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The undersigned, appointed by the

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Evaluating Access to Care and Health Outcomes in Public and Private Insurance

presented by Caroline Kelley Geiger

candidate for the degree of Doctor of Philosophy and hereby
certify that it is worthy of acceptance.

Signature _____

Typed name: Prof. Benjamin Sommers

Signature _____

Typed name: Prof. Jessica Cohen

Signature _____

Typed name: Prof. Timothy Layton

Date: March 29, 2021

Evaluating Access to Care and Health Outcomes in Public and Private Insurance

A dissertation presented

By

Caroline Kelley Geiger

To

The Committee on Higher Degrees in Health Policy

in partial fulfillment of the requirements
for the degree of
Doctor of Philosophy
in the subject of

Health Policy

Harvard University
Cambridge, Massachusetts

March 2021

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Dissertation Advisor: Benjamin D. Sommers Caroline Kelley Geiger

Evaluating Access to Care and Health Outcomes in Public and Private Insurance

Abstract

The objective of this dissertation is to evaluate whether changes in insurance coverage and provider decision making are associated with changes in the use of health care services and health outcomes.

Paper 1: Due to the high rates of maternal morbidity and mortality in the United States, preconception insurance has been identified as critical for addressing risk factors for poor pregnancy outcomes. Using the Pregnancy Risk Assessment Monitoring Survey (2009-2017) and an index measuring state Medicaid program generosity, we find that recent Medicaid expansions for childless adults were associated with increases in insurance coverage in the month before pregnancy. In addition, increased Medicaid generosity was associated with increases in early prenatal care and declines in stress from bills and unintended pregnancies among individuals with a high school degree or less.

Paper 2: Prescription drugs are critical for managing complex physical and mental health conditions for over 10 million disabled Medicaid beneficiaries. However, some state Medicaid programs limit the number of prescription drugs beneficiaries can fill monthly (i.e., "drug cap policies"), which may limit access. Using difference-in-differences methods and Medicaid Analytic eXtract claims data (2007-2012), we find that three-drug monthly limits in Arkansas and Texas were associated with declines in prescription drug use, including drugs to treat mental

health conditions, and increases in inpatient admissions among young, disabled adults. However, the drug cap policies were not associated with any significant changes in total prescription drug spending.

Paper 3: Advanced Maternal Age (AMA), often defined as age 35 or older on the expected delivery date, is a frequently applied designation in clinical obstetrics to identify women at higher risk of pregnancy complications. Using a regression discontinuity design and administrative claims data for a large commercial insurer (2008-2019), we find that the AMA designation is associated with increases in visits with maternal fetal medicine specialists, total ultrasounds, detailed ultrasounds, antenatal surveillance, and aneuploidy screening but no changes in delivery-related practices. In addition, the AMA designation was associated with substantial declines in perinatal mortality.

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Thank you to my classmates in the PhD program for your comradery over the past five years. It has been incredible to watch everyone grow as researchers since we first started in the Health Policy core class and I feel lucky to have learned from everyone's diverse expertise. In addition, I am thankful for my ESS/MPR cohort who helped me survive through endless problem sets over the first two years. I am especially grateful for my "peer mentoring group" with

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This dissertation is dedicated to my mother, Professor Ann Kelley, who first introduced me to academia as a child when I sat in the back of her classroom. We love and miss you.

Paper 1

Medicaid Expansions, Preconception Insurance, and Unintended Pregnancy among First-Time Parents

Caroline K. Geiger, Benjamin D. Sommers, Summer S. Hawkins, Jessica L. Cohen

Abstract

Objective: To assess the relationship between recent changes in Medicaid eligibility and preconception insurance coverage, pregnancy intention, health care use, and risk factors for poor birth outcomes among first-time parents.

Data Source: This study used individual-level data from the national Pregnancy Risk Assessment Monitoring System (2006 -2017), which surveys individuals who recently gave birth in the US on their experiences before, during, and after pregnancy.

Study Design: Outcomes included preconception insurance status, pregnancy intention, stress from bills, early prenatal care, and diagnoses of high blood pressure and diabetes. Outcomes were regressed on an index measuring Medicaid generosity, which captures the fraction of female-identifying individuals who would be eligible for Medicaid based on state income eligibility thresholds, in each state and year.

Data Collection/Extraction Methods: The sample included all individuals aged 20-44 with a first live birth in 2009-2017.

Principal Findings: Among all first-time parents, a 10-percentage point (ppt) increase in Medicaid generosity was associated with a 0.7 ppt increase ($p=0.017$) in any insurance coverage and a 1.5 ppt increase ($p<0.001$) in Medicaid coverage in the month before pregnancy. We also observed significant increases in insurance coverage and early prenatal care and declines in

stress from bills and unintended pregnancies among individuals with a high school degree or less.

Conclusions: Increasing Medicaid generosity for childless adults has the potential to improve insurance coverage in the critical period before pregnancy and help improve maternal outcomes among first-time parents.

Introduction

The United States continues to lag behind all other high-income countries in rates of maternal morbidity and mortality. Rates of maternal mortality reached 17.4 deaths per 100,000 live births in 2018 and every year an additional 50,000 individuals experience a "near miss" that could have resulted in death.[1–3] These high rates of maternal morbidity and mortality vary greatly by state and are even more prominent among individuals of low socioeconomic status.[4,5] With one-third of deaths attributable to preventable complications arising from pre-existing, chronic conditions, the Centers for Disease Control and Prevention (CDC) and American College of Gynecologists and Obstetricians emphasize the need to address these risk factors before pregnancy to reduce morbidity and mortality.[6,7]

Health insurance in the preconception period has been emphasized by the CDC as critical for addressing these risk factors and poor outcomes due to its role in increasing access to preconception health care services, particularly among low-income individuals.[8] Preconception insurance coverage has the potential to increase access to family planning and reduce unintended pregnancies, which are associated with adverse physical and mental health outcomes, including depression.[9,10] In addition, insurance coverage is associated with increases in preventive care, which can provide the opportunity for individuals to address modifiable risk factors, such as hypertension and diabetes.[11] Identification of these risk factors before conception can improve an individual's health entering into pregnancy and reduce the risk of poor outcomes, including maternal and infant mortality.[12–14] Furthermore, increasing preconception coverage may reduce barriers to early prenatal care, which can lead to earlier identification and management of risk factors during pregnancy and improve outcomes.[6,7,15] Finally, increasing Medicaid generosity

may reduce preconception and prenatal stress, which is associated with lower birth weights and preterm births, by reducing the potential for large medical bills.[16,17]

Increasing insurance coverage for childless adults through state Medicaid programs may help to increase preconception insurance coverage and improve maternal outcomes. Medicaid is the payer for nearly half of all births and an important source of coverage for low-income individuals during pregnancy; however, many childless adults enter into pregnancy without coverage or access to health care.[18,19] Prior to the passage of the Affordable Care Act (ACA) in 2010 only five states and the District of Columbia provided comprehensive Medicaid coverage for individuals without dependent children and, in 2009, 23% of all individuals lacked insurance in the month before conception.[18] As of February 2020, a total of 37 states have expanded Medicaid coverage under the ACA to childless adults with incomes up to 138% of the Federal Poverty Limit (FPL).[20] However, the generosity of these Medicaid programs varied significantly across states and over time both before and after the ACA due to different income thresholds and timing of program expansions.[20]

Evidence suggests recent Medicaid expansions have been successful at reducing rates of uninsurance and improving access to care among reproductive-age women.[21–23] Despite the importance of insurance in the critical period before pregnancy, very little is known about the impact of increasing Medicaid eligibility for childless adults on preconception insurance coverage and risk factors for poor maternal outcomes. Two recent studies did not find any changes in preconception insurance coverage and one study found no changes in pregnancy intention; however, these studies did not examine changes among childless adults who would be

most impacted by the recent state Medicaid expansion and they also did not incorporate the variation in the size and timing of expansions.[24,25] In addition, no studies have evaluated the impact of recent Medicaid expansions on stress. This study uses national survey data to examine the association between changes in Medicaid generosity for childless adults between 2009 and 2017 and preconception insurance coverage, pregnancy intention, stress from bills, early prenatal care, and diagnoses of risk factors among first-time parents. We hypothesized that increases in Medicaid generosity would be associated with increases in preconception insurance and reductions in risk factors for poor pregnancy outcomes.

Methods

Data

The primary data source for this study was the Pregnancy Risk Assessment Monitoring System (PRAMS), the largest national survey of individuals who recently gave birth in the US. State health departments, in collaboration with the CDC, sample individuals with a live birth from birth certificates and administer the survey by mail or telephone two to eight months after delivery. The survey includes questions regarding individual's health behaviors, attitudes, and experiences in the preconception, pregnancy, and postpartum periods.[26] The survey is updated every three to five years and this study included data from Phases 6 (2009-2011), 7 (2012-2015), and 8 (2016-2017). Not all states are included in PRAMS each year and data from states that do not meet the minimum response rate in a given year are not released by the CDC. This study included a total of 43 states that participated in PRAMS for at least one year between 2009 and 2017 (Appendix Table 1.1).

Sample

The sample for this study included individuals aged 20-44 who recently gave birth to their first child ("first-time parents"), since most nulliparous individuals would only be eligible for full-benefit Medicaid as a childless adult prior to pregnancy. Multiparous individuals were not included since prior to the ACA all states provided Medicaid coverage for parents with a median income limit of 64% of FPL so these individuals were less likely to be impacted by the recent Medicaid expansions.[27] Individuals under the age of 20 years at delivery were excluded to ensure they were not eligible for Medicaid as a child in the preconception period. Individuals without any information on age, education, race/ethnicity, number of previous births, or time since delivery were also excluded (Appendix Table 1.2).

Medicaid Generosity Index

The main independent variable in this study is a "Medicaid generosity index", which estimates the fraction of female-identifying individuals without dependent children who would be eligible for Medicaid based on states' eligibility rules, consistent with multiple previous studies on Medicaid expansions.[28–30] Although recent research on state Medicaid expansions under the ACA has often relied on difference-in-difference methods which simply categorize states as either expansion vs. non-expansion, this method allows us to incorporate the variation in the extent of the expansions and the potential size of the population impacted by the change in the income limit. In addition, this method allows us to examine changes in states that increased eligibility limits multiple times during the study period. Considering the variation in Medicaid generosity both across states and over time is important since, during the study period, five states in our sample provided comprehensive coverage for childless adults before 2010 at varying income

levels (Delaware, Hawaii, Massachusetts, New York, and Vermont), four states expanded Medicaid between 2010 and 2014 at varying income levels (Colorado, Connecticut, Minnesota, and New Jersey), and one state (Wisconsin) increased eligibility in 2014 but only up to 100% of FPL.[20] Among the remaining states in our sample, 17 states increased eligibility from 0 to 138% of FPL between 2014 and 2016 and 16 states did not expand before 2017 (Appendix Table 1.3).[31] For example, the index will capture the fact that New Jersey increased eligibility for childless adults from 0 to 23% of FPL in 2011 and then to 138% FPL in 2014 while Connecticut increased from 0 to 56% of FPL in 2010 and then 138% in 2014.

The Medicaid generosity index was calculated using the 2008-2016 Annual Social and Economic Supplement (ASEC) of the Current Population Survey (CPS), consistent with previous research.[28–30] The CPS ASEC survey includes detailed information on all individuals in a sampled household, including all sources of income in the past calendar year. Household income, household size, and income as a percent of FPL were calculated for all female-identifying individuals aged 20-44 years without dependent children, consistent with Medicaid eligibility rules. State Medicaid income limits were then applied to the entire sample to estimate the fraction that would be eligible for Medicaid as a childless adult in each state and year between 2008 and 2016. The index was constructed using national data pooled from all years instead of using different CPS data in each year to isolate changes in Medicaid income eligibility from changes in state social and economic characteristics. Details on the index are included in the Appendix.

Dependent Variables

The study outcomes were selected based on two primary criteria. First, we selected preconception and pregnancy-related outcomes that were most likely to be impacted by changes in Medicaid eligibility for childless adults. It was hypothesized that increasing Medicaid eligibility would increase preconception insurance coverage, resulting in improved access to low-cost preconception care, including family planning and preventative services. Therefore, we expected that increases in eligibility would also be associated with declines in unintended pregnancies, earlier initiation of prenatal care, fewer diagnoses of high blood pressure and diabetes, and reductions in stress from bills. Second, we restricted our analysis to outcomes that were collected consistently by PRAMS from the survey or the birth certificate records throughout the study period (i.e., all three survey phases). Some outcomes that could plausibly have been affected by preconception insurance status (e.g., self-reported diagnoses of depression and preconception health care visits) were not included because they were not collected consistently throughout the study period.

Measures of preconception insurance coverage were categorized as either Medicaid, private/other, or no insurance in the month before pregnancy and individuals could have both Medicaid and private/other insurance. The outcome capturing stress from bills was defined as any reported problems paying the rent, mortgage, or other bills in the twelve months before delivery. A pregnancy was considered unintended if the individual reported not trying to get pregnant at the time of conception.

Initiation of early prenatal care was defined in two ways. We first created a dummy variable equal to one if the first prenatal care visit was in the first trimester (12 weeks). In addition, due to

the high prevalence of first trimester prenatal care prior to the ACA, this study analyzed the week of initiation of prenatal care among the subgroup of individuals who initiated prenatal care within the first trimester.[28] Initiation of prenatal care was based on self-reported visits in PRAMS rather than the birth certificate variables due to changes in the prenatal care variables on the 2003 Revision of the U.S. Standard Certificate of Live Birth, which was adopted by 20 of the 43 PRAMS states throughout the study period.[32,33] Diagnoses of high blood pressure and diabetes included diagnoses made both before or during pregnancy that were collected by PRAMS from birth certificates. Additional details on the outcomes are included in Appendix Table 1.5.

Statistical Analyses

To examine the relationship between changes in Medicaid generosity and outcomes among first-time parents, outcomes of interest were regressed on the Medicaid generosity index in each state and year. All individual-level, linear regressions included state and year fixed effects and controlled for individual characteristics, including age (categorized by PRAMS: 20-24, 25-29, 35-39, and 40-44 years), race (black, white, Asian, and other), years of education (categorized by PRAMS: 8 or less, 9-11, 12, 13-15, or 16 or more years), Hispanic ethnicity, marital status, month of delivery, language of survey (English or other), survey method (telephone or mail), and weeks since delivery. Regressions also included time-varying, state-level characteristics, including percent with college degree, median age, median household income, percent unemployed, percent white, percent black, and percent Hispanic, as well as dummy variables for whether a state had a family planning program or a contraceptive mandate in that year.

The Medicaid generosity index and state-level characteristics were merged to the data using the year before delivery to capture the state's Medicaid generosity and socioeconomic characteristics in the preconception period. The regressions were weighted using individual-level analysis weights provided by the CDC, which include the sampling weight and adjust for nonresponse and noncoverage. Heteroskedasticity-robust standard errors were clustered at the state level. Results were similar using the wild cluster bootstrap-t procedure.[34] The analyses were conducted for all first-time parents as well as a subgroup of individuals with a high school degree or less (12 or fewer years of education) who were more likely to be eligible for Medicaid, consistent with prior research.[15,28,35] Although the PRAMS survey also includes questions on household size and income, these variables were not used to select individuals who would be eligible for Medicaid due to the high rate of missingness and invalid responses in those variables as well as the lack of relationship variables necessary to calculate income as a percent of FPL consistent with Medicaid eligibility rules.[36]

Multiple sensitivity analyses were conducted to assess the robustness of these results. First, to test whether any of the observed changes in outcomes could have been driven by changes in the overall number of births, state-level birth rates were regressed on the generosity index in each state and year, similar to the main regression specification. Next, we tested for linear pre-trends by interacting years since the start of the study period with an indicator for whether the state expanded Medicaid during the study period. In addition, a placebo test was conducted by running the regressions among individuals with a reported household income of $50,000 or higher. Although we cannot determine individual Medicaid eligibility due to the limitations of the income and dependents variables, we expect that individuals with annual incomes above $50,000

would be less likely to be impacted by Medicaid policy changes.[35] Therefore, we would not expect the generosity index to be associated with changes in the outcomes in this sample. Finally, since not all states are included in PRAMS each year, a dummy variable indicating whether a state was included in that year was regressed on the index to test whether the results were being driven by changes in the sample of states. Details of sensitivity analyses are included in the Appendix.

Analyses were conducted using STATA/IC 15.1. Results with p-values <0.05 were considered statistically significant.

Results

Sample

The study sample included a total of 112,392 first-time parents (weighted N=5,643,370) who gave birth in 2009-2017 in 43 states. Details of the sample selection are included in Appendix Table 1.2. The number of births included in each state and year are detailed in Appendix Table 1.1.

Among all first-time parents included in the sample, 62.7% were married, 65.4% were under the age of 30, and 72.8% had more than 12 years of education at the time of delivery (Table 1.1). In addition, 73.3% of individuals were white and 13.6% were Hispanic.

A total of 31,359 (weighted N=1,533,828) first-time parents were included in subgroup of individuals with a high school degree or less. The individuals in this subgroup were less likely to

be married (35.8%) and white (66.8%) and more likely to be under the age of 30 (84.4%) and Hispanic (25.0%), compared with all first-time parents.

Table 1.1: Characteristics of First-Time Parents

	All	HS or Less
N	112,392	31,359
Individual characteristics, % (SD)		
Married	62.7 (48.4)	35.8 (47.9)
Age at delivery (years)		
20 - 24	32.0 (46.6)	59.2 (49.2)
25 - 29	33.4 (47.2)	25.2 (43.4)
30 - 34	24.2 (42.8)	10.5 (30.7)
35 - 39	8.6 (28.1)	4.1 (19.9)
40 - 44	1.8 (13.4)	0.9 (9.6)
Education (years)		
≤ 8	1.3 (11.5)	4.9 (21.6)
9 - 11	4.7 (21.2)	17.4 (37.9)
12	21.1 (40.8)	77.7 (41.6)
13 - 15	29.1 (45.4)	0.0 (0.0)
≥ 16	43.7 (49.6)	0.0 (0.0)
Race		
White	73.3 (44.3)	66.8 (47.1)
Asian	6.4 (24.5)	4.1 (19.8)
Black	12.2 (32.7)	16.4 (37.0)
Other	8.5 (27.9)	13.1 (33.7)
Hispanic	13.6 (34.3)	25.0 (43.3)
Completed survey in English	94.3 (23.1)	85.6 (35.1)
Insurance coverage, % (SD)		
Insurance in month before pregnancy		
None	18.5 (38.8)	36.2 (48.1)
Medicaid	9.9 (29.8)	21.5 (41.1)
Private/other	72.0 (44.9)	43.1 (49.5)
Missing	1.3 (11.2)	2.1 (14.4)
Stress from bills in year before delivery, % (SD)		
Experienced stress from bills	15.2 (35.9)	21.6 (41.1)
No stress from bills	79.5 (40.3)	72.8 (44.5)
Missing	5.2 (22.2)	5.6 (23.1)
Pregnancy intention, % (SD)		
Unintended pregnancy	40.0 (49.0)	54.5 (49.8)
Intended pregnancy	56.4 (49.6)	41.7 (49.3)
Missing	3.7 (18.8)	3.8 (19.1)
Prenatal care		
No prenatal care, % (SD)	0.7 (8.3)	1.2 (11.0)
Any prenatal care, % (SD)	99.3 (8.4)	98.7 (11.2)
Prenatal care in 1st trimester, % (SD)	88.2 (32.3)	78.4 (41.2)
Week of 1st prenatal care visit in 1st trimester, mean (SD)	7.2 (2.3)	7.2 (2.5)
Missing, % (SD)	1.7 (13.1)	2.7 (16.1)

Abbreviations: *HS, high school; SD, standard deviation*

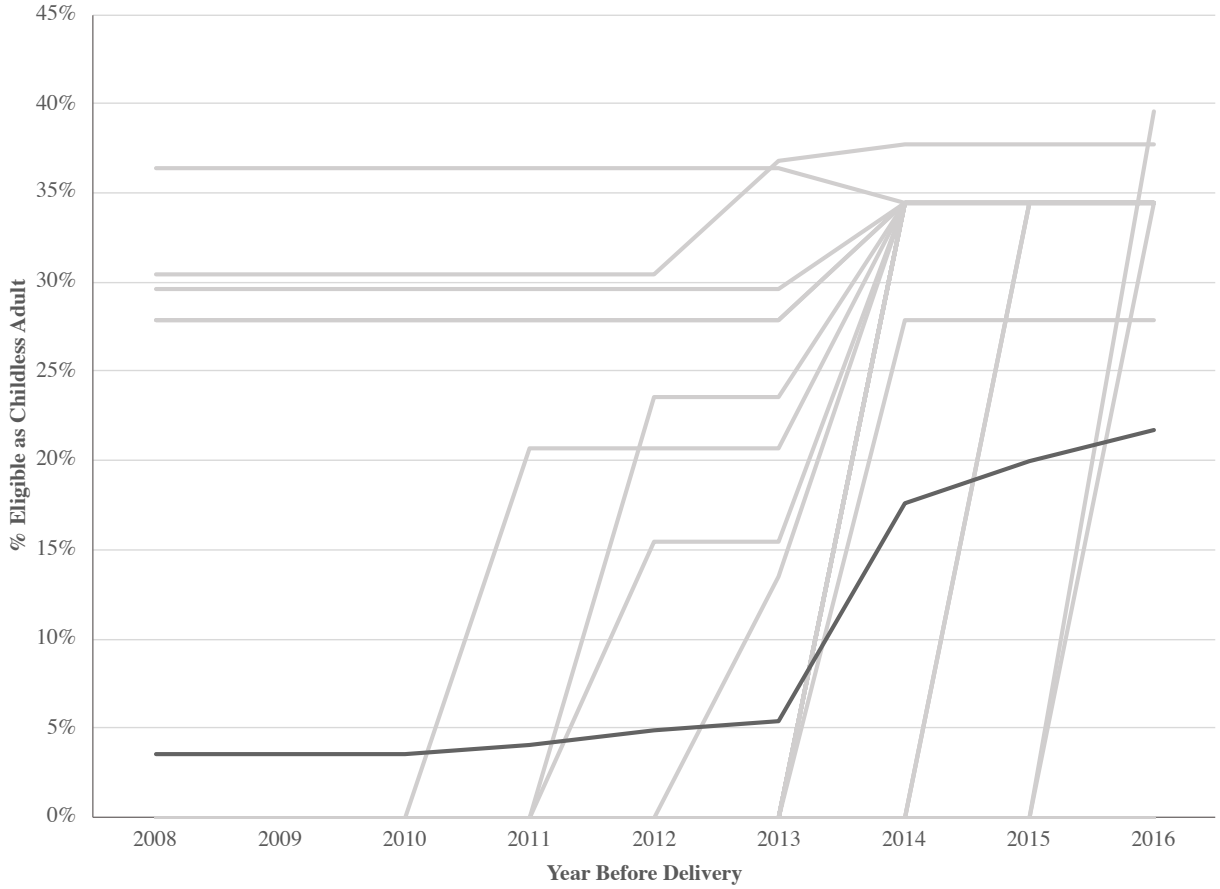
Note: Sample restricted to first-time parents with a live birth between 2009 and 2017. All characteristics estimated using the weights provided by the Center for Disease Control in the PRAMS data.

Source: Authors' analysis of PRAMS data pooled from Phase 6 (2009-2011), Phase 7 (2012-2015), and Phase 8 (2016-2017).

Regression Results

The Medicaid generosity index increased from 3.5 to 21.7% on average over the study period among all states included in PRAMS (Figure 1.1). However, changes in generosity varied across states; during the study period, changes in the Medicaid generosity index ranged from -1.9 to 39.6 ppts (Appendix Table 1.4).

