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The Effects of the Affordable Care Act Medicaid Expansions on Out-Of-Pocket Spending, Healthcare Utilization, and Health Outcomes

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The Effects of the Affordable Care Act Medicaid Expansions on Out-Of-Pocket Spending, Healthcare Utilization, and Health Outcomes

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in Health Policy and Management

by

Hiroshi Gotanda

2019

ABSTRACT OF THE DISSERTATION

The Effects of the Affordable Care Act Medicaid Expansions
on Out-Of-Pocket Spending, Healthcare Utilization, and Health Outcomes

by

Hiroshi Gotanda
Doctor of Philosophy in Health Policy and Management
University of California, Los Angeles, 2019
Professor Gerald F. Kominski, Chair

It is well documented that lack of health insurance negatively affects access to care and health outcomes. Uninsured people are less likely, compared to those with health insurance, to have usual source of care and receive necessary care primarily due to the cost, leading to detrimental health consequences. The Medicaid expansions under the Patient Protection and Affordable Care Act (ACA) were intended to provide access to health insurance coverage for many of the more than 45 million uninsured Americans. This major policy change originally required all states to expand the eligibility of their Medicaid programs to those younger than 65 years with incomes up to 138% of the federal poverty level (FPL), based solely on income without regard to categorical eligibility status. To date, there is ample evidence that the percentage of the uninsured has been significantly reduced nationally despite the fact that 14 states have not

adopted the ACA Medicaid expansions as of August 2019 due to the 2012 Supreme Court ruling making those expansions voluntary rather than mandatory.

This dissertation assessed the further effects of the ACA Medicaid expansions on out-of-pocket spending, healthcare utilization, and health outcomes for chronic conditions using a nationally representative sample of the low-income non-elderly population from the 2010-2016 Medical Expenditure Panel Survey and 2005-2016 National Health and Nutrition Examination Survey. It took advantage of the natural experiment that allowed a comparison of changes in outcomes between the expansion and non-expansion states. The three studies found that the ACA Medicaid expansions were associated with reduced out-of-pocket spending and improved financial risk protection, a modest increase in primary care physician visits without any meaningful change in emergency department visits, and improved clinical measures for hypertension and diabetes (but no improvement in outcomes for hyperlipidemia and depression), during the three years after the policy implementation.

The findings suggest that the ACA has been successful in achieving its goals of removing financial barriers, promoting access to primary care, and improving population health among low-income uninsured Americans. It has important implications for state decisions on adopting the ACA Medicaid expansions and for the ongoing national debate over the repeal of the ACA, including the Medicaid expansions.

The dissertation of Hiroshi Gotanda is approved.

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2019

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Paper #1 of this dissertation is a version of the following manuscript:

Gotanda H, Kominski G, Tsugawa Y. Association between the ACA Medicaid Expansions and Primary Care and Emergency Department Use during the First 3 Years (Revised and Resubmitted at *Journal of General Internal Medicine*)

In Paper #1, author contributions were as follows: All authors conceived and designed the study. HG performed the statistical analyses and data management. HG and YT drafted the initial manuscript. All authors interpreted the data, revised the manuscript critically, and approved the final manuscript.

Paper #2 of this dissertation is a version of the following manuscript:

Gotanda H, Jha AK, Kominski G, Tsugawa Y. Out-of-Pocket Spending and Financial Burden among Low-Income Adults during the First 3 Years of the ACA Medicaid Expansions: A Quasi-Experimental Study (under submission)

In Paper #2, author contributions were as follows: HG, GK, and YT conceived and designed the study. HG performed the statistical analyses and data management. HG and YT drafted the initial manuscript. All authors interpreted the data, revised the manuscript critically, and approved the final manuscript.

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3. **Gotanda, H.**, Kameyama, Y., Yamaguchi, Y., Ishii, M., Hanaoka, Y., Yamamoto, H., Ogawa, S., Iijima, K., Akishita, M., & Ouchi, Y. (2013). Acute exogenous lipoid pneumonia caused by accidental kerosene ingestion in an elderly patient with dementia: a case report. *Geriatr Gerontol Int*, 13(1), 222-225.

Chapter 1. Introduction

1-1. Overview of the Dissertation

This three-paper dissertation evaluates the impact of the Medicaid expansions in 2014 under the Patient Protection and Affordable Care Act (ACA) that primarily aimed to reduce the number of uninsured low-income Americans by providing affordable health insurance. Among a wide variety of outcomes, the three studies in this dissertation examine the effects of the ACA Medicaid expansions on the following:

(i) Out-of-pocket spending, premium contribution spending, out-of-pocket plus premium contribution spending, and catastrophic spending (paper #1);

(ii) Primary care physician and emergency department visits (paper #2); and

(iii) Health outcomes for hypertension, diabetes, hyperlipidemia, and depression (paper #3).

This first chapter introduces the background of the uninsured, ACA Medicaid expansions, the conceptual framework underlying the three studies of this dissertation, and the contributions of these studies to health policy and health services research. The second, third, fourth chapters present papers #1, #2, and #3, respectively. The fifth chapter provides conclusions from the dissertation.

1-2. The Uninsured

The proportion of the population without health insurance in the U.S. has been higher than other comparable countries despite the fact that the U.S. spends substantially more on healthcare.[1,2] In

2010, 46.5 million nonelderly individuals (ages 0-64)—approximately 18% of that age group—lacked health insurance coverage.[3,4] Young adults, minorities, and low-income populations were most likely to be uninsured.[3,4]

It is well documented that lack of health insurance negatively affects access to care and health outcomes. Half of the uninsured non-elderly adults do not have a usual source of care when they are sick or need medical advice.[4] Uninsured people are less likely, compared to those with health insurance, to receive recommended preventive care and treatments for chronic conditions, primarily because of the cost of care.[4-6] As a result, they are more likely to experience detrimental health consequences such as diagnoses at later stages of diseases including cancer and higher mortality rates.[7,8]

The uninsured frequently face financial hardship as well. They are far more likely than their insured counterparts to have a problem paying medical bills or to be unable to pay medical bills.[4] The negative consequences of medical bills include cutting back spending on food, clothing, or basic household items, depleting savings, and having medical bills sent to collection agencies.[9] They are also at high risk of financial catastrophe, especially in the event of emergency medical situations.[10]

1-3. **ACA Medicaid Expansions**

The Patient Protection and Affordable Care Act (ACA) was signed in by President Barack Obama on March 23, 2010, which brought the most significant changes to the U.S. healthcare system since Medicare was established in 1965. One of the primary purposes of the ACA was to

expand access to health insurance coverage for the vast majority of uninsured Americans, particularly among the population with low- and moderate family incomes.[11,12] This major transformation was based on the concept that healthcare is a right, rather than a privilege.[13]

The ACA employed two approaches to achieve its goal. First, it required all states to expand the eligibility of their Medicaid programs to those younger than 65 years with incomes up to 138% of the federal poverty level (FPL) ($16,753 for individuals in 2018), based solely on income without regard to categorical eligibility status for groups such as parents, pregnant women, and individuals with disabilities.[12,14,15] Second, it created Health Insurance Marketplaces (also known as Exchanges)—organized and competitive markets for buying health insurance—through which premium and cost-sharing subsidies are available for those with incomes up to 400% of FPL ($48,560 for individuals in 2018).[12,15,16] Because these two approaches are quite different, this dissertation focuses on the ACA Medicaid expansions, which target the most vulnerable population financially, medically, and socially, consisting of a majority of the uninsured in the U.S.[17]

The ACA Medicaid expansions were originally mandated for all states. The 2012 Supreme Court ruling on the ACA, however, made the Medicaid expansion essentially optional for states.[12] Consequently, 14 states still have not adopted the ACA Medicaid expansions as of August 2019 while 37 states including District of Columbia (D.C.) (hereafter referred to as a state for brevity) adopted the ACA Medicaid expansions (**Table 1-A**).[18] This dissertation takes advantage of this rare opportunity brought by the 2012 Supreme Court ruling that enabled us to examine the

effects of this policy intervention by comparing changes in outcomes in expansion and non-expansion states.

It is important to note that there are several subgroups among those states that have adopted the ACA Medicaid expansions as of May 2019 (**Table 1-A**):

(i) 6 states (California, Connecticut, D.C., Minnesota, New Jersey, and Washington) that have expanded Medicaid to low-income adults through the ACA State Plan Amendment and/or Section 1115 Waiver authority in 2010 to 2011 to prepare for the main implementation in 2014; although the magnitude of expansion was not substantial in New Jersey and Washington;[19,20]

(ii) 19 states that implemented ACA Medicaid expansions on January 1, 2014;

(iii) 9 states that implemented ACA Medicaid expansions after January 1, 2014;

(iv) 3 states (Idaho, Nebraska, and Utah) that adopted ACA Medicaid expansions but have not yet implemented;[18]

(v) 8 states that have approved Section 1115 Waivers for ACA Medicaid expansions;[18]

(vi) 5 states (Delaware, Hawaii, Massachusetts, New York, and Vermont) that had already provided Medicaid or similar coverage to adults with family incomes up to at least 100% of the FPL prior to 2014;[19,21] and

(vii) Wisconsin, which started comprehensive insurance coverage for childless adults with family incomes up to 100% of FPL through a non-Medicaid program as of January 1, 2014.[22]

There is ample evidence that the percentage of the uninsured significantly reduced nationally since the implementation of the ACA Medicaid expansions and that these reductions in the expansion states significantly exceed those in the non-expansion states (**Table 1-B**).[12,23] The reductions in the share of the uninsured in the expansion states seem to be attributable to gains in new Medicaid coverage as intended.[23]

1-4. **Study Outcomes and Conceptual Framework**

While early evaluations of the ACA Medicaid expansions have examined various outcomes in addition to the share of uninsured, there are still knowledge gaps that need to be addressed. This dissertation particularly investigates the impact of Medicaid expansions, comparing expansion vs. non-expansion states, on the following outcomes among the low-income non-elderly population:

(i) Out-of-pocket spending, premium contribution spending, out-of-pocket plus premium contribution spending, and catastrophic spending (paper #1);

(ii) Primary care physician and emergency department visits (paper #2); and

(iii) Health outcomes for hypertension, diabetes, hyperlipidemia, and depression (paper #3).

This section discusses the conceptual framework underlying these three study outcomes. The literature surrounding these outcomes will be detailed in the following chapters.

Figure 1-A, a conceptual model adapted from Anderson behavioral model,[24] depicts expected downstream effects of the ACA Medicaid expansions. Arrows indicated hypothesized directions of effects. Positive and negative signs indicate positive and negative associations, respectively, while arrows without signs indicate that the association could be positive or negative. The first

row includes the independent variable (i.e., the ACA Medicaid expansions) and the main dependent variables. The second row includes unmeasured variables (except income) that are hypothesized to be directly related to dependent variables. The third row includes control variables that are hypothesized to be related to dependent variables through unmeasured variables in the second row. Although individual- and neighborhood-level characteristics have complicated interrelationships, this conceptual model is simplified for the sake of conciseness.

(i) Out-of-pocket spending, premium contribution spending, out-of-pocket plus premium contribution spending, and catastrophic spending (paper #1):

As discussed in the previous section, it has been demonstrated that the ACA Medicaid expansions were associated with a reduction in the share of uninsured and an increase in the share of Medicaid enrollees in the expansion states. It is hypothesized that Medicaid coverage for previously uninsured people following the ACA Medicaid expansions results in less out-of-pocket spending for health services (such as deductibles, copayment, and co-insurance) because the cost-sharing for Medicaid is very low or zero.[25] It should also protect them from financial catastrophe in the event of emergency medical conditions. Premium contributions should not increase by obtaining Medicaid coverage as Medicaid generally charges no premiums.[25] In addition, if there were offsetting decreases in the share of private health insurance following the ACA Medicaid expansion (i.e., "crowd-out effect"), premium contributions should decrease on average among this population. The results of the empirical examination of these outcomes (paper #1) are presented in Chapter 2.

(ii) Primary care physician and emergency department visits (paper #2)

New Medicaid coverage is hypothesized to improve access to primary care providers in two ways. First, no or low cost-sharing for Medicaid coverage would promote primary care visits for those who had postponed or forgone care because of the cost of care.[4] Second, new Medicaid enrollees would no longer be turned down for care by primary care providers because they lack health insurance,[26,27] which should increase the likelihood of having primary care visits. Emergency department (ED) visits could increase or decrease. Increased primary care visits would be expected to improve health status, and therefore, the probability of visiting an ED is hypothesized to decrease. However, lower cost-sharing for Medicaid coverage might encourage them to visit an ED more frequently. Having a primary care provider (as a result of new Medicaid coverage) could promote ED visits because of their referral to an ED as qualitatively described in the analysis of the Oregon Health Insurance Experiment.[28] The results of the empirical examination of these outcomes (paper #2) are presented in Chapter 3.

(iii) Health outcomes for hypertension, diabetes, dyslipidemia, and depression (paper #3)

Improved access to primary care providers is expected to increase the probability of receiving preventive care and treatments of common chronic conditions, including hypertension, diabetes, hyperlipidemia, and depression. Therefore, population health for these conditions is expected to improve in the expansion states. The results of the empirical examination of these outcomes (paper #3) are presented in Chapter 4.

1-5. **Difference-in-differences approach**

One of the major goals of health policy research—including this dissertation—is to evaluate the causal effects of policies and programs on various outcomes to help decide future priorities. While randomized controlled trials (RCTs) are typically considered the "gold standard" for causal inference, large-scale RCTs are very rare in practice due to feasibility and ethical issues, and internal validity in RCTs often comes at the cost of external validity. Therefore, researchers have increasingly relied on quasi-experimental approaches, such as regression discontinuity design, instrumental variable method, propensity score matching, and difference-in-differences (DID) design, to estimate causal effects using observational data.[29] Among these methods, this dissertation employs DID models by taking advantage of an environment created by the Supreme Court's decision in 2012 to make the ACA Medicaid expansion optional for states.

The DID design utilizes the control group (individuals living in non-expansion states) to estimate the counterfactual outcomes of what would have happened to the treatment group (individuals living in expansion states) in the absence of the treatment (i.e., ACA Medicaid expansions). The effects of the treatment can then be elicited without bias by contrasting the changes in outcomes over time between the treatment and control groups. Whereas the simplest form of the DID design can only deal with the data with two groups (treatment and control groups) and two periods (pre- and post-treatment periods), the generalized form of the DID design can accommodate multiple groups and multiple time periods and has been frequently used by researchers in the field of policy evaluation.[19,21,29-31] This dissertation uses the generalized DID to account for multiple states with various time-invariant characteristics and different timings of Medicaid expansions as well as national secular trends in outcomes.

The key assumption in the DID design is the parallel trends assumption. That is, the trends in outcome variables should, without the treatment, be parallel between the treatment and control groups for the control group to serve as an appropriate counterfactual of the treatment group (although the treatment and control groups may have different levels of the outcome at baseline).[29] In assessing the validity of the parallel trends assumption, it is a common practice to examine the trends in both groups during the pre-treatment period (because this cannot be tested directly in the post-treatment period) and to conclude that the assumption is plausible if there is no evidence of differential trends prior to the treatment.[19,21,29-32] This dissertation follows this practice by comparing the trends in outcome variables between the expansion and non-expansion states prior to the ACA Medicaid expansions.

In health policy applications, however, it is not uncommon that the parallel trends assumption does not hold, which leads to biased estimation of the causal effects. Below are possible scenarios and potential solutions:

(i) There is evidence that the trends differ between the treatment and control groups prior to the treatment

Treatment and control groups may vary in terms of critical characteristics that determine outcomes, resulting in non-parallel trends between the two groups. For example, the difference in political stance between the expansion and non-expansion states (e.g., expansion states may be more liberal) could lead to differential trends in outcomes across the two groups, in which case the DID estimates would be biased. There are two emerging approaches to address this issue,

essentially by constructing a control group comparable to the treatment group: a propensity score matching approach and a synthetic control approach.[29,33,34]

(ii) Although there is no evidence that the trends differ between the treatment and control groups prior to the treatment, researchers have reasons to believe that an unexpected event affected the two groups differently and biased the estimation

The parallel trends assumption includes an assumption that an unexpected event (unrelated to the treatment) occurring simultaneously or after the treatment will equally affect the treatment and control groups (occasionally referred to as "common shocks assumption").[32] However, if such events influence the two groups differently, it could become a source of confounding. For example, time-variant macroeconomic factors (e.g., unemployment rate) may affect the expansion and non-expansion states differently and could confound the DID estimate. This confounding may be accounted for by adding an additional control group (that is not exposed to the treatment but is exposed to the problematic time-varying confounder) and estimating the treatment effects using a difference-in-difference-in-difference (DDD) design.[29,33]

(iii) Although there is no evidence that the trends differ between the treatment and control groups prior to the treatment, the statistical test of the parallel trends assumption does not have adequate power to detect violations

Recent studies suggest that the conventional test of the parallel trends assumption may have low power to detect important assumption violations in many cases.[35,36] There does not seem to be consensus on this subject yet and future research is warranted.

In summary, the DID design is regarded as a robust approach to estimate causal effects and widely used in the field of health policy research although it critically relies on the parallel trends assumption, which may not be fully testable. This dissertation aims to examine the causal effects of the ACA Medicaid expansions using the established methodologies of the DID design while recognizing the limitations and emerging methodological advances.

1-6. **Contribution to Health Policy and Health Services Research**

The goal of this dissertation is to evaluate the effects of the ACA Medicaid expansions on important outcomes and to provide critical policy implications for two audiences. First, the findings should promote a better understanding of the outcomes of the ACA Medicaid expansions for policymakers in the non-expansion states who have to decide whether their states should expand Medicaid. Second, the study results should be of significant interest for those policymakers who are currently attempting to prevent the repeal of the ACA including the Medicaid expansions by documenting the negative coverage and health consequences of an action.

1-7. References

1. Davis K, Stremikis K, David Squires, Schoen C. Mirror, Mirror on the Wall, 2014 Update: How the U.S. Health Care System Compares Internationally. 2014; https://www.commonwealthfund.org/sites/default/files/documents/___media_files_publications_fund_report_2014_jun_1755_davis_mirror_mirror_2014.pdf. Accessed September 1, 2018.
2. Papanicolas I, Woskie LR, Jha AK. Health care spending in the united states and other high-income countries. *JAMA.* 2018;319(10):1024-1039.
3. Rice T, Unruh LY, Rosenau P, Barnes AJ, Saltman RB, Ginneken Ev. Challenges facing the United States of America in implementing universal coverage. *Bull World Health Organ.* 2014;92:894-902.
4. The Henry J. Kaiser Family Foundation. Key Facts about the Uninsured Population. 2018; https://www.kff.org/uninsured/fact-sheet/key-facts-about-the-uninsured-population/. Accessed December 31, 2018.
5. Hadley J. Insurance coverage, medical care use, and short-term health changes following an unintentional injury or the onset of a chronic condition. *JAMA.* 2007;297(10):1073-1084.
6. McMorrow S, Kenney GM, Goin D. Determinants of receipt of recommended preventive services: implications for the Affordable Care Act. *Am J Public Health.* 2014;104(12):2392-2399.
7. Wilper AP, Woolhandler S, Lasser KE, McCormick D, Bor DH, Himmelstein DU. Health insurance and mortality in US adults. *Am J Public Health.* 2009;99(12):2289-2295.
8. Simard EP, Fedewa S, Ma J, Siegel R, Jemal A. Widening socioeconomic disparities in cervical cancer mortality among women in 26 states, 1993-2007. *Cancer.* 2012;118(20):5110-5116.
9. The Henry J. Kaiser Family Foundation. The Burden of Medical Debt: Results from the Kaiser Family Foundation/New York Times Medical Bills Survey. 2016; https://www.kff.org/health-costs/report/the-burden-of-medical-debt-results-from-the-

kaiser-family-foundationnew-york-times-medical-bills-survey/. Accessed December 31, 2018.

10. Scott JW, Raykar NP, Rose JA, et al. Cured into Destitution: Catastrophic Health Expenditure Risk Among Uninsured Trauma Patients in the United States. *Annals of Surgery*. 2018;267(6):1093-1099.
11. The Henry J. Kaiser Family Foundation. The Number of Uninsured People Rose in 2017, Reversing Some of the Coverage Gains Under the Affordable Care Act. 2018; https://www.kff.org/uninsured/press-release/the-number-of-uninsured-people-rose-in-2017-reversing-some-of-the-coverage-gains-under-the-affordable-care-act/. Accessed December 30, 2018.
12. Kominski. GF, Nonzee. NJ, Sorensen. A. The Affordable Care Act's Impacts on Access to Insurance and Health Care for Low-Income Populations. *Annu Rev Public Health.* 2017;38:489-505.
13. Maruthappu M, Ologunde R, Gunarajasingam A. Is Health Care a Right? Health Reforms in the USA and their Impact Upon the Concept of Care. *Ann Med Surg (Lond).* 2012;2(1):15-17.
14. The Henry J. Kaiser Family Foundation. The Uninsured: A Primer - Key Facts about Health Insurance and the Uninsured Under the Affordable Care Act. 2019; https://www.kff.org/uninsured/report/the-uninsured-a-primer-key-facts-about-health-insurance-and-the-uninsured-under-the-affordable-care-act/. Accessed May 19, 2019.
15. Office of the Assistant Secretary for Planning And Evaluation. U.S. Federal Poverty Guidelines Used to Determine Financial Eligibility for Certain Federal Programs. 2018; https://aspe.hhs.gov/poverty-guidelines. Accessed February 16, 2018.
16. The Henry J. Kaiser Family Foundation. FAQs: Health Insurance Marketplace and the ACA. 2018; https://www.kff.org/health-reform/faq/health-insurance-marketplace-aca/. Accessed December 30, 2018.
17. Rowland D. Profiles in Coverage: Medicaid, CHIP and The Uninsured. 2011; https://www.medicaid.gov/State-Resource-Center/downloads/0907_CB_1215_1_Profiles_in_Coverage_508.pdf. Accessed February 16, 2018.

18. The Henry J. Kaiser Family Foundation. Status of State Action on the Medicaid Expansion Decision. 2019; https://www.kff.org/health-reform/state-indicator/state-activity-around-expanding-medicaid-under-the-affordable-care-act/?currentTimeframe=0&sortModel=%7B%22colId%22:%22Location%22,%22sort%22:%22asc%22%7D. Accessed August 5, 2019.
19. Simon K, Soni A, Cawley J. The Impact of Health Insurance on Preventive Care and Health Behaviors: Evidence from the First Two Years of the ACA Medicaid Expansions. *J Policy Anal Manage.* 2017;36(2):390-417.
20. Sommers BD, Kenney GM, Epstein AM. New Evidence On The Affordable Care Act: Coverage Impacts Of Early Medicaid Expansions. *Health Aff (Millwood).* 2014;33(1):78-87.
21. Miller S, Wherry LR. Health and Access to Care during the First 2 Years of the ACA Medicaid Expansions. *N Engl J Med.* 2017;376(10):947-956.
22. The Henry J. Kaiser Family Foundation. The Wisconsin Health Care Landscape. 2015; https://www.kff.org/health-reform/fact-sheet/the-wisconsin-health-care-landscape/. Accessed November 24, 2018.
23. The Henry J. Kaiser Family Foundation. The Effects of Medicaid Expansion under the ACA: Updated Findings from a Literature Review. 2018; https://www.kff.org/medicaid/issue-brief/the-effects-of-medicaid-expansion-under-the-aca-updated-findings-from-a-literature-review-march-2018/. Accessed November 17, 2018.
24. Anderson RM, Davidson PL, Baumeister SE. Improving Access to Care. In: Kominski GF, ed. *Changing the U.S. Healthcare System*. 4th ed. San Francisco: Jossy Bass; 2014:33-69.
25. The Henry J. Kaiser Family Foundation. Premium and Cost-Sharing Requirements for Selected Services for Medicaid Adults. 2018; https://www.kff.org/health-reform/state-indicator/premium-and-cost-sharing-requirements-for-selected-services-for-medicaid-expansion-adults/?currentTimeframe=0&sortModel=%7B%22colId%22:%22Location%22,%22sort%22:%22asc%22%7D. Accessed July 26, 2018.
26. Feldman J. Do Doctors in America Turn Away the Uninsured? *Huffpost*2010.

27. Medford-Davis LN, Lin F, Greenstein A, Rhodes KV. "I Broke My Ankle": Access to Orthopedic Follow-up Care by Insurance Status. *Acad Emerg Med.* 2017;24(1):98-105.
28. Finkelstein AN, Taubman SL, Allen HL, Wright BJ, Baicker K. Effect of Medicaid Coverage on ED Use — Further Evidence from Oregon's Experiment. *N Engl J Med.* 2016;375(16):1505-1507.
29. Wing C, Simon K, Bello-Gomez RA. Designing Difference in Difference Studies: Best Practices for Public Health Policy Research. *Annu Rev Public Health.* 2018.
30. Wherry LR, Miller S. Early Coverage, Access, Utilization, and Health Effects Associated With the Affordable Care Act Medicaid Expansions: A Quasi-experimental Study. *Ann Intern Med.* 2016;164(12):795-803.
31. Sommers BD, Maylone B, Blendon RJ, Orav EJ, Epstein AM. Three-Year Impacts Of The Affordable Care Act: Improved Medical Care And Health Among Low-Income Adults. *Health Aff (Millwood).* 2017;36(6):1119-1128.
32. Dimick JB, Ryan AM. Methods for evaluating changes in health care policy: the difference-in-differences approach. *JAMA.* 2014;312(22):2401-2402.
33. Basu S, Meghani A, Siddiqi A. Evaluating the Health Impact of Large-Scale Public Policy Changes: Classical and Novel Approaches. *Annu Rev Public Health.* 2017;38:351-370.
34. O'Neill S, Kreif N, Grieve R, Sutton M, Sekhon JS. Estimating causal effects: considering three alternatives to difference-in-differences estimation. *Health services & outcomes research methodology.* 2016;16:1-21.
35. Roth J. Should We Adjust for the Test for Pre-trends in Difference-in-Difference Designs? *arXiv e-prints.* 2018. https://ui.adsabs.harvard.edu/abs/2018arXiv180401208R. Accessed April 01, 2018.
36. Bilinski A, Hatfield LA. Seeking evidence of absence: Reconsidering tests of model assumptions. *arXiv e-prints.* 2018. https://ui.adsabs.harvard.edu/abs/2018arXiv180503273B. Accessed May 01, 2018.

1-8. **Tables and Figures**

Table 1-A. Status of state decisions on the ACA Medicaid expansions as of August 2019

Adopted (37 states including District of Columbia)				Not adopted (14 states)
Early expansion (6 states)	Normal expansion on 01/01/2014 (19 states)	Late expansion (9 states)	Adopted but not implemented (3 states)	
California	Arizona[a]	Michigan[a] (04/01/2014)	Idaho	Alabama,
Connecticut	Arkansas[a]	New Hampshire[a] (08/15/2014)	Nebraska	Florida
District of Columbia	Colorado	Pennsylvania (01/01/2015)	Utah	Georgia
Minnesota	Delaware[c]	Indiana[a] (02/01/2015)		Kansas
New Jersey	Hawaii[c]	Alaska (09/01/2015)		Mississippi
Washington	Illinois	Montana[a] (01/01/2016)		Missouri
	Iowa[a]	Louisiana (07/01/2016)		North Carolina
	Kentucky[a]	Virginia (01/01/2019)		Oklahoma
	Maryland	Maine (01/10/2019)		South Carolina
	Massachusetts[c]			South Dakota
	Nevada			Tennessee
	New Mexico			Texas
	New York[c]			Wisconsin[b]
	North Dakota			Wyoming
	Ohio			
	Oregon			
	Rhode Island			
	Vermont[c]			
	West Virginia			

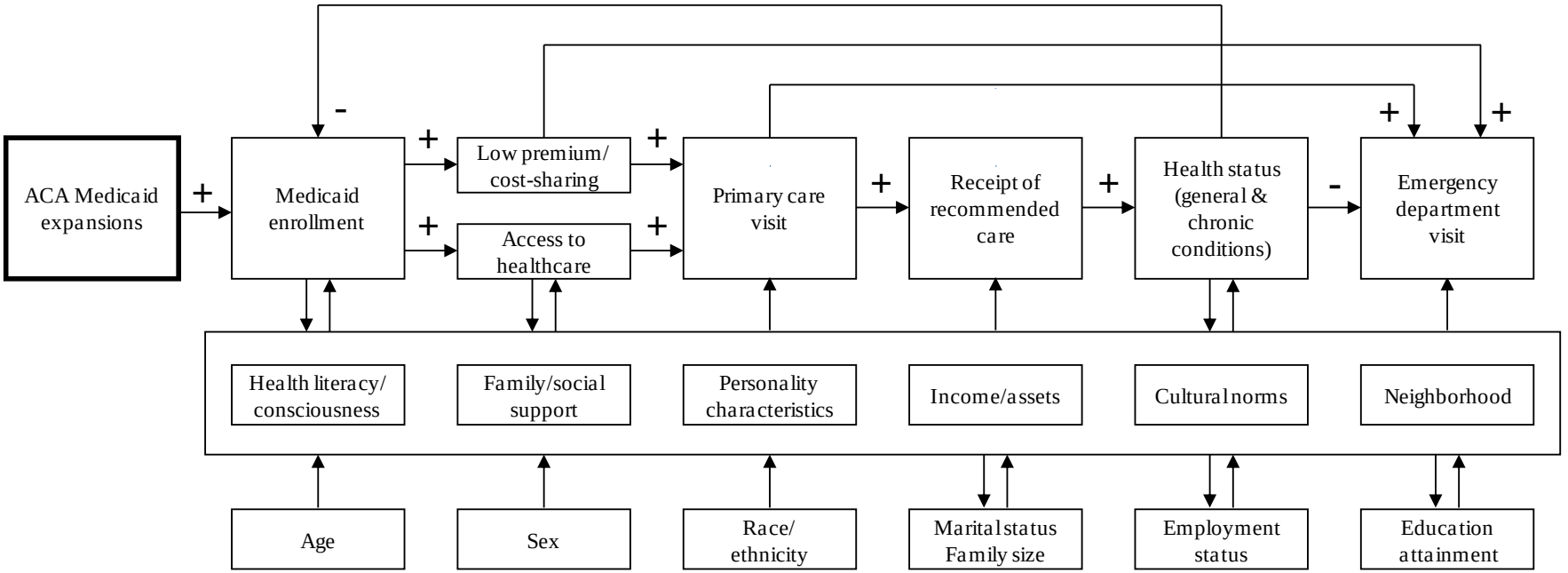
Note:
[a] Arizona, Arkansas, Indiana, Iowa, Kentucky, Michigan, Montana, and New Hampshire have approved Section 1115 waivers for the ACA Medicaid expansions.
[b] Wisconsin started comprehensive insurance coverage to childless adults with family incomes up to 100% of the FPL through a non-Medicaid program since January 1, 2014.
[c] Delaware, Hawaii, Massachusetts, New York, and Vermont had already provided Medicaid or similar coverage to adults with family incomes up to at least 100% of the FPL prior to 2014.

