Title: Effect of Health Service Area on Primary Care Physician Provision of Low-Value Cancer Screening

Running Title: Regional Effect of Low-Value Care Decisions

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Manuscript Type: Original Research

Word count - Abstract: 275

Word count - Main Text: 2997

An abstract of the manuscript was previously presented at the Western Section of the American Urological Association's Annual Meeting, October 2022, in Kauai, HI**.**

Abstract:

Background: Using a health systems approach to investigate low-value care (LVC) may provide insights into structural drivers of this pervasive problem.

Objective: Evaluate influence of service area practice patterns on low-value mammography and prostate specific antigen testing.

Design: Retrospective matched cohort analyzing LVC rates between 2008 and 2018 using a novel approach leveraging physician relocation.

Setting: US Medicare claims data.

Participants: 8,254 physicians and 56,467 patients aged 75 years and older.

Measurements: LVC rate for physicians staying in original service area compared to those relocating to new areas.

Results: Relocating physicians changed LVC delivery to become more like physicians in new service areas. This was most pronounced when relocating from high LVC areas to lower LVC areas. For mammography, staying physicians in high LVC areas provided LVC at a rate of 12.6% (95% CI 11.4%, 14.2%) compared to physicians relocating to medium LVC areas at 9.3% (7.7%, 11.1%) and low LVC areas at 6.3% (5.1%, 7.6%). For PSA testing, staying physicians in the highest LVC service areas provided LVC at a rate of 21.1% (19.3, 14.0%) compared to those relocating to medium and low LVC areas at 15.2% (11.8%, 18.6%) and 10.0% (8.5%, 12.2%).

Limitations: Analysis limited by use of retrospective observational data, possible unmeasured confounding, and potential for relocating physicians to practice differently than those who stay.

Conclusion: Physicians changed LVC behavior when relocating to service areas providing different rates of care. Systemic structures may contribute to LVC irrespective of patient

characteristics. Understanding which factors are contributing may present opportunities for policy and interventions to broadly improve care.

Primary Funding Source: National Cancer Institute of the National Institutes of Health under Award Number K08CA234431.

Introduction

There is growing appreciation for understanding healthcare delivery from a systems science perspective(1,2). Health systems science includes "principles, methods, and practice of improving quality, outcomes, and costs of healthcare delivery for patients and populations within systems of medical care(3)." Applying principles of health systems science may provide helpful insights to the pervasive problem of low-value care (LVC).

Value can be defined as desired outcomes relative to cost(4). LVC refers to services that either reduce quality or increase costs without providing additional benefit. LVC is increasingly recognized as a problem, contributing up to $100 billion in waste to the United States healthcare system annually(5). Cancer screenings, including prostate specific antigen (PSA) for prostate cancer and mammogram screening for breast cancer, can be low-value when ordered in scenarios unlikely to provide benefit(6,7).

Organizational, economic, and political factors have all been shown to contribute to LVC (8). Care delivered in academic versus community hospitals, varying LVC rates in different populations, and training environments have all been implicated in contributing to LVC(8-10). In addition, payment systems, pharmaceutical industry, biased evidence, and a 'more is better' culture are perceived by experts as contributors(11,12).

Despite what is known, how these factors work together at the health system level to influence physician behavior is not well understood. By taking a health systems science approach, we seek to understand the relationship between regional patterns of LVC and individual physician practice. That is, do physicians in similar health systems who are exposed to similar factors respond by delivering similar rates of LVC?

We hypothesized that physician delivery of LVC is related to system-level rates of LVC. To study this, we examined LVC delivery by primary care physicians (PCP) in relation to other PCPs practicing in the same hospital service area, accounting for physician-level factors. We applied matching methods to mimic the characteristics of a hypothetical randomized trial designed to compare physician LVC delivery between physicians who relocate to hospital service areas delivering different rates of LVC compared to physicians who stay.