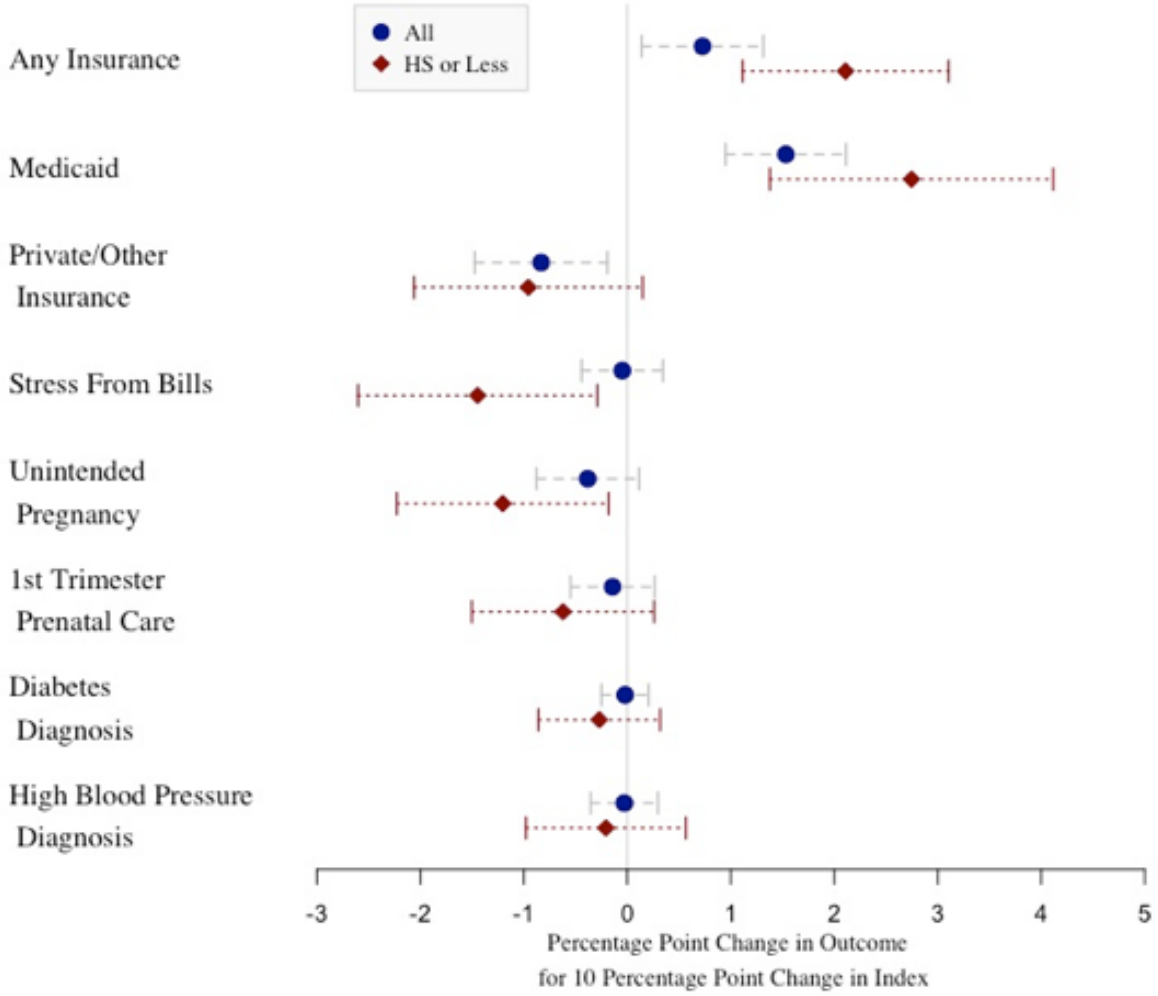
Figure 1.1: Average Generosity Index for All States in PRAMS



Note: Figure includes the Medicaid generosity index for first-time mothers for all 43 states included in Pregnancy Risk Assessment Monitoring Survey (PRAMS) data at any time during the study period (2009-2017). Individual states are shown in light gray and the average across all 43 PRAMS states is shown in dark gray.

In the full sample, higher levels of Medicaid generosity were associated with higher rates of any preconception insurance, primarily due to higher rates of Medicaid coverage (Figure 1.2, Table 1.2). A 10-ppt increase in Medicaid generosity was associated with a 0.7-ppt ($p=0.017$) increase in any type of insurance, a 1.5-ppt ($p<0.001$) increase in Medicaid coverage, and a 0.8-ppt decline ($p=0.012$) in private/other coverage. Gains in preconception insurance coverage were even greater among the sub-sample of individuals with a high school degree or less, where a 10-ppt increase in generosity was associated with a 2.1-ppt ($p<0.001$) increase in any insurance and a 2.7-ppt ($p<0.001$) increase in Medicaid coverage.

Figure 1.2: Regression Results for First-Time Mothers



Note: Figure includes regression coefficient and 95% confidence interval from the regressions estimated in Table 1.2. For results for week of initiation of prenatal care in 1st trimester see Table 1.2. Regressions were estimated among all first-time parents and first-time parents with a high school degree or less.

Table 1.2: Regression Results for Preconception Insurance Coverage Among First-Time Parents

	Any Insurance Preconception	**Medicaid Preconception**	**Private/Other Insurance Preconception**
All first-time mothers			
Index 10ppt, estimate (CI)	0.007 (0.001, 0.013)*	0.015 (0.009, 0.021)***	-0.008 (-0.015, -0.002)*
P-value	0.017	0.000	0.012
Observations	110,999	110,999	110,999
Mean	0.81	0.10	0.73
High school or less			
Index 10ppt, estimate (CI)	0.021 (0.011, 0.031)***	0.027 (0.014, 0.041)***	-0.010 (-0.021, 0.001)
P-value	0.000	0.000	0.088
Observations	30,727	30,727	30,727
Mean	0.63	0.22	0.44

Abbreviations: *ppt, percentage points; CI, 95% confidence interval*
** p-value < 0.05; ** p-value <0.01; *** p-value < 0.001*
Note: Sample restricted to first-time parents aged 20-44 years with a live birth between 2009 and 2017. Linear regressions controlled for individual level characteristics (age, race, ethnicity, education, marital status, month of delivery, survey language, survey method, and time since delivery) and state-level characteristics (education, unemployment, median age, race, ethnicity, family planning programs, and contraceptive mandate). All regressions were estimated using the weights provided by the Center for Disease Control in the PRAMS data.
Source: Authors' analysis of PRAMS data pooled from Phase 6 (2009-2011), Phase 7 (2012-2015), and Phase 8 (2016-2017).

In addition to increases in preconception insurance coverage, higher levels of Medicaid generosity were also associated with reductions in unintended pregnancies. Among individuals with a high school degree or less, a 10-ppt increase in Medicaid generosity was associated with a 1.2-ppt decline in the proportion of pregnancies that were unintended (p=0.022) (Figure 1.2, Table 1.3). While point estimates suggest a negative association for the full sample, no statistically significant effects were found (coefficient: -0.004; p=0.125).

In addition, higher levels of Medicaid generosity were associated with declines in the proportion of first-time parents reporting stress from bills in the year before delivery. Among individuals with a high school degree or less, a 10-ppt increase in Medicaid generosity was associated with a 1.4-ppt decline in stress due to bills (p=0.015). However, results were not statistically significant for the full sample.

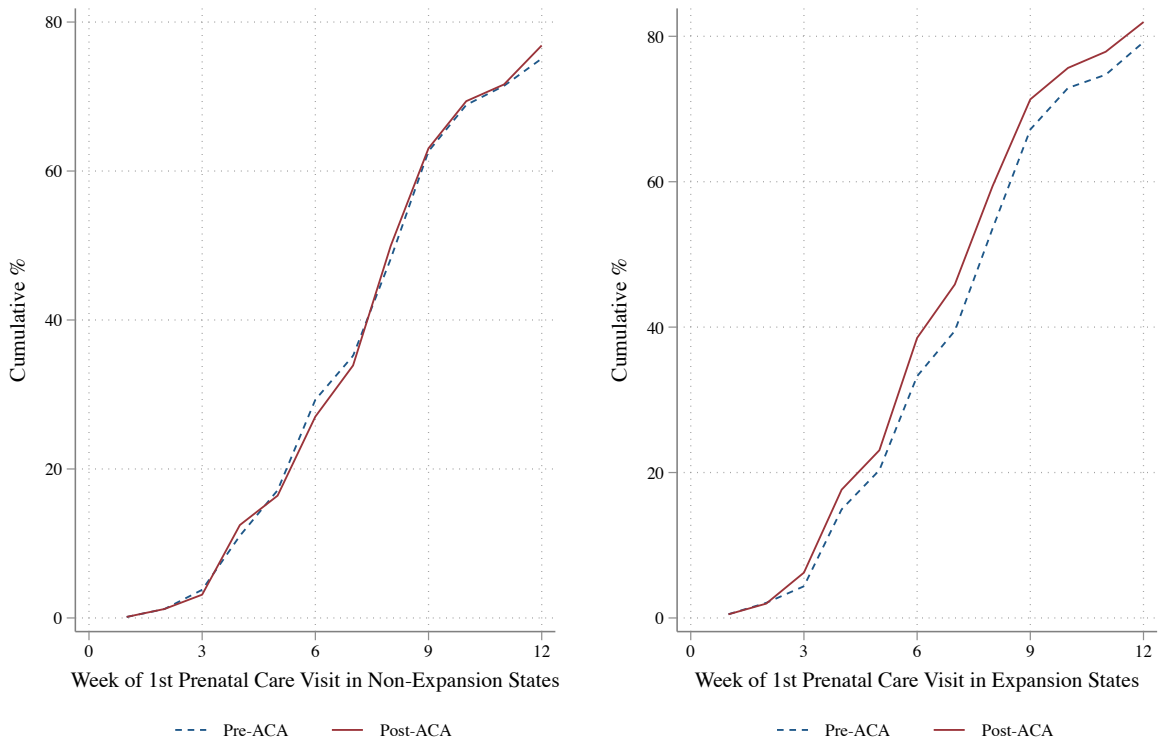
No statistically significant association was found between the Medicaid generosity index and initiation of prenatal care within the first trimester. However, among individuals with a high-school degree or less, a 10-ppt increase in Medicaid generosity was associated with initiating prenatal care 0.053 weeks earlier in the first trimester (p=0.026) (Figure 1.3).

Table 1.3: Regression Results for Preconception and Early Pregnancy Outcomes Among First-Time Parents

			Prenatal Care		Diagnoses at Delivery	
	Stress from Bills	**Unintended Pregnancy**	**Week of Prenatal Care in 1st Trimester**	**1st Trimester Prenatal Care**	**High Blood Pressure**	**Diabetes**
All first-time mothers						
Index 10ppt, estimate (CI)	0.000 (-0.004, 0.003)	-0.004 (-0.009, 0.001)	-0.007 (-0.039, 0.025)	-0.001 (-0.006, 0.003)	0.000 (-0.004, 0.003)	0.000 (-0.003, 0.002)
P-value	0.801	0.125	0.643	0.480	0.850	0.840
Observations	104,479	106,535	97,039	110,315	111,963	111,981
Mean	0.16	0.41	7.17	0.88	0.09	0.05
High school or less						
Index 10ppt, estimate (CI)	-0.014 (-0.026, -0.003)*	-0.012 (-0.022, -0.002)*	-0.053 (-0.100, -0.007)*	-0.006 (-0.015, 0.003)	-0.002 (-0.010, 0.006)	-0.003 (-0.009, 0.003)
P-value	0.015	0.022	0.026	0.161	0.589	0.357
Observations	29,182	29,775	24,141	30,438	31,243	31,250
Mean	0.23	0.57	7.19	0.78	0.08	0.05

Abbreviations: *ppt, percentage points; CI, 95% confidence interval*
** p-value < 0.05; ** p-value < 0.01; *** p-value < 0.001*
Note: Sample restricted to first-time parents aged 20-44 years with a live birth between 2009 and 2017. Linear regressions controlled for individual level characteristics (age, race, ethnicity, education, marital status, month of delivery, survey language, survey method, and time since delivery) and state-level characteristics (education, unemployment, median age, race, ethnicity, family planning programs, and contraceptive mandate). All regressions were estimated using the weights provided by the Center for Disease Control in the PRAMS data.
Source: Authors' analysis of PRAMS data pooled from Phase 6 (2009-2011), Phase 7 (2012-2015), and Phase 8 (2016-2017).

Figure 1.3: Week of First Prenatal Care Visit in First Trimester Among Individuals with a High School Degree or Less



Note: Figure includes the cumulative percent of first-time parents with a high school degree or less who reported initiating prenatal care by week of pregnancy. Expansion states include those states that covered childless adults by 2014 or earlier. Non-expansion states include states that did not provide any coverage for childless adults during the study period. Pre-ACA includes births with a preconception period (one year prior to date of delivery) prior to 2014 and post-ACA includes births with a preconception period after 2014.

Finally, there was no significant association between Medicaid generosity and a diagnosis of either high blood pressure or diabetes before or during pregnancy.

Sensitivity Analyses

In the sensitivity analyses, we found no significant association between the Medicaid generosity index and overall birth rates. In addition, we did not find any evidence of pre-trends among most of our outcomes and there was no evidence of changes in outcomes in the placebo tests among individuals with higher incomes. Finally, the Medicaid generosity index was not associated with the inclusion of states in each year. Results from the sensitivity analyses are included in Appendix.

Discussion

Using a national sample of first-time parents who gave birth between 2009 and 2017, this study found that higher levels of Medicaid generosity were associated with significant, yet modest, increases in insurance coverage in the critical period before pregnancy. These increases in preconception insurance coverage were larger among individuals with a high school degree or less, the subsample most likely to be eligible for Medicaid.[35] Among this vulnerable group, we also found that increases in Medicaid generosity for childless adults was associated with declines in unintended pregnancies, reductions in stress from bills, and modestly earlier initiation of prenatal care; however, there were no changes in diagnoses of diabetes or high blood pressure.

Insurance coverage in the preconception period is a recommended approach to ensuring access to health care services and addressing modifiable risk factors in the critical preconception and early

prenatal period.[6,7] Our results are consistent with a recent study demonstrating that Medicaid expansions for childless adults increased rates of preconception Medicaid coverage.[24,25] However, our study builds on this evidence by incorporating additional years of data, focusing on childless adults who were most likely to benefit from the expansions, and considering the variation in both the timing and size of the Medicaid expansion. In contrast to recent research, we find that Medicaid generosity is also associated with increases in preconception insurance overall.

Our results for childless adults are also consistent in magnitude with prior research which found that increasing Medicaid eligibility for parents prior to 2012 was associated with increases in both Medicaid and overall preconception insurance coverage among multiparous individuals.[28] However, our study found smaller increases in coverage compared with recent research on Medicaid expansions among women of reproductive age.[22,37] In our study, an increase from 0 to 138% of FPL translates to a 34-ppt increase in the generosity index, which is associated with only a 9.2-ppt increase in Medicaid coverage among individuals with a high school degree or less. Our smaller increase in coverage is likely due the fact that we did not limit our sample to individuals in poverty who would be more likely to be eligible for Medicaid. In addition, while our study found that gains in insurance coverage were driven by increases in Medicaid, it is important to note that half of the increase in Medicaid was offset by declines in private/other insurance. This is consistent with there being some “crowd out” associated with Medicaid expansions, as individuals substitute Medicaid in place of other types of coverage.[38] This shift towards Medicaid from private/other insurance in the preconception period may be beneficial for

first-time parents due to the lower cost sharing and more comprehensive benefit packages in Medicaid, which could reduce barriers to care.[38]

This study also found that higher levels of Medicaid generosity were associated with declines in the proportion of pregnancies that were unintended among individuals with a high school degree or less. These findings are consistent with prior evidence that increases in insurance coverage are associated with improvements in access to health care services, including family planning and contraceptives.[39–41] With a total of 251,963 births to first-time parents with a high school degree or less, the average 18-ppt increase in Medicaid generosity translates to an estimated 5,503 fewer unintended births in the 43 PRAMS states in 2017. This reduction in the share of pregnancies that were unintended has important implications for maternal outcomes; individuals with unintended pregnancies are more likely to access prenatal care later, smoke and drink during pregnancy, and report postpartum depression.[42] Despite the reduction in unintended pregnancies, we found that Medicaid generosity was not associated with any significant changes in the overall birth rate, consistent with prior research.[43] A small decline in the birth rate from a 1.2-ppt decline in unintended births is within the 95% confidence interval and, thus, it is possible that either the change in birth rates was too small to detect or there was no change in births and individuals were less likely to report a pregnancy as unintended.

Our finding that Medicaid expansions for childless adults are not associated with increases in the initiation of prenatal care within the first trimester is consistent with recent literature.[15] However, prenatal care within the first trimester is already high at 88%.[15] We do find that Medicaid expansions were associated with a very small but significant shift towards initiating care earlier

in the first trimester among individuals with a high school degree or less. This very modest shift toward earlier prenatal care is consistent with guidelines that recommend initiation of prenatal care in the first eight to ten weeks of pregnancy, since a visit at twelve weeks is often too late to initiate effective interventions to prevent poor pregnancy outcomes.[42] However, a 34-ppt increase in the Medicaid generosity index corresponds to a 1.4 day shift to earlier prenatal care, which is likely not clinically significant. Although these findings suggest that increasing Medicaid generosity may increase individuals' connections with the health care system and enable them to enter into care sooner, there are other individual and structural factors, such as knowledge of prenatal care and clinic location, that must be also addressed in order to improve access to early prenatal care.[44]

Despite the increases in preconception insurance coverage and shift to earlier prenatal care, we did not find any significant changes in diagnoses of diabetes or high blood pressure. Increasing insurance coverage and access to care just before and early in pregnancy may be too late to address risk factors for these conditions, including obesity.[12,45] However, increasing access to preconception and prenatal care may help individuals better control these conditions and prevent poor pregnancy outcomes.[12,45,46]

Finally, this study found reductions in stress from bills before and during pregnancy among individuals with a high school degree or less. While prior research has found that Medicaid expansions have been associated with reductions in problems paying bills and improvements in households' financial health, this is the first study to find that increasing Medicaid generosity is associated with improvements in finances for new mothers.[16,47] This reduction in stress from bills

in before and during pregnancy is particularly important due to the association between stress and poor pregnancy outcomes as well as later life outcomes for children.[17,48,49]

This study has several limitations. First, most of our study outcomes are from self-reported survey data, which provide richer information on pregnancy than birth certificates or administrative claims data but may introduce bias for some variables. While studies comparing PRAMS with birth certificates have found responses for source of payment for delivery were highly reliable, less is known about the reliability of questions such as pregnancy intention, which may be impacted by recall and social desirability biases.[50] However, research has found little evidence that pregnancy intention is impacted by recall bias.[51] In addition, in the free text for "other" types of insurance, some individuals reported the name of Medicaid managed care plans, which may increase the proportion of individuals who report private/other insurance relative to Medicaid. Therefore, we combine all types of coverage to analyze the proportion of individuals with any insurance. This study was also unable to analyze the important outcome of preconception health care use because these questions were not asked consistently across all three survey phases.

In addition, the PRAMS data do not include all states, and not all states are included in every year. If inclusion in the data was associated with changes in Medicaid eligibility, then this could potentially bias the results. However, in the sensitivity analyses there was no significant association between the generosity index and the inclusion of the state in the data (Appendix Table 1.9). The lack of data from all states may also limit the generalizability of the results.

PRAMS does not include several large states such as California and multiple states in the South. However, PRAMS is representative of over 80% of all live births.[52]

Finally, while the use of the generosity index improves upon prior literature, which often either does not take into account the variation in the size and timing of expansions or drops states from the sample, the index may not capture all relevant time-varying policy changes. During the study period, many aspects of the health care system were changing which may bias the results; however, in the placebo tests among individuals with higher incomes who were less likely to be impacted by changes in Medicaid eligibility, the results were not significant (Appendix Table 1.10-1.11). In addition, the Medicaid generosity index only captures the fraction of individuals who are expected to be eligible for Medicaid and does not reflect changes in the uptake of Medicaid. Additional research is needed to understand Medicaid uptake in the preconception period. Furthermore, there were small changes in Medicaid eligibility limits for pregnant individuals during our study period. However, many of our outcomes occur prior to conception and should not be impacted by changes in eligibility limits for pregnant individuals.

Conclusions

This study finds that increases in Medicaid generosity both before and after the ACA were associated with increases in insurance coverage and earlier initiation of prenatal care, as well as reductions in unintended pregnancies and stress from bills. Despite the gains in insurance coverage observed in this study, 14.3% of all first-time parents who gave birth in 2017 still reported having no insurance in the month before conception and rates were twice as high among individuals with a high school degree or less. In addition, 42.2% of births to first-time parents in

2017 were unintended. Increasing Medicaid generosity in the remaining states that do not provide coverage for childless adults may offer benefits for low-income individuals and potentially help address the high rates of poor maternal outcomes.

Paper 2

Impact of Medicaid Prescription Drug Limits on Access to Medications and Health Care Use Among Young Disabled Adults

Caroline K. Geiger, Jessica L. Cohen, Benjamin D. Sommers

Abstract

Importance: Prescription drugs are critical for managing complex physical and mental health conditions for over 10 million disabled Medicaid beneficiaries. However, some state Medicaid programs limit the number of prescription drugs beneficiaries can fill monthly, which may decrease access to essential drugs.

Objective: To determine the impact of the three-drug limit implemented at age 21 in Arkansas and Texas among disabled beneficiaries in Medicaid.

Design: In this cohort study, difference-in-differences analysis was performed using Medicaid Analytic eXtract claims data from January 1, 2007 to December 31, 2012. Analyses were completed December 1, 2020.

Setting: Fee-for-service Medicaid programs in Arkansas and Texas (i.e., "drug cap states") and 16 comparison states without drug cap policies (i.e., "non-drug cap states").

Participants: All disabled Medicaid beneficiaries who turned age 21 during the study period and were continuously enrolled in Medicaid in the year before and after turning age 21.

Exposure: Implementation of a three-drug prescription limit at age 21 in drug cap states.

Main Outcomes and Measures: Monthly fills for all prescription drugs and drugs for mental health conditions, total prescription drug spending, and inpatient and emergency room visits and spending.

Results: Among 27,810 young disabled adults, 8,205 in drug cap states were subject to the three-drug limit at age 21. Over one-half of disabled individuals were diagnosed with a mental health condition before age 21. The drug cap policy was associated with a 19.5% (95% CI: -21.2% to -17.7%; $p<0.001$) decline in monthly prescription fills and a 16.2% (95% CI; -21.6% to -10.4%; $p<0.001$) decline in fills for drugs for mental health conditions, but no significant changes in total prescription drug spending. The drug cap policy was associated with a 13.4% (95% CI: 1.7% to 26.4%; $p=0.023$) increase in the proportion of individuals with any inpatient admission.

Conclusions and Relevance: Drug cap policies reduce access to important medications and increase the risk of hospitalization among disabled individuals.

Introduction

As of 2018, over 10 million individuals enrolled in state Medicaid programs qualified for coverage due to a disability, including physical or mental health conditions, intellectual or developmental disabilities, or functional limitations.[53] The majority of disabled beneficiaries have multiple chronic conditions and nearly half have a serious mental illness.[54] Prescription drugs are critical to managing both physical and mental conditions for disabled Medicaid beneficiaries.[55] However, many state Medicaid programs use "drug cap" policies, which aim to control prescription drug costs by limiting the number of prescriptions a patient may fill each month.[56,57]

As of 2019, 13 states had adopted Medicaid drug caps, with limits as low as three drugs per month in Texas and Arkansas.[57,58] Previous research found the three-drug limit implemented in New Hampshire in 1981 was associated with declines in both "essential" and "nonessential" drugs, as well as increases in acute mental health services and admissions to nursing homes.[59–62] The implementation of more recent drug cap policies have been associated with state-level declines in total prescription fills among all beneficiaries.[57] Declines in prescription drugs caused by drug cap policies are particularly concerning for disabled beneficiaries, who often have the greatest need for prescription medications to manage complex health needs.[55]

Little is known about the impact of the drug cap policies on prescriptions and spending among disabled individuals.[62] Discontinuation and non-adherence to necessary medications is particularly concerning due to the potential increases in hospitalizations and medical costs, as well as lower quality of life, but drug caps have not been evaluated in this particular

population.[63–67] Finally, no recent studies have examined drug caps' potential spillover effects on other types of health care utilization such as inpatient and emergency care.

This study evaluates the impact of the three-drug limit in Arkansas and Texas, which takes effect when Medicaid beneficiaries turn age 21, among young, disabled adults. We examine the impact of these policies on the total number and types of prescription drugs used and on inpatient and emergency department visits. We also examine the effects separately for those with a serious mental illness, who may be at highest risk for adverse events and reduced quality of life due to reduced access to medications.

Methods

Study Design

This study leverages the "natural experiment" created by states' choice to implement drug caps at age 21, thus transitioning young adults from Medicaid without drug caps at age 20 to the three-drug limit at age 21. Using difference-in-differences methods, we compared differences in prescription drug fills and health care utilization for disabled individuals in the 12 months before vs. after turning age 21, in states with a drug cap policy vs. states without any drug cap policy.

Data

The primary data source for this study was the Medicaid Analytic eXtract (MAX) administrative claims data (2007-2012). The MAX data include all medical and prescription drug claims as well as details on monthly enrollment for individuals enrolled in all state Medicaid programs.

This study also used data from the National Library of Medicine (NLM) to classify prescription drugs based on their National Drug Code (NDC) into drug classes using the Anatomical Therapeutic Chemical (ATC) classification system. Using the NLM's RxNorm and RxClass Application Programming Interface, each NDC in the MAX data was mapped to one or more ATC class.[68]

Sample

This study included all young, disabled adults who were enrolled in full-benefit, fee-for-service Medicaid. All individuals enrolled in Medicaid due to a disability prior to age 21 and who turned 21 during the study period (January 1, 2007-December 31, 2012) were included in the sample. Beneficiaries were required to have 12 months of continuous enrollment in the same state Medicaid program both before and after turning age 21. Individuals were excluded if they were pregnant, eligible for Medicaid as a foster child, or in a long-term care facility in the 12 months before turning age 21, or who were dually enrolled in Medicaid and Medicare at any time in the 12 months before or after turning age 21, since they were not subject to the drug cap.