Table 1-B. Trend of uninsured nonelderly adults (18-64 years old) by poverty level

	2010			2013			2016		
Federal Poverty Level (FPL)	Total (million)[a]	Uninsured (million)[b]	Uninsured Rate (%)[c]	Total (million)[a]	Uninsured (million)[b]	Uninsured Rate (%)[c]	Total (million)[a]	Uninsured (million)[b]	Uninsured Rate (%)[c]
<100% FPL	26.2	11.1	42.2%	26.4	10.4	39.3%	22.8	6.0	26.2%
100-199% FPL	31.4	13.5	43.0%	33.5	12.9	38.5%	28.7	6.7	23.2%
≥ 200% FPL	134.4	16.9	12.6%	134.6	15.3	11.4%	145.6	10.5	7.2%
Total	192.0	42.8	22.3%	194.5	39.7	20.4%	197.1	24.4	12.4%
(Expansion)			(20.1%)			(18.4%)			(9.2%)
(Non-expansion)			(24.8%)			(22.7%)			(17.9%)

Note:
[a] Data from Poverty Data Tables by Census Bureau (2010-2017)
[b] Author's estimations based on sources a and c (Data may not sum to totals due to the use of different sources);
[c] Data from Health Insurance Coverage: Early Release of Estimates From the National Health Interview Survey, January – March 2017

Figure 1-A. Conceptual Framework



Chapter 2. Out-of-Pocket Spending, Premium Contributions, and Catastrophic Health Spending among Low-Income Families during the First 3 Years of the ACA Medicaid Expansions (Paper #1)

2-1. Abstract

Background: The Affordable Care Act (ACA) expanded Medicaid eligibility to persons earning up to 138% of the federal poverty level, potentially leading to a reduction in out-of-pocket (OOP) spending and the likelihood of catastrophic health spending among low-income families.

Methods: We compared changes in (1) the annual OOP spending, (2) premium contributions, (3) OOP plus premium spending, and (4) catastrophic health spending (defined as OOP plus premium spending >40% of post-subsistence income) during the first 3 years (2014-2016) following the implementation of ACA Medicaid expansions in states with and without expansion, using a difference-in-differences (DID) design. We analyzed nationally representative families with reference person being a 19-64 years old U.S. citizen and family incomes below 138% of the FPL, using the 2010-2016 Medical Expenditure Panel Survey.

Results: Our analysis included 18,414 families. We found that the Medicaid expansions were associated with approximately 25% lower OOP spending (baseline OOP spending in expansion states, $647; DID estimate, -$160; 95%CI, -$292 to -$27; p=0.02), 21% lower OOP plus premium spending (baseline in expansion states, $1,266; DID estimate, -$268; 95%CI, -$506 to $-30; p=0.03), and 30% lower likelihood of catastrophic health spending (baseline in expansion states, 21.9%; DID estimate, -6.4 percentage points; 95%CI, -10.5 to -2.3 percentage points;

p=0.003) by year 3. We found no evidence that premium contributions changed after the Medicaid expansions.

Conclusions: The ACA Medicaid expansions were associated with reduced OOP spending and improved financial risk protection, for low-income families during the first 3 years of its implementation.

2-2. **Background**

Healthcare in the United States is extremely costly, and many find affordability of healthcare as a major concern for them and their families.[1] This issue is especially salient for low-income families, who often have no or insufficient health insurance coverage and have to make tradeoffs between medical bills and basic living expenses including food, housing, and transportation.[2] Evidence suggests that uninsured people often postpone or forgo necessary healthcare because of cost, leading to detrimental health consequences,[2] and that they are at high risk of financial catastrophe, particularly in emergency medical situations.[3] The Patient Protection Affordable Care Act (ACA) enacted in 2010 was aimed to reduce the burden of healthcare costs by providing affordable health insurance to most of 50 million uninsured Americans at that time.[2,4] As a part of ACA, Medicaid eligibility was expanded to people from ages 19 to 64 with family incomes lower than 138% of the federal poverty level (FPL) in many states in 2014.[5] Evidence to date suggests that the ACA Medicaid expansions have been successful in reducing the number of uninsured patients among the low-income population.[6-9]

Although the ACA's Medicaid expansions were aimed at reducing out-of-pocket (OOP) spending and the likelihood of catastrophic spending among low-income families, empirical

evidence is limited to studies using the data from a small number of states (thus the generalizability of the findings may be questionable),[10] using the self-report of experiencing financial strain (e.g., questionnaire asking if participants were worried about the ability to pay medical bills) without quantitative data on actual changes in household healthcare spending,[9] or using indirect measures of OOP spending (e.g., medical collection balance).[11] Therefore, the national impact of the ACA Medicaid expansions on household spending on healthcare remains largely unknown. Additional empirical evidence is necessary for policymakers to gauge the financial impact of Medicaid expansions on low-income families at the national level.

In this context, using a nationally representative sample of low-income non-elderly population, we examined the impact of the ACA Medicaid expansions on OOP spending and probability of catastrophic health spending during the first three years (from 2014 through 2016) of the ACA Medicaid expansions.

2-3. **Methods**

Data source and study population

This study used the 2010-2016 Medical Expenditure Panel Survey (MEPS), a nationally representative annual survey of the non-institutionalized civilian population in the U.S. by the Agency for Healthcare Research and Quality (AHRQ).[12] MEPS conducts a series of five interviews with households covering two full calendar years and publishes data representing a whole calendar year. Collected data include demographics, family income, health status, healthcare utilization (e.g., office visits, hospitalizations, and prescriptions), and OOP spending for these services that are not covered by insurance and for cost-sharing such as deductibles,

copayments, and coinsurance. MEPS subsequently verifies self-reported spending information with providers, hospitals, and pharmacies.[13] In addition, MEPS collects annual premium contribution data for private health insurance based on self-reports at the first interview of the survey year (typically occurs between January through July).[14] The mean overall response rate of the MEPS data was 51.4%.[15]

Because financial risks are usually shared by members of a family, we conducted family-level analyses in this study. In the Medical Expenditure Panel Survey (MEPS) data, researchers can choose either MEPS-defined or Current Population Survey (CPS)-defined families to examine family-level outcomes. While CPS families do not include non-married partners, foster children, and in-laws, MEPS families do. We decided to use CPS-defined families because income and poverty level variables in MEPS are constructed based on CPS-defined families. A CPS-family is defined as "a group of two people or more (one of whom is the householder) related by birth, marriage, or adoption and residing together".[16] Although a person living alone should not be considered a CPS-family, strictly speaking, we included this type of individual as a family in our analysis. In that sense, we used "family" and "household" interchangeably in this article.

We included families if a family's reference person was a U.S. citizen aged 19-64 years and the family incomes were below 138% of the FPL, following the eligibility criteria of the 2014 ACA Medicaid expansions. We used the information of the reference person as the characteristics of a family. MEPS defines the reference person as the household member 16 years of age or older who owns or rents the home.[17] If more than one person met this definition, the household respondent identified one from among them. If the respondent was unable to identify a person

fitting this definition, the questionnaire asks for the head of household and this person is then considered the reference person. We excluded families if the reference person was a non-U.S. citizen from the main analysis because non-U.S. citizens have to meet specific eligibility requirements to be covered by Medicaid such as the duration of residence in the U.S.[18] We also excluded observations with missing data in covariates from the study sample. We used imputed data for missing income and employment values, which were estimated by AHRQ using logical editing and weighted sequential hot-deck procedures.[17]

Study variables

i) Expansion status

Most states implemented the ACA Medicaid expansion on January 1, 2014. However, the following states expanded Medicaid later: Michigan (April 1, 2014), New Hampshire (August 15, 2014), Pennsylvania (January 1, 2015), Indiana (February 1, 2015), Alaska (September 1, 2015), Montana (January 1, 2016), and Louisiana (July 1, 2016).[19] Expansion states were defined as states that implemented the ACA Medicaid expansion or an equivalent program by June 2016 and non-expansion states were those did not. Based on this definition, our study had 32 expansion states (including the District of Columbia) and 19 non-expansion states (**Table 2-A**).

California, Connecticut, District of Columbia, Minnesota, New Jersey, and Washington enacted ACA Medicaid expansions or started an equivalent program in either 2010 or 2011 while the extent of the expansion was limited in New Jersey and Washington.[20] Five states (Delaware, Hawaii, Massachusetts, New York, and Vermont) had already provided significant coverage prior to 2014. Wisconsin was included in the expansion states even though it did not adopt the

ACA Medicaid expansion because Wisconsin provided comprehensive insurance coverage to childless adults with family incomes up to 100% of the federal poverty level (FPL) through a non-Medicaid program since January 1, 2014, which is considered as a significant change.[21]

For non-expansion states and most expansion states that implemented the ACA Medicaid expansions on January 1, 2014, we defined year 2010-2013 as the "pre-expansion" period, year 2014 as "Year 1", year 2015 as "Year 2", and year 2016 as 'Year 3". For those states that expanded Medicaid after this date, we defined these periods based on when a given state actually expanded Medicaid (**Table 2-A**). If a state expanded the Medicaid before July 1 of a certain year, the whole year was considered as Year 1. On the other hand, if a state expanded after July 1 of a certain year, the whole year was included in the pre-expansion period.

ii) Household healthcare spending

We estimated four annual healthcare spending outcomes at a household level: OOP spending, premium contributions, OOP plus premium spending, and catastrophic health spending. OOP spending included deductibles, copayments, and coinsurance by family members younger than 65 years old (because the ACA Medicaid expansions do not influence individuals 65 years and older).[22] Premium contributions included premiums for private health insurance because MEPS does not collect premium information for non-private insurance. Generally, premiums in Medicaid are not allowed for those with family incomes below 150% of the FPL while five states charged low premiums under Section 1115 waiver authority as of 2016.[23] While each state had different premium rules, three states charged 2% of family incomes as premiums based on certain income criteria.[23] In Montana, for example, a family of two with incomes above 50% of

the FPL was subject to yearly premiums of $320 in 2016 (2% of $16,020).[23,24] Therefore, the average Medicaid premiums per family at the national level would be much lower than $30, which makes it unlikely to bias our estimates significantly. Similarly, Medicare beneficiaries with family incomes lower than 135% of the FPL are eligible for the Medicare Savings Programs, through which they receive Medicaid assistance with at least their Medicare Part B and Part D premiums.[22,25] In addition, 99% of Medicare beneficiaries are not required to pay their Medicare Part A premiums.[26] Subsequently, not including premiums for Medicare should not make a substantial impact on our national estimates. Nevertheless, we conducted a sensitivity analysis by excluding families whose reference person was a Medicare beneficiary.

Catastrophic health spending was represented by a binary outcome variable defined as whether OOP plus premium spending exceeded 40% of post-subsistence income. We calculated post-subsistence income by subtracting food expenses from family incomes. Mean food expenses across income categories were derived from the Consumer Expenditure Survey data.[27] This approach was used in previous literature and is consistent with the definition by the World Health Organization.[28,29] We assumed that post-subsistence income was $100 per year for negative and extremely low values (values less than $100 per year), an approach used by a prior study.[30] All healthcare spending data was adjusted to 2016 U.S. dollars based on the Consumer Price Index.[31]

iii) Health Insurance Coverage

As a supplementary analysis, we examined health insurance coverage among 19-64 years old U.S. citizens with family incomes below 138% of the FPL to understand the causal mechanism

linking the expanded Medicaid eligibility with a potential change in spending outcomes. We used three binary health insurance coverage variables for the supplementary analysis at an individual level: (1) uninsured defined as no coverage by Medicaid, Medicare, private insurance, military programs, or other public programs throughout the survey year, (2) Medicaid defined as Medicaid coverage for at least one day during the survey year, and (3) private health insurance coverage defined as private health insurance coverage for at least one day during the survey year but without any Medicaid coverage throughout the survey year.

iv) Adjustment variables

We included in the following family characteristics represented by the characteristics of the family's reference person to our regression models: age (as continuous), sex, race/ethnicity (non-Hispanic White, non-Hispanic Black, Hispanic, and other), education attainment (less than high school, high school or some college, bachelor's degree, or more than bachelor's degree), employment status, family size (as continuous), and annual family income (as continuous). Family size is the number of family members who are younger than 65 years old. Family incomes are not included in the model for catastrophic health spending as they are used for the definition of this outcome. We also included state- and year-specific fixed effects in our model to account for state time-invariant factors and a secular trend.

Statistical analysis

We used a difference-in-differences (DID) design to compare differential changes in the outcomes between families in states with and without expansion before and after the ACA Medicaid expansions. For each of the outcome variables, we estimate the following regression:

$$Y_{fst} = \theta_s + \lambda_t + \beta_1 T1_{st} + \beta_2 T2_{st} + \beta_3 T3_{st} + \delta X_{fst} + \varepsilon_{fst},$$

Y_{fst} : Outcome for family *f* living in state *s* at time *t* (expressed as year)

θ_s : State-specific fixed effects

λ_t : Year-specific fixed effects

$T1_{st}, T2_{st}, T3_{st}$: Interaction terms between expansion state indicator and each of post-expansion indicators (Years 1, 2, and 3) equal to 1 if the family lived in an expansion state in Year 1, 2, or 3 for the state *s* where the family lived

X_{ist} : Adjustment variables for family *f* (age, sex, race/ethnicity, marital status, education attainment, employment, family size, and family income)

The coefficients β_1, β_2, and β_3 on the interaction terms represent the average adjusted difference between the expansion and non-expansion states in the change in the outcome variable Y_{ist} from the pre-expansion period to the Years 1, 2, and 3.

We used a two-part model (the first part is a logistic regression model indicating whether participants experienced non-zero health spending in a given year, and the second part is a generalized linear model with log link and gamma distribution to account for highly skewed data),[32] and a logistic regression model for the binary outcomes. We then estimated the differences in the predicted outcomes at each category level of the interaction terms (e.g., indicator variable for Year 1 and expansion status) for each observation, and averaged over our national sample for the ease of interpretation (i.e., average marginal effect in dollars for outcomes in dollars and in percentage points for binary outcomes).[33]

We formally tested the parallel trend assumption of the DID model. In the DID model, we assume that the outcomes in the treatment group (i.e., expansion states) would have had a similar trend as those in the control group (i.e., non-expansion states) if the treatment (i.e., ACA Medicaid expansions) had not occurred. We estimated regression models with an interaction term between the expansion state indicator variable and year trend variable (as continuous) for the data during the baseline period. If the coefficient of the interaction term is not equal to zero, it indicates that the linear trends for expansion and non-expansion states differ during the baseline period, which suggests a violation of the parallel trend assumption.

For this test, we used a generalized linear model (GLM) with log link and gamma distribution for OOP spending and OOP plus premium spending and a logistic regression model for binary outcomes. We chose GLM instead of a two-part model because a two-part model yields two coefficients for the interaction term, which leads to difficult interpretation in this case, and because GLM and a two-part model produced very similar results for the main analysis. For premium contribution spending, we used a linear regression model for the test of parallel trend assumption as GLM did not converge for this outcome.

All analyses accounted for the complex survey design of MEPS, and cluster-robust standard errors were estimated to account for the non-independence of observations within the primary sampling unit (a set of neighboring counties).

Sensitivity analysis

We conducted several sensitivity analyses with different sample population definitions. First, we excluded 10 "non-full expansion" states that were different from full expansion states: 5 states (Delaware, Hawaii, Massachusetts, New York, and Vermont) that already provided similar coverage prior to 2014; 4 states (California, Connecticut, Minnesota, and District of Columbia) that enacted ACA Medicaid expansions or started an equivalent program to some extent in either 2010 or 2011 ("early expansion states"); 1 state (Wisconsin) that provided comprehensive insurance coverage to childless adults with family incomes lower than 100% of the FPL through a non-Medicaid program since January 1, 2014, corresponding to previous literature.[20] Second, we excluded five "mild-expansion" (Delaware, District of Columbia, Massachusetts, New York, and Vermont) from expanding states that provided Medicaid or similar coverage to adults with incomes up to 100% of the FPL or greater during 2010-2013, corresponding to previous literature.[9,20] Third, we included families whose reference person was a non-US citizen, who can become eligible for Medicaid under certain circumstances.[18] Fourth, we restricted the study sample to families with incomes lower than 100% of the FPL, who might have had a larger impact of the ACA Medicaid expansions. Fifth, we excluded families whose reference person was a Medicare beneficiary because Medicare beneficiaries were not the target of the ACA Medicaid expansions and our study does not account for Medicare premiums due to data availability. Sixth, we analyzed families with incomes greater than 400% of the FPL as a falsification test because they should not have had an impact of the ACA Medicaid expansion.

We also analyzed the data with alternative model specifications: a generalized linear model with log link and gamma distribution for spending outcomes (instead of a two-part model) as

recommended in previous literature,[34] and a linear probability model for catastrophic health spending (instead of a logistic regression model), corresponding to previous literature (coefficients are presented as DID estimates).[10]

Statistical analyses were conducted with Stata software version 14.1 (StataCorp, Texas, USA). We used restricted-access state identifiers for MEPS participants provided by AHRQ, and all analyses were conducted in the California Census Research Data Center. The University of California, Los Angeles Institutional Review Board approved this study.

2-4. **Results**

Our study included 18,414 families for the main analysis and 26,355 individuals for the supplementary analysis of health insurance coverage (see **Figure 2-A** for the flowchart). **Table 2-B** presents the baseline demographic characteristics of family's reference persons in the expansion and non-expansion states based on the pooled data from 2010 to 2013. There was evidence that race/ethnicity differs in two groups; the proportion of non-Hispanic Black participants was lower (20.3% vs. 28.5%) in expansion states.

Figures 2-B, **2-C**, **and 2-D** show the unadjusted yearly trends in outcomes by expansion status. The formal test showed no evidence that baseline trends are significantly different for all outcomes. The results are presented in Table 2-C.

Out-of-pocket spending

Table 2-D presents DID estimates for the main outcomes. The baseline OOP spending was $647 for expansion states and $794 for non-expansion states. While OOP spending did not change in Years 1 and 2 (DID estimates, -$2 in Year 1 and -$43 in Year 2; 95%CI, -$191 to +$187 in Year 1, -$195 to +$110 in Year 2; p=0.98 and 0.58), we observed a significant decrease in Year 3 (DID estimates, -$160; 95%CI, -$292 to -$27; p=0.02).

Premium contributions

The premium contributions were $619 and $708 for expansion and non-expansion states, respectively, at baseline. We found no evidence that premium spending changed in the post-expansion period.

Out-of-pocket plus premium spending

The OOP plus premium spending was $1,266 and $1,502 for expansion and non-expansion states, respectively, at baseline. Although OOP plus premium spending did not change in Years 1 and 2 (DID estimates, -$147 in Year 1 and -$173 in Year 2; 95%CI, -$406 to +$112 in Year 1, -$418 to +$71 in Year 2; p=0.26 and 0.16), we observed a significant decrease in Year 3 (DID estimates, -$268; 95%CI, -$506 to -$30; p=0.03).

Catastrophic health spending

The probability of experiencing catastrophic health spending was 21.9% and 24.1% for expansion and non-expansion states, respectively, at baseline. While the likelihood catastrophic health spending did not change in Years 1 and 2 (DID estimates, -0.3 percentage points in Year 1

and +0.5 percentage points in Year 2; 95%CI, -4.7 to +4.2 in Year 1, -3.7 to +5.5 in Year 2; p=0.91 and 0.70, we observed a significant decrease in Year 3 (DID estimates, -6.4 percentage points; 95%CI, -10.5 to -2.3; p=0.003).

Health insurance coverage

Table 2-E presents DID estimates for insurance coverage outcomes. The percentage of uninsured significantly decreased and Medicaid share significantly increased in Years 1, 2, and 3. We also found that the private health insurance share significantly decreased in Years 2 and 3.

Sensitivity analyses

Table 2-F and 2-G present the results of the sensitivity analyses. Overall, analyses with alternative sample definitions and model specifications yielded very similar results to the main analysis except for the following. First, the analyses with families with incomes lower than 100% of the FPL and analyses excluding Medicare beneficiaries generally showed a greater magnitude of effects in all outcomes compared to the main analysis. Especially for the analyses with families with incomes lower than 100% of the FPL, the decreases in premium contribution spending became statistically significant in Years 2 and 3. Second, the falsification test by analyzing those with family incomes greater than 400% of the FPL showed a completely different pattern in OOP spending, premium contributions, and OOP plus premium spending, which indicates the robustness of our analysis. The regression model for catastrophic health spending for this population did not converge likely because only a very small proportion experienced catastrophic health spending.

2-5. **Discussion**

Using a nationally representative sample of the low-income non-elderly population in the U.S., we found that the ACA Medicaid expansions were associated with significant reductions in household OOP spending, OOP plus premium spending, and the probability of catastrophic health spending at the national level by year 3 of the implementation. The differences in spending between states with and without Medicaid expansion became larger over time (and became statistically significant by year 3), likely reflecting the gradual penetration of the policy (gradual take-up of Medicaid programs in expansion states). To our knowledge, this is the first study examining the impact of the ACA Medical expansions on household healthcare spending using nationally representative data.

The magnitude of the effects of the ACA Medicaid expansions on study outcomes is arguably large. Our findings suggest that Medicaid expansions reduced annual OOP spending by approximately 25% ($160 reduction in Year 3 from $647 at baseline in expansion states), OOP plus premium spending by 21% ($268 reduction from $1,266), and catastrophic health spending by 30% (6.4 percentage-point reduction from 21.9%). Given that these changes are concentrated in a small proportion of families who actually obtained Medicaid coverage because of Medicaid expansions (approximately one in ten families), the magnitude of actual effects among these families would be even larger than the observed values in our analyses that are diluted by a large proportion of people who were unaffected by the policy (e.g., those who were covered by Medicaid prior to the policy change, who remained uninsured after the expansions, who were covered by private insurance both before and after the expansions).

We found that the differences in spending between states with and without Medicaid expansion were not statistically significant during the first 2 years of Medicaid expansions but became statistically significant in year 3. This probably reflects a gradual take-up of Medicaid programs in expansion states as it may take several years for beneficiaries, program administrators, and providers to learn about a new program.[9,35] It is also possible that a reduction in OOP spending during the first 2 years might have been offset by a "pent-up demand" among newly-insured who were foregoing or delaying care due to lack of insurance before Medicaid expansions.[36]

There are several mechanisms why the ACA's Medicaid expansions lowered household OOP spending and the risk of catastrophic health spending. First, improved coverage by Medicaid among previously uninsured people led to less OOP spending as Medicaid takes up a large share of their spending on healthcare services. Children with family incomes lower than 133% of the FPL generally have no cost-sharing for Medicaid, and the maximum allowable cost-sharing amounts for adults with Medicaid are very low (e.g., $4 for outpatient services for those with family incomes lower than 100% of the FPL).[37] Second, because Medicaid generally charges no premiums, premium contributions would not increase for previously uninsured people who obtained Medicaid coverage and would decrease for those who switched from Medicaid to private health insurance. In fact, our supplementary analysis and existing literature demonstrated offsetting decreases in private health insurance share after the ACA Medicaid expansion (i.e., "crowd-out effect").[5,9,38] While our DID estimates for premium contributions were not statistically significant, this mechanism seems to explain the additional decrease in OOP plus premium spending compared to OOP spending.

Our study is built upon previous studies suggesting the effectiveness of the ACA Medicaid expansions on reducing household spending on healthcare. Sommers and colleagues studied the impact of Medicaid expansions using the data from three states (Kentucky, Arkansas, and Texas) and reported that Medicaid expansions led to a reduction in annual OOP spending by $88.[10] Miller and Wherry analyzed a national survey and found that the ACA Medicaid expansions were associated with a significant decrease in respondent reporting yes to questionnaires asking if they were worried about the ability to pay medical bills in the event of an illness or had accident and problems paying medical bills.[9] Caswell and Waidmann analyzed major credit bureau data and demonstrated reduced probabilities of a medical collection balance of $1,000 or more and of a new bankruptcy filing in expansion states.[11] While informative, these studies were limited as they used a small number of states and have limited generalizability,[10] they relied on self-report about financial concerns without the quantitative data on spending,[9] or they used indirect measures of health spending.[11] To our knowledge, this is the first national study that examined the impact of the ACA Medical expansions on household OOP spending using valid and reliable data.

Our study has limitations. First, although we used a quasi-experimental method—a difference-in-difference method—to account for both measured and unmeasured confounders, we could not completely preclude the possibility of residual confounders. It is possible that expansion and non-expansion states differ in a way that could not be captured by the use of a quasi-experimental approach. However, the fact that the trends in outcome variables were parallel between expanded and non-expanded states before the Medicaid expansions supports the internal validity of our findings. Second, given that lack of data, we could not include premiums for non-

private insurance in our calculation of healthcare spending. Nevertheless, the bias from this exclusion is estimated to be minimal, and the fact that our findings were not qualitatively affected by excluding Medicare beneficiaries in the sensitivity analysis supports the robustness of our findings. Furthermore, our findings the Medicaid expansions were associated with a lower OOP spending were unaffected by the lack of data for premiums. Lastly, the mean response rate of MEPS is just above 50% and people who responded to the survey might be different from those who did not. In order for this to introduce a bias in our estimates (known as non-response bias), these differences between respondents and non-respondents should also differ systematically between expansion and non-expansion states, which we think is unlikely.

In summary, using a nationally representative sample of the low-income non-elderly population, we found that family OOP spending, OOP plus premium spending, and the likelihood of catastrophic health spending decreased significantly in expansion states relative to non-expansion states during the first three years of the implementation of the ACA Medicaid expansions. These findings provide important implication on the financial impact of the ACA Medicaid expansions on low-income families in the U.S., particularly for the policymakers in states currently considering to expand Medicaid programs.

2-6. References

1. The Henry J. Kaiser Family Foundation. New Kaiser/New York Times Survey Finds One in Five Working-Age Americans With Health Insurance Report Problems Paying Medical Bills. 2016; https://www.kff.org/health-costs/press-release/new-kaisernew-york-times-survey-finds-one-in-five-working-age-americans-with-health-insurance-report-problems-paying-medical-bills/. Accessed May 19, 2019.
2. The Henry J. Kaiser Family Foundation. The Uninsured: A Primer - Key Facts about Health Insurance and the Uninsured Under the Affordable Care Act. 2019; https://www.kff.org/uninsured/report/the-uninsured-a-primer-key-facts-about-health-insurance-and-the-uninsured-under-the-affordable-care-act/. Accessed May 19, 2019.
3. Scott JW, Raykar NP, Rose JA, et al. Cured into Destitution: Catastrophic Health Expenditure Risk Among Uninsured Trauma Patients in the United States. *Ann Surg.* 2018;267(6):1093-1099.
4. The Henry J. Kaiser Family Foundation. Health Insurance Coverage in America, 2010. 2012; https://www.kff.org/uninsured/report/health-insurance-coverage-in-america-2010/. Accessed May 19, 2019.
5. The Henry J. Kaiser Family Foundation. The Effects of Medicaid Expansion under the ACA: Updated Findings from a Literature Review. 2018; https://www.kff.org/medicaid/issue-brief/the-effects-of-medicaid-expansion-under-the-aca-updated-findings-from-a-literature-review-march-2018/. Accessed November 17, 2018.
6. National Center for Health Statistics. Health Insurance Coverage: Early Release of Estimates From the National Health Interview Survey, January – March 2017. 2017; https://www.cdc.gov/nchs/data/nhis/earlyrelease/insur201708.pdf. Accessed November 7, 2018.
7. Kominski. GF, Nonzee. NJ, Sorensen. A. The Affordable Care Act's Impacts on Access to Insurance and Health Care for Low-Income Populations. *Annu Rev Public Health.* 2017;38:489-505.
8. Sommers BD, Gawande AA, Baicker K. Health Insurance Coverage and Health - What the Recent Evidence Tells Us. *N Engl J Med.* 2017;377(6):586-593.

