	12.9%	13.8%
Families with children				
Uninsured	12.6%	12.5%	10.2%	8.3%
Medicaid	24.3%	24.6%	25.8%	27.1%
Employer sponsored insurance	59.1%	58.7%	59.1%	59.3%
Non-group private	8.3%	7.8%	8.6%	9.3%

Notes: Table presents weighted means for the population 0–64 years old. All measures are assessed at the level of the Health Insurance Unit and use ACS survey weights, excluding the state of Massachusetts.

Table 2 shows the time series for insurance outcomes. There was a net decrease in the uninsured rate of roughly 3.4 percentage points in 2014 and 6.0 percentage points in 2015, both compared to the 2012–2013 period. By 2015, there had been a 3.3 percentage point increase in Medicaid, 0.9 percentage point increase in ESI, and 1.9 percentage point increase in non-group private coverage. Overall coverage gains were largest for single adults (10.8 percentage points by 2015), with smaller changes for couples (4.6) and families with children (4.2).

5.2. IV and reduced form model results

Table 3 shows the ACA-related coefficients for the 2SLS and reduced form approaches; coefficients for demographic covariates are in Appendix Table 1. Due to computational constraints when attempting to run the 2SLS model with the full set of PUMA fixed effects, we control for state rather than PUMA in the IV model. The estimates are virtually identical between the IV and reduced form

[16] This group contains families with 2 adults and no children 18 or younger. Approximately 99% of the HIUs in this group are married couples. The others are typically single parents with adult dependents (e.g., a 20 year-old student).
[17] Unlike the original Currie-Gruber approach, our model simulates eligibility at the PUMA rather than state-level. However, collapsing our simulated eligibility measure to a state-level estimate for each income band produces similar findings as our main model.

Table 3
Reduced form and IV estimates for ACA effects on percent uninsured.

	(1) 2-stage least squares	(2) Reduced form
2014 policy interactions		
Family percent subsidy* 2014	−0.056***	−0.051***
	(0.002)	(0.002)
Family mandate penalty* 2014 (in $100s)	0.0004***	0.0004***
	(0.0001)	(0.0001)
Previously Medicaid-eligible* 2014	−0.027***	−0.026***
	(0.002)	(0.002)
Early expansion Medicaid-eligible*2014	−0.107***	−0.107***
	(0.006)	(0.006)
Newly Medicaid-eligible* 2014	−0.090***	−0.089***
	(0.004)	(0.002)
2015 policy interactions		
Family percent subsidy* 2015	−0.098***	−0.089***
	(0.002)	(0.002)
Family mandate penalty* 2015 (in $100s)	0.0004***	0.0003***
	(0.0000)	(0.0001)
Previously Medicaid-eligible* 2015	−0.046***	−0.046***
	(0.002)	(0.002)
Early expansion Medicaid-eligible*2015	−0.196***	−0.197***
	(0.007)	(0.007)
Newly Medicaid-eligible* 2015	−0.142***	−0.137***
	(0.004)	(0.003)
Direct effects		
Family percent subsidy$_{2014}$	−0.009	−0.006
	(0.008)	(0.007)
Family percent subsidy$_{2015}$	−0.004	−0.002
	(0.008)	(0.007)
Family mandate penalty$_{2014}$ (in $100s)	−0.0000	−0.0001*
	(0.000)	(0.000)
Family mandate penalty$_{2015}$ (in $100s)	−0.00002***	−0.0000***
	(0.0000)	(0.000)
Previously Medicaid-eligible	−0.120***	−0.110***
	(0.005)	(0.004)
Early expansion Medicaid-eligible	−0.045***	−0.034***
	(0.007)	(0.007)
Newly Medicaid-eligible$_{2014}$	−0.019**	−0.015*
	(0.008)	(0.008)
Newly Medicaid-eligible$_{2015}$	−0.012	−0.011
	(0.008)	(0.008)

Notes: Standard errors in parentheses are clustered at the PUMA level. Dependent variable was the percentage of each Health Insurance Unit without any health insurance. All variables are expressed at the level of the Health Insurance Unit (HIU) and use ACS survey weights, excluding the state of Massachusetts, for the population aged 0–64 years old. Models control for HIU type (single adult, couple, family with children); number of men and women in the family; number of children; educational attainment, age, and race/ethnicity of adults in the family; area-specific annual unemployment rates; and year, income group, and state fixed effects each interacted with HIU type. $N = 5{,}458{,}170$.

* Significant at the 10% level.
** Significant at the 5% level.
*** Significant at the 1% level.

models for each policy measure. For simplicity, we focus on the reduced form estimates for the remainder of the paper, which also enables us to consider a more robust set of PUMA-level fixed effects and various interaction terms as discussed below.