Methods

Overall approach

This analysis met criteria for non-human subjects research and was exempted from review by our Institutional Review Board. The primary question we sought to address was what the effect of physician relocation to low, medium, or high LVC rate service areas would be on physician LVC delivery relative to physicians who stay if patient populations remained the same. We designed our analysis to mimic a hypothetical randomized trial by categorizing physicians as belonging to a service area that provides low, medium, or high rates of LVC. Within each stratum, we identified a set of similar physicians who relocated versus stayed through coarsened-exact matching on baseline physician and service area attributes including baseline physician LVC rate. For each physician, we identified patients treated two years later who matched well to baseline patients. We compared the average physician LVC rates among the matched population.

Study population

Using a 20% Medicare sample from 2008 through 2018, we identified beneficiaries enrolled in FFS Medicare parts A and B accessed through the Virtual Research Data Center. We

identified all males 75 and older without a history of prostate cancer (n=1,434,201) and all females 75 and older without a history of breast cancer (n=1,784,623). For beneficiaries in each cohort we recorded demographic information (age, race/ethnicity), comorbidities (Charlson Comorbidity Index), and family history of breast (female cohort) or prostate cancer (male cohort). We excluded patients with a breast lump, elevated PSA, or a documented BRCA mutation. We identified all PCPs listed as either the performing or referring provider on all claims associated with each beneficiary. PCPs were identified based upon data reported to Medicare (see **Supplement**). Using publicly available National Provider Identifier files, we noted physician year of medical school graduation, degree type (Doctor of Medicine (MD) versus Doctor of Osteopathic Medicine (DO)), residency specialty (Internal Medicine (IM) versus Family Practice (FP)), and gender. Gender was included as previous work supports differences in patient outcomes and LVC delivery based on gender(13-16).

Defining LVC

Any PSA test or mammogram in patients over 75 years was considered LVC. Definitions were chosen based on current US Preventive Task Force (USPSTF) recommendations against screening over age 75(17,18). For PSA screening, the USPSTF does not recommend screening in men 70 years or older. We utilized an age cut-off of 75 years or older to ensure similar populations between mammogram and PSA screening cohorts and to acknowledge other guidelines using a cut-off of 75 years(19).

We identified the zip code where each encounter occurred and assigned each to a Hospital Service Area (HSA), which represents geographic boundaries for healthcare systems. We removed healthcare encounters with missing physician zip codes. We reduced the full set of

claims to each unique combination of patient, physician, year, and HSA. Thus, a patient seeing two physicians in the same year appears twice regardless of number of visits to those physicians in that year. A patient-physician unit involved LVC if the physician was associated with LVC for the patient at any point during the year. Billing and diagnosis codes used for identification can be found in **Supplemental Table 1**.

HSA-level LVC

The primary exposure of interest is relocating or staying in low, medium, or high LVC rate HSA service areas. LVC is calculated by first taking all patient-physician combinations within a given HSA within a given year. Then, take the total number of LVC events (numerator) and divide by total number of patient-physician combinations (denominator) in that HSA. For example, if a given HSA has 100 physicians seeing 1000 patients, representing 1000 unique patient-physician combinations, and 150 patients received LVC, the HSA-level rate would be 150 LVC events divided by 1000 patients, or 15%. This LVC rate was independently calculated for each HSA each year. We calculated separate HSA-level LVC rates for each physician in which each physician's claims were not included in the calculation of the HSA-level rate. In other words, the baseline HSA rate for each physician is the rate of LVC of all other physicians in the market.

Using these measures of market-level LVC, we binned each HSA into high, medium, or low service area tertiles of LVC. For mammogram, high LVC service areas include 10% LVC or higher; medium areas include 7.6% to 10% LVC; and low areas include 7.6% LVC or lower. For PSA, high LVC areas include 14.9% LVC or higher; medium areas include 8% to 14.9% LVC; and low areas include 8% LVC or lower.

