The Role of Public Programs for Early Cancer Detection and Access to Care Among Cancer Survivors

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Youngmin Kwon

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This dissertation was presented

by

Youngmin Kwon

It was defended on

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and approved by

Eric T. Roberts, PhD, Associate Professor, Department of General Internal Medicine, Perelman School of Medicine at the University of Pennsylvania

Evan S. Cole, PhD, Research Associate Professor, Department of Health Policy & Management, University of Pittsburgh School of Public Health

Howard B. Degenholtz, PhD, Professor, Department of Health Policy & Management, University of Pittsburgh School of Public Health

Bruce L. Jacobs, MD, MPH, Assistant Professor, Department of Urology, University of Pittsburgh School of Medicine

Dissertation Director: Lindsay M. Sabik PhD, Associate Professor and Vice Chair for Research, Department of Health Policy & Management, University of Pittsburgh School of Public Health

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Youngmin Kwon, PhD

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Medicare and Medicaid play a critical role in providing health insurance coverage to the large population of patients who are diagnosed with cancer. Medicare is the largest payer of health services for cancer patients and survivors, most of whom are aged 65 or older. Medicaid is a growing source of coverage for younger adults with low income or disabilities, who historically have faced adverse cancer outcomes. Considering the rising incidence and burden of cancer, rigorous policy analysis to inform effective cancer prevention and control in Medicare and Medicaid is crucial.

This dissertation investigates elements of the Medicare and Medicaid programs in the context of cancer prevention and control. In Aim 1, I examine eligibility for Medicare at age 65 and its implications for older cancer survivors' access to and ability to afford care. Using a regression discontinuity design, I find that Medicare eligibility is associated with significant reductions in, but not elimination of, cost-related barriers to care. Aim 2 assesses the impact of Medicaid managed care on early cancer detection. I exploit the expansion of mandatory managed care in Pennsylvania Medicaid as a natural experiment and find that this expansion was associated with improvements in early detection. In Aim 3, I evaluate disparities in cancer screening associated with experiences of homelessness and housing insecurity, an increasing focus of Medicaid programs seeking to address nonmedical determinants of health. Using a novel linkage of Pennsylvania's administrative Medicaid and housing services records, I find that women adult

Medicaid beneficiaries experiencing or at risk of homelessness are significantly less likely to receive guideline-recommended mammograms.

These results point to several avenues for reforming Medicare and Medicaid for effective cancer prevention and control. Aim 1 findings suggest that expanding eligibility and cost protection within Medicare can lessen the financial burden of care among older cancer survivors. Aim 2 illustrates the potential for managed care to address the high incidence of advanced-stage cancer, a key driver of adverse outcomes in Medicaid. Aim 3 demonstrates that optimal cancer prevention will require greater efforts among public programs to address vulnerability linked to housing insecurity and other health-related social needs.

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1.0 Chapter 1: Introduction

1.1 Burden of cancer in the United States

The burden of cancer is steadily increasing in the US. In 2024, there will be estimated 2 million new cancer cases, and the rate of cancer incidence has risen by 1-3% for top 10 cancers from 2015 to 2019.[1] Moreover, the number of individuals diagnosed with cancer is projected to grow from 18.1 million in 2011 to 26 million by 2040,[2] a trend driven by improved cancer survivorship.[3-5] From both the individual patient and public health perspective, cancer can be considered as a "priority" health condition due to its serious economic, health, and other quality-of-life consequences.[6,7] First, cancer care is costly. Estimates of the direct national expenditure associated with cancer care in the US ranged from $124 to $157 billion in 2020, a figure that will rise with the expanding cancer population and increasing prices of anticancer therapies.[8-11] Moreover, there are indirect costs associated with cancer, such as lost productivity or missed hours of work, that are equivalent to tens to thousands of dollars.[12,13] Second, cancer inflicts severe death tolls among the diagnosed population.[14] Cancer is consistently the second leading cause of mortality after cardiovascular diseases, and many patients ultimately die from metastasis.[15,16] This reflects the fact that cancer is one of the most complex and high-risk medical conditions to treat, as there is vast heterogeneity in tumor characteristics and presentation that complicate any single treatment strategy and cancer cells may become resistant to treatment.[17,18] Third, cancer affects patients' quality of life. Not only is a diagnosis of cancer psychologically and emotionally distressful, the symptom burden and toxicities from cancer and its treatment can severely compromise quality of life.[19,20] In light of these facts, there are widescale efforts to improve cancer prevention and control, most notably the Cancer Moonshot campaign that was launched during the Obama administration and continued in the Biden administration,[21,22] with the goal to "end cancer as we know it."[22]

1.2 Understanding care needs of patients with cancer: Cancer care continuum

Patients with cancer and cancer survivors face pronounced needs for healthcare to address a spectrum of health concerns. One useful framework to conceptualize the care needs among cancer patients is the cancer care continuum, which summarizes the key stages of cancer care from initial diagnosis to end-of-life.[23-25] An overview of the cancer care continuum is depicted in Figure 1.1, encompassing four stages of care, with distinct care needs and access issues that may be present at each stage.

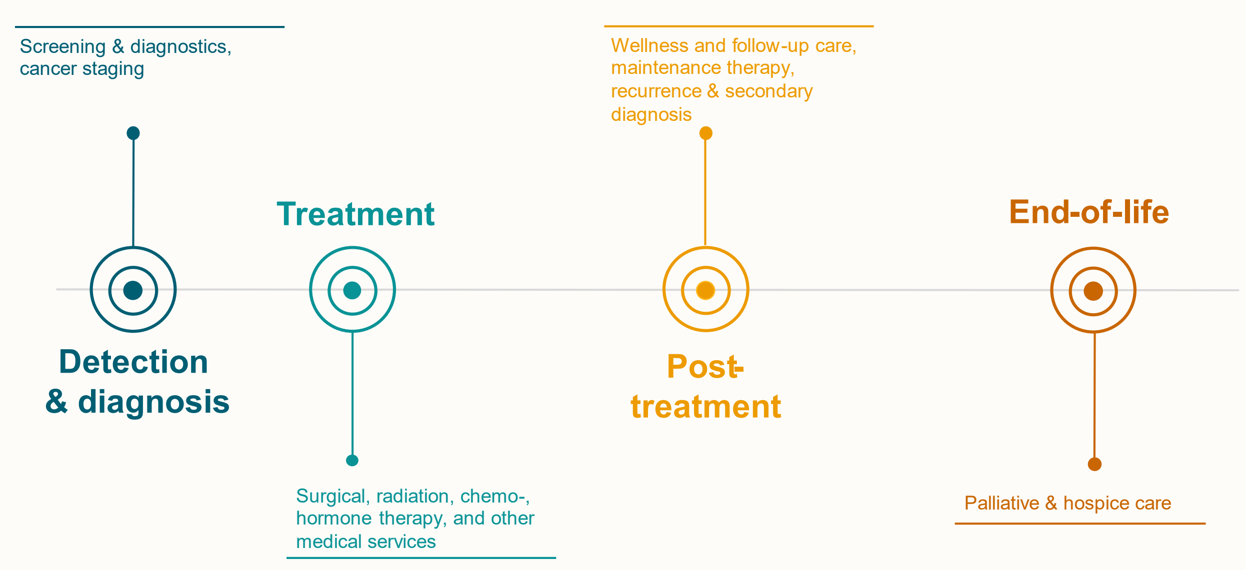


Figure 1.1 Cancer care continuum

At the *detection* stage, access to cancer screening and diagnostic services is essential to facilitate both timely and appropriate diagnosis of cancer, which can drastically improve treatment effectiveness and prognosis.[26,27] Upon diagnosis, cancer also needs to be accurately staged to guide clinical decisions regarding treatment strategies and modalities.[28] Many of these services are provided in more routine care settings, such as physician offices, meaning that access to primary care and having a usual source of care are crucial for screening and early detection.

At the *treatment* stage, patients require access to cancer-directed treatments and management of side effects.[29] In terms of treatment, there has been an influx of novel cancer therapies and technologies, such as biologic and targeted oncologic medications, new radiation therapies such as intensity-modulated radiotherapy, and innovations in surgeries, especially robotic-assisted surgeries.[24] While these medical advancements offer better prognosis, they are expensive and may expose patients to high costs of care.[30] Furthermore, considering the complexity and multimodality of cancer care, high-quality cancer care demands both access to and coordination of services across numerous providers.[18]

Following successful treatment, patients may enter a prolonged period of remission in the *post-treatment* stage. Although the treatment has been "completed," patients may continue to experience late- or long-term effects of cancer diagnosis and treatment, including comorbidities, [31] physical limitations, disabling conditions,[32] or psychosocial vulnerabilities.[33,34] Moreover, patients with a history of cancer experience an elevated risk of a new cancer diagnosis and many are diagnosed with recurrent cancer.[18,35] To address these cancer-related health problems, patients require regular access to health care. Though many health services that patients utilize during this period may be considered routine services, there is still a risk of financial hardship associated with use of care.[36] The estimated monthly out-of-pocket costs among cancer survivors range from $316-$741,[37] and older adults with low income may not have adequate resources to afford care.[36,38,39]

For patients with terminal cancer, the goal of care shifts from treating cancer to maximize quality of life at *end of life*. In this stage, optimal care may involve an appropriate discontinuation of treatment for curative purposes and expanded utilization of supportive care to address the symptom burden of terminal cancer.[40,41] Receipt of supportive care such as palliative[42-45] and hospice care,[46] can be beneficial in helping patients cope with an end stage cancer.

In summary, access to care is essential across the cancer care continuum for successful cancer survivorship. Therefore, a key goal of health policy is to ensure that patients with cancer and cancer survivors are protected from high costs of care and other barriers to care at each stage of the care continuum.

1.3 Role of health insurance for patients with cancer and cancer survivors

1.3.1 Goals of coverage: Access and affordability

Having adequate and affordable insurance coverage is vital to manage the range of healthcare needs experienced by patients with cancer and cancer survivors. Lack of health insurance is a clear barrier to access,[47,48] but there is also evidence that underinsurance is common among cancer survivors due to the high cost-sharing associated with survivorship care.[36,49] For instance, 8.8% of older adult cancer survivors report spending more than 5% of their income on OOP expenses.[50] The prevalence of underinsurance is higher among older adults, who are more likely to utilize health care services.[49] Acknowledging these facts, the Institute of Medicine (IOM) has stated that an important goal of insurance for cancer survivors must be to not only increase *access* to care but also guarantee *affordability* of care within health insurance.[51]

1.3.2 Sources of coverage

Among individuals diagnosed with cancer, the most common type of coverage is Medicare (56.4%), followed by private insurance (27.7%), and Medicaid or other public insurance (10%).[52] This largely reflects the demographic profile of patients with cancer, most of whom are adults aged 65 or older.[52,53] Among the privately-insured individuals, most have employer sponsored coverage, though some are covered via directly purchased health plans.[54] While Medicaid accounts for a small share of the overall cancer population, it is a growing source of insurance coverage in this population. Under the Affordable Care Act (ACA), many states have expanded the eligibility for

Medicaid to cover childless adults with incomes up to 138% of the federal poverty line, which increased the number of cancer patients with Medicaid coverage.[55,56] Since the implementation of ACA Medicaid expansion, combined with other provisions of the ACA that helped to lower the barriers to obtain private insurance outside of employer-sponsored coverage, the rate of uninsurance fell to a historic low (around 6% among patients with cancer).[56,57]

1.4 Importance of Medicare and Medicaid program

This dissertation focuses on the two major public insurance programs—Medicare and Medicaid—that cover over 35% of the US population and are important policy levers to improve cancer outcomes at the population level.[58,59]

1.4.1 Overview of Medicare and Medicaid

Medicare is a federally run insurance program that provides coverage for adults 65 or older, those with disabilities receiving Social Security Disability Insurance (SSDI), people with end-stage renal disease (ESRD) or amyotrophic lateral sclerosis (ALS).[60] Medicare broadly covers hospital-based services (Part A), physician and outpatient services (Part B), and prescription drugs (Part D). Medicare beneficiaries have the option of receiving Medicare-covered benefits directly through the government (Traditional Medicare) or enrolling in private health plans that are contracted to administer Medicare benefits (Medicare Advantage or Medicare Part C). As over

64% of all patients with cancer are aged 65 or older, Medicare is the *largest* payer of cancer-related care in the US.[61]

Medicaid is a joint program funded by both federal and state governments (but administered by states) that primarily insures children and adults younger than age 65 with low-income and/or disabilities.[62,63] Medicaid provides coverage of most health services, non-emergency medical transportation, and long-term care such as nursing home or home and community-based services. Although Medicaid covers only a small portion of cancer patients and survivors compared to Medicare or private insurance, it is responsible to coordinating care for the members of socioeconomically disadvantaged communities and many racial and ethnic minorities who experience pronounced challenges with access to care.[64,65]

1.4.2 Challenges with healthcare access and affordability

One major challenge with Medicare coverage for cancer patients and survivors is considerable out-of-pocket (OOP) costs of care that arise from its cost-sharing requirements.[66] Although Medicare provides near-universal health insurance coverage, there are varying *levels* and *types* of Medicare coverage that have implications for patients' OOP spending burden.[67] Traditional Medicare imposes high cost-sharing without a limit on OOP spending, and many beneficiaries obtain supplemental coverage through an employer, Medigap, or Medicaid.[68,69] Alternatively, Medicare beneficiaries can enroll in Medicare Advantage, where cost sharing for preventive and care management services is often lower (but not fully eliminated) and subject to an annual OOP spending cap.[70] However, beneficiaries in Medicare Advantage may encounter barriers to access because of strict utilization management and limited provider networks in Medicare Advantage.[71-74]

These details of Medicare coverage can meaningfully impact access and affordability of care among cancer patients and survivors. For instance, the 2-year mean OOP spending among recently diagnosed Medicare beneficiaries without any supplemental coverage is \$8,115; the spending among beneficiaries with private supplemental insurance or Medicare Advantage is \$5,492 to \$5,976.[66] These estimates suggest that although attaining Medicare coverage may generally confer benefits for older cancer patients and survivors, especially those uninsured or under-insured who are particularly vulnerable to financial burdens of care,[75] there are significant affordability challenges in Medicare. These challenges are yet to be thoroughly examined within the existing literature on the role of insurance policy for cancer patients and survivors,[76-81] with many studies focusing on financial burden of care among adults younger than 65.[37,82,83]

While the cost of OOP spending presents a key source of concern for ensuring care access and affordability in Medicare, Medicaid programs face a different set of challenges. Because Medicaid programs provide most health services at little to no cost to beneficiaries[84] (meaning that there is typically no demand-side cost sharing), they rely on supply-side levers to control utilization of care.[85] For instance, Medicaid reimburses physicians at a lower rate than Medicare or private insurance, which has been cited as one reason for the reduced pool of providers willing to accept Medicaid patients.[86-88] Moreover, most Medicaid programs contract with private managed care organizations to administer Medicaid services,[89] which are known to adopt utilization management and other rationing tools, analogous to Medicare Advantage.[85,90] Therefore, the specific structure and administration of Medicaid programs are relevant determinants of care access in Medicaid. Navigating these mechanisms of care rationing may be especially onerous for Medicaid beneficiaries, many of whom historically experience gaps in access due to their socioeconomic vulnerabilities.

1.4.3 Disparities in cancer outcomes by insurance status

The details of Medicare and Medicaid coverage and the respective challenges in ensuring care access and affordability within each program are relevant to understanding disparities in cancer outcomes by insurance status.[47,91-93] On the one hand, research shows that access to insurance can improve cancer survival. Silvestri et al. reported that adults aged 60-64 diagnosed with cancer had 5-17% lower 5-year survival compared to Medicare-insured adults aged 65-69 with cancer.[91] Further, Barnes et al. and Han et al. showed positive impacts of the ACA Medicaid expansion on cancer mortality, including 1,616 averted cancer deaths in Medicaid expansion states vs. non-expansion states.[94,95] On the other hand, there are disparities in outcomes by type of coverage *among* the insured. For instance, Zhao et al. found that compared to privately insured patients, Medicaid- and Medicare-insured patients had both higher odds of late-stage diagnosis and all-cause mortality.[96] Moreover, Parikh-Patel et al. highlighted that receipt of recommended cancer treatments was lower in patients with Medicare and Medicaid relative to those with private insurance, indicating that disparities in access to treatment may explain disparities in cancer outcomes by insurance type.[93] These disparities underscore a need to improve elements of the Medicare and Medicaid to optimize cancer outcomes in the US.

1.5 Social determinants of health

There is an emerging body of research that seeks to investigate effects of social determinants of health on cancer outcomes.[97-100] Social determinants of health (SDOH) are broadly defined as conditions of one's living environment that can influence "health, functioning, and quality-of-life outcomes and risks."[101] SDOH encompasses various domains—housing, food security, transportation, social environment, and education—that are correlated with adverse health outcomes, including premature mortality.[102] In the context of cancer outcomes, factors such as food insecurity and hunger,[103] lack of affordable housing,[104] barriers to transportation,[105] and social isolation[106] were associated with disparities in cancer screening, staging, treatment, or survival.

Measuring the extent to which disparities exist by SDOH is a necessary step to inform interventions to address them. However, lack of available SDOH data at the individual-level is one of the major barriers for studying SDOH and cancer outcomes.[107,108] In fact, prior work in this area often examines ecologic associations between SDOH and cancer outcomes (using area-based measures) or self-reported SDOH in public surveys that only provide limited information about health and cancer-related outcomes. In this dissertation, I investigate the relationship between housing insecurity and utilization of cancer screening using a novel data linkage of individual-level housing encounter data and Medicaid claims, which overcomes some of the data limitations in existing studies.

1.5.1 Housing insecurity and health

Housing insecurity is a multi-dimensional construct that is broadly inclusive of experiences with unstable housing such as homelessness, unaffordable rent, residential instability, eviction, and overcrowding.[109] A growing and persistent number of individuals experience housing insecurity in the US.[110,111] During the COVID-19 pandemic, over 44% of renters felt pressured to move from their home, and over 16% of households without housing assistance experienced severe housing problems.[112,113] In 2022, over 582,462 individuals experienced homelessness in the US, the most extreme form of housing insecurity marked by lack of housing.[111] One-fifth of people experiencing homelessness were chronically homeless or individuals with disabilities with a long-term history of homelessness. There are also stark racial and ethnic disparities in housing insecurity, with Black and Hispanic individuals having 2-4 times higher risk of homelessness compared to White individuals.[114,115]

Extensive literature has documented the adverse impacts of housing instability on health.[116,117] Compared to housed individuals, people experiencing homelessness have worse health status and are more likely to suffer from chronic conditions, and mental health and substance use disorders.[118] [119] People experiencing homelessness also have a 3.5 higher all-cause mortality rate compared to the general population due to poor health and comorbidities.[120] Despite the severity of disease burden, people experiencing homelessness are more likely to receive care at emergency departments or inpatient settings, rather than outpatient settings such as physician offices,[118,121-123] suggesting limited access to care and the lack of a usual source of care can exacerbate morbidity and mortality risk in this population.

1.5.2 Importance of screening in housing insecure individuals

Among people experiencing housing insecurity, cancer is one of the leading causes of death, along with heart diseases and drug overdose.[120,124,125] Cancer diagnosis is common in this population due to high prevalence of behavioral and environmental risk factors, including substance use, chronic infections, metabolic disorders, prolonged sun exposure, and inadequate access to care.[126] Among all cancer cases, the mortality risk among those experiencing homelessness is double that of the general population.[127] A major reason for the disproportionate cancer mortality risk is that late-stage diagnoses constitute the majority of incident cancer cases in this population.[128] For example, the share of non-localized breast cancer diagnosis among people experiencing homelessness (PEH) in Boston was nearly 70%, compared to 30% among all other cancer cases in Massachusetts. Therefore, improving access to evidence-based screening and facilitating early detection are important starting points for addressing the disparities in cancer mortality by housing status.

There is scant research examining the utilization of cancer screening among individuals experiencing homelessness. Prior studies have assessed screening in limited and specific settings and generally found low rates of screening among individuals experiencing homelessness, though results varied by type of cancer screening. There are several analyses of screening among homeless individuals residing in shelters. In a survey of adults aged 50 or older living at homeless shelters in New York City (NYC), Marron et al. discovered that only 27% reported receiving a colonoscopy screening within ten years, with 69% reporting no receipt of colonoscopy screening in their lifetime.[129] Asgray et al. analyzed medical records of shelter-based clinics in NYC and found significantly lower rates of colorectal screening among PEH compared to domicile individuals visiting the same clinic, but statistically similar rates of mammogram or Pap test by homelessness status (possibly due to low power) though they were lower than the national average.[130-132] Other analyses have studied people experiencing homelessness at a single health system or a respite care facility, comparing rates of screening between people experiencing homelessness and matched cohort of patients receiving care at the same facility. Mayo et al. compared prostate cancer screening by homeless status at a large metropolitan hospital in Cleveland and documented a significantly lower PSA testing within five years (13 vs. 34%) among people experiencing homelessness aged 50 to 69 years.[133] Kilic et al. also characterized the take-up of breast cancer screening among homeless women receiving care at a hospital system in a Midwestern state, noting that only 18% received mammography.[134] Finally, Bhaarel et al. found only one-third of people experiencing homelessness receiving care at a respite care facility were appropriately screened for cervical cancer in the past year, but many declined screening even when offered.[135]

While these studies provide much-needed evidence on the disparities in cancer screening by housing status, population-level estimates of screening among people experiencing homelessness are still rare. Such estimates are essential to understand the extent to which disparities in screening exist and identify sources of disparities in this population.

1.5.3 Role of Medicaid programs

Medicaid is a critical safety net program for people experiencing homelessness and other housing insecurity, who do not have other means to access health insurance coverage due to low income.[123,136] This is especially true following ACA Medicaid expansion, which broadened Medicaid eligibility for low-income adults not qualifying for Medicaid on the basis of pregnancy or disability. In this population, Medicaid's task of providing and coordinating health services in a cost-efficient manner is complicated by the presence of non-medical drivers of health. Among Medicaid programs, there is increasing recognition that addressing SDOH is necessary to improve health and reduce utilization of costly health services, such as emergency department and inpatient visits.[137] Recently, the Centers for Medicare and Medicaid services provided guidance to state programs on Section 1115 waivers to cover non-medical services as well as other mechanisms that may be used to address health-related social needs (HRSN).[138] As of 2024, over 19 states have approved waiver programs and 6 states, including Pennsylvania, have pending waivers.[139] These waiver programs have potential to foster equity in cancer care by targeting health-related social needs.[140] For example, Pennsylvania's pending 1115 waiver application proposes delivery of housing and tenancy support, including pre-tenancy and transition navigation, case management, transition services, rental subsidies for up to 6 months, and tenancy sustaining services.[141] Separately, states that contract with managed care organizations can leverage managed care to address HRSN outside of the waiver programs.[142] For example, states can use value-based contracting and alternative payment models and direct managed care organizations to re-invest a portion of their profits into local communities. Managed care organizations can also voluntarily provide services that address HRSN through the "in lieu of" services and value-added services provisions in Medicaid.

As states begin to develop and implement initiatives to address HSRN, rigorous evaluation of such initiatives will be crucial to understand their impact on disparities in care utilization and health outcomes. In the interim, preliminary evidence on disparities associated with SDOH will be valuable in helping states understand the extent to which HSRN are experienced by Medicaid populations and setting benchmarks for future evaluation of the initiatives to address HSRN.

1.6 Dissertation objective and aims

The objective of my dissertation is to improve our understanding of public insurance programs and their impact on cancer control to support policy reforms that address the rising cancer burden in the US. The aims of my dissertation are the following:

Paper 1. Investigate changes in access and affordability outcomes for older adult cancer survivors associated with Medicare eligibility at age 65.

This aim focuses on *eligibility policy* for Medicare to elucidate how availability of near-universal Medicare coverage influences access and affordability of care among older cancer survivors—the population of cancer survivors facing a high risk of financial burden of care. Using the National Health Interview Survey, I assess access and affordability outcomes among a nationally representative sample of older cancer survivors. I implement a regression discontinuity design that leverages the age-eligibility threshold for Medicare at age 65 as a source of exogenous variation in health insurance coverage among older cancer survivors.

Paper 2. Examine effects of Medicaid managed care on early detection of cancer among non-elderly Medicaid beneficiaries.

This aim examines how the specific *administration* of Medicaid programs may impact early detection of cancer among Medicaid beneficiaries who often experience adverse cancer outcomes due to late cancer diagnosis. To study this question, I exploit the expansion of mandatory Medicaid managed care in Pennsylvania as a natural experiment. Among newly diagnosed Medicaid beneficiaries in Pennsylvania cancer registry, I use a stacked difference-in-differences design that exploits the staggered implementation of mandatory managed care across different counties in Pennsylvania to isolate the effect of Medicaid managed care on stage at diagnosis.

Paper 3. Evaluate disparities in receipt of breast cancer screening by experience or risk of homelessness within Medicaid.

This aim estimates housing-related disparities in breast cancer screening to contribute to the limited literature on the impact of housing insecurity on access to and use of preventive care services. I use a novel linkage of administrative Medicaid claims and Homelessness Management and Information System (HMIS) data that allow me to analyze longitudinal experiences in housing insecurity and receipt of guideline-recommended mammography among women Medicaid beneficiaries.

2.0 Chapter 2: Association of Medicare eligibility with access to and affordability of care among older cancer survivors

Youngmin Kwon, PhD[1]; Eric T. Roberts, PhD[2]; Howard B. Degenholtz, PhD[1]; Bruce L. Jacobs, MD, MPH[3]; Lindsay M. Sabik, PhD[1]

[1] University of Pittsburgh School of Public Health, Department of Health Policy and Management

[2] Perelman School of Medicine at University of Pennsylvania, Department of General Internal Medicine

[3] University of Pittsburgh School of Medicine, Department of Urology

2.1 Preface

This Chapter was published online as a research article on *Journal of Cancer Survivorship* on Mar 23, 2024. (Kwon Y, Roberts ET, Degenholtz HB, Jacobs BL, Sabik LM. Association of Medicare eligibility with access to and affordability of care among older cancer survivors. *J Cancer Surviv*. 2024 Mar 23. doi: 10.1007/s11764-024-01562-x. Epub ahead of print. PMID: 38520599). I was primarily responsible for conceptualization, statistical analysis, and drafting and editing of the manuscript for this work.

2.2 Abstract

Purpose: Older cancer survivors have substantial needs for ongoing care, but they may encounter difficulties accessing care due to cost concerns. We examined whether near-universal insurance coverage through Medicare—a key source of health insurance coverage in this population—is associated with improvements in care access and affordability among older cancer survivors around age 65.

Methods: In a nationally representative sample of cancer survivors (aged 50-80) from 2006-2018 National Health Interview Survey, we employed a quasi-experimental, regression discontinuity design to estimate changes in insurance coverage, delayed/skipped care due to cost, worries about or problems paying medical bills at age 65.

Results: Medicare coverage sharply increased from 8.3% at age 64 to 98.2% at age 65, ensuring near-universal insurance coverage (99.5%). Medicare eligibility at age 65 was associated with reductions in delayed/skipped care due to cost (discontinuity: -5.7 percentage points or pp; 95% CI: -8.1, -3.3; $P < .001$), worries about paying for medical bills (-7.7 pp; 95% CI: -12.0, -3.2; $P = .001$), and problems paying medical bills (-3.2 pp; 95% CI: -6.1, -0.2; $P = .036$). However, a sizable proportion reported any access or affordability problems (29.7%) between ages 66-80.

Conclusions: Near-universal Medicare coverage at age 65 was associated with a reduction—but not elimination—of access and affordability problems among cancer survivors. These findings reaffirm the role of Medicare in improving access and affordability for older cancer survivor and highlight opportunities for reforms to further alleviate financial burden of care in this population.

2.3 Introduction

In 2022, there were over 18.1 million cancer survivors in the United States.[143] This figure will grow 25% by 2032, reflecting projected increases in cancer survivorship due to advances in screening and treatment.[144,145] For many patients who survive the initial diagnosis of cancer, cancer can be considered a chronic condition that should be managed with timely and appropriate care [146]. However, due to their ongoing and often intensive needs for care, cancer survivors are likely to experience financial strain and report difficulty obtaining care due to cost concerns.[36,49,147,148]

Health insurance can ameliorate financial burdens that might cause cancer survivors to delay or forgo necessary care.[36,47-49] For example, prior studies found that both having health insurance and continuous insurance coverage were associated with reduced financial burden and greater access to care.[47,149] Among older adults, Medicare—the US health insurance program covering people ages 65 and older and younger adults with disabilities—plays a critical role in providing coverage for cancer survivors.[61,150] Over 63.8% of adults with cancer (10.8 million) were above the age of 65 in 2020, making Medicare the largest payer for care among cancer survivors in the United States.[151,152]

While a large literature demonstrates that acquiring Medicare at age 65 is associated with improved access to care and reduced financial strain in the general population of older adults,[153-156] less is known about whether and to what extent Medicare alleviates access and affordability problems among cancer survivors.[157] On the one hand, acquiring Medicare may be beneficial for older cancer survivors, as cancer survivors under age 65 have historically experienced gaps in affordable coverage, even after major coverage provisions of the Affordable Care Act (ACA) took effect.[158] On the other hand, cost sharing in Medicare may leave beneficiaries exposed to high out-of-pocket (OOP) costs, especially for those who lack supplemental coverage.[159] For instance, traditional Medicare has no OOP cost limit, while the mean OOP maximum in Medicare Advantage plans is approximately $5,000 for services delivered in-network.[160] Consequently, Medicare beneficiaries with substantial needs for care may encounter challenges paying for care.

Evidence quantifying the relationship of Medicare eligibility with changes in access to and affordability of care can shed light on how this program functions for older cancer survivors. It can also highlight whether access and affordability barriers persist after cancer survivors become eligible for Medicare, and thus identify opportunities for policy reforms to address these barriers. Moreover, such evidence may be especially pertinent in light of the recent resurgence of debates over modifying Medicare eligibility within broader conversations on reforming entitlement spending and the US health care system.[161] However, little research has examined the association of Medicare eligibility with access to and affordability of care among older cancer survivors. The few existing studies that addressed this question employed broad comparisons of older vs. younger cancer survivors,[162-164] but unmeasured differences between these age groups could have confounded those studies' estimates.

In this study, we used a quasi-experimental, regression discontinuity (RD) approach to examine the relationship between access to and affordability of care among when cancer survivors become eligible for Medicare at age 65, comparing cancer survivors just above vs. below Medicare's age eligibility threshold to isolate differences in outcomes associated with Medicare eligibility from other confounders.

2.4 Methods

2.4.1 Study population

We analyzed a sample of older adult cancer survivors from the 2006-2018 National Health Interview Survey (NHIS), an annual cross-sectional survey of the civilian, non-institutionalized United States population.[165] The survey collects data on a broad range of health topics through face-to-face interviews. We analyzed the household component of the NHIS, which contains questionnaires on basic health information, linked to the sample adult component, which asks detailed health and sociodemographic questions to one adult per sampled household.

We included older adults aged 50-80 who reported having ever been told by a doctor or healthcare professional that they had cancer (Figure A2.3). Consistent with prior studies, we excluded individuals with nonmelanoma skin cancers, as these individuals have different survivorship needs compared to survivors with other cancers.[166] We also excluded individuals who reported having Social Security Disability Insurance, since these individuals can qualify for Medicare before age 65.[167] Because the NHIS asks respondents about their access to and use of care over the prior year, we excluded individuals aged 65 during the survey year, as their responses could cover periods before entering Medicare.[168]

2.4.2 Outcome variables

We analyzed three respondent-reported measures of health care access and affordability problems from the NHIS.[169] The first outcome is cost barriers to care, which measures the extent to which individuals are choosing to delay or forgo access to care due to cost concerns. The other two outcomes are worries about paying medical bills when sick and problem paying medical bills, which measure affordability of care, conditional on utilizing and accessing care. We also created a composite outcome that indicates having any of the access or affordability problems noted above.

