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Examining the "Medicare Effect" on Distant-Stage Cancer Diagnoses by Site, Gender, and Rurality

RESEARCH

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ABSTRACT

Background: Compared to cancers detected early, distant stage cancers are associated with lower survival, diminished quality of life, and higher costs. Evidence suggests that greater access to comprehensive health insurance (i.e., Medicare) improved early detection. Yet, few studies have evaluated the effect of Medicare coverage across cancers or factors influencing healthcare use.

Methods: This study analyzed 35 years of population-based cancer registry data from the Surveillance Epidemiology and End Results program for eight common cancers: Oral, Digestive, Respiratory, Skin, Genital, Urinary, Endocrine, and Breast. Leveraging the subjective threshold determining Medicare's eligibility at age 65, Medicare's effect on the probability of a distant diagnosis was estimated using Robust Non-Parametric Regression Discontinuity models.

Results: Medicare was associated with reduced proportion of distant diagnoses for five common cancers. The proportion of distant cancers declined by 1.7-percentage points for digestive cancers ($p < 0.01$), 1.6-percentage points for respiratory cancers ($p < 0.01$), 0.5-percentage points for genital cancers ($p < 0.05$), 1.4-percentage points for urinary cancers ($p < 0.01$), and 0.8-percentage points for female breast cancers ($p < 0.01$). The relative difference from average distant stage rates for these significant estimates range from 3% (Respiratory) to 15% (Genital). Most estimates were consistent across gender, but Medicare was only associated with declined distant-stage diagnoses for patients in urban and metro regions.

Conclusions: This study reaffirms that Medicare coverage is associated with earlier diagnoses for patients in urban and metro regions for digestive, respiratory, genital, urinary, and female breast cancers. These results stress the importance of healthcare insurance, but also reveal the limitations of insurance expansion policies for patients in rural areas and for cancers without standard screening protocols.

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1. INTRODUCTION

Overall cancer survival and mortality has been improving in the United States for decades [1, 2]. Yet, late-stage cancers continue to burden the population [3, 4, 5]. Along with being associated with increased mortality and lower survival, cancers diagnosed at distant stages are also more costly to treat and dramatically diminish quality of life [6, 7, 8, 9]. To overcome the burden of distant diagnoses, policymakers, providers, and advocates continue to pursue opportunities to increase early detection. Among the approaches to increase the proportion of cancers detected early, increasing access to physician services remains popular. Researchers have hypothesized that late-stage detection may be associated with limited access to the healthcare system. This hypothesis stems from groundbreaking research evaluating the effect of expanding health insurance [10, 11]. Evidence has since identified a causal link between access to health insurance through Medicare and cancer outcomes [12, 13, 14, 15]. Deemed the "Medicare Effect", it is hypothesized that upon turning 65 individuals will use more healthcare services, and thus realize better health. Because essentially all adults qualify for Medicare upon turning 65, the results of these studies can be very informative for future policies expanding access to care.

The "Medicare Effect" suggests that gaining Medicare increases the likelihood of early cancer detection. This hypothesis, however, relies on a foundational assumption that upon gaining Medicare coverage an adult will increase their likelihood of visiting a physician to complete a screen or clinical exam which could detect cancer. While Medicare insurance increases access by lowering the price paid for physician services, there may be other factors which still prevent an individual from visiting a physician and being screened for cancer. First, consider the gap in healthcare utilization patterns between men and women. Even with Medicare insurance coverage, men are less likely to visit a doctor than women [16, 17]. This gap could lead to gender-disparities in cancers detected at distant stages, despite equal access to physician services. Further, while access and affordability may increase physician visits, physician availability remains critical for healthcare utilization [18]. Such availability concerns remain especially pertinent for rural policymakers and rural Medicare beneficiaries [19, 20]. Finally, not all common cancers have standardized, systematic screening protocols. The "Medicare Effect" is likely limited to cancers which are commonly screened for at preventative physician visits.

This study builds off the most recent evidence for the "Medicare Effect" on cancer detection focused on cancers with systematic screening protocols by physicians [15]. To date, most evidence has failed to fully disaggregate the potential heterogeneity of Medicare's effect on cancer detection, specifically related to an individual's propensity to visit a physician or contexts with limited physician availability. This study aims to fill each evidence gap and extend the research on "The Medicare Effect" to determine if gaining coverage from Medicare changes the proportion of distant-stage cancer diagnoses, and if this effect varies across cancer sites, gender, and rurality.

2. MATERIALS AND METHODS

2.1 DATA AND VARIABLES

This study used population-based cancer case data from the Surveillance Epidemiology End Results (SEER) program for eight of the most common cancers in the United States (Oral, Digestive, Respiratory, Skin, Genital, Urinary, Endocrine, and Breast) [21]. Cancers were identified at the case-level. To avoid the results being confounded by recent policy reforms expanding access to health insurance coverage, cases were restricted to cancers diagnosed between 1975–2010. All years are pooled together to ensure adequate sample for estimating aggregate and subgroup effects. In addition to the pooled sample, individuals were categorized by gender and rurality to construct six mutually exclusive groups (rural male, urban male, metro male, rural female, urban female, metro female). Rurality was determined by the SEER provided Rural-Urban continuum code for each decade (1973, 1983, 1993, 2003). Rural-Urban continuum codes were cross referenced with the United States Department of Agriculture Economic Research Service [22]. To account for changing detection technology, practices, and guidelines, we complete a secondary sensitivity analysis which controls for the year of diagnosis. However, changing patterns of early cancer detection due to improved technology or protocols would not bias the results of our primary model given our focus on adults near age 65, who would have experienced similar diagnoses trends throughout the study period.