All disabled individuals in Arkansas and Texas were subject to the three-drug limit after turning age 21 and were included in the treatment group (i.e., "drug cap states"). The comparison group (i.e., "non-drug cap states") included all individuals residing in a state that did not have any drug cap policy, did not have any other drug rationing policies go into effect at age 21, and did not enroll all disabled beneficiaries in comprehensive Medicaid Managed Care (i.e., Alaska, Colorado, Connecticut, Florida, Idaho, Indiana, Missouri, Nebraska, New Hampshire, New Jersey, New Mexico, Nevada, Oregon, Texas, Washington, and Wisconsin).

Disabled young adults were also included in the subgroup of individuals with a serious mental illness if they had a diagnosis of schizophrenia and psychotic disorders (ICD-9-CM: 295, 297), bipolar disorder (296.0, 296.1, 296.4, 296.5, 296.6, 296.7, 296.8, 296.9, 301.11, 301.13), or depression with psychotic features (296.2, 296.3, 300.4, 301.12, 309.1, 311 with 3 or 4 as fifth digit) at any time prior to turning age 21.[69] Individuals diagnosed with these conditions often need multiple prescription medications to manage their conditions and may be most severely impacted by the prescription drug cap limit.[70]

Outcomes

The primary outcomes of interest were the number of outpatient prescription drug fills per month overall and stratified by drug class. Total monthly prescription fills were calculated for all outpatient drugs as well as all drugs used to treat mental health conditions and the subclasses of antipsychotics, anxiolytics, antipsychotics, and psychostimulants (Appendix Table 2.1). We also analyzed whether an individual had more than three prescriptions in each month to test the direct effect of the three-drug limit. In addition, we analyzed the total monthly days' supply for all prescription fills to evaluate changes in the total quantity of prescription drugs. Finally, we analyzed total monthly prescription drug spending, which included all fee-for-service payments by Medicaid for outpatient prescription drugs, and average spending per prescription drug fill in each month.

Secondary outcomes included measures of health care visits and spending. Visit outcomes included the total number of emergency room visits, any inpatient admission, and total inpatient length of stay for all inpatient visits in each quarter. The total number of outpatient visits was not included due to variation across states and over time in the coding of these visits in the data. For

the spending outcomes, inpatient and emergency department spending included all fee-for-service payments made by Medicaid for each type of visit in each quarter. Total combined spending on inpatient admissions, emergency room, and prescription drug spending in each quarter was also analyzed to evaluate the overall impact of any spillover effects on spending. Spending was updated to 2020 U.S. dollars using the medical component of the Consumer Price Index.

Statistical Analysis

For each outcome, the individual-level regression model included an indicator for living in a drug cap state (Arkansas or Texas) and an indicator for whether the individual was over age 21 in that month or quarter as well as an interaction between the two indicator variables. The coefficient on the interaction term measures the impact of the drug cap policy. All regressions adjusted for individual sex and race/ethnicity (white, black, Hispanic, or other) as well as whether the individual lived in an urban county (Rural Urban Continuum Codes 1-3). The regressions also included state, month, and year fixed-effects. Heteroskedastic-robust standard errors were clustered at the individual level.[71] Results were similar when standard errors were calculated using the wild cluster bootstrap-t procedure.[34] Regressions were estimated using a zero-inflated negative binomial model for count outcomes due to the high proportion of zeros while logistic regressions were used for binary outcomes. Details on the statistical analyses are included in the Appendix.

Sensitivity Analyses

We conducted several sensitivity analyses to test the robustness of our findings. First, to test whether changes in prescription fills were due to other policies that come into effect at age 21,

we ran a placebo test (using the regression specification described above) on monthly fills for hormonal contraceptives, which were not included in the drug cap limit.

In addition, we tested whether trends in outcomes prior to age 21 were parallel across drug cap and non-drug cap states, since the difference-in-differences study design relies on the assumption of parallel trends. Details on the sensitivity analyses are included in the Appendix.

Results

Sample

The study sample included a total of 27,810 young, disabled Medicaid beneficiaries (Table 2.1). Among all individuals, 8,205 resided in a drug cap state and were subject to the three-drug limit at age 21. The majority of individuals in both drug cap and non-drug cap states were male (61.5% and 60.8%, respectively) and individuals in drug cap states were less likely to be white compared with individuals in non-drug cap states (36.7% and 49.3%). In both the drug cap and non-drug cap states, over one-half of individuals were diagnosed with a mental health condition before age 21 (57.0% and 59.8%).

Among all disabled young adults, 5,896 individuals were included in the subgroup of individuals with a serious mental illness (Table 2.1). Similarly, the majority of individuals with a serious mental illness in both drug cap and non-drug cap states were male (58.7% and 61.8%) and individuals in drug cap states were less likely to be white compared with individuals in non-drug cap states (40.0% and 56.0%).

Table 2.1: Baseline Characteristics of All Disabled Beneficiaries in Year Before Turning Age 21

	All Disabled Individuals		Disabled Individuals with a Serious Mental Illness	
	Drug Cap States	**Non-Drug Cap States**	**Drug Cap States**	**Non-Drug Cap States**
N	8,205	19,605	1,696	4,200
Patient Demographics, n (%)				
Male	5,045 (61.5%)	11,929 (60.8%)	996 (58.7%)	2,594 (61.8%)
Race / ethnicity				
White	3,014 (36.7%)	9,672 (49.3%)	678 (40.0%)	2,351 (56.0%)
Black	1,828 (22.3%)	3,351 (17.1%)	382 (22.5%)	708 (16.9%)
Hispanic	2,086 (25.4%)	1,693 (8.6%)	379 (22.3%)	330 (7.9%)
Reside in urban county	6,069 (74.0%)	15,088 (77.0%)	1,250 (73.7%)	3,156 (75.1%)
Diagnoses, n (%)				
Chronic obstructive pulmonary disease	1,293 (15.8%)	3,105 (15.8%)	366 (21.6%)	1,081 (25.7%)
Asthma	867 (10.6%)	2,275 (11.6%)	237 (14.0%)	822 (19.6%)
Diabetes	363 (4.4%)	837 (4.3%)	135 (8.0%)	319 (7.6%)
Epilepsy	1,103 (13.4%)	2,449 (12.5%)	212 (12.5%)	465 (11.1%)
Mental health condition	4,678 (57.0%)	11,730 (59.8%)	1,696 (100.0%)	4,200 (100.0%)
Attention deficit disorder	1,038 (12.7%)	2,642 (13.5%)	438 (25.8%)	1,384 (33.0%)
Anxiety	1,007 (12.3%)	2,836 (14.5%)	589 (34.7%)	1,847 (44.0%)
Depression	1,224 (14.9%)	3,120 (15.9%)	914 (53.9%)	2,409 (57.4%)
Depression with psychotic features	719 (8.8%)	1,813 (9.2%)	719 (42.4%)	1,813 (43.2%)
Schizophrenia and psychotic disorders	455 (5.5%)	1,279 (6.5%)	455 (26.8%)	1,279 (30.5%)
Bipolar disorder	1,105 (13.5%)	2,720 (13.9%)	1,105 (65.2%)	2,720 (64.8%)
Substance use disorder	233 (2.8%)	1,012 (5.2%)	156 (9.2%)	688 (16.4%)
Developmental disorders	3,149 (38.4%)	6,829 (34.8%)	621 (36.6%)	1,564 (37.2%)
Autism	589 (7.2%)	1,625 (8.3%)	116 (6.8%)	372 (8.9%)

Source: Authors' analysis of Medicaid Analytic eXtract (MAX) claims data (2007-2012).

Notes: The sample of all disabled individuals includes all Medicaid beneficiaries who were eligible for Medicaid due to a disability prior to turning age 21 and were continuously enrolled in fee-for-service Medicaid in the year before and after turning age 21. The serious mental illness subgroup includes all disabled patients who were diagnosed with schizophrenia and psychotic disorders, bipolar disorder, or depression with psychotic features at any time prior to turning age 21. The drug cap states include all individuals residing in Arkansas and Texas who were eligible for the drug cap policy at age 21. The non-drug cap states include all individuals residing in Alaska, Colorado, Connecticut, Florida, Idaho, Indiana, Missouri, Nebraska, New Hampshire, New Jersey, New Mexico, Nevada, Oregon, Texas, Washington, and Wisconsin who were not eligible for a drug cap policy at age 21. Diagnoses include those made at any time prior to turning age 21.

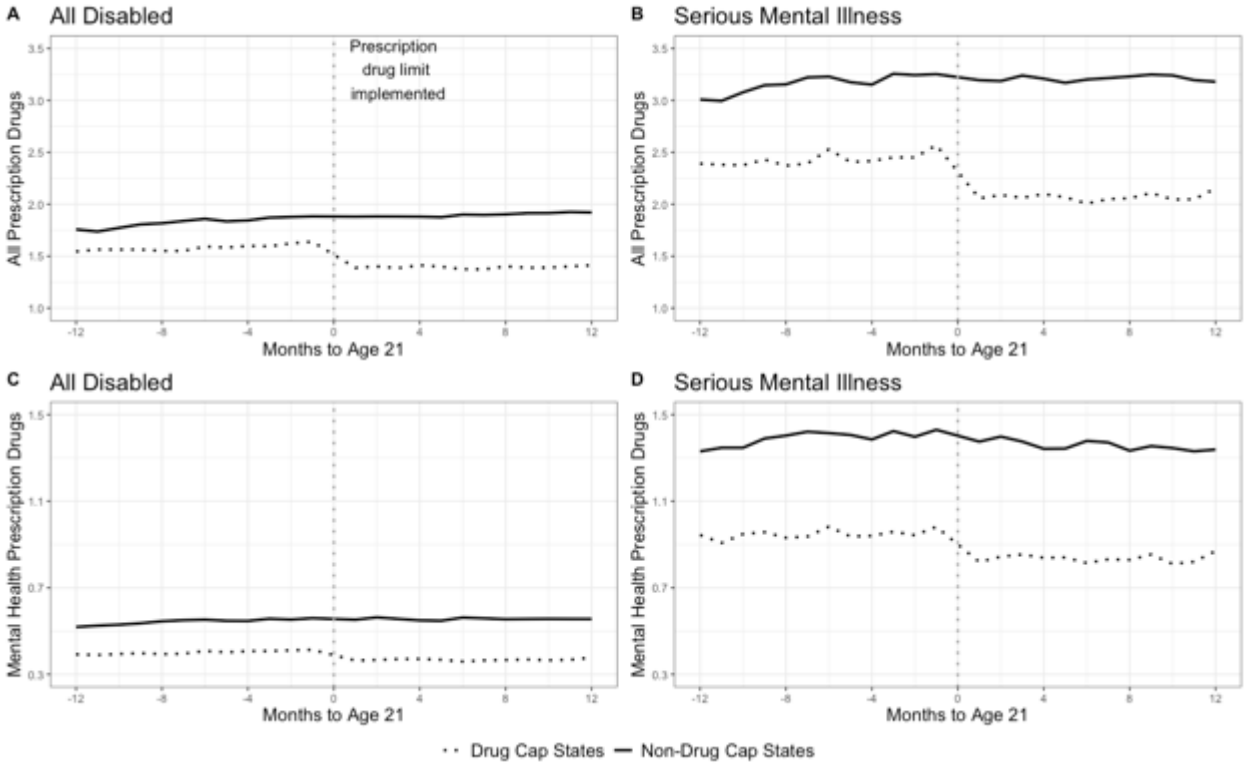
Medication Use: All Disabled

Figure 2.1 presents trends in total monthly prescription fills for individuals in drug cap and non-drug cap states before and after turning age 21. In the 12 months prior to turning age 21, disabled beneficiaries in the drug cap states and non-drug cap states filled an average of 1.58 and 1.82 prescriptions per month, respectively (Figure 2.1A, Appendix Table 2.2). The drug cap policy was associated with a 19.5% (95% confidence interval [CI]: -21.2% to 17.7%; $p<0.001$) decline in monthly total prescription fills, a 10.8% (-12.1% to 9.5%; $p<0.001$) decline in total days' supply for all prescription fills, and a 42.4% (95% CI -44.7% to -40.0%; $p<0.001$) decline in the proportion of individuals with more than three prescription fills per month (Table 2.2).

Prior to turning age 21, disabled beneficiaries filled an average of 0.40 monthly prescriptions for drugs to treat a mental health condition in drug cap states vs. 0.54 in non-drug cap states (Figure 2.1C, Appendix Table 2.2). The drug cap was associated with a 16.2% (95% CI: -21.6% to -10.4%; $p<0.001$) decline in total monthly prescription fills for drugs to treat a mental health condition as well as declines in total monthly fills for antipsychotics, anxiolytics, and antidepressants (all $p<0.01$) (Table 2.2).

Among all disabled individuals, monthly spending on prescription drugs totaled $306 per beneficiary in the year before turning age 21 in drug cap states vs. $350 in non-drug cap states (Appendix Table 2.3). The drug cap policy was not significantly associated with changes in total spending on prescription drugs but was associated with a 13.2% (95%CI: 3.7% to 23.6%; $p=0.006$) increase in average spending per prescription (Table 2.2).

Figure 2.1: Monthly Prescription Drug Fills Before and After Implementation of Drug Cap Policy at Age 21



Notes: Study sample limited to all disabled beneficiaries who turned age 21 during study period (2007-2012) and had 12 months of continuous enrollment in full-benefit Medicaid before and after their twenty-first birthday. The subgroup of disabled beneficiaries with a serious mental illness included those individuals with a diagnosis of schizophrenia and psychotic disorders, bipolar disorder, or depression with psychotic features before turning age twenty-one. Mental health prescription drugs included fills for antipsychotics, anxiolytics, antidepressants, psychostimulants, and hypnotics and sedatives.

Table 2.2: Changes in Monthly Prescription Drug Fills After the Implementation of Drug Cap Policy at Age 21 Among All Disabled Individuals

	Difference-in-Differences Estimates			
	All Disabled Individuals (N = 27,810)			
Prescription drug outcomes	**Pre-age 21 mean in drug cap states**	**OR/IRR**	**95% CI**	**P-value**
Monthly prescription drug fills overall				
Total prescription fills	1.58	0.805***	(0.788, 0.823)	<0.001
> 3 prescriptions in month	16.55%	0.576***	(0.553, 0.600)	<0.001
Total prescription days' supply	43.24	0.892***	(0.879, 0.905)	<0.001
Monthly prescription drug spending				
Total prescription spending	$306.17	0.996	(0.917, 1.083)	0.927
Total spending per prescription fill	$91.30	1.132**	(1.037, 1.236)	0.006
Monthly prescription drug fills by ATC class				
All mental health drugs	0.40	0.838***	(0.784, 0.896)	<0.001
Antipsychotics	0.17	0.893**	(0.829, 0.961)	0.003
Anxiolytics	0.05	0.755***	(0.671, 0.851)	<0.001
Antidepressants	0.12	0.758***	(0.686, 0.838)	<0.001
Psychostimulants	0.05	0.851	(0.715, 1.014)	0.071
Hormonal contraceptives	0.04	0.871	(0.738, 1.028)	0.103

***Abbreviations**: OR = odds ratio; IRR =incidence rate ratio; CI = confidence interval; ATC = Anatomic Therapeutic Chemical.*
** p<0.05; ** p<0.01; *** p<0.001*
Source: Authors' analysis of Medicaid Analytic eXtract (MAX) claims data (2007-2012).
Notes: Regressions adjusted for covariates listed in methods. Pre-age 21 means were calculated in the drug cap states (Arkansas and Texas) among all individuals in the 12 calendar months prior to turning age 21. Prescription drug outcomes were measured in each of the 12 calendar months before and after the individual turned age 21 and prescription drug fills in the month of the twenty-first birthday were not included. All results are from the coefficient on the interaction between treated indicator variable and post-policy indicator. All results for count outcomes (total fills and spending) are reported as incidence rate ratios (IRR) from the zero-inflated negative binomial models while results for binary outcomes (more than 3 prescription fills) are reported as odds ratios (OR) from the logistic models.

Medication Use: Serious Mental Illness

Beneficiaries with a serious mental illness filled 2.43 prescriptions per month prior to turning age 21 in drug cap states vs. 3.16 prescriptions per month in non-drug cap states (Figure 2.1B, Appendix Table 2.4). The drug cap was associated with a 21.1% (95% CI: -23.9% to -18.2%; p<0.001) decline in monthly prescription fills, a 14.4% (95% CI: -16,7% to -12.1%; p<0.001) decline in total days' supply for all prescription fills, and a 49.0% (95% CI: -52.9% to -44.8%; p<0.001) decline in the proportion of individuals with more than three prescription fills in one month (Table 2.3).

Prior to turning age 21, individuals with a serious mental illness filled an average of 0.95 prescriptions per month for drugs to treat a mental health condition in drug cap states vs. 1.39 prescriptions per month in non-drug cap states (Figure 2.1D, Appendix Table 2.4). The drug cap was associated with a 18.3% (95% CI: -24.4% to -11.7%; p<0.001) decline in monthly fills for prescription drugs to treat a mental health condition as well as declines in fills for antipsychotics (p=0.009) and antidepressants (p<0.001) (Table 2.3).

Among all individuals with a serious mental illness, spending on prescription drugs totaled $518 per beneficiary per month in drug cap states prior to turning age 21 vs. $530 per beneficiary per month in non-drug cap states (Appendix Table 2.5). The drug cap was associated with a 7.8% (95% CI: -13.1% to -2.3%; p=0.007) decline in total monthly spending on prescription drugs but was not significantly associated with spending per prescription drug fill (Table 2.3).

Table 2.3: Changes in Monthly Prescription Drug Fills After the Implementation of Drug Cap Policy at Age 21 Among Individuals with a Serious Mental Illness

	Difference-in-Differences Estimates			
	Disabled Individuals with a Serious Mental Illness (N = 5,896)			
Prescription drug outcomes	**Pre-age 21 mean in drug cap states**	**OR/IRR**	**95% CI**	**P-value**
Monthly prescription drug fills overall				
Total prescription fills	2.43	0.789***	(0.761, 0.818)	<0.001
> 3 prescriptions in month	27.33%	0.510***	(0.471, 0.552)	<0.001
Total prescription days' supply	69.73	0.856***	(0.833, 0.879)	<0.001
Monthly prescription drug spending				
Total prescription spending	$517.50	0.922**	(0.869, 0.977)	0.007
Total spending per prescription fill	$136.86	1.063	(0.996, 1.134)	0.065
Monthly prescription drug fills by ATC class				
All mental health drugs	0.95	0.817***	(0.756, 0.883)	<0.001
Antipsychotics	0.48	0.908**	(0.844, 0.976)	0.009
Anxiolytics	0.08	0.836	(0.638, 1.096)	0.195
Antidepressants	0.28	0.695***	(0.584, 0.828)	<0.001
Psychostimulants	0.08	0.978	(0.816, 1.171)	0.808
Hormonal contraceptives	0.05	0.857	(0.481, 1.526)	0.600

***Abbreviations**: OR = odds ratio; IRR =incidence rate ratio; CI = confidence interval; ATC = Anatomic Therapeutic Chemical.*
** p<0.05; ** p<0.01; *** p<0.001*
Source: Authors' analysis of Medicaid Analytic eXtract (MAX) claims data (2007-2012).
Notes: Regressions adjusted for covariates listed in methods. Pre-age 21 means were calculated in the drug cap states (Arkansas and Texas) among all individuals in the 12 calendar months prior to turning age 21. Prescription drug outcomes were measured in each of the 12 calendar months before and after the individual turned age 21 and prescription drug fills in the month of the twenty-first birthday were not included. All results are from the coefficient on the interaction between treated indicator variable and post-policy indicator. All results for count outcomes (total fills and spending) are reported as incidence rate ratios (IRR) from the zero-inflated negative binomial models while results for binary outcomes (more than 3 prescription fills) are reported as odds ratios (OR) from the logistic models.

Health Care Use: All Disabled

The drug cap was associated with a 13.4% increase (95% CI: 1.7% to 26.4%; p=0.023) in the proportion of patients with any quarterly inpatient admission after turning age 21, but not with total inpatient length of stay or total inpatient spending (Table 2.4). In addition, the drug cap was not associated with any significant changes in total emergency room visits, spending on emergency room visits, or in total combined spending on prescription drugs, inpatient visits, and emergency room visits.

Table 2.4: Changes in Quarterly Use of Health Care Services After the Implementation of Drug Cap Policy at Age 21 Among All Disabled Individuals

	Difference-in-Differences Estimates			
	All Disabled Individuals (N = 27,810)			
Health care use outcomes	**Pre-age 21 mean in drug cap states**	**OR/IRR**	**95% CI**	**P-value**
Quarterly emergency department (ED) visits				
Total ED visits	0.43	0.960	(0.888, 1.037)	0.298
Total ED spending	$131.12	0.969	(0.915, 1.025)	0.273
Quarterly inpatient (IP) visits				
Any IP admission	3.11%	1.134*	(1.017, 1.264)	0.023
Total IP length of stay	0.21	0.922	(0.788, 1.078)	0.306
Total IP spending	$547.01	1.168	(0.985, 1.385)	0.074
Quarterly ED, IP, and prescription drug services				
Total prescription spending	$918.52	0.999	(0.920, 1.086)	0.989
Total ED, IP, and prescription spending	$1596.66	0.965	(0.864, 1.078)	0.531

***Abbreviations**: OR=odds ratio; IRR =incidence rate ratio; CI = confidence interval; ATC = Anatomic Therapeutic Chemical; IP = inpatient; ED = emergency department; USD = 2020 United States dollars.*
** p<0.05; ** p<0.01; *** p<0.001*
Source: Author's analysis of Medicaid Analytic eXtract (MAX) claims data (2007-2012).
Notes: Regressions adjusted for covariates listed in methods. Pre-age 21 means were calculated in the drug cap states (Arkansas and Texas) among all individuals in the 12 calendar months prior to turning age 21. Prescription drug outcomes were measured among all individuals on a monthly basis while health care resource use was measured on a quarterly basis before and after the individual turned age 21. Total spending includes all spending on prescription drugs as well as inpatient and emergency department visits. All results are from the coefficient on the interaction between treated indicator variable and post-policy indicator. All results for count outcomes (total visits and spending) are reported as incidence rate ratios (IRR) from the zero-inflated negative binomial models while results for binary outcomes (any emergency or any inpatient visit) are reported as odds ratios (OR) from the logistic models.

Health Care Use: Serious Mental Illness

Among all disabled individuals with a serious mental illness, the drug cap was associated with a 22.3% (95% CI: 0.1% to 49.4%; p=0.049) increase in the proportion of patients with an inpatient admission and a 22.6% (95% CI: 0.2% to 50.0%; p=0.048) increase in inpatient spending (Table 2.5). However, there was no significant association between the policy and total inpatient length of stay, total emergency room visits, or total spending on emergency room visits. Finally, the drug cap was not associated with any significant changes in total combined spending on prescription drugs, inpatient visits, and emergency room visits.

Table 2.5: Changes in Quarterly Use of Health Care Services After the Implementation of Drug Cap Policy at Age 21 Among Individuals with a Serious Mental Illness

	Difference-in-Differences Estimates			
	Disabled Individuals with a Serious Mental Illness (N = 5,896)			
Health care use outcomes	**Pre-age 21 mean in drug cap states**	**OR/IRR**	**95% CI**	**P-value**
Quarterly emergency department (ED) visits				
Total ED visits	0.55	0.999	(0.853, 1.170)	0.987
Total ED spending	$150.37	0.989	(0.892, 1.096)	0.830
Quarterly inpatient (IP) visits				
Any IP admission	4.67%	1.223*	(1.001, 1.494)	0.049
Total IP length of stay	0.32	0.950	(0.768, 1.176)	0.639
Total IP spending	$480.57	1.226*	(1.002, 1.500)	0.048
Quarterly ED, IP, and prescription drug services				
Total prescription spending	$1552.51	0.925**	(0.873, 0.981)	0.010
Total ED, IP, and prescription spending	$2183.45	0.991	(0.916, 1.073)	0.828

Abbreviations*: OR=odds ratio; IRR =incidence rate ratio; CI = confidence interval; ATC = Anatomic Therapeutic Chemical; IP = inpatient; ED = emergency department; USD = 2020 United States dollars.*
** p<0.05; ** p<0.01; *** p<0.001*
Source: Author's analysis of Medicaid Analytic eXtract (MAX) claims data (2007-2012).
Notes: Regressions adjusted for covariates listed in methods. Pre-age 21 means were calculated in the drug cap states (Arkansas and Texas) among all individuals in the 12 calendar months prior to turning age 21. Prescription drug outcomes were measured among all individuals on a monthly basis while health care resource use was measured on a quarterly basis before and after the individual turned age 21. Total spending includes all spending on prescription drugs as well as inpatient and emergency department visits. All results are from the coefficient on the interaction between treated indicator variable and post-policy indicator. All results for count outcomes (total visits and spending) are reported as incidence rate ratios (IRR) from the zero-inflated negative binomial models while results for binary outcomes (any emergency or any inpatient visit) are reported as odds ratios (OR) from the logistic models.

Sensitivity Analyses

In the placebo test, the drug cap was not associated with any significant changes in monthly fills for hormonal contraceptives (Tables 2.2-2.3).