2.4.3 Covariates

Covariates include respondent-level sociodemographic characteristics (sex, race/ethnicity, marital status, education, income, employment status, and region), cancer history (time since most recent cancer diagnosis, number of lifetime cancer diagnoses, and cancer type), presence of other chronic conditions, functional limitations, and survey year. Race and ethnicity were self-reported by survey respondents, and they are included in the analysis to control for racial/ethnic differences in care access and affordability arising from systemic racism in the health care system. For income, the NHIS provides a set of five imputed values (income-to-poverty ratios) for respondents who did not report income. We followed the NHIS recommended procedure for analyzing multiply imputed data and generated pooled point estimates and their standard errors that account for both within- and between-imputation variance.[170]

2.4.4 Statistical analysis

We used a regression discontinuity (RD) design to estimate changes in outcomes associated with Medicare eligibility at age 65. This design compares cancer survivors slightly above and below the age-eligibility threshold for Medicare to isolate the relationship between Medicare eligibility and outcomes from confounders.

For each outcome, we fitted a local linear RD to estimate the level shift (i.e., discontinuity) in the outcome above vs. below the age eligibility threshold for Medicare. Our main analyses included cancer survivors aged 50-80, the age-bandwidth used in a prior study that examined the association of Medicare with breast cancer detection and mortality.[80] To estimate the discontinuity at age 65, we modeled each outcome as a function of a binary indicator for exceeding this age threshold and adjusted for a linear function of age (allowing for different slopes above and below the threshold) to account for the continuous relationship between age and outcomes away from this threshold. Because all study outcomes were binary measures, we report the discontinuities as percentage-point (pp) changes in the probability of reporting access and affordability problems associated with Medicare eligibility. Although we excluded individuals who were 65 at the time of the survey, our models provide an estimate of differences slightly above vs. below the age threshold for Medicare (i.e., discontinuities at age 65).

We conducted several sensitivity analyses. First, we estimated models using narrower age bandwidths. Narrower bandwidths use fewer observations (reducing precision) but may also reduce bias if the continuous relationship between age and outcomes around the eligibility threshold is incorrectly specified. Second, because RD relies on the assumption that adults above vs. below the age 65 threshold are similar, we examined covariate balance between the age groups by estimating an RD for each measured covariate. Third, we conducted stratified analyses by race and ethnicity, education, region, and whether the analysis period preceded or followed 2014 (when major insurance coverage provisions of the ACA were implemented). These analyses enabled us to explore whether observed associations between Medicare eligibility and outcomes of interest were more pronounced in subgroups of cancer survivors who were more likely to be uninsured prior to age 65 and therefore might have experienced greater benefits from being Medicare-eligible. Lastly, we stratified by the results by the duration of cancer survivorship, separately estimating the discontinuity in outcomes by survivors who were recently diagnosed (i.e., less than 2 years since diagnosis) and long-term survivors (i.e., more than 2 years since diagnosis), to account for potentially heterogenous impacts of Medicare eligibility by stage of survivorship.

All analyses were weighted using NHIS survey weights to construct nationally representative estimates. Standard errors were adjusted for the complex survey design. Analyses were performed using Stata software, version 16.0 (StataCorp). A 2-tailed test of significance with an alpha of 0.05 was used for testing study hypotheses.

2.5 Results

2.5.1 Cancer survivor characteristics

Our study sample included 13,670 older cancer survivors in the 2006-2018 NHIS, representing 2.7 million cancer survivors when weighted (Table 2-1). Most survivors were long-term survivors who were alive for more than 1 year since their last cancer diagnosis. Lower proportions of cancer survivors aged 66-80 were female, college educated, employed, and had incomes >400% federal poverty line (FPL), while higher proportions had multiple comorbidities and functional limitations, compared to cancer survivors aged 50-64. In terms of cancer history, there was an increase in prostate cancer diagnosis among cancer survivors above age 65.

Importantly for the RD design, cancer survivors immediately below and above age 65 (i.e., aged 64 vs. 66) were similar in most observed demographic and clinical characteristics; the discontinuities in these measured characteristics are non-significant for most variables and smaller in magnitude compared to the absolute differences in characteristics between the age groups.

Among younger survivors, 8.0% did not report having any health insurance coverage; most received coverage through their employers (73.4%). A small minority reported having directly purchased or ACA Marketplace coverage (7.6%) or Medicaid (3.2%). Among Medicare eligible survivors, the majority (91.3%) were enrolled in both Medicare Parts A & B, and they were more likely to be enrolled in Traditional Medicare vs. Medicare Advantage (79.3% vs 20.1%).

2.5.2 Changes in coverage, health care access and affordability at age 65

At age 65, there was a significant increase in Medicare coverage and any insurance coverage (Table 2-2, Figure 2.1). The share of survivors reporting Medicare coverage increased from 5.4% to 95.3%, representing an 89.9 percentage-point (pp) increase from the pre-65 mean (95% CI: 88.4 to 91.4; $P < .001$). The share reporting any insurance coverage increased from 93.6% to 99.7%, or a 6.1 pp increase (95% CI: 4.6 to 7.6; $P < .001$).

Medicare eligibility at age 65 was associated with improved access to and affordability of care among cancer survivors. Specifically, our regression discontinuity estimates indicated that Medicare eligibility was associated with an 8.6 pp reduction in the probability of reporting any access or affordability problems (95% CI: -13.1 to -4.2; $P < .001$), a 5.7 pp reduction in cost barriers to care (95% CI: -8.1, -3.4; $P < .001$), a 7.6 pp reduction in reporting concern about paying medical bills if sick (95% CI: -12.0, -3.3; $P < .001$), and a 3.2 pp reduction in problems paying medical bills (95% CI: -6.1, -0.2). These changes represent meaningful relative improvements in access and affordability compared to pre-65 means. For example, the decrease cost barriers to care at age 65 represents a 48% relative reduction from the pre-65 mean of 11.9%.

These RD estimates also indicate that Medicare eligibility did not eliminate access and affordability barriers to care. For instance, the estimate for any access or affordability problem implies that 37.8% (=46.4-8.6 pp) of cancer survivors *immediately* above the age threshold for Medicare still report access or affordability problems. Among cancer survivors aged 66-80, over 29.7% experienced care access or affordability challenges.

2.5.3 Subgroup analysis of discontinuities at age 65

Gains in health insurance coverage, access, and affordability were generally consistent across different demographic and geographic subgroups, with point estimates suggesting more pronounced gains among cancer survivors who are Hispanic or non-Hispanic black, those with high school education or less, and survivors living in the South (Figure 2.2). However, these changes were not uniform across the outcomes. The improvements in outcomes remained significant in the post-ACA period as well. For instance, Hispanic/Non-Hispanic Black survivors saw greater reductions in uninsurance and cost barriers to care, but smaller reductions in problem paying medical bills. In addition, cancer survivors living in the South experienced the lowest reductions in any affordability and access problems compare to those living in other regions, even though they also experienced the largest gain in insurance coverage.

2.5.4 Sensitivity analysis

We conducted sensitivity analyses using varying age-bandwidths around the age 65 threshold (Figure A2.4). RD estimates for insurance coverage and cost barriers to care were robust when altering the bandwidths from 3 to 15 years around the threshold, although were less precise at smaller bandwidths. However, the estimates of changes in worries about paying medical bills were imprecise and sensitive to bandwidth. Thus, we are less confident in findings regarding the association of this outcome with Medicare eligibility at age 65. In the stratified analysis, we observed similar reduction in access and affordability problems regardless of survivorship duration, suggesting that Medicare eligibility had protective effects even in the earlier stage of survivorship where the care costs and needs may be particularly pronounced.

2.6 Discussion

In this nationally representative analysis of older adult cancer survivors, we found that Medicare eligibility at age 65 was associated with significant gains in insurance coverage and reductions in cost barriers to care, worries about paying medical bills, and problems paying medical bills. Reductions in uninsurance were more pronounced among racial/ethnic minorities, those with less than high school education, or living in the South—all groups that were less likely to have health insurance prior to age 65. However, these groups generally saw greater changes in cost-barriers to care, but not in worries or problem paying medical bills, implying that, for these groups, Medicare eligibility was associated with a large improvement in care access, but only a minor change in care affordability. Moreover, a sizable portion of older cancer survivors reported any access and affordability issues after 65, which were largely driven by the higher prevalence of problem or worries with paying medical bills. These findings indicate that Medicare is an important source of coverage for cancer survivors, but they also underscore opportunities for further policy reforms to address remaining cost concerns among cancer survivors who have substantial and ongoing needs for care.

As the single largest payer of health services in the US, Medicare plays a pivotal role in providing health insurance coverage for millions of adults. Though the program may be regarded as sacrosanct, it has increasingly become a focal point in policymaking arenas, sparking vigorous debates over its future within broader conversations about improving insurance coverage and healthcare delivery.[161,171,172] On the one hand, there are calls to broaden Medicare eligibility, backed by popular support for the program, as a way to expand coverage for near-elderly adults who historically were most likely to lack coverage despite experiencing high risks of morbidity and mortality.[158,173] On the other hand, there have been countervailing voices advocating for either curtailing the program or raising the age of eligibility to safeguard the program's financial solvency.[161,172] These divergent viewpoints underscore the *saliency* of Medicare in discussions surrounding the US health care reform. Consequently, evidence about the program's effectiveness in ensuring access and affordability of care is critical to facilitate informed discussions about Medicare and healthcare reform.

In this context, this study advances evidence on changes in access and affordability associated with Medicare eligibility unique to the older cancer survivor population. While numerous studies have examined such changes in the general population,[153-156] less has been known about the association of Medicare eligibility with access and affordability among subgroups of adults with high costs and needs for care. Older cancer survivors are a particularly important population to evaluate because they have complex care needs arising from the lasting impacts of cancer diagnosis, treatment, and other comorbidities.[29,31,174] Addressing these health needs requires routine access to health care, and is often associated with high OOP costs.[175] For example, one analysis estimated that cancer survivors incur between $316 to $741 in OOP costs per month.[37] Similarly, other research has linked a diagnosis of cancer to "financial toxicity," meaning that patients are likely to experience adverse financial outcomes such as bankruptcy.[176] Prior evidence also suggests that adults diagnosed with cancer have a higher OOP burden compared to other chronically ill patients, even when not actively receiving treatment for cancer, which means that cancer survivors may endure undue burden of financial toxicity.[75] Using a rigorous, quasi-experimental study design, our study shows that Medicare helps to lessen financial barriers to care among cancer survivors by shrinking gaps in adequate insurance coverage among younger adults below Medicare age, even after the passage of the ACA.

Given the nature of our study design that estimated an average effect of Medicare eligibility, one major limitation of our empirical approach is the inability to disentangle effects of Traditional Medicare vs. Medicare Advantage. When examining the effects of Medicare, Medicare plan choice is an important consideration because Medicare Advantage has experienced dramatic enrollment growth (as of 2023, over half of all Medicare beneficiaries were enrolled in Medicare Advantage[177]) and distinctions between Traditional Medicare and Medicare Advantage may have important consequences for care access and affordability among cancer survivors.[178] For instance, because Medicare Advantage plans often have lower cost sharing and impose a cap on OOP spending (which does not exist in Traditional Medicare), Medicare Advantage plans may lower cost-related care barriers for some enrollees. At the same time, tight provider networks and utilization management in Medicare Advantage may impose barriers to access and generate high OOP spending for care provided out-of-network. These features may make these plans less attractive to individuals with complex care needs, which could account for somewhat higher representation of Traditional Medicare enrollees in our sample. This pattern of Medicare plan choice is consistent with recent evidence showing that individuals with a history of cancer tend to choose more robust coverage (i.e., Traditional Medicare with supplemental coverage).[179] Considering the variation in coverage generosity within Medicare, an important avenue for future studies is a detailed assessment of OOP cost burdens across various types of coverage within Medicare.

Furthermore, our cross-sectional analysis was unable to directly observe specific coverage transitions that may occur at age 65, precluding detailed inferences of heterogenous effects of Medicare eligibility by different types of coverage prior to age 65. Instead, we explored such heterogeneity in two ways. First, we stratified our main analysis by demographic characteristics associated with coverage and access prior to age 65, including race/ethnicity and education.[180] We found that Medicare eligibility conferred greater benefits for care access among racial/ethnic minorities and those with less than a college education, who were more likely to be uninsured prior to age 65. As minoritized populations encounter more severe access barriers related to cost, reforms aimed at expanding eligibility and reducing the cost burden of care may help lessen persistent disparities in care affordability.[181] Second, we provided a descriptive report of sources of insurance coverage prior to age 65, which helps us to hypothesize various mechanisms by which Medicare eligibility may improve care access and affordability. For cancer survivors without any coverage prior to age 65 (8% of the sample), attaining Medicare eligibility provides a clear pathway for obtaining coverage and addressing barriers to care. However, for cancer survivors with some prior coverage (most of whom had employer-sponsored insurance), how and whether Medicare eligibility improves access and affordability is less certain. For the previously insured cancer survivors, it is possible that Medicare may provide more generous insurance option due to its continuity and simplicity of coverage and fewer restrictions on care (especially in Traditional Medicare).[182] Moreover, among individuals with employer-sponsored coverage, increasing enrollment in high-deductible health plans (which usually have an annual deductible amount greater than $1,000[183]) may contribute to considerable financial burden.[184,185] In contrast, the deductible may be lower in Medicare (for instance, the Part B deductible was $134 at the end of study period[186]), which may help lessen OOP cost burdens. Overall, further work is needed to assess these longitudinal changes in coverage at age 65 and their implications for access and affordability for cancer survivors.

2.7 Limitations

We acknowledge several limitations to our study. First, following the National Cancer Institute, we broadly defined cancer survivors as individuals with a prior diagnosis of cancer, including individuals who may be in the active treatment stage and those who may have completed treatment.[187] As only a small portion in our sample report a recent diagnosis of cancer, our estimates primarily reflect the experiences of long-term cancer survivors rather than individuals newly diagnosed with cancer. Second, the RD design focuses on differences in outcomes associated with Medicare eligibility at 65, but these estimates may not generalize to other ages or individuals who receive Medicare due to disability. Third, we cannot rule out that other changes at age 65, including a drop in employment and income, may have confounded our estimates. However, the outcomes we include measure *immediate* differences in access and affordability after individuals turn 65, where the impacts of short-term changes in covariates are less pronounced. We find positive associations between Medicare eligibility and key outcomes after controlling for these and other measured variables. Fourth, the outcome measures ascertain *general* access and affordability problems, rather than problems accessing or paying for specific components of cancer care. However, the measures we analyzed are still relevant in this population given its extensive and ongoing needs for care. Finally, while the NHIS survey provides information typically not available in other data sources (e.g., cancer history, comorbidities, income, and care experiences), these variables are all self-reported, thus may be subject to misclassification and recall bias.

2.8 Conclusion

In this study, Medicare eligibility at age 65 was associated with reductions in uninsurance, cost barriers to care, and affordability of care among older cancer survivors, a growing population with substantial, complex care needs. These improvements were imperfect, as a considerable proportion of Medicare-eligible sample still reported access and affordability problems. These improvements were greater among those who were less likely to have affordable coverage prior to age 65, including racial/ethnic minorities and cancer survivors living in low socioeconomic status. Future Medicare reform may be crucial to close the gap in coverage and address remaining financial barriers to care among older cancer survivors.

2.9 Tables and figures

Table 2-1 Comparison of characteristics of cancer survivors younger and older than age 65

Characteristics	Sample means, N (%)[a]		
	Age, 50-64 y	Age 66-80 y	Regression Discontinuity at age 65[b]
N, unweighted	5,143	8,527	n/a
N, weighted	1,039,318	1,687,227	n/a
Sex			
Male	1,710 (33.8)	3,711 (43.0)	1.6
Female	3,433 (66.2)	4,816 (57.0)	-1.6
Race/ethnicity			
Hispanic	360 (5.1)	416 (3.9)	1.0
Non-Hispanic white	4,137 (84.9)	7,052 (86.5)	-3.2**
Non-Hispanic black	446 (6.9)	776 (7.0)	1.8
Other	200 (3.1)	283 (2.6)	1.0
Education			
Some college	3,548 (69.6)	4,795 (56.8)	2.3
Less than HS	379 (6.6)	1,212 (13.7)	-2.7
HS equivalent	1,202 (23.5)	2,490 (29.2)	0.5
Employment status[c]			
Employed	3,630 (70.9)	1,512 (17.3)	-18.2***
Retired	1,353 (26.0)	6,960 (82.1)	19.1***
Imputed income[d]			
<100% FPL	n/a (5.5)	n/a (5.7)	-0.7
100-200% FPL	n/a (10.5)	n/a (20.5)	2.4
200-400%	n/a (26.0)	n/a (35.7)	5.7**
>400%	n/a (58.0)	n/a (38.0)	-7.4***
Cancer type			
Other	2,704 (53.2)	3,193 (37.5)	-2.0
Breast	1,461 (27.8)	2,277 (26.9)	0.6
Lung	112 (2.1)	383 (4.3)	0.02
Colorectal	320 (6.2)	778 (9.3)	2.7
Prostate	546 (10.7)	1,896 (22.0)	-2.0
Recently diagnosed with cancer[e]	817 (16.3)	1,259 (14.7)	-0.4
Number of lifetime cancer diagnosis			
Single	4,805 (93.3)	7,625 (89.3)	0.2
Multiple	338 (6.7)	902 (10.7)	-0.2
Count of comorbidities[f]			
0	1,720 (33.8)	1,309 (15.4)	-2.8
1	1,761 (33.7)	2,518 (29.6)	-1.8

2+	1,662 (32.5)	4,700 (55.0)	4.7**
Any functional limitations[g]	2,535 (49.5)	5,670 (66.2)	-0.6
Sources of insurance coverage (< 65)[h]			
Uninsured	429 (8.0)	n/a	n/a
Medicaid	182 (3.2)	n/a	n/a
Private (directly purchased/Marketplace)	398 (7.6)	n/a	n/a
Private, employer sponsored insurance	3,698 (73.4)	n/a	n/a
Other	387 (6.9)		
Details of Medicare coverage (>65)			
Parts A + B	n/a	7,545 (91.3)	n/a
Part D	n/a	3,602 (43.1)	n/a
Medicare Advantage	n/a	1,575 (20.1)	n/a
Medicare/Medicaid duals	n/a	355 (3.5)	n/a

Abbreviations: HS, high school; FPL; federal poverty line; CHD, chronic heart disease; MI, myocardial infarction.
*P < .05; ** P < 0.01; *** P < 0.001

[a] Sample means were weighted by the NHIS survey weights.

[b] Unadjusted regression discontinuity in each level of covariates at age 65.

[c] The values for “unemployed” were omitted due to small sample size.

[d] Combined mean of the multiply imputed income-to-poverty ratio values; the sample N is omitted due to the varying cell sizes for each income category across imputations.

[e] Most recent diagnosis was within 1 year at the time of the survey.

[f] Count of ever being diagnosed with the following comorbidities: arthritis, asthma, diabetes, emphysema, chronic heart diseases, hypertension, stroke, angina pectoris, heart attack.

[g] Difficulty in reporting any difficulty with any of the following activities without special equipment: walking 0.25 mile, climbing 10 steps, sitting for more than 2 hours, stoop/bending/kneeling, reaching over head, grasping small objects, lifting/carrying 10 pounds, pushing large objects, going out to events, participating in social activities, relaxing at home.

[h] Mutually exclusive sources of health insurance coverage for cancer survivors younger than age 65; the numbers exclude a miniscule proportion of the sample who reported Medicare coverage before age 65 (N=49).

Table 2-2 Changes in health insurance coverage, healthcare access and affordability problems at age 65

Outcomes	N	Mean, Aged 64^{a}	Adjusted discontinuity at age 65 (95% CI)^{a}	*P* value	Mean, Aged 66-80^{c}
Medicare, %	13474	8.3	89.9 (88.4 to 91.4)	<.001	97.0
Insured, %	13474	93.4	6.1 (4.6 to 7.6)	<.001	99.9
Any access or affordability problems, %	9627	46.4	-8.6 (-13.1 to -4.2)	<.001	29.7
Cost barriers to care, %	13487	11.9	-5.7 (-8.1 to -3.3)	<.001	4.8
Worries about medical bills if sick, %	9639	40.7	-7.6 (-12.0 to -3.2)	.001	26.6
Problem paying medical bills, %	9735	14.2	-3.2 (-6.1 to -0.2)	.036	7.3

[a] Column presents unadjusted mean outcomes for cancer survivors aged 64

[b] Adjusted discontinuities from the main RD models controlling for the continuous income trend, an indicator for those who are aged greater than 65, individual characteristics from Table 1, and year fixed effects; they are presented as percentage points change in outcomes associated with Medicare eligibility at age 65

[c] Column presents unadjusted mean outcomes for Medicare-eligible cancer survivors, ages 66-80

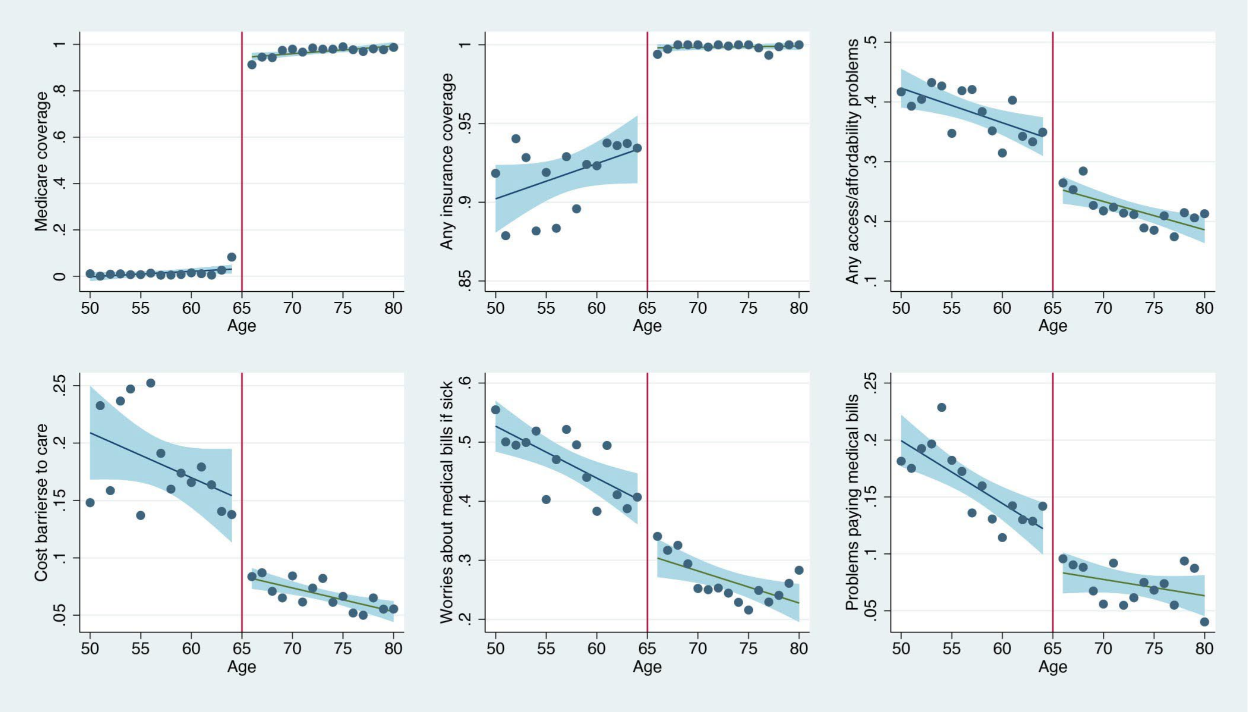


Figure 2.1 Changes in insurance coverage and access and affordability outcomes at age 65 among older cancer survivors

Note: Scatterplot in each panel shows adjusted means of the outcome for 1-year age bins in the 2006-2018 National Health Interview Survey (NHIS). Estimates are adjusted for the NHIS survey weights. We fitted linear regression lines above and below age 65, and the models allowed the age trends to differ above and below this threshold. The distance between the regression lines represents the discontinuity corresponding to Medicare eligibility. We excluded individuals aged 65 in the survey year because their responses to access and affordability questions cover period before attaining Medicare eligibility.

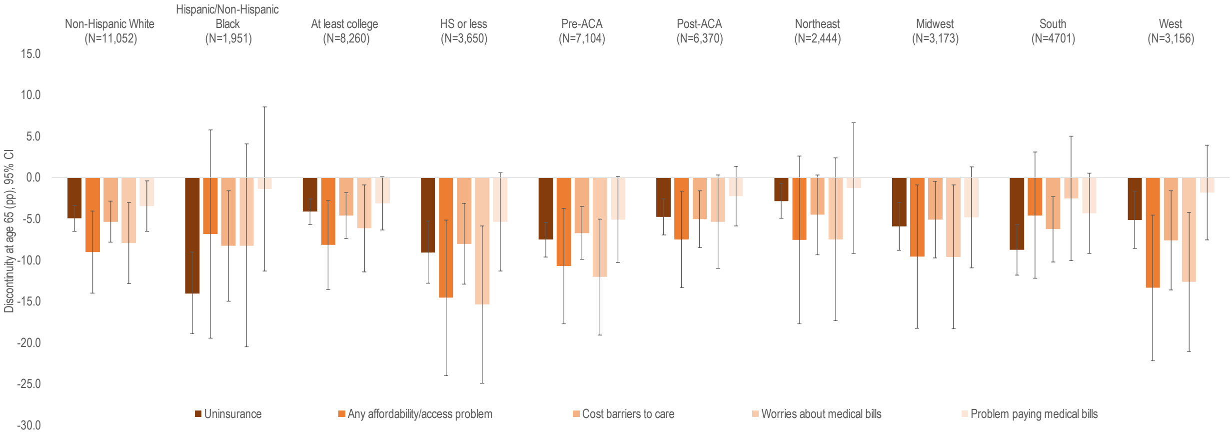


Figure 2.2 Discontinuities in health insurance coverage, healthcare access and affordability at age 65 by race/ethnicity, education status, region, and pre-/post-ACA periods.

Abbreviation: PP, percentage points; HS, high school; ACA, Affordable Care Act. Each bar represents the adjusted discontinuity for outcomes and their 95% confidence intervals as error bars.

2.10 Appendix

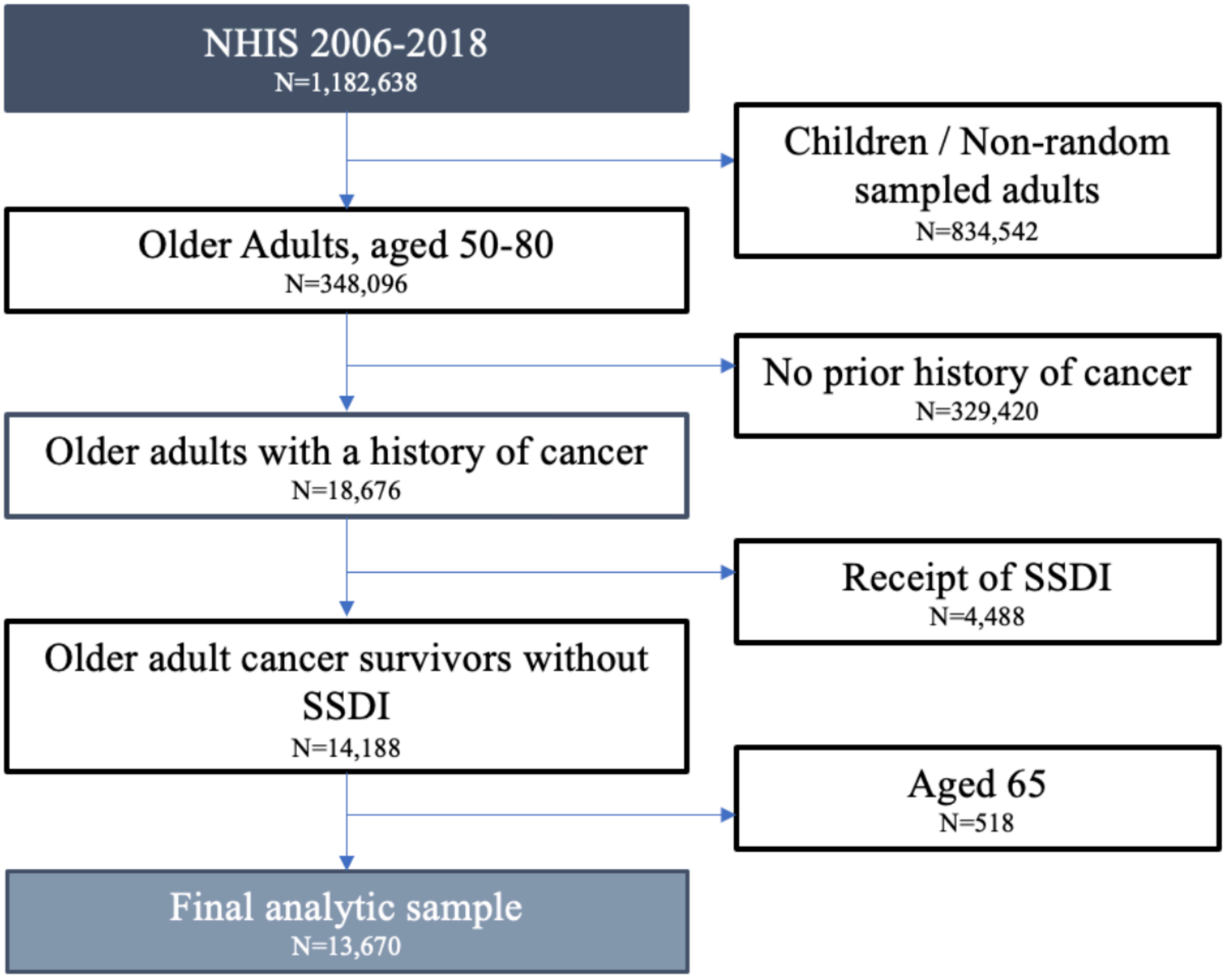


Figure A2.3 Flowchart of sample inclusion and exclusion criteria

Abbreviations: NHIS, National Health Interview Survey; SSDI, Social Security Disability Insurance

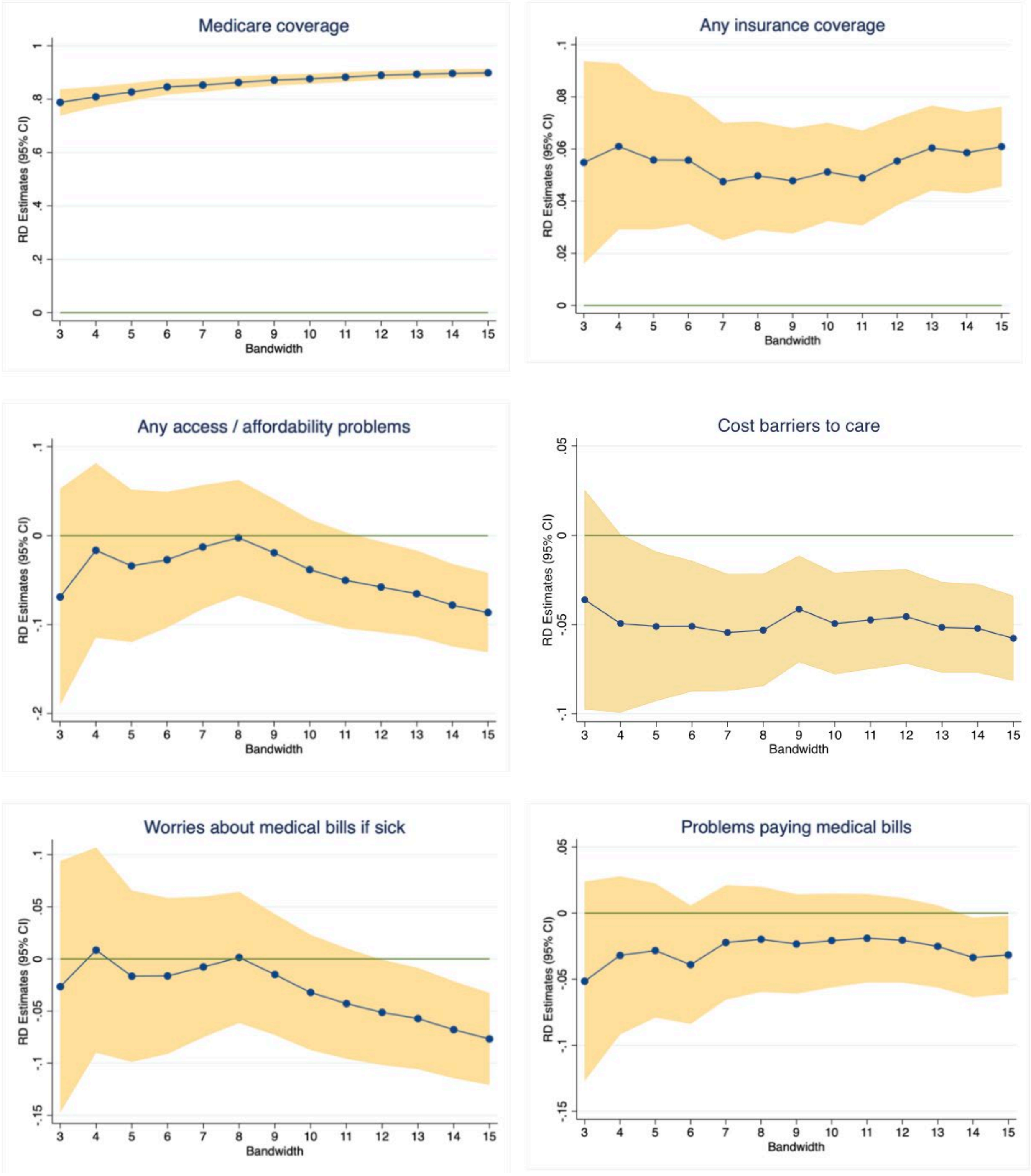


Figure A2.4 Sensitivity of adjusted regression discontinuity estimates to varying bandwidths around age 65

Note: We plotted the regression discontinuity estimates at age 65 and their 95% confidence intervals at varying bandwidths around age 65. We varied the bandwidths from 3 (i.e., age 62-64 and 66-69) to 15 (i.e., age 50-64 and 66-80).