9. Miller S, Wherry LR. Health and Access to Care during the First 2 Years of the ACA Medicaid Expansions. *N Engl J Med.* 2017;376(10):947-956.
10. Sommers BD, Maylone B, Blendon RJ, Orav EJ, Epstein AM. Three-Year Impacts Of The Affordable Care Act: Improved Medical Care And Health Among Low-Income Adults. *Health Aff (Millwood).* 2017;36(6):1119-1128.
11. Caswell KJ, Waidmann TA. The Affordable Care Act Medicaid Expansions and Personal Finance. *Med Care Res Rev.* 2017:1077558717725164.
12. Agency for Healthcare Research and Quality. MEPS Household Component Annual Contractor Methodology Report 2017. 2018; https://meps.ahrq.gov/data_files/publications/annual_contractor_report/hc_ann_cntrct_methrpt.shtml. Accessed July 18, 2019.
13. Agency for Healthcare Research and Quality. Medical Expenditure Panel Survey Medical Provider Component (MEPS-MPC) Methodology Report 2016 Data Collection. 2018; https://meps.ahrq.gov/data_files/publications/annual_contractor_report/mpc_ann_cntrct_methrpt.pdf. Accessed April 2, 2019.
14. Agency for Healthcare Research and Quality. MEPS HC-179: 2015 Person Round Plan Public Use File. 2018; https://meps.ahrq.gov/data_stats/download_data/pufs/h191/h191doc.shtml. Accessed April 2, 2019.
15. Agency for Healthcare Research and Quality. MEPS-HC Response Rates by Panel. 2018; https://meps.ahrq.gov/survey_comp/hc_response_rate.jsp. Accessed April 2, 2019.
16. United States Census Bureau. Current Population Survey (CPS): Subject Definitions. 2015; https://www.census.gov/programs-surveys/cps/technical-documentation/subject-definitions.html#incomemeasurement. Accessed October 13, 2018.
17. Agency for Healthcare Research and Quality. MEPS HC-192: 2016 Full Year Consolidated Data File. 2018; https://meps.ahrq.gov/data_stats/download_data/pufs/h192/h192doc.shtml. Accessed October 14, 2018.
18. Centers for Medicare & Medicaid Services. Coverage for lawfully present immigrants. 2018; https://www.healthcare.gov/immigrants/lawfully-present-immigrants/. Accessed November 7, 2018.

19. The Henry J. Kaiser Family Foundation. Status of State Action on the Medicaid Expansion Decision. 2019; https://www.kff.org/health-reform/state-indicator/state-activity-around-expanding-medicaid-under-the-affordable-care-act/?currentTimeframe=0&sortModel=%7B%22colId%22:%22Location%22,%22sort%22:%22asc%22%7D. Accessed August 5, 2019.
20. Simon K, Soni A, Cawley J. The Impact of Health Insurance on Preventive Care and Health Behaviors: Evidence from the First Two Years of the ACA Medicaid Expansions. *J Policy Anal Manage.* 2017;36(2):390-417.
21. The Henry J. Kaiser Family Foundation. The Wisconsin Health Care Landscape. 2015; https://www.kff.org/health-reform/fact-sheet/the-wisconsin-health-care-landscape/. Accessed November 24, 2018.
22. The Henry J. Kaiser Family Foundation. Medicaid Financial Eligibility for Seniors and People with Disabilities in 2015. 2016; https://www.kff.org/report-section/medicaid-financial-eligibility-for-seniors-and-people-with-disabilities-in-2015-report/. Accessed November 23, 2018.
23. The Henry J. Kaiser Family Foundation. Medicaid and CHIP Eligibility, Enrollment, Renewal, and Cost-Sharing Policies as of January 2016: Findings from a 50-State Survey. 2016; https://www.kff.org/report-section/medicaid-and-chip-eligibility-enrollment-renewal-and-cost-sharing-policies-as-of-january-2016-premiums-and-cost-sharing/. Accessed November 2018, 2018.
24. Office of the Assistant Secretary for Planning And Evaluation. Computations for the 2016 poverty guidelines. 2016; https://aspe.hhs.gov/computations-2016-poverty-guidelines. Accessed December 6, 2018.
25. Centers for Medicare & Medicaid Services. Medicare Savings Programs. 2018; https://www.medicare.gov/your-medicare-costs/get-help-paying-costs/medicare-savings-programs. Accessed November 25, 2018.
26. Centers for Medicare & Medicaid Services. 2016 Medicare Parts A & B Premiums and Deductibles Announced. 2015; https://www.cms.gov/newsroom/press-releases/2016-medicare-parts-b-premiums-and-deductibles-announced. Accessed November 25, 2018.

27. Bureau of Labor Statistics. Consumer Expenditure Surveys: 2016 Combined Expenditure, Share, and Standard Error Tables. 2017; https://www.bls.gov/cex/2016/combined/income.pdf. Accessed October 17, 2018.
28. Khera R, Valero-Elizondo J, Okunrintemi V, et al. Association of Out-of-Pocket Annual Health Expenditures With Financial Hardship in Low-Income Adults With Atherosclerotic Cardiovascular Disease in the United States. *JAMA cardiology.* 2018.
29. World Health Organization. Distribution of health payments and catastrophic expenditures methodology. 2005; http://www.who.int/health_financing/documents/dp_e_05_2-distribution_of_health_payments.pdf. Accessed November 23, 2018.
30. Banthin JS, Bernard DM. Changes in financial burdens for health care: National estimates for the population younger than 65 years, 1996 to 2003. *JAMA.* 2006;296(22):2712-2719.
31. Bureau of Labor Statistics. Archived Consumer Price Index Detailed Reports. 2017; https://www.bls.gov/cpi/tables/detailed-reports/home.htm. Accessed May 19, 2019.
32. Deb P, Norton EC. Modeling Health Care Expenditures and Use. *Annu Rev Public Health.* 2018;39(1):489-505.
33. Williams R. Using the margins command to estimate and interpret adjusted predictions and marginal effects. *Stata Journal.* 2012;12(2):308-331.
34. Buntin MB, Zaslavsky AM. Too much ado about two-part models and transformation? Comparing methods of modeling Medicare expenditures. *J Health Econ.* 2004;23(3):525-542.
35. Sommers B, Kronick R, Finegold K, Po R, Schwartz K, Glied S. Understanding Participation Rates In Medicaid: Implications For The Affordable Care Act. 2012; https://aspe.hhs.gov/basic-report/understanding-participation-rates-medicaid-implications-affordable-care-act. Accessed January 23, 2019.
36. Fertig AR, Carlin CS, Ode S, Long SK. Evidence of Pent-Up Demand for Care After Medicaid Expansion. *Med Care Res Rev.* 2017;75(4):516-524.
37. The Henry J. Kaiser Family Foundation. The Effects of Premiums and Cost Sharing on Low-Income Populations: Updated Review of Research Findings. 2017; https://www.kff.org/medicaid/issue-brief/the-effects-of-premiums-and-cost-sharing-on-

low-income-populations-updated-review-of-research-findings/. Accessed December 8, 2018.

38. Wehby GL, Lyu W. The Impact of the ACA Medicaid Expansions on Health Insurance Coverage through 2015 and Coverage Disparities by Age, Race/Ethnicity, and Gender. *Health Serv Res.* 2017;53(2):1248-1271.

2-7. Tables and Figures

Table 2-A. Definition of expansion states and pre- and post-expansion periods

States (date of expansion)	Definitions of periods by MEPS year			
	Pre-expansion	Post-expansion		
		Year 1	Year 2	Year 3
Non-expansion states (19 states)				
Alabama, Florida, Georgia, Idaho, Kansas, Louisiana, Maine, Mississippi, Missouri, Nebraska, North Carolina, Oklahoma, South Carolina, South Dakota, Tennessee, Texas, Utah, Virginia, and Wyoming	2010-2013	2014	2015	2016
Expansion states (32 states)				
Arizona, Arkansas, California, Colorado, Connecticut, Delaware, District of Columbia, Hawaii, Illinois, Iowa, Kentucky, Maryland, Massachusetts, Minnesota, Nevada, New Jersey, New Mexico, New York, North Dakota, Ohio, Oregon, Rhode Island, Vermont, Washington, West Virginia, Wisconsin (All expanded on Jan 1, 2014)	2010-2013	2014	2015	2016
Michigan (April 1, 2014)	2010-2013	2014	2015	2016
New Hampshire (August 15, 2014)	2010-2014	2015	2016	N/A
Pennsylvania (January 1, 2015)	2010-2014	2015	2016	N/A
Indiana (February 1, 2015)	2010-2014	2015	2016	N/A
Alaska (September 1, 2015)	2010-2015	2016	N/A	N/A
Montana (January 1, 2016)	2010-2015	2016	N/A	N/A

Abbreviations: MEPS, Medical Expenditure Panel Survey.

Table 2-B. Baseline characteristics of family's reference persons by ACA Medicaid expansion status[a]

Characteristics	Expansion States (N=6,361)	Non-Expansion States (N=4,454)	P-value
Mean age, y	38.2 (13.8)	38.3 (15.0)	0.89
Female, %	59.1	61.0	0.27
Race/ethnicity, %			
White, Non-Hispanic	63.5	57.9	0.03
Hispanic	10.4	10.1	
Black, Non-Hispanic	20.3	28.5	
Other	5.8	3.5	
Education, %			
<High school	19.5	21.0	0.054
High school or some college	69.8	71.0	
Bachelor's degree	8.9	6.9	
>Bachelor's degree	1.8	1.2	
Employed, %	43.1	45.7	0.19
Married, %	15.1	17.3	0.14
Mean family size[b]	1.9 (1.5)	2.0 (1.7)	0.10
Mean family income[c], $	11357 (8904)	11826 (9642)	0.11

Abbreviations: ACA, Patient Protection and Affordable Care Act.
Notes: a. Presented values are weighted to be nationally representative of families whose reference person is a U.S. citizen 19-64 years old with family incomes lower than 138% of the federal poverty level based on the pooled data of Medical Expenditure Panel Survey 2010-2013. Standard deviations are shown in parentheses.
b. Family size is the number of family members younger than 65 years old.
c. Income is adjusted to 2016 dollars using the Consumer Price Index.

Table 2-C. Test of parallel trend assumption

Outcome	Interaction term between expansion state indicator and year trend	
	Coefficient estimate [95% CI]	P-value
OOP plus premium spending	-0.097 [-0.209,0.015]	0.09
OOP spending	-0.107 [-0.219,0.004]	0.06
Premium contributions	-43.089 [-130.208,44.029]	0.33
Catastrophic health spending	-0.056 [-0.184,0.073]	0.39
Uninsured	-0.018 [-0.128,0.092]	0.75
Medicaid	-0.035 [-0.135,0.066]	0.50
Private health insurance	-0.003 [-0.132,0.125]	0.96

Abbreviations: CI, confidence interval; OOP, out-of-pocket.
Notes: We estimated regression models with an interaction term between the expansion state indicator variable and year trend variable (as continuous) for the data during the baseline period (2010-2013). We used a generalized linear model with log link and gamma distribution for OOP spending and OOP plus premium spending, a linear regression model for premium contributions, and a logistic regression model for binary outcomes. See text for more detail and Notes for Tables 2-D and 2-E for other details.

Table 2-D. Change in spending and financial burden outcomes following ACA Medicaid expansions[a]

Outcome	Baseline (2010-2013)		Post-Expansion[b]					
	Unadjusted Mean in Expansion States	Unadjusted Mean in Non-Expansion States	Year 1		Year 2		Year 3	
			DID Estimate[c] [95% CI]	P-value	DID Estimate[c] [95% CI]	P-value	DID Estimate[c] [95% CI]	P-value
OOP plus premium spending[d], $	1266	1502	-147 [-406,112]	0.26	-173 [-418,71]	0.16	-268 [-506,-30]	0.03
OOP spending[d], $	647	794	-2 [-191,187]	0.98	-43 [-195,110]	0.58	-160 [-292,-27]	0.02
Premium contributions[d], $	619	708	-50 [-237,137]	0.60	-98 [-304,107]	0.35	-40 [-244,163]	0.70
Catastrophic health spending[e], %	21.9	24.1	-0.3 [-4.7,4.2]	0.91	0.9 [-3.7,5.5]	0.70	-6.4 [-10.5,-2.3]	0.003

Abbreviations: ACA, Patient Protection and Accountable Care Act; CI, confidence interval; DID, difference-in-differences; OOP, out-of-pocket.
Note: a. Presented values are weighted to be nationally representative of families whose reference person is a U.S. citizen 19-64 years old with family incomes lower than 138% of the federal poverty level based on the 2010-2016 Medical Expenditure Panel Survey. Spending outcomes are annual values converted to 2016 U.S. dollars using the Consumer Price Index.
b. Years 1, 2, and 3 indicate years 2014, 2015, and 2016, respectively, for most states but not for all (see text for more detail).
c. DID estimates are differential changes (in dollars for spending outcomes and in percentage points for catastrophic health spending) between families in expansion states and those in non-expansion states comparing the pre-expansion period and each of the post-expansion periods (Years 1, 2, and 3). We used multivariable regression models controlled for age, sex, race/ethnicity, education, employment, marital status, family size, and family incomes (for spending outcomes only) as well as state- and year-specific fixed effects, and then calculated average marginal effects (see text for more detail).
d. OOP plus premium spending is the sum of OOP spending and premium contributions. Because each outcome was estimated from separate regression models, DID estimates for OOP spending and premium contributions may not sum to combined spending.
e. Catastrophic health spending indicates OOP plus premium spending exceeding 40% of post-subsistence income. See text for more detail.

Table 2-E. Change in insurance coverage following ACA Medicaid expansions[a]

Insurance, %	Baseline (2010-2013)		Post-Expansion[c]					
	Unadjusted Mean in Expansion States	Unadjusted Mean in Non-Expansion States	Year 1		Year 2		Year 3	
			DID Estimate[d] [95% CI]	P-value	DID Estimate[d] [95% CI]	P-value	DID Estimate[d] [95% CI]	P-value
Uninsured	26.0	37.0	-10.0	<0.001	-8.8	<0.001	-11.1	<0.001
			[-13.5,-6.4]		[-12.9,-4.7]		[-15.1,-7.1]	
Medicaid	44.6	28.6	8.2	<0.001	11.4	<0.001	9.2	0.001
			[3.9,12.6]		[6.9,15.9]		[3.7,14.7]	
Private health insurance	26.0	30.2	-1.5	0.51	-8.3	<0.001	-5.6	0.02
			[-5.9,3.0]		[-12.3,-4.3]		[-10.0,-1.1]	

Abbreviations: ACA, Patient Protection and Accountable Care Act; CI, confidence interval; DID, difference-in-differences.
Note: a. Presented values are weighted to be nationally representative of families whose reference person is a U.S. citizen 19-64 years old with family incomes lower than 138% of the federal poverty level based on the 2010-2016 Medical Expenditure Panel Survey.
b. Years 1, 2, and 3 indicate years 2014, 2015, and 2016, respectively, for most states but not for all (see text for more detail).
c. DID estimates are differential changes (in percentage points) between individuals in expansion states and those in non-expansion states comparing the pre-expansion period and each of the post-expansion periods (Years 1, 2, and 3). We used multivariable regression models controlled for age, sex, race/ethnicity, education, employment, marital status, family size, and family income as well as state- and year-specific fixed effects, and then calculated average marginal effects (see text for more detail).

Table 2-F. Sensitivity analyses using alternate sample definitions

	Year 1			Year 2			Year 3		
	DID Estimate	[95% CI]	P-value	DID Estimate	[95% CI]	P-value	DID Estimate	[95% CI]	P-value
OOP plus premium spending, $									
(1) Excluding "non-full expansion" states	-195	[-498,109]	0.21	-134	[-414,146]	0.35	-291	[-574,-7]	0.04
(2) Excluding "mild expansion" states	-126	[-412,160]	0.39	-129	[-388,130]	0.33	-258	[-516,-1]	0.049
(3) Including non-U.S. citizens	-132	[-345,80]	0.22	-182	[-382,18]	0.07	-308	[-504,-111]	0.002
(4) Restricting to <100% FPL	-165	[-444,114]	0.25	-259	[-518,-1]	0.049	-317	[-573,-62]	0.02
(5) Excluding Medicare beneficiaries	-150	[-437,136]	0.30	-248	[-501,5]	0.055	-331	[-573,-90]	0.01
(6) Analyzing >400% FPL	242	[-219,703]	0.30	591	[46,1136]	0.03	403	[-74,879]	0.10
OOP spending, $									
(1) Excluding "non-full expansion" states	-3	[-224,218]	0.98	-6	[-188,176]	0.95	-204	[-345,-62]	0.01
(2) Excluding "mild expansion" states	-2	[-205,201]	0.99	-16	[-183,151]	0.85	-172	[-310,-35]	0.01
(3) Including non-U.S. citizens	-3	[-165,160]	0.98	-48	[-179,83]	0.47	-137	[-252,-22]	0.02
(4) Restricting to <100% FPL	46	[-185,277]	0.69	-51	[-218,117]	0.55	-180	[-324,-35]	0.02
(5) Excluding Medicare beneficiaries	13	[-191,217]	0.90	-86	[-239,67]	0.27	-192	[-322,-61]	0.004
(6) Analyzing >400% FPL	136	[-107,378]	0.27	188	[-127,503]	0.24	139	[-157,435]	0.36
Premium contributions, $									
(1) Excluding "non-full expansion" states	-93	[-290,105]	0.36	-45	[-275,186]	0.70	7	[-237,251]	0.95
(2) Excluding "mild expansion" states	-33	[-230,165]	0.74	-69	[-281,142]	0.52	-29	[-239,181]	0.79
(3) Including non-U.S. citizens	-68	[-221,85]	0.38	-108	[-270,55]	0.19	-103	[-262,56]	0.20
(4) Restricting to <100% FPL	-149	[-327,29]	0.10	-273	[-435,-111]	0.001	-188	[-375,-1]	0.049
(5) Excluding Medicare beneficiaries	-61	[-267,145]	0.56	-117	[-341,107]	0.31	-59	[-276,158]	0.59
(6) Analyzing >400% FPL	90	[-279,460]	0.63	326	[-40,692]	0.08	200	[-176,577]	0.30
Catastrophic health spending, %									
(1) Excluding "non-full expansion" states	-0.9	[-5.8,4.1]	0.73	1.5	[-3.5,6.6]	0.55	-7.1	[-12.3,-1.9]	0.008
(2) Excluding "mild expansion" states	0.3	[-4.3,4.9]	0.89	1.6	[-3.1,6.3]	0.50	-6.1	[-10.5,-1.8]	0.006
(3) Including non-U.S. citizens	-0.1	[-3.9,3.7]	0.95	0.3	[-3.6,4.2]	0.89	-5.8	[-9.4,-2.1]	0.002
(4) Restricting to <100% FPL	0.1	[-5.7,5.8]	0.99	2.1	[-4.0,8.2]	0.49	-7.6	[-12.9,-2.4]	0.005
(5) Excluding Medicare beneficiaries	-1.7	[-6.2,2.8]	0.45	0.8	[-3.8,5.4]	0.74	-7.4	[-11.6,-3.3]	0.001
(6) Analyzing >400% FPL	N/A			N/A			N/A		

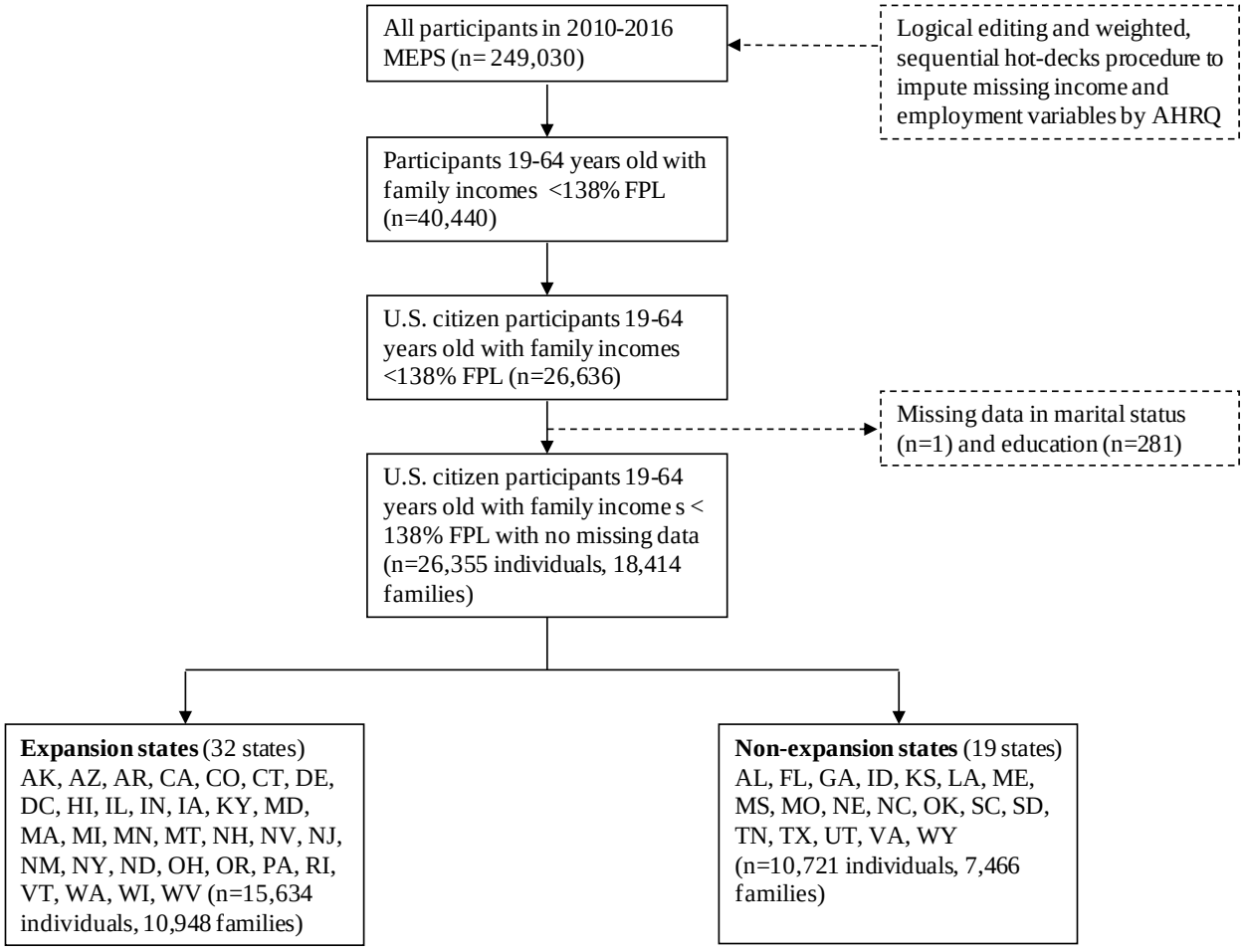
Abbreviations: CI, confidence interval; DID, difference-in-differences; FPL, Federal Poverty Level; OOP, out-of-pocket.
Notes: The regression model for catastrophic health spending for alternate sample definition (6) did not converge. See text for the details of alternate sample definitions. See Notes for Table 2-D for other details.

Table 2-G. Sensitivity analysis using alternate model specifications

Outcomes	Baseline (2010-2013)		Post-expansion					
	Unadjusted Mean in Expansion States	Unadjusted Mean in Non-Expansion States	Year 1		Year 2		Year 3	
			DID Estimate [95% CI]	P-value	DID Estimate [95% CI]	P-value	DID Estimate [95% CI]	P-value
OOP plus premium spending, $	1266	1502	-139	0.32	-195	0.12	-305	0.01
			[-417,138]		[-442,53]		[-546,-64]	
OOP spending, $	647	794	1	0.99	-40	0.63	-170	0.02
			[-205,207]		[-204,124]		[-314,-27]	
Premium contributions, $	619	708	-205	0.10	-213	0.06	-85	0.52
			[-451,40]		[-438,12]		[-346,176]	
Catastrophic health spending, %	21.9	24.1	-0.2	0.93	1.0	0.66	-6.5	0.01
			[-4.4,4.1]		[-3.3,5.2]		[-11.4,-1.5]	

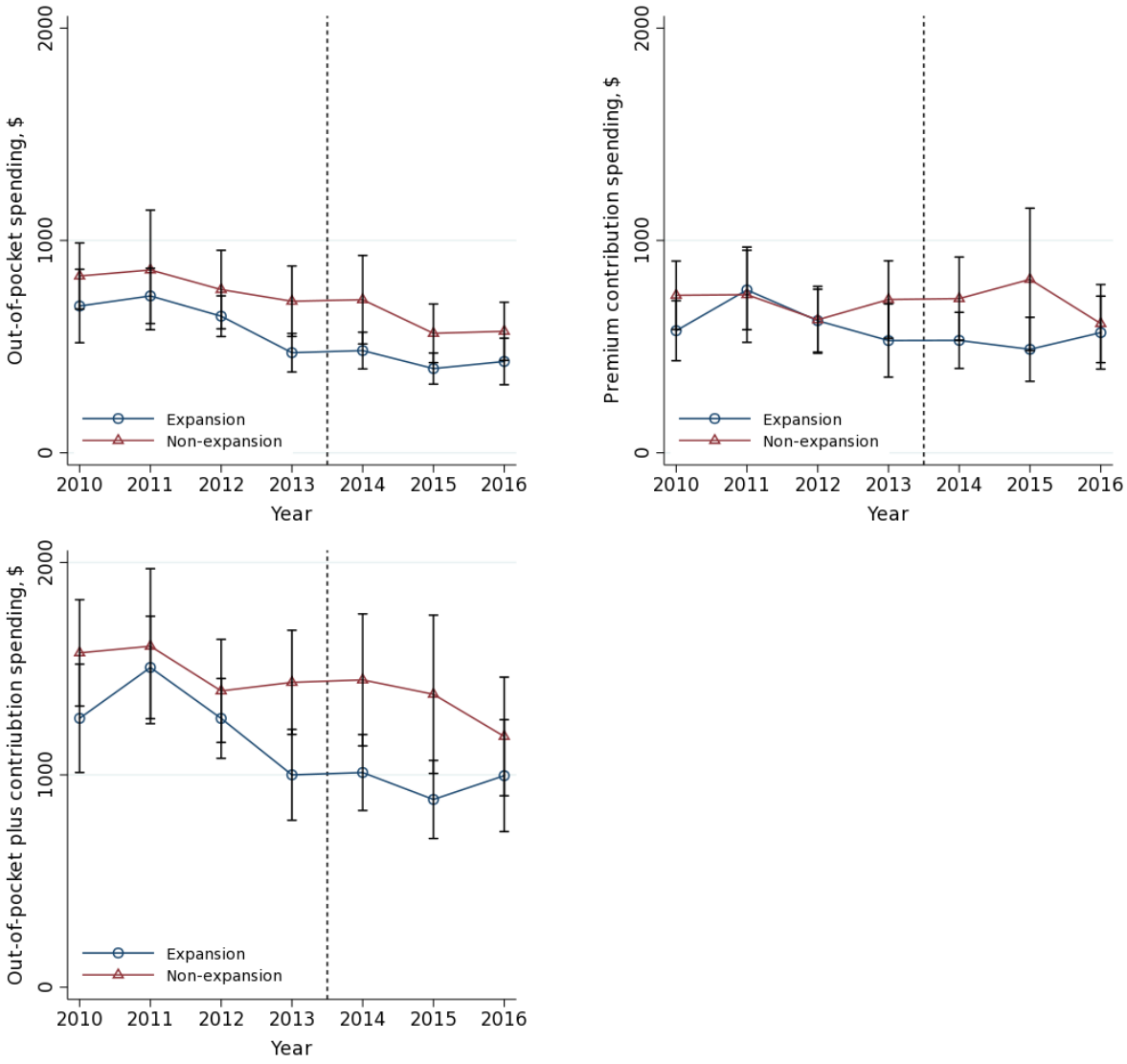
Abbreviations: CI, confidence interval; DID, difference-in-differences; OOP, out-of-pocket.
Notes: We used a generalized linear model (instead of a two-part model) for spending outcomes and a linear probability model (instead of a logistic regression model) for catastrophic health spending (see text for more detail). See Notes for Table 2-D for other details.

Figure 2-A. Flow diagram of the study population



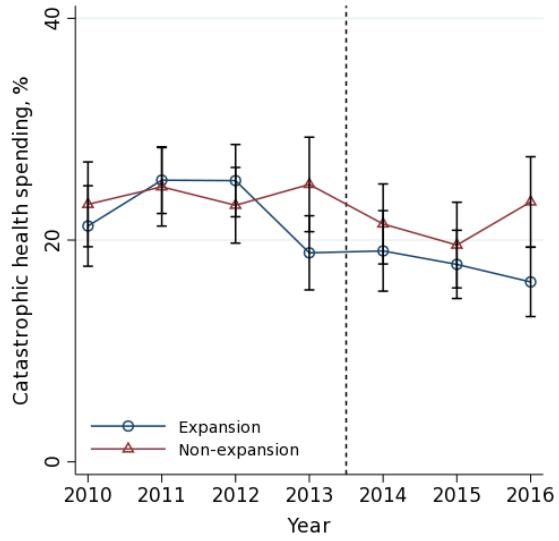
Abbreviations: MEPS, Medical Expenditure Panel Survey; FPL, federal poverty level.