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The outcome of interest is a binary variable indicating if a cancer was diagnosed at a distant-stage, defined by SEER as a "Distant" diagnosis [23]. This binary indicator was derived from the SEER Historic Summary Stage A variable, coded as 1 if the cancer was diagnosed at a "Distant" stage and coded as 0 if the cancer was diagnosed at a "Localized", "Regional", or "In Situ" stage. All unstaged cancers were excluded from the analysis. The SEER Historic Summary Stage A variable provides the most unified conceptualization of cancer staging across time and cancer sites. This measure was available for most, but not all, cancer organ sites throughout the study period. Supplemental Table 1 presents each of the eight cancer sites and describes the availability of historic summary stage data.

2.2 STATISTICS & ANALYSIS

The "Medicare Effect" is modelled as the change in probability of a distant diagnosis given a change in exposure to Medicare coverage, conditional on being diagnosed with cancer.

$$\text{Medicare Effect} = \Delta Y/\Delta X = \frac{\Delta P(Distant|Cancer)}{\Delta Exposure\,to\,Medicare}$$

To estimate the effect of Medicare on the probability of a distant-stage cancer diagnosis, this study constructed a Regression Discontinuity Design (RDD) which exploits exogenous thresholds determining exposure to treatment [24, 25, 26]. An RDD estimates a Local Average Treatment Effect (LATE), comparing outcomes just before and just after an arbitrary threshold assigning treatment [27].

$$LATE = E[Y(age \geq 65) - Y(age < 65)]$$

Adults become eligible for Medicare at age 65, regardless of their health needs or behavioral patterns of health services use. Thus, Medicare coverage can be deemed independent of potential outcomes for detecting cancer early, at least for adults near age 65. The critical assumption for valid inference states that the probability of a distant-stage cancer diagnosis is continuous and does not differ between age groups near the cutoff (age 65) in ways unrelated to Medicare. More simply, if Medicare did not exist, we would expect distant stage cancer diagnoses in 64-year-old adults to be similar to 65-year-old adults, as cancer incidence, risk factors, and screening protocols are similar for the two groups. Any difference we observe between these two groups should then be attributed to Medicare.

To assess the validity of this assumption, we construct two robustness checks of the primary bias-corrected regression discontinuity model. Both robustness checks are essentially placebo tests. For each cancer site and subgroup, we modify the cutoff point from age 65 to 55 and 75, separately. We should not expect to observe any significant differences between distant stage diagnoses between groups at and around these two pseudo-cutoffs. If we observe significant RDD estimates, our primary estimates and identifying assumption may be called into question. However, null placebo results help justify our identifying assumption.

Each Regression Discontinuity was estimated via a robust, non-parametric local polynomial specification [27, 28]. Standard errors robust to heteroskedasticity were estimated by three-nearest neighbor variance-covariance approach [28]. The bandwidth around the cutoff age was determined using the "Optimal-Mean Squared Error" method [28]. Alternative analyses report local linear and bias-corrected estimates with conventional standard errors. Statistical significance was set at $p < 0.05$ for all analyses. The RDD estimates were illustrated graphically, by modelling age-specific means in the probability of distant stage diagnoses, fitted by a non-parametric polynomial (order of 4) models. All analyses used the *rdrobust* package in STATA v. 17 [29]. The author's publicly available repository contains the SEER-9 data dictionary and STATA analytical code [30].

2.3 ETHICS APPROVAL OF RESEARCH

This retrospective cross-sectional analysis used publicly available SEER cancer registry data. The data for this study was accessed and analyzed between June 1, 2021, and December 15, 2021. The research was not subject to ethics review, as it is not Human Subjects Research. Support for this study came from a National Institutes of Health / National Institute of Dental and Craniofacial Research grant.

2.4 DATA AVAILABILITY STATEMENT

SEER prohibits unauthorized data sharing. However, investigators who are interested in replicating the dataset for this study can request access to the publicly available SEER database and then obtain the SEER 9 datafile through the SEER*Stat program.

3. RESULTS

3.1 SAMPLE AND SUMMARY STATISTICS

The SEER 9 cancer registry contained 5,914,565 observations for Oral, Digestive, Respiratory, Skin, Genital, Urinary, Endocrine, and (female) Breast cancer sites in years 1975–2010. The analysis only included cases with non-missing SEER Historic Summary Stage A data. The full sample of observations consisted of 5,113,595 cancer cases (Figure 1). However, the Robust Regression Discontinuity method excludes observations without kernel (polynomial) support. Among the 4,802,123 observations included in the analysis, only 1,561,994 observations were considered "effective." More simply, the data driven-approach of the Robust Regression Discontinuity method minimizes the mean-square error of the analysis by selecting an optimal set of effective observations at and around the eligibility cutoff. See Figure 1 for the sample selection flow chart. Supplemental Table 2 lists the aggregate and group-specific cancer case totals for each of the eight cancers analyzed in this study. Supplemental Table 3 reports the rates of distant diagnoses for each cancer and mutually exclusive subgroup category, for adults between ages 55–75 (an approximation of the distant diagnosis rate for patients near Medicare eligibility). Supplemental Table 4 reports the number of "effective" observations, to the right and left of the age-65 cutoff, for each cancer site.