3.0 Chapter 3: Effects of Medicaid managed care on early detection of cancer: Evidence from mandatory Medicaid managed care program in Pennsylvania

Youngmin Kwon, PhD[1]; Eric T. Roberts, PhD[2]; Evan S. Cole, PhD[1]; Howard B. Degenholtz, PhD[1]; Bruce L. Jacobs, MD, MPH[3]; Lindsay M. Sabik, PhD[1]

[1] University of Pittsburgh School of Public Health, Department of Health Policy and Management

[2] Perelman School of Medicine at University of Pennsylvania, Department of General Internal Medicine

[3] University of Pittsburgh School of Medicine, Department of Urology

3.1 Abstract

Objective: To examine changes in late vs. early-stage diagnosis of cancer associated with the introduction of mandatory Medicaid managed care (MMC) in Pennsylvania.

Data Sources and Study Setting: We analyzed data from the Pennsylvania cancer registry (2010-2018) for non-elderly Medicaid beneficiaries aged 21 to 64 newly diagnosed with a solid tumor. To ascertain Medicaid and managed care status around diagnosis, we linked the cancer registry to statewide hospital-based facility records collected by an independent state agency (Pennsylvania Health Care Cost Containment Council).

Study Design: We leveraged a natural experiment arising from county-level variation in mandatory MMC in Pennsylvania. Using a stacked difference-in-differences design, we compared changes in the probability of late-stage cancer diagnosis among those residing in counties that newly transitioned to mandatory managed care to contemporaneous changes among those in counties with mature MMC programs.

Results: Mandatory MMC was associated with a reduced probability of late-stage cancer diagnosis (-3.9 percentage points; 95% CI: -7.2, -0.5; *P* = .02), particularly for screening-amenable cancers (-5.5 percentage points; 95% CI: -10.4, -0.6; *P* = .03). We found no significant changes in late-stage diagnosis among non-screening amenable cancers.

Conclusions: In Pennsylvania, the implementation of mandatory MMC for non-elderly Medicaid beneficiaries was associated with earlier-stage diagnosis among newly diagnosed cancer patients with Medicaid, especially those diagnosed with screening-amenable cancers. Considering that over half of the sample was diagnosed with late-stage cancer even after the transition to mandatory MMC, Medicaid programs and managed care organizations should continue to carefully monitor the receipt of cancer screening and design strategies to reduce barriers to guideline-concordant screening or diagnostic procedures.

3.2 Introduction

Medicaid is an increasingly important source of health insurance coverage for low-income individuals with cancer.[188] After the Affordable Care Act (ACA), uninsurance among individuals newly diagnosed with cancer declined by one-third, and Medicaid covers a growing number of patients with cancer.[189] Because cancer contributes substantially to morbidity, mortality, and medical spending, state Medicaid programs must consider strategies to manage cancer care, control costs associated with this care, and improve cancer outcomes among Medicaid beneficiaries.[190-194]

In this context, efforts to detect cancers earlier are imperative, as early diagnosis drastically improves the chance of survival.[195-200] Evidence shows that disparities in cancer survival among Medicaid enrollees are largely explained by stage at diagnosis rather than differences in care received, implying that early detection is a prerequisite for effective cancer control.[201] The financing and organization of Medicaid may affect early cancer detection by influencing enrollees' access to care and receipt of screening and diagnostic services. However, there is little research on the impacts of Medicaid's programmatic features on early detection.

One salient trend across Medicaid programs that may affect early detection is the increasing reliance on managed care.[202] Medicaid managed care (MMC) involves the outsourcing of the administration and delivery of Medicaid services from states to private managed care organizations (MCOs) that receive capitated payments to manage a pool of beneficiaries; this contrasts with a fee-for-service (FFS) model in which Medicaid directly pays providers for services. Managed care is widespread across Medicaid programs, with over 41 states having some form of managed care program (comprehensive/risk-based managed care or primary care case management) as of July 2022 and 75% of Medicaid beneficiaries receiving services through MCOs.[203]

The decision to administer Medicaid through MCOs has implications for cancer detection. Capitation may incentivize MCOs to promote primary care and preventive services to offset demand for costly downstream care, such as acute or emergency services.[204-206] This may facilitate early detection by increasing access to cancer screening and diagnostic services.[207-211] Conversely, capitation may induce MCOs to deliver too little care (as delaying care until their beneficiaries lose Medicaid coverage, switch MCOs, or become eligible for Medicare may be financially advantageous)or aggressively manage utilization, which may impose barriers to receiving screening and diagnostic services. These countervailing incentives raise important empirical questions about the relationship between MMC and early cancer detection.

In this study, we examined changes in cancer stage at diagnosis associated with the implementation of mandatory MMC in Pennsylvania, which operates one of the largest Medicaid programs in the country, covering more than 3 million adults in 2022.[212] We analyzed incident cancer cases in the Pennsylvania cancer registry, which contains data on a nearly complete census of cancer cases in the state and reports the stage at diagnosis for each case. Consistent with prior literature, we interpret the stage at diagnosis (e.g., late vs. early stage diagnosis) as a marker of access to timely cancer screening and detection.[213] Using a stacked difference-in-differences design that leveraged the staggered regional implementation of mandatory MMC as a natural experiment, we compared changes in stage at diagnosis among newly diagnosed Medicaid beneficiaries in counties transitioning to mandatory MMC during the study period (2010-2018) to contemporaneous changes in counties with mature MMC programs that had been in operation since 1997.

3.2.1 Implementation of mandatory MMC in Pennsylvania

Pennsylvania introduced MMC as a pilot program with voluntary enrollment in 1986. Over subsequent decades, Pennsylvania expanded MMC and made MMC enrollment mandatory.[214,215] MMC penetration increased beginning in 1997 when the state established PA HealthChoices, a fully-capitated managed care program with mandatory enrollment for most non-elderly adult Medicaid beneficiaries.[216] Under this arrangement, MCOs receive per-member-per-month capitated payments and fully assume the financial risk of managing Medicaid-covered spending among enrolled beneficiaries. While MCOs were entirely at risk, how the MCOs reimbursed providers in their networks varied (e.g., some providers were paid on a FFS model).[217]

The state phased in the HealthChoices program over time across five different geographic zones, with the initial implementation occurring in 25 primarily urban counties of the Southeastern and Southwestern regions in 1997 (herein referred to as the "original HealthChoices counties"; see Figure A3.3). In remaining counties, beneficiaries could either enroll in voluntary MMC (if an MMC plan was offered in a county) or be assigned to an enhanced primary care case management (PCCM) program within Medicaid FFS called ACCESS Plus. Consequently, there was a stark difference in rates of MMC coverage between the original HealthChoices counties and other counties in Pennsylvania.

Eventually, the program was expanded to the remaining counties in three waves, which occurred in July 2012 (Wave 1), October 2012 (Wave 2), and March 2013 (Wave 3; Figure A3.4). The expansion of the HealthChoices program in these counties sharply increased the share of newly diagnosed Medicaid beneficiaries (i.e., incident cases) with MMC coverage from 10-20% in 2010 to nearly 70% in 2015, closing the gap in enrollment between the original and newly expanded counties (Figure A3.5). See Section 3.9.1 for more details of the transition.

3.2.2 Conceptual model and prior literature on the effects of MMC

MMC may influence early cancer detection through several channels.[218] MMC may improve access to care through case management and coordination within defined provider networks, lowering beneficiaries' transaction costs of seeking care.[219] In contrast, there are no defined networks in FFS, incentives for care management are limited, and access challenges are common because of low provider participation.[220] Moreover, conditional on accessing and seeking care, enrollees in MMC may be more likely to receive a comprehensive set of primary and preventive care services, which MCOs may encourage to reduce the use of costly health services downstream. MCOs may tie a portion of provider payments to performance based on quality and utilization management measures.[204-206] In addition, state agencies can influence care access through quality oversight and contracting.[221,222] In Pennsylvania's Medicaid, plan performance is monitored through quality measures such as the Healthcare Effectiveness Data and Information Set (HEDIS) measures, which include items on breast and cervical cancer screening since the 1990s.[223] Finally, MCOs can use capitation payments to cover nonmedical services via the in-lieu-of-services and value-added services provisions in managed care contracts,[224,225] which may address other barriers to cancer screening, such as lack of transportation or patient accompaniment.

At the same time, MCOs face incentives to control utilization to contain costs, which could adversely impact care access and utilization. For instance, MCOs employ gatekeeping (e.g., requiring primary care provider referrals to specialists) and utilization review.[226] Gatekeeping may limit access to specialists[227-229] who provide essential follow-up care, including diagnostic workup and actual staging of cancer.[230,231] Although these aspects of care management were also present in the Medicaid FFS, the degree of care management and coordination activities may have been limited in this model because it did not delegate responsibility to a single organization for managing the entirety of enrollee Medicaid spending.[232] Further, plans' willingness and abilities to provide coordinated care may also be influenced by the "churn" in Medicaid enrollment, which may alter the pool of Medicaid beneficiaries whose care is financially managed by MCOs. Therefore, *a priori,* the direction of the effect of MMC on early cancer detection is ambiguous.

To date, the literature on the effects of MMC has documented mixed findings related to changes in access and utilization across different states and Medicaid populations experiencing transitions in Medicaid administration.[204,233] Earlier studies of MMC examined outcomes among Medicaid-covered pregnant women and infants in specific states, finding conflicting results on whether MMC influences prenatal care utilization and birth outcomes.[217,220,234-236] Among Medicaid adults, studies have found inconsistent associations of MMC with access to care and health services use and preventable hospitalizations in studies using national surveys or state hospitalization records.[218,237-243] More recently, several studies have explored potential mechanisms that may account for the range of results from prior work.[244-248] Broadly, how beneficiaries access and use care within managed care may be determined by the details of managed care programs, including provider reimbursements and incentives,[246,249] network breadth,[248] competition among plans,[245] and specific utilization management practices.[247] In our context, only a few analyses have investigated outcomes related to cancer screening and early cancer detection, leaving a substantial gap in understanding how MMC may affect cancer outcomes.[211,250,251]

3.3 Methods

3.3.1 Data and sample

The primary data source was the Pennsylvania Cancer Registry, a population-based registry that collects information on nearly all newly diagnosed cases in Pennsylvania.[252,253] Using the registry, we identified primary solid tumor cases among adults aged 21 to 64. We excluded brain and hematological cancers, which do not follow conventional staging criteria.[254,255] We excluded cases with missing or invalid diagnosis dates, a secondary diagnosis within 365 days, or a diagnosis established through autopsy or death.[256] See Section 3.9.2 & 3.9.3 for detailed descriptions of the data sources and inclusion criteria.

3.3.2 Identifying Medicaid beneficiaries and managed care status

Although the registry provides information about the source of insurance for each cancer case, previous research has documented considerable misclassification in the registry-based classification of insurance (e.g., miscoding Medicaid as private insurance).[257-260] Therefore, we linked cancer cases in the registry with their inpatient discharge and outpatient procedure records, provided by the Pennsylvania Health Care Cost Containment Council (PHC4), as the next best alternative to identify Medicaid and managed care status. The PHC4 is an independent state agency to which all licensed healthcare facilities in Pennsylvania, including hospitals and freestanding ambulatory surgery centers, must report data.[261] Although not a true "gold standard," the PHC4 records provide a more reliable means to classify Medicaid and managed care coverage because the reporting facilities are required to verify records' accuracy and face financial incentives to accurately list payers for reimbursement purposes.[260-264] In addition, the PHC4 records utilize multiple payer variables and contain more granular information about each payer, which aids in more precise identification of both Medicaid and managed care status.

To ascertain the source of insurance around the time of diagnosis, we used the PHC4 record within a 30-days window of diagnosis (Section 3.9.4). All cases in the registry were linked to at least one PHC4 record, and over 76% (N = 202,283) had at least one linked record around the time of diagnosis. In this sample, we constructed a sample of Medicaid enrollees (Medicaid MMC or FFS) based on the payer information on the linked record. Because the MMC mandate exempted dual eligibles (i.e., older adults and persons with disabilities covered by Medicare and Medicaid), they were excluded.

3.3.3 Cancer stage outcome

We created a binary variable that characterized each diagnosis as either late-stage (=1) or early-stage (=0). We defined early-stage diagnosis as in situ, localized, or regional by direct extension and late-stage diagnosis as regional with lymph nodes involved, regional not otherwise specified, or distant stage.[213] We grouped unstaged cases (<5% of the sample) with late-stage cases because lack of staging may indicate poor access to care, especially in medically underserved populations,[265-267] and is associated with worse prognosis.[268] In a sensitivity analysis, we excluded the unstaged cases.

3.3.4 Covariates

We extracted demographic and clinical information from the cancer registry, including cancer type, sex, race and ethnicity, and age at diagnosis. Race and ethnicity information were abstracted from medical records by cancer registrars according to the standardized data fields.[269]

Based on this information, we created combined race and ethnicity categories. We controlled for race and ethnicity as a proxy for institutional and structural racism that may engender disparities in early detection within managed care.[270,271] We supplemented the registry data with other area-level variables matched to each case based on the Census tract or county of residence. We characterized the urbanicity of the census tract of residence using Rural-Urban Commuting Area (RUCA) codes from the US Department of Agriculture.[272] We obtained the Area Deprivation Index (ADI) for each census tract and created ADI quartiles based on the national ranks of ADI, with higher quartiles representing more disadvantaged tracts. Using the Area Health Resources Files, we constructed annual, county-level measures of health care resources (i.e., primary care physicians, nurse practitioners, physician assistants, federally qualified health centers, rural health centers, hospital beds) per 100,000 population.

3.3.5 Empirical framework

A key challenge in identifying the effects of MMC is endogenous selection into managed care.[249,273] In circumstances when enrollment in MMC is optional, Medicaid beneficiaries who voluntarily enroll in MMC may systematically differ from FFS beneficiaries, biasing comparisons of the two delivery models. To address selection, we exploit the fact MMC enrollment became *mandatory* for nearly all adult Medicaid beneficiaries in Pennsylvania.

We estimated the effect of mandatory MMC on cancer stage using a difference-in-differences (DD) design. In our framework, the original HealthChoices counties with established MMC programs served as controls because they experienced no changes in mandatory MMC status during the study period (i.e., always treated), and the counties newly transitioning to mandatory MMC are in the treated group. A key assumption of DD is that outcome trends in counties that transition to mandatory MMC ("treated") would have been similar to the original HealthChoices counties ("control") in the absence of MMC mandate.

In our context, the timing in the transition to mandatory MMC varies by county. Therefore, we partitioned our data into three cohorts, each containing observations from all control counties and counties belonging to each wave of the HealthChoices expansion. Then, we used a "stacked" DD analysis that aggregated cohort-specific treatment effects[274] (Section 3.9.5).

Our main regression specification is a pooled DD model, where *i* indexes Medicaid beneficiaries diagnosed with cancer, *c* indexes the county, *t* indexes the year-quarter of diagnosis, and *k* indexes a cohort. Specifically, we estimated linear probability DD models of the form:

$$y_{ictk} = \beta_0 + \beta_1 \mathrm{Treated}_{ick} * \ \mathrm{Post}_{itk} + \delta X_i + \theta X_{ct} + (\gamma_t * \mu_k) + (\tau_c * \mu_k) + \varepsilon_{ictk}$$

$\mathrm{Treated}_{ick}$ equals 1 if beneficiary *i* was diagnosed in the treated county *c* in cohort *k* and, Post_{itk} equals 1 if beneficiary *i* was diagnosed in time *t* after mandatory MMC went into effect in cohort *k*. X_i includes a vector of case-level covariates, which control for observed compositional changes in the sample. We further adjusted for a vector of time-varying, county-level healthcare resources (X_{ct}). Year-quarter fixed effects (γ_t) and county fixed effects (τ_c) adjusted for secular trends and time-invariant differences across counties, respectively. These fixed effects were interacted with cohort fixed effects (μ_k), thus identifying treatment effects from changes in outcomes between treated and control counties *within* the same cohort and eliminating comparisons between earlier vs. later treated counties. We clustered standard errors at the county level.

We also fit an event-study model to estimate dynamic treatment effects and test for parallel trends in the pre-treatment period:

$$y_{ictk} = \beta_0 + \sum_{\tau=-3,\tau\neq-1}^{5} \beta_\tau \, \mathrm{Treated}_{ick} * I[\tau = t]_{itk} + \delta X_i + \theta X_{ct} + (\gamma_t * \mu_k) + (\tau_c * \mu_k) + \varepsilon_{ictk}$$

Here, the Post_{itk} is replaced by a series of year dummies $I[\tau = t]_{itk}$, taking the year immediately before treatment as the reference year ($\tau = -1$). Parallel trends in the pre-period support the plausibility of the DD assumption that outcome trends in the treated and control counties would have evolved similarly in the absence of mandatory MMC.

3.3.6 Stratified analysis

We hypothesized that changes in stage would be more pronounced among cases diagnosed with cancers amenable to screening and early detection (i.e., breast, cervical, colorectal, lung, and prostate cancers for which guideline-recommended screening procedures exist[189,213]). Moreover, we expected stronger effects for breast and cervical cancers, for which screening was monitored by the state using quality measures throughout the study period and the diagnostic procedures were relatively routine. Therefore, we stratified the models by screening amenable vs. non-amenable cancers and major cancer types. To account for the different distributions of cancer types by sex, we also reported results separately by cancer type for females and males.

3.3.7 Robustness checks

We conducted several robustness checks to address possible threats to the DD design. First, the exclusion of cases without a PHC4 record around diagnosis poses a concern that the sample may be changing systematically over the study period. Hence, our DD estimates may be biased by any unmeasured characteristics that are *correlated* with the probability of linkage (i.e., inpatient or outpatient visits) and *differential* between the treated and control counties. To analyze how the exclusion may affect our findings, we compared the characteristics of cases with vs. without a PHC4 linkage and investigated any differential changes in the linkage.

Second, we explored other compositional changes in the Medicaid sample. Notably, our study period spans the years after Pennsylvania expanded eligibility for Medicaid under the Affordable Care Act, introducing the newly eligible groups whose characteristics may differ from existing beneficiaries into the sample. Therefore, we assessed time-varying effects before and after the date Pennsylvania expanded Medicaid (January 1, 2015) and the potential differential take-up of insurance coverage in treated vs. control counties. To broadly assess other changes in beneficiary characteristics over time, we checked for any differential trends in measured covariates between the treated and control counties.

Third, we conducted a falsification test, using individuals with private insurance and the uninsured as placebo groups. Because they were not targeted by the MMC mandate, any changes in outcomes in this population could reveal other unmeasured time-varying factors, such as provider care patterns, that may bias the DD estimates. Therefore, the null effect among these patients can help rule out potential time-varying factors that would have affected all non-elderly adults, not just those with Medicaid.

Finally, we performed a “leave-one-out” analysis, in which we replicated the main model by sequentially excluding one county at a time to identify any influential outlier counties.

3.4 Results

3.4.1 Characteristics of newly diagnosed Medicaid beneficiaries

We included 29,322 Medicaid beneficiaries newly diagnosed with cancer (Figure A3.8**,** Figure A3.6). Summary statistics in Table 3-1 show that the sample in the treated counties was more likely to be non-Hispanic white (89% vs. 56%) residing in non-urban (41% vs. 4%) and higher deprived areas (third ADI quartile: 36% vs 24%), compared to those in the control counties. Treated counties had fewer primary care physicians and physician assistants but more federally qualified health centers and rural health centers per 100,000 residents. These differences are expected, given that the treated counties were predominantly in rural areas.

3.4.2 Changes in MMC coverage

Following the implementation of mandatory MMC, there was a sharp and sustained increase in MMC coverage in the treated vs. control counties (Figure 3.2). Table 3-2 presents this change from the pooled DD models. Column 1 presents the estimate from the baseline model (only controlling for the fixed effects), showing a 41.8 percentage points (pp) differential increase in MMC coverage (95% CI: 37.8, 45.8; $P < .001$). The take-up of MMC coverage is incomplete, likely because some beneficiaries remain in Medicaid FFS while waiting for placement in a managed care plan and there are measurement errors in classifying MMC coverage. Columns 2-4 show that our estimate of MMC coverage is robust to covariate adjustments.

3.4.3 Changes in the probability of late-stage diagnosis

Table 3-3 presents unadjusted and adjusted DD estimates showing differential changes in the probability of late-stage diagnosis. Because the unadjusted and adjusted estimates are statistically indistinguishable, we emphasize the adjusted estimates that are more precise and account for differences in population characteristics across counties and over time. In the fully adjusted model, mandatory MMC was associated with a 3.9 pp (95% CI: -7.2, -0.5; P = .02) reduction in the probability of late-stage diagnosis among all cancer cases, representing a 7% relative decrease from the baseline mean (55.9%). The event study estimates in Figure 3.2 suggest a delayed effect of MMC (starting in the second year in the post-period) and no significant differential pre-trend. In Figure A3.9, we show that the differential reduction in late-stage diagnosis in the treated counties is driven by an overall increase in cancer detection and an increase in the number of early-stage cases.

3.4.4 Stratified analysis

The effect of mandatory MMC was greater among screening-amenable cancer cases (DD: -5.5 pp; 95% CI: -10.4, -0.6; *P* = .03; Figure 3.2). We found no significant changes among non-screening amenable cancer cases (*P* = .31), although we cannot rule out a reduction as large as 6.5 pp. Among screening-amenable cancers, the effect was driven by more significant changes among breast cancer cases, though there were also large but imprecise reductions in late-stage diagnosis among cervical and prostate cancer cases, likely due to smaller sample sizes.

3.4.5 Robustness checks

One central threat to our DD design arises from the decision to exclude cases without linkage to a PHC4 record around diagnosis. We found a significant increase in the probability of PHC4 linkage in the treated counties by 2.3 pp (*P* < .01) relative to the contemporaneous change in the control counties (Figure A3.11). Though this represents only a 3% increase in the probability of linkage from the baseline mean (74.9%), it poses a concern that our main estimates reflect changes in the populations included in the treated vs. control counties, rather than actual changes in cancer stage.

We conducted two alternate specifications to gauge the impact of the differential linkage on our main estimates. In the first model, we retained patients without a linked PHC4 record, used their primary payer at diagnosis listed in the cancer registry to impute Medicaid status, and controlled for the PHC4-linked status as a covariate. The main treatment effect was similar in this model compared to the main specification (DD = -3.4 pp; 95% CI: -6.5, -0.04; *P* = 0.028). In the second model, we only included cases that were *not* linked but whose information in the registry indicated Medicaid coverage at diagnosis. We recovered a treatment effect similar in magnitude (DD = -2.4 pp; 95% CI: -10.0, 5.3; *P* = 0.54). These results strongly suggest that differential linkage is unlikely to appreciably drive our findings.

In other robustness checks, we provide other evidence supporting the validity of our DD design. Our falsification test showed no significant changes in late-stage diagnosis among the placebo groups, minimizing concerns about other unmeasured time-varying factors (Figure A3.13). We also did not detect significant impacts from the ACA Medicaid expansion or any major changes in covariate trends (Figure A3.14**,** Table A3-8**,** Table A3-7). Moreover, no outlier counties were driving our main estimate. (Figure A3.15) Finally, the results are robust to excluding the unstaged cases (Table A3-9**).**

3.5 Discussion

Leveraging a natural experiment in Pennsylvania's Medicaid program that mandated MMC enrollment, we found a significant reduction in the probability of late-stage diagnosis among incident cancer cases in non-elderly Medicaid beneficiaries. Improvements in early detection were driven by reductions in late-stage diagnosis among screening-amenable cancers (i.e., breast, cervical, colorectal, lung, and prostate cancers), especially for breast cancers. Putting our results in context, we note that the changes in late-stage diagnosis observed (-7.0% reduction) align with estimates from other studies examining coverage expansions on early detection. For instance, Lin et al. noted a 9.1% differential increase in the population rate of early-stage diagnosis following Medicaid expansion in states that expanded Medicaid following the ACA.[213] In addition, Myerson et al. found a 12% increase in early-stage detection at the age-eligibility threshold for Medicare.[79] Our study complements these prior studies by elucidating how the details of administering insurance benefits *among* the insured may impact the stage at diagnosis. Our findings also add to the general literature on the effects of MMC by granularly assessing an outcome relevant to low-income adults with cancer—a growing share of Medicaid enrollees who are at a higher risk of experiencing adverse health outcomes, including mortality.

Although we cannot illuminate the exact mechanisms leading to early detection, our results are consistent with two hypotheses. First, MMC may improve beneficiaries' *overall* access to care,[238,239] facilitating either the frequency or type of contact with the healthcare system, which creates opportunities for more timely cancer identification through diagnostic and screening tests. The fact that we observed a more significant reduction in late-stage diagnosis among screening-amenable cancers suggests that MMC may have improved access to primary and outpatient care.[211,229,275-277] In contrast, variations in late-stage diagnosis among non-screening amenable cancers by type of insurance may be small, suggesting a more limited role for insurers in improving timely detection. Second, conditional on access, the use of preventive screening may be higher in MMC than in Medicaid FFS due to financial incentives introduced by the capitated reimbursement.[278-280] To explore this hypothesis, we examined the heterogeneity in MMC's effects by cancer type. We found that the reduction in late-stage diagnosis was most clearly demonstrated for breast cancer cases. This may suggest that MCOs prioritized screening for breast cancer because of its widespread incidence among younger female beneficiaries that are disproportionately reflected in Pennsylvania's Medicaid population.[281-283] Furthermore, managed care plan quality measures during the study period included items on breast screening, providing additional impetus for MCOs to focus on screening for breast cancer as plan performance may be incorporated into contracting decisions (e.g., value-based purchasing).[284-287] To the extent that state oversight of plan quality facilitates targeted efforts for early detection, expanded monitoring of screening for other screening-amenable cancers such as colorectal or lung cancers may be valuable.[288,289] More evidence on how quality reporting influences receipt of cancer screening may be timely, especially since the measure on colorectal cancer screening was added to the Medicaid Core Set in 2022.[290]

It is important to emphasize that our findings are specific to the experiences of mandatory MMC in Pennsylvania and may not generalize to other states with different managed care contexts and trajectories. For example, a recent study by Sunkara et al. examined changes in early detection following Connecticut Medicaid's transition from managed care to FFS in 2012 and reached an opposite conclusion, noting that the transition *improved* early detection.[291] These conflicting results provide yet another example of inconsistent effects of MMC across states and demonstrate the importance of accounting for particular attributes of Medicaid and managed care programs in contextualizing our findings. To this end, several features of Pennsylvania's MMC program are worth mentioning. First, a prior evaluation of the program suggested that MCOs reimbursed providers at a rate similar to or higher than the FFS payment rate to optimize provider participation in the care network,[292] which may have translated into higher acceptance of Medicaid patients and better access to care (during the study period, over 80% of physicians accepted new Medicaid patients[293]). This is consistent with prior empirical work establishing a strong link between generous provider payments and increased primary and preventive care utilization.[246,249,250,294] Second, there is a fair amount of competition between plans within Pennsylvania's HealthChoices program, with at least 4 MCOs operating within each MMC region[217,295], motivating improvements in plan quality by increasing spending in high-value preventive care.[245] Third, MCOs employed a bundle of disease management strategies (such as health assessments) using integrated data systems, and these specific case management tools may further contribute to identifying enrollees with high care needs, some of who may have presented with symptoms that indicate cancer.[247,292] Lastly, the staggered adoption of MMC allowed plans to mature by accumulating lessons and experiences over time, fostering a more seamless transition to managed care with each wave. This is relevant to our analysis that assessed the effects of the final wave of transition to MMC in Pennsylvania.

While the finding that MMC improved early detection is encouraging, further efforts are warranted to address remaining disparities in early detection, especially among screening amenable cancers. In our sample, late-stage diagnosis was common for colorectal and lung cancer (73.6%), even though there are guideline-recommended screening procedures for these cancers. One factor that may contribute to this variation in early detection is screening modality. For instance, screening for breast cancer relies on procedures such as mammography that are widely available and performed non-invasively.[296] In contrast, colonoscopies—the most common and definitive screening procedure for colorectal cancer—are clinically more complex, requiring more intensive preparation and time.[297] There are additional access barriers to colonoscopies, such as lack of transportation or accompaniment.[298] There may be opportunities for MCOs to address these barriers by using capitated payments to cover nonmedical services (i.e., "in lieu of" services or value-added services) such as patient navigation services, which have been shown to increase rates of guideline-concordant screening.[299] Moreover, MCOs can design interventions that target plan members who are not up to date with screening.[300] These strategies will be essential in helping to reduce disparities in screening among patients in Medicaid.[301]

3.6 Limitations

We acknowledge several limitations to our analysis. First, because we included cancer cases a corresponding record for a hospitalization or an outpatient procedure, our sample may not represent the broader Medicaid population. However, we found that the measured characteristics of the cases with vs. without linked records were generally similar, which is in line with prior studies suggesting that hospital-based registries may perform relatively well in capturing cancer cases in a given population, especially cases that are typically treated with surgery and more prevalent in younger populations (e.g., breast).[302,303] Furthermore, the distribution of cancer stage in this study was comparable to a previously reported estimate showing that over 50% of cases with Medicaid were diagnosed with Stage III & IV cancers.[96] Second, we cannot precisely identify Medicaid MMC vs. FFS status due to a lack of detailed Medicaid eligibility and enrollment information, introducing measurement errors in classifying Medicaid and MMC coverage. However, our study design leveraged the introduction of mandatory MMC enrollment, which we could observe precisely, and we only directly used individual-level MMC information in the hospital records to demonstrate that this mandate corresponded to a large increase in MMC enrollment. In so far as our sample includes certain beneficiaries that are exempt from the MMC mandate, such as newly enrolled Medicaid FFS beneficiaries waiting placement in managed care plans, it will bias the result towards the null (since these beneficiaries likely received little to no care management compared to established Medicaid beneficiaries). However, it is also possible that MCOs may have rapidly connected these individuals to primary care upon enrollment and facilitate preventive screening,[287,304,305] which is consistent with our hypothesis regarding MMC. Furthermore, we provide descriptive evidence suggesting that our sample largely includes established Medicaid beneficiaries with hospital records indicating Medicaid enrollment one year before cancer diagnosis (Table A3-5). Third, the data did not permit unpacking the mechanisms leading to early cancer detection. There are opportunities for further research utilizing administrative Medicaid or survey data to specifically examine potential changes in access to care and utilization of various cancer screening services. Future research should also incorporate person-level factors that may mediate the effects of MMC, such as prior experience with Medicaid and churning in enrollment.