Figure 2-B. Unadjusted yearly trend in spending outcomes by ACA Medicaid expansion status



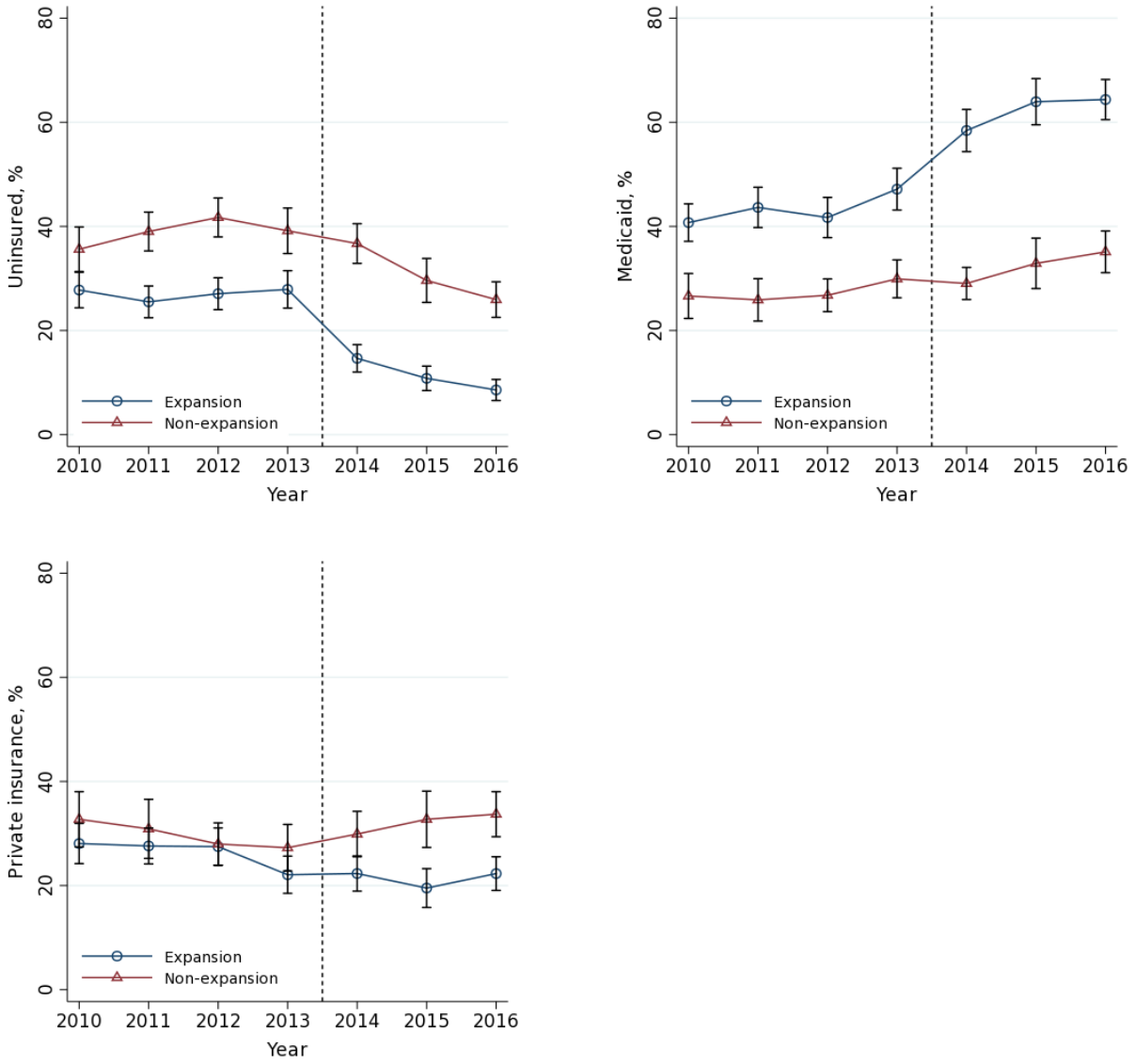
Abbreviations: ACA, Patient Protection and Accountable Care Act; OOP, out-of-pocket.
Note: Data shown are weighted means of annual OOP spending, premium contributions, and OOP plus premium spending of families whose reference person is a U.S. citizen 19-64 years old with family incomes lower than 138% of the federal poverty level in states that expanded Medicaid on January 1, 2014, and non-expansion states based on the 2010-2016 Medical Expenditure Panel Survey. Spending values are converted to 2016 U.S. dollars using the Consumer Price Index. The dashed line indicates the implementation of the ACA Medicaid expansion on January 1, 2014. I bars indicate 95% confidence interval.

Figure 2-C. Unadjusted yearly trend in catastrophic health spending by ACA Medicaid expansion status



Abbreviations: ACA, Patient Protection and Accountable Care Act; OOP, out-of-pocket.
Note: Data shown are weighted prevalence of catastrophic health spending due to OOP plus premium spending of families whose reference person is a U.S. citizen 19-64 years old with family incomes lower than 138% of the federal poverty level in states that expanded Medicaid on January 1, 2014 and non-expansion states based on the 2010-2016 Medical Expenditure Panel Survey. The dashed line indicates the implementation of the ACA Medicaid expansion on January 1, 2014. I bars indicate 95% confidence interval. Catastrophic health spending indicates OOP plus premium spending exceeding 40% of post-subsistence income (see text for more detail).

Figure 2-D. Unadjusted yearly trends in insurance coverage by ACA Medicaid expansion status



Abbreviations: ACA, Patient Protection and Accountable Care Act.
Note: Data shown are weighted means of health insurance coverage with 95% confidence intervals (I bars) of U.S. citizens 19-64 years old with family incomes lower than 138% of the federal poverty level in states that expanded Medicaid on January 1, 2014, and non-expansion states using the 2010-2016 Medical Expenditure Panel Survey. The dashed line indicates the implementation of the ACA Medicaid expansion on January 1, 2014.

Chapter 3. Association between the ACA Medicaid Expansions and Emergency Department and Primary Care Use during the First 3 Years (Paper #2)

3-1. Abstract

Background: Evidence is limited and mixed as to how the Patient Protection and Affordable Care Act (ACA) Medicaid expansions affected the utilization of primary care physicians (PCPs) and emergency departments (EDs) at the national level.

Objective: To examine the association between the ACA Medicaid expansions and changes in the utilization of PCP and ED visits at the national level during the first 3 years (2014-2016) of the implementation.

Design: A difference-in-differences analysis to compare outcomes between individuals in 32 states that expanded Medicaid versus individuals in 19 non-expansion states.

Participants: A nationally representative sample of U.S. citizens 26-64 years old with family incomes lower than 138% of the federal poverty level from the 2010-2016 Medical Expenditure Panel Survey.

Intervention: ACA Medicaid expansions

Main measures: We examined PCP-related outcomes: (i) whether a participant had any PCP visit during a year, and (ii) the annual number of PCP visits among those who had any PCP visit during a year; and ED-related outcomes: (i) whether a participant had any ED visit during a year, and (ii) the annual number of ED visits among those who had any ED visit during a year.

Key results: A total of 19,319 participants were included in our analysis. We found that the proportion of individuals with any PCP visit during a year significantly increased (difference-in-

differences estimate, +3.6 percentage points; 95% CI, +0.4 to +6.8; P=0.03) following the Medicaid expansions, without any change in the number of PCP visits among those with any PCP visit. We found no evidence that ED utilization changed meaningfully after the Medicaid expansions.

Conclusion: Using the nationally-representative data of individuals who were affected by the ACA, we found that the ACA Medicaid expansions were associated with a modest improvement in access to PCPs without an increase in ED use.

3-2. **Background**

Expanding the eligibility for the Medicaid program to individuals earning up to 138% of the federal poverty level (FPL) was one of the key components of the Patient Protection and Affordable Care Act (ACA) signed into law in 2010. Literature indicates that the introduction of the ACA led to a significant decline in the number of uninsured patients and a substantial improvement in financial risk protection.[1-3] One of the goals of the ACA was that, by removing financial barriers, Medicaid expansions would allow low-income people who were previously uninsured to gain access to appropriate primary care physicians (PCPs), and as a consequence, reduce unnecessary use of emergency departments (EDs) and hospitalizations. However, evidence is limited and mixed as to how the ACA Medicaid expansions affected the utilization of PCPs and EDs at the national level.

The Oregon Health Insurance Experiment (OHIE) was a randomized controlled trial that examined the impact of expanded Medicaid coverage among low-income families in the state of Oregon from 2008 through 2010. The results of the OHIE found a 50% increase in the number of

outpatient visits and a 40% increase in the number of ED visits among those who were newly-covered by Medicaid.[4-6] Observational studies found mixed findings as to how the Medicaid expansions affect the utilization of primary care [7-13] and ED [7-10,14-19]. While informative, previous studies (including the OHIE) were restricted to a small number of states, and therefore, it remains unclear whether their findings are generalizable to the national level.[4-8,14-19] In addition, many studies relied solely on self-reported data to identify PCP and ED visits (without verification by clinicians and hospitals), and therefore, there have been concerns about the accuracy of measurements.[5,7-12] Given that many states are currently considering to expand their Medicaid programs, and that expensive ED visits could potentially put a financial burden on the states' budgets,[20] it is critically important for policymakers to understand the national impact of the ACA Medicaid expansions on the utilization of PCPs and EDs.

In this context, using a nationally representative data of low-income working-age Americans, we examined how the ACA Medicaid expansions impacted on the utilization of PCP and ED visits in the first 3 years with a quasi-experimental difference-in-differences approach.

3-3. **Methods**

Data source and population

The primary data source for this study is the 2010-2016 Medical Expenditure Panel Survey (MEPS), a nationally representative annual survey of the non-institutionalized civilian population in the U.S. by the Agency for Healthcare Research and Quality (AHRQ).[21] Households participate in a series of five interviews that collect various data including utilization of PCP and ED visits covering two full calendar years. MEPS subsequently verifies self-reported

information with clinicians and hospitals about the utilization of PCP and ED visits including dates of service, event type, and diagnoses, and publishes data representing a whole calendar year.[22] The mean overall response rate of the MEPS data was 51.4%.[23]

We restricted our study sample to U.S.-born individuals 26-64 years old with family incomes lower than 138% of the FPL based on the eligibility criteria of the ACA 2014 Medicaid expansions. Non-U.S.-born participants were excluded from the main analysis because there are specific requirements to be eligible for Medicaid (e.g., many non-citizens must wait 5 years after receiving qualified immigration status before they can receive Medicaid coverage).[24] We also excluded adults 19-25 years old because many of them have access to their parents' health insurance under the 2010 dependent coverage mandate of the ACA,[25] a similar approach used by a prior study.[13] Observations with missing data in covariates were also excluded from the study sample. We used imputed data for missing income values, which were estimated by AHRQ using logical editing and weighted, sequential hot-decks.[26] To obtain information about which state participants lived in, we used restricted-access state identifiers for MEPS provided by AHRQ and all analysis was conducted in the California Census Research Data Center. The University of California, Los Angeles Institutional Review Board approved this study.

Expansion status

The ACA Medicaid expansion became effective on January 1, 2014 for all expansion states except for the following: Michigan (April 1, 2014), New Hampshire (August 15, 2014), Pennsylvania (January 1, 2015), Indiana (February 1, 2015), Alaska (September 1, 2015), Montana (January 1, 2016), Louisiana (July 1, 2016), Virginia (January 1, 2019), and Maine

(January 10, 2019).[27] We defined expansion states as those states that expanded Medicaid or an equivalent program by June 2016. Based on this criterion, 32 states (including the District of Columbia [D.C.]) were identified as expansion states and 19 were considered non-expansion states (**Table 3-A**).[27]

We defined the years 2010-2013 as the "pre-expansion" period, 2014-2016 as the "post-expansion" period for non-expansion states and most expansion states that expanded Medicaid on January 1, 2014. For those states that expanded Medicaid after January 1, 2014, we defined pre- and post-expansion periods based on the actual implementation date of a given state (**Table 3-A**). If a state expanded Medicaid before July 1 of a certain year, the whole year was included in the pre-expansion period while if a state expanded after July 1 of a certain year, the whole year was included in the post-expansion period. Although we could define pre- and post-expansion periods more precisely based on the date of a certain event (e.g., ED visit) relative to the implementation date of each state, we did not take this approach as it would bias our estimates if we could not fully account for the seasonality (e.g., the significance of an ED visit in July may not be the same as that of an ED visit in January).

Of note, California, Connecticut, District of Columbia, Minnesota, New Jersey, and Washington enacted ACA Medicaid expansions or started an equivalent program in either 2010 or 2011 although the early expansion in New Jersey and Washington was very limited.[11] Five states (Delaware, Hawaii, Massachusetts, New York, and Vermont) had already provided prior coverage similar to the eligibility of the ACA Medicaid expansions.[11] Wisconsin provided

comprehensive insurance coverage through a non-Medicaid program starting January 1, 2014[11] and was included in the expansion state in the main analysis.

Health Insurance Coverage

We examined health insurance coverage outcomes to understand the pathway from the expanded Medicaid eligibility to potential changes in PCP and ED utilization. We used three insurance coverage variables: (i) uninsured defined as no coverage by Medicaid, Medicare, private insurance, military programs, or other public programs throughout the survey year; (ii) Medicaid defined as Medicaid coverage for at least one day during the survey year; and (iii) private health insurance defined as private health insurance coverage for at least one day during the survey year without any Medicaid coverage throughout the survey year.

Primary Care Physician and Emergency Department Visits

Our outcomes of interest were the utilization of PCPs and EDs. We examined two outcomes related to PCP visits: (i) whether a participant had any PCP visit during a year (as a binary outcome variable), and (ii) the annual number of PCP visits among those who had any PCP visit during a year (as a continuous outcome variable). A physician was considered a PCP if their specialty was family practice, general practice, or internal medicine, excluding telephone encounters. Similarly, we analyzed two outcomes related to ED visits: (i) whether a participant had any ED visit during a year (as binary), and (ii) the annual number of ED visits among those who had any ED visit during a year (as continuous).

Statistical analysis

We used a difference-in-differences (DID) design to compare changes in outcomes between individuals in expansion states and those in non-expansion states before and after the ACA Medicaid expansions. Our model specification is shown below.

$$Y_{ist} = \theta_s + \lambda_t + \beta(EXP_s \times POST_t) + \delta X_{ist} + \varepsilon_{ist},$$

where Y_{ist} indicates outcomes for individual *i* living in state *s* at time *t* (expressed as year), θ_s denotes state-specific fixed effects, λ_t denotes year-specific fixed effects, EXP_s denotes the expansion state indicator, $POST_t$ denotes the post-expansion period indicator, and X_{ist} denotes adjustment variables for individual *i* including age (as continuous), sex, race/ethnicity (non-Hispanic White, non-Hispanic Black, Hispanic, and other), education attainment (less than high school, high school or some college, bachelor's degree, or more than bachelor's degree), employment status, and household size (as continuous). We used multivariable ordinary least squares (OLS) regression models that include an interaction term between expansion state indicator and post-expansion period indicator. The coefficients β for the interaction terms (i.e., DID estimates) represent the changes in the outcomes that are attributable to the Medicaid expansions and are interpreted as percentage point changes for binary outcomes and as changes in annual numbers for number of visits outcomes. A similar approach has been used by Miller and Wherry.[9,10]

We tested the parallel trend assumption of the DID model: the outcomes in the expansion states would have had a similar trend as those in the non-expansion states if the ACA Medicaid expansions had not been implemented. First, we compared the trends of the outcomes during the pre-expansion period between the expansion and non-expansion states visually in the graphs.

Second, we estimated regressions with interaction terms between the expansion state indicator variable and the time (year) indicator variables for all pre-expansion years (using 2013 as the reference year) for the data during the pre-expansion period. We formally tested the null hypothesis that the coefficients on all of these interaction terms are equal to 0 with an F-test.

All analyses accounted for the complex survey design of MEPS and the results were presented with Huber-White cluster-robust standard errors to account for the non-independence of observations within the MEPS primary sampling unit (a set of neighboring counties). Statistical analyses were conducted with Stata software version 14.1 (StataCorp, Texas, USA).

Sensitivity analyses

We conducted a series of secondary analyses. First, we re-analyzed the data with different sample population definitions: (i) excluding participants living in 5 expansion states (Delaware, Hawaii, Massachusetts, New York, and Vermont) where comprehensive insurance coverage was provided for low-income adults prior to 2014, an approach used in prior studies; [9,10] (ii) excluding participants living in 4 "early expansion states" (California, Connecticut, District of Columbia, and Minnesota) that partially implemented the ACA Medicaid expansions or started a similar program in either 2010 or 2011 (we did not include New Jersey and Washington in the early expansion states because the extent of implementation was limited);[11,28] (iii) excluding participants living in 6 "late expansion states" (Michigan, New Hampshire, Pennsylvania, Indiana, Alaska, and Montana) that implemented the ACA Medicaid expansions after January 1, 2014 because these states might differ from the states that expanded on January 1, 2014; (iv) excluding participants living in Wisconsin because it has not adopted the ACA Medicaid

expansion (in the main analysis we included Wisconsin in the expansion states as it started comprehensive insurance coverage for low-income adults under Section 1115 waiver authority since January 1, 2014);[11] (v) Including non-US citizens, who need to meet specific requirements to become eligible for Medicaid such as a 5-year waiting period (and therefore, we excluded them in the main analysis);[24] (vi) Including participants 19-25 years, many of whom had access to their parents' health insurance under the 2010 dependent coverage mandate of the ACA (and therefore, we excluded them in the main analysis); and (vii) Analyzing participants 26-64 years old with incomes greater than 400% of the federal poverty level, who should not have had a significant impact from the ACA Medicaid expansion (a falsification test).

Second, to test whether our findings were sensitive to the model specification, we repeated the analyses using a (i) Ordinary least squares (OLS) regression models clustered at the state level (as opposed to primary sampling units) which is recommended in previous literature,[29] by using sampling weights and the CLUSTER option in Stata (although without accounting for the stratified structure of the MEPS sampling design); (ii) Logistic regression models for binary outcomes (DID estimates are reported as adjusted odds ratios); (iii) Poisson regression models for number of visits outcomes using average marginal effects for ease of interpretation (DID estimates are reported as changes in the number of visits), by estimating the differences in the predicted outcomes at each category level of the interaction terms for each observation and averaging over the entire study sample; [30] and (iv) OLS regression models including three interaction terms between expansion state indicator and each of post-expansion year indicator based on a finer definition of the post-expansion period (year 1=2014, year 2=2015, and year 3=2016 for most expansion states but not for all; see **Table 3-A** for the definition).

3-4. **Results**

A total of 19,319 participants were included for the analyses (see **Figure 3-A** for the flow chart). Table 1 shows the demographic characteristics of participants in expansion and non-expansion states based on the pooled data from 2010 to 2013. The proportion of non-Hispanic Black participants was significantly lower in expansion states compared to non-expansion states (22.2% vs. 29.6%).

The analysis for health insurance coverage showed that the probability of being covered by Medicaid increased by 10.6 percentage points ($p<0.001$) and the probability of being uninsured reduced by 8.0 percentage points ($p<0.001$) in expansion states relative to non-expansion states (**Table 3-B**).

Figures 3-B and **3-C** present unadjusted yearly trends in the utilization of PCPs and EDs, respectively, by expansion status. The trends of the proportion of individuals with any PCP visit during a year were similar between the two groups before 2014. The formal statistical tests showed no significant difference in baseline trends between the two groups for all outcomes we studied (**Table 3-C**).

Primary Care Physician Visits

We observed a significant increase in the proportion of those who had any PCP visit during a year in expansion states relative to non-expansion states after the ACA Medicaid expansions (DID estimates, +3.6 percentage points; 95% CI, +0.4 to +6.8; P=0.03) (**Table 3-D**). However, we did not observe any significant change in the annual number of PCP visits among those who

had any PCP visit during a year (DID estimates, -0.28 visits; 95% CI, -0.66 to +0.10; P=0.15) (**Table 3-D**).

Emergency Department Visits

We found no evidence that the proportion of those who had any ED visit during a year changed significantly in expansion states relative to non-expansion states after the ACA Medicaid expansions (DID estimates, -0.5 percentage points; 95% CI, -3.7 to +2.7; P=0.76) (**Table 3-E**). The annual number of ED visits among those who had any ED visit during a year also did not change (DID estimates, +0.04 visits; 95% CI, -0.15 to +0.24; P=0.65) (**Table 3-E**).

Sensitivity Analyses

Our findings were qualitatively unaffected by alternate sample definitions (**Table 3-F**) or different model specifications (**Table 3-G**).

3-5. **Discussion**

Using a nationally representative sample of low-income, working-age Americans, we found that the ACA Medicaid expansions were associated with a higher likelihood of receiving care provided by PCPs at the national level during the first three years of its implementation. We found no evidence that the number of PCP visits changed among those who had at least one PCP visit, or that the utilization of EDs (both the likelihood of receiving care at EDs and the number of ED visits among those who had a least one ED visit) changed due to the ACA Medicaid expansions. Taken together, these findings suggest that the ACA Medicaid expansions have

achieved its goal of improving access to primary care, at least with respect to the likelihood of seeing a PCP once a year. Our findings indicating the lack of meaningful change in the utilization of EDs should be reassuring for states and policymakers who were concerned about the potential financial burden of increased use of EDs associated with the ACA Medicaid expansions.

Our finding that the ACA Medicaid expansions were associated with increased utilization of PCPs was consistent with previous studies. For example, the OHIE observed a 50% increase in the annual number of office visits.[5] Several observational studies examining the impact of the ACA Medicaid expansions also found increased use of primary care providers[7,8,10,13] (whereas other observational studies found no evidence that the utilization of primary care changed after the Medicaid expansions[9,11,12]). However, these observational studies had limitations because they were conducted in a small number of states,[7,8] relied solely on self-reports (without verification by clinicians and hospitals as done in MEPS),[7-12] or examined only short-term effects of the policy implementation.[13] To our knowledge, this is the first study that examined the long-term impact of Medical expansions on the utilization of PCP visits using nationally representative data and valid and reliable measurements.

Improved access to primary care providers due to Medicaid coverage can, in theory, prevent patients from receiving care at EDs. However, it is also possible that people visit an ED more frequently because of both perceived and actual lower out-of-pocket costs for receiving care at ED, or because PCPs (to whom they have improved access) could refer more patients to EDs.[6] Our findings contradict with the findings from the OHIE showing a dramatic increase in ED

visits after the Medicaid expansion in Oregon,[4-6] suggesting that the impact of the Medicaid expansion vary by state. Previous observational studies found mixed evidence as to how the ACA Medicaid expansions affected the utilization of EDs,[7-10,14-19] but these studies have the same limitations that they studied a small number of states,[7,8,14-19] relied totally on self-reported data,[5,7-10] or evaluated only the short-term impact.[15,17]

There are several reasons why our findings differed from the findings from the OHIE. First, given substantial variation in how Medicaid programs are designed and implemented in each state,[31] it is possible that the findings from Oregon were not generalizable to the national level. For example, Oregon spent 13% more on Medicaid ($6,272 per Medicaid enrollee) compared to the national average ($5,527 per enrollee) in 2009,[31] which suggests that Medicaid beneficiaries in Oregon might have better access to healthcare providers allowing them to utilize more healthcare services than other states. Second, the participants of the OHIE might have had higher medical needs than our national sample, because the OHIE recruited uninsured adults who voluntarily signed up for a lottery for Medicaid coverage (those with low healthcare needs may not have signed up for a lottery, to begin with).[4] This hypothesis is supported by the data showing the control group in the OHIE experienced a substantially higher number of ED visits (0.68 visits per person-year) compared with the national average of age group 18-64 years (0.40 visits per person-year).[4,5,32]

Our study has limitations. First, although we used a quasi-experimental difference-in-differences approach to account for both measured and unmeasured confounders, it is still possible that expansion and non-expansion states differ in a way that could not be captured by this approach.

However, observed parallel trends in outcome variables between expanded and non-expanded states before the Medicaid expansions support the validity of our study design. Second, people who responded to the survey may be different from those who did not. However, in order for this to introduce a "non-response bias," the characteristics that differ between respondents and non-respondents should also be associated with the expansion status of states, which we believe is unlikely. Finally, we analyzed the impact of the ACA Medicaid expansions in states that actually expanded Medicaid under the ACA. Therefore our findings may not be generalizable to the remaining non-expansion states if they were to expand their Medicaid programs in the future.

In conclusion, using a nationally representative sample of low-income non-elderly adults, we found that the ACA Medicaid expansions were associated with a modest increase in PCP utilization but did not affect the utilization of EDs during the first three years of the implementation. These findings provide important information regarding the impact of the ACA Medicaid expansions on health care utilization and warrant further studies to better understand how we can make sure Medicaid beneficiaries receive care from appropriate healthcare providers.

3-6. **References**

1. Kominski. GF, Nonzee. NJ, Sorensen. A. The Affordable Care Act's Impacts on Access to Insurance and Health Care for Low-Income Populations. *Annu Rev Public Health.* 2017;38:489-505.
2. Sommers BD, Gawande AA, Baicker K. Health Insurance Coverage and Health - What the Recent Evidence Tells Us. *N Engl J Med.* 2017;377(6):586-593.
3. The Henry J. Kaiser Family Foundation. The Effects of Medicaid Expansion under the ACA: Updated Findings from a Literature Review. 2018; https://www.kff.org/medicaid/issue-brief/the-effects-of-medicaid-expansion-under-the-aca-updated-findings-from-a-literature-review-march-2018/. Accessed November 17, 2018.
4. Taubman SL, Allen HL, Wright BJ, Baicker K, Finkelstein AN. Medicaid increases emergency-department use: evidence from Oregon's Health Insurance Experiment. *Science.* 2014;343(6168):263-268.
5. Baicker K, Taubman SL, Allen HL, et al. The Oregon Experiment—Effects of Medicaid on Clinical Outcomes. *N Engl J Med.* 2013;368(18):1713-1722.
6. Finkelstein AN, Taubman SL, Allen HL, Wright BJ, Baicker K. Effect of Medicaid Coverage on ED Use — Further Evidence from Oregon's Experiment. *N Engl J Med.* 2016;375(16):1505-1507.
7. Long SK, Stockley K, Dahlen H. Massachusetts health reforms: uninsurance remains low, self-reported health status improves as state prepares to tackle costs. *Health Aff (Millwood).* 2012;31(2):444-451.
8. Sommers BD, Maylone B, Blendon RJ, Orav EJ, Epstein AM. Three-Year Impacts Of The Affordable Care Act: Improved Medical Care And Health Among Low-Income Adults. *Health Aff (Millwood).* 2017;36(6):1119-1128.
9. Miller S, Wherry LR. Health and Access to Care during the First 2 Years of the ACA Medicaid Expansions. *N Engl J Med.* 2017;376(10):947-956.
10. Wherry LR, Miller S. Early Coverage, Access, Utilization, and Health Effects Associated With the Affordable Care Act Medicaid Expansions: A Quasi-experimental Study. *Ann Intern Med.* 2016;164(12):795-803.

11. Simon K, Soni A, Cawley J. The Impact of Health Insurance on Preventive Care and Health Behaviors: Evidence from the First Two Years of the ACA Medicaid Expansions. *J Policy Anal Manage.* 2017;36(2):390-417.
12. Cawley J, Soni A, Simon K. Third Year of Survey Data Shows Continuing Benefits of Medicaid Expansions for Low-Income Childless Adults in the U.S. *J Gen Intern Med.* 2018;33(9):1495-1497.
13. Biener AI, Zuvekas SH, Hill SC. Impact of Recent Medicaid Expansions on Office-Based Primary Care and Specialty Care among the Newly Eligible. *Health Serv Res.* 2018;53(4):2426-2445.
14. Miller S. The effect of insurance on emergency room visits: An analysis of the 2006 Massachusetts health reform. *J Public Econ.* 2012;96(11):893-908.
15. Pines JM, Zocchi M, Moghtaderi A, et al. Medicaid Expansion In 2014 Did Not Increase Emergency Department Use But Did Change Insurance Payer Mix. *Health Aff (Millwood).* 2016;35(8):1480-1486.
16. Dresden SM, Powell ES, Kang R, McHugh M, Cooper AJ, Feinglass J. Increased Emergency Department Use in Illinois After Implementation of the Patient Protection and Affordable Care Act. *Ann Emerg Med.* 2017;69(2):172-180.
17. Nikpay S, Freedman S, Levy H, Buchmueller T. Effect of the Affordable Care Act Medicaid Expansion on Emergency Department Visits: Evidence From State-Level Emergency Department Databases. *Ann Emerg Med.* 2017;70(2):215-225.e216.
18. Klein EY, Levin S, Toerper MF, et al. The Effect of Medicaid Expansion on Utilization in Maryland Emergency Departments. *Ann Emerg Med.* 2017;70(5):607-614.e601.
19. Xu T, Klein EY, Zhou M, Lowenthal J, Sharfstein JM, Peterson SM. Emergency Department Utilization Among the Uninsured During Insurance Expansion in Maryland. *Ann Emerg Med.* 2018;72(2):156-165.
20. Galarraga JE, Pines JM. Costs of ED episodes of care in the United States. *Am J Emerg Med.* 2016;34(3):357-365.
21. Agency for Healthcare Research and Quality. MEPS Household Component Annual Contractor Methodology Report 2017. 2018; https://meps.ahrq.gov/data_files/publications/annual_contractor_report/hc_ann_cntrct_methrpt.shtml. Accessed July 18, 2019.

22. Agency for Healthcare Research and Quality. MEPS Medical Provider Component Annual Contractor Methodology Report 2015 Data Collection. 2018; https://meps.ahrq.gov/data_files/publications/annual_contractor_report/mpc_ann_cntrct_methrpt.shtml#providerrecruitment. Accessed November 7, 2018.
23. Agency for Healthcare Research and Quality. MEPS-HC Response Rates by Panel. 2018; https://meps.ahrq.gov/survey_comp/hc_response_rate.jsp. Accessed April 2, 2019.
24. Centers for Medicare & Medicaid Services. Coverage for lawfully present immigrants. 2018; https://www.healthcare.gov/immigrants/lawfully-present-immigrants/. Accessed November 7, 2018.
25. Collins SR, Robertson R, Garber T, Doty MM. Young, Uninsured, and in Debt: Why Young Adults Lack Health Insurance and How the Affordable Care Act Is Helping—Findings from the Commonwealth Fund Health Insurance Tracking Survey of Young Adults, 2011. 2012; https://www.commonwealthfund.org/sites/default/files/documents/___media_files_publications_issue_brief_2012_jun_1604_collins_young_uninsured_in_debt_v4.pdf. Accessed March 5, 2019.
26. Agency for Healthcare Research and Quality. MEPS HC-192: 2016 Full Year Consolidated Data File. 2018; https://meps.ahrq.gov/data_stats/download_data/pufs/h192/h192doc.shtml. Accessed October 14, 2018.
27. The Henry J. Kaiser Family Foundation. Status of State Action on the Medicaid Expansion Decision. 2019; https://www.kff.org/health-reform/state-indicator/state-activity-around-expanding-medicaid-under-the-affordable-care-act/?currentTimeframe=0&sortModel=%7B%22colId%22:%22Location%22,%22sort%22:%22asc%22%7D. Accessed August 5, 2019.
28. The Henry J. Kaiser Family Foundation. States Getting a Jump Start on Health Reform's Medicaid Expansion. 2012; https://www.kff.org/health-reform/issue-brief/states-getting-a-jump-start-on-health/. Accessed February 14, 2019.
29. Bertrand M, Duflo E, Mullainathan S. How Much Should We Trust Differences-in-Differences Estimates? *The quarterly journal of economics.* 2004;119:249-275.