Physician Relocation

For each year, we assigned a primary HSA to all physicians, defined as the HSA with the highest share of patient encounters. To reduce error arising from physicians whose claims are largely split between markets, we reduced the cohort to only physicians with at least 70% of their claims coming from a primary HSA. To assign a primary HSA we considered all of a physician's Medicare claims, not just those from patients that fit our inclusion criteria. Physician relocation was defined to be any physician whose primary HSA changed from one year to the next by a 30% or greater shift in claims. We determined these thresholds through a robust process prioritizing identification of a relationship between system-level rates of LVC and individual physician behavior rather than attempting to identify a precise effect size. The thresholds we selected had high specificity for primary market identification and physician relocation.

We divided our cohorts into nine 3-year blocks (i.e. claims from 2008-2010, 2009-2011, etc.) and classified each physician in the same HSA in each block as 'staying' or 'relocating.' We excluded physicians whose new HSA service-area was in the same LVC tertile as the baseline market. We also excluded physicians who were in a different HSA each year of the three-year block or who moved in the second year after baseline.

We compared LVC rates between 'staying' and 'relocating' physicians at year one (baseline) and two years after baseline (final year) to understand the relationship between changing HSA LVC rates and physician provision of LVC. To accomplish this, we grouped physicians based upon the category of HSA LVC (high, medium, low) in the baseline year and

compared LVC rates for ‘staying’ physicians and for physicians relocating into a different category.

Patient-Physician Matching

We created a matched dataset to address potential confounding that may arise from changes in a physician’s patient population between the baseline and final year, or from biases in physician characteristics between those who stay and those who relocate(20). For each 3-year block of claims, we performed coarsened exact matching to create a set of similar patients within each physician between the baseline and final year. Patient factors used for matching included age (coarsened to 5-year age blocks), CCI, and family history of cancer. We prohibited self-matches so that a patient in the baseline year would not be matched to themselves in the final year.

After creating a matched set of patients for each physician, we created matched sets of physicians. Each matched physician set included four physicians in the same LVC tertile for the baseline year. Two physicians in each match set were ‘staying’ physicians. The other two physicians relocated to each of the other two LVC categories so that ‘staying’ and ‘relocating’ physicians would have similar physician-level characteristics. Physician characteristics used for matching include gender, years since graduation (coarsened to 5-year blocks), MD vs DO, Internal Medicine vs Family Practice, the baseline rate of LVC (coarsened to 5%-blocks) and median patient characteristics including age, CCI, and familial cancer history.

Across 100 bootstrap replicates of the above matching procedure, we estimated the average two-year LVC rates for each exposure group. We report the bootstrap mean of the

estimates and the quantile-based 95% Confidence Interval. A flowchart summarizing cohort selection, exclusions, and matching is provided in **Supplement Figure 1**.

The main outcome of interest is individual physician rate of LVC. We calculated each physician's LVC rate based on the new set of matched patients. The original HSA-level rates were preserved as the primary baseline level of HSA-level rates. The physician-level LVC rate is defined as the number of patients cared for by a given physician who received LVC divided by the total number of patients seen by that physician. This LVC rate was independently calculated for each physician in each year.

Role of the Funding Source

National Cancer Institute of the National Institutes of Health had no role in the design, data collection, analysis, preparation, or approval of the manuscript for submission.

Results

Study Population

After applying exclusion criteria, we identified 216,701 physicians and 1,278,954 patients in the PSA cohort and 223,464 physicians and 1,720,159 patients in the mammogram cohort. After matching, there were 3,363 physicians seeing 19,304 patients in PSA analysis and 4,891 physicians caring for 37,163 patients in the mammogram analysis.

Patients in the matched cohorts appeared healthier with 50% having no documented comorbidities versus unmatched where 25% had a CCI of 3 or higher. The matched cohort represented more male and MD credentialed physicians relative to the unmatched cohort. Patient and provider cohorts were otherwise similar. Median patient age was 80.5 in the matched PSA screening cohort and 83 in the mammogram screening cohort. The majority of

patients in the matched and unmatched groups were non-Hispanic white. Physicians who relocated were similar to those that stayed in terms of years in practice, gender, and specialty. Unmatched physicians that relocated had lower rates of LVC compared to staying physicians. Matched physicians had similar characteristics comparing those that relocated to those that stayed (**Tables 1 and 2**).