3.7 Conclusion

Among non-elderly adult Medicaid beneficiaries in Pennsylvania, mandatory MMC was associated with improved early detection of cancer, driven by pronounced reductions in late-stage diagnosis of cancers for which screening is most accessible, widespread, and incentivized through targeted quality measures. Given existing disparities in cancer outcomes in this population, Medicaid programs should dedicate further efforts to improve early detection.

3.8 Tables and figures

Table 3-1 Characteristics of Medicaid beneficiaries newly diagnosed with a solid tumor in Pennsylvania cancer registry, 2010-2018

Characteristic	Treated Counties (N = 7,588)	Control Counties (N = 21,734)	Standardized mean difference
Sex			
Male	43.8%	42.9%	0.02
Female	56.2%	57.1%	0.02
Race and ethnicity[a]			
Hispanic	2.6%	8.1%	0.25
Non-Hispanic White	88.9%	55.5%	0.80
Non-Hispanic Black	5.5%	30.1%	0.68
Other[b]	0.8%	3.4%	0.18
Unknown	2.3%	2.9%	0.04
Age at diagnosis			
21-39	13.4%	12.5%	0.03
40-49	20.0%	20.2%	0.01
50-59	44.6%	44.2%	0.01
60-64	22.0%	23.1%	0.03
Urbanicity of residence[c]			
Urban	58.7%	96.0%	1.00
Large town	24.5%	3.2%	0.65
Small town	9.4%	0.4%	0.43
Rural	7.5%	0.4%	0.37
Area deprivation index[d]			
Quartile 1	1.7%	14.7%	0.49
Quartile 2	20.7%	21.4%	0.02
Quartile 3	36.4%	23.3%	0.29
Quartile 4	41.2%	40.6%	0.01
Cancer type[e]			
Breast	15.1%	16.7%	0.04
Cervical	2.5%	2.6%	0.01
Colorectal	10.1%	11.2%	0.03
Lung & bronchus	18.9%	17.0%	0.05
Prostate	3.4%	4.5%	0.06
Non-screening amenable cancers	50%	48%	0.04
County-level healthcare resources per 100,000 residents[f]			
Federally qualified health centers	3.8	2.1	0.28

Hospital beds	330.8	227.9	0.34
Primary care physicians	46.3	58.3	0.30
Physician assistants	39.0	46.4	0.19
Nurse practitioners	63.6	42.6	0.23
Rural health centers	3.8	0.4	0.76

Note: The table displays the means and standardized mean difference in characteristics between individuals residing in the control counties (i.e. the original HealthChoices counties) and the treated counties that newly transitioned to mandatory managed care in Pennsylvania during the study period. The sample includes incident cancer cases from the Pennsylvania Cancer Registry (2010-2018) with at least one linked PHC4 record that listed Medicaid as a payer source.

[a] Race and ethnicity were separately recorded by cancer registrars based on the information they received from various sources, including medical records and face sheets. Based on the recorded information, we created combined race and ethnicity categories as listed in the table.

[b] "Other" group includes individuals who were identified as non-Hispanic and belonging to at least one of these race categories: American Indian, Aleutian, Eskimo, Chinese, Japanese, Japanese, Filipino, Hawaiian, Korean, Vietnamese, Laotian, Hmong, Kampuchean (including Khmer & Cambodian), Thai, Asian Indian, Pakistani, Micronesian, Chamorro, Guamanian, Polynesian, Tahitian, Samoan, Tongan, Melanesian, Fiji Islander, or New Guinean.

[c] Urbanicity and area deprivation index were characterized at the case level using the census tract of residence. [d]Higher area deprivation index quartiles represent areas with greater socioeconomic deprivation.

[e] Cancers other than breast, cervical, colorectal, lung, and prostate cancers were categorized as non-screening amenable.

Mean healthcare resources were calculated at the county level using the Area Health Resources Files.

Table 3-2 Changes in Medicaid managed care coverage among newly diagnosed Medicaid beneficiaries between the treated and control counties, before and after mandatory Medicaid managed care

	(1)	(2)	(3)	(4)
DD estimate (percentage points)	41.8	42.0	42.3	40.3
95% CI	[37.8, 45.8]	[37.9, 46.0]	[38.1, 46.4]	[36.5, 44.1]
P-value	< .001	< .001	< .001	< .001
Cancer fixed effects	No	Yes	Yes	Yes
Case-level controls[a]	No	No	Yes	Yes
County-level controls[b]	No	No	No	Yes
No. of cases[c]	67,617	67,617	67,617	67,617
F-statistic	151.5	232.3	481.4	491.1

Abbreviation: DD, difference-in-differences

Note: The table displays the difference-in-differences coefficients (transformed to percentage point changes), their 95% confidence intervals, and the F-statistics, modeling Medicaid managed care coverage around the time of diagnosis as the outcome. Information on Medicaid and managed care status was extracted from the linked PHC4 records around the time of diagnosis. All models controlled for year-by-stack and county-by-stack fixed effects. Standard errors were clustered at the county level.

[a] Case-level controls included sex, race/ethnicity, age at diagnosis, urbanicity of residence, and Area Deprivation Index quartiles.

[b] County-level controls included yearly healthcare resources (i.e., federally qualified health centers, hospital beds, primary care physicians, physician assistants, nurse practitioners, and rural health centers) per 100,000.

[c] The number of cases is greater than the total from Table 1 because certain control observations are replicated in each stacked cohort.

Table 3-3 Changes in late-stage diagnosis among newly diagnosed Medicaid beneficiaries between the treated and control counties, before and after mandatory Medicaid managed care

Unadjusted mean, % (95% CI)				Difference-in-differences in pp			
Controls		Treated		Unadjusted[a]		Adjusted[b]	
Pre	Post	Pre	Post	Estimate (95% CI)	P	Estimate (95% CI)	P
51.8 (50.6, 52.9)	50.4 (48.5, 52.4)	55.9 (53.4, 58.4)	52.0 (50.4, 53.6)	-2.6 (-6.2, 1.0)	0.15	-3.9 (-7.2, -0.5)	0.02

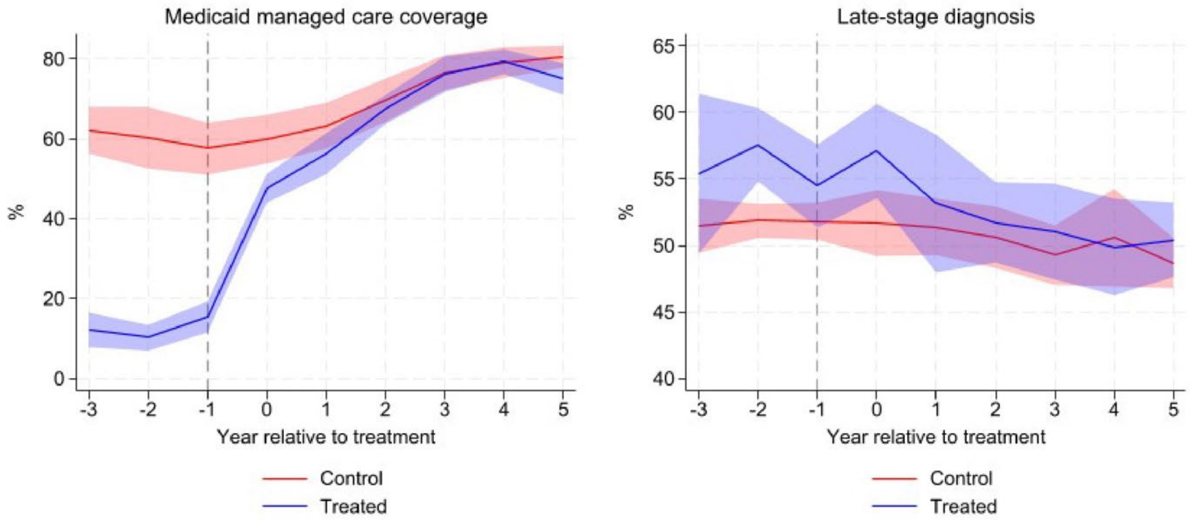
Abbreviation: pp, percentage points

Notes: The table displays unadjusted mean (in percentage) outcomes in pre- vs. post-period for control and treated counties and the adjusted difference-in-differences coefficients (in percentage points). Standard errors were clustered at the county level.

[a] The unadjusted model only controlled for the county- and year-quarter-by-stack fixed effects.

[b] Adjusted for county- and year-quarter-by-stack fixed effects, case-level controls (i.e., sex, race/ethnicity, age at diagnosis, urbanicity of residence, and Area Deprivation Index quartiles) and yearly county-level healthcare resources (i.e., federally qualified health centers, hospital beds, primary care physicians, physician assistants, nurse practitioners, and rural health centers) per 100,000.

Panel A: Trends in outcomes



Panel B: Differential changes in outcomes

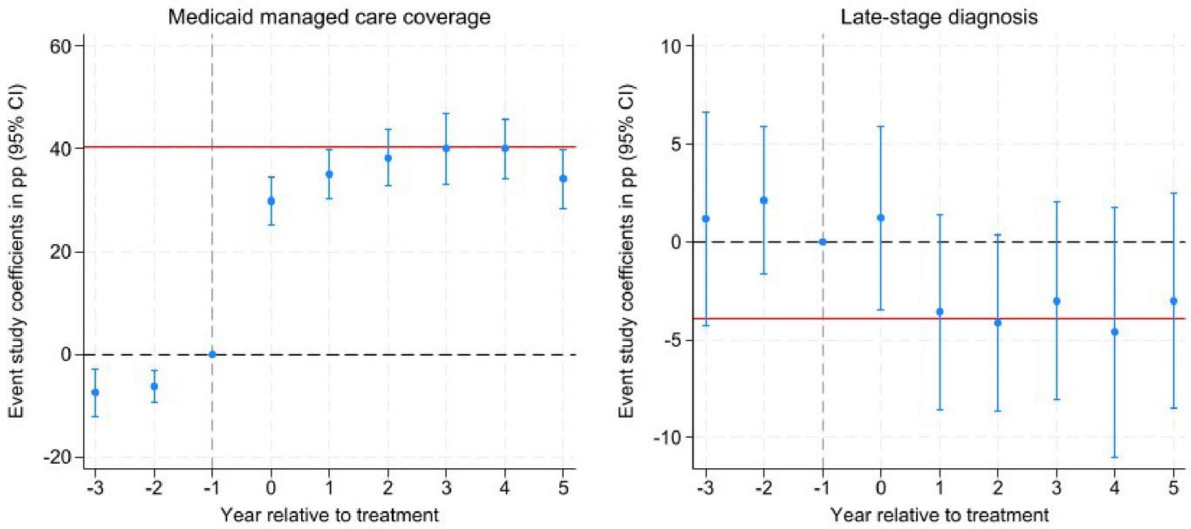


Figure 3.1 Trends and differential changes in the probability of Medicaid managed care coverage and late-stage diagnosis among cancer cases in non-elderly adults with Medicaid coverage in the treated vs. control counties

Abbreviation: pp, percentage-points

Note: In Panel A, we display trends in the proportion of Medicaid managed care coverage and late-stage diagnosis among cancer cases in Medicaid-covered adults between the treated and control counties, respectively. In Panel B, we show difference-in-differences event study coefficients that modeled the differential probability of Medicaid managed care coverage and late-stage diagnosis, respectively. The event study models adjusted for cancer fixed effects, case-level controls, yearly county-level healthcare resources per 100,000, year-quarter-by-stack, and county-by-stacked fixed effects. We clustered standard errors at the county level. The dotted vertical line represents the reference year, or one year before the transition date to mandatory Medicaid managed care within each stacked cohort (Cohort 1: July 1, 2012; Cohort 2: October 1, 2012; Cohort 3: March 1, 2013. The dotted red lines correspond to the pooled difference-in-differences estimates.

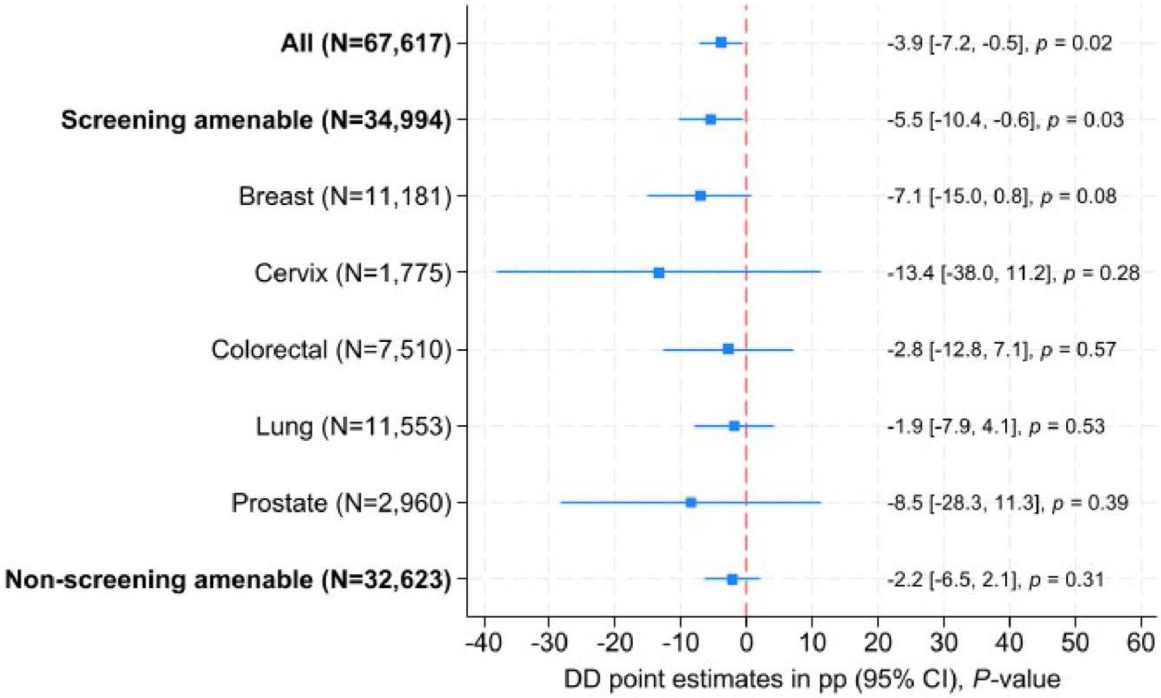


Figure 3.2 Differential changes in the probability of late-stage diagnosis in the treated vs. control counties, stratified by cancer type

Abbreviation: DD, difference-in-differences
Note: The figure displays difference-in-differences coefficients showing the effects of Medicaid managed care by cancer type. Each model adjusted for cancer fixed effects, patient-level controls, yearly county-level healthcare resources per 100,000 population, year-quarter-by-stack, and county-by-stack fixed effects. "Screening amenable" cancers included cancers amenable to early detection and preventive screening, including breast, cervical, colorectal, lung, and prostate cancers. All other cancers were categorized as "non-screening amenable."

3.9 Appendix

3.9.1 Details on Pennsylvania Medicaid and the HealthChoices program

Pennsylvania's Medicaid program (Medical Assistance; MA) has provided health insurance coverage to children, pregnant women, families with children, individuals with disabilities, and aged Medicaid beneficiaries meeting defined income eligibility thresholds (before the expansion of Medicaid under the Affordable Care Act).[214] While MA was initially designed as a fee-for-service program, Pennsylvania experimented with *voluntary* managed care in MA via a pilot program that allowed MA beneficiaries in urban areas in Pennsylvania to enroll in a managed care plan starting in 1986. Concluding that the pilot experiment was largely successful, Pennsylvania submitted a waiver to the Health Care Financing Administration (HCFA) to establish a mandatory Medicaid managed care (MMC) program called HealthChoices.[216] Before the establishment of the HealthChoices program in 1997, over 4.5 million beneficiaries had enrolled in MMC plans in Pennsylvania.[306] By further mandating MMC enrollment, the state sought to control growing Medicaid spending while improving care access and quality.

When implementing the HealthChoices program, Pennsylvania used a zone-based, phased-in schedule, which introduced mandatory MMC across zones at different points in time.[307] Figure A3.3 shows these zones: Northeast, Northwest, Lehigh/Capital, Southeast, and Southwest. The staggered implementation of the program allowed the state to dedicate enough time and resources to each wave of expansion, allowing lessons learned from prior expansion to guide future waves of transition. This schedule also helped managed care organizations (MCOs), which had primarily served beneficiaries residing in urban areas, to tailor plans to meet the needs of beneficiaries in more rural parts of Pennsylvania. Because existing penetration of managed care was relatively high in all counties in the Southeast and parts of Lehigh/Capital & Southwest zones, the state first introduced the MMC mandate in these counties in 1997, planning to gradually expand mandatory MMC statewide.

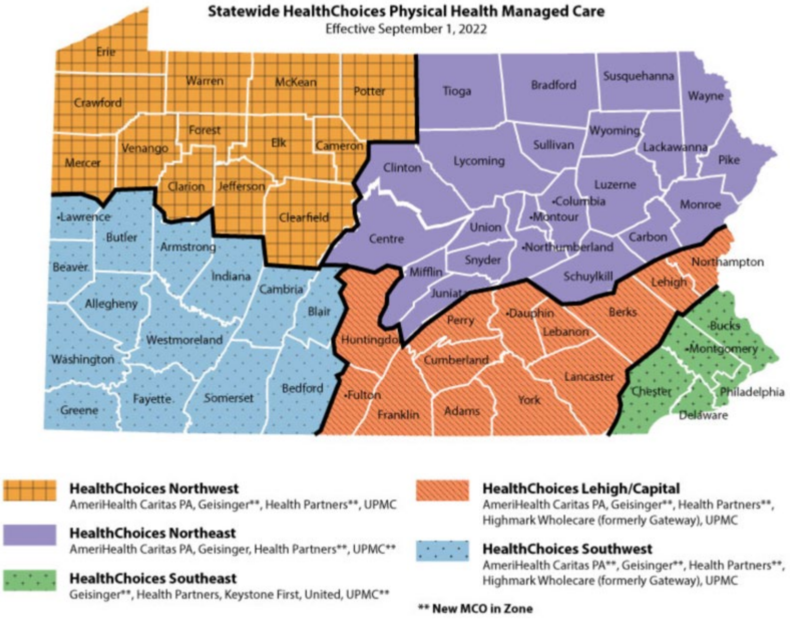


Figure A3.3 Pennsylvania HealthChoies zones

Abbreviation: MCO, Managed care organizations
Note: This map displays the counties in Pennsylvania belonging to each managed care zone. Below the map, the list of operating managed care organizations within each zone is included. Source: PA Department of Human Services. "Statewide Managed Care Map," https://www.dhs.pa.gov/providers/Providers/Pages/Statewide-Managed-Care-Map.aspx

In remaining counties where MMC enrollment was not yet mandatory, beneficiaries could either choose MMC coverage (if a managed care plan was available in a county) or receive coverage through an enhanced Primary Care Case Management (PCCM) program called ACCESS Plus.[308] Although ACCESS Plus adopted certain elements of managed care, it was not a fully capitated program and reimbursed providers on a traditional, fee-for-service basis. All Medicaid beneficiaries in fee-for-service Medicaid were enrolled in ACCESS Plus, though they could voluntarily enroll in a managed care plan if at least one plan were available in their country of residence. Upon enrollment, beneficiaries in ACCESS Plus were assigned to a primary care practitioner (i.e., a physician or a certified nurse practitioner) responsible for managing patient care, including providing referrals for health care services. Moreover, the state contracted with a separate disease management vendor tasked with providing more intensive disease management services for beneficiaries with certain chronic illnesses. During this time, the state increased provider reimbursement rates from 0.52 of the Medicaid-to-Medicare fee index in 2003 to 0.73 in 2008 (aligned with the national average of 0.72). The state also provided pay-for-participation incentives (about $10-40 per patient) for higher-quality providers meeting certain process and clinical standards. However, no single entity akin to an MCO was responsible for the entirety of an enrollee's Medicaid spending.[232]

Several factors drove the decision to rely on the enhanced PCCM model in the counties without mandatory MMC.[308] First, there were concerns about the abilities of MCOs to negotiate adequate and affordable networks in rural areas featuring only a limited number of providers. Second, the state felt confident about its internal claims and utilization management capabilities and did not see a need to outsource such functions to MCOs. Third, in areas with voluntary managed care, ACCESS Plus represented a source of competition and provided a basis for evaluating the cost and quality of MMC. Therefore, there was a lag in mandatory MMC implementation outside the original HealthChoices counties. In the meantime, a coalition of MCOs conducted an independent evaluation of mandatory MMC, which found larger cost savings and improved access and quality of care under MMC vs. ACCESS Plus.[292]

In April 2012, the state announced that all Medicaid beneficiaries, unless they fell into an exempted category, would be required to enroll in MMC, expanded the HealthChoices program in the remaining counties.[309] The exact schedule of the expansion and counties included in each wave of expansion is shown in Figure A3.4.

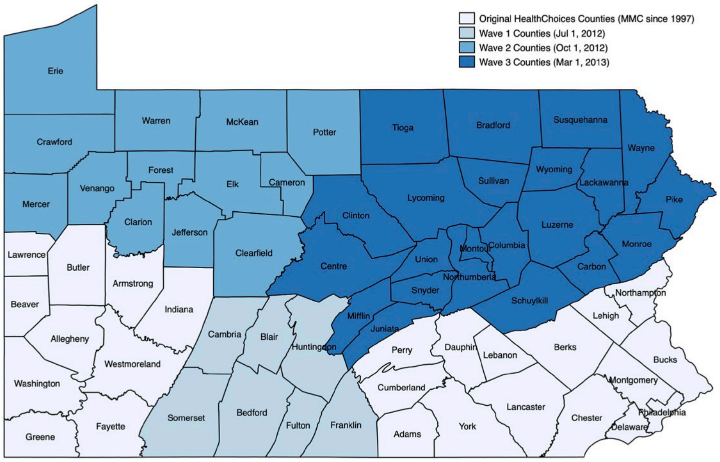


Figure A3.4 Schedule of HealthChoices expansion by counties in Pennsylvania

Abbreviation: MMC, Medicaid managed care
Note: The map displays the counties in Pennsylvania belonging to each wave of transition to Medicaid managed care (PA HealthChoices). In the original HealthChoices counties, managed care was mandatory for eligible non-elderly adult Medicaid beneficiaries since 1997. During the study period, there were three waves of transitions to Medicaid managed care: Wave 1 counties switched to mandatory Medicaid managed care on July 1, 2012; Wave 2 counties switched on October 1, 2012; Wave 3 counties switched on March 1, 2013.

In the top panel of Figure A3.5, we show that the implementation of mandatory MMC via expansions of the HealthChoices program resulted in large MMC coverage increases among Medicaid beneficiaries newly diagnosed with cancer (i.e., incident cases) in our data. Specifically, the share of MMC coverage increased from 10-20% in 2010 to nearly 60% by 2014, closing the gap in MMC enrollment between the original HealthChoices and the counties in Waves 1-3. Moreover, the bottom panel indicates a sharp increase in MMC coverage even among cancer cases residing in counties where MMC enrollment was optional (less than 18% had MMC coverage in 2010). In our analysis, the counties in Waves 1-3 served as treated counties, while the original HealthChoices counties, which had mature MMC programs by 2012, were included as control counties.

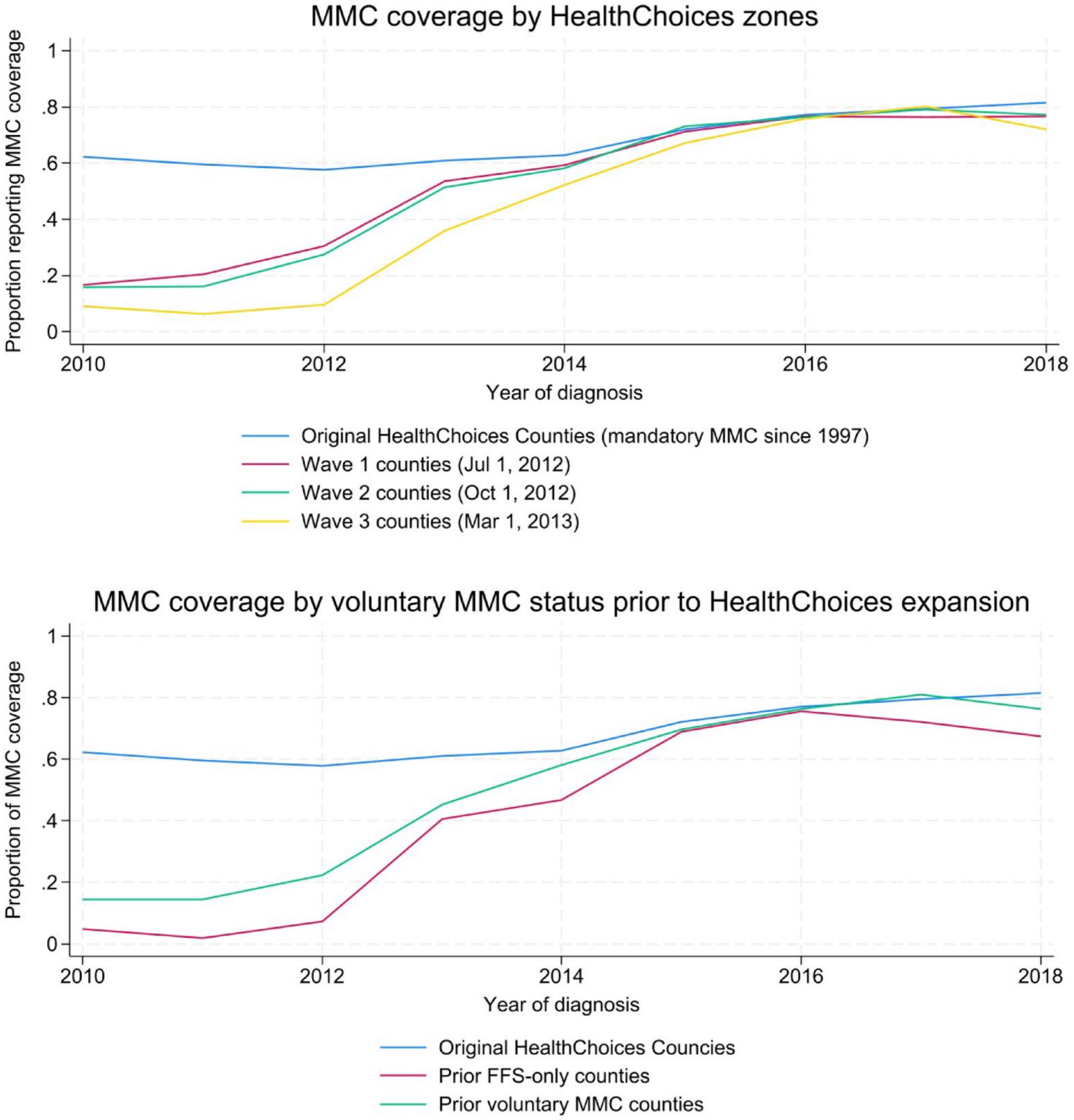


Figure A3.5 Trends in Medicaid managed care coverage in cancer cases among non-elderly adults with Medicaid during the study period

Abbreviations: MMC, Medicaid managed care; FFS, fee-for-service
Note: The top panel plots yearly proportions of MMC coverage separately by counties belonging to each wave of Medicaid managed care expansion. The bottom panel shows trends in MMC coverage separately for the original HealthChoices counties, the counties that had voluntary managed care ("Prior voluntary MMC counties"), and the counties fully served by ACCESS Plus, the primary care case management program within Medicaid fee-for-service ("Prior FFS-only counties")

3.9.2 Details about data sources

3.9.2.1 Pennsylvania cancer registry

The primary data source for our study is the Pennsylvania Cancer Registry (PCR), a population-based registry that collects information on all incident cases of cancer diagnosed or treated in Pennsylvania.[310] As a part of the National Program of Cancer Registries (NPCR), administered and funded by the Centers for Disease Control and Prevention, the PCR ensures the availability of reliable, high-quality data on cancer incidence and treatment in Pennsylvania. The PCR is also annually certified by the North American Association of Central Cancer Registries (NAACCR) and NPCR for meeting the standard of completeness and timeliness for a population-based cancer registry.

The PCR collects cancer data from various reporting sources, including hospitals, clinics, laboratories, radiation facilities, cancer and surgery centers, doctor’s offices, and death certificates. Reporting to the PCR is mandated per the Pennsylvania Cancer Control, Prevention, and Research Act of 1980 and regulations on reporting communicable and non-communicable diseases.[311] Each year, the PCR receives information on roughly 76,000 newly diagnosed cancer cases and their demographic and medical information, including cancer types, stage at diagnosis, the first course of treatment, and vital status.

From the PCR, we extracted the following variables: sex, race/ethnicity, age at diagnosis, census tract and county of residence, cancer type, and stage at diagnosis. The entities submitting information to the PCR, such as health care facilities and practitioners, provide demographic information about each cancer case. Although detailed protocols are in place to ensure standardization of the collected data by the PCR[312], prior investigations have reported that there may be some inconsistencies in which information about race and ethnicity[269] or sex[313] is recorded and abstracted in cancer registry data. We categorized cancer types using the International Classification of Diseases for Oncology, 3rd edition (ICD-O-3) codes. To determine the stage at diagnosis, we used the SEER summary stage variable, routinely provided by the PCR after reviewing a combination of the clinical and pathological documentation of cancer.[314]

3.9.2.2 Pennsylvania Health Care Cost Containment Council records

We linked the data from PCR with inpatient discharge and outpatient procedure records provided by PHC4, an independent state agency that collects data about the cost and quality of healthcare in Pennsylvania. The PHC4 collects approximately 5.2 million inpatient and ambulatory/outpatient records from all licensed hospitals and free-standing ambulatory service facilities in Pennsylvania annually.[315] The collected data also include financial data, including expected payer source for each facility visit[316], which we used to identify sources of insurance coverage for individuals newly diagnosed with cancer. To flag Medicaid beneficiaries, we include individuals whose PHC4 record around the time of diagnosis listed “Medicaid, FFS” or “Medicaid, HMO.”

We relied on PHC4 records to ascertain sources of insurance coverage around the time of diagnosis for two reasons. First, although the PCR data contain a variable on insurance status, existing literature has documented misclassification in the payer variable in the registry.[260,262,317,318] In particular, previous research suggests that Medicaid managed care plans may be misclassified as commercial insurance,[319] which complicates efforts to accurately identify Medicaid beneficiaries enrolled in Medicaid managed care during the study period. Second, the registry summarizes coverage information using a single variable that may be updated over time, which makes it difficult to pinpoint the source of coverage precisely around the time of diagnosis.[260] For instance, prior coverage information would be no longer available for patients who switched insurance at diagnosis or during treatment.

We acknowledge that payer information in PHC4 records does not meet a proper "gold standard" in verifying sources of coverage. However, in the absence of administrative Medicaid records, inpatient and outpatient visit records are one of the best available alternatives to ascertain sources of coverage more reliably.[320] Since payers listed on each PHC4 record are the entities from which facilities expect reimbursement, facilities are incentivized to code payer information accurately and comprehensively.