3.2 AGGREGATE EFFECTS

In five cancer sites (Digestive, Respiratory, Genital, Urinary, Breast), Medicare eligibility appeared to significantly reduce the proportion of cancers diagnosed at distant stages (Table 1). The proportion of distant-stage Digestive cancers declined by 1.73-percentage points ($p < 0.01$; Figure 2), which represents a 6% change from baseline. For Respiratory cancers, the proportion of distant-stage diagnoses declined by 1.49-percentage points ($p < 0.05$; Figure 3). This effect represents a 3% change from baseline. Distant-stage Urinary cancers declined by 1.40-percentage points, ($p < 0.01$; Figure 4), and the point-estimate represents a 15% reduction. Finally, Medicare was found to reduce the probability of a distant-stage Female Breast Cancer diagnosis by 0.83-points ($p < 01$; Figure 5), a 13% change from pre-Medicare rates (Figure 5). Overall, there was no effect for oral cancer or skin cancer (Figures 6–7). However, distant-stage genital cancers declined 0.49-percentage points ($p < 0.05$), representing a 5% change from baseline (Figure 8). There was also no effect for endocrine cancers (Figure 9).

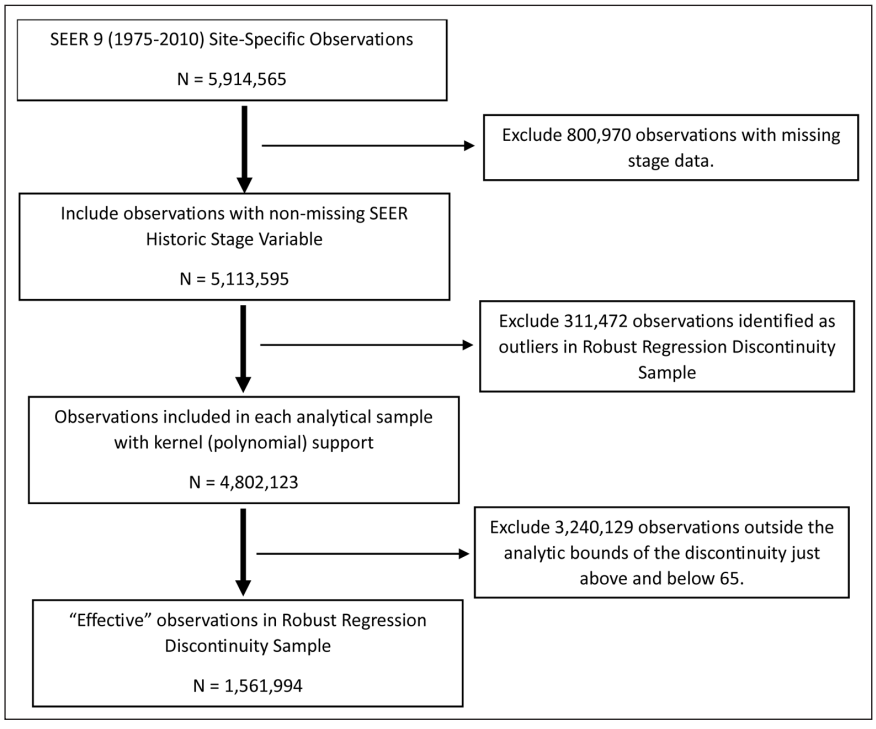

Figure 1 Selecting Analytical Sample.

Legend: Figure 1 visually depicts the process of selecting the final analytical sample for the 8 cancer sites. Surveillance Epidemiological and End Results (SEER) 9 data for years 1975–2010 were obtained for the 8 cancer sites (oral, digestive, respiratory, skin, genital, urinary, endocrine, female breast). Observations with missing stage data were excluded. The Robust Regression Discontinuity design uses a data-driven approach to select an optimal (lowest mean-square error) and least biased (due to systematic "bunching" around the cutoff age 65) in part by excluding observations without kernel (polynomial) support and only including a small subset of observations to estimate the coefficient of interest.

	ALL	RURAL MEN	URBAN MEN	METRO MEN	RURAL WOMEN	URBAN WOMEN	METRO WOMEN
Oral	0.00621	–0.0139	0.00929	0.00873	0.0110	–0.00658	–0.00503
	(0.00859)	(0.0437)	(0.0230)	(0.0108)	(0.0752)	(0.0313)	(0.0180)
Digestive	–0.0173**	–0.00865	–0.00671	–0.0155*	–0.0168	–0.00103	–0.0257**
	(0.00553)	(0.0222)	(0.0169)	(0.00749)	(0.0287)	(0.0182)	(0.00991)
Respiratory	–0.0149**	0.0376	–0.00454	–0.0168	0.00170	–0.0488*	–0.0160*
	(0.00497)	(0.0434)	(0.0180)	(0.00860)	(0.0477)	(0.0249)	(0.00803)
Skin	–0.00499	0.00430	0.0274	–0.0167*	–0.0234	–0.0497	0.0129
	(0.00476)	(0.0375)	(0.0155)	(0.00688)	(0.0520)	(0.0286)	(0.00882)
Genital	–0.00538*	0.0257	0.00652	–0.000353	0.108	–0.00713	–0.0104
	(0.00241)	(0.0197)	(0.00532)	(0.00232)	(0.0576)	(0.0220)	(0.00877)
Urinary	–0.0140**	0.0276	–0.0155	–0.0150*	0.0386	–0.0136	–0.00933
	(0.00527)	(0.0307)	(0.0161)	(0.00647)	(0.0575)	(0.0248)	(0.00922)
Endocrine	–0.0179	0.0364	–0.0231	–0.0248	0.0559	–0.0132	–0.0122
	(0.00943)	(0.0845)	(0.0505)	(0.0247)	(0.0531)	(0.0297)	(0.0117)
Breast	–0.00825**	n/a	n/a	n/a	–0.00253	–0.0153	–0.00653
	(0.00289)				(0.0176)	(0.00881)	(0.00350)

Table 1 Regression Discontinuity Estimates (Bias-Corrected Estimates, Robust Standard Errors).