30. Williams R. Using the margins command to estimate and interpret adjusted predictions and marginal effects. *Stata Journal.* 2012;12(2):308-331.
31. Kaiser Commission on Medicaid and the Uninsured. Why does Medicaid spending vary across states: a chart book of factors driving state spending. 2012; https://kaiserfamilyfoundation.files.wordpress.com/2013/01/8378.pdf. Accessed November 7, 2018.
32. Sun. R, Karaca. Z, Wong. HS. Trends in Hospital Emergency Department Visits by Age and Payer, 2006-2015. HCUP Statistical Brief #238. 2018; https://www.hcup-us.ahrq.gov/reports/statbriefs/sb238-Emergency-Department-Age-Payer-2006-2015.jsp. Accessed November 7, 2018.

3-7. **Tables and Figures**

Table 3-A. Definition of expansion states and expansion period

States (Date of Expansion)	Definitions of Periods by MEPS Year				
	Pre-Expansion	Post-Expansion (Main Analysis)	Post-Expansion (Sensitivity Analysis)		
			Year 1	Year 2	Year 3
Non-expansion states (19 states)					
Alabama, Florida, Georgia, Idaho, Kansas, Louisiana, Maine, Mississippi, Missouri, Nebraska, North Carolina, Oklahoma, South Carolina, South Dakota, Tennessee, Texas, Utah, Virginia, and Wyoming	2010-2013	2014-2016	2014	2015	2016
Expansion states (32 states)					
Arizona, Arkansas, California, Colorado, Connecticut, Delaware, District of Columbia, Hawaii, Illinois, Iowa, Kentucky, Maryland, Massachusetts, Minnesota, Nevada, New Jersey, New Mexico, New York, North Dakota, Ohio, Oregon, Rhode Island, Vermont, Washington, West Virginia, Wisconsin [a] (All expanded on Jan 1, 2014)	2010-2013	2014-2016	2014	2015	2016
Michigan (April 1, 2014)	2010-2013	2014-2016	2014	2015	2016
New Hampshire (August 15, 2014)	2010-2014	2015-2016	2015	2016	N/A
Pennsylvania (January 1, 2015)	2010-2014	2015-2016	2015	2016	N/A
Indiana (February 1, 2015)	2010-2014	2015-2016	2015	2016	N/A
Alaska (September 1, 2015)	2010-2015	2016	2016	N/A	N/A
Montana (January 1, 2016)	2010-2015	2016	2016	N/A	N/A

Abbreviations: MEPS, Medical Expenditure Panel Survey.
Notes: [a] Although Wisconsin has not adopted the ACA Medicaid expansion, we included Wisconsin in the expansion states because it started comprehensive insurance coverage for low-income adults under Section 1115 waiver authority since January 1, 2014.

Table 3-B. Baseline characteristics of participants by ACA Medicaid expansion status

Characteristics	Expansion States (n = 6,322)	Non-Expansion States (n = 4,499)	P-Value
Mean age (year)	43.5 (12.1)	43.8 (12.9)	0.27
Male sex (%)	44.0	42.2	0.21
Race/ethnicity (%)			
White, non-Hispanic	62.6	58.6	
Hispanic	9.7	9.2	0.047
Black, non-Hispanic	22.2	29.6	
Other	5.5	2.6	
Education (%)			
Less than High school	20.0	21.5	
High school or some college	69.0	69.6	0.09
Bachelor's degree	8.6	7.4	
More than Bachelor's degree	2.5	1.5	
Married (%)	29.8	34.0	0.079
Mean household size	2.5 (1.9)	2.6 (2.0)	0.30

*****Presented values are weighted baseline characteristics of U.S. citizens 26-64 years old with family incomes lower than 138% of the federal poverty level from the pooled data of the Medical Expenditure Panel Survey 2010-2013. Standard deviations are shown in parentheses for mean age and household size.

Table 3-C. Association between ACA Medicaid expansions and insurance coverage

Outcome	Baseline (2010-2013)		Post-Expansion (2014-2016)		
	Mean in Expansion States	Mean in Non-Expansion States	DID Estimate	[95% CI]	P-Value
Private insurance (%)	23.4%	28.5%	-3.8pp	[-7.9pp,+0.3pp]	0.07
Medicaid (%)	45.7%	28.4%	+10.6pp	[+6.4pp,+14.8pp]	<0.001
Uninsured (%)	26.4%	37.7%	-8.0pp	[-11.8pp,-4.2pp]	<0.001

Abbreviations: ACA, Patient Protection and Affordable Care Act; CI, confidence interval; DID, difference-in-differences.
Notes: See notes for Table 3-E for detail.

Table 3-D. Test for parallel trend assumption

Outcome	Interaction Term between Expansion Status and Year			P-Value for F-Test
	Coefficient	[95% CI]	P-Value	
Any PCP visit during a year				
2011 x Expansion	0.023	[-0.041,0.088]	0.47	0.65
2012 x Expansion	0.037	[-0.029,0.102]	0.27	
2013 x Expansion	0.047	[-0.030,0.125]	0.23	
2014 x Expansion	0.041	[-0.021,0.102]	0.20	
2015 x Expansion	0.091	[0.017,0.165]	0.02	
2016 x Expansion	0.063	[-0.014,0.141]	0.11	
Annual number of PCP visits among those with any PCP visit during a year				
2011 x Expansion	-0.184	[-0.856,0.487]	0.59	0.18
2012 x Expansion	0.168	[-0.454,0.791]	0.59	
2013 x Expansion	-0.566	[-1.382,0.249]	0.17	
2014 x Expansion	-0.470	[-1.131,0.191]	0.16	
2015 x Expansion	-0.039	[-0.805,0.728]	0.92	
2016 x Expansion	-0.451	[-1.096,0.193]	0.17	
Any ED visit during a year				
2011 x Expansion	0.020	[-0.032,0.071]	0.45	0.54
2012 x Expansion	-0.026	[-0.076,0.025]	0.32	
2013 x Expansion	-0.005	[-0.059,0.049]	0.86	
2014 x Expansion	-0.026	[-0.076,0.024]	0.31	
2015 x Expansion	0.046	[-0.010,0.103]	0.11	
2016 x Expansion	-0.028	[-0.089,0.034]	0.37	
Annual number of ED visits among those with any ED visit during a year				
2011 x Expansion	0.144	[-0.277,0.565]	0.50	0.25
2012 x Expansion	0.373	[-0.031,0.777]	0.07	
2013 x Expansion	0.351	[-0.064,0.766]	0.10	
2014 x Expansion	0.466	[0.081,0.851]	0.02	
2015 x Expansion	0.116	[-0.254,0.486]	0.54	
2016 x Expansion	0.403	[0.022,0.784]	0.04	

Abbreviations: CI, confidence interval; ED, emergency department; PCP, primary care physician.
Notes: See main text for detail.

Table 3-E. Association between ACA Medicaid expansions and emergency department and primary care use

Outcome	Baseline (2010-2013)		Post-Expansion (2014-2016)†	
	Mean in Expansion States	Mean in Non-Expansion States	DID Estimate‡ [95% CI]	P-Value
PCP-related outcome				
Any PCP visit during a year (%)	50.9%	46.3%	+3.6pp [+0.4pp,+6.8pp]	0.03
Annual number of PCP visits among those with any PCP visit during a year	3.34	3.16	-0.28 [-0.66,+0.10]	0.15
ED-related outcome				
Any ED visit during a year (%)	24.0%	23.6%	-0.5pp [-3.7pp,+2.7pp]	0.76
Annual number of ED visits among those with any ED visit during a year	1.70	1.67	+0.04 [-0.15,+0.24]	0.65

*Presented values are unadjusted weighted means in the baseline period and difference-in-differences (DID) estimates from ordinary least squares regression models adjusted for age, sex, race/ethnicity, education attainment, marital status, household size, and state- and year- fixed effects based on the data of Medical Expenditure Panel Survey 2010-2016.

†Post-expansion period indicates years 2014-2016 for most states but not for all (see **Table 3-A** for detail).

‡DID estimates are reported as percentage point changes for binary outcomes and as changes in annual number for number of visits outcomes.

Abbreviations: ACA, Patient Protection and Affordable Care Act; CI, confidence interval; DID, difference-in-differences; ED, emergency department; PCP, primary care physician.

Table 3-F. Sensitivity analysis using alternate sample definitions

Alternate Sample Definition	DID Estimate	[95% CI]	P-Value
Any PCP visit during a year (percentage point changes)			
(i) Including 5 states with prior significant coverage	+2.8pp	[-0.5pp,+6.1pp]	0.10
(ii) Excluding 4 "early expansion states"	+3.3pp	[-0.2pp,+6.8pp]	0.06
(iii) Excluding 6 "late expansion states"	+4.0pp	[+0.5pp,+7.5pp]	0.03
(iv) Excluding Wisconsin	+3.6pp	[+0.4pp,+6.9pp]	0.03
(v) Including non-U.S. born participants	+2.1pp	[-0.2pp,+4.4pp]	0.07
(vi) Including 19-25 years old	+2.9pp	[+0.1pp,+5.8pp]	0.046
(vii) Analyzing >400% FPL (falsification test)	+0.4pp	[-3.0pp,+3.8pp]	0.82
Annual number of PCP visits among those with any PCP visit during a year (changes in the number of visits)			
(i) Including 5 states with prior significant coverage	-0.33	[-0.67,+0.02]	0.06
(ii) Excluding 4 "early expansion states"	-0.28	[-0.68,+0.13]	0.18
(iii) Excluding 6 "late expansion states"	-0.22	[-0.61,+0.18]	0.29
(iv) Excluding Wisconsin	-0.28	[-0.67,+0.10]	0.15
(v) Including non-U.S. born participants	-0.17	[-0.48,+0.14]	0.29
(vi) Including 19-25 years old	-0.25	[-0.62,+0.12]	0.19
(vii) Analyzing >400% FPL (falsification test)	+0.01	[-0.13,+0.14]	0.92
Any ED visit during a year (percentage point changes)			
(i) Including 5 states with prior significant coverage	-0.5pp	[-3.8pp,+2.8pp]	0.76
(ii) Excluding 4 "early expansion states"	-0.6pp	[-4.0pp,+2.9pp]	0.75
(iii) Excluding 6 "late expansion states"	+0.2pp	[-3.3pp,+3.7pp]	0.91
(iv) Excluding Wisconsin	-0.4pp	[-3.6pp,+2.8pp]	0.81
(v) Including non-U.S. born participants	-0.4pp	[-2.9pp,+2.2pp]	0.79
(vi) Including 19-25 years old	-0.3pp	[-3.6pp,+3.0pp]	0.87
(vii) Analyzing >400% FPL (falsification test)	+0.6pp	[-1.0pp,+2.3pp]	0.45
Annual number of ED visits among those with any ED visit during a year (changes in the number of visits)			
(i) Including 5 states with prior significant coverage	+0.10	[-0.10,+0.29]	0.34
(ii) Excluding 4 "early expansion states"	+0.03	[-0.17,+0.24]	0.75
(iii) Excluding 6 "late expansion states"	+0.10	[-0.11,+0.31]	0.35
(iv) Excluding Wisconsin	+0.05	[-0.14,+0.25]	0.59
(v) Including non-U.S. born participants	-0.02	[-0.18,+0.14]	0.82
(vi) Including 19-25 years old	+0.02	[-0.15,+0.18]	0.83
(vii) Analyzing >400% FPL (falsification test)	+0.10	[-0.02,+0.22]	0.11

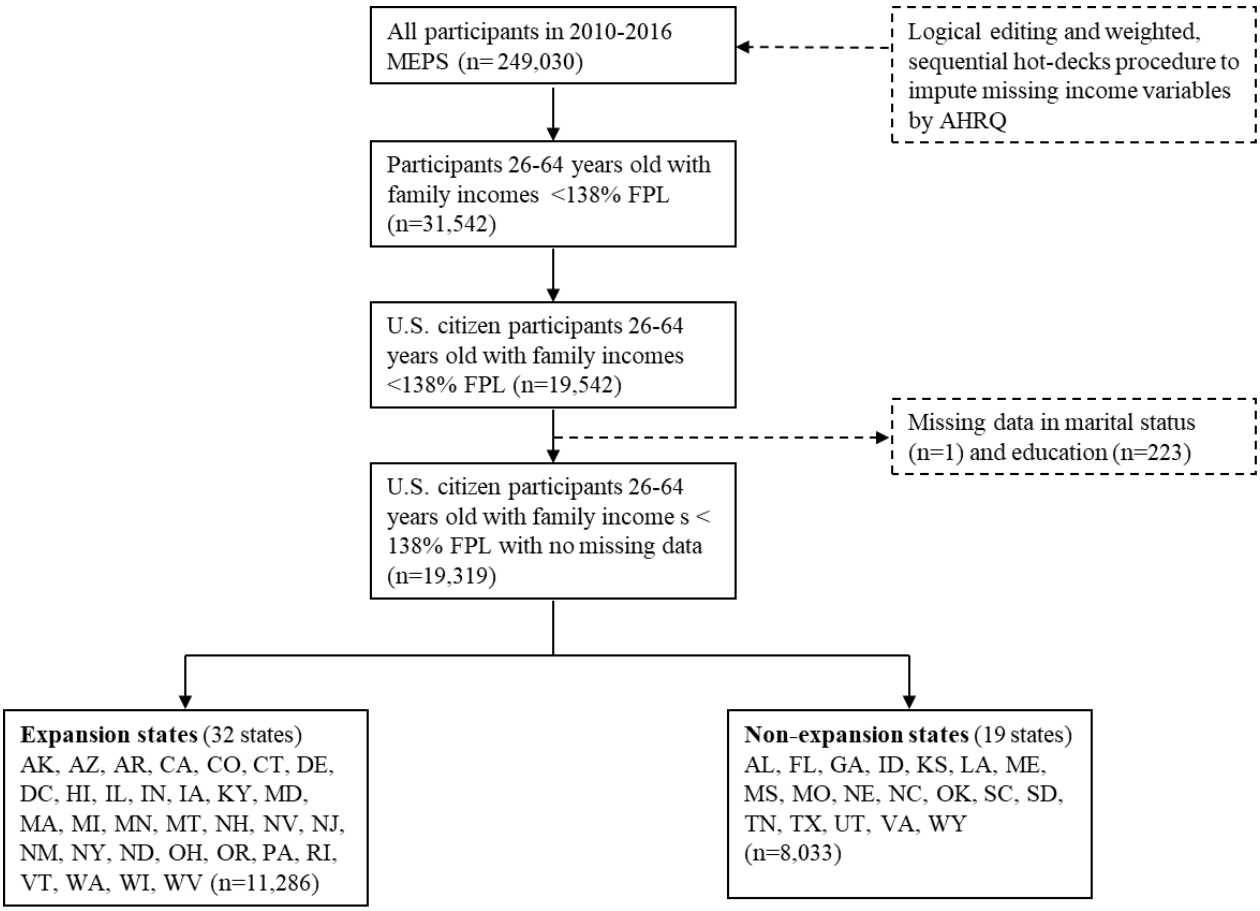
Abbreviations: CI, confidence interval; ED, emergency department; FPL, federal poverty level; PCP, primary care physician.
Notes: See main text for detail.

Table 3-G. Sensitivity analysis using alternate model specifications

Alternative Model Specification	DID Estimate	[95% CI]	P-Value
Any PCP visit during a year			
(i) OLS regression model clustered at the state level (percentage point change)	+3.6pp	[-0.4pp,+7.6pp]	0.08
(ii) Logistic regression model (adjusted odds ratio)	1.17	[1.02,1.35]	0.03
(iv) OLS regression model using finer post-expansion period definition (percentage point change)			
Year 1	+2.6pp	[-1.6pp,+6.8pp]	0.22
Year 2	+4.8pp	[-0.1pp,+9.6pp]	0.055
Year 3	+3.8pp	[-2.2pp,+9.7pp]	0.21
Annual number of PCP visits among those with any PCP visit during a year (changes in the number of visits)			
(i) OLS model clustered at the state level	-0.28	[-0.57,+0.01]	0.055
(iii) Poisson regression model [a]	-0.28	[-0.65,+0.08]	0.13
(iv) OLS model using finer post-expansion period definition			
Year 1	-0.42	[-0.90,+0.07]	0.09
Year 2	-0.08	[-0.60,+0.44]	0.76
Year 3	-0.29	[-0.83,+0.25]	0.29
Any ED visit during a year			
(i) OLS regression model clustered at the state level (percentage point change)	-0.5pp	[-4.3pp,+3.3pp]	0.80
(ii) Logistic regression model (adjusted odds ratio)	0.98	[0.83,1.16]	0.81
(iv) OLS regression model using finer post-expansion period definition (percentage point change)			
Year 1	-3.6pp	[-7.3pp,+0.2pp]	0.06
Year 2	+4.7pp	[-0.6pp,+9.9pp]	0.08
Year 3	-1.6pp	[-7.2pp,+4.0pp]	0.57
Annual number of ED visits among those with any ED visit during a year (changes in the number of visits)			
(i) OLS model clustered at the state level	+0.04	[-0.19,+0.28]	0.71
(iii) Poisson regression model [a]	+0.05	[-0.15,+0.24]	0.65
(iv) OLS model using finer post-expansion period definition			
Year 1	+0.10	[-0.16,+0.36]	0.45
Year 2	-0.03	[-0.27,+0.21]	0.79
Year 3	+0.04	[-0.23,+0.31]	0.77

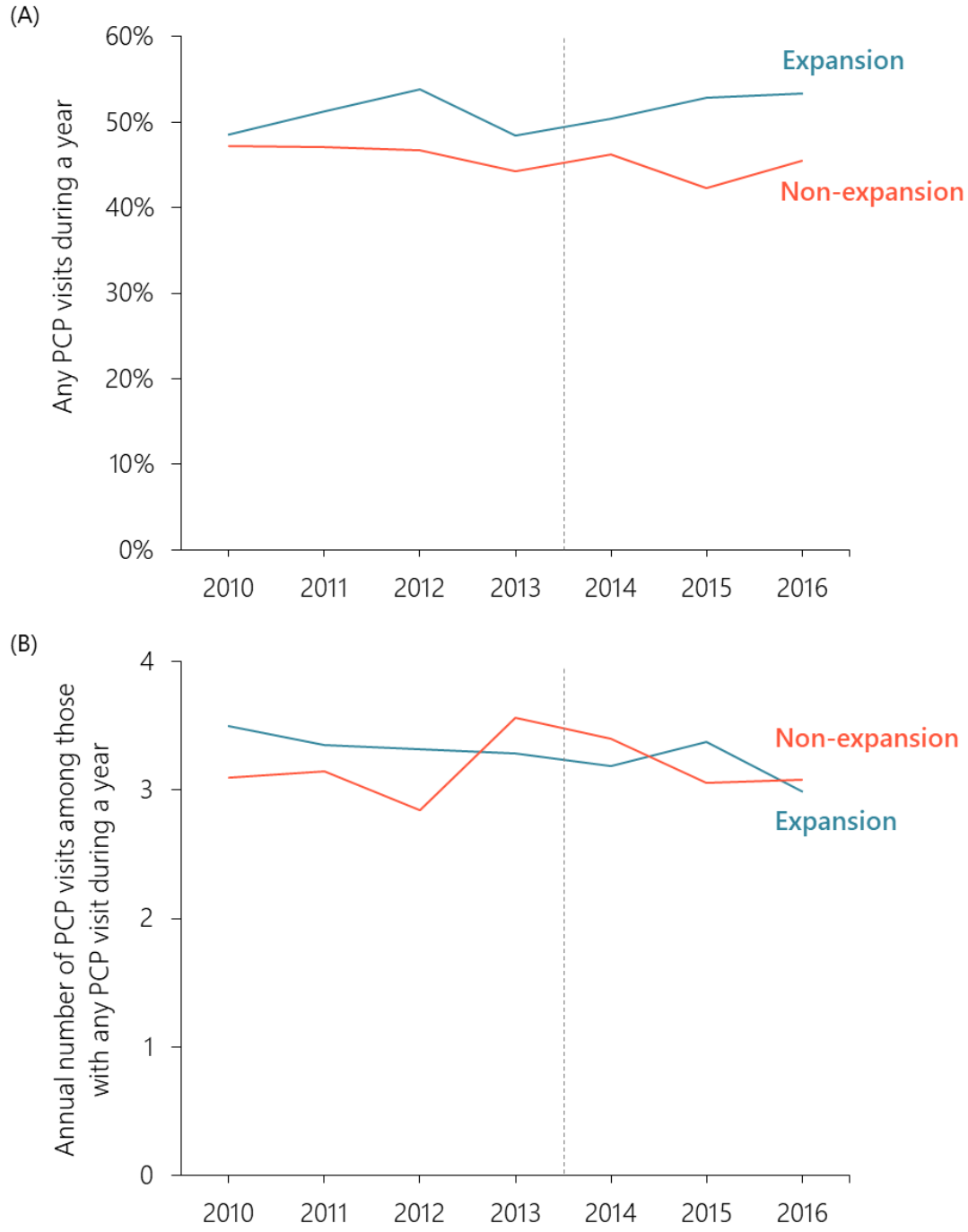
Abbreviations: CI, confidence interval; ED, emergency department; OLS, ordinary least squares; PCP, primary care physician.
Notes: See main text for detail. [a] DID estimates for Poisson regression models are reported as changes in the number of visits using average marginal effects.

Figure 3-A. Flow diagram of the study population



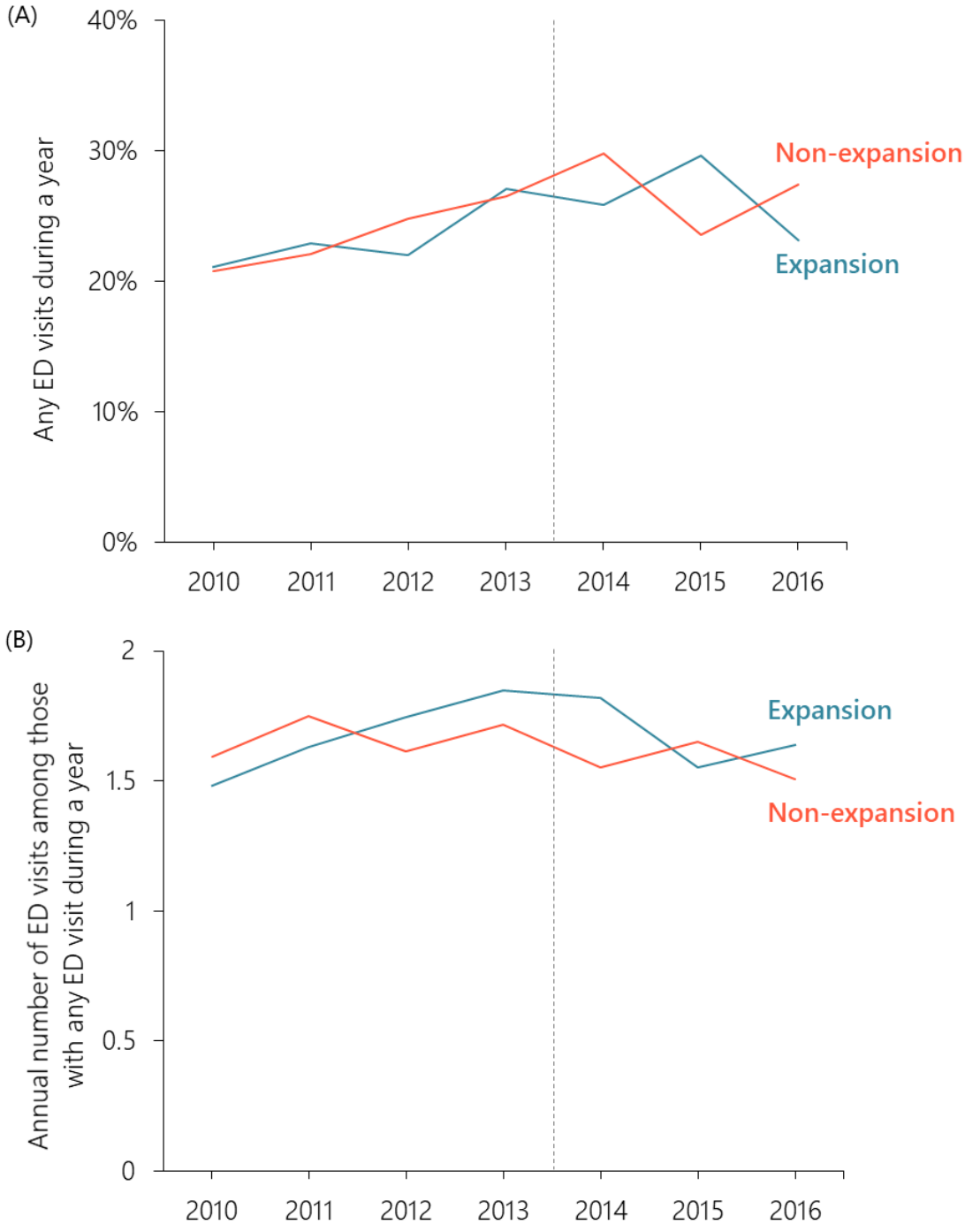
Abbreviations: AHRQ, Agency for Healthcare Research and Quality; MEPS, Medical Expenditure Panel Survey; FPL, federal poverty level.

Figure 3-B. Unadjusted yearly trends in PCP use by ACA Medicaid expansion



Data shown are unadjusted weighted mean (A) percentages of individuals who had any PCP visit during a year and (B) annual numbers of PCP visits among those with any PCP visit during a year for states that expanded Medicaid on January 1, 2014 and non-expansion states. The sample included U.S. citizens 26-64 years old with family incomes lower than 138% of the federal poverty level from the Medical Expenditure Panel Survey 2010-2016. The dashed line indicates the implementation of the ACA 2014 Medicaid expansion. Note the difference in scales in the y-axis. Abbreviations: ACA, Patient Protection and Affordable Care Act; PCP, primary care physician.

Figure 3-C. Unadjusted yearly trends in ED use by ACA Medicaid expansion status



Data shown are unadjusted weighted mean (A) percentages of individuals who had any ED visit during a year and (B) annual numbers of ED visits among those with any ED visit during a year for states that expanded Medicaid on January 1, 2014 and non-expansion states. The sample included U.S. citizens 26-64 years old with family incomes lower than 138% of the federal poverty level from the Medical Expenditure Panel Survey 2010-2016. The dashed line indicates the implementation of the ACA 2014 Medicaid expansion. Note the difference in scales in the y-axis. Abbreviations: ACA, Patient Protection and Affordable Care Act; ED, emergency department.

Chapter 4. Association between the ACA Medicaid Expansions and Health Outcomes for Hypertension, Diabetes, Hyperlipidemia, and Depression (Paper #3)

4-1. Abstract

Background: The Affordable Care Act (ACA) expanded Medicaid eligibility to persons earning below 138% of the federal poverty level (FPL) in 2014. However, evidence is scarce and mixed as to whether the ACA Medicaid expansions were associated with improved health outcomes for chronic conditions.

Methods: We compared changes in measured clinical outcomes before (2005 through 2012) and after (2015 and 2016) the implementation of ACA Medicaid expansions between states with and without Medicaid expansion, using a difference-in-differences design. We analyzed nationally representative individuals 19-64 years old with family incomes below 138% of the FPL from the 2005-2016 National Health and Nutrition Examination Survey. Measures included blood pressure, hemoglobin A1c (HbA1c) levels, cholesterol levels, and screening for depression.

Results: Our study included 9,177 individuals. We found that the ACA Medicaid expansions were associated with significantly lower systolic blood pressure (difference-in-differences [DID] estimate, -3.0 mmHg; 95%CI, -5.3 mmHg to -0.7 mmHg; p=0.01) and lower HbA1c levels (DID estimate, -0.14 percentage points [pp]; 95%CI, -0.24 pp to -0.03 pp; p=0.01) in expansion states relative to the non-expansion states. We observed no significant change in diastolic blood pressure, cholesterol levels, or the probability of a positive screening for depression following the ACA Medicaid expansions.

Conclusions: The ACA Medicaid expansions were associated with statistically significant and clinically meaningful improvement in measured health outcomes in two out of four major chronic conditions among low-income families during the second and third years of the policy implementation. Our findings add important evidence on the effects of the ACA Medicaid expansions on population health.

4-2. **Background**

Studies have shown that people without health insurance are less likely than those with health insurance to receive recommended screening tests and treatments for chronic conditions such as hypertension and diabetes,[1,2] and experience worse health outcomes including delayed diagnoses and higher mortality rates.[3-5] One of the goals of the Patient Protection Affordable Care Act (ACA) enacted in 2010 was to improve population health outcomes through providing affordable health insurance to the majority of 50 million uninsured Americans.[6,7] Under the ACA, many states expanded Medicaid eligibility to working-age adults with family incomes below 138% of the federal poverty level (FPL) in 2014.[8] The literature to date suggests that the ACA Medicaid expansions have significantly reduced the number of uninsured patients as intended.[9-11] However, little is known as to whether the ACA Medicaid expansions led to better health outcomes for chronic conditions among low-income individuals.