3.9.2.3 Area health resources files

To obtain county-level information on health care resources, we used the Area Health Resources Files (AHRF) maintained by the Health Resources & Services Administration (HRSA).[321,322] The AHRF provides comprehensive information on health care use, providers, facilities, and local environmental and socio-demographics, compiled from over 50 databases and other sources. For each county, we constructed a health care resource density measure, calculated as the number of health care providers or facilities per 100,000. See Table A3-4 for the complete list of AHRF variables we extracted.

Table A3-4 County-level healthcare resource variables extracted from the Area Health Resources Files

Variable field in AHRF	Variable	Data source[a]	Year of data availability
F11984	County population estimate	Census	Yearly
F14677	MD, primary care	AMA Masterfile	Yearly
F14642	Nurse practitioners	CMS	Yearly
F14641	Physician assistants	CMS	Yearly

F13218	Rural Health Clinics	CMS	Yearly
F13320	Federal Qualified Health Centers	CMS	Yearly
F08921	Hospital beds	AHA survey	Every five years

Abbreviations: AHRF, Area Health Resources Files; MD, Doctor of Medicine; AMA, American Medical Association; CMS, Centers for Medicare & Medicaid Services; AHA, American Hospital Association

3.9.2.4 Other area-level variables

We supplemented the data in the PCR with two area-level data sources using an individual's census block of residence. First, we constructed a variable characterizing the rurality of residence based on Agriculture Rural-Urban Commuting Area (RUCA) codes from the United States Department of Agriculture. We designate urban areas (RUCA codes 1-3), large town areas (RUCA codes 4-6,) and rural areas (RUCA codes 7-10).[272] Second, we obtained the Area Deprivation Index (ADI) from the Neighborhood Atlas,[323] which ranks socioeconomic disadvantage in neighborhoods based on various domains from the American Community Survey (ACS), including income, education, employment, and housing quality. We assigned the ADI ranks using the 2015 data (the data is only available for 2015 and 2020). We created county-level ADI quartiles, with higher quartiles indicating counties with greater neighborhood deprivation.

3.9.3 Inclusion criteria

Figure A3.6 shows the flowchart illustrating how we derived the study sample. We included all cancer cases in the Pennsylvania Cancer Registry with dates of diagnosis from 2010 to 2018. We applied conventional exclusion criteria used in secondary research using cancer registries,[256,324,325] excluding cases with a secondary cancer diagnosis within 365 days of the primary diagnosis, cases with invalid diagnosis date (i.e., missing the month or year of diagnosis), cases for which diagnosis was established at autopsy or death, and cases with missing covariates.

We also excluded a small share of individuals who transitioned genders (N=46; <1% of the sample) because of their different risk profiles for cancer development.[326-329] We recognize that transgender individuals are an important minority group requiring more nuanced and specific analyses of cancer risks, but the decision to exclude them was made because the small sample size in the Pennsylvania cancer registry precluded any generalizable inferences and we did not want to assign a sex value in this group. We then limited the sample to adults aged 21 to 64.

To ascertain the source of insurance coverage around the time of diagnosis, we linked each case in the cancer registry to a PHC4 inpatient discharge or outpatient procedure record within one month of the diagnosis and excluded cases without the corresponding PHC4 recorded. We excluded cases whose payer source for the linked PHC4 record did not list Medicaid (i.e., non-Medicaid sample) and those for which the payer source included Medicare in addition to Medicaid (i.e., dually enrolled in Medicare and Medicaid).

In the remaining sample of non-elderly adults with Medicaid coverage around the time of diagnosis, we excluded individuals diagnosed with brain or hematological tumors. The final sample consists of 29,332 cases who were newly diagnosed with a primary solid tumor.

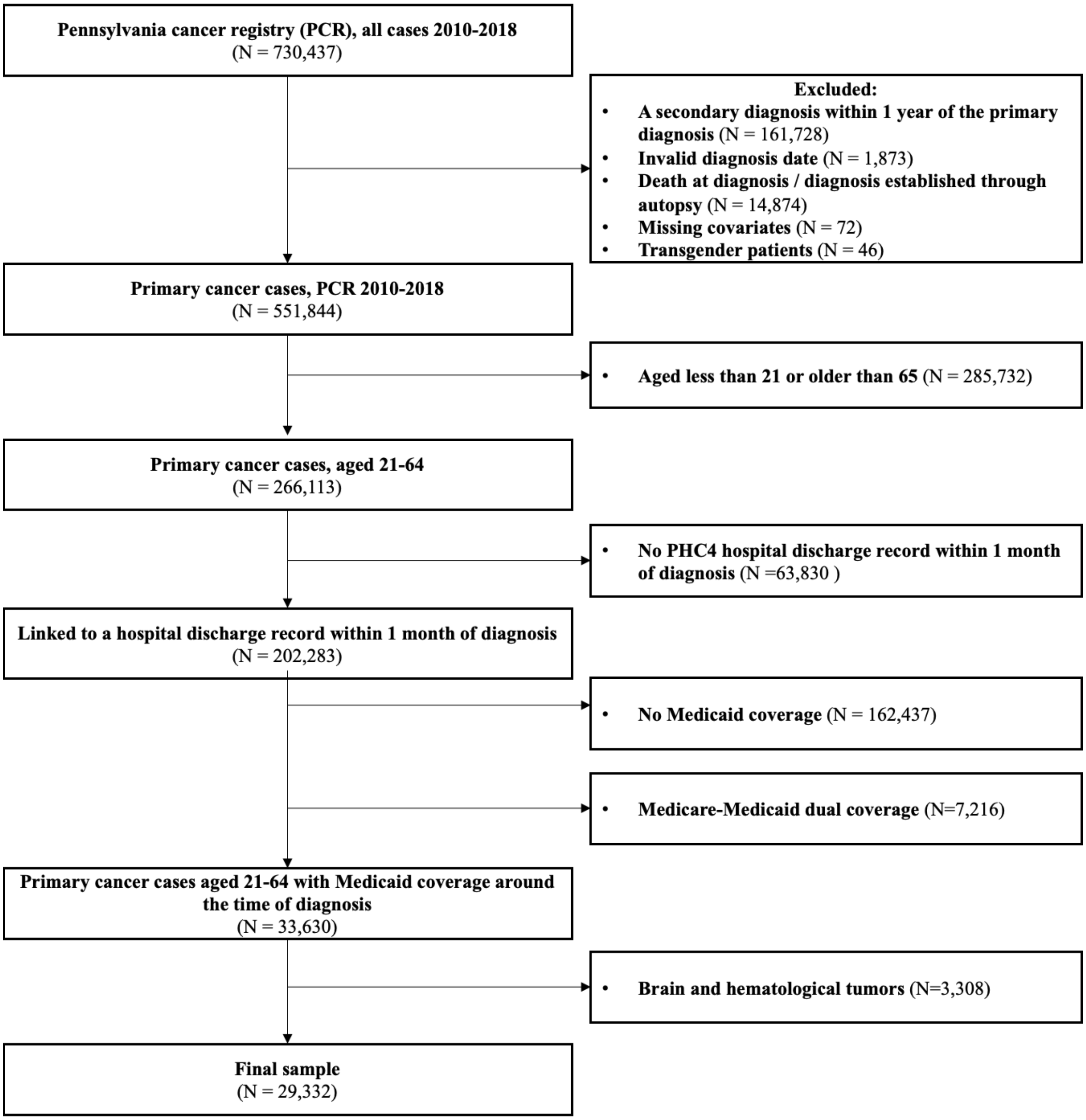


Figure A3.6 Sample selection flowchart using the Pennsylvania cancer registry and linked PHC4 records

Abbreviations: PCR, Pennsylvania cancer registry; PHC4, Pennsylvania Health Care Cost Containment Council

3.9.4 Linkage of Pennsylvania cancer registry with PHC4 records

The linkage of the Pennsylvania cancer registry and inpatient and outpatient discharge records was provided by administrators and staff at the Pennsylvania Health Cost and Containment Council (PHC4). PHC4 data contained a unique patient ID that matches the ID in the cancer registry, which we used to link each case in the registry with their discharge records. All primary cancer cases aged 21-64 were linked to at least one PHC4 record (N = 266,133). The linked data also contain a variable indicating the number of days from the date of diagnosis in the cancer registry to the date of admission in the PHC4 records. Using this variable, we identified a PHC4 record (whether for an inpatient discharge or an outpatient procedure) within +/- 30 days of the date of diagnosis. We retained the record closest to the date of diagnosis. Over 76% (N = 202,283) of non-elderly patients with a new primary cancer had a visit around the time of cancer diagnosis. Figure A3.7 shows that for most visits, the date of admission coincides exactly with the date of the diagnosis (~60%).

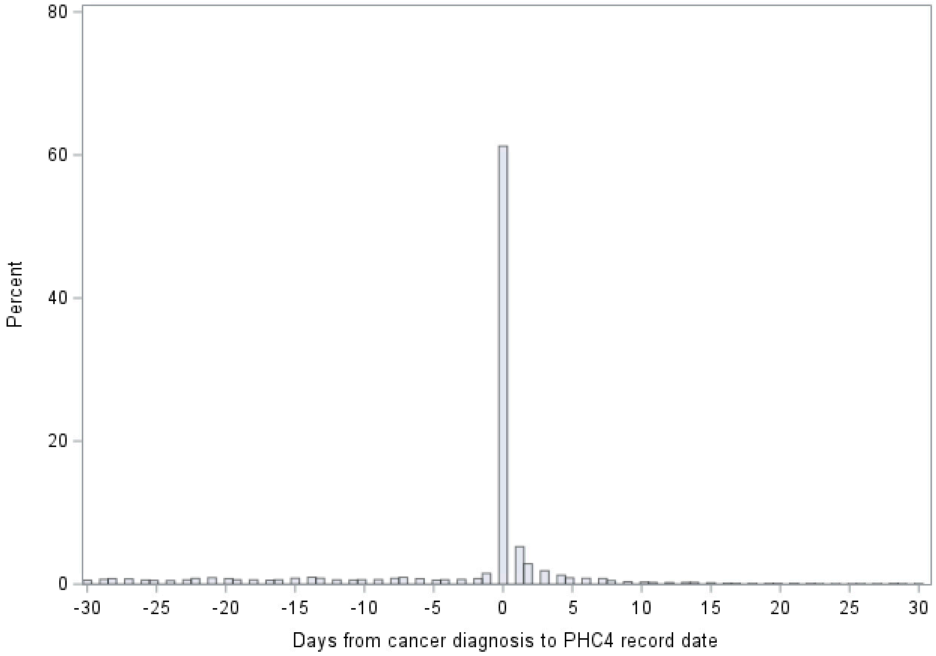


Figure A3.7 Distribution of the days from the date of cancer diagnosis to the date of PHC4 records among the linked sample

Abbreviation: PHC4, Pennsylvania Health Care Cost Containment Council
Note: The figure displays the histogram of the variable showing the date of the linked PHC4 record relative to the date of diagnosis. This variable was calculated by (date of the linked PHC4 record – date of cancer diagnosis). Therefore, the value of 0 indicates that an inpatient or an outpatient visit for the linked record occurred on the date of cancer diagnosis; a positive (negative) value indicates that such a visit occurred after (before) cancer diagnosis.

3.9.5 Stacked difference-in-difference analysis

Recent literature on difference-in-difference methods has extensively documented a potential bias in estimating a treatment effect in standard two-way fixed effects models when the timing of the treatment varies across treated units.[274,330,331] A critical problem lies in comparing earlier-treated units with later-treated units (i.e., “forbidden” comparisons) when treatment effects are heterogeneous, which generates negative weights that bias difference-in-differences coefficients. Moreover, the standard model assigns more weight to observations treated in the middle of the study period, which may be inappropriate depending on the context of the treatment studied. In our context, we are more concerned about the "negative" weighting problem since the transition to mandatory Medicaid managed care occurred in a staggered fashion (with ~6 months gaps in treatment between the treated counties after the first transition date on July 1, 2012) but all treatment occurred in the middle of the study period (2012-2013).

To address the potential bias in the standard difference-in-differences framework, we implemented a "stacked" difference-in-differences analysis.[332,333] The basic idea of the stacked analysis is to partition the study sample into several stacks of data or cohorts, in which a "clean" comparison is made between treated and control units. The analysis specifically estimates treatment effects *within* each cohort, which includes "clean" controls (i.e., always-treated or not-ever-treated) and newly treated units, and aggregates cohort-specific treatment effects to recover an average treatment effect.

To generate the stacked data, we divided the final sample into the following three cohorts, as shown in Figure A3.8:

1) <u>Cohort 1</u> = counties with mandatory Medicaid managed care mandate throughout the study period (control) + Wave 1 counties (transitioned to mandatory Medicaid managed care on July 1, 2012);

2) <u>Cohort 2</u> = control counties + Wave 2 counties (transitioned on October 1, 2012); and

3) <u>Cohort 3</u> = control counties + Wave 3 counties (transitioned on March 1, 2013).

Each cohort contains observations within the 30 months of pre-period and 69 months of post-period, the common event window for all three cohorts. The cohort data were then appended in one "stacked" dataset, which formed the final analytic sample for the difference-in-differences analysis. The final stacked data contains 67,617 observations (N, Control = 60,595, N, treated=7,022), some of which were duplicates since observations in the control counties are replicated in all three cohorts.

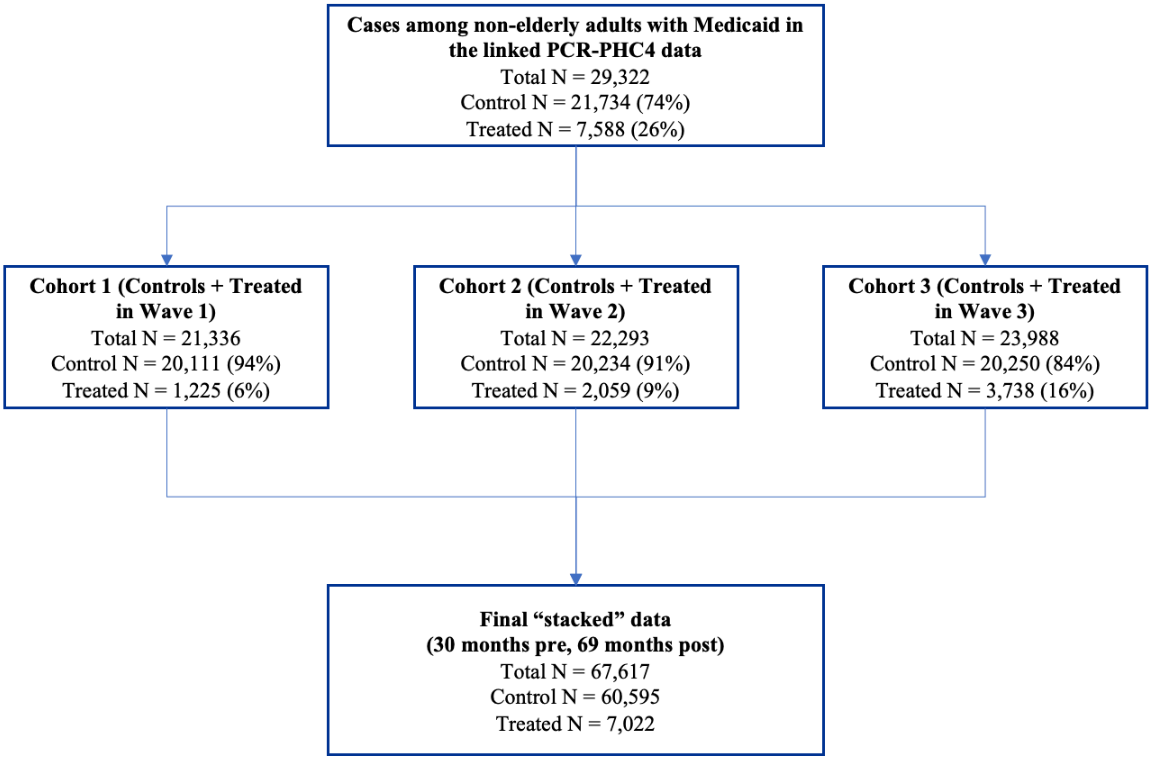


Figure A3.8 Flowchart of the sample construction process for stacked difference-in-difference analysis

Abbreviations: PCR, Pennsylvania cancer registry; PHC4, Pennsylvania Health Care Cost Containment Council
Note: The figure displays the flowchart detailing creating the "stacked" data for our main analysis. Using the final sample of cancer cases among non-elderly adults with Medicaid, we created three different cohorts. Each cohort includes cancer cases in the control counties (i.e., original HealthChoices counties with mandatory Medicaid managed care throughout the study period) and cancer cases belonging to each wave of Medicaid managed care expansion (see Figure S2 for more details). The number of controls in each cohort differs slightly because some observations at the tail-ends of the study period were dropped to ensure the same number of pre-period (30 months) and post-period (69 months) across cohorts.

Using the stacked data, we estimated an intent-to-treat model, where *i* indexes a Medicaid beneficiary diagnosed with cancer, *c* indexes the county, *t* indexes the calendar year of diagnosis, and *k* indexes a cohort of individuals within each stack:

$$y_{ictk} = \beta_0 + \beta_1 \mathrm{Treated}_{ick} * \mathrm{Post}_{itk} + \delta X_i + \theta X_{ct} + (\gamma_t * \mu_k) + (\tau_c * \mu_k) + \varepsilon_{ictk}$$

$\text{Treated}_{\text{ick}}$ is 1 if a beneficiary *i* was diagnosed in a treated county *c* in cohort *k* and Post_{it} equals 1 if a beneficiary i was diagnosed after the mandatory Medicaid managed care was in effect in a county *c* in cohort *k*. X_i is a vector of case-level covariates and X_{ct} is a vector of time-varying healthcare resources at the county level. We also included year fixed-effects (γ_t) to control for secular trends and county fixed-effects (τ_c) to adjust for time-invariant differences across counties. We interacted the year- and county-fixed effects with cohort fixed-effects (μ_k), which essentially estimates the difference-in-differences in each cohort, thus eliminating the "forbidden" comparison between earlier vs. later treated counties. We clustered standard errors at the county level to account for the within-county clustering of observations.

We used an event-study form to estimate dynamic treatment effects and to test for parallel trends in the outcomes in the pre-period.

$$y_{ictk} = \beta_0 + \sum_{\tau=-3,\tau\neq-1}^{5} \beta_\tau \, \text{Treated}_{ick} * \, I[\tau = t]_{itk} + \delta X_i + \theta X_{ct} + (\gamma_t * \mu_k) + (\tau_c * \mu_k) + \varepsilon_{ictk}$$

The post-indicator is replaced by a series of year-period dummies $I[\tau = t]_{itk}$, taking the year immediately before the treatment time as the reference year ($\tau = -1$). We tested whether the event-study coefficients for $\tau = -3, -2$ are statistically indistinguishable from 0, testing whether there are significant differences in outcome trends prior to treatment between the treated and control counties.

3.9.6 Supplement to the main results

3.9.6.1 Changes in population-based rates of cancer detection

Our main results showed evidence of a differential reduction in the probability of late-stage diagnosis among cancer cases diagnosed in the treated vs. control counties. We assume that increases in early diagnosis explain this reduction, though it could theoretically also result from fewer cancers diagnosed overall and a larger drop in late-stage than early-stage cancers.

Here, we provide descriptive data suggesting the overall increase in early-stage cancers drives our results. To show this, we first aggregated our data at the county level, summing up the number of newly diagnosed cases with Medicaid. We then generated population-based rates of cancer detection in each county, dividing the aggregated number of diagnoses by the number of insured among non-elderly, low-income individuals (<138% of FPL and aged 18-64) from the Census data, which served as a proxy for the denominator of individuals with Medicaid. We plot the trends in these population-based rates by treatment status. We also replicated this analysis among privately insured as an additional placebo check (for this group, the population denominator was the number of non-elderly individuals with incomes >138% FPL).

In Figure A3.9, we observe a differential increase in the overall cancer detection rates among cases with Medicaid in the treated vs. control counties in the years following the implementation of mandatory MMC. We break down the population rates by early- and late-stage diagnosis and find stable trends in the control counties but pronounced changes in the treated counties, especially in rates of early-stage diagnosis. These descriptive data support the claim that our main finding of the differential *decrease* in late-stage diagnosis is driven by a *higher* share of early-stage diagnosis accounting for the overall increase in cancer detection in the treated vs.

control counties. Conversely, we found no visible changes in the rates of cancer detection among the privately insured throughout the study period, ruling out other factors that may have caused spurious changes in overall cancer detection during the implementation of mandatory MMC.

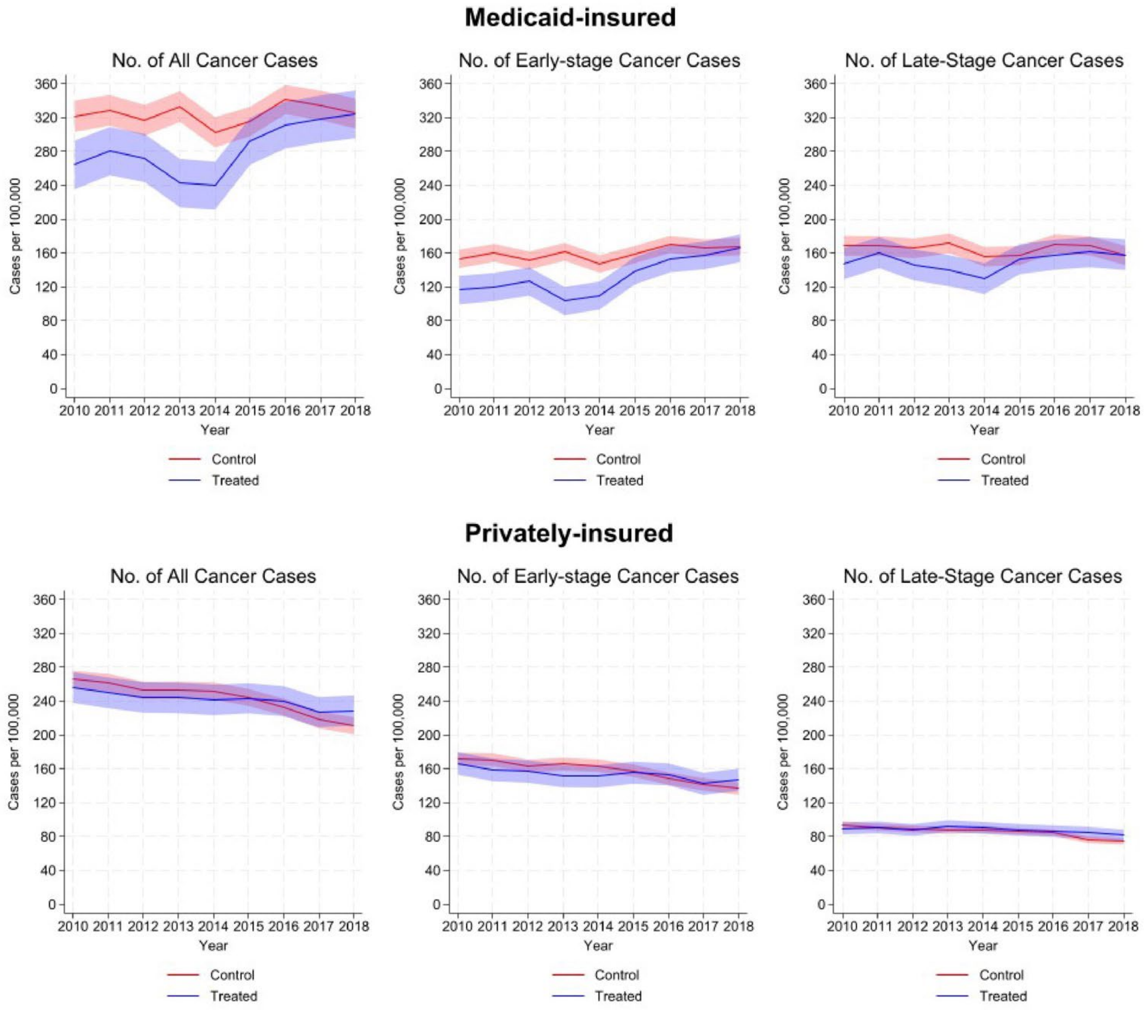


Figure A3.9 Trends in population rates of cancer detection among non-elderly adults with Medicaid and private insurance in the treated and control counties

Abbreviation: No., number
Note: The figures plot the population rates of all cancer cases, early-stage and late-stage cancer cases among adults aged 21 to 64 with Medicaid and private insurance (aggregated at the county level). The denominator for each group is the estimated number of non-elderly individuals (aged 18-64) with income <138% FPL and >138% FPL in a county from the Small Area Health Insurance Estimates (U.S. Census Bureau), respectively. The post-period encompasses years following 2012 (for the stacked cohort 1) and 2013 (for stacked cohorts 2 and 3).

3.9.6.2 Main results stratified by gender and cancer type

To account for the different distribution of cancer types by gender, we stratified the main analysis by gender and cancer type. In Figure A3.10, we observed signs of heterogeneity in the effects of mandatory Medicaid managed care by gender, which may point to potentially distinct mechanisms of early detection by gender. Among women, clear evidence of reductions in late-stage diagnosis for breast and cervical cancer cases is expected, with capitation incentivizing the use of guideline-recommended screening services for these cancers. In contrast, our findings suggest that among men, Medicaid managed care is associated with changes in late-stage diagnosis across multiple cancer types, including non-screening amenable cancers. These differences may reflect gender-based disparities in the utilization of preventive care and access to care that should be explored in future research.

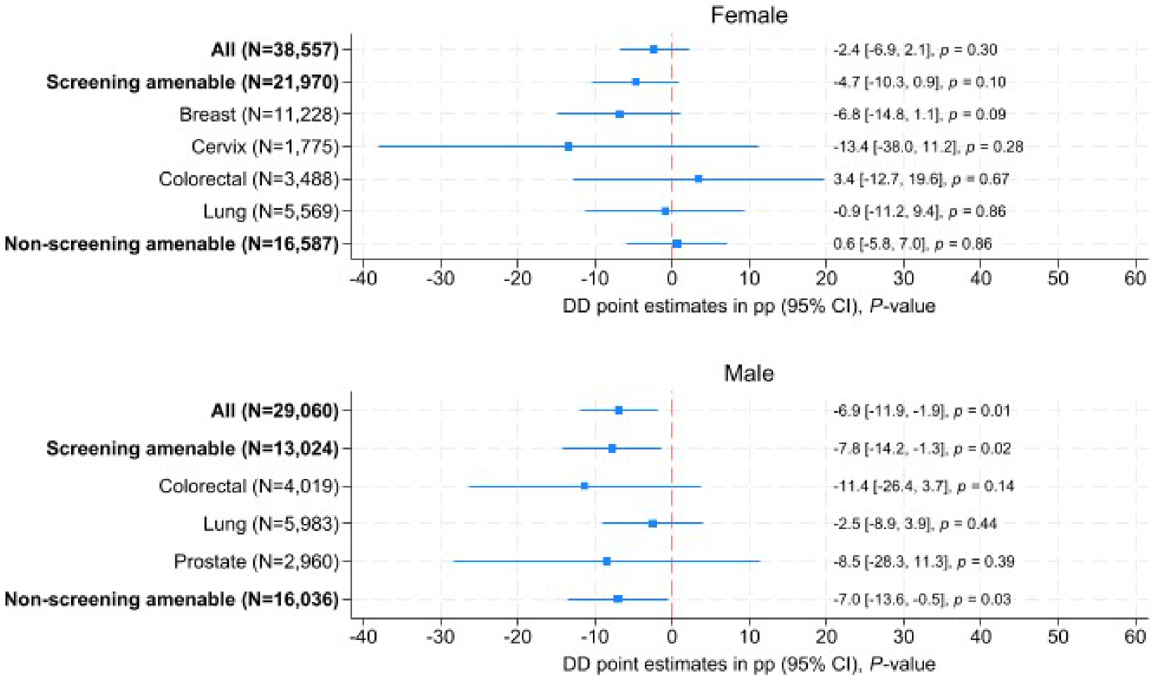


Figure A3.10 Differential changes in the probability of late-stage diagnosis in the treated vs. control counties, stratified by gender and cancer type

Abbreviation: DD, difference-in-differences; pp, percentage points
Note: The figure displays a set of the difference-in-differences coefficients showing the effects of Medicaid managed care by cancer type and gender. Each model adjusted for cancer fixed effects, patient-level controls, yearly county-level healthcare resources per 100,000 population, year-quarter-by-stack, and county-by-stack fixed effects. “Screening amenable” cancers included cancers amenable to early detection and preventive screening, including breast, cervical, colorectal, lung, and prostate cancers. All other cancers were categorized as “non-screening amenable.”

3.9.7 Potential bias from excluding cases without a PHC4 record

The fact that our study sample excludes cases in the cancer registry without a PHC4 record within one month of diagnosis poses a concern about systematically biasing the sample. We explored how excluding these cases may have impacted our study findings.

We first compared measured characteristics of cases with and without a PHC4 record around the time of diagnosis. Table A3-5 demonstrates that for most characteristics, there were no large differences in individual-level characteristics between those with vs. without a PHC4 record around the time of diagnosis (i.e., the standardized mean difference [SMD] < 0.2). However, a higher share of individuals with a PHC4 record around the time of diagnosis were female (56.8% vs. 43.7%; SMD = 0.26) and diagnosed with lung or bronchus cancer (9.5% vs. 2.4%; SMD=0.30).

Table A3-5 Characteristics of non-elderly cancer cases in the PCR by the availability of a PHC4 record

Variables	Without a PHC4 record around the time of diagnosis (N=63,830)	With a PHC4 record around the time of diagnosis (N=202,283)	Standardized Mean difference
Sex, %			
Male	56.3	43.2	0.26
Female	43.7	56.8	0.26
Race/ethnicity, %[a]			
Hispanic	2.6	2.6	<0.01
Non-Hispanic white	73.3	80.7	0.18
Non-Hispanic black	8.9	10.6	0.06
Other	1.9	2.0	0.01
Unknown	2.6	2.6	<0.01
Age at diagnosis, %			
21-39	8.3	10.1	0.06
40-49	15.9	18.2	0.06
50-59	43.8	43.1	0.01
60-64	32.1	28.6	0.07
Urbanicity of residence, %[b]			
Urban	88.2	87.1	0.03
Large town	7.6	8.5	0.03
Small town	2.1	2.4	0.02
Rural	2.1	2.0	0.01
Area deprivation index, %[c]			
Quartile 1	32.1	26.1	0.13
Quartile 2	28.6	28.6	0.00
Quartile 3	22.6	24.5	0.05
Quartile 4	16.8	20.8	0.10
Cancer type, %			
Breast	15.3	20.6	0.14
Cervical	1.0	1.0	<0.01
Lung & bronchus	2.4	9.5	0.30

Prostate	28.5	6.1	0.62
Other	49.0	52.7	0.07

Abbreviation: PCR, Pennsylvania cancer registry; PHC4, Pennsylvania Health Care Cost Containment Council

Note: The table displays the means and standardized mean difference in characteristics between individuals aged 21 to 64 with vs. without a PHC4 record around the time of diagnosis (+/- 30 days).

[a] Race and ethnicity were separately recorded by cancer registrars based on the information they received from various sources, including medical records and face sheets. Based on the recorded data, we created combined race and ethnicity categories as listed in the table. "Other" group includes individuals who were identified as non-Hispanic and belonging to at least one of these race categories: American Indian, Aleutian, Eskimo, Chinese, Japanese, Japanese, Filipino, Hawaiian, Korean, Vietnamese, Laotian, Hmong, Kampuchean (including Khmer & Cambodian), Thai, Asian Indian, Pakistani, Micronesian, Chamorro, Guamanian, Polynesian, Tahitian, Samoan, Tongan, Melanesian, Fiji Islander, or New Guinean.