Legend: Table 1 reports the local polynomial, optimal-MSE (Mean-Square Error) bandwidth bias-corrected regression discontinuity point-estimates. Robust standard errors are reported in parentheses SEER 1975–2010. * $p < 0.05$, ** $p < 0.01$.

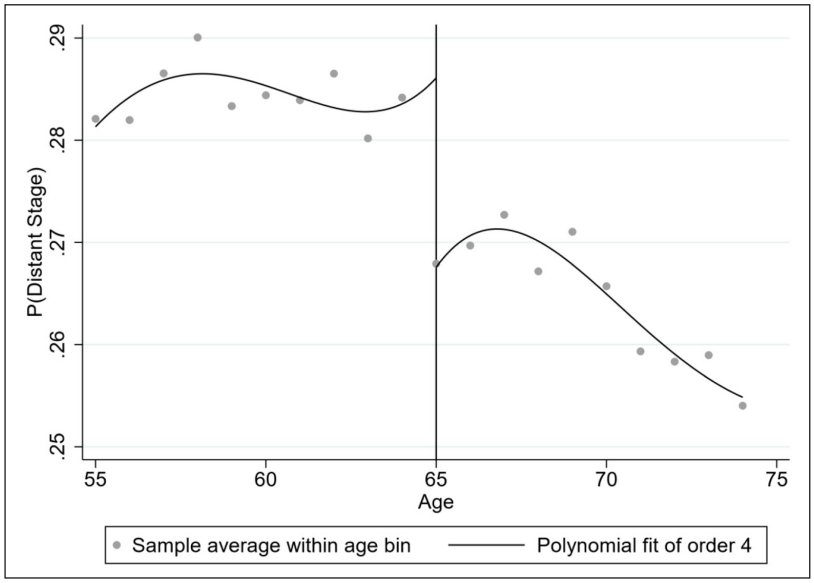

Figure 2 Regression Discontinuity Plot for Distant-Stage Digestive Cancers.

Legend: Figure 2 *plots the discontinuity of distant-stage digestive cancers at the Medicare-eligibility cutoff (age 65). The y-axis shows the Probability of a Distant Stage diagnosis, conditional on the patient being diagnosed with digestive cancer. The x-axis shows the age at diagnosis. Each grey dot represents the mean probability of distant diagnoses in each age bin. The polynomial fit (order of 4) is the parametric, bias-corrected regression.*

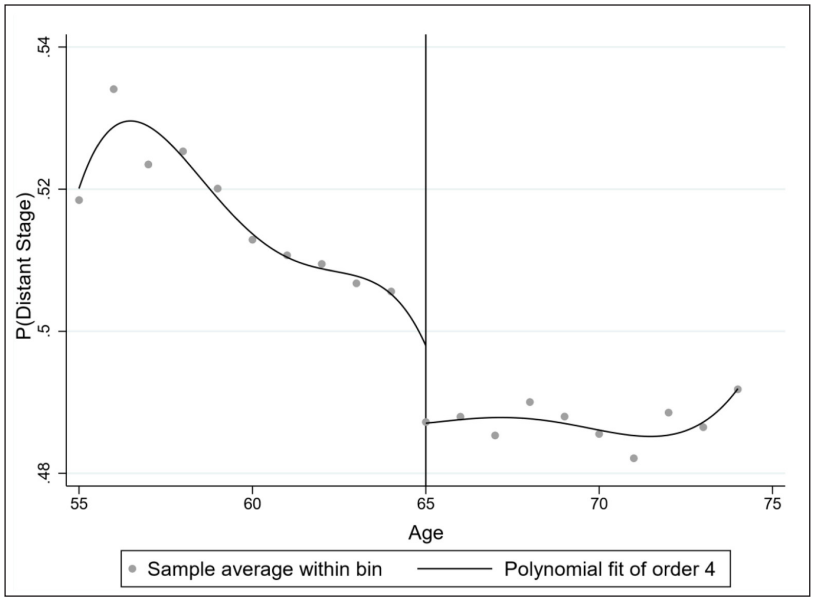

Figure 3 Regression Discontinuity Plot for Distant-Stage Respiratory Cancers.

Legend: Figure 3 *plots the discontinuity of distant-stage respiratory cancers at the Medicare-eligibility cutoff (age 65). The y-axis shows the Probability of a Distant Stage diagnosis, conditional on the patient being diagnosed with respiratory cancer. The x-axis shows the age, restricted to age 55–75. Each grey dot represents the mean probability of distant diagnoses in each age bin. The polynomial fit (order of 4) is the parametric, bias-corrected regression line.*