LVC and Physician Movement

Using the matched patient-physician datasets, we identified consistent patterns of LVC whose trend was most clearly demonstrated among physicians who started in high LVC service areas and relocated to low or medium LVC areas. There also appear to be a dose effect in this relationship. In general, those relocating from high LVC to medium LVC areas had modest reductions in LVC rates, while those moving from high LVC to low LVC had the most substantial decreases **(Figure 1 and Supplement Table 2).**

For the mammogram cohort, staying physicians in high LVC areas provided LVC at a rate of 12.6% (95% CI 11.4%, 14.2%) compared to those that relocated to medium LVC areas at 9.3% (7.7%, 11.1%) and low LVC areas at 6.3% (5.1%, 7.6%). Among the PSA cohort, staying physicians in high LVC areas provided LVC at a rate of 21.1% (19.3%, 24.0%) with physicians relocating to medium LVC and low LVC areas delivering LVC to 15.2% (11.8%, 18.6%) and 10.0% (8.5%, 12.2%) of patients respectively.

When physicians started in the low or medium LVC service areas, the results were more mixed. For the mammography cohort, physicians beginning in low LVC areas did not appear to increase the rates of LVC provision when relocating to either medium (5.4%; 4.1%, 6.7%) or high (6.9%; 5.7%, 8.4%) LVC areas compared to those who stayed 7.1% (6.0%, 8.2%). For PSA testing,

physicians relocating from low LVC areas to high LVC areas provided LVC at a higher rate (8.0%; 5.5%, 11.5%) than those who stayed (5.8%; 3.5%, 8.1%) or moved to medium LVC areas (5.9%; 3.3%, 8.9%). Physicians in both cohorts whose baseline HSA was in a medium LVC area, did not increase LVC when moving to high LVC areas. A similar downward shift in care as seen in those starting in high LVC areas and moving to a low or medium LVC area also appeared among those who started in a medium LVC area and relocated to a low area.

Discussion

In viewing care provided in the broader context of health systems, we hypothesized that physicians are influenced by system-level factors to deliver LVC. By leveraging physician movement and robust patient-physician matching, we found evidence to support this hypothesis. The clearest evidence showed that physicians who initially practiced in areas with high LVC rates and relocated to areas with low LVC rates provided substantially lower LVC than physicians who stayed. Further, we observed a dose-response effect in which physicians who relocate from high LVC to medium LVC areas provide more LVC than those who move to low LVC areas, but less than those who stay in high LVC areas.

This pattern was not entirely consistent among physicians relocating from low LVC HSAs to higher LVC areas. This suggests that physicians appear to be more strongly influenced by system-level factors that encourage reduction of LVC and more resistant to factors that encourage an increase. This differential response to the downward pressure argues for further study in hopes of better understanding which structures or factors encourage a reduction in LVC.

Existing literature supports numerous factors as drivers of LVC which include perverse payment models that may encourage or discourage physicians to deliver LVC(11,21-23). Knowledge gaps, such as perceiving inexpensive measures to be of little financial consequence, despite evidence showing that low-cost services ordered at high volumes contribute more to unnecessary spending than expensive services(24). Physicians training in lower-intensity practices have also been shown to be more likely to appropriately order conservative management(10). Similarly, physicians working in nearby clinical practices may adopt similar practice styles; there could exist social pressure to assimilate with system level norms leading to similar rates of LVC amongst physicians who work near one another(25-26). Accountable Care Organizations (ACOs) may also incentivize high quality care for physicians who work in systems with more ACO support(27).

By taking a systems approach, we add to the existing work by viewing the problem of LVC from a broader perspective that recognizes the combined effect of individual factors. This perspective offers two important additions.