We estimate a significant negative effect of the subsidy rate on the risk of being uninsured. The subsidy rate estimate shows that for each 1.0 percentage-point of subsidy, the uninsured rate fell by 0.051 percentage points in 2014. This effect was nearly twice as large in 2015, with a coefficient of 0.089. Put another way, each 10% increase in average subsidy produced a decrease in the uninsured rate of 0.89 percentage points in 2015, equal to roughly 2.4 million Americans (given 273 million non-elderly Americans).

The coefficient on the mandate penalty is quite small in magnitude and presumably wrong-signed (i.e., higher mandate leads to more uninsured). The magnitude of the coefficient implies that each $100 in mandate in 2014 (when the average penalty was roughly $460) increases the uninsured rate by 0.04 percentage-points, which is negligible. The coefficient in 2015 was similarly small – 0.03. This could be because individuals are not aware of the precise exemption parameters, or because they do not respond to the affordability exemption. It does not necessarily imply that the mandate had no effect, though it does suggest that individuals did not respond to their income-specific mandate. This still leaves open the possibility of a more general impact of a "taste for compliance" that some have hypothesized (Saltzman et al., 2015).

The coefficients on all three Medicaid eligibility variables are highly significant. The results indicate a marginal reduction in the uninsured rate of 8.9 percentage points in 2014 and 13.7 percentage points in 2015 among individuals made newly for Medicaid. Take-up rates were even higher (10.7 and 19.7 points in 2014 and 2015, respectively) for those who became eligible under the ACA's early Medicaid expansions. Meanwhile, we also detect smaller but significant insurance changes among those who were previously eligible for Medicaid. Our coefficient suggests that the ACA expansion led to 2.6 and 4.6 percentage-point increases in coverage in 2014 and 2015, respectively, for those who were already eligible for Medicaid prior to the ACA – the so-called "woodwork effect."

Overall, our Medicaid findings build on prior analyses of the Medicaid expansion, which used standard difference-in-differences methods and several data sources to estimate 2014 coverage gains ranging from 3 to 6 percentage points (Courtemanche et al., 2016; Kaestner et al., 2015; Sommers et al., 2015a). Importantly, those analyses did not attempt to model other aspects of the law simultaneously and did not disentangle the various types of Medicaid eligibility – they present estimates for overall take-up among the broad group of low-income adults. One paper (Simon et al., 2016) that took an approach closer to our "newly-eligible" estimate separately identified childless adults, who were the main group to become newly eligible; they found larger take-up rates on the order of 15 percentage points, closer to our newly-eligible coefficient.

The next set of coefficients show the direct impact of our policy measures when not interacted with 2014 or 2015 – i.e., the impact in 2012–2013. Pre-existing and early expansion Medicaid eligibility are negatively associated with uninsurance as one would expect. It is somewhat surprising that there are significant coefficients on several other policy measures – though these point estimates are generally small. This suggests the possibility of omitted factors across PUMA-income cells that are correlated with both our policy measures and coverage. We can address this concern by further enriching the model to incorporate interactions of PUMA and income category, so that the identification purely comes from differences in effects within each PUMA-income category. We do so in Table 5, with minimal impact on the results.

Fig. 4 plots the ACA policy coefficients from the reduced form model for each year of our study as a visual test of our DDD approach. For clarity, we have separated the 2014 and 2015 results. We find generally flat trend lines for 2012–2013 before large changes in 2014 and 2015 for premium subsidies, new Medicaid eligibility, and previous Medicaid eligibility. For the early expansions, we see a slight downward trend in the uninsured coefficient from 2012–2013, consistent with the implementation of those expansions during that period, before a much larger drop occurred in 2014 and 2015. Meanwhile, the trend for the mandate penalty is essentially flat throughout the study period. This offers strong evidence that our model is capturing a discontinuous change in outcomes related to these policy measures in 2014 and 2015, rather than spurious variation in outcomes that predated the ACA's implementation.

5.3. Decomposing coverage changes by ACA policy provision

In Table 4, we apply our estimates to model the population-level changes in insurance coverage in 2014 that are accounted