[b] The urbanicity and area deprivation index were characterized at the individual level, using the Census block of residence.

[c] Higher area deprivation index quartiles represent areas with greater socioeconomic deprivation.

However, the differences in patient characteristics noted in Table A3-5 are not necessarily problematic for difference-in-differences *if* rates of exclusions are similar over time between the treated and control counties. We, therefore, examined whether there were differential exclusions due to the lack of a PHC4 record around the time of diagnosis between treated and control counties throughout the study period by modeling the availability of such a record for each case as the outcome. Figure A3.11 shows a 2.3 percentage-point increase in the probability of linkage with a PHC4 record in the treated counties vs. control counties, before and after the treatment (95% CI: 0.6, 4.0; $P = 0.01$). This represents a ~3% relative increase from the baseline mean of 74.9%. The event study plot suggests the probability of linkage with a PHC4 record remained similar between the treated and control counties from Year 0 to 1 but increased from Year 3 to Year 5.

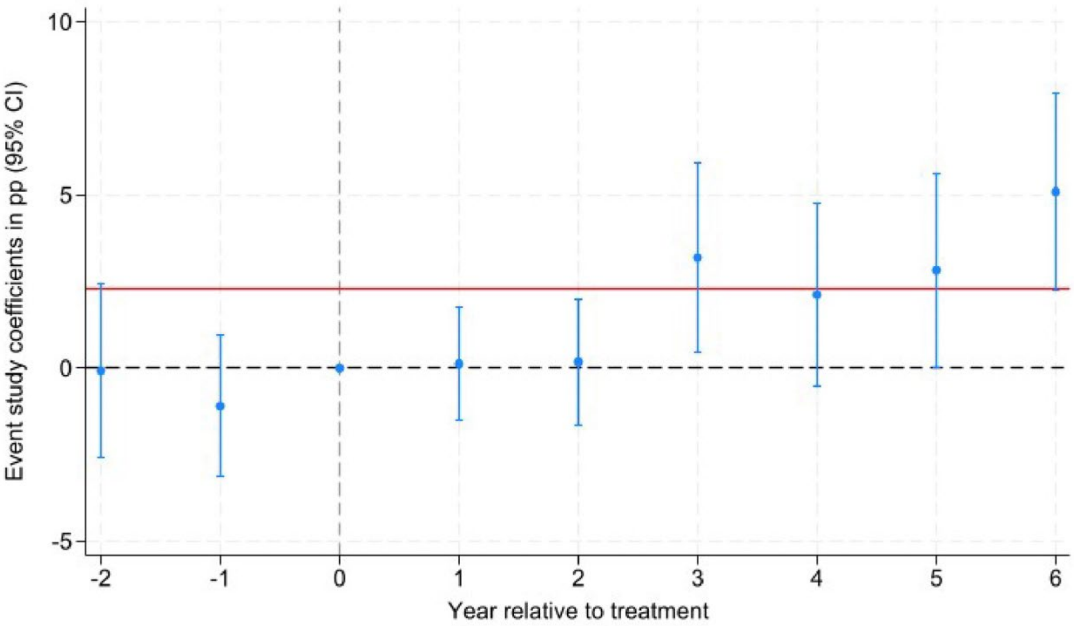


Figure A3.11 Differential change in the probability of linkage with a PHC4 record around the time of diagnosis in the treated vs. control counties by year

Abbreviation: pp, percentage points
Note: The figure displays the event study coefficients and their 95% confidence intervals, modeling the probability of having a PHC4 record around the diagnosis. The models only include the year-quarter-by-stack and county-by-stack fixed effects. Standard errors were clustered at the county level. The dotted vertical line represents the reference year "-1" in each stack, representing one year immediately before when mandatory Medicaid managed care went into effect in each cohort (Cohort 1: July 1, 2012; Cohort 2: October 1, 2012; Cohort 3: March 1, 2013). The solid red line corresponds to the pooled difference-in-differences coefficient (2.3 percentage points).

We conducted a sensitivity analysis that further explores the potential impact of the differential linkage on our main estimates. In this alternate specification, we retained individuals initially excluded from the sample for lacking a PHC4 record around the time of diagnosis and imputed their Medicaid status using the primary payer information in the cancer registry. We also adjust for an indicator for the PHC4 linkage as a covariate.

In column (2) of Table A3-6, we show that the estimated effect of the mandatory MMC remained similar to that in the main model. Importantly, the coefficient for the PHC4 linkage was significantly positive (β = 4.3 pp; 95% CI: 2.6, 6.0; $P < 0.001$), meaning that cases linked to PHC4 records had a higher probability of late-stage diagnosis. This suggests that the differential increase in the rate of linkage among cases in the treated counties is likely to bias the result towards the null, as they are generally more likely to be diagnosed with late-stage cancer. In column (3), we report results *only* among the non-linked Medicaid sample. We observed reductions in the probability of late-stage diagnosis of similar magnitude (β = -2.7 pp; 95% CI: -10.4, 4.9; $P < 0.477$), though the effect is no longer significant due to the smaller sample size. Thus, the consistency in the effect of mandatory MMC, even among the non-linked cases, implies that differential linkage is unlikely to drive our main results.

Table A3-6 Sensitivity to the addition ot the non-PHC4 linked Medicaid sample

	(1) Main Sample[a]	**(2) Main Sample + Excluded Medicaid sample from the cancer registry**[b]	**(3) Excluded Medicaid sample only**[c]
Post x Treated	-3.9	-3.7	-2.7
95% CI	[-7.2, -0.5]	[-6.9, -0.5]	[-10.4, 4.9]
P-value	(0.023)	(0.023)	(0.477)
Linkage with PHC4[d]		4.2	
95% CI		[2.5, 5.9]	
P-value		(<0.001)	
N	67,617	76,831	9,213
F-stat	1763.4	3464.3	234.5

Notes: The table displays the difference-in-differences coefficients representing a change in the probability of late-stage diagnosis associated with the implementation of MMC (reported in percentage points) and their 95% confidence intervals (in brackets) and p-values (in parenthesis).

[a] Column (1) contains the main results (from Table 3 in the main text).

[b] Column (2) reports the estimates from an analysis that retained individuals initially excluded for lacking a linked PHC4 record around the time of diagnosis but had Medicaid according to the registry.

[c] The excluded sample who had Medicaid according to the registry.

[d] An indicator variable, which is 1 for observations linked with a PHC4 record around diagnosis.

3.9.8 Falsification test

We conducted a falsification test to help rule out other unmeasured time-varying confounders that could differentially impact outcomes in the treated and control counties. To do this, we replicated our main analysis among non-elderly adults with private insurance around the time of diagnosis as a placebo group. Because they were unaffected by the Medicaid managed care mandate, we should expect no substantial changes in outcomes in this group.

It is plausible that there may be some spillover effects from changes in Medicaid managed care because providers and managed care organizations serve beneficiaries across Medicaid, Medicare, and private markets.[319,334] Furthermore, some beneficiaries enrolled in Medicaid managed care may also be misclassified as "privately insured" in the hospital discharge data.[335] Notwithstanding these spillover effects, a large treatment effect in the placebo group may illuminate other temporal changes that differentially affected *all* adults in the treated vs. control counties, raising concerns about unmeasured, time-varying factors that may bias our main estimate.

Figure A3.12 plots event study coefficients and the pooled difference-in-differences estimate from the falsification test. Among *privately* insured non-elderly adults, there was a 1.1 percentage point (95% CI: -0.1, 2.3; $P = 0.06$) differential increase in the probability of being diagnosed with late or unstaged cancer in the treated vs. control counties, before and after treatment. This treatment effect is non-significant and smaller compared to the effect from the main analysis (i.e., -3.9 percentage points).

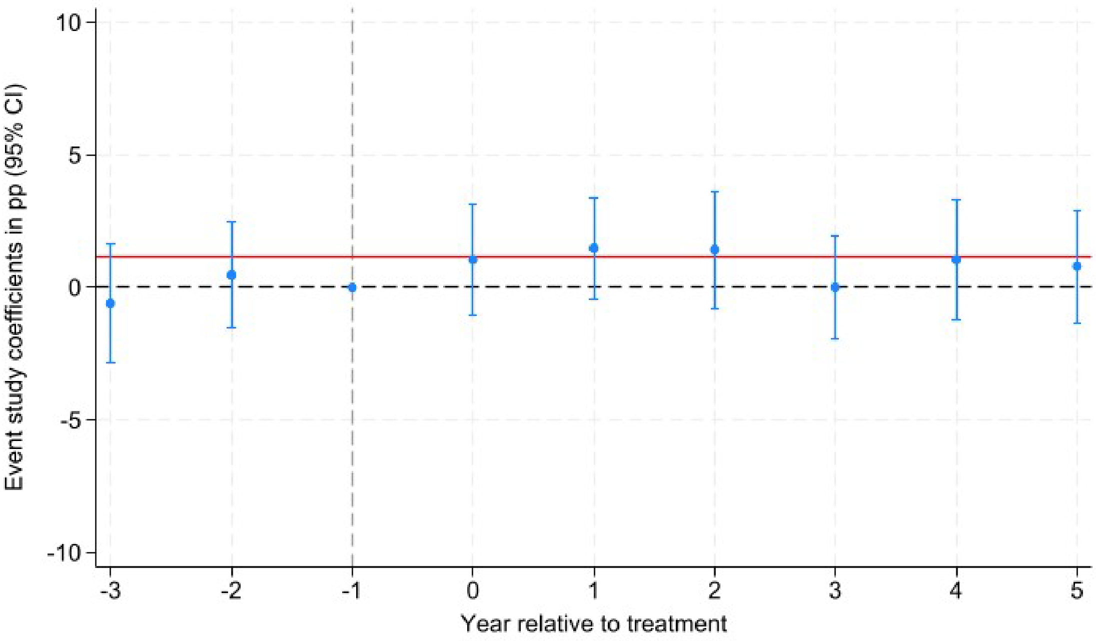


Figure A3.12 Differential change in the probability of late-stage diagnosis among cancer cases in non-elderly adults with private insurance in the treated vs. control counties by year

Abbreviation: pp, percentage points
Note: The figure displays the event study coefficients and their 95% confidence intervals among non-elderly adults with private insurance. Models controlled for covariates, year-by-stack, and county-by-stack fixed effects. Standard errors were clustered at the county level. The dotted vertical line is the reference year "-1" in each cohort, representing one year immediately before when mandatory Medicaid managed care went into effect in each cohort (Cohort 1: July 1, 2012; Cohort 2: October 1, 2012; Cohort 3: March 1, 2013). The solid red line indicates the pooled difference-in-differences coefficient (1.1 percentage points, P = 0.060).

3.9.9 Compositional changes in the Medicaid sample

We investigated potential sources of bias that may arise if there are changes in the composition of the Medicaid sample over time. We acknowledge that the extent to which we can examine the compositional changes is limited since we lack access to administrative Medicaid data; however, we utilize the information in the linked registry-PHC4 data that may provide some insights about the characteristics of the Medicaid beneficiaries in our sample.

3.9.9.1 Medicaid churn

We first examined rates of churning (i.e., interruptions in Medicaid coverage due to eligibility and coverage renewal processes and/or changing life circumstances), which is not a trivial issue among Medicaid beneficiaries. In 2018, over 12.1% of adult Medicaid beneficiaries experienced gaps in coverage within one year.[336] Importantly, churning is associated with decreased office-based visits,[337] which may delay cancer diagnosis. To evaluate churning, we calculated the proportion of PHC4 visits with Medicaid out of all PHC4 records from one year before the date of cancer diagnosis to 30 days before the date of diagnosis. In our data, over 84.6% of PHC4 records were attributed to Medicaid one year before diagnosis; this share of PHC4 records did not meaningfully differ between individuals residing in the treated counties (83.4%) and control counties (85.0%), with SMD = 0.04.

3.9.9.2 Impact of ACA Medicaid expansion

On January 1st, 2015, Pennsylvania expanded Medicaid under the Affordable Care Act, which made adults under age 65 living below 138% of the federal poverty level eligible for Medicaid coverage.[338] By 2022, almost 1.1 million newly eligible low-income individuals were enrolled in Medicaid. Prior research suggests that there may be important differences in demographic and health characteristics and health care utilization patterns between newly vs. previously eligible individuals for Medicaid.[282,339,340] These differences may bias our estimates if Medicaid expansion *differentially* affected Medicaid enrollment among newly eligible individuals (and individuals previously eligible but not enrolled) between the treated and control counties. We may also expect that the effects of Medicaid managed care may be heterogeneous in periods before vs. after Medicaid expansion.

We conducted several additional analyses to gauge how Medicaid expansion may have influenced our main findings:

1) We examined whether the effects of MMC differed in the post-period before and after Pennsylvania expanded Medicaid. Any large and significant differences in the treatment effects in these two periods may signal that the changes in the composition of the Medicaid population may be driving our results. We estimated the following model, which is a modified form of the main analysis that included separate post-indicators for years before Medicaid expansion ($\mathrm{PostBeforeExpansion}_{\mathrm{itk}}$=1 if diagnosis occurred before January 1, 2015) and after Medicaid expansion ($\mathrm{PostAfterExpansion}_{\mathrm{itk}}$=1 if diagnosis occurred after January 1, 2015):

$$\begin{aligned} y_{\mathrm{ictk}} = \beta_0 + \beta_1 \mathrm{Treated}_{\mathrm{ick}} * \ \mathrm{PostBeforeExpansion}_{\mathrm{itk}} + \beta_2 \mathrm{Treated}_{\mathrm{ick}} * \ \mathrm{AfterExpansion}_{\mathrm{itk}} \\ + \delta X_{\mathrm{i}} + \theta X_{\mathrm{ct}} + (\gamma_{\mathrm{t}} * \mu_{\mathrm{k}}) + (\tau_{\mathrm{c}} * \mu_{\mathrm{k}}) + \varepsilon_{\mathrm{ictk}} \end{aligned}$$

In Table A3-7, we show that the effect of mandatory Medicaid managed care in years in the post-period before Medicaid expansion went into effect in Pennsylvania (β_1= -2.3 [95% CI: -6.0, 1.3]; *P* = 0.20) was similar to that in the post-period after Medicaid expansion (β_2= -4.5 [95% CI: -8.3, -0.6]; *P* = 0.02). We also formally tested that the difference in coefficients β_1 and β_2 was statistically indistinguishable from 0 (*P* = 0.271).

Table A3-7 Differential change in the probability of late-stage diagnosis in cancer cases among Medicaid-covered individuals in the treated vs. control counties, separately by years before and after Pennsylvania Medicaid expansion under the Affordable Care Act in the post-period

	Estimate (95% CI)	***P*-value**
Post x Treated, Before Expansion [β_1], 95% CI	-2.3 (-6.0, 1.3)	0.203
Post x Treated, After Expansion [β_2], 95% CI	-4.5 (-8.3, -0.6)	0.023
Test $(\beta_1 - \beta_2) = 0$[a]		0.271

Note: The table displays the difference-in-differences coefficients representing a change in the probability of late-stage diagnosis associated with the implementation of MMC (reported in percentage points) and their 95% confidence intervals separately for years in the post-period before Pennsylvania's Medicaid expansion under the Affordable Care Act (i.e., before Jan 1, 2015; β1) and years in the post-period after Medicaid expansion (β2). The models controlled for year-quarter-by-stack, county-by-stack fixed effects, and covariates. Standard errors were clustered at the county level.

[a] The P-value from an F-test of whether β1 was significantly different from β2.

We conducted a placebo test, replicating our main analysis among the uninsured patients. The intuition behind this placebo test is that as coverage expansions under the ACA tend to shift uninsured individuals to Medicaid, we may expect a symmetric and positive treatment effect for the uninsured *if* the estimated treatment effect in our main result was purely a composition effect. One caveat to this placebo test is that uninsurance categorization in the PHC4 records lumps those who otherwise could not afford care (i.e., the population targeted by the coverage expansions) and self-paying individuals who had the financial means to afford care. Moreover, the proportion of uninsured patients with cancer *prior* to the ACA is generally low in Pennsylvania (N=2,335), so the analysis may not be powered to detect a "true" null effect in this population.

Notwithstanding these limitations, the placebo test result suggests no significant effect of the MMC on the probability of late-stage diagnosis among the uninsured (Figure A3.13). The estimated difference-in-difference was 0.6 percentage points (95% CI: -8.3, 9.5; *P* = 0.891), though there are some noises in the event study coefficients.

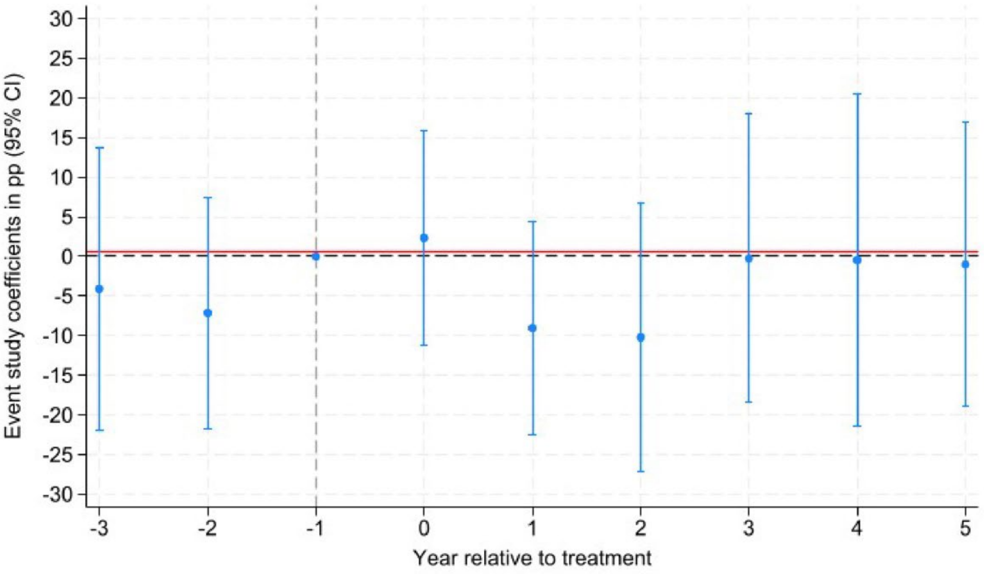


Figure A3.13 Differential change in late-stage diagnosis among uninsured cancer cases in the treated vs. control counties by year

Abbreviation: pp, percentage points
Note: The figure displays the event study coefficients and their 95% confidence intervals among uninsured non-elderly adults according to their PHC4 record. Models controlled for covariates, year-by-stack, and county-by-stack fixed effects. Standard errors were clustered at the county level. The dotted vertical line is the reference year "-1" in each cohort, representing one year immediately before when mandatory Medicaid managed care went into effect in each cohort (Cohort 1: July 1, 2012; Cohort 2: October 1, 2012; Cohort 3: March 1, 2013). The solid red line indicates the pooled difference-in-differences coefficient (0.6 percentage points, P=0.891)

We investigated whether the coverage expansions resulted in any differential take-up of insurance coverage in the treated vs. control counties. In our difference-in-differences framework, changes in the take-up of insurance among the population targeted by the ACA do not bias the model if they occur uniformly across all counties (i.e., they would be absorbed by the county and year fixed effects). This may be a reasonable assumption given that the coverage expansions impacted all eligible low-income adults across all counties in Pennsylvania.

To check whether this assumption holds in our context, we conducted a separate difference-in-difference analysis that compared the proportion of insurance coverage among low-income adults residing in the treated vs. control counties, before and after 2015. To do so, we used data from the Census Bureau to construct a county-year panel of proportions of insurance coverage among low-income, non-elderly adults (<138% FPL, age 18-64). We then estimated our difference-in-difference regression, adjusting county and year fixed effects and clustering standard errors at the county level. We also weighted the regression by the county population size of non-elderly, low-income adults. The result of this analysis is shown in Figure A3.14, which confirms no differential trend in the take-up of insurance by the treated vs. control counties (difference-in-difference: 0.01 percentage-points; 95% CI: -1.0, 1.2) *P* = 0.885).

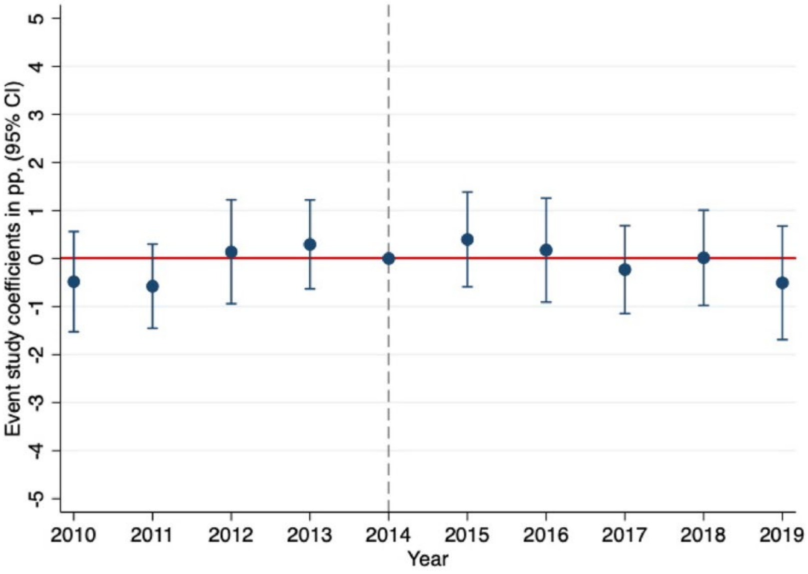


Figure A3.14 Differential changes in the proportion of insured low-income adults in the treated and control counties by year, before and after Pennsylvania Medicaid expansion under the Affordable Care Act

Abbreviation: pp, percentage points
Note: The figure displays difference-in-differences event study coefficients and their 95% confidence intervals showing differential change in the proportion of insured among low-income adults (aged 21-64, with incomes below 138% of the Federal Poverty Line), which was calculated using the Small Area Health Insurance Estimates data from the Census Bureau. The difference-in-differences model included county and year-fixed effects and their interactions. We clustered standard errors at the county level and weighted the model by the number of low-income adults in each county. Each coefficient indicates the differential changes in the proportion of insured relative to 2014, one year before Pennsylvania expanded Medicaid eligibility under the Affordable Care Act in 2015. The solid red line corresponds to the pooled difference-in-difference estimate (0.01 percentage points; P = 0.885).

3.9.9.3 Covariate trends test

Finally, as a general test of other compositional changes in the sample, we examined potential differential trends in covariates between the treated and control counties by modeling each level of covariate as a dependent variable. The difference-in-differences estimates in Table A3-8 suggest no significant differential trends for most sociodemographic and cancer characteristics between the treated and control counties ($P > 0.05$), except for the proportion of male and other cancers.

Table A3-8 Test of differential covariate trends

Covariate	Difference-in-differences in pp (95% CI)	*P*-value
Male	3.9 (1.0, 6.8)	0.010
Non-Hispanic White[a]	2.3 (-1.3, 5.9)	0.212
Non-Hispanic Black	-0.6 (-2.2, 0.9)	0.413
Hispanic	-0.3 (-1.5, 0.9)	0.644
Other race/ethnicity[b]	-0.8 (-1.5, -0.1)	0.035
Unknown race/ethnicity	-0.6 (-3.5, 2.2)	0.662
Age 20-39	-0.2 (-1.8, 1.5)	0.817
Age 40-49	1 (-1.8, 3.8)	0.486
Age 50-59	-0.1 (-2.9, 2.6)	0.924
Age 60-64	-0.7 (-3.4, 2.1)	0.638
Urban[c]	0.7 (-1.4, 2.8)	0.528
Large town	-0.2 (-2.3, 1.9)	0.873
Small town	-0.8 (-2.2, 0.5)	0.225
Rural	0.3 (-1.1, 1.7)	0.648
ADI, 1st quartile[d]	0.1 (-1.2, 1.4)	0.845
ADI, 2nd quartile	0.7 (-1.0, 2.4)	0.401
ADI, 3rd quartile	0.5 (-1.9, 3.0)	0.655
ADI, 4th quartile	-1.4 (-3.8, 1.1)	0.262
Breast cancer	-2 (-4.8, 0.7)	0.143
Cervical cancer	-0.7 (-1.8, 0.5)	0.265
Colorectal cancer	-0.9 (-3.0, 1.3)	0.411
Prostate cancer	0.4 (-0.7, 1.5)	0.494
Lung cancer	-0.2 (-3.1, 2.6)	0.865
Other cancers	3.4 (0.2, 6.7)	0.036

Abbreviation: ADI, area deprivation index; pp, percentage points

Note: The table displays the difference-in-differences coefficients and their 95% confidence intervals with p-values of each level of covariate as an outcome. The models only adjusted for year-quarter-by-stack and county-by-stack fixed effects. Standard errors were clustered at the county level.

[a] Race and ethnicity were separately recorded by cancer registrars based on the information they received from various sources, including medical records and face sheets. Based on the recorded information, we created combined race and ethnicity categories as listed in the table.

[b] "Other" group includes individuals who were identified as non-Hispanic and belonging to at least one of these race categories: American Indian, Aleutian, Eskimo, Chinese, Japanese, Japanese, Filipino, Hawaiian, Korean, Vietnamese, Laotian, Hmong, Kampuchean (including Khmer & Cambodian), Thai, Asian Indian, Pakistani, Micronesian, Chamorro, Guamanian, Polynesian, Tahitian, Samoan, Tongan, Melanesian, Fiji Islander, or New Guinean.

[c] The urbanicity and area deprivation index were characterized at the individual level using the Census block of residence.

[d] Higher area deprivation index quartiles represent areas with a greater degree of socioeconomic deprivation.

3.9.10 Leave-one-out analysis

We performed a leave-one-out analysis to investigate whether certain influential counties in Pennsylvania drive our main results. To do this, we iterated the main analysis 67 times (i.e., the number of counties in Pennsylvania) and dropped observations from each county (either a treated or a control county) within each iteration. We then plotted the range of estimates we obtained from each iteration and compared them to the main result in Figure A3.15. The figure shows that the estimates from the leave-one-out analysis cluster closely around the estimate from the main model, confirming no influential county that is driving our baseline results.

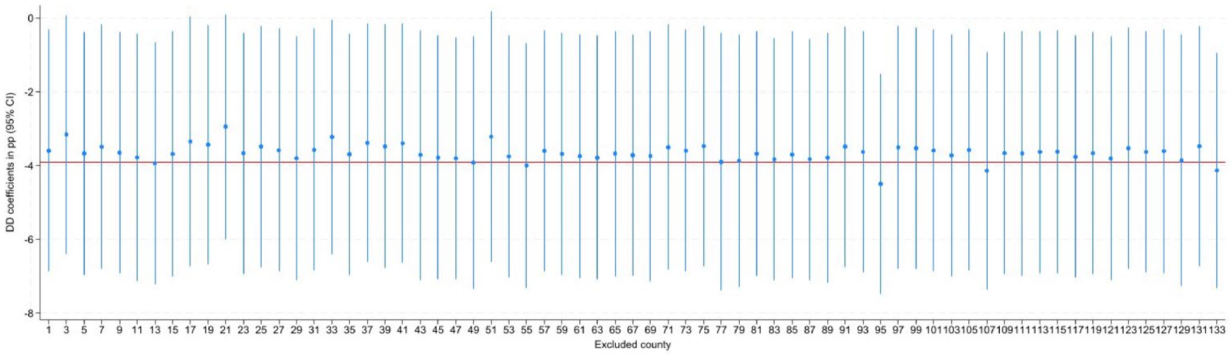


Figure A3.15 Sensitivity of main difference-in-differences estimate to excluding observations from each county

Abbreviations: DD, difference-in-differences; pp, percentage points
Note: The figure displays a range of the main difference-in-differences coefficients and their 95% confidence intervals, estimated in a series of models that sequentially excluded each county from the sample. The number on the x-axis corresponds to the county ID (FIPS code) that was excluded from the analysis. The red horizontal line equates to the size of the main effect (-3.9 percentage points).

3.9.11 Alternative staging definition

In the main analysis, we grouped cases with unstaged cancer with late-stage cases because lack of staging may both reflect disparities in care among medically underserved populations (e.g., poor access to providers who perform staging[265-267]) and be associated with worse prognosis as late-stage diagnosis.[268]

We ran two additional models that varied the definition of staging outcome; first, we estimated the probability that cancer is unstaged (vs. staged), and second, we estimated the probability of late-stage (vs. early-stage) diagnosis only, excluding the unstaged cancers from the analysis. In Column 2 of Table A3-9, we show that mandatory MMC did not significantly impact the likelihood that cancer is unstaged vs. staged (adjusted DD: -0.4 percentage points [95% CI: -2.1, 1.3]; P = 0.629). In Column 3, we note that our main results are virtually unchanged after excluding the unstaged cases from the sample.

Table A3-9 Differential changes in the probability of late-stage and unstaged cancers among cancer cases covered by Medicaid in the treated vs. control counties

	[1] Main specification[a]	**[2] Unstaged vs. staged[b]**	**[3] Excluding unstaged[c]**
DD coefficients in pp (95% CI)	-3.9 (-7.2, -0.5)	-0.4 (-2.1, 1.3)	-3.9 (-7.2, -0.6)
P-value	0.023	0.629	0.020
N	67617	67617	65042

Abbreviation: DD, difference-in-differences; pp, percentage points

Note: The table displays the difference-in-differences coefficients and their 95% confidence intervals with p-values. The models fully adjusted for all case-level and county-level covariates, year-quarter-by-stack, and county-by-stack fixed effects. Standard errors were clustered at the county level.

aWe report the main results, which modeled the probability of late-stage and unstaged diagnosis.

bWe modeled the probability of unstaged diagnosis (i.e., the reference group is staged cancers).

c We excluded unstaged cancer cases from the model.

4.0 Chapter 4: Housing-related disparities in receipt of mammography: evidence among adult women Medicaid beneficiaries in Pennsylvania

Youngmin Kwon, PhD[1]; Eric T. Roberts, PhD[2]; Howard B. Degenholtz, PhD[1]; Bruce L. Jacobs, MD, MPH[3]; Lindsay M. Sabik, PhD[1]; Evan S. Cole, PhD[1]

[1] University of Pittsburgh School of Public Health, Department of Health Policy and Management

[2] Perelman School of Medicine at University of Pennsylvania, Department of General Internal Medicine

[3] University of Pittsburgh School of Medicine, Department of Urology

4.1 Abstract

Importance: People experiencing housing insecurity (PEHI) may experience barriers to preventive care and cancer screening, but the extent to which PEHI receive these services at the population-level remain understudied.

Objective: To examine disparities in utilization of breast cancer screening associated with housing insecurity among women beneficiaries enrolled in a large Medicaid program

Design, Setting, and Participants: This retrospective cohort study assessed breast cancer screening among women Medicaid beneficiaries aged 50-64 in administrative Medicaid data linked to encounter-level records on housing-related services in Pennsylvania (Homelessness

Management Information System; HMIS) from 2011 to 2019. We characterized disparities in screening between beneficiaries with any encounter for housing-related services in HMIS (indicating experience or history of housing insecurity) and comparison beneficiaries without any such encounter.

Main outcome measures: Receipt of biennial mammography

Results: This study included 73,456 women Medicaid beneficiaries in Pennsylvania, including 1,792 HMIS service recipients and 71,664 comparison beneficiaries. The mean age (SD) was 56.1 (3.7) years, 12.3% were non-Hispanic Black, 8.3% were Hispanic, 73.6% were non-Hispanic White, and 5.9% had other or unknown race and ethnicity. The rate of mammography was 44.8% (95% CI: 42.4-47.1) among HMIS service recipients and 50.1% (95% CI: 49.7-50.5), representing a disparity of 5.3 percentage-points (95% CI: -7.6 to -2.9; P < .001). The disparity widened between HMIS service recipients with 12 or more months of experiencing homelessness relative to comparison beneficiaries (-9.4 percentage-points; 95% CI: -18.3 to -0.6; P = .036) but was attenuated among HMIS service recipients receiving supportive housing (-5.1 percentage-points; 95% CI: -9.9 to -0.3; P = .037) or unstably housed beneficiaries (-3.1 percentage-points; 95% CI: -6.9-0.8; P = .119). In stratified analyses, beneficiaries without any primary care visits at baseline had the lowest rate of mammography, though a significant disparity by receipt of HMIS services remained among those with any primary care visits.