Evidence is scarce and mixed as to whether health insurance coverage is associated with improved clinical outcomes for chronic conditions. The Oregon Health Insurance Experiment (OHIE) is a seminal randomized control trial conducted from 2008 to 2010 to evaluate the impact of providing Medicaid coverage among the previously uninsured population. Although

the OHIE led to a significant improvement in health insurance coverage, they found no impact on their measured clinical data after two years of Medicaid coverage, except for a reduction in the number of people with depression.[12] Only a handful studies examined as to how the ACA Medicaid expansions affected health outcomes for chronic conditions,[13-17] and these studies, including the OHIE, have limitations in that they (i) were conducted in a small number of states (resulting in restricted generalizability),[12,14] (ii) solely relied on self-reports without clinical data (e.g., blood pressure values),[13,15] or (iii) analyzed aggregated data (as opposed to individual-level data).[16,17] Given the ongoing discussions regarding the benefits and costs of the ACA, it is critical to understand whether expanded Medicaid coverage improves population health outcomes among low-income adults at the national level.

In this context, we examined the effect of the 2014 ACA Medicaid expansions on health outcomes for chronic conditions using a nationally representative sample of low-income working-age adults with clinical data. We focused on outcomes related to hypertension, diabetes, hyperlipidemia, and depression because these conditions are prevalent and important risk factors for mortality and considered modifiable in a relatively short time-frame.[12]

4-3. **Methods**

Data source and study population

We analyzed the 2005-2016 National Health and Nutrition Examination Survey (NHANES), a nationally representative survey of the non-institutionalized population in the U.S. conducted by the National Center for Health Statistics (NCHS).[18] NHANES first conducts interviews in participants' homes to collect information about their health, disease, medications, and diet.

Qualified participants are subsequently invited to a mobile examination center (MEC) for additional interviews, physical examinations, and laboratory tests (blood and urine). In addition, a subsample of MEC participants is randomly selected for morning fasting laboratory testing.[19] NHANES data are released in 2-year cycles and the mean overall response rate was 68.5%.[20]

We also linked the American Community Survey (ACS) data to NHANES using census tract identifiers to collect information about the neighborhood socioeconomic status (SES) of participants. The ACS is an annual survey by the U.S. Census Bureau and produces estimates for socioeconomic information at various geographic levels.[21,22] The ACS 5-year summary files provide precise estimates even for smaller geographic levels, including at the census tract level.[23] These data enables us to incorporate information about the neighborhood socioeconomic status (SES) of participants, which can affect participants' health status through access to healthy food and preventive healthcare services.[24,25] The 2005-2010 NHANES data were linked to the ACS 2005-2009 summary file and the 2011-2016 NHANES to the ACS 2012-2016 summary file.

We restricted our study sample to individuals 19-64 years old with family incomes lower than 138% of the FPL, the eligibility criteria of the ACA Medicaid expansions. NHANES provides data on the ratio of family income to poverty (INDFMPIR) by dividing family (or individual) income by the relevant poverty guidelines. If the respondent was unable to report greater detail about family income than < $20,000 or ≥$20,000, then these two categories were used to report the family income but INDFMPIR was not computed.[22] For our analytic sample, we first included individuals 19-64 years old with INDFMPIR lower than 1.38 in the 2005-2016 NHANES data (n=8,925). If an observation had a missing value in INDFMPIR but family

income was coded as < $20,000, we then included this observation in our main analysis (n= 263) because the poverty thresholds for household of one, two, and three in 2016 were $11,880, $16,020, and $20,160, respectively.[26] As this may result in including some participants with income greater than 138% of the FPL (particularly households of one), we conducted a sensitivity analysis by restricting our study sample with a non-missing value in INDFMPIR. We excluded observations with missing values in education attainment and neighborhood SES (n=11). See **Figure 4-A** for a flowchart.

Expansion Status

While most of the expansion states implemented the ACA Medicaid expansion on January 1, 2014, the following states expanded Medicaid after that day ("late expansion states"): Michigan (expanded on April 1, 2014), New Hampshire (August 15, 2014), Pennsylvania (January 1, 2015), Indiana (February 1, 2015), Alaska (September 1, 2015), Montana (January 1, 2016), Louisiana (July 1, 2016), Virginia (January 1, 2019), and Maine (January 10, 2019).[27] In our study, a state was considered as an expansion state if the state expanded Medicaid or an equivalent program by the end of 2016. We included Wisconsin in the expansion states because it started comprehensive insurance coverage to childless adults with family incomes up to 100% of the FPL through a Section 1115 waiver program since January 1, 2014 although Wisconsin has not adopted the ACA Medicaid expansion.[27] Based on this definition, there would be 33 expansion states (including the District of Columbia) and 18 non-expansion states (**Table 4-A**). However, NHANES does not collect data from all 51 states; to achieve cost-efficiency, the survey is designed to produce national estimates.[28] As a result, our study included 25 expansion states and 15 non-expansion states. We analyzed the data using a masked state variable provided

by NHANES due to disclosure risk. We conducted several sensitivity analyses with alternative definitions of expansion states to test the robustness of our findings.

For non-expansion states and most expansion states that expanded Medicaid on January 1, 2014, we defined survey cycles 2005/2006, 2007/2008, 2009/2010, and 2011/2012 as "pre-expansion" period, 2013/2014 as "transition" period, 2015/2016 as "post-expansion" period (**Table 4-A**). We accounted for the transition period because the ACA Medicaid expansions were implemented during the survey cycle 2013/2014 and this period may contain data both before and after the implementation. For those states that implemented the ACA Medicaid expansion after January 1, 2014, we defined these study periods based on the actual implementation data (**Table 4-A**).

Health Outcomes

i) Hypertension

We examined mean systolic and diastolic blood pressures (BPs) for participants with at least one recorded BP (See **Figure 4-A** for a flowchart). Mean systolic and diastolic BPs were calculated after excluding the first reading for individuals with more than one values as recommended by NHANES.[29] We also examined current use of medications for hypertension, defined as the use of one or more antihypertensive medications in the past 30 days of the interview. Medication names were ascertained from medication containers during the household interview and coded using a proprietary drug database (Lexicon Plus; Cerner Multum, Inc.).[22] Lastly, we calculated the prevalence of hypertension, defined by: (1) mean systolic BP ≥140mmHg and/or mean diastolic BP ≥90mmHg, and/or (2) current use of medication for hypertension.

The definition of hypertension in this study relied on the Seventh Report of the Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure (JNC 7) in 2003.[30] We did not use different hypertension criteria for patients with diabetes mellitus or chronic kidney disease (CKD) (≥130/≥80mmHg) that were recommended by JNC 7 because of the controversy over this stringent goal at that time.[31] Similarly, we did not use the updated hypertension criteria for patients 60 years and older (≥150/≥90mmHg) recommended by JNC 8 in 2014 due to the discrepancy with other guidelines.[32,33]

Antihypertensive medications in this study include angiotensin converting enzyme inhibitors, beta-adrenergic blocking agents, calcium channel blocking agents, diuretics, angiotensin II inhibitors, aldosterone receptor antagonists, vasodilators, renin inhibitors, antiadrenergic agents, and antihypertensive combinations, according to the classification by Lexicon Plus.

ii) Diabetes

We analyzed hemoglobin A1c (HbA1c) levels for participants 20 years and older with recorded HbA1c values (**Figure 4-A**). We also examined whether a participant's HbA1c level was 6.5% or greater, which is one of the diagnostic criteria for diabetes. Similarly to hypertension, we analyzed current use of anti-diabetic medications and the prevalence of diabetes. A participant was considered to have diabetes by: (1) HbA1c level of 6.5% or greater, and/or (2) current use of medication for diabetes.

While fasting plasma glucose (FPG) and 2-hour plasma glucose (PG) levels are used as diagnostic criteria (in addition to HbA1c) by American Diabetes Association (ADA),[34] we did not use these values in deciding prevalent diabetes cases because these require fasting testing, and therefore, it would significantly decrease our study sample size. In addition, while ADA recommends a repeat measurement of HbA1c for diabetes diagnosis,[34] we are unable to account for this due to NHANES data availability.

Anti-diabetic medications in this study include sulfonylureas, biguanides, alpha-glucosidase inhibitors, thiazolidinediones, meglitinides, dipeptidyl peptidase 4 inhibitors, amylin analogs, GLP-1 receptor agonists, SGLT-2 inhibitors, insulin, and antidiabetic combinations, according to the classification by Lexicon Plus.

iii) Hyperlipidemia

We examined the levels of low-density lipoprotein cholesterol (LDL-C), total cholesterol (T-Chol), triglycerides (TG), and high-density lipoprotein cholesterol (HDL-C) for participants older than 20 years in a fasting subsample who had recorded values (**Figure 4-A**). LDL-C values were calculated from measured values of T-Chol, TG, and HDL-C according to the Friedewald calculation (participants with triglycerides >400 mg/dL were excluded from the analysis).[35] We also analyzed current use of anti-hyperlipidemic medications and the prevalence of high LDL-C levels. A high LDL-C level was defined as the LDL-C level above the specific goal for each risk category specified by a guideline and/or current use of anti-hyperlipidemic medications.

Our analysis relied on the National Cholesterol Education Program Adult Treatment Panel III (NCEP ATP III) [36] in 2001 instead of the 2013 guidelines by the American College of Cardiology and the American Heart Association (ACC/AHA) because the target of the new guidelines is adults 40 to 75 years,[37] and therefore, the sample size would decrease significantly. It should not bias our results as this recommendation change occurred nationwide.

In calculating the prevalence of high LDL-C, we used the following criteria: (1) LDL-C ≥100 mg/dL in participants with coronary heart disease (CHD) or CHD risk equivalents and those with 10-year CHD risk >20%; (2) LDL-C ≥130 mg/dL in participants with at least two major CHD risk factors and/or 10-year CHD risk 10% to 20%; (3) LDL-C ≥160 mg/dL in participants with no or one major CHD risk factor and 10-year CHD risk <10%; or (4) current use of anti-hyperlipidemic medications.

CHD and CHD risk equivalents include diabetes mellitus and self-reported history of CHD, angina, myocardial infarction, and stroke. Peripheral arterial disease and abdominal aortic aneurysm were not accounted for because of NHANES data availability. 10-year CHD risk was calculated based on the Framingham risk scoring using categorical values for age, total cholesterol level, cigarette smoking status, HDL-C level, and systolic blood pressure. Major CHD risk factors include current cigarette smoking, hypertension, HDL-C <40mg/dL, family history of premature CHD, and age (men ≥45 years; women ≥55 years). The presence of HDL-C ≥60mg/dL removes one risk factor from the total count of major CHD risk factors. While ATP-III defines family history of premature CHD as CHD in male first-degree relative <55 years or CHD in female first-degree relative <65 years, we used CHD in first-degree relative.

Anti-hyperlipidemic medications in this study include HMG-COA reductase inhibitors, fibric acid derivatives, bile acid sequestrants, cholesterol absorption inhibitors, miscellaneous anti-hyperlipidemic agents, anti-hyperlipidemic combinations, and omega-3 polyunsaturated fatty acids, according to the classification by Lexicon Plus.

iv) Depression

We analyzed the prevalence of a positive depression screening result, defined by the 9-item Patient Health Questionnaire (PHQ-9) depression scale score of 10 or greater, among MEC participants (**Figure 4-A**). The PHQ-9 asks about the frequency of symptoms of depression over the past 2 weeks with a total score ranging from 0 to 27, and this cut point is recommended for depression screening purpose.[38] Participants with one or more missing responses to PHQ-9 items were excluded. We also examined current use of antidepressant medications. Antidepressant medications in this study include SSRI antidepressants, tricyclic antidepressants, monoamine oxidase inhibitors, phenylpiperazine antidepressants, tetracyclic antidepressants, SSNRI antidepressants, and miscellaneous antidepressants, according to the classification by Lexicon Plus.

Adjustment Variables

We included the following individual characteristics in our regression models as adjustment variables: age (as continuous), sex, race/ethnicity (non-Hispanic White, non-Hispanic Black, Hispanic, and other), education attainment (less than high school, high school, some college, or bachelor's degree or more), family size (as continuous), and neighborhood SES (as continuous).

Additionally, we included state- and year-specific fixed effects to account for time-invariant state factors and a secular trend.

All responses of participants aged 80 years and older are coded as 80 by NHANES for disclosure risk.[22] Similarly, family size was top-coded at 7 by NHANES.[22] We constructed an index of neighborhood SES using six variables previous literature:[24] (1) percentage of family households with children not headed only by a female (non-single mother households); (2) percentage of population ages 25 and older with high school diploma or higher education; (3) percentage of households with income higher than the poverty threshold; (4) median household income; (5) percentage of households that do not receive public assistance income; and (6) percentage of male population ages 16 and older that are employed. We calculated a summary measure of neighborhood SES by summing z scores for the 6 variables (higher score indicated higher neighborhood SES) and included this as a covariate.

Statistical Analysis

We employed a difference-in-differences (DID) approach to compare changes in outcomes between participants in the expansion and non-expansion states before and after the ACA Medicaid expansions. Our model specification is shown below.

$$Y_{ist} = \theta_s + \lambda_t + \beta_1(EXP_s \times TRAN_t) + \beta_2(EXP_s \times POST_t) + \delta X_{ist} + \varepsilon_{ist},$$

where Y_{ist} denotes outcomes for individual *i* living in state *s* at time *t* (expressed as survey cycle), θ_s denotes state-specific fixed effects, λ_t denotes survey cycle-specific fixed effects, EXP_s denotes the expansion state indicator, $TRAN_t$ denotes the transition period indicator, $POST_t$ denotes the post-expansion period indicator, and X_{ist} denotes adjustment variables (age,

sex, race/ethnicity, education attainment, family size, and neighborhood SES). The coefficient β_2 for the interaction term between the expansion state indicator and the post-expansion period indicator represents the changes in the outcomes that are attributable to the ACA Medicaid expansions. We also included an interaction term between the expansion state indicator and the transition period because the ACA Medicaid expansions were implemented on January 1, 2014 in most states and the data from survey cycle 2013/2014 may include data both before and after the implementation. A similar approach has been used by Miller and Wherry.[13,39] We report estimates for the post-expansion period only as estimates for the transition period may not be interpretable.

To examine the validity of our estimates, we tested the parallel trend assumption of the DID model. That is, the outcomes in the expansion states would have had a similar trend as those in the non-expansion states if the ACA Medicaid expansions had not been implemented. We estimated regression models with an interaction term between the expansion state indicator variable and survey cycle variable (as continuous) during the baseline period (i.e., 2005 through 2012). If the coefficient of the interaction term is close to zero, it suggests that the linear trends for expansion and non-expansion states are similar during the baseline period.

All analyses were conducted with Stata software version 14.1 (StataCorp, Texas, USA) accounting for the complex survey design of NHANES with the weights specified for each of household interview sample, mobile MEC participants, and fasting subsample. We used cluster-robust standard errors to account for the non-independence of observations within a state, as recommended in the previous literature,[40] by using sampling weights and the CLUSTER option

in Stata. We used restricted-access state and census tract identifiers provided by NCHS and all analysis was conducted in a California Census Research Data Center. The University of California, Los Angeles Institutional Review Board approved this study.

Sensitivity Analysis

We conducted a series of sensitivity analyses with different sample population definitions to test the robustness of the results: (1) excluding 5 states (Delaware, District of Columbia, Massachusetts, New York, and Vermont) from expanding states that provided Medicaid or similar coverage to adults with incomes up to 100% of the FPL or greater during prior to 2014, an approach used in previous literature;[13,41] (2) excluding 7 states that expanded Medicaid after January 1, 2014; (3) Excluding non-US citizens from the study sample (because non-US citizens have to meet certain requirements to be eligible for Medicaid coverage[42]); (4) excluding observations with a missing value in the ratio of family income to poverty but with family income recoded as "under $20,000"; (5) excluding people 19-25 years old, the target of the 2010 ACA Dependent Coverage Mandate; and (6) analyzing participants with family incomes greater than 400% of the FPL as a falsification test because this population should not have had a significant impact of the ACA Medicaid expansions.

4-4. **Results**

Our study included 9,177 individuals (**Figure 4A**). **Table 4B** presents the baseline characteristics of individuals by expansion status based on the NHANES 2005-2012 data. There were no statistical differences in the characteristics of participants between the expansion and non-expansion states.

Figures 4B through **4D** present unadjusted yearly trends in outcomes for the expansion and non-expansion states (see **Figure 4E** for unadjusted trends in other outcomes). The formal tests showed no evidence that the baseline trends in outcome variables differ between expansion and non-expansion states except for diastolic blood pressure. See **Table 4-C** for the results of the tests for the parallel trend assumption.

Health Outcomes

i) Hypertension

We found that the mean BPs at baseline were 118.1/70.0 mmHg in the expansion states and 119.5/70.2 in the non-expansion states (**Table 4-D**). We found that the ACA Medicaid expansions were associated with a significantly lower systolic BP (difference-in-differences [DID] estimate, -3.03 mmHg; 95%CI, -5.33 mmHg to -0.73 mmHg; p=0.01) although there was no significant changes in diastolic BP (DID estimate+1.05 mmHg; 95%CI, -2.44 mmHg to +4.53 mmHg; p=0.55). We did not observe any changes in current use of medication for hypertension or the prevalence of hypertension following the ACA Medicaid expansions.

ii) Diabetes

We found that the mean HbA1c at baseline was 5.6% in the expansion states and 5.7% in the non-expansion states (**Table 4-D**). The proportions of participants with HbA1c levels of 6.5% or greater were 7.15% in the expansion states and 9.71% in the non-expansion states. We observed significantly reduced HbA1c levels (DID estimate, -0.14 percentage points [pp]; 95%CI, -0.24 pp to -0.03 pp; p=0.01) following the ACA Medicaid expansions although we

found no significant change in the proportion of participants with HbA1c levels of 6.5% or greater (DID estimate -1.14 pp; 95%CI, -3.89 pp to +1.60 pp; p=0.40). There was no significant change in current use of medication for diabetes or the prevalence of diabetes following the ACA Medicaid expansions.

iii) Hyperlipidemia

Mean blood cholesterol levels at baseline for the expansion and non-expansion states are presented in **Table 4-D**. We found no significant changes in LDL-C levels (DID estimate, -6.82 mg/dL; 95%CI, -16.75 mg/dL to +3.11 mg/dL; p=0.17), triglyceride levels (DID estimate, -4.66 mg/dL; 95%CI, -31.64 mg/dL to +22.32 mg/dL; p=0.73), total cholesterol levels (DID estimate, -4.49. mg/dL; 95%CI, -11.45 mg/dL to +2.48 mg/dL; p=0.20), or HDL-C levels (DID estimate, -1.05 mg/dL; 95%CI, -4.18 mg/dL to +2.09 mg/dL; p=0.50) following the ACA Medicaid expansions. There was no significant change in current use of medication for hyperlipidemia or the prevalence of hyperlipidemia after the ACA Medicaid expansions.

iv) Depression

We observed no significant change in the proportion of participants with a positive depression screening result (DID estimate -0.22 pp; 95%CI, -7.43 pp to +6.99 pp; p=0.95) or current use of medication for depression (DID estimate -2.34 pp; 95%CI, -8.91 pp to +4.22 pp; p=0.48) (**Table 4-D)**.

Sensitivity Analysis

Alternative sample definitions did not affect our findings qualitatively. The falsification test analyzing individuals with incomes greater than 400% FPL showed that health outcomes did not change following the ACA Medicaid expansions for this population. See **Tables 4-E** and **4-F** for the results.

4-5. Discussion

We found that the ACA Medicaid expansions were associated with a significantly lower systolic BP and HbA1c during the second and third years of program implementation, using a nationally representative sample of the low-income working-age population in the U.S. We did not observe any significant changes in diastolic BP, blood cholesterol levels, or the likelihood of having a positive depression screening result. These findings suggest that expanding Medicaid coverage under ACA led to a modest improvement in health outcomes for prevalent and important chronic conditions among low-income adults at the national level, which should be reassuring for the policymakers.

The magnitudes of the changes in the present study are arguably clinically meaningful. Our estimates are significantly diluted by a large subset of the study population who did not have relevant clinical conditions (i.e., hypertension and diabetes) and were unaffected by the ACA Medicaid expansions (e.g., individuals who were covered by Medicaid or private health insurance both before and after the expansions, those who remained uninsured after the expansions). In other words, the changes we observed are concentrated within a small portion of our study population with hypertension and/or diabetes who newly obtained Medicaid coverage

following the expansions. Therefore, the actual impact among these individuals would be much larger than the estimates in our analyses and have clinical significance given that even a 2 mmHg decrease in systolic BP and 0.4 percentage point reduction in HbA1c have shown to decrease major cardiovascular events in randomized controlled studies.[43,44] The improvements we observed were probably driven by lifestyle modification given non-significant changes in medication use.

Our present study builds on prior studies that examined the effects of Medicaid coverage on health outcomes for chronic conditions. The OHIE observed no significant change in BPs, HbA1c levels, the percentage of participants with HbA1c levels of 6.5% or higher, or total and HDL cholesterol levels among the uninsured who won the opportunity to apply for a new Medicaid program in Oregon, whereas the probability of a positive screening for depression significantly decreased.[12] Sommers et al. studied the impact of the ACA Medicaid expansions based on the data from three southern states (Kentucky, Arkansas, and Texas) and found that the expansions were associated with a reduction in the probability of a positive depression screening using a two-item mental health screening questionnaire.[14] Other reported that the ACA Medicaid expansions were associated with increases in self-reported diagnoses of diabetes, high cholesterol levels, and depression,[13,15] an increase in the percentage of those with BPs less than 140/90 mmHg among patients in federally-funded community centers,[16] and lower cardiovascular mortality at the county level.[17] While informative, these studies are limited because they were restricted to a small number of states,[12,14] based on self-reported data,[13,15] or analyzed aggregated data.[16,17] To our best of knowledge, this is the first national study that

examined the impact of the ACA Medicaid expansions on health outcomes based on individual-level clinical data using a robust quasi-experimental design.

Several potential mechanisms could explain the difference between our findings and those by the OHIE. First, our estimates may be representing longer-term effects than were observed in the OHIE. The 2015/2016 NHANES data—post-expansion data in our study—were collected between 12 and 35 months after coverage under the ACA Medicaid expansions became effective on January 1, 2014 whereas the OHIE examined outcomes in participants who gained an average of 17 months.[12] Therefore, clinical effects might not have accumulated enough to be detected at the interview/examination in the OHIE. Second, the OHIE participants, who voluntarily signed up for the lottery for a new Medicaid program, might have had more medical and social needs compared to our national sample, and therefore the findings from the OHIE may not be generalizable to other states. For example, 30 percent of the control group in the OHIE had a positive depression screening result, substantially higher than the national prevalence of depression among low-income adults 20 years and older (up to 15 percent).[12,45] Similarly, the control group in the OHIE had more frequent emergency department visits (0.68 visits per person-year) in comparison to the national average of age group 18-64 years (approximately 0.40 visits per person-year).[46,47] It is possible that, given the complex needs of the OHIE participants, the new Medicaid coverage did not benefit them as much as it did in our study population.

Our study has to be interpreted with caution. First, the power of our study might not have been adequate to detect small but clinically meaningful changes in cholesterol levels using a fasting sample. Future studies with a larger sample size are warranted to determine the association

between the ACA Medicaid expansions and cholesterol levels. Second, while our quasi-experimental study design helps to control unmeasured confounders, there is still a possibility that expansion and non-expansion states are different in a way that our approach could not account for. However, the parallel trends between the two groups prior to the ACA Medicaid expansions provide confidence in the validity of our findings. Lastly, our study only included 25 expansion and 15 non-expansion states due to the NHANES sampling design, and the findings may not be applicable to the states that were not included, especially in the context of evaluating a policy change. However, NHANES is designed to produce national estimates by accounting for various state-level health-related variables,[28] and our study arguably provides precise estimates at the national level.

In summary, using a nationally representative sample of the low-income working-age population, we found statistically significant and clinically meaningful reductions in measured health outcomes in two out of four chronic conditions in the second and third year after the implementation of the ACA Medicaid expansions. Our findings should be reassuring for policymakers and add important evidence to the national debate over whether the Medicaid expansions improved health.

4-6. References

1. Hadley J. Insurance coverage, medical care use, and short-term health changes following an unintentional injury or the onset of a chronic condition. *JAMA.* 2007;297(10):1073-1084.
2. McMorrow S, Kenney GM, Goin D. Determinants of receipt of recommended preventive services: implications for the Affordable Care Act. *Am J Public Health.* 2014;104(12):2392-2399.
3. Wilper AP, Woolhandler S, Lasser KE, McCormick D, Bor DH, Himmelstein DU. Health insurance and mortality in US adults. *Am J Public Health.* 2009;99(12):2289-2295.
4. Medicine Io. *Care Without Coverage: Too Little, Too Late.* Washington, DC: The National Academies Press; 2002.
5. Simard EP, Fedewa S, Ma J, Siegel R, Jemal A. Widening socioeconomic disparities in cervical cancer mortality among women in 26 states, 1993-2007. *Cancer.* 2012;118(20):5110-5116.
6. The Henry J. Kaiser Family Foundation. Health Insurance Coverage in America, 2010. 2012; https://www.kff.org/uninsured/report/health-insurance-coverage-in-america-2010/. Accessed May 19, 2019.
7. The Henry J. Kaiser Family Foundation. The Uninsured: A Primer - Key Facts about Health Insurance and the Uninsured Under the Affordable Care Act. 2019; https://www.kff.org/uninsured/report/the-uninsured-a-primer-key-facts-about-health-insurance-and-the-uninsured-under-the-affordable-care-act/. Accessed May 19, 2019.
8. The Henry J. Kaiser Family Foundation. The Effects of Medicaid Expansion under the ACA: Updated Findings from a Literature Review. 2018; https://www.kff.org/medicaid/issue-brief/the-effects-of-medicaid-expansion-under-the-aca-updated-findings-from-a-literature-review-march-2018/. Accessed November 17, 2018.
9. National Center for Health Statistics. Health Insurance Coverage: Early Release of Estimates From the National Health Interview Survey, January – March 2017. 2017;

https://www.cdc.gov/nchs/data/nhis/earlyrelease/insur201708.pdf. Accessed November 7, 2018.

10. Kominski. GF, Nonzee. NJ, Sorensen. A. The Affordable Care Act's Impacts on Access to Insurance and Health Care for Low-Income Populations. *Annu Rev Public Health.* 2017;38:489-505.
11. Sommers BD, Gawande AA, Baicker K. Health Insurance Coverage and Health - What the Recent Evidence Tells Us. *N Engl J Med.* 2017;377(6):586-593.
12. Baicker K, Taubman SL, Allen HL, et al. The Oregon Experiment—Effects of Medicaid on Clinical Outcomes. *N Engl J Med.* 2013;368(18):1713-1722.
13. Miller S, Wherry LR. Health and Access to Care during the First 2 Years of the ACA Medicaid Expansions. *N Engl J Med.* 2017;376(10):947-956.
14. Sommers BD, Maylone B, Blendon RJ, Orav EJ, Epstein AM. Three-Year Impacts Of The Affordable Care Act: Improved Medical Care And Health Among Low-Income Adults. *Health Aff (Millwood).* 2017;36(6):1119-1128.
15. Winkelman TNA, Chang VW. Medicaid Expansion, Mental Health, and Access to Care among Childless Adults with and without Chronic Conditions. *J Gen Intern Med.* 2018;33(3):376-383.
16. Cole MB, Galarraga O, Wilson IB, Wright B, Trivedi AN. At Federally Funded Health Centers, Medicaid Expansion Was Associated With Improved Quality Of Care. *Health Aff (Millwood).* 2017;36(1):40-48.
17. Khatana SAM, Bhatla A, Nathan AS, et al. Association of Medicaid Expansion With Cardiovascular Mortality. *JAMA cardiology.* 2019.
18. Centers for Disease Control and Prevention. About the National Health and Nutrition Examination Survey. 2017; https://www.cdc.gov/nchs/nhanes/about_nhanes.htm. Accessed December 12, 2018.
19. Centers for Disease Control and Prevention. NHANES 2015-2016 Examination Data Overview. https://wwwn.cdc.gov/nchs/nhanes/continuousnhanes/overviewexam.aspx?BeginYear=2015.