First, by isolating the relationship of individual factors to LVC, we may underestimate other factors that have a larger impact. Second, by shifting our focus from individual physician behavior around LVC to systemic structural drivers, we may be able to develop interventions that improve care without harming physicians. For example, developing interventions to reduce LVC in a framework that places blame on individual physicians may contribute to greater physician burnout. Alternatively, understanding structures that drive systemic LVC may improve care by creating opportunities to remove barriers or perverse incentives that are greater than individual physician decision-making.

Within a health system context, our work adds evidence that when a physician's environment changes, the new factors driving LVC may influence physicians to change. Understanding that physician behavior, at least to some degree, is likely a reflection of the environment in which they work emphasizes the importance of identifying systemic factors driving behavior. These factors may provide targetable solutions for reduction of LVC across different service areas in order to have broad impacts on care delivery.

This study has several limitations. First, the analysis is limited to retrospective observational data. Second, our methods included robust physician-patient matching to minimize confounding, which resulted in a reduced sample size for physicians and patients. This has potential to impact the generalizability of the results. Third, we leveraged physician movement as a form of natural experiment. However, fundamental differences between physicians who relocate and physicians who stay may persist. It is possible that relocating physicians may be more connected with the medical community beyond their health system, having greater access to resources such as current guidelines against LVC. Physicians who stay may have less access to these factors leading to greater entrenchment in local practices and creating an environment in which physicians are less responsive to changing recommendations. It is also possible that physicians who are unhappy with their local health system may relocate to areas that are more aligned with their desired care delivery patterns.

While we are not completely able to account for these issues, we attempted to mitigate these effects by matching on physician characteristics including years since graduation, gender, and specialty (IM vs FP) and credentials (MD vs DO).

In conclusion, this analysis suggests that physicians change LVC behavior when relocating to a new service area to practice more like physicians in their new area. This appears strongest as a downward pressure on the provision of LVC for physicians moving to areas that deliver lower levels of LVC.

Grant Support:

Funding for this study was graciously provided by the National Cancer Institute of the National Institutes of Health under Award Number K08CA234431. The content is solely the responsibility of the authors and does not necessarily represent the official views of the National Institutes of Health. This manuscript has been authored by UT-Battelle, LLC, under contract DE-AC05-00OR22725 with the US Department of Energy (DOE). The publisher, by accepting the article for publication, acknowledges that the US government retains a nonexclusive, paid-up, irrevocable, worldwide license to publish or reproduce the published form of this manuscript, or allow others to do so, for US government purposes. DOE will provide public access to these results of federally sponsored research in accordance with the DOE Public Access Plan (http://energy.gov/downloads/doe-public-access-plan).

Reproducible Research Statement:

Protocol: Not Applicable

Statistical Code: Submitted with final manuscript.

Data: Not available, the data use agreement that covers the use of Medicare and the Virtual Research Data Center do not permit the researchers from publishing or sharing the data used in this analysis.

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Figure Legends:

Figure 1 Title: Matched Cohort Mean Low Value Care Rate of Mammogram and PSA Testing Stratified by Baseline and Final Year Rates.

Figure 1 Caption: Clustered bar graph representing mean low-value care (LVC) rates for mammography (left pane) and PSA testing (right pane) clustered by LVC category (low, medium, and high) in the baseline service area. On the X-axis, baseline tertile refers to the LVC category in the service area in which a physician practiced prior to relocating, with low LVC representing markets with the lowest average LVC (left cluster) and high LVC representing markets with the highest LVC (right cluster). The final year tertile represents the LVC category of the market the physician belonged to after relocating. Stayers are represented by the bars in which final year category is the same as the baseline category. For example, the darkest gray bar in the "low" baseline tertile (furthest left) represents the stayers, since the baseline tertile and final year tertile are both "low." The Y-axis represents average physician LVC rate. Error bars represent 95% confidence intervals. Abbreviations: LVC – low-value care; PSA – prostate specific antigen.