Conclusion: Housing insecurity was associated with a significantly disparity in mammography among women Medicaid beneficiaries. Narrowing this disparity will require further expansion of supportive housing services, connecting of PEHI to primary care, and proactive counseling for cancer screening among PEHI.

4.2 Introduction

Homelessness is a persistent social issue affecting over 580,000 individuals in the US annually and has severe repercussions on health.[116,125,341] People experiencing homelessness (PEH) are more likely to suffer from physical and mental health conditions, and they face 8.1 to 16.6 times higher mortality risks compared to domiciled individuals.[125] In this population, cancer is one of the leading drivers of mortality, with one estimate showing that cancer contributed to almost 19% of all deaths in a major US city.[124] Cancer incidence is pronounced among PEH because they suffer from various behavioral and environmental risk factors associated with cancer development, including smoking, substance use, chronic infections, and lack of access to healthcare.[126]

Despite their increased susceptibility to cancer, PEH are more likely to be diagnosed with advanced-stage disease, suggesting barriers to preventive screening services.[128] This is especially true for breast cancer, the most commonly diagnosed cancer,[342] for which non-localized diseases account for the majority of incident cases among PEH.[128] However, there is limited data examining cancer screening utilization among PEH.[343] While few studies have found low screening rates among PEH, they often assessed screening in specific settings (e.g., a homeless shelter[344-346] or a hospital system[347]) and only provided limited insights into disparities in screening associated with experience of homelessness. Moreover, existing research often relies on self-reported[118,348,349] or claims-based indicators[347] of housing history that are inadequate to precisely characterize the longitudinal experience of homelessness, precluding a more granular assessment of disparities.

In this paper, we investigate disparities in receipt of cancer screening in a population covered by Medicaid—the largest single source of health insurance coverage for individuals who are low-income or with disabilities.[350] Medicaid is an important policy lever for addressing disparities in cancer screening for two reasons. First, Medicaid disproportionately insures PEH or those at risk of homelessness[350], and thus, it can influence access and utilize health services and preventive cancer screening. Second, there is a growing interest in using Medicaid funding to directly address housing insecurity by integrating supportive housing services (such as permanent supportive housing) and traditional medical care.[351,352] In this context, further evidence assessing disparities in Medicaid can inform efforts to improve its administration and develop other initiatives to target such disparities.

Using a novel linkage of the administrative Medicaid records with encounter-level data on housing-related services in Pennsylvania, we examined receipt of guideline-recommended breast cancer screening among adult women Medicaid beneficiaries utilizing housing-related services who were experiencing or at risk of homelessness. We focus on mammogram screening for breast cancer, the most common cancer among Medicaid beneficiaries,[96] because it is widely available and accepted as an effective tool for early detection, and there is a clear clinical case for lessening disparities in its use among women experiencing socioeconomic and housing vulnerabilities.[296,353,354]

4.3 Methods

4.3.1 Data

We analyzed individual-level data from Pennsylvania's Homelessness Management Information System (HMIS) from 2011 to 2017 that were linked to the state Medicaid claims and enrollment records. The PA HMIS provides client-level information on housing and services provided to PEH or those at risk of homelessness.[355,356] We utilized available HMIS data for 59 out of 67 counties in Pennsylvania, representing diverse geographic areas, including Pittsburgh, most rural counties, and select mid-sized urban counties. The HMIS data provides rich information on the type of housing services and support received (e.g., emergency shelter, street outreach, homelessness prevention, permanent supportive housing), service entry and exit date, and residence before service entry. HMIS data were linked to the state Medicaid claims and enrollment records using individual-level identifiers provided by the Pennsylvania Department of Human Services.

4.3.2 Study design and population

Our analytic approach compared rates of biennial mammograms between a cohort of Medicaid beneficiaries receiving housing-related services in HMIS (who were experiencing or at risk of homelessness) and a random sample of comparison beneficiaries without any HMIS services use. To create the main cohort, we identified initial encounters for housing-related services among individuals in HMIS and designated the index date of the encounter using the service entry date. We used merged monthly Medicaid enrollment files to identify HMIS service users who were also enrolled in Medicaid. In the comparison cohort, we included Medicaid beneficiaries without HMIS encounters and randomly selected a pseudo-index date from enrolled Medicaid days between 2011 and 2017 (Figure A4.3). We combined the two cohorts to form a preliminary analytic sample.

In this sample, we applied several inclusion and exclusion criteria. First, we required six months of continuous Medicaid enrollment pre-index (to characterize baseline healthcare utilization and comorbidities) and at least 18 months of Medicaid enrollment in the 24-month window post-index (to examine receipt of biennial mammography). The 18 months of continuous enrollment in the post-index period is roughly equivalent to the two-year average duration of Medicaid enrollment during the study period and thus captures many Medicaid beneficiaries who experience "churning" in enrollment (i.e., disruptions in coverage).[357] Second, we excluded beneficiaries dually enrolled in Medicare whose healthcare utilization is likely not observed in Medicaid claims. Third, we limited the sample to women aged 50 to 64 who were recommended for biennial mammograms by the US Preventive Services Task Force (Grade B recommendation).[358] Finally, we excluded a small number of beneficiaries whose enrollment records indicated residence in counties without available HMIS data or outside Pennsylvania.

4.3.3 Exposure

The primary exposure variable was the receipt of housing-related support and services, which we use as a proxy for experience or risk of homelessness. We also created the following four programmatically relevant subcategories of HMIS services users: 1) beneficiaries with any supportive housing (e.g., permanent supportive housing); 2) beneficiaries with 12 or more months of observed homelessness (defined as using shelter, street outreach, homelessness assistance, or "homeless" as prior residence at the index HMIS encounter); 3) beneficiaries with less than 12 months of observed homelessness; and 4) unstably housed beneficiaries (including beneficiaries with all other HMIS service types, including homelessness prevention services).

4.3.4 Outcome

We measured any receipt of mammograms in the 24-month post-index period. We identified mammography in the outpatient and professional Medicaid claims using a combination of the relevant ICD diagnosis and procedure, CPT, and HCPCS codes (Table A4-3). In the main analysis, the outcome measured receipt of mammograms for both screening and diagnostic purposes (based on the code description) to follow the Healthcare Effectiveness Data and Information Set (HEDIS) measure used to evaluate breast cancer screening in Medicaid and to account for the fact that claims may not reliably distinguish these two types of mammograms.[359,360]

4.3.5 Covariates

We controlled for key demographic and Medicaid eligibility characteristics (i.e., age groups, race and ethnicity, county of residence, year of index date, eligibility pathways, and continuous enrollment in the post-index period) from the Medicaid enrollment records. We also characterized healthcare utilization (i.e., primary care and inpatient visits) and diagnoses for major comorbidities at baseline. We identified primary care visits using procedure codes for evaluation and management visits for providers whose specialty type indicated primary care and internal medicine, Federally Qualified Health Centers, and Rural Health Centers (Table A4-4). For comorbidities, we grouped each comorbidity in the Chronic Conditions Warehouse algorithm[361] to generate several categories of health conditions that are more prevalent among PEH and Medicaid populations, including mental health conditions, substance use disorders, diabetes, and other metabolic disorders (Table A4-5).

4.3.6 Statistical analysis

We compared the rates of biennial mammograms between women Medicaid beneficiaries in the HMIS and non-HMIS cohorts (reference group) using a series of nested regression models, each controlling for a greater amount of confounding. For each model, we implemented a linear probability model, and calculated the marginal effects and adjusted probability of mammograms associated with each level of covariate.

First, we estimated an overall, unadjusted disparity in receipt of mammography by only including the exposure variable (i.e., a categorical variable for the service use in HMIS). In Model 1, we controlled for key demographic and Medicaid eligibility characteristics, county, and year fixed effects. County fixed effects adjust for fixed differences across counties correlated with receipt of mammograms, such as local healthcare resources or social support, while year fixed effects adjust for secular trends in rates of mammograms. In Model 2, we added baseline healthcare utilization measures, hypothesizing that access to healthcare may partly or fully explain the disparity in receipt of mammograms. In Model 3, we adjusted for baseline comorbidities, which can influence the probability of receiving a mammogram in either direction. For instance, these comorbidities may represent competing needs for care that may crowd out opportunities for administering preventive care for conditions like cancer that may be perceived as less urgent. At the same time, sicker patients may be more likely to seek screening or receive recommendations for screening due to their increased risks of cancer.

4.3.7 Supplementary analyses

We conducted several supplementary analyses. First, we stratified our main analysis by key covariates of interest to examine heterogeneity in mammogram disparity across subpopulations. Second, we separately estimated the probability of receiving mammograms for screening vs. diagnostic purposes; the former is a proxy for access to and utilization of preventive care, whereas the latter is more likely to measure cancer risk or incidence of cancer. Third, we performed a sensitivity analysis to gauge the effects of unmeasured confounding on the estimated disparity. In this analysis, we simulate how much an unmeasured confounder would need to vary between the exposure and be associated with the outcome to fully explain our main disparity estimate.

4.4 Results

4.4.1 Medicaid beneficiary characteristics

We included 1,792 Medicaid beneficiaries with an HMIS encounter and 71,664 comparison beneficiaries (Table 4-1). Beneficiaries in the HMIS cohort were more likely to be younger, non-Hispanic black, eligible for Medicaid due to disability, and continuously enrolled in Medicaid. At baseline, those in the HMIS cohort had more primary care and inpatient visits. The prevalence of baseline comorbidities was higher in the HMIS cohort for all categories, especially for mental health conditions and substance use disorders.

4.4.2 Disparity in receipt of mammogram

The unadjusted proportion receiving mammogram was 44.8% (95% CI: 42.4-47.1) and 50.1% (95% CI: 49.7-50.5) in the HMIS vs. non-HMIS cohort, with an overall disparity of 5.3 percentage-points (pp, 95% CI: -7.6 to -2.9; *P* <.001; Table 4-2**,** Figure 4.1) or an 11% lower probability of receiving mammogram. The disparity was larger when comparing beneficiaries with 12 or more months of homelessness (-9.4 pp; 95% CI: -18.3 to -0.6; *P* = .036) and less than 12 months of homelessness (-7.0 pp; 95% CI: -11.1 to -3.0; *P* = .001) relative to the non-HMIS cohort. In contrast, there was a smaller disparity among those with any supportive housing (-5.1 pp; 95% CI: -9.9 to -0.3; *P* = .037) or unstably housed beneficiaries (-3.1 pp; 95% CI: -6.9-0.8; *P* = .119).

In nested regression models, the disparities in mammograms remained significant even after adjusting for demographic and Medicaid eligibility characteristics (Model 1), baseline healthcare utilization (Model 2), and comorbidities (Model 3). In the fully adjusted model, the overall disparity between the HMIS vs. non-HMIS cohort was -4.3 pp (95% CI: -6.4 to -2.1; *P* < .001). Disparities among beneficiaries with any supportive housing or unstably housed beneficiaries are marginally significant; in these two groups, we cannot reject the difference in receipt of mammograms as large as -8.1 and -6.8 pp relative to the comparison beneficiaries, respectively. In supplementary analyses, we found that the disparity was driven by lower utilization of screening mammograms rather than diagnostic mammograms (Figure A4.5).

4.4.3 Stratified analysis

In the stratified analysis, we generally observed consistent disparity across all stratifications, though the overall rate of mammograms differed meaningfully for certain subpopulations (Figure 4.2). We found that the share receiving mammograms was higher among non-Hispanic black and Hispanic than non-Hispanic white beneficiaries. Beneficiaries without any primary care visit at baseline had the lowest share of receiving mammograms. Conditional on having any primary care visit, there was still a significant disparity in mammograms between the HMIS and non-HMIS cohorts. A greater number of baseline comorbidities was also associated with a higher probability of receiving a mammogram, but the disparity was more pronounced among beneficiaries with a greater count of comorbidities.

4.4.4 Assessing effects of unmeasured confounding

In the sensitivity analysis, we obtained and plotted joint combinations of the two parameters of interest: γ, the difference of the mean in the unmeasured confounder (U) between the HMIS and non-HMIS cohort; and η, the association between U and the outcome (Figure A4.6). At the optimum of these combinations, U would have to vary by 20% ($\gamma = 0.20$) and be associated with a 20 pp lower probability of mammogram ($\eta = 0.20$) to fully explain a disparity as large as -

4.3 pp. In our context, none of the *measured* covariates in the model reached these values of γ and η, suggesting a high threshold for omitted variable bias.

4.5 Discussion

In this retrospective analysis of a linked Medicaid and housing service records in Pennsylvania, women Medicaid beneficiaries experiencing or at risk of homelessness who had encounters for housing-related services were significantly less likely to receive guideline-recommended mammograms than the general Medicaid population. This disparity was pronounced among beneficiaries with prolonged experience of homelessness, though our results suggest that even unstably *housed* beneficiaries had lower utilization of mammograms. We document a strong, independent association of experience or risk of homelessness with receipt of mammograms after adjusting for important confounders such as healthcare utilization and comorbidities.

To our knowledge, this is the first study to examine a population-wide disparity in mammogram use in a Medicaid population, encompassing beneficiaries living in geographically diverse areas and including the largest sample of individuals with experience or risk of homelessness. The rate of mammograms among the HMIS cohort in our study (40%-47%) is generally close to or within the range reported in prior literature. Several studies of women using shelter-based services at certain cities estimated that 32% to 57% have received biennial mammograms.[344-346] Others studies using national surveys, including the National Health Interview Survey[349,362] and Health Center Patient Survey,[118] found that 51% to 69% of low-income individuals receiving housing assistance or care at community health centers received screening. The most expansive analysis on this topic studied PEH presenting for care at a large hospital system in the Midwest, which noted that only 18% of PEH received screening compared to 32% among non-PEH.[347] The discrepancies in these rates can be explained by the different methods used to ascertain housing and screening history and sample characteristics. For instance, studies that use self-reported screening data are likely to overestimate the actual rate of screening compared to others that use medical records or claims.[363,364] Moreover, the screening rate is lower in populations that include uninsured patients or those lacking a usual source of care,[347] whereas the rate is generally higher among individuals with insurance coverage (which is the case for our study) and existing contact with providers.[347] A key strength of our approach is the use of administrative data to precisely measure receipt of housing-related services and mammograms among a large sample of Medicaid beneficiaries, which provided sufficient power to detect a significant disparity in mammogram utilization associated with experience and risk of homelessness.

This disparity likely reflects a complex web of factors that impose barriers to preventive cancer screening among PEH.[126,343] Qualitative reports of PEH have highlighted salient barriers such as lack of knowledge and awareness of screening, inadequate insurance, and access to care.[345-347,365,366] We highlight two major findings consistent with these reports. First, our results show that beneficiaries without primary care visits are the least likely to receive mammograms, indicating that connecting PEH to a regular source of care is a vital pre-condition to facilitate access to screening.[344,346] At the same time, we found that the disparity in mammograms persists even among those with pre-existing engagement with care, which points to other barriers to screening. It is possible that PEH may feel unwelcome in their interaction with care providers and avoid discussions about less urgent care needs, while providers may prioritize treating more acute health problems within the time constraints of each clinical visit.[343,366,367] This could explain the pronounced disparity in mammograms among beneficiaries with greater comorbidities who may present with other competing needs for care in clinical encounters. Future studies should further elucidate these dynamics of patient-provider interactions, which may identify avenues to improve the take-up of screening among PEH at the point of contact with healthcare systems.

As a predominant source of health insurance coverage among PEH,[350,368,369] Medicaid must assume considerable responsibility for ameliorating disparities in cancer screening. In our analysis, mammogram disparity was most attenuated among beneficiaries receiving supportive housing. This suggests that one way for Medicaid programs to lessen disparities is through Medicaid coverage of nontraditional services to ensure adequate and affordable housing.[370-373] During the study period, many of these services in Pennsylvania were provided through reinvestment of excess funds by counties responsible for providing behavioral health services for Medicaid beneficiaries.[374,375] Further expansion of these services may address disparities in screening and access to other health services by directly targeting housing needs.[376-382] Moreover, in states that use Medicaid managed care, agencies can leverage managed care contracts to indirectly address disparities arising from housing insecurity.[142,383] For example, states can require plans to provide patient navigation and coordination services[384,385] to improve screening rates among PEH and other individuals experiencing socioeconomic vulnerabilities.[386,387] In addition, states can design payment incentives for plans tied to cancer screening among PEH[384], building upon the existing process of managed care plan oversight using HEDIS measures that include quality metrics for breast cancer screening.[388] Finally, states may direct plans to design alternative payment models for reimbursing providers based on metrics related to housing and cancer screening.[384]

One unexpected finding in our analysis was that racial and ethnic minorities, who are disproportionately represented among PEH[115] and served by Medicaid,[64] were more likely to receive mammograms compared to non-Hispanic white beneficiaries. Though this result is surprising considering the deep rooted inequities in access to care among racial and ethnic minorities,[389] it is corroborated by several studies examining mammogram use in national surveys and Medicaid data.[390-394] In particular, one study found that Pennsylvania was one of the few states where the rate of mammograms in Medicaid was higher among black and Hispanic beneficiaries relative to white beneficiaries.[392] While the exact causes that led to the reversal in racial and ethnic disparities in mammograms are unclear, it is likely that initiatives to facilitate screening (e.g., National Breast and Cervical Cancer Early Detection program and other outreach programs) have played a key role in increasing uptake of screening among racial and ethnic minorities.[391] In so far as our result reflects the success of these targeted programs, it further bolsters the case for policy- and community-based solutions to mitigate unequal access to cancer screening among those who experience the most severe risk of cancer development.

4.6 Limitations

We acknowledge a few limitations. First, we used receipt of housing-related services in the HMIS as an imperfect proxy for experience or risk of homelessness, and our sample may have failed to capture individuals who had *needs* for these services but did not receive them, such as those who are unsheltered.[117] As such, we may have underestimated the true disparity in screening. On the other hand, our sample selection process excluded HMIS service users without a prior history of Medicaid enrollment and Medicaid beneficiaries without continuous enrollment, which does not represent all Medicaid beneficiaries. This may have overestimated the prevalence of screening in our sample if the excluded beneficiaries experienced worse access to care (due to having more gaps in coverage, for example). Second, this was an observational study, and we cannot rule out biases from failing to control for residual confounders. Third, as this was a single-state study of Medicaid beneficiaries in Pennsylvania (excluding certain counties of Pennsylvania, including Philadelphia, for which we lacked the HMIS data), its results may not generalize.

4.7 Conclusion

We documented a significant disparity in the utilization of guideline-concordant mammograms among women Medicaid beneficiaries experiencing or at risk of homelessness in Pennsylvania, especially those who suffer from chronic homelessness. Medicaid programs should consider expanding provisions of housing-related services that target the *fundamental* source of this disparity while dedicating efforts to increase access to primary care among beneficiaries with housing needs to ensure that they are appropriately screened for breast cancer.

4.8 Tables and figures

Table 4-1 Characteristics of women Medicaid beneficiaries in Pennsylvania who were eligible for recommended biennial mammography from 2011 to 2019 between HMIS and non-HMIS cohort

	HMIS cohort (N=1,792)	HMIS Cohort Any supportive housing[b] (N = 420)	HMIS Cohort ≥12 months homelessness[c] (N = 123)	HMIS Cohort <12 months homelessness[d] (N = 590)	HMIS Cohort Unstably housed (N = 659)	Non-HMIS cohort (N = 71,664)	*P*-value[f]
Age, %							
50-54	54.4	59.5	51.2	52.9	53.0	42.6	<.001
55-69	35.0	31.9	35.8	36.6	35.5	37.7	0.101
60-64	10.6	8.6	13.0	10.5	11.5	19.7	<.001
Race and ethnicity, %[g]							
Non-Hispanic white	63.9	63.3	52.8	60.8	69.0	73.8	<.001
Non-Hispanic black	31.9	32.9	43.9	34.2	26.9	11.8	<.001
Hispanic	2.4	1.4	3.3	2.7	2.6	8.4	<.001
Other (including unknown)	1.8	2.4	0.0	2.2	1.5	6.0	<.001
Medicaid eligibility, %[h]							
Disabled or chronically Ill	56.8	57.4	52.8	58.6	55.4	41.7	<.001
Newly eligible	21.9	20.2	25.2	21.2	22.9	34.1	<.001
Non-disabled adults	6.8	7.4	6.5	4.6	8.3	6.1	0.053
Other	16.0	15.7	17.1	16.6	15.5	19.0	0.032
Continuously enrolled, %[i]							
Yes	94.4	95.2	96.7	94.1	93.8	91.6	<.001
No	5.6	4.8	3.3	5.9	6.2	8.4	<.001
No. of primary care visits at baseline, %							
0	42.0	42.9	49.6	43.6	38.5	44.2	0.035
1-3	37.7	35.5	36.6	37.8	39.3	39.7	0.354
4-5	11.3	11.9	8.1	10.8	12.0	9.2	0.021
6+	9.0	9.8	5.7	7.8	10.2	6.9	0.002

No. of FQHC or RHC visits at baseline, %							
0	90.0	90.2	91.1	91.0	88.8	92.2	0.007
1	4.2	4.5	3.3	4.6	3.9	3.0	0.027
2+	5.7	5.2	5.7	4.4	7.3	4.8	0.060
No. of inpatient visits at baseline, %							
0	81.4	80.0	86.2	76.1	86.2	93.3	<.001
1	12.3	12.6	9.8	14.9	10.3	4.9	<.001
2+	6.3	7.4	4.1	9.0	3.5	1.7	<.001
Comorbidities diagnoses at baseline, %							
Diabetes and metabolic disorder[sl]	39.7	35.7	39.0	41.0	41.3	33.3	<.001
Neurological conditions[m]	5.9	4.5	5.7	7.3	5.6	3.3	<.001
CVDs[n]	11.9	11.4	9.8	13.9	10.9	8.6	<.001
Asthma or COPD	19.0	18.6	12.2	21.4	18.5	10.3	<.001
CKD	5.2	5.2	5.7	5.6	4.7	3.8	0.041
Mental health conditions[o]	55.2	56.0	48.0	57.5	54.2	29.7	<.001
Disability and limitations[p]	22.2	19.3	19.5	24.7	22.2	16.5	<.001
Liver conditions[q]	6.0	7.9	4.9	8.3	2.9	2.8	<.001
Substance use disorders[r]	32.5	35.0	32.5	37.5	26.6	10.3	<.001

Abbreviations: HMIS, Housing Management Information System; PA, Pennsylvania; No., numbers; FQHC, Federally Qualified Health Centers; RHC, Rural Health Centers; CVD, cardio-cerebrovascular diseases; COPD, chronic obstructive pulmonary disease.

[a] Characteristics of women Medicaid beneficiaries in PA who were aged 50-64 by receipt of housing-related services in HMIS. We report characteristics separately among the four subgroups of HMIS services users (defined below) and the comparison group of randomly sampled beneficiaries without any HMIS services use.

[b] receipt of any supportive housing services (e.g. permanent supportive housing) at or after the index HMIS encounter.

[c] At least 12 months of observed homelessness (i.e., shelter use, street outreach, homelessness assistance, or homeless as prior residence in coordinated entry or assessment).

[d] Less than 12 months of observed homelessness.

[e] Beneficiaries with an encounter for all other HMIS service types, including homelessness prevention services.

[f] P-values from Chi-square tests of differences in sample means between specific HMIS groups and non-HMIS group.

[g] Race and ethnicity were reported for beneficiaries who completed specific demographic questions during enrollment. We combined separate race and ethnicity variables into the listed categories. The "other" category includes non-Hispanic beneficiaries who self-identified as Asian, American Indian/Alaskan Native, Native Hawaiian/Pacific Islanders, or other races.

[h] Medicaid eligibility at the index date. Newly eligible beneficiaries refer to those who were eligible through Medicaid expansion pathway starting in 2015 (i.e., childless adults with income above 138% of federal poverty line). Non-disabled adult beneficiaries include those who met the Medicaid income eligibility prior to Medicaid expansion.

[I] Continuous enrollment was defined as at least having 720 days of enrollment in the 24-months period following the index date.

[l] Any diagnoses of diabetes, acquired hypothyroidism, anemia, hyperlipidemia, or hypertension.

[m] Any diagnoses of Alzheimer's diseases and related disorders/dementia, epilepsy, spina bifida, traumatic brain injury, non-psychotic mental disorders due to brain damage, migraine, chronic headache, or other congenital anomalies of the nervous system.

[n] Any diagnoses of acute myocardial infarction, atrial fibrillation, heart failure, ischemic heart diseases, stroke, transient ischemic attack, or peripheral vascular diseases.

[o] Any diagnoses of depression, anxiety, bipolar disorder, personality disorders, post-traumatic stress disorders, depressive or other psychotic disorders.

[p] Conditions indicating physical or developmental, or intellectual disability, mobility limitations, or chronic pain (i.e., hip or pelvic fracture, osteoporosis, arthritis, attention deficit/hyperactivity disorder, autism, cerebral palsy, cystic fibrosis, fibromyalgia, multiple sclerosis, muscular dystrophy).

[q] Any diagnoses of liver diseases, cirrhosis, or hepatitis.

[r] Any disorders of alcohol, drug (including opioids), or tobacco use.

Table 4-2 Disparities in receipt of biennial mammography between HMIS services users and non-users among women Medicaid beneficiaries in Pennsylvania

	Difference in screening rate in each group relative to the non-HMIS cohort, pp (95% CI)[b]				
Model[a]	**HMIS Cohort**	**Any supportive housing**	**>12 months of homelessness**	**< 12 months of homelessness**	**Unstably housed**
Unadjusted[c]	-5.3 (-7.6 to -2.9)***	-5.1 (-9.9 to -0.3)*	-9.4 (-18.3 to -0.6)*	-7.0 (-11.1 to -3.0)**	-3.1 (-6.9-0.8)
Model 1[d]	-4.4 (-6.7 to -2.2)***	-4.8 (-9.3 to -0.3)*	-10.4 (-18.7 to -2.1)*	-6.4 (-10.2 to -2.5)**	-1.3 (-4.9-2.4)
Model 2[e]	-4.4 (-6.6 to -2.3)***	-4.2 (-8.6-0.1)	-8.5 (-16.6 to -0.5)*	-5.2 (-8.9 to -1.5)**	-3.2 (-6.7-0.4)
Model 3[f]	-4.3 (-6.4 to -2.1)***	-3.7 (-8.1-0.7)	-8.5 (-16.5 to -0.5)*	-5.0 (-8.7 to -1.2)**	-3.3 (-6.8-0.3)

***, P < .001; **, P < 0.01; *, P < 0.05

Abbreviations: pp, percentage-points; CI, confidence interval.

[a] Nested regression models sequentially controlled for greater amounts of confounding.

[b] Estimated marginal effects (in percentage-points) capture the adjusted mean difference in the probability of receiving biennial mammography between each HMIS subgroup and the comparison group of non-HMIS service users; the unadjusted mean in the comparison group was 50.1 (95% CI: 49.7-50.5).

[c] The unadjusted model only included HMIS subgroup indicators.

[d] Model 2 adjusted for the variables from Model 1, demographic characteristics (i.e., age, race and ethnicity) and Medicaid eligibility characteristics (i.e., eligibility pathway and continuous enrollment), county and year fixed effects.

[e] Model 3 adjusted for the variables from Model 2, and baseline healthcare use (i.e., count of primary care visits, federally qualified health centers and rural health centers visits, and inpatient visits).

[f] Model 4 adjusted for the variables from Model 3, and baseline diagnoses of each comorbidity .

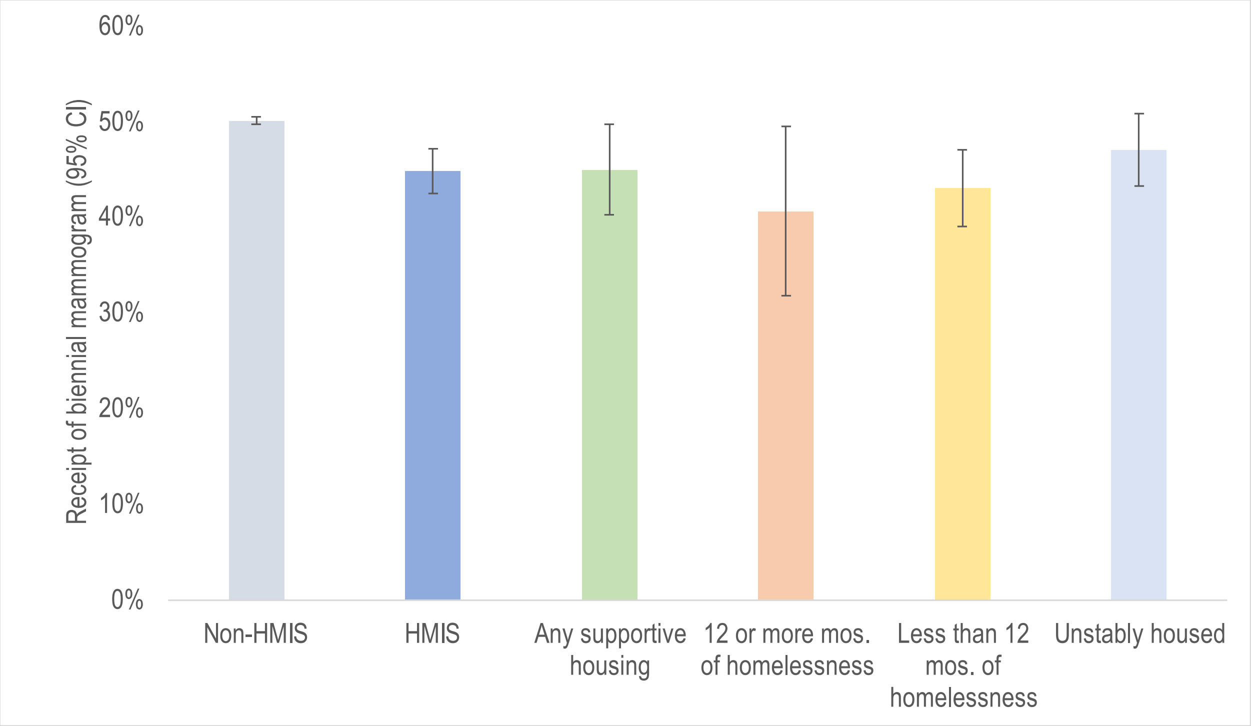


Figure 4.1 Receipt of biennial mammogram between HMIS services users and non-users among women Medicaid beneficiaries in Pennsylvania

Abbreviation: Housing Management Information System; Mo, months
The bar graphs show unadjusted proportion of receipt of biennial mammography between HMIS service users and non-users. Among HMIS service users, we separately report proportions among those with any supportive housing, at least 12 months of observed homelessness, less than 12 months of observed homelessness, and unstably housed beneficiaries with an encounter for all other HMIS service types, including homelessness prevention services.