In our sensitivity analyses, there were no significant differences in pre-trends for all of the outcomes of interest before implementation of the drug cap at age 21 (Appendix Tables 2.6-2.7).

Discussion

This study found that the implementation of a three-drug prescription limit at age 21 was associated with significant declines in monthly prescription fills among young, disabled Medicaid beneficiaries as well as those with a serious mental illness. The drug cap policies effectively restricted prescription fills for many individuals, with declines in important medications used to treat mental illness, including antipsychotics, anxiolytics, and antidepressants. Despite these declines in prescriptions, the drug cap policies were not associated with declines in spending on prescription drugs among all disabled individuals and only modest savings among those with a serious mental illness. In addition, there was also evidence of spillover effects with increases in inpatient admissions.

These declines in prescription drug fills may have significant implications for the treatment of both physical and mental health conditions. Prior research has demonstrated the importance of adherence to prescription drugs for depression and schizophrenia and also reducing overall medical costs and use of health care services.[72] Reducing the burden of symptoms is particularly critical in this population of disabled patients due to the high prevalence of comorbid physical and mental health conditions. In addition to increasing the costs associated with mental health conditions, nonadherence to drugs such as antidepressants and antipsychotics can complicate the

treatment of other chronic conditions. For example, patients with symptoms of depression are less likely to achieve glycemic control, compared with patients without symptoms of depression.[73]

By reducing access to necessary prescription drugs, the drug cap policies may also have a negative impact on patient quality of life. Mental health conditions are among the leading causes of disability-adjusted life years, particularly among young adults, and the implementation of the drug cap policies at age 21 is likely to limit access to treatment and exacerbate the detrimental effects of these conditions.[74,75] For example, symptoms of mental health conditions, including depression and bipolar disorder, are associated with declines in productivity and functional status.[73,76] Furthermore, non-adherence among psychiatric patients has also been linked to increases in the risk of incarceration, suicide, and premature mortality.[77,78] Additional research is necessary to understand potential long-term consequences of the drug cap policies on quality of life among young adults.

Combined with the declines in critical medications, the lack of savings from the drug cap policy suggests that, in our sample of disabled beneficiaries, the policy failed to provide measurable benefits for state Medicaid programs. The absence of a significant decline in prescription drug spending among all patients can be explained by an increase in average spending per prescription fill, suggesting that beneficiaries may be either discontinuing less expensive, lower-value drugs or paying for prescriptions out-of-pocket. This finding that the prescription drug cap was not associated with any savings but had spillover effects on health care use is consistent with prior literature that finds that other drug rationing policies, including prior authorization and step therapy, generally do not save state Medicaid programs money, but contribute to worse patient

outcomes.[79] Together, these results suggest that states should reevaluate the use of drug rationing policies due to the potential for adverse effects among disabled individuals.

Limitations

This study had several limitations. First, the MAX data only include claims for Medicaid-paid prescriptions so out-of-pocket prescription purchases are not observed. However, prior research on Medicaid copayment policies suggests that due to the high out-of-pocket costs of prescription drugs, few beneficiaries are likely to pay for prescriptions above the three-drug limit.[80]

In addition, we did not include total outpatient visits because the "place of service" and "type of service" codes varied both across states and over time, which would impact the validity of the analyses. However, we expect that the drug cap would have the largest spillover effects on emergency department and inpatient visits, which were measured consistently in the MAX data.[81,82]

Finally, results may be biased by benefits changes occurring at age 21. For example, in most state Medicaid programs, individuals lose or have reduced dental, hearing, vision, and chiropractic benefits at age 21. Reduced dental benefits could reduce prescriptions for opioids and antibiotics, while reduced chiropractic benefits may increase prescriptions for opioids.[83,84] Due to these changes in benefits, we do not analyze changes in prescriptions for opioids or total spending on all services. However, these other changes in benefits are not expected to impact the use of the specific classes of drugs in the analyses.

Conclusions

Drug cap policies in Texas and Arkansas were associated with declines in total prescription fills and fills for drugs used to treat mental health conditions among young, disabled beneficiaries. These declines in prescription drugs combined with increases in inpatient admissions suggest that the drug cap policies used by many states may be limiting access to critical health care services and increasing the risk of hospitalization, without any significant changes in prescription drug spending.

Paper 3

Advanced Maternal Age, Prenatal Care Services, and Perinatal Mortality: A Regression Discontinuity Design

Caroline K. Geiger, Mark A. Clapp, Jessica L. Cohen

Abstract

Background: Maternal and fetal risks increase with maternal age. An arbitrary cutoff of age 35 or older at delivery ("advanced maternal age", or AMA) is frequently used in clinical obstetrics to stratify pregnancies by risk. However, it is unknown how the AMA designation is used in clinical practice and whether it is associated with perinatal outcomes.

Methods: Using a regression discontinuity design and claims data from a large, commercial insurer, we analyzed the impact of the AMA designation on prenatal care services, delivery-related practices, preterm birth, and perinatal outcomes. Outcomes were compared for women within 120 days above vs. below the age 35 AMA cutoff on her expected date of delivery.

Results: AMA was associated with a 4.3%-point (ppt) increase in the fraction of women with an MFM visit (95% confidence interval [CI]: 0.023, 0.063), 0.22 increase in total ultrasounds (95% CI; 0.070, 0.373), 15.7-ppt increase in any detailed ultrasound (95% CI: 0.137, 0.177), and 5.0-ppt increase in any antepartum surveillance (95% CI: 0.030, 0.070) but no changes in delivery-related practices. However, AMA was associated with a 0.4-ppt decline in perinatal mortality (95% CI: -0.0078, -0.0002).

Conclusions: The jump in prenatal care services at the age 35 cutoff indicates that the AMA designation impacts clinical decision-making. Substantial reductions in perinatal mortality are observed just above the AMA cutoff, but more research is needed on which interventions are producing these benefits.

Introduction

Amidst a generally declining birth rate in the United States, birth rates among women aged 35-44 have been increasing, with 10% of infants born to first-time mothers over age 35 in 2014.[85,86] Advanced maternal age (AMA) is a frequently applied designation in clinical obstetrics, used to stratify maternal and fetal risks based on maternal age. Pregnancies in older women are at higher risk of adverse maternal and newborn outcomes, including stillbirth and neonatal mortality.[87–89] While no consensus exists on the appropriate age threshold for this designation, as the risks of complications likely increase continuously with maternal age, AMA is frequently defined as 35 years or older on the expected delivery date.[90,91]

In an effort to avert poor outcomes, providers may use the AMA designation to target interventions aimed at detecting or mitigating age-related risks in pregnancy. For example, antepartum fetal surveillance (e.g., biophysical profile ultrasounds and non-stress tests) may be used to screen for fetuses at risk of stillbirth.[92–95] Similarly, insurance carriers and payers have used this designation to justify reimbursement for additional genetic testing.[96] However, it is unknown whether the AMA designation alters provider practice or is associated with pregnancy outcomes.[97]

We leveraged the arbitrary age 35 cutoff in a quasi-experimental regression discontinuity (RD) design, comparing women just above versus just below the AMA age cutoff. to explore the association between AMA and prenatal care services, delivery-related practices, and perinatal outcomes.

Methods

Data

The primary data source is un-identifiable administrative claims from a large commercial insurer. The data include medical claims and monthly enrollment details for over 60 million individuals enrolled between 2008 and 2019. Billed medical claims and encounter data were used to identify services provided before, during, and after childbirth. The data also include the woman's exact date of birth.

Sample

The sample includes all women with a delivery covered by the insurer who were within 120 days of turning age 35 on the expected delivery date (Appendix Table 3.1). The woman's age on the expected delivery date (assuming 40 weeks gestation) was calculated using her exact birth date and the infant's gestational age on the actual date of delivery. If there was no diagnosis code for gestational age, then it was assumed the delivery occurred at 40 weeks (Appendix Table 3.2). Inclusion criteria included continuous enrollment during the entire pregnancy period, at least one outpatient encounter with any provider, and one ultrasound during the pregnancy period.

Outcomes

We analyzed the association between the age 35 cutoff and three sets of outcomes, including utilization of prenatal care services, delivery-related practices, and perinatal outcomes. Prenatal care services included the total number of visits with an obstetrician-gynecologist (OBGYN), any visit with a maternal-fetal medicine specialist (MFM), total number of ultrasounds, any detailed ultrasound, any antepartum fetal surveillance (i.e., biophysical profile ultrasound and/or

nonstress test), and any aneuploidy screening (i.e., serum analyte screening, cell-free DNA, or invasive genetic testing via amniocentesis or chorionic villus sampling) (Appendix Table 3.3). Delivery-related practices included cesarean delivery and induction of labor (Appendix Table 3.3). Perinatal outcomes included an indicator for preterm birth (< 37 weeks) and an indicator for perinatal mortality, a commonly reported metric reflecting the quality of pregnancy-related care and defined as by the National Center for Health Statistics as a fetal death at 28 weeks gestation or more or neonatal death within 7 days after delivery (Appendix Table 3.4).[98,99]

Analysis

We used an RD design to analyze the association between AMA and the outcomes of interest. RD overcomes the issue of selection bias in comparing individuals with and without an intervention by exploiting an arbitrary cutoff in clinical decision-making rules, providing transparent visual evidence of changes in the outcome at the cutoff.[100,101] The RD method relies on the assumption that individuals within a narrow bandwidth around the cutoff are the same on average, with the exception of the likelihood of receiving the intervention. While the risk of adverse outcomes increases with maternal age, women several months older or younger than age 35 should not have different underlying risks. There is also no reason to expect any underlying abrupt discontinuities in outcomes at age 35, other than those stemming from differences in care due to the AMA designation. The RD method thus attributes any changes in outcomes at the age 35 cutoff to the AMA designation.

We used local linear regression, with a binary indicator for age 35 or older on the expected delivery date as the main independent variable. Regressions controlled for the total number of

days between the woman's 35th birthday and the expected date of delivery (the "running variable"), and the following variables to improve precision: pre-pregnancy maternal characteristics, zip code and county of residence characteristics, and fixed effects for state of residence, year, and month of delivery. All regressions were estimated using a bandwidth of 120 days around the cutoff with weights from a triangular kernel function, which gives more weight to women closer to the cutoff and is recommended for RD analyses.[102] Since we could only measure gestational age (and thus expected delivery date) in weeks, we used a "donut hole" RD method, excluding women with an expected delivery date within 7 days of her 35th birthday.[103] In addition, we plotted outcomes by the running variable to visually inspect the discontinuities in the outcome at the AMA cutoff.

We conducted a subgroup analysis among women with a low-risk pregnancy--defined as women with a singleton gestation without chronic or gestational diabetes, chronic or pregnancy-related hypertension, or obesity—since these women would be less likely to have an indication for additional prenatal care services separate from maternal age (Appendix Table 3.5).[104]

Analyses were implemented using R v3.6.1. Local linear regressions were estimated using the 'rdd' package. The threshold of $p<0.05$ was used for statistical significance.

Sensitivity Analyses

Following the RD literature, we conducted a number of sensitivity analyses and falsification tests. First, we used a McCrary test to test whether the number of deliveries was smooth across the age 35 cutoff.[105] Second, we tested for significant changes in maternal or fetal characteristics

across the cutoff (Appendix Table 3.5). Third, we tested whether the likelihood of a pregnancy ending in abortion or miscarriage jumped at the age 35 cutoff, as described in the Appendix. Fourth, we show that our results are not sensitive to the choice of bandwidth or to the inclusion of covariates. Finally, we verified that providers were in fact identifying women as AMA based on age on the calculated expected delivery date by testing for changes in whether the woman had a diagnosis code for "elderly primigravida and/or multigravida" at the cutoff.

We also explored several additional outcomes, including severe maternal morbidity (SMM, as defined by the Centers for Disease Control and Prevention), maternal intensive care unit (ICU) admissions, and neonatal ICU (NICU) admission.[106] Full details of all sensitivity analyses are provided in the Appendix.

Results

Sample Characteristics

A total of 51,290 women met all sample selection criteria and had an expected delivery date within 120 days of their 35th birthday (Appendix Table 3.6). Among these women, 33,199 (64.7%) had a low-risk pregnancy (Table 3.1). Prenatal care services were common in this age range, with nearly half of women visiting an MFM specialist, nearly three-quarters receiving aneuploidy screening, over 40% receiving a detailed ultrasound, and more than half receiving at least one fetal non-stress test or biophysical profile. Low-risk pregnancies were somewhat less likely to have antepartum fetal surveillance, labor induction, cesarean delivery, or to result in perinatal mortality.

Table 3.1: Characteristics of Women Within 120 Days of Age 35 on the Expected Date of Delivery

	All Women		Women with Low-Risk Pregnancy	
Characteristics	**34.7-34.9 years**	**35.0-35.3 years**	**34.7-34.9 years**	**35.0-35.3 years**
Total Deliveries	26,108	25,182	16,942	16,257
Prenatal Care Services				
Total OBGYN visits	8.44 (6.25)	8.92 (6.43)	7.21 (5.31)	7.73 (5.55)
Any visit with MFM specialist	12,991 (49.76%)	14,104 (56.01%)	7,588 (44.79%)	8,392 (51.62%)
Any aneuploidy screening	19,448 (74.49%)	19,328 (76.75%)	12,431 (73.37%)	12,310 (75.72%)
Serum analyte	17,569 (67.29%)	15,746 (62.53%)	11,242 (66.36%)	9,920 (61.02%)
Cell-free DNA	3,877 (14.85%)	6,871 (27.29%)	2,390 (14.11%)	4,337 (26.68%)
Invasive test	712 (2.73%)	1,065 (4.23%)	422 (2.49%)	625 (3.84%)
Total ultrasound visits	5.45 (3.88)	5.83 (4.07)	4.57 (3.03)	4.96 (3.3)
Any detailed ultrasound	11,270 (43.17%)	16,195 (64.31%)	6,532 (38.56%)	10,070 (61.94%)
Any antepartum fetal surveillance	13,539 (51.86%)	14,507 (57.61%)	7,146 (42.18%)	7,967 (49.01%)
Fetal non-stress test	10,664 (40.85%)	11,454 (45.48%)	5,445 (32.14%)	6,103 (37.54%)
Biophysical profile	7,844 (30.04%)	8,643 (34.32%)	3,779 (22.31%)	4,400 (27.07%)
Delivery-Related Practices				
Cesarean delivery	10,467 (40.09%)	10,173 (40.4%)	6,021 (35.54%)	5,794 (35.64%)
Induction of labor	4,189 (16.04%)	4,121 (16.36%)	2,537 (14.97%)	2,467 (15.18%)
Diagnoses				
High-risk pregnancy diagnoses	9,166 (35.11%)	8,925 (35.44%)	0 (0%)	0 (0%)
Preexisting diabetes	1,226 (4.7%)	1,212 (4.81%)	0 (0%)	0 (0%)
Gestational diabetes	3,761 (14.41%)	3,636 (14.44%)	0 (0%)	0 (0%)
Chronic hypertension	1,138 (4.36%)	1,127 (4.48%)	0 (0%)	0 (0%)
Gestational hypertension	1,300 (4.98%)	1,211 (4.81%)	0 (0%)	0 (0%)
Preeclampsia	718 (2.75%)	712 (2.83%)	0 (0%)	0 (0%)
Eclampsia	86 (0.33%)	87 (0.35%)	0 (0%)	0 (0%)
Obesity	2,529 (9.69%)	2,434 (9.67%)	0 (0%)	0 (0%)
Multiple gestation	1,198 (4.59%)	1,209 (4.8%)	0 (0%)	0 (0%)
Perinatal Outcomes				
Perinatal mortality	245 (0.94%)	227 (0.9%)	70 (0.41%)	56 (0.34%)
Preterm birth	3,143 (12.04%)	3,149 (12.5%)	1,339 (7.9%)	1,373 (8.45%)

Abbreviations*: OBGYN = obstetrician-gynecologist; MFM = maternal-fetal medicine.*

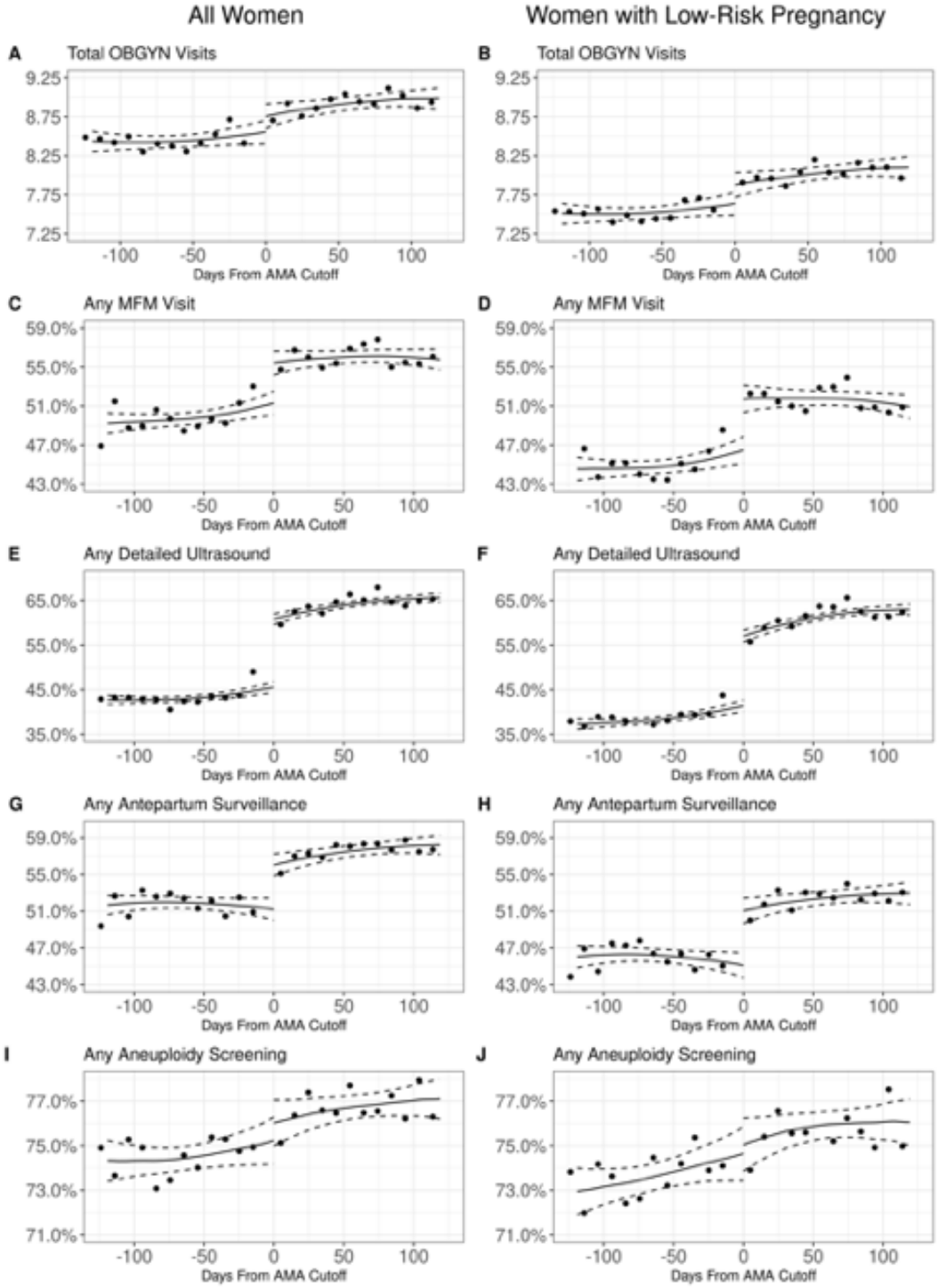
Notes:

Sample includes all women with a delivery during the study period (2008-2019) who turned age 35 within 120 days of the expected delivery date. The expected delivery date (assuming 40 weeks gestation) was defined based on the actual delivery date and gestational age at delivery. Women were required to have continuous eligibility during entire pregnancy period, have a non-missing zip code of residence in the data, and also have at least one outpatient visit and one ultrasound during pregnancy. Women who turned age 35 within 7 days of the expected delivery date were excluded since gestational age is only measured in weeks in the data.

Prenatal Care Services

Prenatal care services increased gradually with maternal age, but visible jumps were observed at the age 35 cutoff (Figure 3.1). Among the full sample, AMA was not associated with total OBGYN visits but was associated with a 4.3%-point (ppt) increase in MFM visits (95% CI: 0.023, 0.063; p<0.001) (Table 3.2). AMA was also associated with increased ultrasound use: 0.22 increase in total ultrasounds (95% CI; 0.070, 0.373; p=0.004) and 15.7-ppt increase in any detailed ultrasound (95% CI: 0.137, 0.177; p<0.001). AMA was associated with a 5.0-ppt increase in antepartum fetal surveillance (95% CI: 0.030, 0.070; p<0.001). Finally, AMA was not associated with any changes in aneuploidy screening, as aneuploidy screening shifted from serum analyte screening toward cell-free DNA and invasive genetic tests at the cutoff (Appendix Figure 3.2). The associations between AMA and prenatal care services were similar—though, in all cases, larger—for the subgroup of women with a low-risk pregnancy (Table 3.2).

Figure 3.1: Prenatal Monitoring and Testing by Weeks Relative to Age 35 on Expected Delivery Date



Notes: Figures represent binned outcomes for sample of women with an expected delivery date within 120 days of her 35th birthday. Women with an expected delivery date within 7 days of the 35th birthday were excluded. Solid line represents the local linear regression results for the regression discontinuity analyses. Dotted lines represent the 95% confidence intervals.

Table 3.2: Local Linear Regression Estimates of Association between AMA and Prenatal Care Services, Delivery-Related Practices, and Perinatal Outcomes

	All Women (N = 51,290)		Women with Low-Risk Pregnancy (N = 33,199)	
	Adjusted		Adjusted	
Outcomes	**Coefficient (95% CI)**	**P-value**	**Coefficient (95% CI)**	**P-value**
Prenatal Care Services				
Total OBGYN visits	0.236 (-0.008, 0.480)	0.058	0.322 (0.046, 0.598)	0.022*
Any MFM visit	0.043 (0.023, 0.063)	0.000***	0.056 (0.031, 0.081)	0.000***
Total ultrasounds	0.222 (0.070, 0.373)	0.004**	0.236 (0.076, 0.397)	0.004**
Any detailed ultrasound	0.157 (0.137, 0.177)	0.000***	0.168 (0.143, 0.193)	0.000***
Any antepartum fetal surveillance	0.050 (0.030, 0.070)	0.000***	0.067 (0.041, 0.093)	0.000***
Non-stress test	0.035 (0.015, 0.055)	0.001***	0.051 (0.027, 0.076)	0.000***
Biophysical profile	0.038 (0.020, 0.056)	0.000***	0.048 (0.026, 0.069)	0.000***
Any aneuploidy screening	0.010 (-0.008, 0.028)	0.262	0.012 (-0.010, 0.035)	0.274
Serum analyte	-0.040 (-0.059, -0.021)	0.000***	-0.041 (-0.065, -0.016)	0.001***
Cell-free DNA test	0.094 (0.080, 0.109)	0.000***	0.091 (0.074, 0.108)	0.000***
Invasive genetic test	0.011 (0.004, 0.018)	0.004**	0.008 (-0.001, 0.018)	0.073
Delivery-Related Practices				
Induction of labor	0.004 (-0.011, 0.020)	0.595	0.007 (-0.011, 0.026)	0.440
Cesarean delivery	0.007 (-0.013, 0.028)	0.491	-0.012 (-0.037, 0.013)	0.356
Perinatal Outcomes				
Perinatal mortality	-0.004 (-0.008, 0.000)	0.040*	-0.004 (-0.007, -0.001)	0.014*
Preterm birth	0.006 (-0.007, 0.020)	0.376	0.002 (-0.012, 0.017)	0.757

***Abbreviations**: CI = confidence interval; OBGYN = obstetrician-gynecologist; MFM = maternal-fetal medicine.*
**p <0.05, ** p<0.01, ***p<0.001*

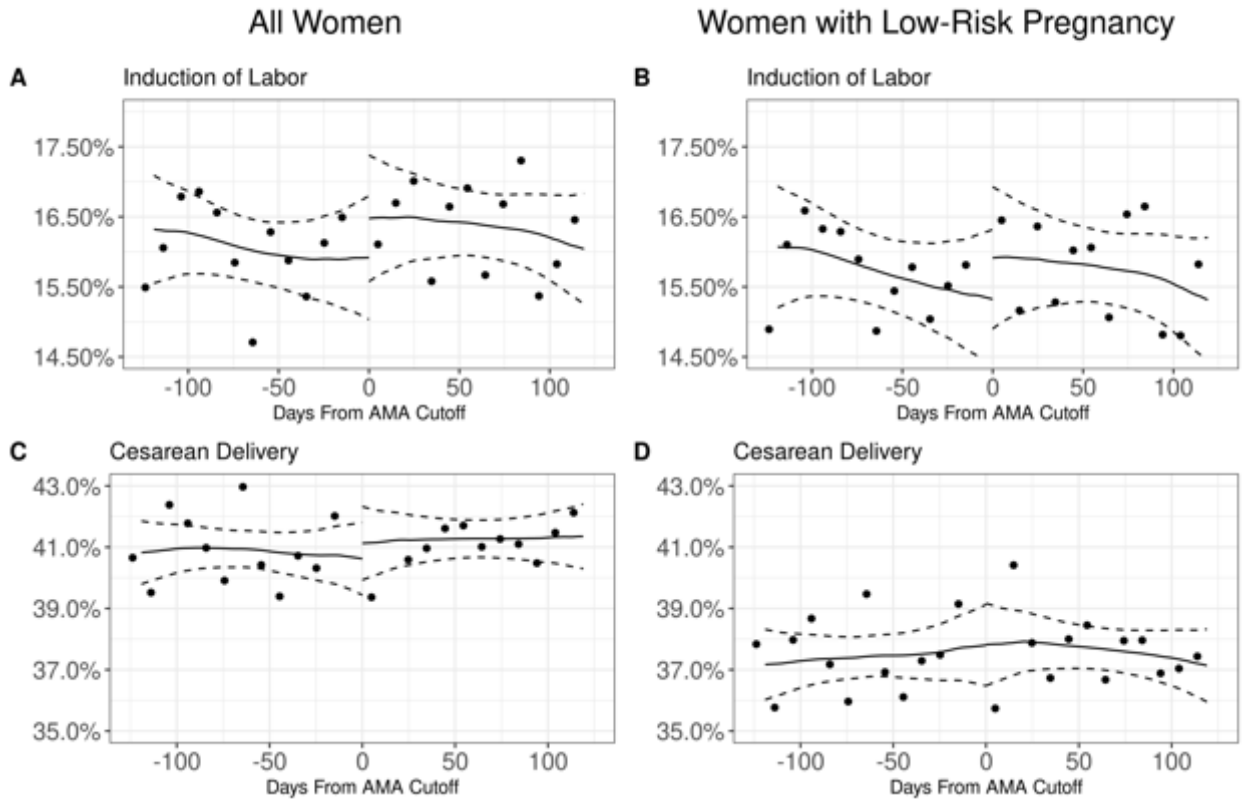
Notes:

1. Sample includes all women with an expected delivery date within 120 days of her 35th birthday. Women with an expected delivery date within 7 days of the 35th birthday were excluded.
2. Women with a low-risk pregnancy include all women without a diagnosis code for chronic or gestational diabetes, chronic or pregnancy-related hypertension, obesity, or multiple gestation.
3. All regressions control for individual-level characteristics (chronic and gestational diabetes, chronic and pregnancy-related hypertension, obesity, multiple gestation), zip-code characteristics (percent white, percent Hispanic, median household income, and whether the zip code is urban), and county-level characteristics (any hospital with neonatal intensive care unit and OBGYNs per 10,000 deliveries). All regressions include state of residence, year, and month of delivery fixed effects.