412 **Tables:**

Table 1. Patient Characteristics								
Variable	**PSA Cohort**				**Mammogram Cohort**			
	Initial		**Matched[b]**		**Initial**		**Matched[b]**	
Total	1278223		19304		1719163		37163	
Age[a]	80 (77-85)		80.5 (77-85)		82 (78-88)		83 (78-87)	
Race								
Non-Hispanic White	1136279	88.9%	17447	90.4%	1510366	87.9%	32569	87.6%
Black	72950	5.7%	1007	5.2%	117103	6.8%	2619	7.0%
Other	19221	1.5%	256	1.3%	20342	1.2%	405	1.1%
Asian	25755	2.0%	334	1.7%	35693	2.1%	775	2.1%
Hispanic	19048	1.5%	198	1.0%	28061	1.6%	632	1.7%
Native American, Pacific Islander	4970	0.4%	62	0.3%	7598	0.4%	163	0.4%
CCI								
0	461699	36.1%	11302	58.5%	571128	33.2%	20603	55.4%
1	236504	18.5%	3026	15.7%	376805	21.9%	7204	19.4%
2	223230	17.5%	2579	13.4%	330548	19.2%	5152	13.9%
3+	356790	27.9%	2397	12.4%	440682	25.6%	4204	11.3%

Notes. CCI - Charlson Comorbidity Index; a. Median (Interquartile Range); b. Patients were matched on age, CCI, and family history of cancer

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Table 2. Provider Characteristics

	PSA Cohort								Mammogram Cohort							
	Initial				Matched				Initial				Matched			
	Non-movers		Movers		Non-movers		Movers		Non-movers		Movers		Non-movers		Movers	
Total	156277		60330		1524		1839		157248		66145		2163		2728	
Years practicing[a]	6.5 (4.8-7)		6.7 (5.5-7.4)		6 (4-6.5)		5 (4-6)		6.5 (5-7)		6.7 (5.5-7.3)		5.5 (4-6)		5 (3-6)	
Gender																
Female	57072	36.5%	23168	38.4%	405	26.6%	465	25.3%	57861	36.8%	26974	40.8%	774	35.8%	935	34.3%
Male	97773	62.6%	36821	61.0%	1117	73.3%	1372	74.6%	97921	62.3%	38800	58.7%	1387	64.1%	1791	65.7%
Missing	1432	0.9%	341	0.6%	2	0.1%	2	0.1%	1466	0.9%	371	0.6%	2	0.1%	2	0.1%
Specialty																
Family practice	70915	45.4%	26132	43.3%	640	42.0%	770	41.9%	71562	45.5%	29634	44.8%	921	42.6%	1135	41.6%
Internal medicine	85362	54.6%	34198	56.7%	884	58.0%	1069	58.1%	85686	54.5%	36511	55.2%	1242	57.4%	1593	58.4%
Credentials																
MD	135958	87.0%	51905	86.0%	1432	94.0%	1739	94.6%	136689	86.9%	56875	86.0%	1987	91.9%	2530	92.7%
DO	20319	13.0%	8425	14.0%	92	6.0%	100	5.4%	20559	13.1%	9270	14.0%	176	8.1%	198	7.3%
Mean LVC rate by tertile[b]																
Low	4.1% (11.0%)		2.6% (7.7%)		1.8% (11.9%)		1.6% (11.0%)		5.9% (11.1%)		4.2% (8.7%)		2.9% (14.1%)		2.2% (12.3%)	
Medium	10.3% (17.0%)		6.0% (11.9%)		9.0% (25.4%)		7.8% (23.9%)		8.7% (12.8%)		5.8% (9.9%)		3.8% (15.2%)		3.2% (14.1%)	
High	17.2% (22.0%)		11.1% (17.3%)		14.2% (30.6%)		12.2% (28.8%)		11.0% (14.4%)		8.1% (11.7%)		5.6% (18.6%)		4.4% (16.6%)	

Notes: LVC- Low Value Care; a. Median (Interquartile range), b. Values in parentheses represent standard deviations; Physicians were matched on gender, years since graduation, MD vs DO, Internal Medicine vs Family Practice, baseline rate of LVC care, and median patients characteristics including age, CCI, and familial cancer history