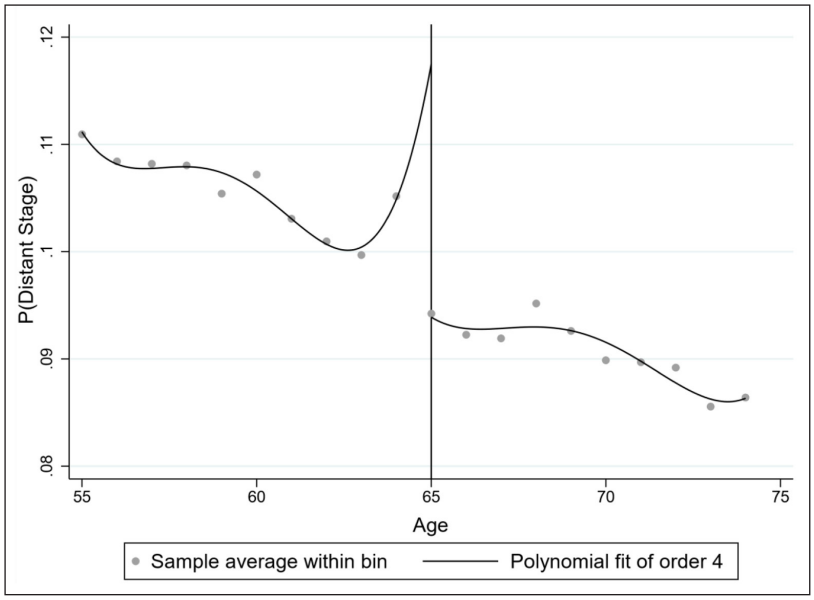

Figure 4 Regression Discontinuity Plot for Distant-Stage Urinary Cancers.

Legend: Figure 4 *plots the discontinuity of distant-stage urinary cancers at the Medicare-eligibility cutoff (age 65). The y-axis shows the Probability of a Distant Stage diagnosis, conditional on the patient being diagnosed with urinary cancer. The x-axis shows the age, restricted to age 55–75. Each grey dot represents the mean probability of distant diagnoses in each age bin. The polynomial fit (order of 4) is the parametric, bias-corrected regression line.*

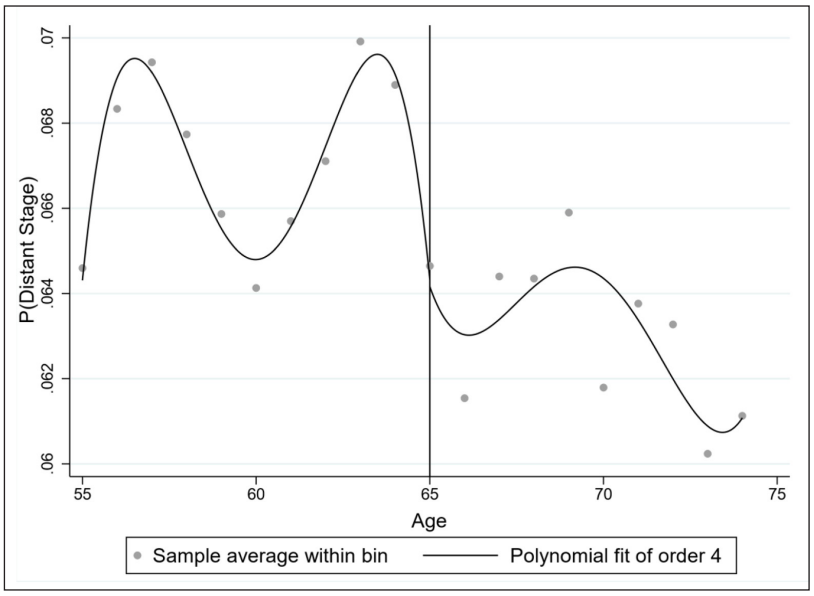

Figure 5 Regression Discontinuity Plot for Distant-Stage Female Breast Cancers.

Legend: Figure 5 *plots the discontinuity of distant-stage female breast cancers at the Medicare-eligibility cutoff (age 65). The y-axis shows the Probability of a Distant Stage diagnosis, conditional on the (female) patient being diagnosed with breast cancer. The x-axis shows the age, restricted to age 55–75. Each grey dot represents the mean probability of distant diagnoses in each age bin. The polynomial fit (order of 4) is the parametric, bias-corrected regression line.*

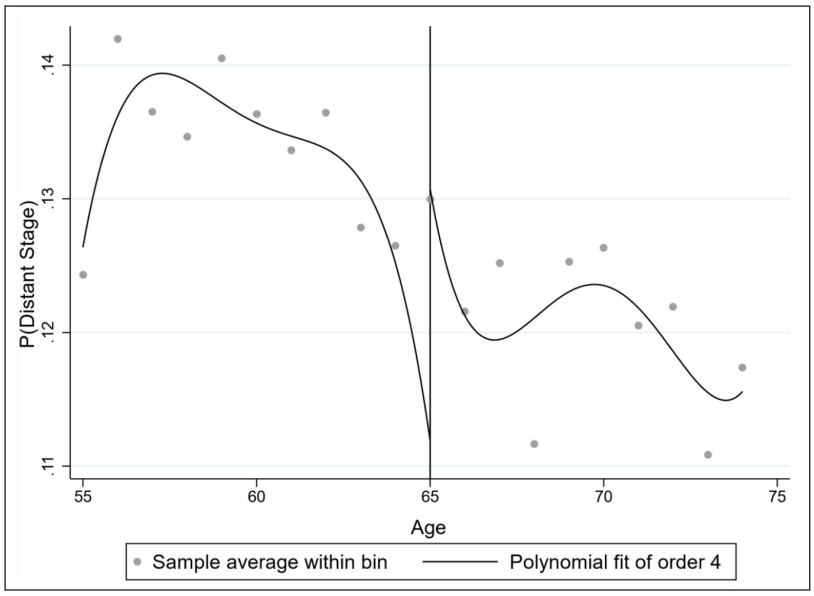

Figure 6 Regression Discontinuity Plot for Distant-Stage Oral Cancers.