Delivery-Related Practices

AMA was not significantly associated with labor induction or cesarean delivery for either the full sample or those with a low-risk pregnancy (Figure 3.2, Table 3.2).

Figure 3.2: Delivery-Related Practices by Weeks Relative to Age 35 on Expected Delivery Date

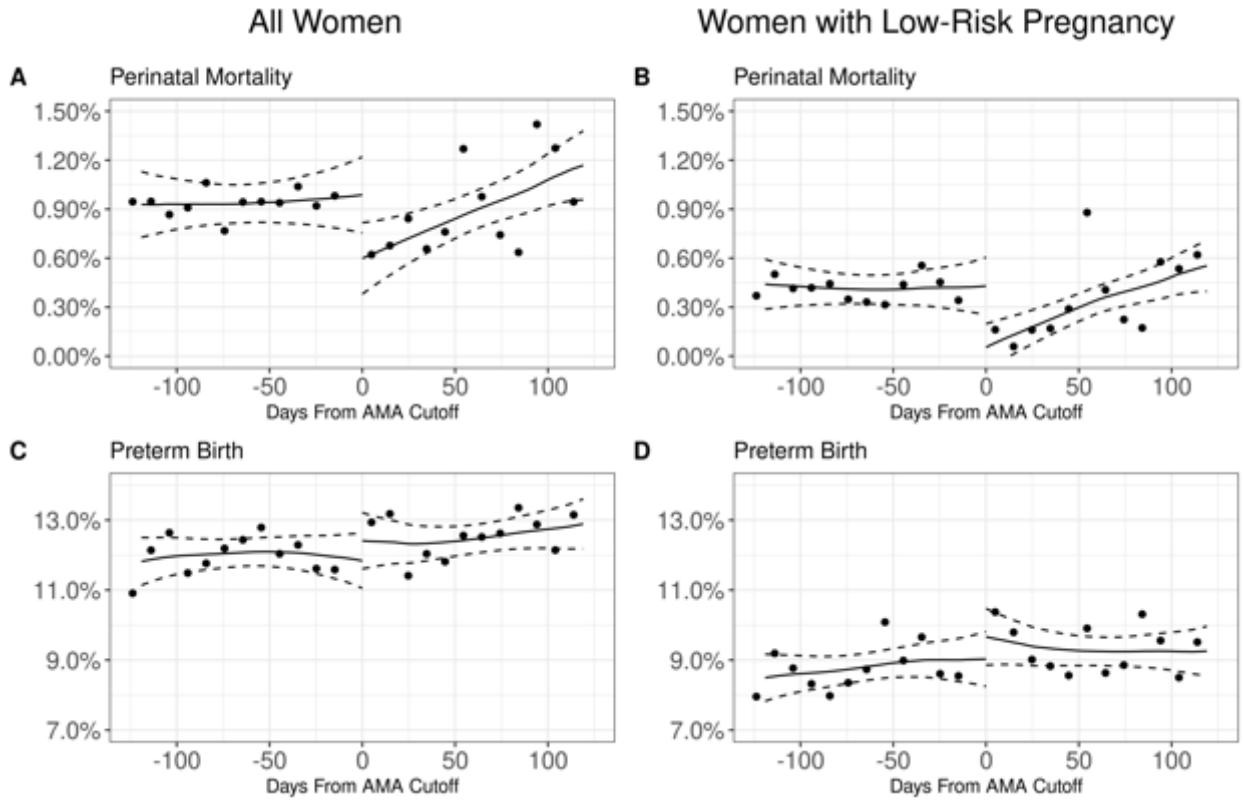


Notes: Figures represent binned outcomes for sample of women with an expected delivery date within 120 days of her 35th birthday. Women with an expected delivery date within 7 days of the 35th birthday were excluded. Solid line represents the local linear regression results for the regression discontinuity analyses. Dotted lines represent the 95% confidence intervals.

Perinatal Outcomes

Visually, perinatal mortality appeared to drop discontinuously at the age 35 cutoff (Figure 3.3). In the RD analyses, AMA was associated with a 0.4-ppt decline in perinatal mortality in the full sample (95% CI: -0.0078, -0.0002, p=0.040; Table 3.2) and among women with a low-risk pregnancy (95% CI: -0.0072, -0.0002; p=0.014). No association between AMA and preterm birth was found.

Figure 3.3: Perinatal Outcomes by Weeks Relative to Age 35 on Expected Delivery Date



Notes: Figures represent binned outcomes for sample of women with an expected delivery date within 120 days of her 35th birthday. Women with an expected delivery date within 7 days of the 35th birthday were excluded. Solid line represents the local linear regression results for the regression discontinuity analyses. Dotted lines represent the 95% confidence intervals.

Sensitivity Analyses

In the sensitivity analyses, we did not find any discontinuity in the number of deliveries at the AMA cutoff (Appendix Figure 3.1), and AMA was also not associated with any changes in maternal or pregnancy characteristics (Appendix Table 3.7) or the proportion of pregnancies that resulted in an abortion or miscarriage (Appendix Table 3.8). Results were also consistent using 90 and 150-day bandwidths (Appendix Tables 3.9-3.10) and when regressions were run without covariate adjustment (Appendix Table 3.11). A 50.5-ppt (95% CI: 0.487, 0.522; $p<0.001$) increase in the proportion of women with a diagnosis code for elderly primigravida and/or multigravida was estimated at the AMA cutoff (Appendix Table 3.12, Appendix Figure 3.3). Finally, no significant changes in SMM, ICU, or NICU admissions were found at the cutoff (Appendix Table 3.13).

Discussion

In this national sample of privately-insured pregnant women who were close to their 35th birthday, we found pronounced jumps in prenatal care services as her expected delivery date crossed her 35th birthday, the age threshold frequently used to indicate "Advanced Maternal Age". The AMA cutoff was significantly associated with MFM specialist visits and with the use of detailed ultrasounds and antepartum surveillance tests, but no changes in changes in delivery-related practices. The AMA cutoff was associated with a substantial decline in perinatal mortality.

Maternal and fetal risks are known to increase with maternal age. To our knowledge, no evidence exists suggesting that these risks change abruptly at age 35. The age 35 threshold was historically set for routinely offering invasive diagnostic testing for trisomy 21, based on clinical

consensus using available evidence in 1979.[107] It has since been extrapolated to other maternal and fetal risks during pregnancy and is now commonly used in clinical obstetrics to justify increased antenatal screening.[108,109] As maternal mortality and morbidity continue to rise in the U.S. despite increasing intervention and monitoring of pregnancy and delivery, experts have called for a fresh look at the evidence-base for commonly-used guidelines in clinical obstetrics.[110] In addition, as rates of perinatal mortality remain unchanged in recent years, it is critical to investigate what aspects of care can improve perinatal outcomes.[99]

The association between maternal age and aneuploidy and congenital anomalies has been well established.[111,112] We observed changes in prenatal diagnosis practices (ultrasound and aneuploidy screening) across the threshold. The increased use of cell-free DNA across the threshold likely reflects in part the clinical guidance issued by some professional societies, including the American College of Obstetricians and Gynecologists (ACOG), which initially recommended the use of this test primarily for "high risk" populations, including women over age 35.[113] The observed practice patterns may also reflect the fact that many insurers required women to be at increased risk (including over age 35) to justify the costs for these services.[95,96] Despite the observed changes in prenatal diagnosis screening across the threshold, we did not observe differences in pregnancy terminations or miscarriages, implying that the baseline risk for other outcomes in the study, namely stillbirth, of ongoing pregnancies was unlikely altered by the changes in screening tests.

Similarly, increasing maternal age is associated with an increased underlying risk of perinatal mortality. Multiple observational studies have demonstrated the role of antepartum fetal

surveillance in identifying fetuses at increased risk for stillbirth and it is widely incorporated into clinical practice.[114–117] However, guidelines for the indications and frequency of use are often based on expert opinion as randomized clinical trial data do not exist.[118] ACOG and the Society for Maternal-Fetal Medicine (SMFM) acknowledge the lack of insufficient evidence supporting antepartum fetal surveillance for AMA and do not explicitly recommend that AMA be used as a sole indication for testing.[91,118,119] However, we observed a roughly 10% (15%) jump in antepartum surveillance testing at age 35 in the full sample (low-risk sample), suggesting that some providers use AMA as a criteria to initiate screening in the absence of other comorbidities.

Previous research has found increases in cesarean delivery among women over age 35.[120,121] In addition, increases in monitoring during pregnancy have been associated with a "cascade of care", leading to additional interventions during delivery.[122] However, we did not find an association between the AMA designation and labor induction or cesarean delivery. This difference from previous literature may be attributed to our study design, which isolated the effect of the AMA designation and removes the potential bias from the continuous increase in risk factors for these interventions with maternal age.

The AMA cutoff was associated with a 0.4 ppt decline in perinatal mortality, equivalent to a 39.9% decline in the full sample and an 85.7% decline for low-risk pregnancies. This finding is consistent with a prior study, which found that women over age 35 who underwent weekly antenatal testing had rates of stillbirth comparable to younger women.[92] The decline in perinatal mortality, combined with increases in the use of antepartum fetal surveillance, suggests that the increased monitoring or interventions associated with the AMA designation may have averted

some perinatal deaths in this cohort. We hypothesize that this association may have been larger among the low-risk subgroup as they were less likely to have other indications for antepartum testing (i.e., more opportunity to observe the isolated effects of the AMA designation). However, we are unable to ascertain or fully understand the causal pathway between the AMA designation and lower risk of perinatal mortality as there are many aspects of clinical care and decision-making that are not captured in claims data. Overall, our results suggest that some aspects of provider decision-making and intervention that change at age 35 are having sizeable benefits in reductions in perinatal mortality, but more research is needed on precisely which aspects of care are facilitating this important outcome.

Limitations

This study faces several limitations. First, claims data for maternity services may not include all relevant visits and services, because a global billing code/single payment is often used for prenatal, intrapartum, and postpartum care. However, genetic tests, laboratory tests, and non-routine aspects of care, including antepartum fetal surveillance, are often be billed separately and observable in claims. With an average of 16.8 outpatient encounters and 8.4 OBGYN visits during pregnancy, it seems unlikely we are missing many visits. Second, diagnosis codes switched from ICD-9 to ICD-10 during our study period, which appears to have initially reduced the coding of induction of labor but improved the recording of gestational age (Appendix Table 3.2). As these changes affected women above and below the age 35 threshold equally, their effects on the related outcomes are limited. Third, our findings may not be generalizable to women with different types of insurance.

As with all quasi-experimental methods, there is potential for unmeasured confounding. We find no evidence that the age 35 cutoff is significantly associated with maternal or infant characteristics, the number of deliveries, or the likelihood of abortion or miscarriage, supporting the identifying assumptions of the RD design. However, claims data limits the number of covariates that could be explored and there is still a possibility that the sample composition changes across the cutoff.

Finally, the results may not be generalizable to women very far from the AMA cutoff, as much older or younger women may differ markedly in terms of chronic conditions and other pregnancy risk factors.

Conclusions

In sum, the designation of "advanced maternal age" using the arbitrary, yet clinically adopted cutoff of age 35, is associated with increased use of prenatal care services and various risk-screening interventions for this privately insured national sample of women. The designation was associated with declines in perinatal mortality for women just above the age 35 cutoff, suggesting that either the measured or potentially unmeasured differences in clinical practice at this cutoff may be improving perinatal outcomes. Additional research is needed to clarify who can benefit from increased prenatal care services and what age cutoff is appropriate to best target women at high risk of poor perinatal outcomes.

Appendix for Chapter 1

Appendix Table 1.1: All Births to First-Time Parents Included in PRAMS Sample

State	2009	2010	2011	2012	2013	2014	2015	2016	2017	Total
Alabama						320	300		266	886
Alaska	330	329		244	401	390	380	307	286	2667
Arkansas	381	459	358	234	298		240	269		2239
Colorado	691	690	655	412	608		669	603	372	4700
Connecticut						458	365	500	538	1861
Delaware	387	384	355	353	359	331	330	331	293	3123
Georgia	279	338	363	273	245				306	1804
Hawaii	572	531	553	513	525	439	21	375		3529
Illinois	495	489	521	371	487	465	515	452	412	4207
Iowa					320	294	287	274	260	1435
Kansas									326	326
Kentucky									207	207
Louisiana							558	270	258	1086
Maine	463	490	443	289	327	385	378	356	375	3506
Maryland	515	500	463	377	498	497	449	425	368	4092
Massachusetts	576	604	656	567	609	609	527	485	581	5214
Michigan	473	456	551	615	627		533	549	589	4393
Minnesota	443	418	482	325	472					2140
Mississippi	415									415
Missouri	464	515	434	268	378	396	379	350	349	3533
Montana									306	306
Nebraska	514	566	490	356	504	451	430	444		3755
New Hampshire					253	260	248	264	271	1296
New Jersey	533	503	506	405	335	483	410	455	430	4060
New Mexico			440	248	435	386	395	323	323	2550
New York		955	961	615	870	874	935	899	818	6927
North Carolina									381	381
North Dakota									160	160
Ohio	414	422		579		543	491			2449
Oklahoma	700	671	653	592	636	641	628	516	453	5490
Oregon	543	607	572	283	546		504			3055
Pennsylvania	393	387	371	278	405	387	404	359	438	3422
Rhode Island	424	424	440	418	370	405		397	395	3273
South Dakota									292	292
Tennessee	248			284	244	245	335			1356
Texas	448	495					419	601		1963
Utah	389	397	349	385	377	368	337	388	397	3387
Virginia							266	235	383	884
Vermont	426	409	424	406	389	390	330	339	329	3442
Washington	537	564	395	361	380	421	409	457	445	3969
West Virginia	528	499	518	398	510	427	390	248	232	3750
Wisconsin	263		407	374	421	415	389	336	381	2986
Wyoming	255	308	228	193	201	199	166	192	134	1876
Total births	13099	13410	12588	11016	13030	11479	13417	11999	12354	112392

Note:
Sample counts are raw counts of births to first-time parents and are not weighted. Sample limited to all first-time parents aged 20-44 years who gave birth between 2009 and 2017. Individuals with no information on previous number of births, marital status, education, age, race, ethnicity, or time since delivery were excluded.
Source:
Authors' analysis of Pregnancy Risk Assessment Monitoring Survey (PRAMS) data pooled from Phase 6 (2009-2011), Phase 7 (2012-2015), and Phase 8 (2016-2017).

Appendix Table 1.2: Sample Selection

	Sample Size	Sample Size (Weighted)
All births included in PRAMS 2009-2017	333,359	16,848,426
No previous live birth (first-time parents)	135,438	6,715,450
Aged 20-44 years at time of delivery	115,112	5,748,527
Known time since delivery	115,071	5,747,391
Known marital status	114,983	5,745,527
Known educational status	113,832	5,700,931
Known race/ethnicity	112,392	5,643,370

Note:
Sample restricted to first-time parents with a live birth between 2009 and 2017. Weighted sample size calculated using the weights provided by the Center for Disease Control in the Pregnancy Risk Assessment Monitoring Survey (PRAMS) data.

Source:
Authors' analysis of PRAMS data from pooled Phase 6 (2009-2011), Phase 7 (2012-2015), and Phase 8 (2016-2017).

Medicaid Eligibility Index

The Medicaid eligibility index has been used in a number of studies examining the impact of Medicaid expansions in different populations and has been widely accepted as valid. The index was first described in the Appendix of Currie and Gruber (1996) and it has continued to be used in research.[123] For example, in *Health Services Research*, Wherry (2018) used the Medicaid eligibility index to examine changes in preconception coverage for multiparous individuals in 1997-2012.[28] More recently, the Medicaid eligibility index has been used to evaluate the impact of Medicaid expansions under the ACA. For example, Margerison et al. (2019) examined the impact of increasing Medicaid eligibility among women of reproductive age using both difference-in-differences methods and an eligibility index and highlights the need for the index to capture variation in eligibility across states and over time.[37] In addition, Palmer (2020) also used a Medicaid eligibility index to examine the impact of Medicaid expansions under the ACA on birth rates.[43]

The Medicaid eligibility index was calculated using the 2008-2016 Annual Social and Economic Supplement (ASEC) of the Current Population Survey (CPS). Specific steps to calculate the eligibility index and sources are specified below:

1. Identified all female-identifying aged 20-44 years without any dependent children in the 2008-2016 CPS ASEC. These individuals were selected since they would be eligible as a childless adult prior to pregnancy.
2. Calculated household size for all female-identifying individuals aged 20-44. Household size was determined using the relationship and dependency status variables to be

consistent with Medicaid eligibility criteria since not all individuals in the CPS household may count towards the Medicaid household size. These eligibility rules were based on training provided by the Center for Medicaid and Medicare Services.[124]

3. Calculated household income for all female-identifying individuals aged 20-44. Similar to household size, household income was determined using the relationship and tax dependency variables to be consistent with Medicaid eligibility rules. Household income was calculated only using the specific types of income included in the Medicaid eligibility rules. Total household income was calculated using both the original methods used by states as well as using the Modified Adjusted Gross Income (MAGI) rules which went into effect in October of 2013.[36,124,125]
4. Calculated income as a percent of the Federal Poverty Limit (FPL) for all female-identifying individuals aged 20-44 using the Medicaid-specific household income and household size. FPL was determined using the poverty thresholds used for federal programs published by the Assistant Secretary for Planning and Evaluation (ASPE) in each year (2008-2016).[126] Income as a percent of FPL was calculated using the FPL thresholds published by ASPE separately for the 48 continental states, Hawaii, and Alaska.
5. Estimates of income as a percent of the FPL were pooled for all female-identifying individuals aged 20-44 across all years. Income as a percent of FPL was compared with published Medicaid income eligibility limits throughout the study period to calculate the percent of female-identifying individuals that would have been eligible as a childless adult prior to pregnancy. Medicaid eligibility limits only included comprehensive Medicaid coverage for childless adults (Appendix Table 1.3). Income as a percent of FPL

calculated using MAGI rules was used for the eligibility index starting in 2014. Percent eligible for Medicaid and Hawaii was determined using income as a percent of FPL based on the FPL thresholds specific to Alaska and Hawaii.

Appendix Table 1.3: Medicaid Eligibility Limit Changes and Sources

States in PRAMS that Increased Eligibility Limit During Study Period	***Date of Change in Eligibility Limit[a]***	***Change in Eligibility Limit***
Alaska	0 to 138% FPL	9/1/2015
Arkansas	0 to 138% FPL	1/1/2014
Colorado	0 to 10% FPL	4/1/2012
Colorado	10 to 138% FPL	1/1/2014
Connecticut[31,127]	0 to 56% FPL	4/1/2010
Connecticut	56 to 138% FPL	1/1/2014
Delaware[128,129]	110 to 138% FPL	1/1/2014
Hawaii[129]	100% to 138% FPL	1/1/2014
Illinois	0 to 138% FPL	1/1/2014
Iowa	0 to 138% FPL	1/1/2014
Kentucky	0 to 138% FPL	1/1/2014
Louisiana	0 to 138% FPL	7/1/2016
Maryland	0 to 138% FPL	1/1/2014
Massachusetts[b,129]	100 to 138% FPL	1/1/2014
Michigan[130]	0 to 138% FPL	4/1/2014
Minnesota[31]	0 to 75% FPL	3/1/2011
Minnesota	75 to 138% FPL	1/1/2014
Montana	0 to 138% FPL	1/1/2016
New Hampshire[131]	0 to 138% FPL	8/15/2014
New Jersey[31]	0 to 23% FPL	4/14/2014
New Jersey	23 to 138% FPL	1/1/2014
New Mexico	0 to 138% FPL	1/1/2014
New York[31,132]	100 to 138% FPL	1/1/2014
North Dakota	0 to 138% FPL	1/1/2014
Ohio	0 to 138% FPL	1/1/2014
Oregon	0 to 138% FPL	1/1/2014
Pennsylvania[133]	0 to 138% FPL	1/1/2015
Rhode Island	0 to 138% FPL	1/1/2014
Vermont[129,134]	160 to 138% FPL	1/1/2014
Washington[c,31]	0 to 138% FPL	1/1/2014
West Virginia	0 to 138% FPL	1/1/2014
Wisconsin	0 to 100% FPL	1/1/2014

Abbreviations: *FPL, Federal Poverty Limit*

Note:

a) Medicaid eligibility income limits were identified from the Kaiser Family Foundation Medicaid Income Eligibility Limit tracker.[135] Additional references for changes in eligibility are included when applicable.

b) Massachusetts covered long-term unemployed childless adults up to 100% FPL prior to 2014 through MassHealth Essential coverage. Although this coverage is limited, due to the number of services and to be consistent with prior research, this plan was included in the analyses.[136,137]

c) Washington expended Medicaid early on 1/3/2011 from 0 to 133% of FPL; however, this expansion primarily transitioned prior enrollees from the state-funded Basic Health Plan to Medicaid. Therefore, this early expansion was not included.[138]

Appendix Table 1.4: Medicaid Generosity Index for States in PRAMS Sample

	Medicaid Generosity Index		
State	**2008**	**2016**	**Percentage Point Change 2008-2016**
Alabama	0%	0%	0%
Alaska	0%	40%	40%
Arkansas	0%	34%	34%
Colorado	0%	34%	34%
Connecticut	0%	34%	34%
Delaware	30%	34%	5%
Georgia	0%	0%	0%
Hawaii	30%	38%	7%
Illinois	0%	34%	34%
Iowa	0%	34%	34%
Kansas	0%	0%	0%
Kentucky	0%	34%	34%
Louisiana	0%	0%	0%
Maine	0%	0%	0%
Maryland	0%	34%	34%
Massachusetts	28%	34%	7%
Michigan	0%	34%	34%
Minnesota	0%	34%	34%
Mississippi	0%	0%	0%
Missouri	0%	0%	0%
Montana	0%	34%	34%
Nebraska	0%	0%	0%
New Hampshire	0%	34%	34%
New Jersey	0%	34%	34%
New Mexico	0%	34%	34%
New York	28%	34%	7%
North Carolina	0%	0%	0%
North Dakota	0%	34%	34%
Ohio	0%	34%	34%
Oklahoma	0%	0%	0%
Oregon	0%	34%	34%
Pennsylvania	0%	34%	34%
Rhode Island	0%	34%	34%
South Dakota	0%	0%	0%
Tennessee	0%	0%	0%
Texas	0%	0%	0%
Utah	0%	0%	0%
Virginia	0%	0%	0%
Vermont	36%	34%	-2%
Washington	0%	34%	34%
West Virginia	0%	34%	34%
Wisconsin	0%	28%	28%
Wyoming	0%	0%	0%
Mean (standard deviation)	4% (10%)	22% (17%)	18% (17%)

Note:
The Medicaid generosity index was calculated as the fraction of all female-identifying individuals aged 20-44 years without dependent children in the Current Population Survey Annual Social and Economic Supplement who would be eligible for Medicaid as childless adult given each state's income thresholds in each year. Medicaid eligibility in a given state and year was estimated for all female-identifying individuals based on household income reported in previous calendar year, household size, and states' income thresholds.