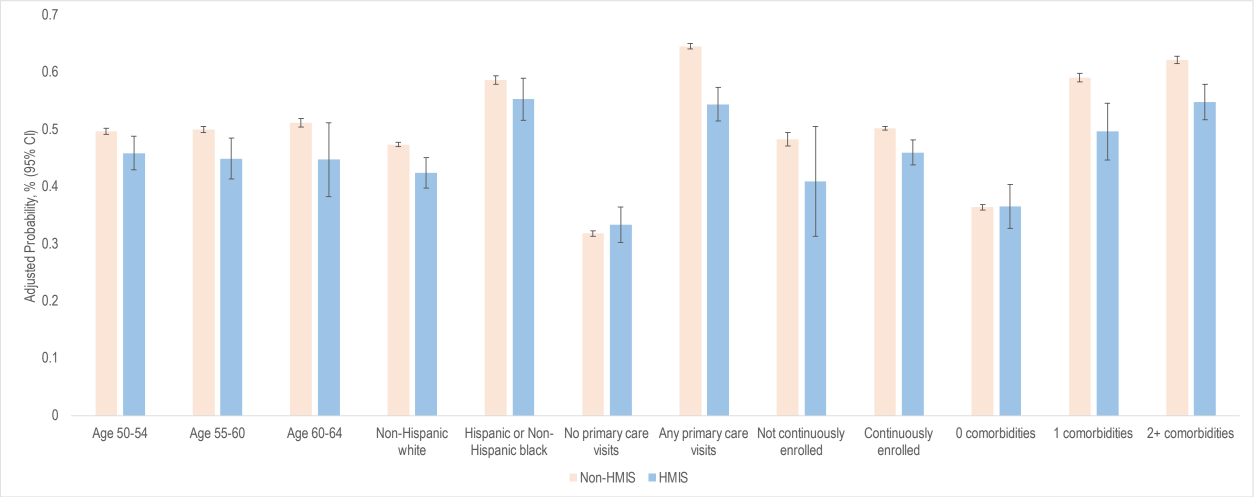


Figure 4.2 Disparities in receipt of biennial mammography between HMIS services users and non-users among women Medicaid beneficiaries in Pennsylvania, stratified by age, race and ethnicity, baseline healthcare use, and clinical characteristics

Abbreviation: pp, percentage-points; CI, confidence-interval
The bar graphs show the main adjusted disparities in receipt of biennial mammography between HMIS service users and non-users that were stratified by several covariates of interest. The estimates are shown as percentage-points. Primary care visits and comorbidities were measured at baseline (6 months prior to the index date). Comorbidities count was calculated by summing up the indicator for each category of conditions.

4.9 Appendix

Table A4-3 Codes to identify screening and diagnostic mammography

Code type	Code	Description	Screening or diagnostic[a]
CPT	77061	Diagnostic digital breast tomosynthesis; unilateral	Diagnostic
CPT	77062	Diagnostic digital breast tomosynthesis; bilateral	Diagnostic
CPT	77065	Diagnostic mammography, including CAD when performed; unilateral	Diagnostic
CPT	77066	Diagnostic mammography, including CAD when performed; bilateral	Diagnostic
CPT	77063	Screening digital breast tomosynthesis, bilateral	Screening
CPT	77067	Screening mammography, bilateral, including CAD when performed	Screening
HCPCS	G0204	Diagnostic mammography, including CAD when performed; bilateral	Diagnostic
HCPCS	G0205	Diagnostic mammography, film processed to produce digital image analyzed for potential abnormalities, bilateral, all views	Diagnostic
HCPCS	G0206	Diagnostic mammography, including CAD when performed; unilateral	Diagnostic
HCPCS	G0207	Diagnostic mammography, film processed to produce digital image analyzed for potential abnormalities, unilateral, all views	Diagnostic
HCPCS	G0202	Screening mammography film processed to produce digital image, bilateral all views	Screening
HCPCS	G0203	X-ray breast screening mammography	Screening
ICD-10-CM	Z1231	Encounter for screening mammogram for malignant neoplasm of breast	Screening
ICD-9-CM	V7611	Screening mammogram for high-risk patient	Screening
ICD-9-CM	V7612	Other screening mammogram	Screening
UB-revenue code	0403	Screening mammography	Screening
UB-revenue code	0401	Diagnostic mammography	Diagnostic

Abbreviation: CPT, Current Procedural Terminology; HCPCS, Healthcare Common Procedure Coding System; ICD, International Classification of Diseases; CM, Clinical Modification; UB, Uniform Billing; CAD, computer-aided detection

[a] We distinguished screening and diagnostic mammography based on the code description or the presence of “GG” modifier code along with a CPT code for diagnostic mammography.

Table A4-4 Codes for identifying primary care, FQHC, and RHC providers

Provider type	Identification algorithm
Primary care providers	Provider specialty code is ('083', '090', '091', '092','316','318', '322', '344', '345', '093', '100') For those with "internal medicine" as specialty, we excluded providers that did not have the following primary care sub-specialties: not in ('Internal Medicine', 'Family Medicine', 'Pediatrics', 'General Practice', 'Physician Assistant', 'Nurse Practitioner', 'Geriatric MedicineInternal Medicine', 'Geriatric MedicineFamily Medicine', 'Primary CareClinic/Center', 'Adolescent MedicineInternal Medicine', 'Adult HealthNurse Practitioner', 'Adult MedicineFamily Medicine', 'FamilyNurse Practitioner', 'Federally Qualified Health Center (FQHC)Clinic/Center')
FQHC/RHC providers	Provider specialty code is ('080', '081', '083', '090','091', '092','316','318', '322', '344', '345', '093', '100') For those with "internal medicine" as specialty, we excluded providers that did not have the following primary care sub-specialties: not in ('Internal Medicine', 'Family Medicine', 'Pediatrics', 'General Practice', 'Physician Assistant', 'Nurse Practitioner', 'Geriatric MedicineInternal Medicine', 'Geriatric MedicineFamily Medicine', 'Primary CareClinic/Center', 'Adolescent MedicineInternal Medicine', 'Adult HealthNurse Practitioner', 'Adult MedicineFamily Medicine', 'FamilyNurse Practitioner', 'Federally Qualified Health Center (FQHC)Clinic/Center')

Abbreviations: FQHC, Federally Qualified Health Centers; RHC, Rural Health Centers

Our measures of baseline healthcare utilization included number of primary care visits, Federally Qualified Health Centers (FQHC)/Rural Health Center (RHC) visits, and inpatient visits. For characterizing primary care, we counted visits with evaluation and management procedure codes (CPT: 99201-99205, 99211-99215, 99381-99387, 99391-99397, 99241-99245, 99271-99275, 99499 and HCPCS: G0402, G0438, G0439) to providers in primary care specialties, which were identified using the Medicaid provider files that contain the National Provider Identifier (NPI) and provider specialty. For providers listing only "internal medicine" as their specialties, we examined whether they listed any non-primary care sub-specialties in the National Plan and Provider Enumeration System (NPPES) and excluded providers who listed any non-primary care specialties.

Table A4-5 Categories of comorbidities identified using the Chronic Conditions Warehouse algorithm

Category	Conditions[a]
Diabetes and metabolic disorders	Diabetes, acquired hypothyroidism, anemia, hyperlipidemia, or hypertension
Neurological conditions	Alzheimer's diseases and related disorders/dementia, epilepsy, spina bifida, traumatic brain injury, non-psychotic mental disorders due to brain damage, migraine, chronic headache, or other congenital anomalies of the nervous system
CVD	Acute myocardial infarction, atrial fibrillation, heart failure, ischemic heart diseases, stroke, transient ischemic attack, or peripheral vascular diseases
Asthma or COPD	Asthma, COPD
Chronic kidney disease	Chronic kidney disease
Mental health conditions	Depression, anxiety, bipolar disorder, personality disorders, post-traumatic stress disorders, depressive or other psychotic disorders
Disability or mobility limitations and other pain conditions	Physical or developmental, or intellectual disability, mobility limitations, or chronic pain (i.e., hip or pelvic fracture, osteoporosis, arthritis, attention deficit/hyperactivity disorder, autism, cerebral palsy, cystic fibrosis, fibromyalgia, multiple sclerosis, muscular dystrophy)
Liver conditions	Liver diseases, cirrhosis, or hepatitis
Substance use disorders	Alcohol, drug (including opioids), or tobacco use

Abbreviation: CVD, cardio and cerebrovascular diseases; COPD, chronic obstructive pulmonary disorder

[a] These conditions map directly to the list of “chronic conditions” and “chronic and other disabling conditions” provided by the Chronic Conditions Warehouse.

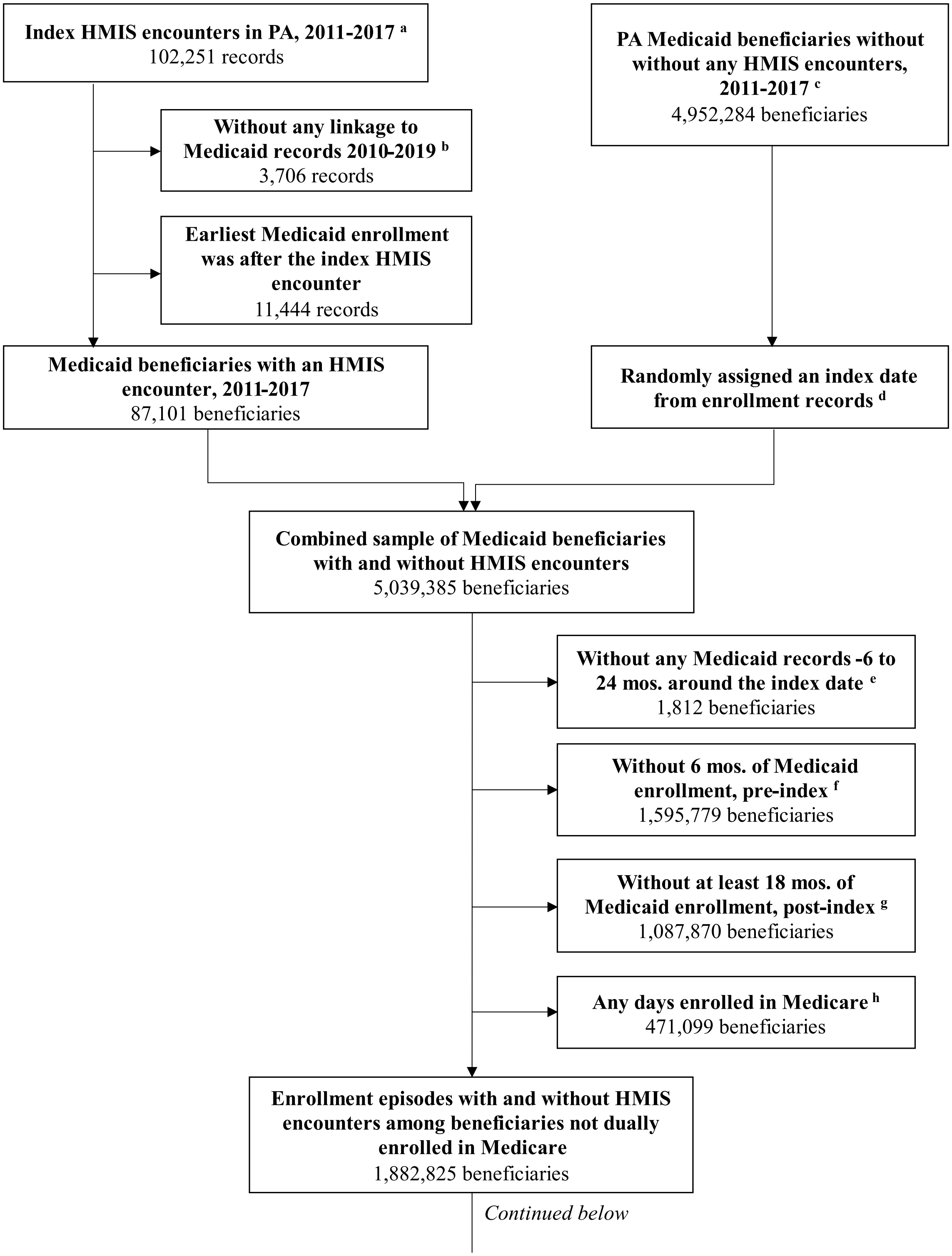


Figure A4.3 Flow diagram of the study inclusion criteria

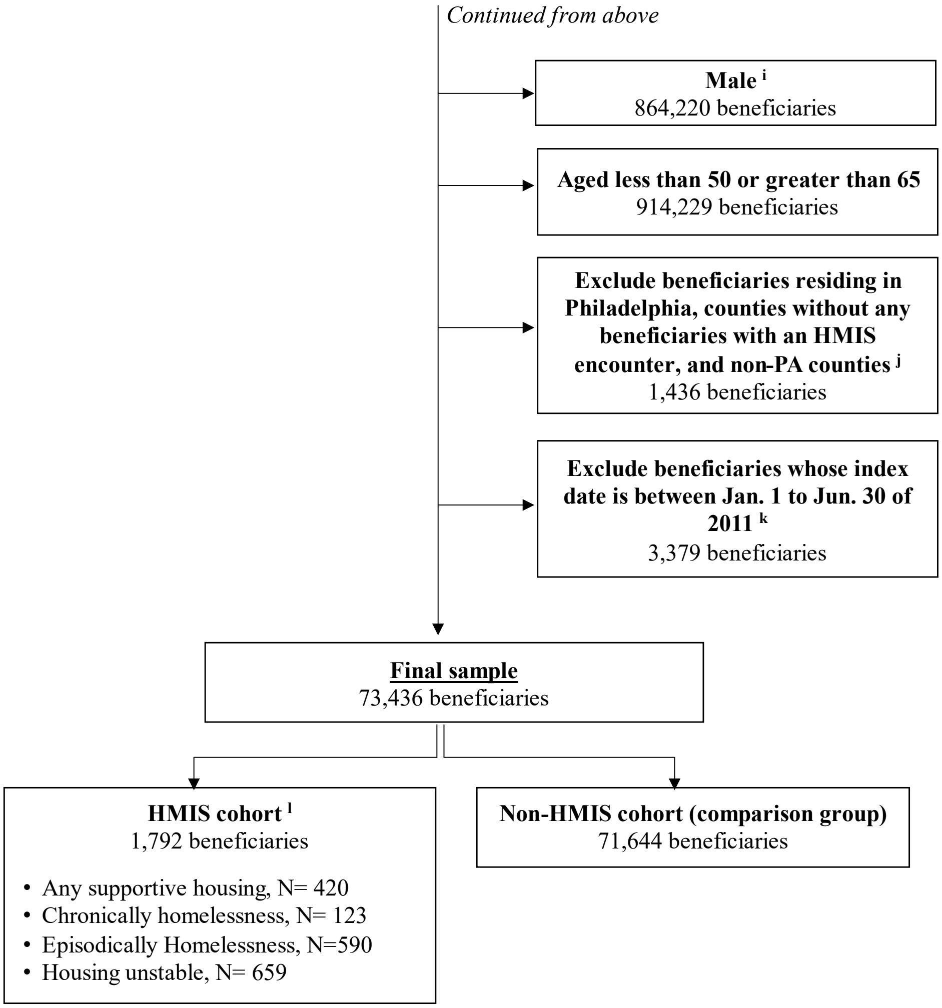


Figure A4.3 Flow diagram of the study inclusion criteria (cont.)

Abbreviation: HMIS, Housing Management Information System; PA, Pennsylvania; Mos, months

[a] We identified the first ever HMIS encounters in the data.

[b] We used Medicaid records from 2010 to 2018 to observe at least 1 year prior to and 2 years following the index HMIS encounter.

[c] Among monthly Medicaid enrollment records, we excluded beneficiaries who had any HMIS encounters from 2011-2016

[d] We performed a simple random sampling to extract one monthly record per each beneficiary that will provide the "index" date for the comparison cohort.

[e] The index date for the HMIS cohort is the date of the index HMIS encounter. The index date for the comparison cohort is the date indicated on the randomly sampled monthly Medicaid record.

[f] We required 6 months of continuous Medicaid enrollment prior to the index date to observe baseline health services use (i.e., primary care visits, Federally Qualified Health Centers visits, and inpatient visits) and comorbidities.

[g] We required at least 18 months of Medicaid enrollment following the index date to examine receipt of biennial mammography. We used 18 months, instead of 24 months, to account for the fact that many beneficiaries temporarily lose Medicaid coverage but then re-enroll ("churning"). The 18-months interval reflects the average duration of Medicaid enrollment each year in Pennsylvania, which is around 9 months.25

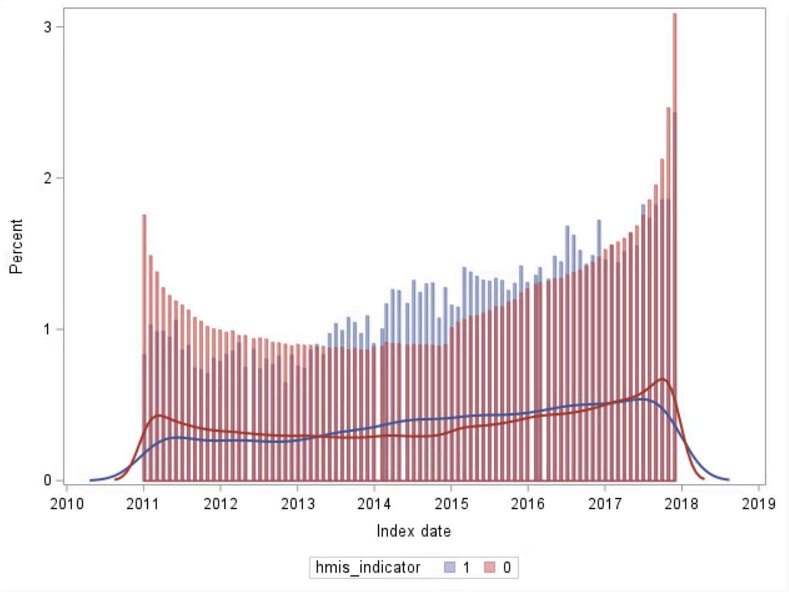
[h] We excluded beneficiaries with any days in Medicare enrollment during the -6 to 24 months window around the index date

[I] We used the gender information listed on Medicaid records to exclude male beneficiaries.

[j] We used the county listed on the Medicaid record for the index date to exclude beneficiaries who were residing in Philadelphia and counties outside of Pennsylvania; we excluded those residing in Philadelphia because no HMIS encounters data from Philadelphia were available during the study period.

[k] We used the following hierarchical rule to categorize the beneficiaries in the HMIS cohort: 1) Any supportive housing (received any supportive housing services, including permanent supportive housing, in the post-index period); 2) Chronically homeless (more than 12 months of observed homelessness as indicated by shelter use, street outreach, homelessness assistance, or homeless as prior residence in coordinated entry or assessment; 3) Episodically homeless (less than 12 months of observed homelessness); 4) Housing unstable (includes all other HMIS services use, including homelessness prevention services).

Panel A. Distributions in the combined sample, prior to applying any exclusion criteria



Panel b. Distributions in the final sample

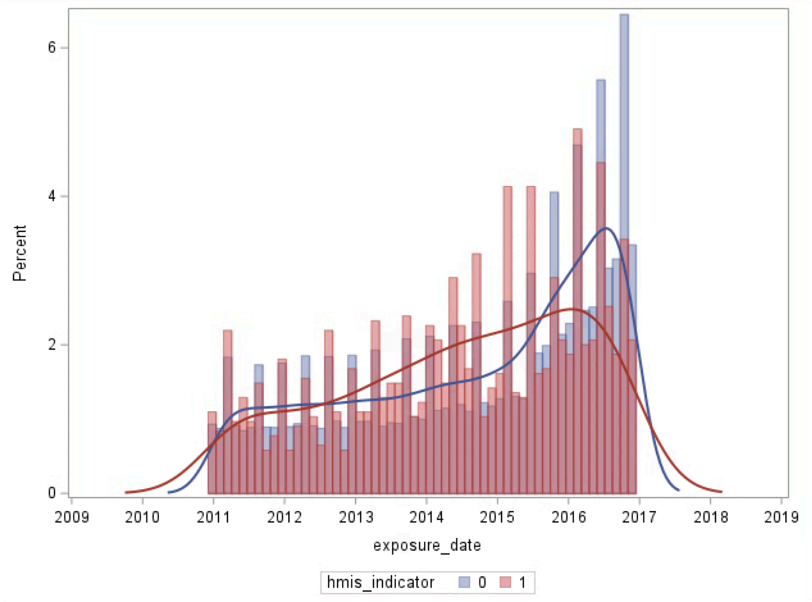


Figure A4.4 Frequency distributions of the index date among the HMIS and comparison cohort

Note: The figures plot the histogram and kernel density of the index date among beneficiaries in the HMIS (hmis_indicator=1) and comparison cohorts (hmis_indicator=0). The index date for the HMIS cohort was the date of the index HMIS encounter. The index date for the comparison cohort is the date of randomly sampled Medicaid enrollment record from 2011 to 2016. The top panel shows the distributions in the combined sample (containing HMIS encounters among prior Medicaid beneficiaries and the random sample of Medicaid records) prior to applying exclusion criteria. The bottom panel shows the distributions in the final analytic sample.

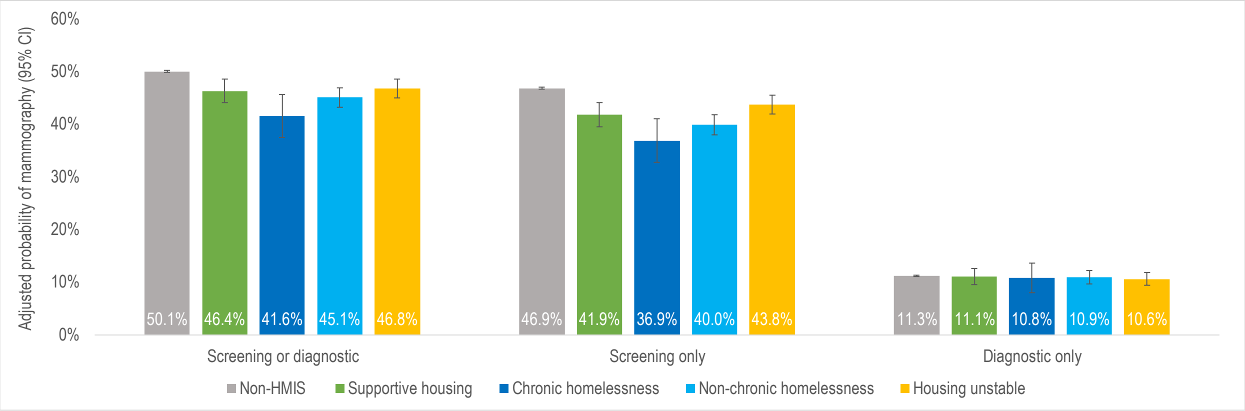


Figure A4.5 Adjusted probability of screening vs. diagnostic biennial mammography

Note: These sets of bar graphs separately show the adjusted probabilities of biennial mammography for study cohorts separately for screening vs. diagnostic mammography (categorized based on descriptions of procedure codes). We adjusted for county and year fixed effects, demographic and Medicaid eligibility characteristics, and baseline healthcare utilization and comorbidities. The first set of bar graphs present the probability of receiving either screening or diagnostic mammography (i.e., the main specification). The second and third set each presents the probability of receiving screening and diagnostic mammography, respectively.

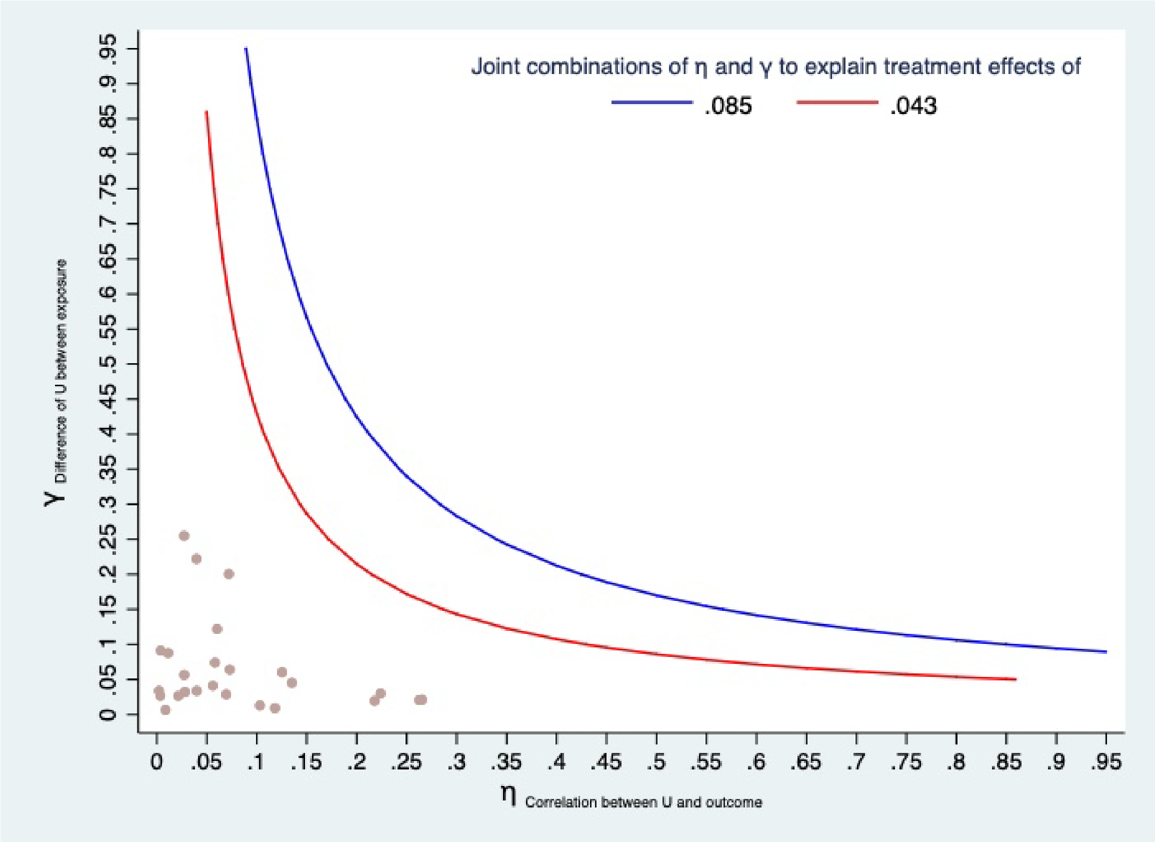


Figure A4.6 Assessment of effects of a potential unmeasured confounder on the estimated relationship between receipt of HMIS-related services and biennial mammography

Note: Two bolded lines plot the combination of γ (difference in prevalence of an unmeasured confounder U between exposure groups) and η (correlation between U and probability of receiving biennial mammography) that would fully explain away the magnitude of the disparity in receipt of biennial mammogram that was estimated between the HMIS and non-HMIS cohort (i.e., -4.3 percentage points) and beneficiaries experiencing chronic homelessness and non-HMIS beneficiaries (i.e., -8.4 percentage points) in the main analysis. The dots in the scatterplot show the joint combination of γ and η for each measured covariate. For simplicity, we assigned positive values of γ and η in the sensitivity analysis, which would lead to a positive treatment effect.

5.0 Conclusion

5.1 Dissertation summary

The goal of this dissertation was to enrich our understanding of two major insurance programs—Medicare and Medicaid—as providers of health insurance coverage for patients with cancer and cancer survivors and to highlight their role in addressing disparities in cancer screening, early detection, and survivorship. I summarize the key conclusions, policy implications, and suggested directions for future research from each chapter below.

5.1.1 Association of Medicare eligibility with access to and affordability of care among older cancer survivors

Older cancer survivors have pronounced needs for ongoing medical care, which make them vulnerable to high out-of-pocket (OOP) costs and financial burden of care. This burden is disproportionately high for those who are immediately below age 65 (the age at which individuals are eligible for Medicare). While Medicare eligibility was associated with significant reductions in cost-barriers to care, problems paying or worries about medical bills, it did not eliminate these access and affordability challenges. The finding highlights the importance of Medicare coverage, but also underscores the need for further policy reforms to reduce gaps in coverage and improve Medicare coverage among cancer survivors. First, proposals to expand Medicare coverage, by lowering the age of Medicare eligibility or creating a Medicare buy-in option, may provide clear pathways for coverage among uninsured cancer survivors who face the greatest risk of financial toxicity. Expanding Medicare eligibility may also benefit cancer survivors who currently have coverage through their employers or non-group insurance markets because Medicare has lower premium and deductible amounts and a higher actuarial value, relative to that of certain private plans. Second, reforms are needed to address the high OOP spending burden within Medicare. In Traditional Medicare, considerable cost sharing, combined with no limit on OOP spending, can expose certain Medicare beneficiaries to catastrophic healthcare costs. One method of Medicare benefit redesign to provide protections against such catastrophic spending would be to impose an OOP spending maximum.[395] Furthermore, expanding eligibility for Medicaid supplemental coverage by raising its income eligibility threshold (from 100% to 200% FPL, for example) can increase availability of supplemental coverage to low-income beneficiaries who are particularly vulnerable to high OOP costs yet are ineligible for Medicaid and unable to afford private supplemental coverage.[396]

As this research only examined the average effect of Medicare eligibility, an important avenue for future research is to examine differences in access and affordability of care by specific types of Medicare coverage, including enrollment into Medicare Advantage and supplemental insurance such as Medigap or Medicaid. Moreover, there are opportunities to use longitudinal data on coverage changes at age 65 to study transitions into Medicare, which may illuminate heterogenous effects of Medicare eligibility by prior level and experience of coverage.

5.1.2 Effects of Medicaid managed care on early detection of cancer: Evidence from mandatory Medicaid managed care program in Pennsylvania

Medicaid beneficiaries have historically experienced adverse cancer outcomes, including premature mortality, largely because many Medicaid beneficiaries are diagnosed with advanced-stage cancers for which prognosis is worse and treatment options may be limited or less effective. Hence, a key goal for improving cancer outcomes in this population is to improve early detection of cancer. In this aim, I examined how private administration of Medicaid through managed care organizations impacted early detection among Medicaid beneficiaries, using Pennsylvania's transition to mandatory Medicaid managed care as a natural experiment. In Pennsylvania, this transition was associated with significant reductions in late-stage diagnosis among newly diagnosed Medicaid beneficiaries, especially among those who were diagnosed with breast and cervical cancers. This result suggests potential for managed care to facilitate access to care and preventive screening among Medicaid beneficiaries, though specific design of managed care may matter. In Pennsylvania's context, several factors may have contributed to improved early detection, including increased provider payment rates, emphasis on managed care plan competition, the staggered adoption of managed care to allow a more seamless transition to managed care, care coordination by plans using integrated data systems and infrastructure, and plan oversight by Medicaid agency. These specific elements of the managed care program in Pennsylvania may provide blueprints for other states in structuring their Medicaid programs, though more research is needed to understand effects of such elements on health outcomes. Future research may leverage between-state variations in Medicaid managed care and investigate distal cancer outcomes, such as access to treatment and mortality, to assess the effects of Medicaid managed care on cancer control more comprehensively.

5.1.3 Housing-related disparities in receipt of mammography: evidence among adult women Medicaid beneficiaries in Pennsylvania

There is recognition that social determinants of health (SDOH) are associated with striking disparities in cancer outcomes, including access to cancer screening. At the same time, limited research exists that estimates such disparities using granular person-level information on specific SDOH and cancer screening. This aim evaluated disparities in screening associated with housing insecurity in Medicaid, which disproportionately serves low-income individuals experiencing or at risk of homelessness. I specifically compared receipt of guideline-recommended mammography between women Medicaid beneficiaries with vs. without an encounter for housing-related services (e.g., supportive housing, services for individuals experiencing homelessness, and homelessness prevention services), finding that such an encounter was associated with a lower probability of screening. The disparities in mammography were pronounced among those who experienced chronic homelessness, pointing to the pernicious consequences of housing insecurity on utilization of screening, but such disparities were attenuated among women with supportive housing.

Medicaid has an important role to play in lessening the impact of housing insecurity by expanding provisions of housing services in covered Medicaid benefits. Many Medicaid programs have elected to provide such benefits or plan to do so, providing a critical opportunity to examine their effectiveness in increasing the take-up of screening among beneficiaries experiencing housing insecurity. In the interim, Medicaid programs should coordinate with managed care organizations to target housing insecurity and other health-related social needs through targeted case management. Future research should also investigate how housing insecurity can affect care access and utilization throughout the cancer care continuum, as screening is only the first step for successful treatment and survivorship.

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