Legend: Figure 6 *plots the discontinuity of distant-stage oral cancers at the Medicare-eligibility cutoff (age 65). The y-axis shows the Probability of a Distant Stage diagnosis, conditional on the patient being diagnosed with oral cancer. The x-axis shows the age, restricted to age 55–75. Each grey dot represents the mean probability of distant diagnoses in each age bin. The polynomial fit (order of 4) is the parametric, bias-corrected regression line from.*

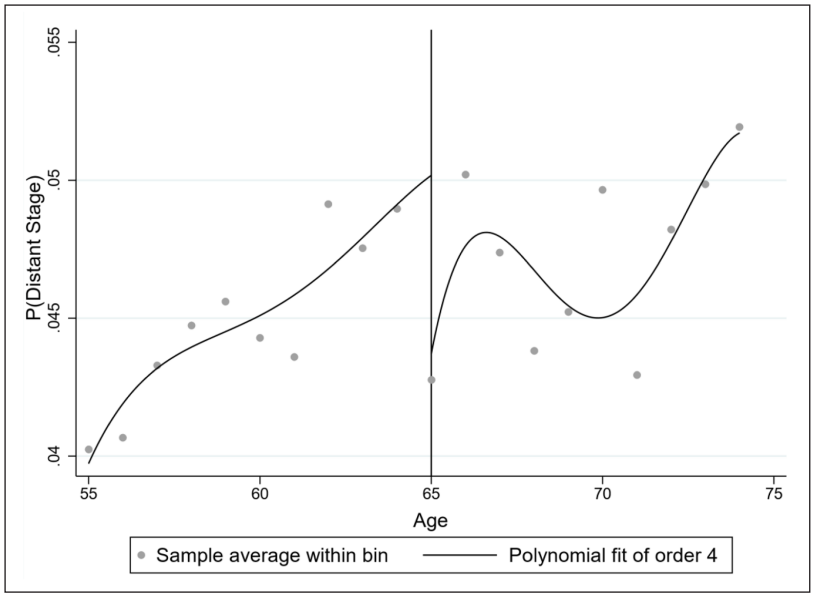

Figure 7 Regression Discontinuity Plot for Distant-Stage Skin Cancers.

Legend: Figure 7 *plots the discontinuity of distant-stage skin cancers at the Medicare-eligibility cutoff (age 65). The y-axis shows the Probability of a Distant Stage diagnosis, conditional on the patient being diagnosed with skin cancer. The x-axis shows the age, restricted to age 55–75. Each grey dot represents the mean probability of distant diagnoses in each age bin. The polynomial fit (order of 4) is the parametric, bias-corrected regression line from.*

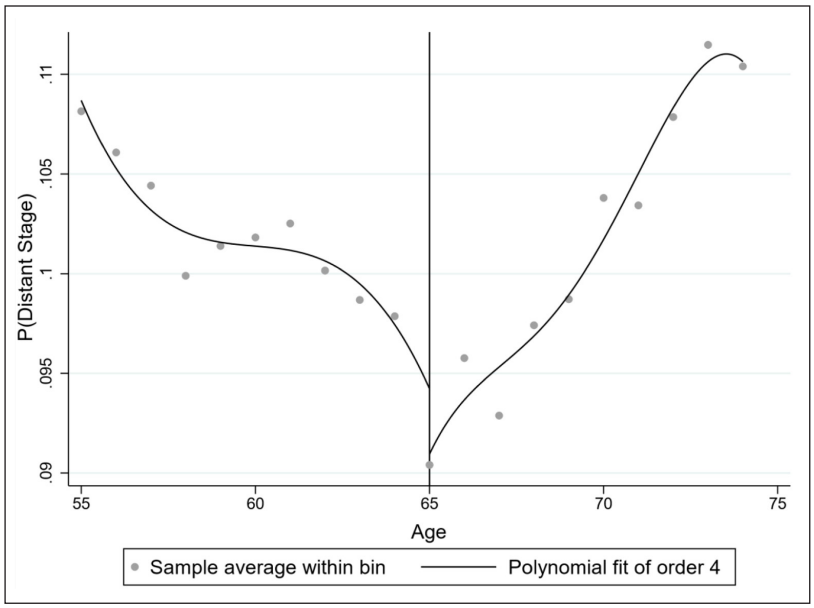

Figure 8 Regression Discontinuity Plot for Distant-Stage Genital Cancers.

Legend: Figure 8 *plots the discontinuity of distant-stage genital cancers at the Medicare-eligibility cutoff (age 65). The y-axis shows the Probability of a Distant Stage diagnosis, conditional on the patient being diagnosed with genital cancer. The x-axis shows the age, restricted to age 55–75. Each grey dot represents the mean probability of distant diagnoses in each age bin. The polynomial fit (order of 4) is the parametric, bias-corrected regression line.*