Appendix Table 1.5: Measurement of Outcomes of Interest by PRAMS

Outcome	Question in PRAMS	Response Options	Notes
Preconception insurance coverage	Phase 6: During the month before you got pregnant with your new baby, were you covered by any of these health insurance plans? Phases 7/8: During the month before you got pregnant with your new baby, what kind of health insurance did you have?	Phase 6: • Health insurance from your job or the job of your husband, partner, or parents • Health insurance that you or someone else paid for (not from a job) • Medicaid • TRICARE or other military health care • Other source(s), please tell us: *[free text]* • I did not have any health insurance before I got pregnant Phase 7: • Private health insurance from my job or the job of my husband, partner, or parents • Private health insurance purchased directly from an insurance company • Medicaid • Some other kind of health insurance, please tell us: *[free text]* • I did not have any health insurance during the month before I got pregnant Phase 8: • Private health insurance from my job or the job of my husband or partner • Private health insurance from my parents • Private health insurance from the <*State*> Health Insurance Marketplace or <*state website*> or HealthCare.gov • Medicaid • Other health insurance, please tell us: *[free text]* • I did not have any health insurance during the month before I got pregnant	In addition to the responses provided by PRAMS, states could also include their own state-specific options for insurance coverage. Individuals who selected "Medicaid" or wrote in "Medicaid" under "Other" were categorized as having Medicaid for preconception insurance coverage. All other types of insurance coverage were classified as "Private/Other".

Appendix Table 1.5 (continued): Measurement of Outcomes of Interest by PRAMS

Outcome	Question in PRAMS	Response Options	Notes
Stress from bills	Phases 6/7: Pregnancy can be a difficult time for some women. The next questions are about things that may have happened before and during your most recent pregnancy. This question is about things that may have happened during the 12 months before your new baby was born. I had problems paying the rent, mortgage, or other bills.	Yes, no	Question not included in core questions for Phase 8 but was still included in survey by the majority of states so was included in our analysis.
Unintended pregnancy	Phases 6/7: When you got pregnant with your new baby, were you trying to get pregnant?	Yes, no	Question not included in core questions for Phase 8 but was still included in survey by the majority of states so was included in our analysis.
First-trimester prenatal care	Phases 6/7/8: How many weeks or months pregnant were you when you had your first visit for prenatal care?	Specify number of weeks or months	Total number of weeks calculated by PRAMS. Individuals were categorized as initiating prenatal care in first trimester if reported initiating care by week twelve.
Week of initiation of prenatal care in first trimester	Phases 6/7/8: How many weeks or months pregnant were you when you had your first visit for prenatal care?	Specify number of weeks or months	Outcome was continuous measure in weeks. Total number of weeks calculated by PRAMS. Limited to Individuals who initiated prenatal care within twelve weeks.
High blood pressure	Phases 6/7/8: Collected by PRAMS from the birth certificate.	Yes, no	PRAMS reports chronic high blood pressure and gestational hypertension from the birth certificate together.
Diabetes	Phases 6/7/8: Collected by PRAMS from the birth certificate.	Yes, no	PRAMS reports chronic diabetes and gestational diabetes from the birth certificate together.

Birth Rates

To test whether any changes in the maternal outcomes were due to changes in birth rates, this study also evaluated the association between birth rates and Medicaid generosity. State-level birth rates were calculated using state-identified, restricted access birth certificate data. The birth certificate data was obtained with permission from the National Center for Health Statistics at the CDC and includes all births that occurred in the United States between 2009 and 2017. The birth certificate data includes characteristics of the individual giving birth (e.g., age, education, marital status, race/ethnicity, and previous birth count) as well as select pregnancy characteristics and birth outcomes. The total number of births in each state, year, and month was calculated for all individuals aged 20-44 without a previous live birth. To calculate birth rates, population data for female-identifying individuals aged 20-44 years was obtained from the 1-year American Community Survey public use files. Birth rates were calculated as the total number of births to first-time parents aged 20-44 years divided by the total number of female-identifying individuals aged 20-44 in that state in the year of delivery. In addition, birth rates were calculated among individuals with a high school degree or less. Education attainment was only included in states that had adopted the 2003 revised birth certificate by the date of birth; therefore, birth rates for individuals with a high school degree of less are not available in every state and year.

To assess the association between birth rates and Medicaid generosity, state-level birth rates for first-time parents aged 20-44 years were regressed on the Medicaid generosity index in the state of birth in the year prior to delivery. In addition to the generosity index, the regression included time-varying, state-level characteristics, as previously described, and state and year fixed effects and the regressions were weighted by the total population size of female-identifying individuals

aged 20-44 in that state. Heteroskedasticity-robust standard errors were clustered at the state level. Regressions were estimated separately for the birth rates among all first-time parents as well as birth rates among individuals with a high school degree or less. In addition, regressions were estimated among all 50 states and DC as well as the subset of 43 states that contributed data to PRAMS.

During the study period, the national birth rate declined from 25.7 to 24.1 births to first-time parents per 1,000 female-identifying individuals aged 20-44. However, there was no significant association between the Medicaid generosity index in the preconception period and the overall birth rate for all individuals (coefficient: 0.001; p=0.505) or individuals with a high school degree or less (coefficient: 0.001; p=0.645). Results were similar among the 43 states included in PRAMS (Appendix Table 1.6).

Appendix Table 1.6: Regression Results for Birth Rates Among All First-Time Parents

	All	HS or Less
All States		
Index 10ppt, estimate (CI)	0.001 (-0.002, 0.004)	-0.006 (-0.034, 0.022)
P-value	0.505	0.667
Observations	474,000,000	428,000,000
Mean	3.218	3.074
All States in PRAMS		
Index 10ppt, estimate (CI)	0.001 (-0.003, 0.005)	0.003 (-0.029, 0.035)
P-value	0.645	0.847
Observations	352,000,000	311,000,000
Mean	3.222	3.064
All States and Years in PRAMS		
Index 10ppt, estimate (CI)	0.003 (-0.002, 0.008)	0.004 (-0.023, 0.030)
P-value	0.193	0.794
Observations	245,000,000	220,000,000
Mean	3.220	3.062

Abbreviations: *HS, high school; ppt, percentage points; CI, 95% confidence interval; PRAMS, Pregnancy Risk Assessment Monitoring Survey*

** p-value < 0.05; ** p-value <0.01; *** p-value < 0.001*

Notes:

Sample limited to all first-time parents aged 20-44 years with a live birth between 2009 and 2017 in the restricted access birth certificate data. State birth rates calculated using counts of all women aged 20-44 in the 1-year American Community Survey. Linear regressions of the birth rates on the eligibility index controlled for state-level characteristics (education, unemployment, median age, race, ethnicity, family planning programs, and contraceptive mandate). Educational attainment was only included in states that had adopted the 2003 revised birth certificate by the date of birth; therefore, birth rates for individuals with a high school degree of less are not available in every year. Regressions were weighted by the population size of female-identifying individuals aged 20-44 in that state and year.

Source:

Authors' analysis of restricted access birth certificate data (2009-2017) obtained from the National Center for Health Statistics at the Centers for Disease Control and Prevention and American Community Survey data.

Test for Pre-Trends

Our study methods rely on the assumption that outcomes in states that did not expand Medicaid are a valid counterfactual for outcomes in states that did expand Medicaid following the policy change. Although we cannot directly test this assumption, we can test the "parallel trends" assumption to examine whether trends in outcomes differed between states that did and did not expand Medicaid prior to the policy change. To test this assumption, we regressed the outcomes of interest on a continuous measure of the number of years since the beginning of the study period and an interaction between the number of years since the start of the study period and a dummy variable for whether the state expanded Medicaid during the study period. The regressions also included state and year fixed effects as well as all covariates that were included in the main regressions. Heteroskedasticity-robust standard errors were clustered at the state level. Regressions were weighted using the weights provided by PRAMS. Since we were testing pre-trends, the regressions included data before 2014 when the majority of states expanded Medicaid. If a state expanded Medicaid prior to 2014, data for the years in which Medicaid was expanded in those states were dropped.

Results are included below in Appendix Table 1.7-1.8. The coefficient of interest on the interaction between the number of years since the start of the study period and expansion status measures the difference in trends between states that did and did not expand Medicaid prior to the policy changes. This coefficient was only significant in the regressions for prenatal care in the first trimester among all individuals and private/other insurance coverage among individuals with a high school degree or less. These outcomes were not significant in the main regressions with the Medicaid eligibility index.

Appendix Table 1.7: Regression Results for Test for Pre-Trends for Preconception Insurance

	Preconception Insurance		
	Any Insurance	**Medicaid**	**Private/ Other**
All first-time parents			
Years * Expansion, estimate (CI)	0.007 (-0.003, 0.018)	0.003 (-0.001, 0.007)	0.004 (-0.006, 0.013)
P-value	0.157	0.173	0.419
Observations	57,034	57,034	57,034
Mean	0.77	0.07	0.71
High school or less			
Years * Expansion, estimate (CI)	-0.004 (-0.019, 0.011)	0.009 (-0.004, 0.023)	-0.017 (-0.032, -0.001)*
P-value	0.588	0.157	0.033
Observations	16,756	16,756	16,756
Mean	0.56	0.17	0.42

Abbreviations: *CI, 95% confidence interval*
** p-value < 0.05; ** p-value < 0.01; *** p-value < 0.001*

Note:
Sample restricted to first-time parents with a live birth between 2009 and 2013. The coefficient on the interaction between number of years since the start of the study period and the dummy variable for whether the state expanded during the study period (2009-2017) measures the difference in pre-trends. Linear regressions controlled for individual level characteristics (age, race, ethnicity, education, marital status, month of delivery, survey language, survey method, and time since delivery) and state-level characteristics (education, unemployment, median age, race, ethnicity, family planning programs, and contraceptive mandate). All regressions were estimated using the weights provided by the Center for Disease Control in the PRAMS data. If a state expanded Medicaid prior to 2014, data for the years in which Medicaid was expanded in those states were dropped.

Source:
Authors' analysis of PRAMS data pooled from Phase 6 (2009-2011), Phase 7 (2012-2015), and Phase 8 (2016-2017).

Appendix Table 1.8: Regression Results for Test for Pre-Trends for Preconception and Early Pregnancy Outcomes

			Prenatal Care		Diagnoses at Delivery	
	Stress from Bills	**Unintended Pregnancy**	**Week in 1st Trimester**	**1st Trimester**	**High Blood Pressure**	**Diabetes**
All first-time parents						
Years * Expansion, estimate (CI)	-0.002 (-0.009, 0.005)	-0.005 (-0.014, 0.004)	-0.027 (-0.088, 0.034)	-0.014 (-0.020, -0.007)***	-0.004 (-0.008, 0.001)	-0.001 (-0.005, 0.002)
P-value	0.625	0.279	0.377	0.000	0.096	0.377
Observations	57,206	56,934	49,384	56,756	57,418	57,436
Mean	0.18	0.44	7.31	0.87	0.08	0.04
High school or less						
Years * Expansion, estimate (CI)	-0.012 (-0.030, 0.005)	-0.001 (-0.017, 0.015)	-0.069 (-0.176, 0.038)	-0.025 (-0.041, -0.009)**	0.001 (-0.009, 0.010)	-0.003 (-0.009, 0.004)
P-value	0.155	0.891	0.197	0.003	0.864	0.443
Observations	16,872	16,825	13,080	16,667	17,055	17,062
Mean	0.25	0.59	7.29	0.77	0.08	0.05

Abbreviations: *CI, 95% confidence interval*
** p-value < 0.05; ** p-value < 0.01; *** p-value < 0.001*

Note:
Sample restricted to first-time parents with a live birth between 2009 and 2013. The coefficient on the interaction between number of years since the start of the study period and the dummy variable for whether the state expanded during the study period (2009-2017) measures the difference in pre-trends. Linear regressions controlled for individual level characteristics (age, race, ethnicity, education, marital status, month of delivery, survey language, survey method, and time since delivery) and state-level characteristics (education, unemployment, median age, race, ethnicity, family planning programs, and contraceptive mandate). All regressions were estimated using the weights provided by the Center for Disease Control in the PRAMS data. If a state expanded Medicaid prior to 2014, data for the years in which Medicaid was expanded in those states were dropped.

Source:
Authors' analysis of PRAMS data pooled from Phase 6 (2009-2011), Phase 7 (2012-2015), and Phase 8 (2016-2017).

Appendix Table 1.9: Regression Results for Inclusion of States in PRAMS

	State/Year Included
Index 10ppt, estimate (CI)	0.052 (-0.386, 0.490)
P-value	0.813
Observations	5,508
Mean	0.556

Abbreviations: *ppt, percentage points; CI, 95% confidence interval*
** p-value < 0.05; ** p-value < 0.01; *** p-value < 0.001*

Notes:
Indicator variable for whether a state or question was included in the Pregnancy Risk Assessment Monitoring Survey (PRAMS) data in a year was regressed on Medicaid eligibility index in that year. Linear regressions controlled and state-level characteristics (education, unemployment, median age, race, ethnicity, family planning programs, and contraceptive mandate).

Source:
Authors' analysis of PRAMS data pooled from Phase 6 (2009-2011), Phase 7 (2012-2015), and Phase 8 (2016-2017).

Appendix Table 1.10: Regression Results for Preconception Insurance Among All First-Time Parents with Higher Incomes

	Preconception Insurance		
	Any Insurance	**Medicaid**	**Private/ Other**
All first-time parents with income ≥ $50,000			
Index 10ppt, estimate (CI)	-0.001 (-0.004, 0.002)	0.001 (0.000, 0.003)	-0.003 (-0.006, 0.001)
P-value	0.535	0.100	0.102
Observations	44,783	44,783	44,783
Mean	0.98	0.01	0.97

Abbreviations: *ppt, percentage points; CI, 95% confidence interval*
** p-value < 0.05; ** p-value < 0.01; *** p-value < 0.001*

Note:
Sample restricted to first-time parents aged 20-44 years with a live birth between 2009 and 2017 with a household income ≥ $50,000. Linear regressions controlled for individual level characteristics (age, race, ethnicity, education, marital status, month of delivery, survey language, survey method, and time since delivery) and state-level characteristics (education, unemployment, median age, race, ethnicity, family planning programs, and contraceptive mandate). All regressions were estimated using the weights provided by the Center for Disease Control in the Pregnancy Risk Assessment Monitoring Survey data.

Source:
Authors' analysis of PRAMS data pooled from Phase 6 (2009-2011), Phase 7 (2012-2015), and Phase 8 (2016-2017).

Appendix Table 1.11: Regression Results for Pregnancy and Preconception Outcomes Among All First-Time Parents with Higher Incomes

			Prenatal Care		Diagnoses at Delivery	
	Stress from Bills	**Unintended Pregnancy**	**Week in 1st Trimester**	**1st Trimester**	**High Blood Pressure**	**Diabetes**
All first-time parents with income ≥ $50,000						
Index 10ppt, estimate (CI)	0.001 (-0.002, 0.004)	-0.006 (-0.011, 0.000)	0.003 (-0.001, 0.007)	0.003 (-0.001, 0.007)	0.000 (-0.005, 0.005)	0.001 (-0.002, 0.004)
P-value	0.600	0.056	0.115	0.115	0.886	0.502
Observations	41,868	42,757	44,624	44,624	44,985	44,991
Mean	0.05	0.21	0.96	0.96	0.08	0.05

Abbreviations: *ppt, percentage points; CI, 95% confidence interval*
** p-value < 0.05; ** p-value <0.01; *** p-value<0.001*

Note:
Sample restricted to first-time parents aged 20-44 years with a live birth between 2009 and 2017 with a household income ≥ $50,000. Linear regressions controlled for individual level characteristics (age, race, ethnicity, education, marital status, month of delivery, survey language, survey method, and time since delivery) and state-level characteristics (education, unemployment, median age, race, ethnicity, family planning programs, and contraceptive mandate). All regressions were estimated using the weights provided by the Center for Disease Control in the Pregnancy Risk Assessment Monitoring Survey data.

Source:
Authors' analysis of PRAMS data pooled from Phase 6 (2009-2011), Phase 7 (2012-2015), and Phase 8 (2016-2017).

Appendix for Chapter 2

Main Analyses

The regression model for the difference-in-differences analyses was specified as:

$$y_{ims} = \alpha_o + \beta_1 Age21_{im} + \beta_2 DrugCap + \beta_3 DrugCap_s * Age21_{im} + +X_i + \theta_s + \gamma_t + \epsilon_{ims}$$

In the regression model, the variable $Age21_{im}$ is a dummy variable that indicates whether the individual was age 21 or older in that month or quarter and $DrugCap_s$ is an indicator for whether the individual resides in one of the drug cap states (Arkansas or Texas). The coefficient of interest is β_3 which identifies the change in the outcome of interest before versus after age 21 in drug cap states compared with non-drug cap states. All outcomes were calculated in each month or quarter in the 12 calendar months before and after the month of an individual's 21st birthday. The month of an individual's twenty-first birthday was defined as a transition period and not included in the analyses. The regression adjusted for individual sex and race/ethnicity (white, black, or other) as well as whether the individual lived in an urban county (Rural Urban Continuum Codes 1-3) prior to turning age 21. Heteroskedastic-robust standard errors were clustered at the individual level. The functional form of the model differed based on the distribution of the outcomes of interest. Regressions were estimated using a zero-inflated negative binomial model for skewed count outcomes with a high proportion of zeros (i.e., prescription fills, total emergency department visits, inpatient length of stay, and spending) while logistic regressions were used for binary outcomes (i.e., any prescription fill, more than 3 prescription fills, and any inpatient visit).

All analyses were implemented using STATA/MP version 15. Results with p-values <0.05 were considered statistically significant.

Test for Pre-Trends

The difference-in-difference analysis relies on the assumption that the trends in the outcomes of interest would have been parallel in the absence of the policy change at age 21. Although this "parallel trends" assumption cannot be tested directly, we tested whether this assumption is plausible by testing whether the trends in the outcomes were parallel in the pre-policy period.

The regression model for the pre-trends test was specified as:

$$y_{ims} = \alpha_o + \beta_1 AMonths21_{im} + \beta_2 DrugCap_s + \beta_3 DrugCap_s * Months21_{im} + +X_i + \theta_s + \gamma_t + \epsilon_{ims}$$

In the regression model, the variable $Months21_{im}$is a continuous measure of the number of months until the individual turns age 21 (i.e., values range from 1-12) and $DrugCap_s$ is an indicator for whether the individual resides in one of the drug cap states (Arkansas or Texas). β_3 represents any difference in the trends in the outcomes in the drug cap states compared with the non-drug cap states prior to age 21. The regression only used data for the 12 calendar months before the individual turned age 21. Similar to the main analyses, the model also included state and calendar month and year fixed-effects as well as individual characteristics and heteroskedastic-robust standard errors that were adjusted for clustering at the individual level.

Results for the pre-trend analyses are included below in Appendix Table 2.6.

Appendix Table 2.1: Anatomic Therapeutic Chemical Classification for Drugs Used to Treat Mental Health Conditions

Type of Prescription Drug	ATC Class
Drugs to treat mental health conditions	N05, N06
Psycholeptics	N05
Antipsychotics	N05A
Anxiolytics	N05B
Hypnotics and sedatives	N05C
Psychoanaleptics	N06
Antidepressants	N06A
Psychostimulants	N06B
Psycholeptics and psychoanaleptics	N06C
Hormonal contraceptives	G03A

Abbreviations: *ATC = Anatomic Therapeutic Chemical*.

Appendix Table 2.2: Use of Prescription Drugs Before and After Implementation of Drug Cap Policy at Age 21 Among All Disabled Individuals

	All Disabled Individuals			
	Drug Cap States		Non-Drug Cap States	
	Pre	Post	Pre	Post
N	8,205	8,205	19,605	19,605
Monthly Prescription Drug Use				
Any prescription, n (%)	6,474 (78.9%)	6,438 (78.5%)	14,774 (75.4%)	14,867 (75.8%)
Average prescriptions, mean (SD)	1.58 (2.16)	1.39 (1.92)	1.82 (2.61)	1.90 (2.65)
Average total days supply, n (%)	43.24 (62.59)	40.26 (57.59)	47.61 (68.05)	50.24 (70.91)
Average % with > 3 prescriptions in month, mean (SD)	16.55 (28.60)	10.82 (25.84)	19.05 (31.74)	19.96 (32.52)
Any month with > 3 prescriptions, n (%)	3,433 (41.8%)	1,904 (23.2%)	8,164 (41.6%)	8,353 (42.6%)
Any Prescription Fill in ATC Class in Month, n (%)				
Drugs for mental health conditions	3,245 (39.5%)	3,150 (38.4%)	8,046 (41.0%)	8,122 (41.4%)
Psycholeptics	2,470 (30.1%)	2,383 (29.0%)	6,190 (31.6%)	6,243 (31.8%)
Antipsychotics	1,718 (20.9%)	1,698 (20.7%)	4,487 (22.9%)	4,450 (22.7%)
Anxiolytics	1,046 (12.7%)	970 (11.8%)	2,624 (13.4%)	2,760 (14.1%)
Hypnotics and sedatives	399 (4.9%)	369 (4.5%)	922 (4.7%)	982 (5.0%)
Psychoanaleptics	2,094 (25.5%)	2,044 (24.9%)	5,297 (27.0%)	5,435 (27.7%)
Antidepressants	1,679 (20.5%)	1,667 (20.3%)	4,262 (21.7%)	4,503 (23.0%)
Psychostimulants	719 (8.8%)	621 (7.6%)	1,868 (9.5%)	1,757 (9.0%)
Hormonal contraceptives	659 (8.0%)	631 (7.7%)	2,039 (10.4%)	2,075 (10.6%)
Monthly Fills per ATC Class, mean (SD)				
Drugs for mental health conditions	0.40 (0.78)	0.37 (0.73)	0.54 (1.06)	0.56 (1.05)
Psycholeptics	0.23 (0.54)	0.22 (0.52)	0.32 (0.73)	0.32 (0.73)
Antipsychotics	0.17 (0.44)	0.16 (0.43)	0.24 (0.63)	0.24 (0.62)
Anxiolytics	0.05 (0.20)	0.05 (0.19)	0.06 (0.22)	0.06 (0.22)
Hypnotics and sedatives	0.01 (0.09)	0.01 (0.09)	0.02 (0.12)	0.02 (0.13)
Psychoanaleptics	0.17 (0.39)	0.15 (0.35)	0.23 (0.52)	0.23 (0.52)
Antidepressants	0.12 (0.31)	0.11 (0.28)	0.16 (0.42)	0.17 (0.41)
Psychostimulants	0.05 (0.20)	0.04 (0.18)	0.07 (0.25)	0.06 (0.25)
Hormonal contraceptives	0.04 (0.15)	0.03 (0.15)	0.05 (0.18)	0.05 (0.18)

Abbreviations*: SD = standard deviation; ATC = Anatomic Therapeutic Chemical.*

Notes: The sample of all disabled individuals includes all Medicaid beneficiaries who were eligible for Medicaid due to a disability prior to turning age 21 and were continuously enrolled in fee-for-service Medicaid in the year before and after turning age 21. The treatment group includes all individuals residing in Arkansas and Texas who were eligible for the drug cap policy at age 21. The control group includes all individuals residing in Colorado, Connecticut, Idaho, Missouri, Nebraska, New Hampshire, Nevada, Virginia, Texas, Washington, and Wisconsin who were not eligible for a drug cap policy at age 21. The pre-period includes all prescription drug and health care services in the 12 calendar months before an individual turns age 21 and post-period includes all prescription drug and health care services in the 12 calendar months after an individual turns age 21.