20. Centers for Disease Control and Prevention. NHANES Response Rates and Population Totals. 2016; https://wwwn.cdc.gov/nchs/nhanes/ResponseRates.aspx. Accessed December 12, 2018.
21. United States Census Bureau. About the American Community Survey. 2018; https://www.census.gov/programs-surveys/acs/about.html. Accessed February 27, 2018.
22. Centers for Disease Control and Prevention. National Health and Nutrition Examination Survey 2015-2016 2017; https://wwwn.cdc.gov/nchs/nhanes/continuousnhanes/default.aspx?BeginYear=2015. Accessed July 3, 2019.
23. United States Census Bureau. When to Use 1-year, 3-year, or 5-year Estimates. 2016; https://www.census.gov/programs-surveys/acs/guidance/estimates.html. Accessed February 28, 2018.
24. Merkin SS, Basurto-Davila R, Karlamangla A, et al. Neighborhoods and cumulative biological risk profiles by race/ethnicity in a national sample of U.S. adults: NHANES III. *Ann Epidemiol.* 2009;19(3):194-201.
25. Nelson K, Schwartz G, Hernandez S, Simonetti J, Curtis I, Fihn SD. The Association Between Neighborhood Environment and Mortality: Results from a National Study of Veterans. *J Gen Intern Med.* 2017;32(4):416-422.
26. Office of the Assistant Secretary for Planning And Evaluation. Computations for the 2016 poverty guidelines. 2016; https://aspe.hhs.gov/computations-2016-poverty-guidelines. Accessed December 6, 2018.
27. The Henry J. Kaiser Family Foundation. Status of State Action on the Medicaid Expansion Decision. 2019; https://www.kff.org/health-reform/state-indicator/state-activity-around-expanding-medicaid-under-the-affordable-care-act/?currentTimeframe=0&sortModel=%7B%22colId%22:%22Location%22,%22sort%22:%22asc%22%7D. Accessed August 5, 2019.
28. Centers for Disease Control and Prevention. National Health and Nutrition Examination Survey: Sample Design, 2011–2014. 2014; https://www.cdc.gov/nchs/data/series/sr_02/sr02_162.pdf. Accessed December 23, 2018.
29. Centers for Disease Control and Prevention. National Health and Nutrition Examination Survey (NHANES) Physician Examination Procedures Manual. 2015;

https://www.cdc.gov/nchs/data/nhanes/nhanes_13_14/Phys_Exam_Manual_2013.pdf. Accessed December 13, 2018.

30. Chobanian AV, Bakris GL, Black HR, et al. The seventh report of the joint national committee on prevention, detection, evaluation, and treatment of high blood pressure: The JNC 7 report. *JAMA.* 2003;289(19):2560-2571.
31. Egan BM, Li J, Qanungo S, Wolfman TE. Blood Pressure and Cholesterol Control in Hypertensive Hypercholesterolemic Patients: NHANES 1988–2010. *Circulation.* 2013;128(1):29-41.
32. James PA, Oparil S, Carter BL, et al. 2014 evidence-based guideline for the management of high blood pressure in adults: Report from the panel members appointed to the eighth joint national committee (jnc 8). *JAMA.* 2014;311(5):507-520.
33. Egan BM, Li J, Hutchison FN, Ferdinand KC. Hypertension in the United States, 1999 to 2012: progress toward Healthy People 2020 goals. *Circulation.* 2014;130(19):1692-1699.
34. American Diabetes Association. Diagnosis and classification of diabetes mellitus. *Diabetes Care.* 2010;33 Suppl 1(Suppl 1):S62-S69.
35. Centers for Disease Control and Prevention. National Health and Nutrition Examination Survey 2013-2014 Data Documentation, Codebook, and Frequencies: Cholesterol - LDL & Triglycerides (TRIGLY_H). 2016; https://wwwn.cdc.gov/Nchs/Nhanes/2013-2014/TRIGLY_H.htm. Accessed December 14, 2018.
36. Expert Panel on Detection Evaluation and Treatment of High Blood Cholesterol in Adults. Executive Summary of The Third Report of The National Cholesterol Education Program (NCEP) Expert Panel on Detection, Evaluation, And Treatment of High Blood Cholesterol In Adults (Adult Treatment Panel III). *JAMA.* 2001;285(19):2486-2497.
37. Stone NJ, Robinson JG, Lichtenstein AH, et al. 2013 ACC/AHA Guideline on the Treatment of Blood Cholesterol to Reduce Atherosclerotic Cardiovascular Risk in Adults. *J Am Coll Cardiol.* 2014;63(25 Part B):2889.
38. Kroenke K, Spitzer RL, Williams JB. The PHQ-9: validity of a brief depression severity measure. *J Gen Intern Med.* 2001;16(9):606-613.
39. Wherry LR, Miller S. Early Coverage, Access, Utilization, and Health Effects Associated With the Affordable Care Act Medicaid Expansions: A Quasi-experimental Study. *Ann Intern Med.* 2016;164(12):795-803.

40. Bertrand M, Duflo E, Mullainathan S. How Much Should We Trust Differences-in-Differences Estimates? *The quarterly journal of economics.* 2004;119:249-275.
41. Simon K, Soni A, Cawley J. The Impact of Health Insurance on Preventive Care and Health Behaviors: Evidence from the First Two Years of the ACA Medicaid Expansions. *J Policy Anal Manage.* 2017;36(2):390-417.
42. Centers for Medicare & Medicaid Services. Coverage for lawfully present immigrants. 2018; https://www.healthcare.gov/immigrants/lawfully-present-immigrants/. Accessed November 7, 2018.
43. Turnbull F. Effects of different blood-pressure-lowering regimens on major cardiovascular events: results of prospectively-designed overviews of randomised trials. *Lancet.* 2003;362(9395):1527-1535.
44. Qaseem A, Wilt TJ, Kansagara D, et al. Hemoglobin A1c Targets for Glycemic Control With Pharmacologic Therapy for Nonpregnant Adults With Type 2 Diabetes Mellitus: A Guidance Statement Update From the American College of PhysiciansACP Guidance Statement on HbA1c Targets With Pharmacologic Therapy. *Ann Intern Med.* 2018;168(8):569-576.
45. Centers for Disease Control and Prevention. Prevalence of Depression Among Adults Aged 20 and Over: United States, 2013–2016. 2018; https://www.cdc.gov/nchs/products/databriefs/db303.htm. Accessed July 26, 2019.
46. Taubman SL, Allen HL, Wright BJ, Baicker K, Finkelstein AN. Medicaid increases emergency-department use: evidence from Oregon's Health Insurance Experiment. *Science.* 2014;343(6168):263-268.
47. Sun. R, Karaca. Z, Wong. HS. Trends in Hospital Emergency Department Visits by Age and Payer, 2006-2015. HCUP Statistical Brief #238. 2018; https://www.hcup-us.ahrq.gov/reports/statbriefs/sb238-Emergency-Department-Age-Payer-2006-2015.jsp. Accessed November 7, 2018.

4-7. **Tables and Figures**

Table 4-A. Definitions of expansion states and expansion periods

States (date of expansion)	Definitions of periods by NHANES survey cycle		
	Pre-expansion	Transition	Post-expansion
Non-expansion states (18 states)			
Alabama, Florida, Georgia, Idaho, Kansas, Maine, Mississippi, Missouri, Nebraska, North Carolina, Oklahoma, South Carolina, South Dakota, Tennessee, Texas, Utah, Virginia, Wyoming	2005/2006; 2007/2008; 2009/2010; 2011/2012	2013/2014	2015/2016
Expansion states (33 states)			
Arizona, Arkansas, California, Colorado, Connecticut, Delaware, District of Columbia, Hawaii, Illinois, Iowa, Kentucky, Maryland, Massachusetts, Minnesota, Nevada, New Jersey, New Mexico, New York, North Dakota, Ohio, Oregon, Rhode Island, Vermont, Washington, West Virginia, Wisconsin (All expanded on Jan 1, 2014)	2005/2006; 2007/2008; 2009/2010; 2011/2012	2013/2014	2015/2016
Michigan (April 1, 2014), New Hampshire (August 15, 2014)	2005/2006; 2007/2008; 2009/2010; 2011/2012; 2013/2014	2015/2016	N/A
Pennsylvania (January 1, 2015), Indiana (February 1, 2015), Alaska (September 1, 2015), Montana (January 1, 2016), Louisiana (July 1, 2016)	2005/2006; 2007/2008; 2009/2010; 2011/2012; 2013/2014	2015/2016	N/A

Note: Even though Wisconsin has not adopted the ACA Medicaid expansion, it was considered as an expansion state because it provided comprehensive insurance coverage to childless adults with family incomes below 100% of the federal poverty level through a non-Medicaid program since January 1, 2014.

Table 4-B. Baseline characteristics of participants by ACA Medicaid Expansion status [a]

Characteristics	Expansion States (n = 4,232)	Non-Expansion States (n = 1,869)	P-Value
Mean age (year)	37.1±13.3	37.1±13.5	0.99
Female sex (%)	54.4	53.9	0.74
Race (%)			0.25
White, non-Hispanic	51.1	40.2	
Hispanic	15.9	22.4	
Black, non-Hispanic	26.2	31.1	
Other	6.8	6.4	
Education (%)			0.39
Less than high school	35.3	35.8	
High school	26.9	25.6	
Some college	28.5	32.1	
College degree or more	9.3	6.4	
Mean family size	3.7±1.9	3.7 ±1.9	0.90
Neighborhood SES index [b]	-0.3±0.8	-0.4±0.7	0.94

Abbreviations: ACA, Patient Protection and Affordable Care Act; SES, socioeconomic status.
Notes: a. Presented values are weighted to be nationally representative of individuals 19 to 64 years of age with family incomes lower than 138% of the federal poverty level based on the pooled data of National Health and Nutrition Examination Survey 2005-2011. Plus-minus values are means ±SD.
b. Neighborhood socioeconomic status (SES) is a continuous variable in a Z-score based on American Community Survey 5-year summary files, and a larger number indicates a higher SES (see main text for more detail).

Table 4-C. Test of parallel trend assumption

Outcomes	Interaction Term Between Expansion State Indicator and Year Trend	
	Coefficient [95% CI]	P-Value
Hypertension-related outcomes		
Systolic BP among all participants (mmHg)	-0.197 [-1.076,+0.682]	0.65
Diastolic BP among all participants (mmHg)	+0.922 [+0.221,+1.624]	0.01
Current use of medication for hypertension (%)	+0.001 [-0.008,+0.010]	0.88
Prevalence of hypertension (%)	0 [-0.013,+0.014]	0.99
Diabetes-related outcomes		
Hemoglobin A1c (%)	-0.010 [-0.036,+0.016]	0.43
Hemoglobin A1c ≥ 6.5% (%)	-0.007 [-0.014,+0.001]	0.07
Current use of medication for diabetes (%)	-0.003 [-0.008,+0.003]	0.36
Prevalence of diabetes (%)	-0.008 [-0.016,+0.001]	0.07
Cholesterol-related outcomes		
LDL-cholesterol (mg/dL)	-1.128 [-2.780,+0.525]	0.17
Triglyceride (mg/dL)	+2.768 [-7.050,+12.585]	0.57
Total cholesterol (mg/dL)	+0.821 [-0.460,+2.103]	0.20
HDL-cholesterol (mg/dL)	-0.354 [-1.055,+0.348]	0.31
Current use of medication for high cholesterol (%)	+0.004 [-0.005,+0.013]	0.33
Prevalence of high LDL-cholesterol (%)	-0.009 [-0.028,+0.010]	0.33
Depression-related outcomes		
Positive depression screening	+0.013 [-0.001,+0.026]	0.08
Current use of medication for depression (%)	-0.001 [-0.010,+0.007]	0.73

Abbreviations: CI, confidence interval
Notes: We estimated regression models with an interaction term between the expansion state indicator variable and survey cycle variable (as continuous) for the data during the baseline period (2005-2012). See main text for more detail and Notes for Table 4D for other details.

Table 4-D. Change in health outcomes following ACA Medicaid expansions [a]

Outcomes	Baseline (2005-2012)		Post-Expansion [b] (2015-2016)	
	Mean in Expansion States	Mean in Non-Expansion States	DID Estimate [c] [95% CI]	P-Value
Hypertension-related outcomes				
Systolic blood pressure (mmHg)	118.06	119.53	-3.03 [-5.33 to -0.73]	0.01
Diastolic blood pressure (mmHg)	70.01	70.23	+1.05 [-2.44 to +4.53]	0.55
Current use of medication for hypertension (%) [d]	13.79	17.03	-0.26 [-4.81 to +4.30]	0.91
Prevalence of hypertension (%) [e]	22.39	24.69	-1.46 [-7.03 to +4.11]	0.60
Diabetes-related outcomes				
Hemoglobin A1c (%)	5.57	5.70	-0.14 [-0.24 to -0.03]	0.01
Hemoglobin A1c ≥ 6.5% (%)	7.15	9.71	-1.14 [-3.89 to +1.60]	0.40
Current use of medication for diabetes (%) [d]	5.60	7.40	+0.66 [-3.19 to +4.50]	0.73
Prevalence of diabetes (%) [e]	9.08	12.23	+0.35 [-3.89 to +4.60]	0.87
Hyperlipidemia-related outcomes				
LDL-cholesterol (mg/dL)	116.13	113.12	-6.82 [-16.75 to +3.11]	0.17
Triglyceride (mg/dL)	140.73	139.55	-4.66 [-31.64 to +22.32]	0.73
Total cholesterol (mg/dL)	194.28	192.75	-4.49 [-11.45 to +2.48]	0.20
HDL-cholesterol (mg/dL)	50.70	49.08	-1.05 [-4.18 to +2.09]	0.50
Current use of medication for high cholesterol (%) [d]	7.86	8.66	-1.83 [-6.47 to +2.81]	0.43
Prevalence of high LDL-cholesterol (%) [e]	28.39	26.87	-8.47 [-20.27 to +3.34]	0.15
Depression-related outcomes				
Positive depression screening result (%) [f]	15.54	16.82	-0.22 [-6.80 to +6.36]	0.95
Current use of medication for depression (%) [d]	10.75	9.89	-1.82 [-8.03 to +4.38]	0.56

Abbreviations: ACA, Patient Protection and Accountable Care Act; CI, confidence interval; DID, difference-in-differences; HDL, high-density lipoprotein; LDL, low-density lipoprotein.
Note: a. Presented values are weighted to be nationally representative of individuals 19-64 years old with family incomes below 138% of the federal poverty level (FPL) based on the 2005-2016 National Health and Nutrition Examination Survey.
b. Post-expansion period indicates years 2015 and 2016 for most states but not for all (see main text and **Table 4-A**).
c. DID estimates are differential changes between individuals in expansion states and those in non-expansion states comparing the pre-expansion and post-expansion periods. We used multivariable linear regression models controlled for age, sex, race/ethnicity, education, family size, neighborhood socioeconomic status as well as state- and year-specific fixed effects. Estimates are reported as percentage point changes for binary outcomes and hemoglobin A1c.
d. Current use of medication was ascertained by medication containers. See main text for detail.
e. For the definitions of prevalence for each condition, see main text.
f. A positive depression screening was defined by the 9-item Patient Health Questionnaire (PHQ-9) depression scale score of 10 or greater.

Table 4-E. Sensitivity analyses using alternative sample definitions (hypertension and diabetes-related outcomes)

Alternate Sample Definition	DID Estimate 95% CI]	P-Value
Systolic blood pressure (mmHg)		
(i) Excluding 5 states with prior significant coverage	-2.41 [-4.56,-0.25]	0.03
(ii) Excluding 7 states that expanded Medicaid after 1/1/2014	-2.57 [-4.74,-0.40]	0.02
(iii) Excluding non-U.S. citizens	-3.00 [-5.40,-0.60]	0.02
(iv) Excluding 19-25 years old	-3.55 [-6.09,-1.01]	0.007
(v) Excluding observations with missing income to poverty ratio	-3.11 [-5.28,-0.95]	0.006
(vi) Analyzing >400% FPL (falsification test)	-1.54 [-3.72,+0.64]	0.16
Diastolic blood pressure (mmHg)		
(i) Excluding 5 states with prior significant coverage	+1.73 [-1.85,+5.32]	0.33
(ii) Excluding 7 states that expanded Medicaid after 1/1/2014	+1.07 [-2.69,+4.83]	0.57
(iii) Excluding non-U.S. citizens	+1.27 [-2.01,+4.55]	0.44
(iv) Excluding 19-25 years old	+1.29 [-2.40,+4.97]	0.48
(v) Excluding observations with missing income to poverty ratio	+0.94 [-2.61,+4.50]	0.59
(vi) Analyzing >400% FPL (falsification test)	+1.50 [-0.94,+3.94]	0.22
Current use of medication for hypertension (%)		
(i) Excluding 5 states with prior significant coverage	-0.51 [-5.15,+4.12]	0.82
(ii) Excluding 7 states that expanded Medicaid after 1/1/2014	-0.35 [-4.42,+3.71]	0.86
(iii) Excluding non-U.S. citizens	+0.23 [-5.04,+5.51]	0.93
(iv) Excluding 19-25 years old	+0.38 [-6.02,+6.79]	0.90
(v) Excluding observations with missing income to poverty ratio	-0.87 [-5.30,+3.55]	0.69
(vi) Analyzing >400% FPL (falsification test)	+2.29 [-4.59,+9.16]	0.50
Prevalence of hypertension (%)		
(i) Excluding 5 states with prior significant coverage	-1.31 [-6.91,+4.30]	0.64
(ii) Excluding 7 states that expanded Medicaid after 1/1/2014	-1.29 [-6.90,+4.33]	0.64
(iii) Excluding non-U.S. citizens	-0.87 [-7.30,+5.56]	0.79
(iv) Excluding 19-25 years old	-1.34 [-8.96,+6.28]	0.72
(v) Excluding observations with missing income to poverty ratio	-2.58 [-8.34,+3.18]	0.37
(vi) Analyzing >400% FPL (falsification test)	-3.57 [-11.58,+4.45]	0.37
Hemoglobin A1c (%)		
(i) Excluding 5 states with prior significant coverage	-0.16 [-0.27,-0.06]	0.004
(ii) Excluding 7 states that expanded Medicaid after 1/1/2014	-0.14 [-0.25,-0.03]	0.01
(iii) Excluding non-U.S. citizens	-0.17 [-0.37,+0.02]	0.07
(iv) Excluding 19-25 years old	-0.18 [-0.31,-0.05]	0.009
(v) Excluding observations with missing income to poverty ratio	-0.15 [-0.26,-0.04]	0.008
(vi) Analyzing >400% FPL (falsification test)	+0.01 [-0.14,+0.17]	0.89
Hemoglobin A1c ≥ 6.5% (%)		
(i) Excluding 5 states with prior significant coverage	-0.78 [-3.47,+1.90]	0.56
(ii) Excluding 7 states that expanded Medicaid after 1/1/2014	-1.31 [-4.06,+1.45]	0.34
(iii) Excluding non-U.S. citizens	-2.84 [-6.10,+0.42]	0.09
(iv) Excluding 19-25 years old	-1.32 [-4.58,+1.94]	0.42
(v) Excluding observations with missing income to poverty ratio	-1.63 [-4.34,+1.07]	0.23
(vi) Analyzing >400% FPL (falsification test)	+0.73 [-4.76,+6.23]	0.79
Current use of medication for diabetes (%)		
(i) Excluding 5 states with prior significant coverage	+0.56 [-3.63,+4.74]	0.79
(ii) Excluding 7 states that expanded Medicaid after 1/1/2014	+0.60 [-3.29,+4.49]	0.76

(iii) Excluding non-U.S. citizens	+0.89	[-2.99,+4.77]	0.64
(iv) Excluding 19-25 years old	+1.08	[-3.92,+6.09]	0.66
(v) Excluding observations with missing income to poverty ratio	+0.27	[-3.61,+4.14]	0.89
(vi) Analyzing >400% FPL (falsification test)	+0.19	[-3.26,+3.64]	0.91
Prevalence of diabetes (%)			
(i) Excluding 5 states with prior significant coverage	+1.09	[-3.14,+5.32]	0.61
(ii) Excluding 7 states that expanded Medicaid after 1/1/2014	+0.57	[-3.73,+4.87]	0.79
(iii) Excluding non-U.S. citizens	-0.81	[-4.98,+3.36]	0.70
(iv) Excluding 19-25 years old	+0.48	[-4.69,+5.65]	0.85
(v) Excluding observations with missing income to poverty ratio	-0.30	[-4.48,+3.88]	0.89
(vi) Analyzing >400% FPL (falsification test)	+0.24	[-4.95,+5.43]	0.93

Abbreviations: CI, confidence interval; DID, difference-in-differences; FPL, federal poverty level.
Notes: See main text for more details about alternative sample definitions and Notes for Table 4D for other details.

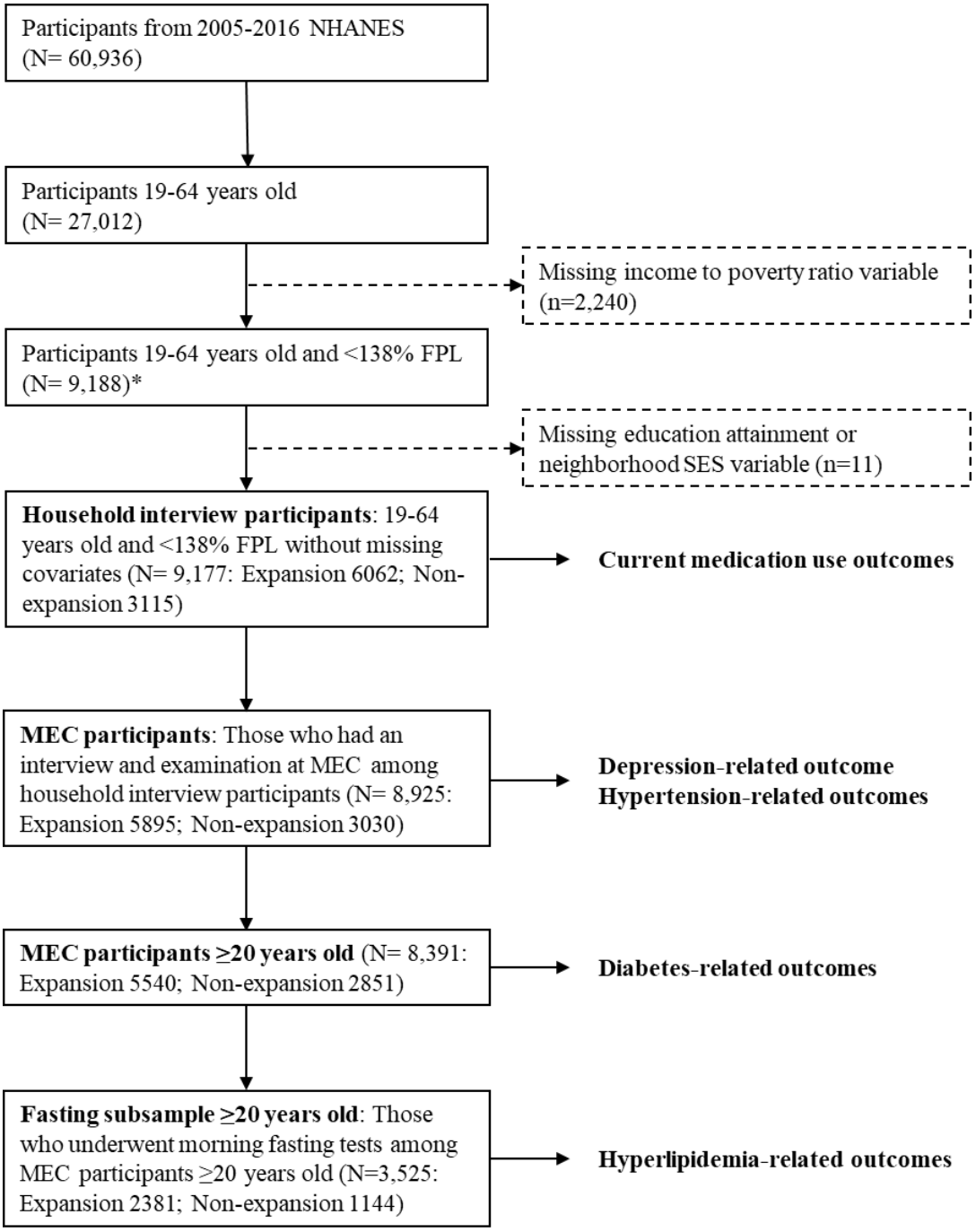
Table 4-F. Sensitivity analyses using alternative sample definitions (hyperlipidemia and depression-related outcomes)

Alternate Sample Definition	DID Estimate [95% CI]	P-Value
LDL-cholesterol (mg/dL)		
(i) Excluding 5 states with prior significant coverage	-3.90 [-12.81,+5.00]	0.38
(ii) Excluding 7 states that expanded Medicaid after 1/1/2014	-7.43 [-18.04,+3.18]	0.16
(iii) Excluding non-U.S. citizens	-6.11 [-17.39,+5.17]	0.28
(iv) Excluding 19-25 years old	-5.56 [-17.66,+6.54]	0.36
(v) Excluding observations with missing income to poverty ratio	-7.79 [-17.12,+1.54]	0.10
(vi) Analyzing >400% FPL (falsification test)	+2.55 [-3.67,+8.76]	0.41
Triglyceride (mg/dL)		
(i) Excluding 5 states with prior significant coverage	-2.11 [-31.61,+27.39]	0.89
(ii) Excluding 7 states that expanded Medicaid after 1/1/2014	-4.14 [-31.31,+23.04]	0.76
(iii) Excluding non-U.S. citizens	-25.36 [-55.87,+5.15]	0.10
(iv) Excluding 19-25 years old	-5.91 [-44.98,+33.16]	0.76
(v) Excluding observations with missing income to poverty ratio	-5.06 [-31.55,+21.44]	0.70
(vi) Analyzing >400% FPL (falsification test)	-2.35 [-32.66,+27.97]	0.88
Total cholesterol (mg/dL)		
(i) Excluding 5 states with prior significant coverage	-2.01 [-8.07,+4.04]	0.50
(ii) Excluding 7 states that expanded Medicaid after 1/1/2014	-3.87 [-10.67,+2.93]	0.26
(iii) Excluding non-U.S. citizens	-5.63 [-12.41,+1.16]	0.10
(iv) Excluding 19-25 years old	-4.16 [-11.96,+3.63]	0.29
(v) Excluding observations with missing income to poverty ratio	-4.49 [-11.57,+2.59]	0.21
(vi) Analyzing >400% FPL (falsification test)	-3.91 [-11.46,+3.63]	0.30
HDL-cholesterol (mg/dL)		
(i) Excluding 5 states with prior significant coverage	-1.22 [-4.55,+2.11]	0.46
(ii) Excluding 7 states that expanded Medicaid after 1/1/2014	-0.67 [-3.66,+2.33]	0.65
(iii) Excluding non-U.S. citizens	-1.19 [-5.00,+2.62]	0.53
(iv) Excluding 19-25 years old	-0.89 [-3.60,+1.81]	0.51
(v) Excluding observations with missing income to poverty ratio	-1.21 [-4.17,+1.75]	0.41
(vi) Analyzing >400% FPL (falsification test)	-2.72 [-5.88,+0.44]	0.09
Current use of medication for hyperlipidemia (%)		
(i) Excluding 5 states with prior significant coverage	-3.81 [-8.13,+0.52]	0.08
(ii) Excluding 7 states that expanded Medicaid after 1/1/2014	-1.36 [-5.99,+3.27]	0.55
(iii) Excluding non-U.S. citizens	-0.80 [-6.39,+4.80]	0.77
(iv) Excluding 19-25 years old	-1.58 [-7.57,+4.41]	0.60
(v) Excluding observations with missing income to poverty ratio	-1.93 [-6.50,+2.64]	0.40
(vi) Analyzing >400% FPL (falsification test)	+1.85 [-5.59,+9.29]	0.62
Prevalence of high LDL-cholesterol (%)		
(i) Excluding 5 states with prior significant coverage	-10.69 [-23.76,+2.37]	0.11
(ii) Excluding 7 states that expanded Medicaid after 1/1/2014	-9.26 [-21.24,+2.71]	0.13
(iii) Excluding non-U.S. citizens	-9.07 [-21.79,+3.65]	0.16
(iv) Excluding 19-25 years old	-11.85 [-26.75,+3.05]	0.12
(v) Excluding observations with missing income to poverty ratio	-9.68 [-21.27,+1.91]	0.10
(vi) Analyzing >400% FPL (falsification test)	-1.25 [-9.84,+7.34]	0.77
Positive depression screening		
(i) Excluding 5 states with prior significant coverage	-2.58 [-9.66,+4.49]	0.46
(ii) Excluding 7 states that expanded Medicaid after 1/1/2014	-2.22 [-9.26,+4.81]	0.52

(iii) Excluding non-U.S. citizens	-2.44	[-11.05,+6.18]	0.57
(iv) Excluding 19-25 years old	-2.15	[-11.04,+6.73]	0.63
(v) Excluding observations with missing income to poverty ratio	-2.75	[-9.59,+4.08]	0.42
(vi) Analyzing >400% FPL (falsification test)	+2.19	[-6.14,+10.53]	0.60
Current use of medication for depression (%)			
(i) Excluding 5 states with prior significant coverage	-2.58	[-9.66,+4.49]	0.46
(ii) Excluding 7 states that expanded Medicaid after 1/1/2014	-2.22	[-9.26,+4.81]	0.52
(iii) Excluding non-U.S. citizens	-2.44	[-11.05,+6.18]	0.57
(iv) Excluding 19-25 years old	-2.15	[-11.04,+6.73]	0.63
(v) Excluding observations with missing income to poverty ratio	-2.75	[-9.59,+4.08]	0.42
(vi) Analyzing >400% FPL (falsification test)	+2.19	[-6.14,+10.53]	0.60

Abbreviations: CI, confidence interval; DID, difference-in-differences; FPL, federal poverty level; HDL, high-density lipoprotein; LDL, low-density lipoprotein.
Notes: See main text for more details about alternative sample definitions and Notes for Table 4D for other details.