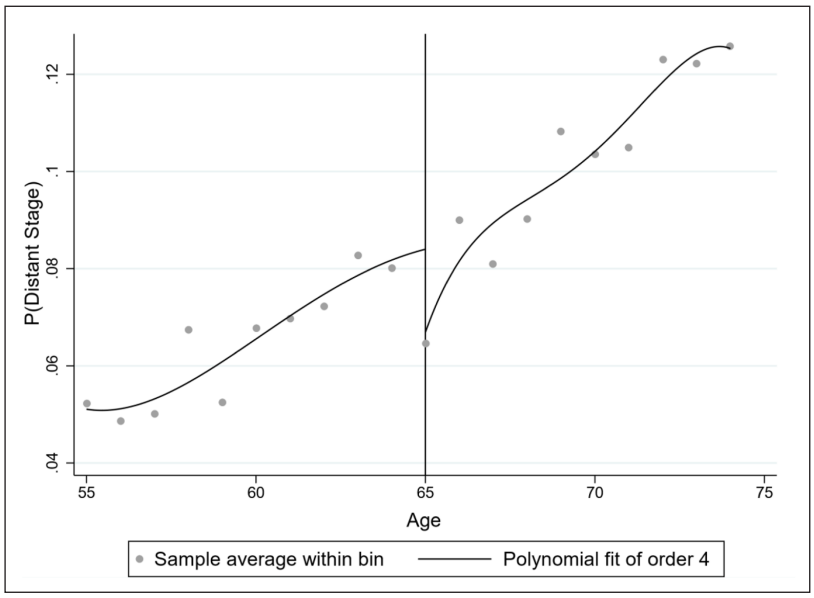

Figure 9 Regression Discontinuity Plot for Distant-Stage Endocrine Cancers.

Legend: Figure 9 *plots the discontinuity of distant-stage endocrine cancers at the Medicare-eligibility cutoff (age 65). The y-axis shows the Probability of a Distant Stage diagnosis, conditional on the patient being diagnosed with endocrine cancer. The x-axis shows the age, restricted to age 55–75. Each grey dot represents the mean probability of distant diagnoses in each age bin. The polynomial fit (order of 4) is the parametric, bias-corrected regression line.*

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3.3 SUBGROUP EFFECTS

When stratifying results by rurality and gender, the "Medicare Effect" for reducing distant-stage diagnoses appears to be concentrated in non-rural regions. For cancers of the Digestive site, both men and women in metro counties were found to have reduced the probability of a distant-stage cancer diagnosis (Metro/Male Estimate = –1.55-percentage points, Metro/Female Estimate = –2.57-percentage points). No other Digestive site subgroup estimates were significant, even with the conventional estimation method. Further, while the aggregate estimates were insignificant for Skin cancers, distant-stage Skin cancers were found to have declined after Medicare eligibility for metro men (Metro/Male Estimate = –1.67 percentage points). This result was significantly different than zero ($p < 0.01$). A significant reduction was also identified for urban males and urban females when using the conventional standard error calculation. For cancers of the Urinary site, only males in metro counties were found to have reduced distant-stage diagnoses after gaining Medicare coverage (Metro/Male Estimate = –1.50-percentage points, $p < 0.05$). Although, it should be reiterated that distant-stage diagnoses rates varied considerably between men and women (Supplemental Table 3), so observing a change in females would be unlikely. Finally, for female breast cancers, using the bias-corrected, estimates with conventional standard errors, this study found that the proportion of distant-stage breast cancer diagnoses significantly declined but only for urban and metro females. In urban areas, the proportion of distant stage diagnoses in women declined by 1.53-percentage points ($p < 0.05$) and in metro areas the proportion declined by 0.7-percentage points ($p < 0.05$).

No significant reductions in in distant stage cancer diagnoses were detected for any rural subgroup.

3.4 NULL EFFECTS

These results do not suggest that Medicare reduced distant-stage diagnoses for Oral. In fact, in the aggregate, while not statistically significant, the direction of the point-estimates for Medicare's' effect on distant-stage Oral Cancer reversed. The point-estimates are quite small, especially relative to baseline rates of distant-stage Oral Cancers, so the lack of significant findings may be most likely attributed to null effects rather than small sample sizes or noisy estimates. The one exception are the results for rural women, where there is a larger, but still insignificant, estimated reduction in distant-stage oral cancer. While the robust estimates for Endocrine cancer were insignificant, the bias-corrected estimate with conventional standard errors suggests the proportion of distant stage diagnoses in the population declined by 1.79-percentage points ($p < 0.05$). However, this inference assumes the absence of heteroskedasticity [28].

4. DISCUSSION

This study revisits the hypothesis that access to physician services through the "Medicare Effect" impacts cancer detection—a pertinent question as policymakers continue debating whether or not to expand the Medicare program to cover more older adults or more benefits. Using thirty-five years of population-based cancer registry data, robust estimation, and conservative inference, the results support the hypothesis that Medicare improves early detection. Compared to adults approaching Medicare eligibility, adults newly eligible for Medicare coverage had a lower probability of a distant stage diagnosis for three common cancers with standardized screening protocols (Digestive, Respiratory, Breast).

These reductions in distant stage diagnoses may be especially critical for Digestive and Respiratory cancers, as distant diagnoses account for nearly 1 in 3 site-specific diagnoses (Supplemental Table 2). Additionally, the seemingly minor 0.8-percentage point reduction in distant diagnoses for Female Breast Cancer was in fact a relatively large decline given the lower rates of Breast cancers diagnosed at distant stages. There was also a significant decline in the proportion of Urinary cancers diagnosed at distant stages, seeming to support the hypothesis that access to Medicare may increase screening and healthcare services such as cystoscopies [31]. That Medicare improved early detection in Digestive, Respiratory, Urinary, and Breast cancer is consistent with recent evidence and reaffirms the potential policy consequences for

expanding access to physician services for adults nearly, but not yet eligible for Medicare (i.e. adults age 60–64) [15]. These results indicate that once adults gain Medicare they are more likely to visit a physician and ultimately be screened for these common cancers. Earlier detection of these cancers could improve mortality and quality of life, as well as lower treatment costs for cancer patients and their caregivers.