Appendix Table 2.3: Use of Health Care Services Before and After Implementation of Drug Cap Policy at Age 21 Among All Disabled Individuals

	All Disabled Individuals			
	Drug Cap States		Non-Drug Cap States	
	Pre	Post	Pre	Post
N	8,205	8,205	19,605	19,605
Monthly Health Care Services, mean (SD)				
Total IP admittances	0.01 (0.05)	0.01 (0.05)	0.01 (0.07)	0.01 (0.08)
Total IP length of stay	0.07 (0.50)	0.08 (0.39)	0.11 (0.81)	0.11 (0.84)
Total ED visits	0.14 (0.46)	0.16 (0.57)	0.06 (0.14)	0.06 (0.15)
Monthly Health Care Spending (USD), mean (SD)				
Prescription drugs	306.17 (1,020.50)	292.09 (1,466.78)	350.11 (4,141.60)	339.12 (2,775.52)
IP services	182.34 (1,733.83)	157.81 (874.10)	186.64 (1,443.39)	186.40 (1,480.34)
ED visits	43.71 (213.49)	49.24 (241.93)	12.38 (49.41)	13.31 (69.72)

Abbreviations*: SD = standard deviation; IP = inpatient; ED = emergency department; USD = 2020 United States dollars.*

Notes: The sample of all disabled individuals includes all Medicaid beneficiaries who were eligible for Medicaid due to a disability prior to turning age 21 and were continuously enrolled in fee-for-service Medicaid in the year before and after turning age 21. The treatment group includes all individuals residing in Arkansas and Texas who were eligible for the drug cap policy at age 21. The control group includes all individuals residing in Colorado, Connecticut, Idaho, Missouri, Nebraska, New Hampshire, Nevada, Virginia, Texas, Washington, and Wisconsin who were not eligible for a drug cap policy at age 21. The pre-period includes all prescription drug and health care services in the 12 calendar months before an individual turns age 21 and post-period includes all prescription drug and health care services in the 12 calendar months after an individual turns age 21.

Appendix Table 2.4: Use of Prescription Drugs and Health Care Services Before and After Implementation of Drug Cap Policy at Age 21 Among Disabled Individuals with a Serious Mental Illness

	Disabled Individuals with a Serious Mental Illness			
	Drug Cap States		Non-Drug Cap States	
	Pre	Post	Pre	Post
N	1,696	1,696	4,200	4,200
Monthly Prescription Drug Use				
Any prescription, n (%)	1,576 (92.9%)	1,556 (91.7%)	3,925 (93.5%)	3,879 (92.4%)
Average prescriptions, mean (SD)	2.43 (2.55)	2.07 (2.34)	3.16 (3.21)	3.21 (3.23)
Average total days supply, n (%)	69.73 (75.42)	62.34 (70.89)	81.66 (79.86)	84.42 (85.06)
Average % with > 3 prescriptions in month, mean (SD)	27.33 (33.57)	16.56 (31.75)	35.37 (37.35)	35.98 (37.99)
Any month with > 3 prescriptions, n (%)	1,075 (63.4%)	532 (31.4%)	2,878 (68.5%)	2,830 (67.4%)
Any Prescription Fill in ATC Class in Month, n (%)				
Drugs for mental health conditions	1,328 (78.3%)	1,263 (74.5%)	3,432 (81.7%)	3,286 (78.2%)
Psycholeptics	1,152 (67.9%)	1,080 (63.7%)	2,950 (70.2%)	2,845 (67.7%)
Antipsychotics	1,014 (59.8%)	943 (55.6%)	2,639 (62.8%)	2,525 (60.1%)
Anxiolytics	348 (20.5%)	333 (19.6%)	984 (23.4%)	1,031 (24.5%)
Hypnotics and sedatives	179 (10.6%)	154 (9.1%)	436 (10.4%)	449 (10.7%)
Psychoanaleptics	913 (53.8%)	847 (49.9%)	2,456 (58.5%)	2,366 (56.3%)
Antidepressants	812 (47.9%)	746 (44.0%)	2,155 (51.3%)	2,108 (50.2%)
Psychostimulants	257 (15.2%)	210 (12.4%)	747 (17.8%)	650 (15.5%)
Hormonal contraceptives	221 (13.0%)	192 (11.3%)	693 (16.5%)	687 (16.4%)
Monthly Fills per ATC Class, mean (SD)				
Drugs for mental health conditions	0.95 (1.05)	0.84 (0.98)	1.39 (1.53)	1.36 (1.46)
Psycholeptics	0.60 (0.77)	0.54 (0.75)	0.87 (1.12)	0.85 (1.09)
Antipsychotics	0.48 (0.67)	0.44 (0.65)	0.72 (1.01)	0.70 (0.97)
Anxiolytics	0.08 (0.23)	0.07 (0.21)	0.11 (0.29)	0.11 (0.28)
Hypnotics and sedatives	0.03 (0.13)	0.03 (0.13)	0.04 (0.17)	0.04 (0.17)
Psychoanaleptics	0.35 (0.50)	0.29 (0.44)	0.52 (0.73)	0.50 (0.70)
Antidepressants	0.28 (0.42)	0.23 (0.38)	0.40 (0.62)	0.40 (0.59)
Psychostimulants	0.08 (0.23)	0.07 (0.21)	0.12 (0.32)	0.11 (0.31)
Hormonal contraceptives	0.05 (0.18)	0.05 (0.18)	0.07 (0.21)	0.07 (0.21)

Abbreviations*: SD = standard deviation; ATC = Anatomic Therapeutic Chemical.*

Notes: The serious mental illness subgroup includes all disabled patients who were diagnosed with schizophrenia and psychotic disorders, bipolar disorder, or depression with psychotic features at any time prior to turning age 21. The treatment group includes all individuals residing in Arkansas and Texas who were eligible for the drug cap policy at age 21. The control group includes all individuals residing in Colorado, Connecticut, Idaho, Missouri, Nebraska, New Hampshire, Nevada, Virginia, Texas, Washington, and Wisconsin who were not eligible for a drug cap policy at age 21. The pre-period includes all prescription drug and health care services in the 12 calendar months before an individual turns age 21 and post-period includes all prescription drug and health care services in the 12 calendar months after an individual turns age 21.

Appendix Table 2.5: Use of Prescription Drugs and Health Care Services Before and After Implementation of Drug Cap Policy at Age 21 Among Disabled Individuals with a Serious Mental Illness

	Disabled Individuals with a Serious Mental Illness			
	Drug Cap States		**Non-Drug Cap States**	
	Pre	**Post**	**Pre**	**Post**
N	1,696	1,696	4,200	4,200
Monthly Health Care Services, mean (SD)				
Total IP admittances	0.02 (0.05)	0.02 (0.06)	0.03 (0.11)	0.03 (0.11)
Total IP length of stay	0.11 (0.43)	0.12 (0.45)	0.23 (1.07)	0.22 (1.13)
Total ED visits	0.18 (0.56)	0.20 (0.77)	0.12 (0.22)	0.12 (0.22)
Monthly Health Care Spending (USD), mean (SD)				
Prescription drugs	517.50 (1,010.84)	473.67 (917.19)	529.91 (899.93)	524.33 (877.12)
IP services	160.19 (546.68)	175.17 (735.06)	335.68 (1,773.16)	292.38 (1,508.17)
ED visits	50.12 (232.78)	58.17 (278.66)	29.19 (83.75)	28.32 (78.93)

Abbreviations*: SD = standard deviation; IP = inpatient; ED = emergency department; USD = 2020 United States dollars.*

Notes: The serious mental illness subgroup includes all disabled patients who were diagnosed with schizophrenia and psychotic disorders, bipolar disorder, or depression with psychotic features at any time prior to turning age 21. The treatment group includes all individuals residing in Arkansas and Texas who were eligible for the drug cap policy at age 21. The control group includes all individuals residing in Colorado, Connecticut, Idaho, Missouri, Nebraska, New Hampshire, Nevada, Virginia, Texas, Washington, and Wisconsin who were not eligible for a drug cap policy at age 21. The pre-period includes all prescription drug and health care services in the 12 calendar months before an individual turns age 21 and post-period includes all prescription drug and health care services in the 12 calendar months after an individual turns age 21.

Appendix Table 2.6: Pre-Policy Period Test for Parallel Trends Among All Disabled Individuals

	Pre-Policy Trends		
	All Disabled Individuals (N=27,810)		
	OR/IRR	**95% CI**	**P-value**
Monthly prescription drug fills overall			
Total prescription fills	0.998	(0.995, 1.000)	0.081
> 3 prescriptions in month	0.998	(0.993, 1.002)	0.313
Total prescription days supply	0.999	(0.997, 1.001)	0.368
Monthly prescription drug fills by ATC class			
All mental health drugs	1.001	(0.996, 1.006)	0.742
Antipsychotics	1.004	(0.994, 1.013)	0.460
Anxiolytics	0.988	(0.948, 1.029)	0.551
Antidepressants	1.004	(0.993, 1.014)	0.483
Psychostimulants	1.003	(0.974, 1.033)	0.851
Hormonal contraceptives	1.008	(0.985, 1.032)	0.501
Monthly prescription drug spending			
Total prescription spending	0.998	(0.990, 1.005)	0.561
Total spending per prescription fill	0.992	(0.981, 1.003)	0.160
Quarterly health care resource use			
Total ED visits	1.008	(0.969, 1.048)	0.708
Total ED spending (USD)	1.020	(0.990, 1.050)	0.194
Any IP visit	1.052	(0.984, 1.125)	0.140
Total IP length of stay	1.042	(0.970, 1.120)	0.257
Total IP spending (USD)	0.975	(0.847, 1.124)	0.730
Total prescription spending (USD)	0.987	(0.966, 1.008)	0.233
Total (ED, IP, prescription) spending (USD)	0.986	(0.925, 1.051)	0.668

Abbreviations*: OR=odds ratio; IRR =incidence rate ratio; CI = confidence interval; ATC = Anatomic Therapeutic Chemical; IP = inpatient; ED = emergency department; USD = 2020 United States dollars.*
** p<0.05; ** p<0.01; *** p<0.001*

Source: Author's analysis of Medicaid Analytic eXtract (MAX) claim data (2007-2012).

Notes: Regressions adjusted for covariates listed in methods. Pre-policy means were calculated in the treated states (Arkansas and Texas) among all individuals in the 12 calendar months prior to turning age 21. Prescription drug outcomes were measured among all individuals on a monthly basis while health care resource use was measured on a quarterly basis in the 12 calendar months before the individual turned age 21. Total spending includes all spending on prescription drugs as well as inpatient and emergency department visits. All results are from the coefficient on the interaction between treated indicator variable and continuous measure of months until 21st birthday in the pre-policy period. All results are reported as incidence rate ratios (IRR) from the zero-inflated negative binomial models except odds ratios (OR) are reported for outcomes from the logistic models (any emergency or any inpatient visit).

Appendix Table 2.7: Pre-Policy Period Test for Parallel Trends Among Individuals with a Serious Mental Illness

	Pre-Policy Trends		
	Disabled Individuals with a Serious Mental Illness (N=5,896)		
	OR/IRR	**95% CI**	**P-value**
Monthly prescription drug fills overall			
Total prescription fills	0.998	(0.994, 1.003)	0.484
> 3 prescriptions in month	0.994	(0.985, 1.003)	0.207
Total prescription days supply	0.998	(0.995, 1.002)	0.334
Monthly prescription drug fills by ATC class			
All mental health drugs	0.997	(0.991, 1.004)	0.419
Antipsychotics	0.996	(0.986, 1.005)	0.396
Anxiolytics	1.003	(0.959, 1.049)	0.884
Antidepressants	0.995	(0.980, 1.010)	0.519
Psychostimulants	1.004	(0.986, 1.022)	0.641
Hormonal contraceptives	0.970	(0.938, 1.004)	0.079
Monthly prescription drug spending			
Total prescription spending	0.997	(0.990, 1.003)	0.311
Total spending per prescription fill	0.993	(0.984, 1.002)	0.152
Quarterly health care resource use			
Total ED visits	1.010	(0.925, 1.103)	0.827
Total ED spending (USD)	1.030	(0.973, 1.089)	0.309
Any IP visit	1.078	(0.949, 1.224)	0.247
Total IP length of stay	0.967	(0.868, 1.077)	0.542
Total IP spending (USD)	1.005	(0.902, 1.119)	0.929
Total prescription spending (USD)	0.992	(0.972, 1.012)	0.422
Total (ED, IP, prescription) spending (USD)	1.031	(0.995, 1.069)	0.088

Abbreviations*: OR=odds ratio; IRR =incidence rate ratio; CI = confidence interval; ATC = Anatomic Therapeutic Chemical; IP = inpatient; ED = emergency department; USD = 2020 United States dollars.*
** p<0.05; ** p<0.01; *** p<0.001*

Source: Author's analysis of Medicaid Analytic eXtract (MAX) claim data (2007-2012).

Notes: Regressions adjusted for covariates listed in methods. Pre-policy means were calculated in the treated states (Arkansas and Texas) among all individuals in the 12 calendar months prior to turning age 21. Prescription drug outcomes were measured among all individuals on a monthly basis while health care resource use was measured on a quarterly basis in the 12 calendar months before the individual turned age 21. Total spending includes all spending on prescription drugs as well as inpatient and emergency department visits. All results are from the coefficient on the interaction between treated indicator variable and continuous measure of months until 21st birthday in the pre-policy period. All results are reported as incidence rate ratios (IRR) from the zero-inflated negative binomial models except odds ratios (OR) are reported for outcomes from the logistic models (any emergency or any inpatient visit).

Appendix for Chapter 3

Identification of Deliveries

Deliveries were identified in the data using a combination of procedure and diagnosis codes, detailed below in Appendix Table 3.1. Individuals were required to have at least one delivery-related diagnosis and procedure code on the date of delivery. Infants were linked to woman's delivery based on a shared subscriber identification number and an infant was only linked if the woman had an identified delivery date within seven days of the infant's recorded date of birth.

Appendix Table 3.1: Diagnosis and Procedure Codes for Identification of Deliveries

Code Type	Codes
ICD-9 Diagnosis Codes	V27, V30-V39, 669.71, 649.81, 649.82, 650, 669.61, 669.51, 669.01, 669.02, 669.11, 669.12, 669.81, 669.82, 669.81, 669.82
ICD-10 Diagnosis Codes	Z37, Z38, O75.82, O82, O90.0, P03.4, O80, O66.41, O86.13, O30.009, O75.0, O75.2, O75.5, O75.8, O75.9 O34.21
ICD-9 Procedure Codes	72, 73, 74
ICD-10 Procedure Codes	10D00Z0, 10D00Z1, 10D00Z2, 10D07Z3, 10D07Z4, 10D07Z5, 10D07Z6, 10D07Z7, 10D07Z8, 10E0XZZ
CPT Codes	59400, 59409, 59410, 59510, 59514, 59515, 59525, 59605, 59611, 59612, 59614, 59618, 59620, 59622, 59610, 01960, 01961, 01967, 01968, 01969
DRG	765, 766, 767, 768, 774, 775, 783, 784, 785, 786, 787, 788, 796, 797, 798, 805, 806, 807

Calculation of Gestational Age at Delivery

Gestational age at delivery was calculated using diagnosis codes during pregnancy and delivery. ICD codes were used to identify the number of weeks of gestation during pregnancy and gestational age at delivery was calculated based on the number of weeks between the date of service with the gestational age code and the delivery date (Appendix Table 3.2). If gestational age was not specified at any visit during pregnancy, then gestational age was identified based on codes specified at delivery. If a specific week of gestation was not specified during pregnancy or delivery, then gestational age was coded as 27 weeks if there was a code for extremely preterm delivery, 36 weeks if there was a code for preterm delivery, 40 weeks if there was a code for full term delivery, and 41 weeks if there was a code for a post term delivery. If there were no diagnosis codes indicating gestational age, it was assumed that the delivery was full term and gestational age was coded as 40 weeks. Among all deliveries that occurred before October 1, 2016 when ICD-10 codes were implemented, 86.0% of deliveries had at least one code from Appendix Table 3.2. Among deliveries that occurred on or after October 1, 2016, 98.7% of deliveries had at least one code from Appendix Table 3.2.

Appendix Table 3.2: Diagnosis Codes to Identify Gestational Age at Delivery

Gestational Age	ICD-9	ICD-10
Weeks		
≤ 7		Z3A.01
8		Z3A.08
9		Z3A.09
10		Z3A.10
11		Z3A.11
12		Z3A.12
13		Z3A.13
14		Z3A.14
15		Z3A.15
16		Z3A.16
17		Z3A.17
18		Z3A.18
19		Z3A.19
20		Z3A.20
21		Z3A.21
22		Z3A.22
23	765.21	Z3A.23, P07.22
24		Z3A.24, P07.23
25		Z3A.25, P07.24
26	765.23	Z3A.26, P07.25
27		Z3A.27, P07.26
28	765.24	Z3A.28, P07.31
29		Z3A.29, P07.32
30	765.25	Z3A.30, P07.33
31		Z3A.31, P07.34
32	765.26	Z3A.32, P07.35
33		Z3A.33, P07.36
34	765.27	Z3A.34, P07.37
35		Z3A.35, P07.38
36	765.28	Z3A.36, P07.39
37		Z3A.37
38		Z3A.38, O75.82
39		Z3A.39
40		Z3A.40
41	766.21, 645.1	Z3A.41, P08.21, O48.0
42		Z3A.42
43	766.22, 645.2	Z3A.49, P08.22, O48.1
Extremely preterm (< 28 weeks)	765.0, 765.21, 765.22, 765.23	P07.2, O60.12
Preterm (< 37 weeks)	644.21, 765.0, 765.1, 765.21-765.28	P07.2, P07.3, O60.1, O60.3
Full term (40 weeks)	650, 765.29	O80, O60.2
Post term (> 40 weeks)	645	P08.2

Appendix Table 3.3: Diagnosis and Procedure Codes Prenatal Care Services

Prenatal Care Services	CPT and Other Codes
Visits with specialists	
Obstetrician-gynecologist visits	Encounter with provider specialty recorded as obstetrician-gynecologist
Maternal-fetal medicine visits	Encounter with provider specialty recorded as maternal-fetal medicine specialist
Prenatal monitoring	
Ultrasounds	76800-76819, 76820, 76821, 76825, 76826, 76827, 76828
Detailed Ultrasound	76811, 76812
Antepartum surveillance	
Biophysical profile	76818, 76819
Non-stress test	59025, 76818
Aneuploidy screening	
Serum analyte	Part 1: 84163, 84702; Part 2: 82105, 82677, 84702, 86336; with ultrasound
Cell-free DNA	81507, 81420, 0168U 0009M, 0060U
Invasive testing	59000, 59001, 76946, 59015, 76945, 59012

Appendix Table 3.4: Diagnosis and Procedure Codes for Identification Delivery-Related Practices and Perinatal Outcomes

Maternal Outcomes	ICD-9	ICD-10	CPT and Other Codes
Delivery-Related Practices			
Cesarean delivery	669.7, 649.8 V30.01, V31.01, V32.01, V33.01, V34.01, V35.01, V36.01, V37.01, V39.01, 763.4	O75.82, O82, P03.4, Z38.01, Z38.31, Z38.62, Z38.64, Z38.66, Z38.69, P03.4, 10D00Z0, 10D00Z1, 10D00Z2	59510, 59514, 59515, 59525, 59618, 59620, 59622, 01961, 01968; DRG: 765, 766, 783, 784, 785, 786, 787, 788
Induction of labor	659.0, 659.1, 73.4, 73.01, 73.1	O61, 3E033VJ, 3E0P7GC, 3E0P7VZ, 0U7C7ZZ, 0U7C7DZ, 3E0P3VZ	
Perinatal Outcomes			
Perinatal mortality			
Stillbirth (including intrauterine death), at 28 weeks gestation or later	V27.1, V27.3, V27.4, V27.6, V27.7, 656.4	Z37.1, Z37.3, Z37.4, Z37.6, Z37.7, P95, O36.4	
Neonatal death within 7 days of delivery (including death during labor)	768.0, 768.1, 798	R99	Discharge status of 'expired'
Preterm birth (< 37 weeks)[1]	644.21, 765.0, 765.1, 765.21, 765.22, 765.23, 765.24, 765.25, 765.26, 765.27, 765.28	O60.1, P07.2, P07.3, O60.3	

Note:

1. Delivery was also identified as preterm birth if gestational age at delivery was calculated to be < 37 weeks.

Appendix Table 3.5: Diagnosis and Procedure Codes for Identification of Maternal Characteristics

Maternal Characteristics	ICD-9	ICD-10	CPT and Other Codes
Diagnoses			
Chronic diabetes	250, V58.67, 648.0	O24.0, O24.1, O24.3, O24.8, O24.9, Z79.4, Z79.84, E10, E11, E13	
Gestational diabetes[1]	648.8	O24.4, O99.81	
Chronic hypertension	642.0, 642.1, 642.2	O10	
Gestational hypertension[2]	642.3, 642.9	O13, O16	
Preeclampsia	642.4, 642.5, 642.7	O11, O14	
Eclampsia	642.6	O15	
Obesity	278.00, 278.01, 278.03, V85.3, V85.4, 649.1	E66.0, E66.1, E66.2, E66.8, E66.9, Z68.3, Z68.4, O99.21	
Multiple gestation	651, 646.0, 678.1, V27.1, V27.3, V27.4, V27.5, V27.6, V27.7, V91, V31, V32, V33, V34, V35, V36, V37	O30, O31, Z37.2, Z37.3, Z37.4, Z37.5, Z37.6, Z37.3, Z38.3, Z38.4, Z38.5, Z38.6, Z38.7, Z38.8, O3x.xx2, O3x.xx3, O3x.xx4, O3x.xx5, O40.xx2, O40.xx3, O40.xx4, O40.xx5, O41.xx2, O41.xx3, O41.xx4, O41.xx5	
Trisomy 21	758.0	Q90.9	
Elderly primigravida and/or multigravida	V23.81, V23.82, 659.50, 659.51, 659.53, 659.60, 659.61, 659.63	O09.51, O09.52	

Notes:

1. Gestational diabetes not flagged if woman already had a diagnosis for chronic diabetes.
2. Gestational hypertension not flagged if woman already had a diagnosis for chronic hypertension.

Appendix Table 3.6: Sample Selection

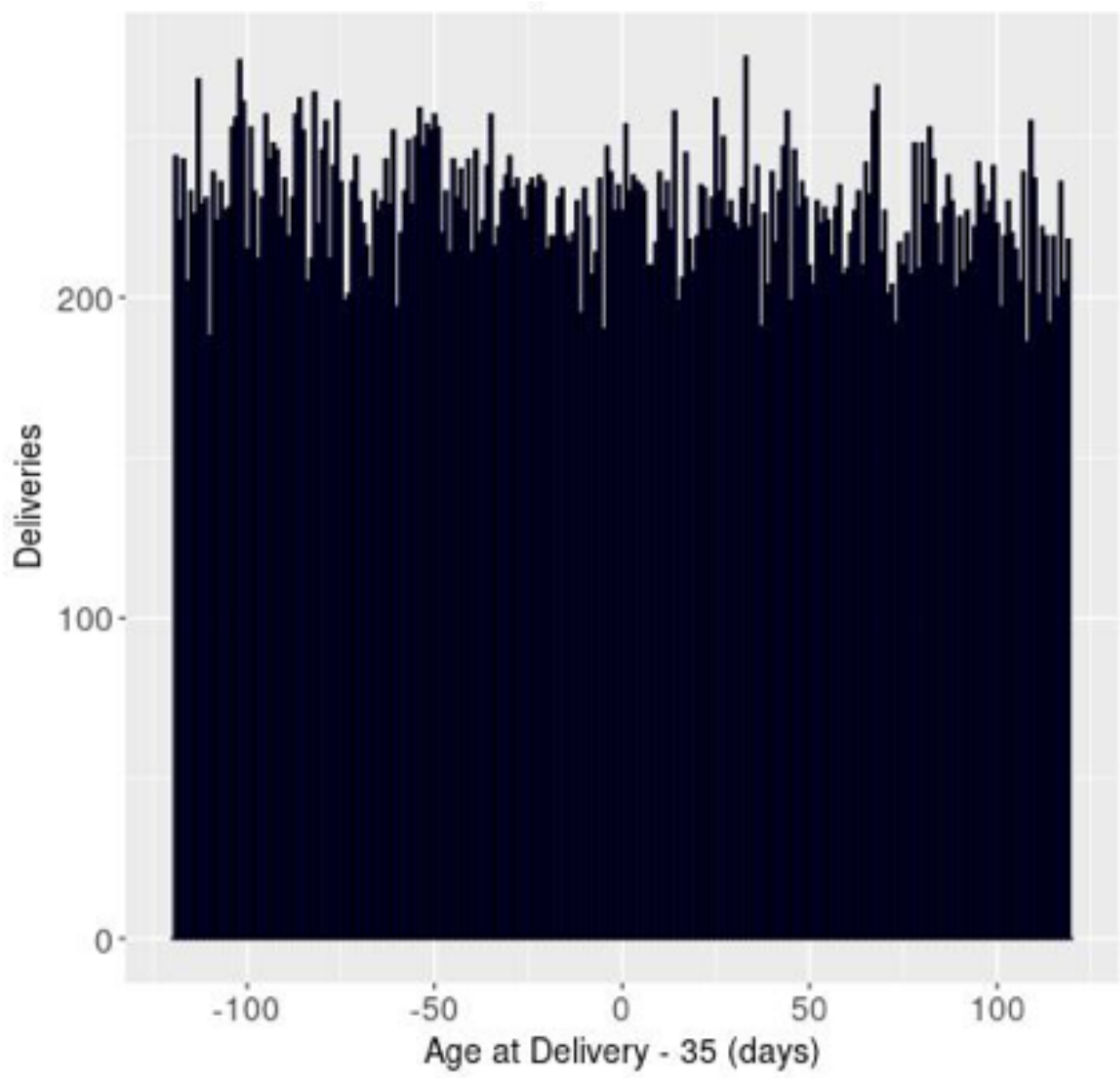
	Total Deliveries
0. All deliveries	1,919,868
1. All deliveries with expected delivery date within 120 days of AMA cutoff (date of 35th birthday)	75,198
2. Any eligibility data	74,946
3. Continuous eligibility during pregnancy period	56,208
4. Valid zip code	55,957
5. Outpatient visit and ultrasound during pregnancy	54,745
6. Exclude deliveries within 7 days of AMA cutoff	51,290

Testing for Bunching at Age 35 Cutoff (McCrary Test)

In our study, the regression discontinuity design relies on the assumption that there is no manipulation of the running variable (i.e., days between expected date of birth and the women's 35th birthday) so that women just above and below are the same on average except for the fact that women above the cutoff are flagged as being AMA. This assumption may be violated if women are able to manipulate the timing of their expected delivery date to be on side of the AMA cutoff; however, we do not expect this to occur due to the difficulty in timing an expected delivery date. In addition, this assumption may be violated if there were differences in the outcome of pregnancies among women just above and below the age 35 cutoff. Due to the increase in genetic testing at age 35, it is plausible that we could see a decline in pregnancies just above the cutoff if women choose to terminate the pregnancy based on the results of the genetic test. To test this assumption of the regression discontinuity design, we first conduct a McCrary test which provides a formal test for manipulation of the running variable.21 Specifically, the McCrary test formally tests whether there are any differences in the marginal density of the running variable.