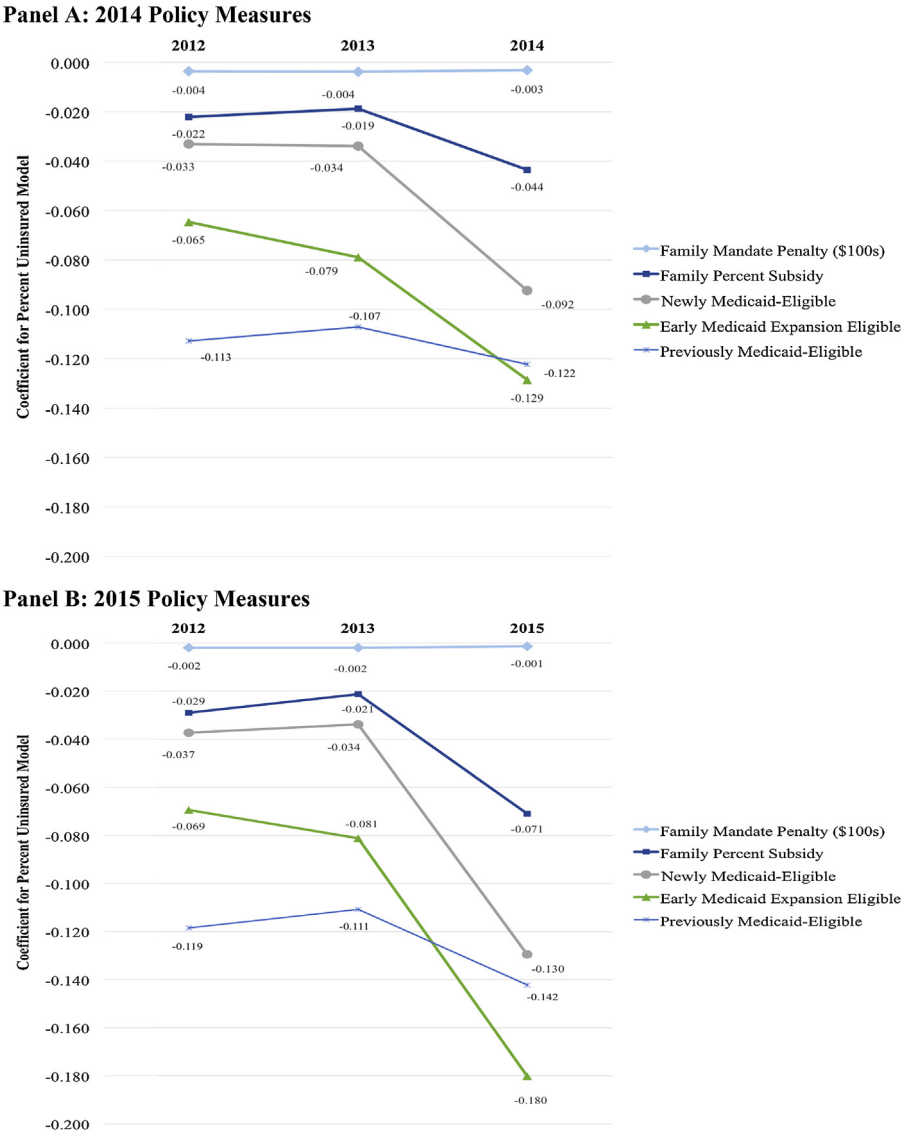

Fig. 4. Policy coefficients by year. *Note*: Estimates are the reduced-form coefficients for each policy measure's direct effect (see Appendix for reduced-form regression equation), with the regression separately estimated for each year of the sample. Panel A shows results for the 2014 policy measures, and Panel B shows results for the 2015 policy measures.

Table 4
Projected time series impact of ACA policy variables on percent uninsured.

	Reduced form coefficient (1)	Population mean (simulated measure) (2)	Implied percentage point change (3)	Share of total ACA-related change (4)
2014 effects				
Family percent subsidy × 2014	−0.051	0.162	−0.83%	41%
Family mandate penalty × 2014 (in $100s)	0.0004	4.58	0.18%	N/A
Previously Medicaid-eligible × 2014	−0.026	0.230	−0.60%	29%
Early expansion Medicaid-eligible × 2014	−0.107	0.020	−0.21%	10%
Newly Medicaid-eligible × 2014	−0.089	0.045	−0.40%	20%
2015 effects				
Family percent subsidy × 2015	−0.089	0.161	−1.43%	40%
Family mandate penalty × 2015 (in $100s)	0.0003	9.56	0.29%	N/A
Previously Medicaid-eligible × 2015	−0.046	0.227	−1.04%	29%
Early expansion Medicaid-eligible × 2015	−0.197	0.019	−0.37%	10%
Newly Medicaid-eligible × 2015	−0.137	0.055	−0.75%	21%

Notes: Dependent variable was the percentage of each Health Insurance Unit without any health insurance. All variables are expressed at the level of the Health Insurance Unit (HIU) and use ACS survey weights, excluding the state of Massachusetts, for the population aged 0–64 years old. Models control for HIU type (single adult, couple, family with children); number of men and women in the family; number of children; educational attainment, age, and race/ethnicity of adults in the family; area-specific annual unemployment rates; and year and state fixed effects both interacted with HIU type.