The "Medicare Effect", however, does not extend to cancers without standard screening protocols for adults near Medicare eligibility. Interestingly, despite a negative association for genital cancers in the aggregate and female subgroups, men had reversed (insignificant) point estimates. This null result is likely due to the lack of physician-based screening for genital cancer in older adult men, low proportion of Genital cancers diagnosed at distant stages, and the standard recommendation that adult men conduct self-exams or visual screening instead of seeing a professional [32, 33]. Compared to men, however, women across have relatively high rates of genital cancers diagnosed at distant stages. Currently, women above age fifty are recommended to be screened every five years [34, 35]. Reducing the burden of distant stage genital cancers in women must remain a priority for policymakers and advocates, as access to physician services through Medicare coverage alone does not appear to improve early detection [36].

Similarly, Medicare does not appear to improve early detection for adults with oral cancer. This result is not surprising, given that no public authority recommends physicians systematically screen for oral cancer in the general population or in high-risk groups [37]. The null effects in this study run contrary to recent evidence suggesting that access to Medicaid, through the Affordable Care Act expansions, increased early-stage oral cancer detection [38, 39]. I do not claim, however, that the results in this current study and the evidence from Medicaid expansions contradict each other. Rather, these null effects may provide insights into the potential mechanism driving the changing patterns of early-stage oral cancer detection after Medicaid Expansion. Consider the possibility of access to dental coverage. Medicare provides comprehensive health coverage to older adults, but traditionally does not offer dental coverage. This discrepancy could explain why Medicare improves detection in cancers with screening regimens provided by physicians but does not impact cancers with a screening regimen typically provided by a dentist. Research improving our knowledge on the mechanisms linking access to healthcare services with oral cancer detection remain necessary, especially given the renewed debate over access to dental benefits for traditional Medicare beneficiaries.

While the results for rural populations are disappointing, rural health researchers and policymakers are not likely to find them surprising given the lower utilization and availability of healthcare services in rural regions. Neither rural men nor rural women experienced a "Medicare Effect" on distant stage cancer diagnoses. The null effects could be attributed to small sample sizes (Table 1). Yet, that explanation is not satisfactory, given the null estimates using less conservative inference strategies. Further, not only are the null estimates for rural populations much smaller in magnitude than the non-rural populations, but many of the effect also estimates for rural groups changes direction to become positive. Rather than discounting the null effects for rural cancer patients on analytical limitations, I argue that Medicare's effect on distant stage cancer diagnoses is limited by healthcare utilization patterns and availability of providers who can screen for cancer early. Expanding access to care is critical for improving population health. But access to health insurance coverage without available or appropriate care is not true access. As policymakers continue pursuing universal insurance coverage, they must also address the gaps in service availability. Failing to reform these gaps will only intensify the rural-urban divide in cancer disparities.

4.1 LIMITATIONS

Striving for causal inference, the RDD approach consistently estimates the Local Average Treatment Effect [27, 40, 41]. A common critique of traditional RDD's is the selection of the bandwidth around the threshold determining treatment. This study used data-generating bandwidths to minimize the Mean-Square Error around the threshold and estimated distinct polynomial models on each side of the cutoff [27, 28]. These approaches reduce the potential bias introduced by outlier outcomes further away from the cutoff. The downsides to this approach are twofold. First, the bandwidth is model specific and not easily generalizable across estimates. Second, the approach minimizes bias, but also limits externalizing the results

to other populations outside the age bandwidth. More simply, these results should not be extended to age groups "far" from the Medicare eligibility age of 65, and the definition of "far" varies for each cancer site and population group. Additionally, many readers may be troubled by the absence of covariates in the model, as matching regression models are common in health services research. However, covariates are only useful in RDD's if all covariates are continuous around the cutoff threshold and typically provide little correction for bias within the optimal bandwidth of the RDD estimate. Some RDD studies have included fixed effects, but the evidence for their consistent estimation, not to mention interpretation in LATE frameworks, has yet to be fully explored [42]. Further, the cancer registry data for years in the study period did not offer a standard set of adequate, theoretically appropriate control variables (i.e., household income, education status, valid insurance data). Instead of modelling the RDD with covariates, this study took the approach of estimating subgroup analyses by gender and rurality, two key determinants of healthcare services use. Future studies should continue investigating the appropriateness and interpretation of using covariates and fixed-effects in robust RDD's.

5. CONCLUSIONS

This study reaffirms the positive impact of Medicare on health [43, 44]. As policymakers debate expanding Medicare eligibility and offering new Medicare benefits, this study adds to the growing evidence that Medicare improves cancer outcomes. Medicare coverage reduced the proportion of distant diagnoses in five common cancers (Breast, Digestive, Respiratory, Genital, Urinary) by 0.6 to 1.8 percentage points. Under less stringent statistical assumptions, Medicare may have been associated with small declines in distant-stage skin and endocrine cancers. No effect was identified for oral cancers, likely due to limited screening by physicians in the population newly eligible for Medicare. Most results were consistent across gender, but distant diagnoses only declined in urban or metro populations, not rural. These results reiterate the importance of access to physician services, while also illuminating the potential limitations of insurance expansion policies for patients without available physicians and for cancers without standard physician screening protocols. Future health policy reforms should strive to pair coverage expansion with efforts to expand the provider workforce and scope of practice for cancer screening.

ADDITIONAL FILE

The additional file for this article can be found as follows:

- **Supplemental File.** Supplemental Tables 1 to 9. DOI: https://doi.org/10.29024/jsim.171.s1

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COMPETING INTERESTS

The author has no competing interests to declare.

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