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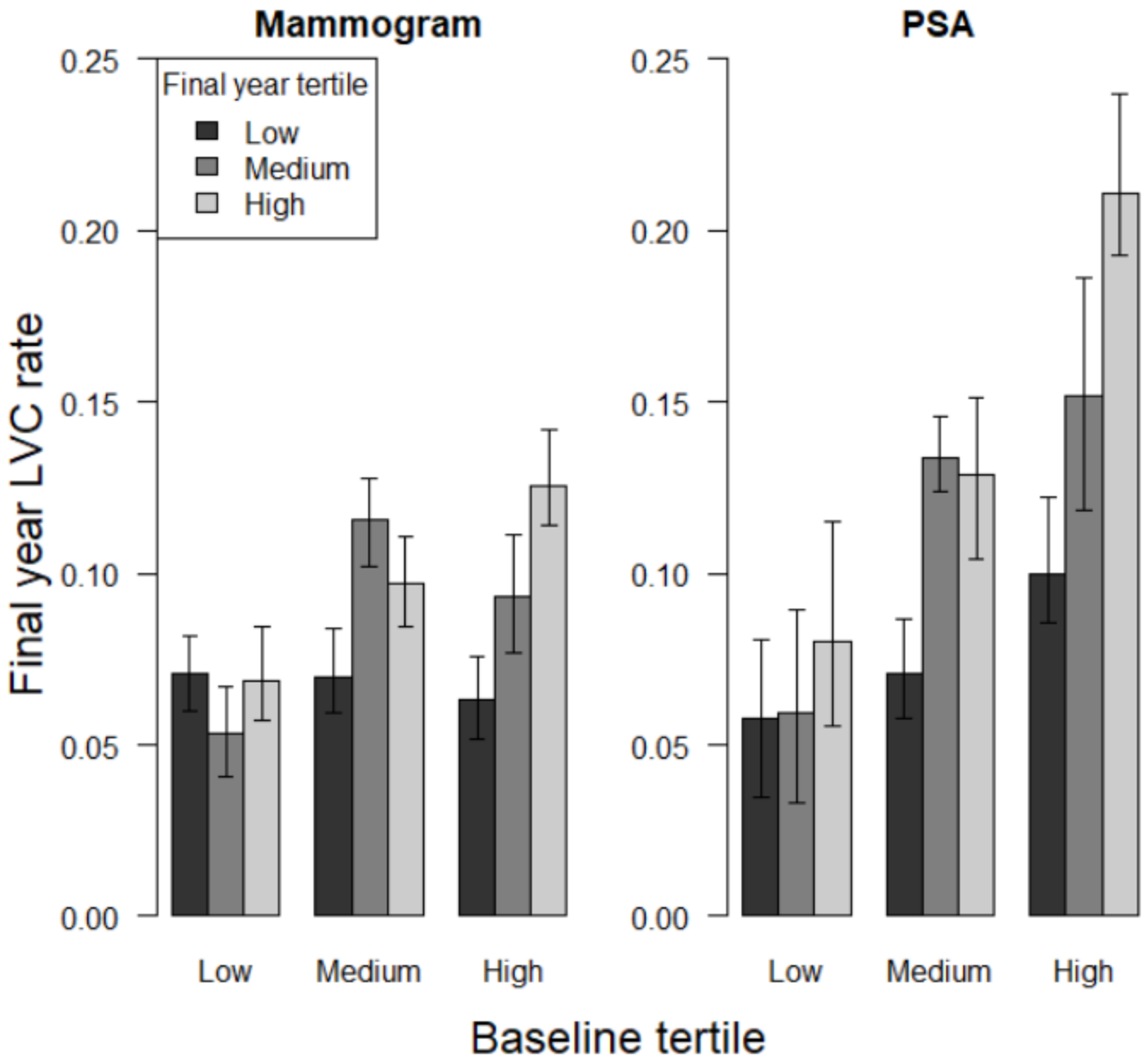
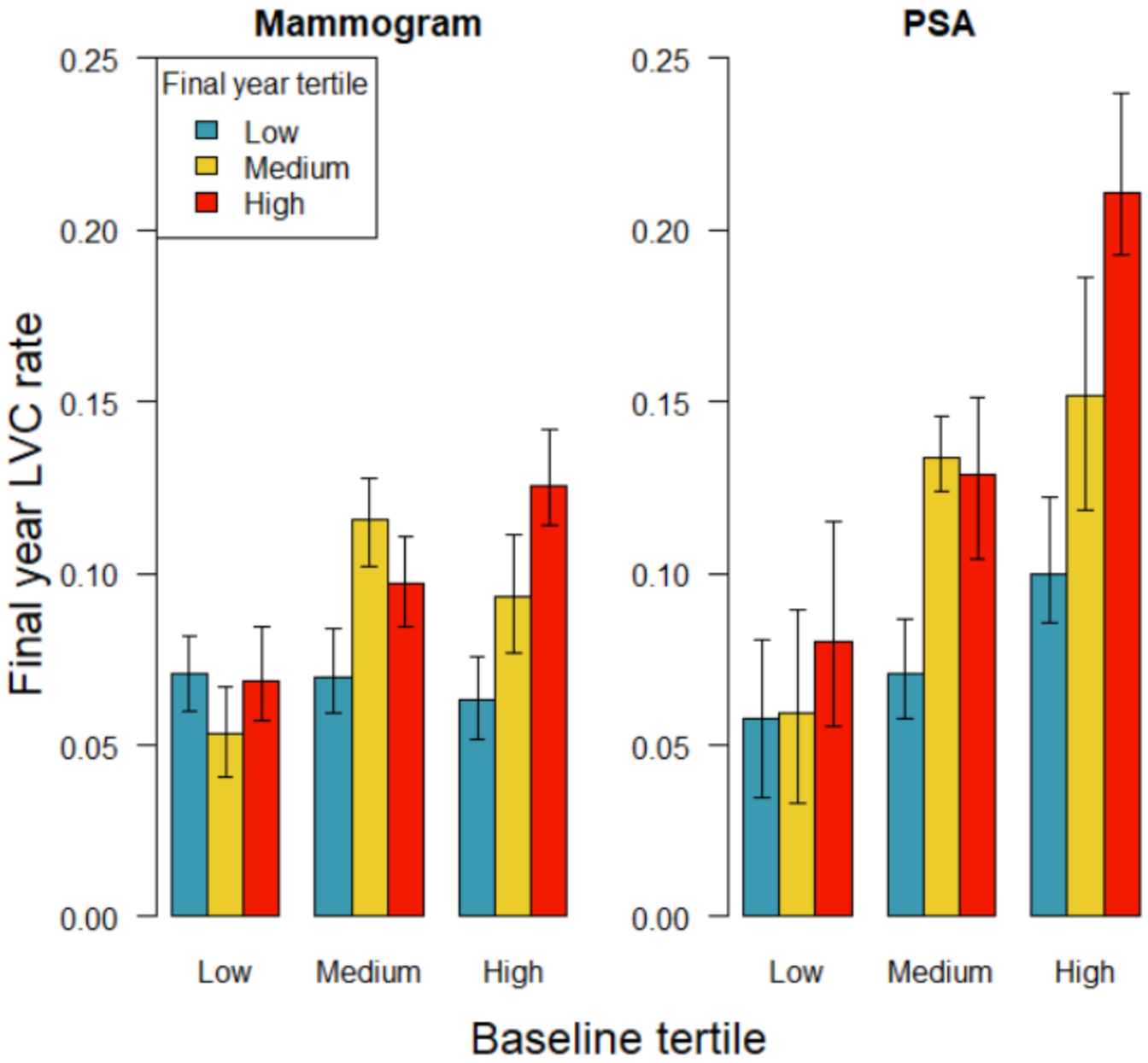

Mammogram
PSA
Final year tertile
Low
Medium
High
Final year LVC rate
0.25
0.20
0.15
0.10
0.05
0.00
Low
Medium
High
Baseline tertile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