for by these aspects of the ACA. Over the period from 2012–2013 to 2014, the rate of uninsurance as measured by the ACS fell by 3.4 percentage points. We find that the average 16% subsidy to exchange coverage in the full sample implies a reduction in uninsurance of 0.83 percentage points. The estimates for the mandate are small (as well as inconsistent and non-significant in robustness checks we present below), so we ignore this in our calculations. We estimate that the 2014 Medicaid expansion to 4.5% of our sample reduced uninsurance by 0.40 percentage points; the early expansions affected 2% of the sample and reduced uninsurance by 0.21 percentage points; and the "woodwork effect" – impacting 23% of our sample – led to a decline in uninsurance of 0.60 percentage points. Taken together, the policy variables in our model sum to nearly a 2.1 percentage-point reduction in the uninsured rate. Of this total, 41% is attributable to premium subsidies, 20% to the expansion of Medicaid eligibility in 2014, 10% the early expansion, and 29% to the woodwork effect. The relative magnitudes of the changes for each policy were quite similar in 2015. The prominence of the woodwork effect is due to the fact that nearly 5 times as many people (disproportionately children) were already eligible for Medicaid before the ACA than those made newly eligible in 2014. Our estimates are slightly more oriented toward Medicaid gains than previous estimates by Carman et al. (2015), but broadly consistent with their results, despite different analytical approaches and data sources. However, Carman and colleagues only assessed Medicaid and premium subsidies, without examining different types of Medicaid coverage gains, heterogeneity across state Marketplace type, or effects of the mandate penalty.

Overall, our parameterization of the ACA explains approximately 60% of the 3.4 percentage-point decrease observed in 2014 and a nearly equal fraction of the 6.0 percentage-point change in 2015. Several other analyses have attributed nearly all of the national change in coverage in 2014 to the ACA, even after adjustment for the improving economy (Blumberg et al., 2016; Sommers et al., 2015a). In our model, the area unemployment rate is a significant predictor of coverage (with each percentage point drop in unemployment reducing the uninsured rate by 0.2 percentage points), but our ACA policy coefficients are nearly identical with or without this adjustment. Thus, the remaining decline in uninsurance in 2014–2015 may be due to other unmeasured aspects of the ACA, such as the social effect of the individual mandate, guaranteed issue requirements, simplification of purchasing coverage due to the creation of the exchanges, and any measurement error in our policy variables.

5.4. Robustness checks

Table 5 considers the robustness of our estimates; for simplicity, we list only the 2015 policy effects (the 2014 coefficients follow a similar pattern, but with smaller magnitudes). Column 1 shows the same reduced form model used in Table 3, but replaces state fixed effects with PUMA fixed effects. The results are nearly identical to the baseline model. Columns 2–4 include various second-level interactions to test whether omitted variables may be driving the results. Column 2 allows for an interaction between PUMA and income categories. This allows us to drop the direct effects of our simulated policy variables (set at the PUMA-income level), and leaves only the policy interactions with *Year2014* and *Year2015*. The results again are nearly identical. Column 3 allows for PUMA-income interactions and income-year fixed effects, to address possible time-varying differences in insurance trends across income groups unrelated to the ACA. This model reduced the point estimates somewhat though with the same basic pattern, except the mandate penalty becomes negative and non-significant. Column 4 tests PUMA-year interactions and income-year interactions, with generally similar estimates. We also consider replacing the *Mandate Penalty* variable with *Any Mandate* (i.e., percent of families that are not exempt from the mandate) or the mandate penalty as a percentage of income. These results (Columns 5 and 6) again demonstrate small and inconsistent impacts of the mandate.

Finally, we consider an alternative premium subsidy measure. Column (7) replaces *Percent Subsidy* with *Net Premium* (in $1000s), which shows a significant positive effect of the premium on uninsurance – but the implied effect is much smaller than that captured by the percent subsidy in our main model. Applying this coefficient to the type of analysis shown in Table 4, we estimate a change in uninsured in 2015 due to subsidies of just 0.73 percentage points, as opposed to the 1.53 percentage points from the percent subsidy. Column (8) shows that when both measures are included together, the coefficient for *Percent Subsidy* is unchanged from our primary model, while the coefficient for *Net Premium* is essentially zero. These results indicate that the percent subsidy – by capturing information on both price and the potential benefits of coverage – better reflects exchange consumer decision-making than the out-of-pocket premium alone. This suggests, for example, that older individuals or those in areas with more costly insurance are more likely to take up exchange coverage than younger individuals or those in cheaper rating areas, conditional on facing a similar net premium after subsidies.

5.5. Results by type of insurance

Next, we decompose our findings on uninsurance into changes among three types of coverage: Medicaid/government assistance plan, employer-sponsored insurance, and non-group private insurance (Table 6). As discussed earlier, the ACS survey wording makes it reasonable for respondents receiving subsidized exchange coverage to report either "Medicaid/government assistance plan for those with low incomes" or "insurance purchased directly from an insurance company." The positive coefficient on percent subsidy in the "Medicaid/government assistance plan" regressions indeed suggests that some individuals report their publicly-subsidized exchange coverage in this way. This is consistent with evidence from the Census Bureau that some respondents in the ACS describe their private coverage using this option (Pascale et al., 2016).