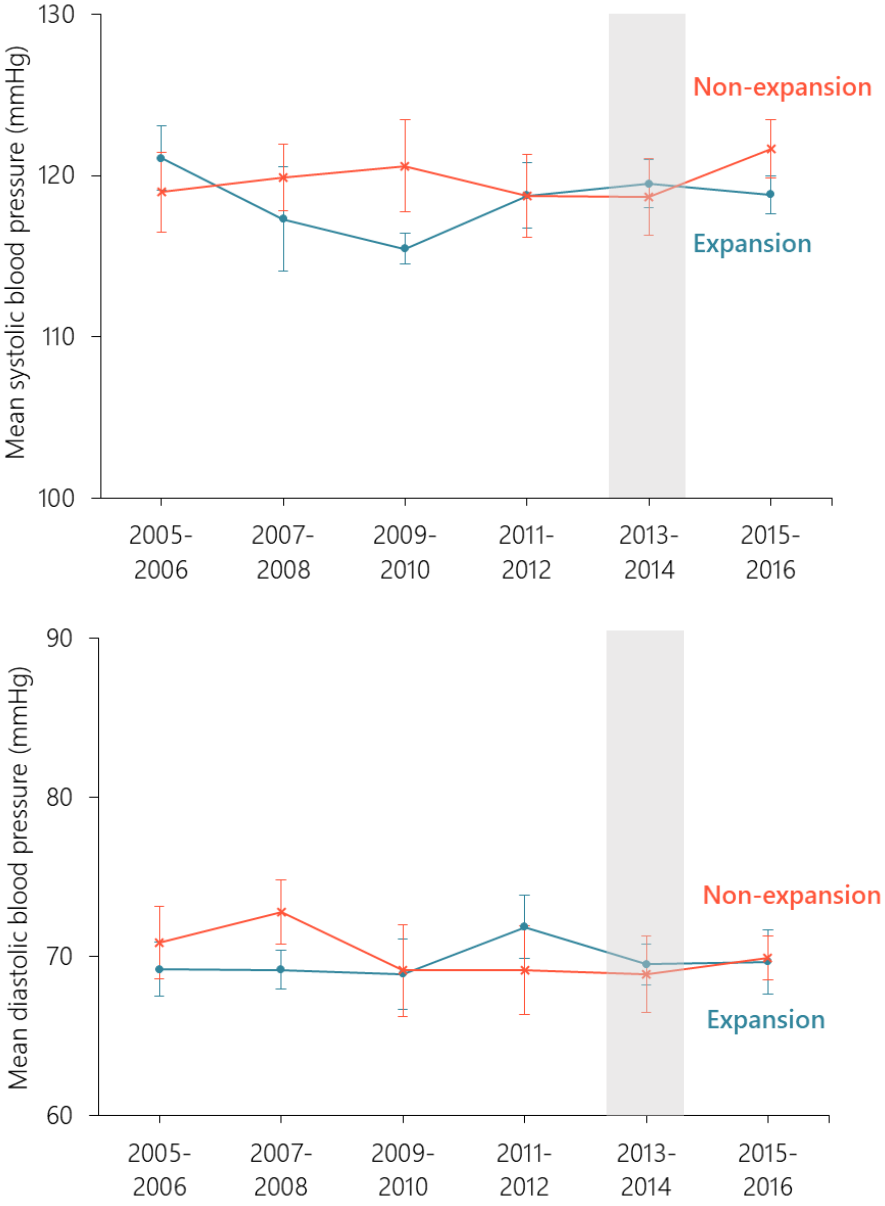
Figure 4-A. Flowchart of the study population



Abbreviations: FPL, federal poverty level; MEC, mobile examination center; NHANES, National Health and Nutrition Examination Survey

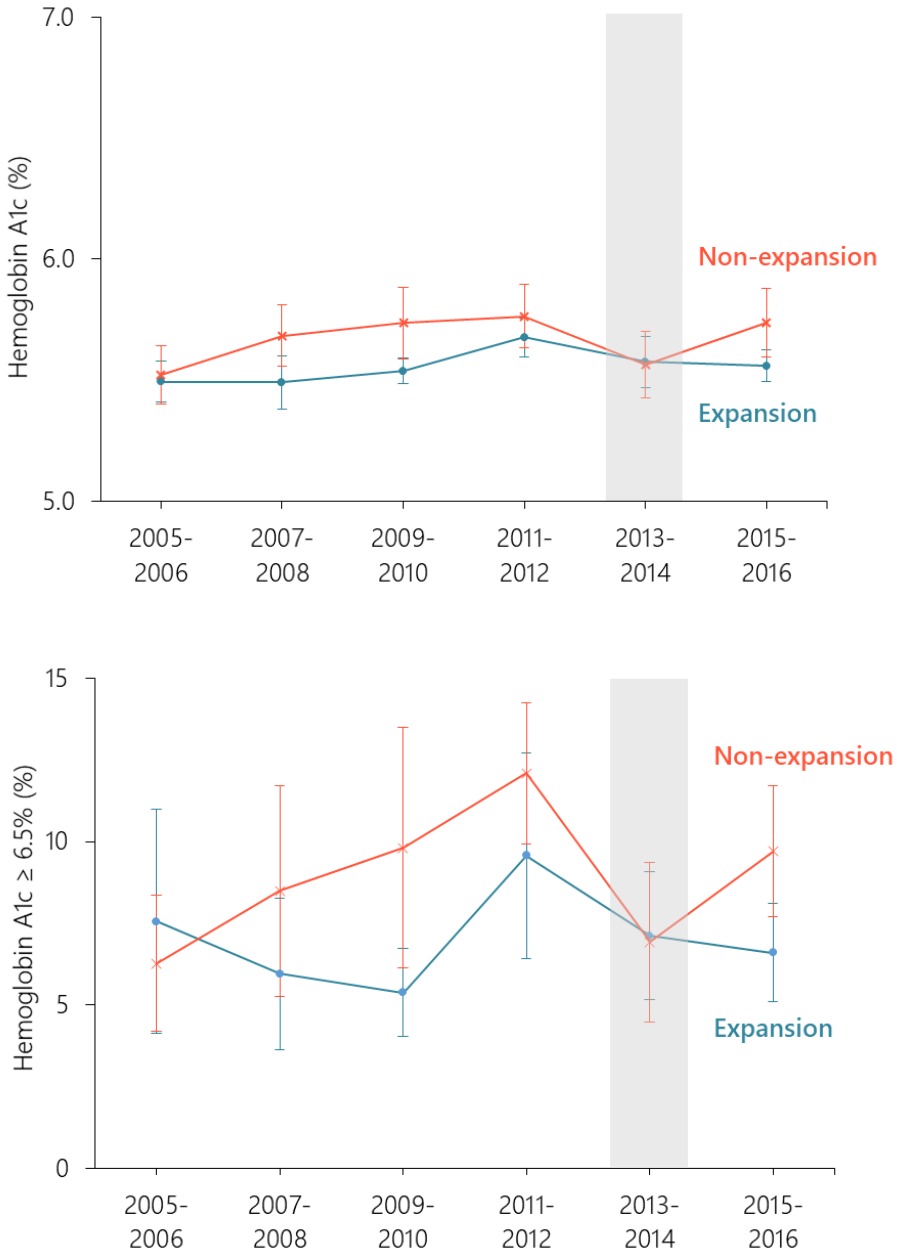
*Includes those with a missing value in income to poverty ratio variable but family income variable coded as < $20,000 (n= 263). See main text for more detail.

Figure 4-B. Unadjusted yearly trend of blood pressures by ACA Medicaid expansion status



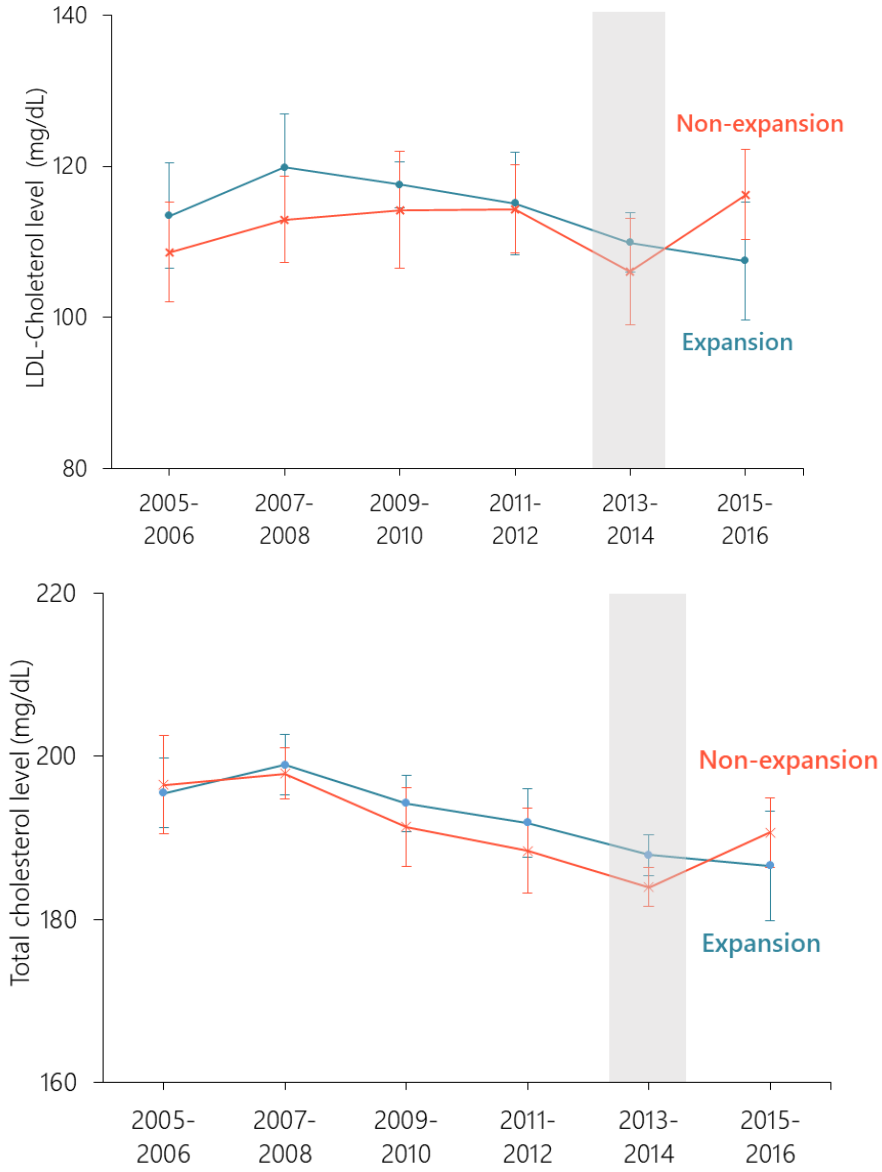
Data shown are weighted means of systolic and diastolic blood pressures among individuals 19-64 years old with family incomes below 138% of the federal poverty level (FPL) in states that expanded Medicaid on January 1, 2014 and non-expansion states based on the 2005-2016 National Health and Nutrition Examination Survey. Gray bars indicate the implementation of the ACA Medicaid expansion on January 1, 2014. I bars indicate 95% confidence interval. Note the differences in scales on y-axes. Abbreviations: ACA, Patient Protection and Accountable Care Act.

Figure 4-C. Unadjusted yearly trend of hemoglobin A1c by ACA Medicaid expansion status



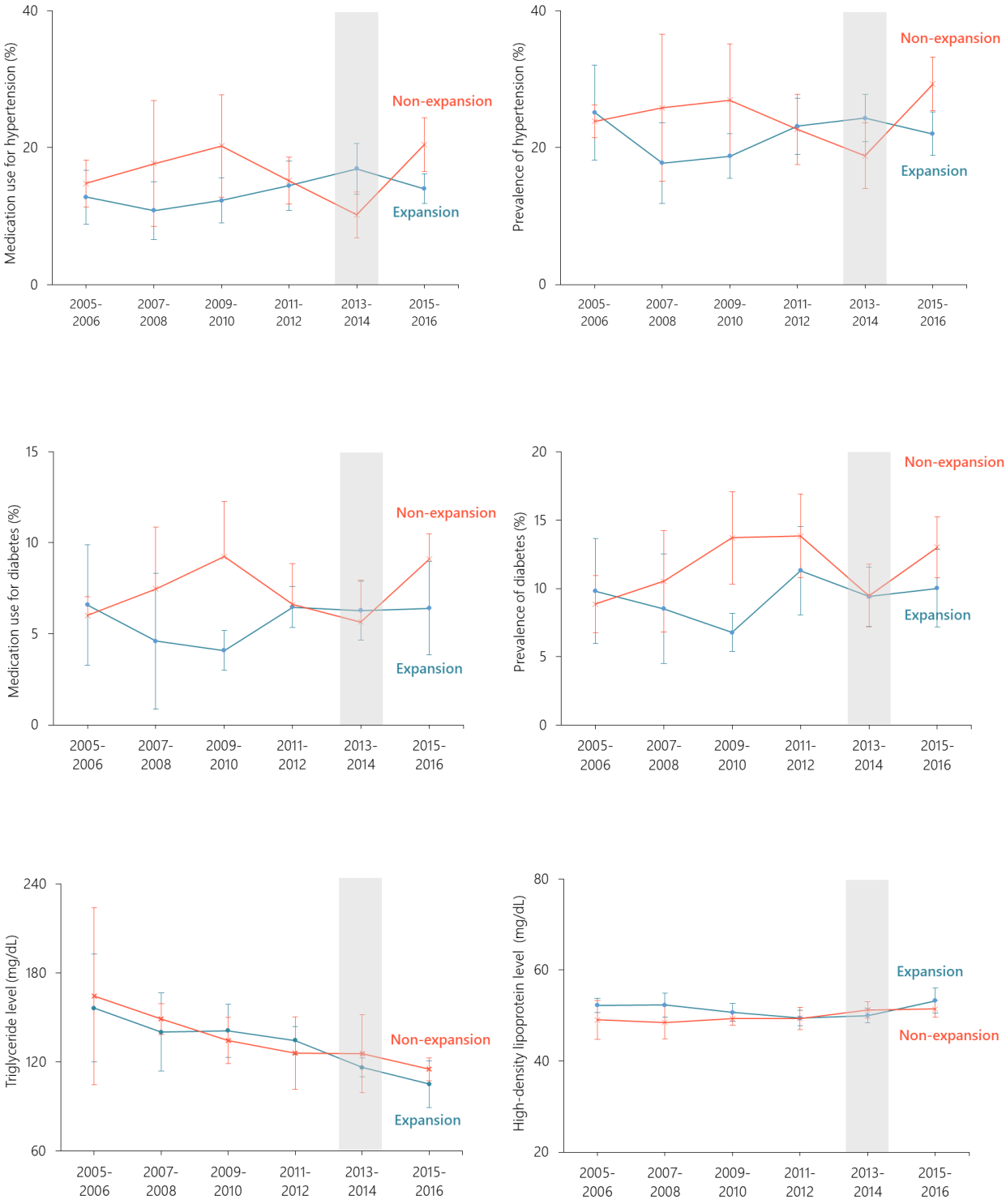
Data shown are weighted means of hemoglobin A1c and proportions of those with hemoglobin A1c ≥ 6.5% among individuals 19-64 years old with family incomes below 138% of the federal poverty level (FPL) in states that expanded Medicaid on January 1, 2014 and non-expansion states based on the 2005-2016 National Health and Nutrition Examination Survey. Gray bars indicate the implementation of the ACA Medicaid expansion on January 1, 2014. I bars indicate 95% confidence interval. Note the differences in scales on y-axes. Abbreviations: ACA, Patient Protection and Accountable Care Act.

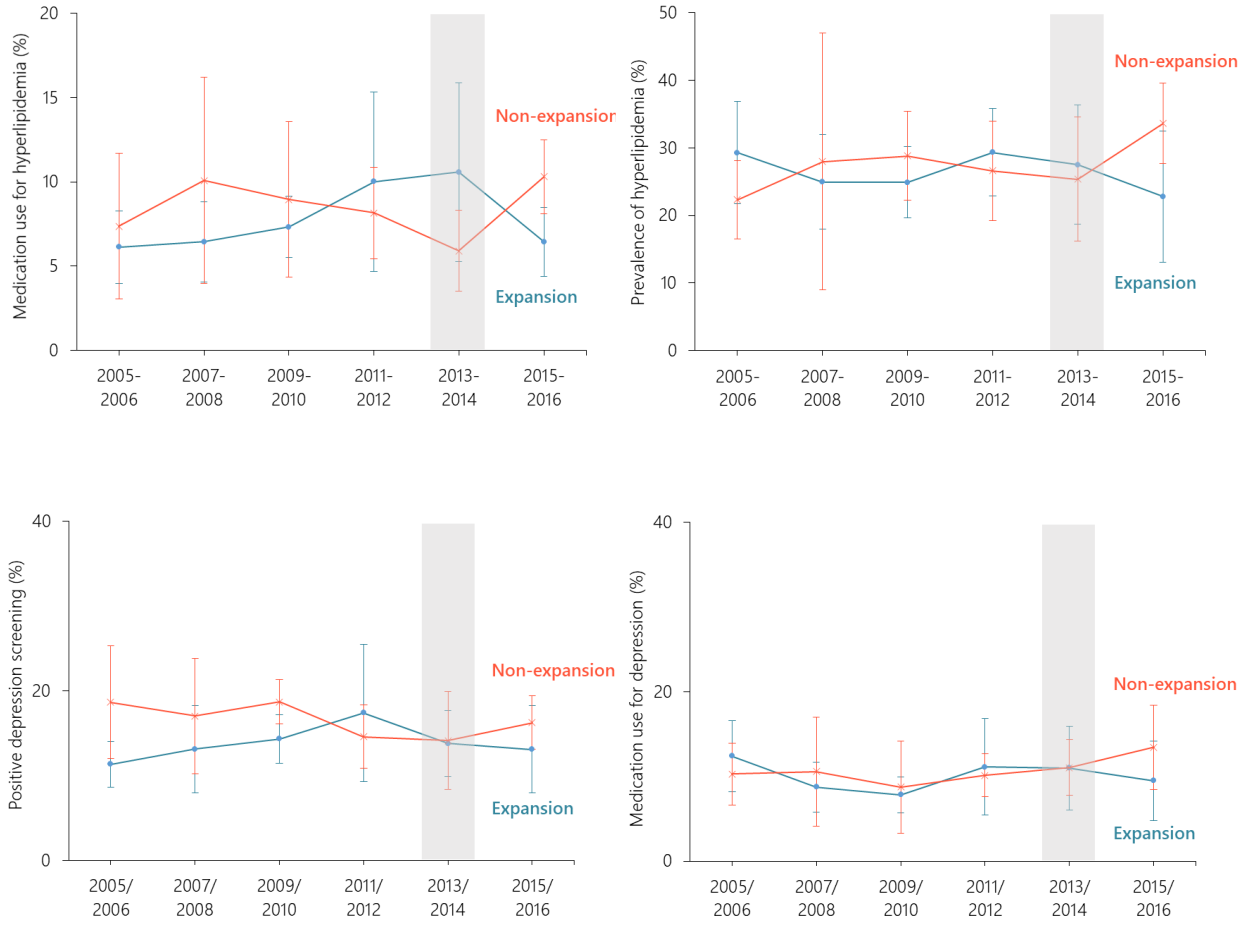
Figure 4-D. Unadjusted yearly trend of cholesterol levels by ACA Medicaid expansion status



Data shown are weighted means of LDL-Cholesterol and total cholesterol levels among individuals 19-64 years old with family incomes below 138% of the federal poverty level (FPL) in states that expanded Medicaid on January 1, 2014 and non-expansion states based on the 2005-2016 National Health and Nutrition Examination Survey. Gray bars indicate the implementation of the ACA Medicaid expansion on January 1, 2014. I bars indicate 95% confidence interval. Note the differences in scales on y-axes. Abbreviations: ACA, Patient Protection and Accountable Care Act; LDL, low-density lipoprotein.

Figure 4-E. Unadjusted yearly trend of other outcomes by ACA Medicaid expansion status





Data shown are weighted means of various outcomes among individuals 19-64 years old with family incomes below 138% of the federal poverty level (FPL) in states that expanded Medicaid on January 1, 2014 and non-expansion states based on the 2005-2016 National Health and Nutrition Examination Survey. Gray bars indicate the implementation of the ACA Medicaid expansion on January 1, 2014. I bars indicate 95% confidence interval. Note the differences in scales on y-axes. Abbreviations: ACA, Patient Protection and Accountable Care Act.

Chapter 5. Conclusions

5-1. Summary of Key Findings

The Medicaid expansions under the ACA aimed to improve access to health insurance coverage among low-income uninsured people in the U.S. Evidence to date suggests that the percentage of the uninsured has been significantly reduced nationally. This dissertation evaluated the further impact of the ACA Medicaid expansions using a nationally representative sample of the low-income working-age population in the U.S. with a robust quasi-experimental study design.

Paper #1 (Chapter 2) examined the effects of the ACA Medicaid expansions on financial protection against medical expense using MEPS data. It found that the ACA Medicaid expansions were associated with significant reductions in household OOP spending, OOP plus premium spending, and the probability of catastrophic health spending in the third year of the program implementation. Paper #2 (Chapter 3) evaluated the impact on healthcare utilization also with MEPS data and showed that the ACA Medicaid expansions were associated with a modest increase in the likelihood of having a PCP visit during a year but unchanged ED utilization during the three years of the program implementation. Paper #3 (Chapter 4) used NHANES data and found that the ACA Medicaid expansions were associated with improved clinical measures for hypertension and diabetes but unchanged outcomes for hyperlipidemia and depression in the second and third years after the program implementation.

5-2. Implications for Policy

The findings of the dissertation suggest that the ACA Medicaid expansions have been successful in removing financial barriers, promoting access to primary care (without a meaningful increase in ED utilization), and improving health among low-income uninsured Americans. It has important implications for state decisions on adopting the ACA Medicaid expansions and for the ongoing national debate over the repeal of the ACA, including the Medicaid expansions.

As of August 2019, 37 states (including D.C.) have adopted the Medicaid expansion, including three conservative states that voted to expand in the mid-term elections on November 6, 2018, and millions of people have gained insurance coverage since the program implementation.[1] However, due to 14 states' decisions not to expand Medicaid, more than two million low-income uninsured adults are left in the coverage gap of having incomes above the eligibility limits for the state Medicaid programs but below the lower limit for Health Insurance Marketplace Advanced Premium Tax Credits.[2] A growing literature—including this dissertation—suggesting positive impacts of the ACA Medicaid expansions provides support for those governors, legislators, and voters who are attempting to expand Medicaid coverage among low-income uninsured adults under the ACA or through other mechanisms. For example, the state of Georgia, one of 14 non-expansion states, is actively considering expanding Medicaid coverage under the leadership of the new governor, and the findings of this dissertation would be of significant interest for the stakeholders.[3,4]

At the national level, Republicans have repeatedly attempted to repeal the ACA since it was signed into law in 2010, while state and federal Democrats have been defending the ACA.[5] As of

this writing, the constitutionality of the ACA is being challenged in the courts by 18 states' attorneys general given the elimination of the individual shared responsibility requirement (also known as the individual mandate), and this case could prompt an appeal to the U.S. Supreme Court.[5,6] It is estimated that nearly 30 million people, including more than 10 million people with Medicaid or Children's Health Insurance Program, would lose their health insurance if the ACA were repealed.[7] Given the findings of this dissertation along with other studies documenting positive impacts of the ACA, the repeal of the ACA would highly likely cause negative financial and health outcomes to those who are expected to lose their health insurance.[8]

In addition, the 2020 presidential election will undoubtedly have significant consequences for the future of U.S. health care policy. The major Democratic presidential contenders have been advocating to expand healthcare coverage for more Americans such as through Medicare-for-All plan.[9] This dissertation has implications in terms of the positive effects of providing health insurance coverage for the uninsured.

5-3. Future research directions

Future research should continue to address knowledge gaps about the impact of the ACA Medicaid expansions in a variety of ways.

First, the mechanism of improved clinical outcomes in hypertension and diabetes indicated in Paper #3 needs to be investigated. As Paper #3 found no evidence of increased medication use for these conditions, it can be hypothesized that having a healthier lifestyle (e.g., balanced diet and regular exercise) recommended by a PCP led to better health outcomes. Examining the

effects of the ACA Medicaid expansions on lifestyle outcomes such as diet, weight, and exercise would have significant implications.

Second, it would be important to disentangle why we observed significant improvement in outcomes for hypertension and diabetes but not in hyperlipidemia and depression in Paper #3. It is possible that the study did not have adequate power to detect small but clinically relevant changes—particularly because the analysis of LDL-C used a fasting subsample and showed a statistically insignificant yet relatively large DID estimate indicating an improvement. Further studies with a larger sample size would be necessary to determine if the ACA has improved these outcomes.

Third, racial and ethnic disparities in health outcomes following the ACA Medicaid expansions should be evaluated. While previous evidence suggests that the ACA Medicaid expansions helped to reduce racial and ethnic disparities in measures of insurance coverage, access to care, and affordability of care,[10] it is unknown whether the program reduced disparities in health outcomes. Non-Hispanic black persons have a significantly higher prevalence of hypertension, and non-Hispanic black and Mexican-American persons have a significantly higher prevalence of diabetes, compared to non-Hispanic white persons.[11] Therefore, it would be imperative to understand how the ACA Medicaid expansion affected the disparities in clinical outcomes to consider additional interventions.

Fourth, evaluating longer-term clinical effects of the ACA Medicaid expansions would have critical policy implications. Recent studies suggest that the ACA Medicaid expansions were

associated with reduced county-level all-cause mortality and cardiovascular mortality.[12,13] Future studies should confirm these effects using different data sources and investigate the mechanism of reduced mortality, such as by examining the effects of program implementation on major cardiovascular event rates.

Lastly, studies of healthcare expenditures are warranted to determine the cost-effectiveness of the ACA Medicaid expansions. The improvement in financial protection observed in Paper #1 was realized through cost-shifting from patients to the federal government, which covers nearly 100% of the costs of newly eligible enrollees during the period studied.[14] Similarly, at the state level, it has been reported that the ACA Medicaid expansions brought savings by moving adults who had been in existing state-funded health programs into expanded coverage, which has a higher federal matching rate.[14] As expected, total Medicaid spending showed high growth rates nationally following initial program implementation in 2014 and 2015, although this growth rate slowed in 2016.[10] Because providing insurance coverage to the uninsured could improve health status as suggested in Paper #3 and potentially contain healthcare expenditure through prevention, early detection, and treatment of diseases at the same time, it would be meaningful to evaluate the cost-effectiveness of the program in the long run.

5-4. References

1. The Henry J. Kaiser Family Foundation. Status of State Action on the Medicaid Expansion Decision. 2019; https://www.kff.org/health-reform/state-indicator/state-activity-around-expanding-medicaid-under-the-affordable-care-act/?currentTimeframe=0&sortModel=%7B%22colId%22:%22Location%22,%22sort%22:%22asc%22%7D. Accessed August 5, 2019.
2. The Henry J. Kaiser Family Foundation. The Coverage Gap: Uninsured Poor Adults in States that Do Not Expand Medicaid. 2019; https://www.kff.org/medicaid/issue-brief/the-coverage-gap-uninsured-poor-adults-in-states-that-do-not-expand-medicaid/. Accessed August 5, 2019.
3. Georgia Health News. Deloitte briefs state advisory group on health care waiver effort. 2019; https://www.georgiahealthnews.com/2019/07/deloitte-briefs-state-advisory-group-waiver-effort/. Accessed August 5, 2019.
4. Advisory Board. Where the states stand on Medicaid expansion. 2019; https://www.advisory.com/daily-briefing/resources/primers/medicaidmap. Accessed August 5, 2019.
5. Rovner J. The Affordable Care Act Is Back In Court: 5 Facts You Need To Know. 2019; https://www.npr.org/sections/health-shots/2019/07/09/739653482/the-affordable-care-act-is-back-in-court-5-facts-you-need-to-know. Accessed August 6, 2019.
6. Raymond N. U.S. appeals court signals sympathy to bid to strike down Obamacare. 2019; https://www.reuters.com/article/us-usa-court-obamacare/u-s-appeals-court-signals-sympathy-to-bid-to-strike-down-obamacare-idUSKCN1U40ZU. Accessed August 5, 2019.
7. Blumberg LJ, Buettgens M, Holahan J. Implications of Partial Repeal of the ACA through Reconciliation. 2016; https://www.urban.org/research/publication/implications-partial-repeal-aca-through-reconciliation. Accessed August 7, 2019.
8. Sommers BD, Gawande AA, Baicker K. Health Insurance Coverage and Health - What the Recent Evidence Tells Us. *N Engl J Med.* 2017;377(6):586-593.

9. Uhrmacher K, Schaul K, Firozi P, Stein J. Where 2020 Democrats stand on Medicare-for-all. 2019; https://www.washingtonpost.com/graphics/politics/policy-2020/medicare-for-all/. Accessed August 6, 2019.
10. The Henry J. Kaiser Family Foundation. The Effects of Medicaid Expansion under the ACA: Updated Findings from a Literature Review. 2018; https://www.kff.org/medicaid/issue-brief/the-effects-of-medicaid-expansion-under-the-aca-updated-findings-from-a-literature-review-march-2018/. Accessed November 17, 2018.
11. Fryar CD, Hirsch R, Eberhardt MS, Yoon SS, Wright JD. Hypertension, high serum total cholesterol, and diabetes: Racial and ethnic prevalence differences in U.S. adults, 1999–2006 (NCHS data brief, no 36). 2010; https://www.cdc.gov/nchs/data/databriefs/db36.pdf. Accessed August 7, 2019.
12. Khatana SAM, Bhatla A, Nathan AS, et al. Association of Medicaid Expansion With Cardiovascular Mortality. *JAMA cardiology.* 2019.
13. Miller S, Altekruse S, Johnson N, Wherry LR. Medicaid and Mortality: New Evidence from Linked Survey and Administrative Data. *National Bureau of Economic Research Working Paper Series.* 2019;No. 26081.
14. Hayes SL, Coleman A, Collins SR, Nuzum R. The Fiscal Case for Medicaid Expansion. 2019; https://www.commonwealthfund.org/blog/2019/fiscal-case-medicaid-expansion. Accessed August 8, 2019.