Using the McCrary test, we do not find any evidence of manipulation of the running variable (p=0.249). As seen in Appendix Figure 3.1, the number of deliveries appears to decline smoothly across the AMA cutoff.

Appendix Figure 3.1: Histogram of All Deliveries to Women Within 120 Days of the AMA Cutoff



Note: Figure shows the number of deliveries by the running variable, i.e., the number of days between the expected delivery date and the woman's 35th birthday. Sample includes all women with an expected delivery date within 120 days of her 35th birthday.

Sensitivity Analyses

Appendix Table 3.7: Test for Changes in Sample Characteristics Among Women Within 120 Days of the AMA Cutoff

	All Women (N = 51,290)	
Outcomes	**Coefficient (95% CI)**	**P-value**
Infant characteristics		
Trisomy 21	0.001 (0.000, 0.003)	0.107
Maternal characteristics		
Any high-risk diagnoses before or during pregnancy	0.003 (-0.017, 0.023)	0.771
Chronic hypertension	0.003 (-0.006, 0.012)	0.469
Gestational hypertension	-0.004 (-0.013, 0.005)	0.416
Preeclampsia	0.006 (-0.001, 0.013)	0.101
Eclampsia	0.002 (0.000, 0.005)	0.093
Chronic diabetes	-0.006 (-0.015, 0.003)	0.167
Gestational diabetes	-0.001 (-0.016, 0.014)	0.882
Obesity	0.002 (-0.011, 0.014)	0.809
Multiple gestation	0.003 (-0.006, 0.012)	0.469

Abbreviations*: CI = confidence interval.*

Notes:

Sample includes all women with an expected delivery date within 120 days of her 35th birthday. Women with an expected delivery date within 7 days of the 35th birthday were excluded. All regressions control for zip-code characteristics (percent white, percent Hispanic, median household income, and whether the zip code is urban) and county-level characteristics (any hospital with neonatal intensive care unit and OBGYNs per 10,000 deliveries). All regressions include state of residence, year, and month of delivery fixed effects.

Pregnancy Outcomes

To test whether there were any potential changes in the sample of women just above or below the cutoff, we also conducted a sensitivity analysis on the outcomes of all pregnancies. Instead of limiting to only livebirths or stillborn analyses, we expanded the sample to include all pregnancies to women around the age 35 AMA cutoff. Then, we identified the outcome of the pregnancy based on diagnosis and procedure codes.

Using regression discontinuity methods similar to those previously described, we analyzed whether there were any changes in the outcomes of all pregnancies at the age 35 cutoff. In addition, we also analyzed changes in the outcomes of low-risk pregnancies, defined as pregnancies among women without a diagnosis code for chronic or gestational diabetes, chronic or gestational hypertension, preeclampsia, eclampsia, obesity, or multiple gestation. Due to the limitations of the claims data which does not always allow for differentiation between miscarriages and pregnancy terminations, we also analyzed the proportion of pregnancies that ended in either a termination or abortion.

Results of the analysis are included in would not have made it here to graduate school without my parents. We did not find any change in the proportion of pregnancies ending in termination and/or miscarriage at the AMA cutoff. These findings provide evidence to support the assumption made in our main analyses that women on either side of the age 35 cutoff are the same on average and the AMA sample is unlikely to be biased due to any increase in abortions due to increases in genetic testing.

Appendix Table 3.8: Regression Results for Changes in Abortion or Miscarriage at Age 35 Cutoff

	All Pregnancies (N = 136,477)		Low-Risk Pregnancies (N = 98,143)	
Outcomes	**Coefficient (95% CI)**	**P-value**	**Coefficient (95% CI)**	**P-value**
End of pregnancy				
Termination or miscarriage	-0.004 (-0.013, 0.005)	0.369	-0.006 (-0.017, 0.006)	0.332
Termination	-0.002 (-0.006, 0.002)	0.225	-0.002 (-0.008, 0.003)	0.373
Miscarriage	-0.002 (-0.010, 0.007)	0.703	-0.003 (-0.014, 0.007)	0.550

Abbreviations*: CI = confidence interval.*
**p <0.05, ** p<0.01, ***p<0.001*

Notes:

1. All regressions included state of residence, year, and month of delivery fixed effects.
2. Sample limited to all pregnancies with an expected delivery date within 120 days of the woman's 35th birthday. Pregnancies with an expected delivery date within 7 days of the AMA cutoff were not included in the analyses.
3. Low-risk pregnancies included all pregnancies among women without a diagnosis code for chronic or gestational diabetes, chronic or pregnancy-related hypertension, obesity, or multiple gestation.

Appendix Table 3.9: Regression Results with Varying Bandwidth for All Women

	All Women - Adjusted			
	90 Day Bandwidth (N = 37,596)		150 Day Bandwidth (N = 64,831)	
Outcomes	**Coefficient (95% CI)**	**P-value**	**Coefficient (95% CI)**	**P-value**
Prenatal Care Services				
Total OBGYN visits	0.121 (-0.174, 0.416)	0.421	0.318 (0.105, 0.531)	0.003**
Any MFM visit	0.030 (0.006, 0.054)	0.015*	0.049 (0.032, 0.066)	0.000***
Total ultrasounds	0.157 (-0.027, 0.341)	0.094	0.274 (0.143, 0.405)	0.000***
Any detailed ultrasound	0.134 (0.109, 0.158)	0.000***	0.169 (0.151, 0.186)	0.000***
Any antepartum fetal surveillance	0.045 (0.021, 0.069)	0.000***	0.052 (0.035, 0.069)	0.000***
Non-stress test	0.026 (0.001, 0.050)	0.040*	0.040 (0.023, 0.057)	0.000***
Biophysical profile	0.039 (0.017, 0.061)	0.000***	0.036 (0.020, 0.052)	0.000***
Any aneuploidy screening	0.003 (-0.019, 0.024)	0.795	0.014 (-0.001, 0.030)	0.064
Serum analyte	-0.043 (-0.066, -0.019)	0.000***	-0.039 (-0.056, -0.023)	0.000***
Cell-free DNA test	0.085 (0.067, 0.102)	0.000***	0.100 (0.088, 0.113)	0.000***
Invasive genetic test	0.010 (0.000, 0.019)	0.039*	0.011 (0.005, 0.018)	0.001***
Delivery-Related Practices				
Induction of labor	0.000 (-0.019, 0.019)	0.989	0.005 (-0.008, 0.018)	0.465
Cesarean delivery	0.004 (-0.021, 0.029)	0.763	0.005 (-0.013, 0.022)	0.610
Perinatal Outcomes				
Perinatal mortality	-0.005 (-0.009, 0.000)	0.044*	-0.003 (-0.007, 0.000)	0.038*
Preterm birth	0.012 (-0.005, 0.028)	0.162	0.005 (-0.006, 0.017)	0.372

***Abbreviations**: CI = confidence interval; OBGYN = obstetrician-gynecologist; MFM = maternal-fetal medicine.*

**p <0.05, ** p<0.01, ***p<0.001*

Notes:

1. Sample includes all women with an expected delivery date within 120 days of her 35th birthday. Women with an expected delivery date within 7 days of the 35th birthday were excluded.
2. All regressions control for individual-level characteristics (chronic and gestational diabetes, chronic and pregnancy-related hypertension, obesity, multiple gestation), zip-code characteristics (percent white, percent Hispanic, median household income, and whether the zip code is urban), and county-level characteristics (any hospital with neonatal intensive care unit and OBGYNs per 10,000 deliveries). All regressions include state of residence, year, and month of delivery fixed effects.

Appendix Table 3.10: Regression Results with Varying Bandwidth for Women with Low-Risk Pregnancy

	Women with Low-Risk Pregnancy - Adjusted			
	90 Day Bandwidth (N = 37,596)		150 Day Bandwidth (N = 64,831)	
Outcomes	**Coefficient (95% CI)**	**P-value**	**Coefficient (95% CI)**	**P-value**
Prenatal Care Services				
Total OBGYN visits	0.231 (-0.103, 0.564)	0.175	0.380 (0.140, 0.620)	0.002**
Any MFM visit	0.041 (0.010, 0.071)	0.009**	0.063 (0.041, 0.085)	0.000***
Total ultrasounds	0.156 (-0.038, 0.350)	0.114	0.289 (0.149, 0.428)	0.000***
Any detailed ultrasound	0.140 (0.110, 0.171)	0.000***	0.183 (0.161, 0.205)	0.000***
Any antepartum fetal surveillance	0.063 (0.032, 0.095)	0.000***	0.068 (0.046, 0.091)	0.000***
Non-stress test	0.040 (0.010, 0.070)	0.009**	0.056 (0.034, 0.077)	0.000***
Biophysical profile	0.051 (0.025, 0.076)	0.000***	0.045 (0.026, 0.063)	0.000***
Any aneuploidy screening	0.002 (-0.025, 0.029)	0.882	0.016 (-0.003, 0.035)	0.101
Serum analyte	-0.047 (-0.076, -0.018)	0.002**	-0.041 (-0.062, -0.020)	0.000***
Cell-free DNA test	0.081 (0.060, 0.102)	0.000***	0.098 (0.083, 0.112)	0.000***
Invasive genetic test	0.009 (-0.003, 0.020)	0.128	0.008 (0.000, 0.016)	0.054
Delivery-Related Practices				
Induction of labor	0.006 (-0.017, 0.029)	0.593	0.006 (-0.010, 0.022)	0.460
Cesarean delivery	-0.016 (-0.047, 0.014)	0.300	-0.011 (-0.033, 0.011)	0.318
Perinatal Outcomes				
Perinatal mortality	-0.005 (-0.008, -0.001)	0.010*	-0.003 (-0.006, -0.001)	0.016*
Preterm birth	0.007 (-0.011, 0.024)	0.454	0.003 (-0.010, 0.015)	0.676

***Abbreviations**: CI = confidence interval; OBGYN = obstetrician-gynecologist; MFM = maternal-fetal medicine.*

**p <0.05, ** p<0.01, ***p<0.001*

Notes:

1. Sample includes all women with an expected delivery date within 120 days of her 35th birthday. Women with an expected delivery date within 7 days of the 35th birthday were excluded. Women with a low-risk pregnancy include all women without a diagnosis code for chronic or gestational diabetes, chronic or pregnancy-related hypertension, obesity, or multiple gestation.
2. All regressions control for individual-level characteristics (chronic and gestational diabetes, chronic and pregnancy-related hypertension, obesity, multiple gestation), zip-code characteristics (percent white, percent Hispanic, median household income, and whether the zip code is urban), and county-level characteristics (any hospital with neonatal intensive care unit and OBGYNs per 10,000 deliveries). All regressions include state of residence, year, and month of delivery fixed effects.

Appendix Table 3.11: Unadjusted Regression Results

	All Women (N = 51,290)		Women with Low-Risk Pregnancy (N = 33,199)	
	Unadjusted		Unadjusted	
Outcomes	**Coefficient (95% CI)**	**P-value**	**Coefficient (95% CI)**	**P-value**
Prenatal Care Services				
Total OBGYN visits	0.210 (-0.048, 0.468)	0.111	0.311 (0.035, 0.587)	0.027*
Any MFM visit	0.043 (0.022, 0.063)	0.000***	0.056 (0.031, 0.081)	0.000***
Total ultrasounds	0.204 (0.040, 0.369)	0.015*	0.231 (0.071, 0.392)	0.005**
Any detailed ultrasound	0.156 (0.136, 0.176)	0.000***	0.167 (0.142, 0.192)	0.000***
Any antepartum fetal surveillance	0.048 (0.027, 0.069)	0.000***	0.067 (0.041, 0.093)	0.000***
Non-stress test	0.033 (0.012, 0.054)	0.002**	0.051 (0.026, 0.076)	0.000***
Biophysical profile	0.036 (0.018, 0.055)	0.000***	0.047 (0.026, 0.069)	0.000***
Any aneuploidy screening	0.010 (-0.008, 0.027)	0.285	0.012 (-0.010, 0.035)	0.285
Serum analyte	-0.040 (-0.060, -0.021)	0.000***	-0.040 (-0.065, -0.016)	0.001**
Cell-free DNA test	0.094 (0.080, 0.108)	0.000***	0.091 (0.073, 0.108)	0.000***
Invasive genetic test	0.011 (0.003, 0.018)	0.004**	0.008 (-0.001, 0.018)	0.078
Delivery-Related Practices				
Induction of labor	0.004 (-0.011, 0.020)	0.599	0.007 (-0.012, 0.026)	0.457
Cesarean delivery	0.007 (-0.014, 0.028)	0.515	-0.012 (-0.037, 0.013)	0.362
Perinatal outcomes				
Perinatal mortality	-0.004 (-0.008, 0.000)	0.044*	-0.004 (-0.007, -0.001)	0.013*
Preterm birth	0.006 (-0.008, 0.020)	0.407	0.003 (-0.012, 0.017)	0.715

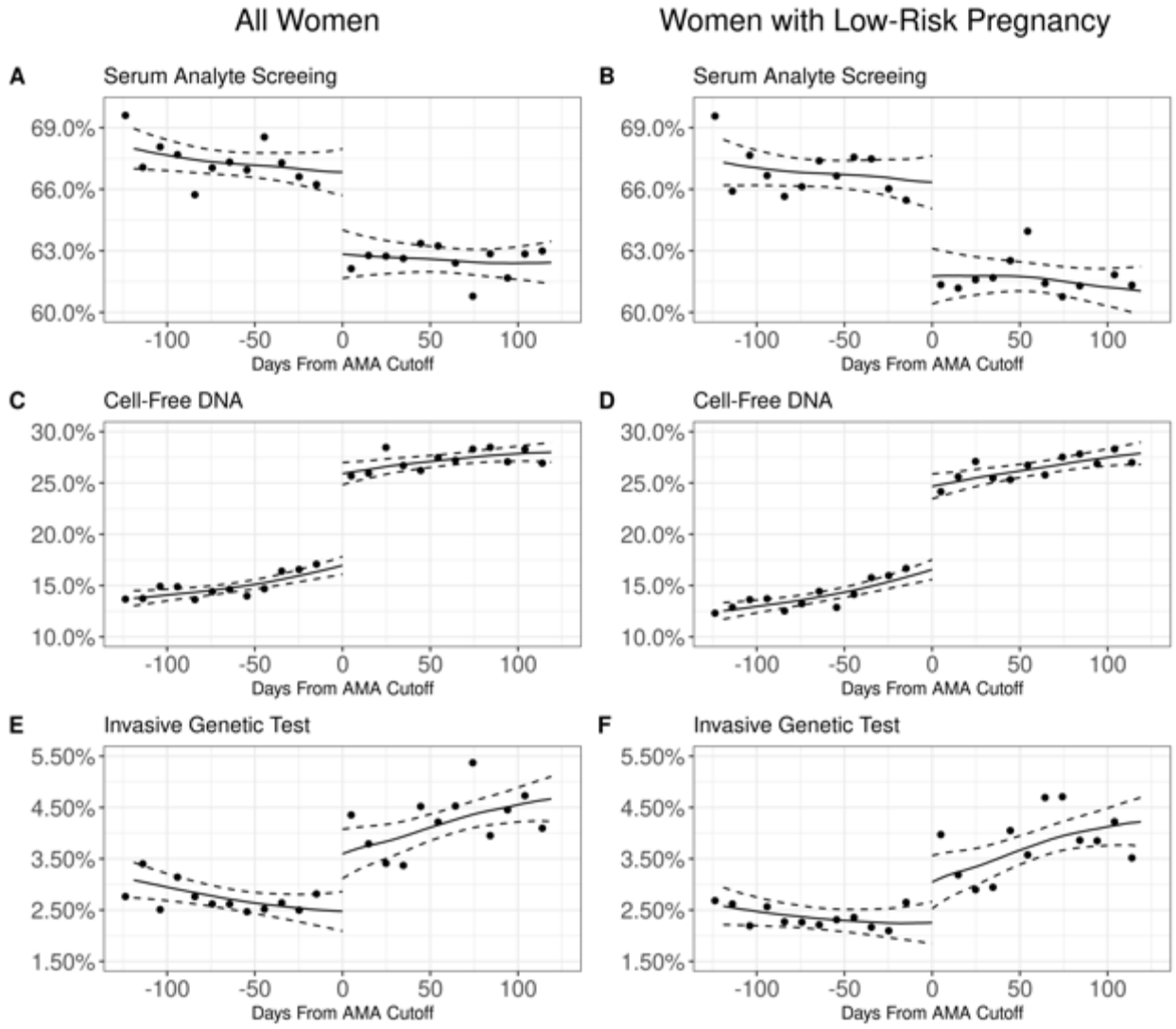
Abbreviations*: CI = confidence interval; OBGYN = obstetrician-gynecologist; MFM = maternal-fetal medicine.*

**p <0.05, ** p<0.01, ***p<0.001*

Notes:

1. Sample includes all women with an expected delivery date within 120 days of her 35th birthday. Women with an expected delivery date within 7 days of the 35th birthday were excluded.
2. Women with a low-risk pregnancy include all women without a diagnosis code for chronic or gestational diabetes, chronic or pregnancy-related hypertension, obesity, or multiple gestation.
3. All regressions include state of residence, year, and month of delivery fixed effects.

Appendix Figure 3.2: Regression Plots for Aneuploidy Screening by Type of Screening

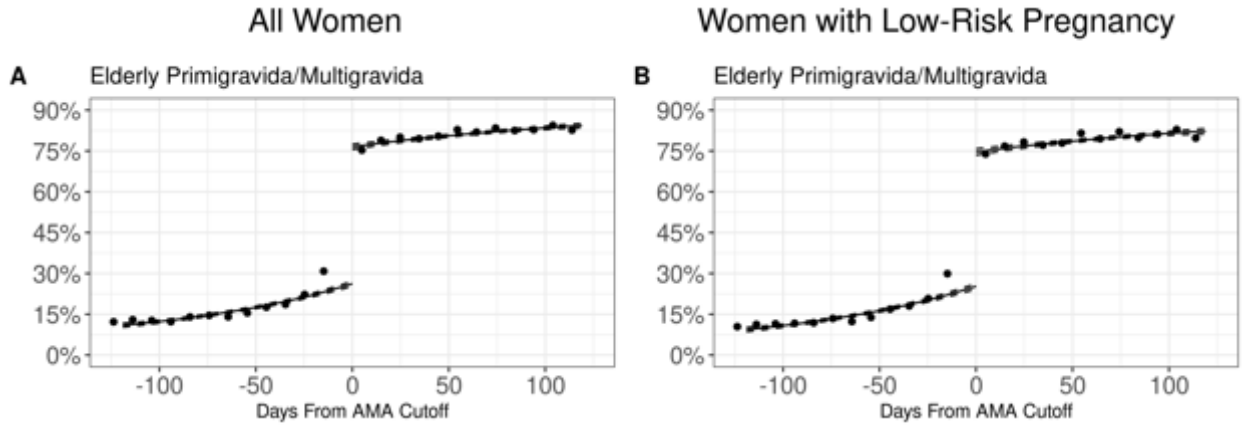


Notes: Figures represent binned outcomes for sample of women with an expected delivery date within 120 days of her 35th birthday. Women with an expected delivery date within 7 days of the 35th birthday were excluded. Solid line represents the local linear regression results for the regression discontinuity analyses. Dotted lines represent the 95% confidence intervals.

Diagnosis of Elderly Primigravida and/or Multigravida

In order to evaluate whether providers were recognizing women as being designated as AMA at the age 35 cutoff that we calculated, rather than during pregnancy, we examined diagnosis codes for "elderly primigravida and/or multigravida" during pregnancy. This diagnosis code should we used for women of AMA, defined as age 35 years or older on the expected date of delivery, and be consistent with our identification of women of AMA at the age 35 cutoff. Using the previously described RD methods, we ran the local linear regressions using an indicator for having a diagnosis code for elderly primigravida and/or multigravida as the outcome (Appendix Table 3.2). As shown in Appendix Figure 3.3 and Appendix Table 3.10, the use of this diagnosis code jump substantially at the cutoff. Taken together with our results that also showed sharp increases in prenatal care services at the cutoff, this indicates that providers do frequently recognize AMA based on the age at the expected date of delivery consistent with our study design.

Appendix Figure 3.3: Regression Plots for Diagnosis Code for Elderly Primigravida and/or Multigravida During Pregnancy



Notes: Figures represent binned outcomes for sample of women with an expected delivery date within 120 days of her 35th birthday. Women with an expected delivery date within 7 days of the 35th birthday were excluded. Solid line represents the local linear regression results for the regression discontinuity analyses. Dotted lines represent the 95% confidence intervals.

Appendix Table 3.12: Regression Results for Diagnosis Code for Elderly Primigravida and/or Multigravida During Pregnancy

	All Women (N = 51,290)		Women with Low-Risk Pregnancy (N =33,199)	
	Adjusted		Adjusted	
Outcomes	**Coefficient (95% CI)**	**P-value**	**Coefficient (95% CI)**	**P-value**
Elderly primigravida and/or multigravida	0.505 (0.487, 0.522)	0.000***	0.503 (0.481, 0.525)	0.000***

Abbreviations: *CI = confidence interval*
**p <0.05, ** p<0.01, ***p<0.001*

Notes:

1. Sample includes all women with an expected delivery date within 120 days of her 35th birthday. Women with an expected delivery date within 7 days of the 35th birthday were excluded.
2. Women with a low-risk pregnancy include all women without a diagnosis code for chronic or gestational diabetes, chronic or pregnancy-related hypertension, obesity, or multiple gestation.
3. All regressions control for individual-level characteristics (chronic and gestational diabetes, chronic and pregnancy-related hypertension, obesity, multiple gestation), zip-code characteristics (percent white, percent Hispanic, median household income, and whether the zip code is urban), and county-level characteristics (any hospital with neonatal intensive care unit and OBGYNs per 10,000 deliveries). All regressions include state of residence, year, and month of delivery fixed effects.

Appendix Table 3.13: Regression Results for Maternal Outcomes and Neonatal Intervention

	All Women (N = 51,290)		Women with Low-Risk Pregnancy (N = 33,199)	
	Adjusted		Adjusted	
Outcomes	**Coefficient (95% CI)**	**P-value**	**Coefficient (95% CI)**	**P-value**
Maternal Outcomes				
Any severe maternal morbidity	-0.005 (-0.012, 0.002)	0.187	-0.007 (-0.015, 0.001)	0.103
Admission to ICU	-0.004 (-0.009, 0.001)	0.140	-0.004 (-0.009, 0.002)	0.192
Neonatal Interventions				
Admission to NICU	-0.001 (-0.010, 0.008)	0.848	-0.009 (-0.019, 0.001)	0.067

Abbreviations: *CI = confidence interval; ICU = intensive care unit; NICU = neonatal intensive care unit.*

**p <0.05, ** p<0.01, ***p<0.001*

Notes:

1. Sample includes all women with an expected delivery date within 120 days of her 35th birthday. Women with an expected delivery date within 7 days of the 35th birthday were excluded.
2. Women with a low-risk pregnancy include all women without a diagnosis code for chronic or gestational diabetes, chronic or pregnancy-related hypertension, obesity, or multiple gestation.
3. All regressions control for individual-level characteristics (chronic and gestational diabetes, chronic and gestational hypertension, obesity, multiple gestation), zip-code characteristics (percent white, percent Hispanic, median household income, and whether the zip code is urban), and county-level characteristics (any hospital with neonatal intensive care unit and OBGYNs per 10,000 deliveries). All regressions include state of residence, year, and month of delivery fixed effects.

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