Still, as expected, we find the largest effect of the premium subsidies on non-group insurance. We estimate that each 10% rise in subsidy increased the share of the population with non-group insurance by 0.48 percentage points by 2015. At the mean subsidy (16.2%) and baseline non-group coverage rate (8.8%), this implies an elasticity of demand for non-group coverage of −0.09. If we treat the subsidy coefficients on Medicaid as part of the exchange effect, the elasticity is −0.17. While lower than the elasticity used in typical microsimulation modeling of the ACA (Gruber, 2011), the 2015 estimate is nearly twice as large as the 2014 estimate, suggesting that increased awareness of the law and resolving technical challenges in the exchanges likely improved consumer responsiveness over time. Our data source does not allow us to detect whether an individual has an "affordable" offer of employer coverage (defined by the ACA to be $\leq$9.5% of income), which precludes a person from receiving a premium subsidy. However, previous research suggests that only 1.1% of those who are uninsured or with individual coverage and potentially income-eligible for premium subsidies have an employer offer for coverage (Dorn and Buettgens, 2013). Accounting for this omission and multiplying our elasticity by 1/.989 is within the rounding error on our overall estimate.

The coefficient on the mandate penalty remains small, wrong-signed, and only statistically significant for non-group coverage.

We estimate highly significant impacts of all three Medicaid variables on Medicaid coverage. These coefficients reflect marginal take-up rates among those eligible for the program. Strikingly,

Table 5
Robustness to alternative specifications for ACA effects on percent uninsured.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Premium subsidies								
Family percent subsidy* 2015	−0.091***	−0.093***	−0.050***	−0.045***	−0.099***	−0.095***		−0.091***
	(0.002)	(0.002)	(0.005)	(0.006)	(0.002)	(0.002)		(0.003)
Family net subsidized premium ($1000s)* 2015							0.0052***	−0.00002
							(0.0002)	(0.0002)
Individual mandate								
Family mandate penalty ($100s)* 2015	0.0003***	0.0003***	−0.0001	0.0004*			0.0005***	0.0003***
	(0.0001)	(0.0001)	(0.0001)	(0.0002)			(0.0002)	(0.0000)
Subject to mandate* 2015					0.011***			
					(0.002)			
Family mandate penalty (percent of income)* 2015						−0.042		
						(0.053)		
Medicaid eligibility								
Previously Medicaid-eligible* 2015	−0.045***	−0.046***	−0.020***	−0.027***	−0.043***	−0.053***	−0.028***	−0.045***
	(0.002)	(0.002)	(0.005)	(0.005)	(0.002)	(0.002)	(0.002)	(0.002)
Early expansion Medicaid-eligible* 2015	−0.196***	−0.197***	−0.159***	−0.104***	−0.194***	−0.193***	−0.179***	−0.196***
	(0.007)	(0.007)	(0.008)	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)
Newly Medicaid-eligible* 2015	−0.137***	−0.138***	−0.108***	−0.092***	−0.138***	−0.129***	−0.114***	−0.137***
	(0.003)	(0.003)	(0.005)	(0.005)	(0.003)	(0.003)	(0.003)	(0.003)
Fixed effects (all interacted with HIU-type)								
Year fixed effects	✓	✓			✓	✓	✓	✓
Income fixed effects	✓				✓	✓	✓	✓
PUMA fixed effects	✓				✓	✓	✓	✓
PUMA-income fixed effects		✓	✓					
Income-year fixed effects			✓	✓				
PUMA-year fixed effects				✓				

Notes: PUMA, public use microdata area. Standard errors in parentheses are clustered at the PUMA level. Dependent variable was the percentage of each Health Insurance Unit without any health insurance. All variables are expressed at the level of the Health Insurance Unit (HIU) and use ACS survey weights, excluding the state of Massachusetts, for the population aged 0–64 years old. Models control for HIU type (single adult, couple, family with children); number of men and women in the family; number of children; educational attainment, age, and race/ethnicity of adults in the family; and area-specific annual unemployment rates. All fixed effects are interacted with HIU type. All coefficients refer to 2015 policy estimates.

* Significant at the 10% level.
** Significant at the 5% level.
*** Significant at the 1% level.

Table 6
ACA policy effects in 2015 by type of coverage.

	(1) Uninsured	(2) Medicaid or "government assistance plan" for low-income families	(3) Employer Sponsored	(4) Non-group Private
Family percent subsidy* 2015	−0.091***	0.040***	0.011***	0.048***
	(0.002)	(0.002)	(0.003)	(0.002)
Family mandate penalty* 2015 ($100s)	0.0003***	−0.0001	−0.00004	−0.0003***
	(0.0001)	(0.00003)	(0.0001)	(0.0001)
Previously Medicaid-eligible* 2015	−0.045***	0.038***	0.008***	0.005**
	(0.002)	(0.002)	(0.003)	(0.002)
Early expansion Medicaid-eligible* 2015	−0.196***	0.210***	−0.000	−0.001
	(0.007)	(0.007)	(0.005)	(0.004)
Newly Medicaid-eligible* 2015	−0.137***	0.148***	0.002	0.002
	(0.003)	(0.004)	(0.003)	(0.002)

Notes: Regressions in table include fixed effects from Model 1 described in Table 5. Standard errors in parentheses are clustered at the PUMA level. Dependent variable was the percentage of each Health Insurance Unit without any health insurance. All variables are expressed at the level of the Health Insurance Unit (HIU) and use ACS survey weights, excluding the state of Massachusetts, for the population aged 0 to 64 years old. Models control for HIU type (single adult, couple, family with children); number of men and women in the family; number of children; educational attainment, age, and race/ethnicity of adults in the family; area-specific annual unemployment rates; and year, income group, and PUMA fixed effects each interacted with HIU type. All coefficients refer to 2015 policy estimates.

* Significant at the 10% level.
** Significant at the 5% level.
*** Significant at the 1% level.

these Medicaid effects are very close to the effects for overall insurance coverage; that is, we estimate virtually no crowd-out of private coverage by the Medicaid expansion or woodwork effect. This is illustrated further in the next two columns of Table 6. We observe no negative impact of the Medicaid eligibility variables on either ESI or non-group insurance (and in fact detect a significant but small *positive* effect of pre-ACA eligibility on both, on the order of 0.5–0.8 percentage points). This is a notable finding, as most previous literature suggested at least some crowd-out was likely under the ACA.

At least one analysis of the ACA has detected moderate crowd-out – roughly 25% for parents, less for childless adults (Kaestner et al., 2015). However, this appears to be an artifact of modeling Medicaid eligibility alone. In the 100–138% income range, individuals in non-expansion states are able to receive premium subsidies as a fallback to Medicaid. This increases private coverage in those states. In a simple differences-in-differences model with a simple binary Medicaid expansion vs. non-expansion independent variable, this larger increase in private coverage in non-expansion states appears as a form of "crowd-out" (i.e., a negative DD coef-

ficient on private insurance – see Appendix Table 3). However, this is not crowd-out in the traditional sense: Medicaid is not leading some to drop private insurance coverage. Rather, in the absence of Medicaid expansion, some adults obtain premium subsidies. In our model, which explicitly accounts for both Medicaid and premium subsidies, we find no crowd-out at all.[18]

One previous coverage expansion without much crowd-out occurred in Massachusetts, suggesting that the individual mandate may play an important role here (Hackmann et al., 2015). In addition, Clemens (2015) showed that community rating in private insurance – as required by the ACA – may also reduce crowd-out from Medicaid.[19]

5.6. Heterogeneity in coverage changes

We examine patterns of ACA effects across different demographic groups and states (Table 7). To do so, we repeat our reduced form analysis for several stratified samples, based on family type (single adults, adult couples without children, and families with children) and state policies. We compared states that had established their own exchanges in 2014 ($n = 14$) to those using the federal exchange.[20] We also compared states based on their ACA Medicaid policies, classified into three groups – non-expansion states ($n = 21$); early (2011–2013) expansion states ($n = 6$, including Washington DC); and states that expanded eligibility in 2014 or 2015 ($n = 24$).

Coverage gains associated with premium subsidies were significantly larger for adult couples ($\beta = -0.108$) than single adults ($\beta = -0.085$) or for families with children ($\beta = -0.070$). The 2015 effects of Medicaid eligibility were largest in for adult couples, with take-up rates of over 18% for both previously-eligible and newly-eligible adults, compared to 5.1% and 11.7% for single adults. Among families with children, the woodwork effect was smaller – 4.1% – which likely reflects the fact that Medicaid/CHIP take-up rates for children were already quite high (Kenney et al., 2011). However, since children make up such a large portion of Medicaid eligibility, this is a non-trivial population effect. In children-only models, we estimate that they account for 28–45% of the overall population woodwork effect in 2015.[21]

In our analysis by state policy, exchange subsidies were significantly more effective at reducing the uninsured rate in states with state-based exchanges than in states using the federal exchange. Conditional on the subsidy amount, gains in coverage were essentially twice as high in the state exchanges ($\beta = -0.129$) as in the federal exchange ($\beta = -0.076$). While technical difficulties plagued the launch of the federal website, several state exchanges were similarly affected, and these difficulties would not explain the differences we observe well into 2015. More likely is that states that implemented their own exchanges were more consistent supporters of coverage expansion, with greater outreach efforts and stronger application assistance programs (Shin et al., 2014; Sommers et al., 2015b). However, our analysis here is merely suggestive and without a clear causal interpretation.

The pattern by Medicaid expansion decision also showed significantly larger effects of exchange subsidies in states more supportive of the ACA (expansion states, particularly the early expansion states). This finding suggests that the early eligibility expansions from 2011–2013 laid the groundwork for increased Medicaid participation later on. Notably, we find large and similarly-sized woodwork effects in all groups of states, regardless of Medicaid expansion status.

6. Policy implications and conclusions

In what we believe is the most comprehensive analysis to date of coverage changes under the ACA related to the law's primary policy measures, we identify several notable findings. First, of the ACA's reduction in the uninsured rate in 2014 and 2015 that is attributable to our policy measures, roughly 40% was due to the creation of premium subsidies for exchange coverage. The other 60% was due to increased Medicaid coverage – much of it the result of enrolling individuals eligible for Medicaid before 2014, including many children. While some policymakers and researchers had anticipated this potential "woodwork effect," the fact that it is such a large policy lever is somewhat surprising, and simple differences-in-differences models of the Medicaid expansion obscure this important policy heterogeneity across eligibility groups.

In part, our large woodwork estimate may reflect some measurement error in Medicaid eligibility, and if some share of our sample appeared eligible based on 2013 data but in fact was not eligible until 2014 or 2015, this could bias our findings toward a larger woodwork effect.[22] However, federal administrative data on Medicaid enrollment confirm that a substantial woodwork effect is evident, and this effect exists whether or not a state expanded Medicaid under the ACA. Even in non-expansion states, Medicaid enrollment by January 2015 had increased by 8% over pre-ACA levels. In expansion states, of course, it had increased even more – by 26% – but our results suggest that a sizable portion of the gains in these states was in fact from the woodwork effect (CMS, 2014). Moreover, even among the childless adult group that comprises the bulk of the newly-eligible population, as of late 2014 roughly 1/3 of this enrollment group was eligible under pre-ACA criteria (CMS, 2016).[23] These findings are also consistent with enrollment spillovers detected in pre-ACA Medicaid expansions (Aizer and Grogger, 2003; Dubay and Kenney, 2003; Sonier et al., 2013), as well as one recent analysis of children's coverage under the ACA (Kenney et al., 2016).

[18] The simple D-in-D model also shows a reduction in ESI associated with Medicaid expansion. This effect also disappears in our full model, in which we do not simply analyze Medicaid expansion as a binary variable but take into account how many people actually gained eligibility.

[19] Table 6 also includes some counterintuitive results that are statistically significant but of such small magnitude as to be economically negligible. For instance, the coefficient on "Previously Medicaid Eligible * 2015" for ESI is significantly positive. However, the mean level of this independent variable is .227, which means that the coefficient in question relates to a predicted increase in ESI of 0.0018 – less than 2/10ths of a percentage point. The statistical significance here most likely just reflects the very large sample size of the ACS.

[20] The 14 states with state-based exchanges were CA, CO, CT, DC, HI, ID, KY, MA, MD, MN, NY, RI, VT, and WA. For 2016, Hawaii has reverted to the federal exchange, and Kentucky will do so for 2017.

[21] This requires adapting our HIU-level model to run an individual-level analysis for children only. If we use the same simulated instruments as our main model for premium subsidies and the mandate, but substitute child-level Medicaid/CHIP eligibility for the three-part Medicaid eligibility modeled in Eq. (1), we estimate that the uninsured rate among children eligible for Medicaid or CHIP fell by 1.0 percentage point in 2014 and 1.8 percentage points in 2015, with no significant private insurance crowd-out. At the population level, this accounts for 28% of the overall woodwork effect in Table 4 (given that 57% of children were already eligible), or equivalently, 800,000 additionally insured children in 2015. An alternative model that includes *only* Medicaid/CHIP eligibility provides an upper bound of 1.4 million additionally insured children, which would represent roughly 45% of the woodwork effect.

[22] Of course, the converse is also possible – our approach may define some individuals as ineligible in 2013 even though they were eligible. But these two mismeasurement effects are likely to be asymmetric, since the marginal take-up rate in 2014 among newly-eligible individuals should (and does) exceed the marginal take-up rate among previously eligible individuals. Essentially, mismeasurement of pre-ACA Medicaid eligibility should bias the woodwork coefficient upwards and the newly-eligible coefficient downwards.

[23] Massachusetts, due to its 2006 health reform law, and New York and Arizona, due to their large 2002–2003 expansions of Medicaid under Section 1115 waivers, were the largest contributors to this group in the CMS statistics.

Table 7
Uninsured results by family type, exchange type, and Medicaid expansion status.

	Number of observations	Family percent subsidy* 2015	Family mandate penalty* 2015 ($100s)	Previously Medicaid-eligible* 2015	Early expansion Medicaid-eligible* 2015	Newly Medicaid-eligible* 2015
Family type						
Single adults	2,594,364	−0.085***	0.0028***	−0.051***	−0.155***	−0.117***
		(0.004)	(0.0002)	(0.006)	(0.007)	(0.004)
Adult couples	990,805	−0.108***	0.0006***	−0.187***	−0.258***	−0.187***
		(0.004)	(0.0001)	(0.016)	(0.020)	(0.009)
Families with children	1,873,001	−0.070***	0.0001***	−0.041***	−0.268***	−0.126***
		(0.004)	(0.00004)	(0.002)	(0.016)	(0.009)
Exchange type						
State-based	1,706,327	−0.129***	0.0002***	−0.046***	−0.203***	−0.162***
		(0.004)	(0.00005)	(0.003)	(0.007)	(0.006)
Federal	3,751,843	−0.076***	0.0004***	−0.044***	−0.137***	−0.129***
		(0.003)	(0.00004)	(0.003)	(0.002)	(0.004)
Medicaid expansion status						
No expansion	2,197,199	−0.064***	0.0005***	−0.042***	N/A	N/A
		(0.003)	(0.0001)	(0.004)		
Early expansion in 2011–2013	1,130,446	−0.166***	0.0003***	−0.057***	−0.200***	−0.164***
		(0.005)	(0.0001)	(0.004)	(0.007)	(0.007)
Expansion in 2014 or 2015	2,130,525	−0.099***	0.0001**	−0.045***	N/A	−0.146***
		(0.003)	(0.00005)	(0.003)		(0.004)

Notes: Regressions in table include fixed effects from Model 1 described in Table 5. Standard errors in parentheses are clustered at the PUMA level. Dependent variable was the percentage of each Health Insurance Unit without any health insurance. All variables are expressed at the level of the Health Insurance Unit and use ACS survey weights, excluding the state of Massachusetts, for the population aged 0–64 years old. Models control for family type (single adult, couple, family with children); number of men and women in the family; number of children; educational attainment, age, and race/ethnicity of adults in the family; and area-specific annual unemployment rates. All coefficients refer to 2015 policy estimates.

* Significant at the 10% level.
** Significant at the 5% level.
*** Significant at the 1% level.

Another key finding is the lack of private insurance crowd-out. We find no evidence of significant crowd-out of employer-sponsored coverage by the new premium subsidies, and no evidence of crowd-out of either employer coverage or non-group private coverage by the Medicaid expansion. These results have implications for the ACA's efficiency and effects on social welfare, as expanding coverage without crowding out alternative sources of health insurance reduces the law's total cost and potential deadweight loss (Gruber, 2008).

In terms of premium subsidies, our findings offer some useful insights for policy and future research. We find that modeling the net premiums is a fairly weak approach to predicting enrollment behavior, with coverage gains much more responsive to the percent subsidy received. It also suggests that much of the recent attention to absolute premium rate increases may be less relevant than the subsidy rate received by most exchange customers. By necessity, our model only examined a single representative premium in each market – the second lowest cost silver plan. Further research is needed into how consumers enrolling in exchange plans choose among their various options, in terms of the relative tradeoffs between overall subsidy rates, net premiums, and other plan features such as cost-sharing requirements and provider networks.

We find small and inconsistent effects of the individual mandate in 2014 and 2015. In some models, the coefficient is wrong-signed, while in others it is in the expected direction, with varying levels of statistical significance. Overall, it is the least robust of our estimates, and in all models, the coefficients indicate minimal policy impact. In part, this may indicate a lack of consumer awareness about the intricacies of the tax penalty rules and exemptions. It may also reflect the low levels of the mandate penalty in the law's early years, though we saw no increase in the mandate's effect in 2015 even with steeper penalties. Finally, the mandate likely exerts a generalized effect that encourages people to obtain coverage in a way that is independent of its precise details and whether one is even subject to it. In Massachusetts, for instance, researchers have shown an increase in Medicaid participation among adults after the implementation of the mandate, even though most had incomes too low to make them subject to it (Sonier et al., 2013).

One of our paper's main contributions is its comprehensive framework for rigorous causal evaluation of the ACA's effects. Given the intense interest in many outcomes from this wide-ranging law, including health care utilization, labor market outcomes, and health effects, our approach will likely be useful for many subsequent analyses of the law.

However, the 2016 election results have cast significant doubt over the law's future. There has been discussion of a full repeal, as well as more targeted changes such as repealing the individual mandate, shifting Medicaid to block grants, and scaling back or eliminating premium tax credits. Our findings offer insight into how each of these pieces of the law are interacting to produce coverage gains and how their repeal would likely do the opposite. Overall, we find that the bulk of the coverage gains in 2014–2015 are directly attributable to expanded eligibility for subsidized insurance via exchanges and Medicaid. While we also detect large gains in coverage for previously-Medicaid eligible populations (including many children), the underlying mechanism for these gains in 2014–2015 is presumably a combination of the ACA's other features, such as a streamlined application process, the elimination of Medicaid asset tests, the mandate, and expanded eligibility for parents that likely improved Medicaid take-up rates for children as well. It is therefore possible that much of these latter coverage gains would also unravel after a repeal of the ACA. Undoubtedly, how patterns of coverage evolve over time in this policy environment – and how they affect other domains of health care and the economy – will remain worthy of continued study.

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Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at http://dx.doi.org/10.1016/j.jhealeco.2017.02.004.

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