PHYSICIAN NETWORKS AND LOW-VALUE CANCER SCREENING: A CROSS-SECTIONAL ECONOMICS STUDY OF 2008 MEDICARE CLAIMS DATA

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By

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ABSTRACT

Recent developments in healthcare economics literature suggest that various low-value healthcare services can be reliably detected through querying claims data; further, advances in the study of physician networks relationship with the cost and quality of care provoke the hypothesis that physician networks may be associated with the usage of low-value services. In this study, we investigate the distribution of low-value cancer screening services amongst physician networks in 5 states, testing for differences between networks using econometric methods and exploring potential drivers of low-value service usage amongst networks. Using data mining techniques on 2008 Medicare claims data, we identify three low-value cancer screening services amongst 417 physician referral networks developed in prior research. A fixed effects negative binomial model and a multivariate regression model were used to test for significance of low-value service usage variation between networks and for investigating potential associative significance of network-level characteristics, respectively. We found statistically significant variation ($p<.01$) in the usage of two of the three cancer screening services between the physician networks after controlling for patient and physician characteristics. Additionally, we identified three network variables which significantly predict the dependent variable (low-value services per 100 “at-risk” beneficiaries in the network): percentage of network physicians trained in the U.S.; percentage of physicians with an MD (compared to DO); and the mean-adjusted valued degree (a measure for the level of “patient-sharing” within the network).

BIOGRAPHICAL SKETCH

Derek Lake is submitting this thesis in order to satisfy the requirements for the conferral of the degree Master of Science in Healthcare Economics and Policy at Weill Cornell Medicine. Derek's mentor was Lawrence Casalino, MD, Ph.D, and he worked closely with Michael Pesko, Ph.D, both of the Weill Cornell Medicine Health Policy & Research division. Derek matriculated to the college in September 2015, and graduated in July 2016. He will begin working as a healthcare economics analyst at Crystal Run Healthcare beginning immediately after graduation.

Prior to attending Weill Cornell Medicine, Derek studied at Rider University in New Jersey, where he completed undergraduate degrees in Accounting and Finance, while enrolled in two separate honors programs. He completed two undergraduate theses, entitled "The Impact of Job Automation on the United States Labor Force: A 20 Year Forecast" and "Impact of the Dodd-Frank Act on Systemically Important Financial Institutions". While enrolled at Rider, Derek competed for four years as an NCAA Division 1 XC/TF athlete, serving as team captain during his junior and senior years. He also served periodically as president of the Chinese Language Club and Economics Club. Amongst his other accomplishments include: Rider University record holder in two track events; ICAAAA All-East Recipient, Division 1; and an Eagle Scout.

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LIST OF ABBREVIATIONS

Acronym	Definition
LVS	Low Value Service
LVC	Low Value Care
PSA	Prostate-Specific Antigen
ABIM	American Board of Interal Medicine
NICE	National Institute of Health and Clinical Excellence
USPSTF	U.S. Preventive Services Task Force
PFP	Pay For Performance
ACO	Accountable Care Organization
SES	Socio-Economic Status
MD	Medical Doctor
DO	Doctor of Osteopathic Medicine
PPC	Physician Practice Community
HCPCS	Healthcare Common Procedure Coding System
AMA	American Medical Association
DRG	Diagnosis Related Group
MEDPAR	Medicare Provider Analysis and Review
CPT	Current Procedural Terminology
SD	Standard Deviation

INTRODUCTION

The purpose of this study is to investigate the relationship between physician networks—whether formal or organically occurring—and the usage of low value services. Given American healthcare policymaker's objective to reduce expenditure while improving both quality of care and the patient experience, it is essential to identify inefficiencies in care delivery. Amongst inefficiencies in the healthcare sector, one which detracts from all three of the prior "objectives", is the usage of low value services—those services which have been deemed to be of little-to-no clinical benefit to the patient. Research estimates have claimed that as much as 30% of healthcare expenditures in the United States are wasteful.(1) Unsurprisingly, the greatest driver of total healthcare expenditures is the national aggregate of physician's clinical decisions—accounting for nearly 80% of healthcare spending(2). The prevalence and patterns of low-value services' usage amongst physicians and their referral networks, as well as the potential drivers of their usage, are of interest to healthcare policy researchers, commercial and public payers, and providers alike because they provide the market with a potential means to reduce wasteful spending and possibly improve both patient care and experience.

During the past decade, a substantial effort from both public and private institutions and physician specialty groups has generated a wealth of published data regarding the specifications for "low-value" healthcare interventions.(3-5)

The National Institute of Health and Clinical Excellence (NICE) took initiative in 2007 to create a list of '*do not do'* recommendations with specific clinical interventions which should not be performed under a set of restrictive criteria.(6, 7) Since then, the American Board of Internal Medicine (ABIM) has worked with Consumer Reports to release lists of the "top five" low value medical "treatments" for each of twenty-six physician specialties as well as additional state-level physician organizations as part of the *Choosing Wisely* campaign.(8, 9) Independent from the ABIM, since 2007 the U.S. Preventive Services Task Force (USPSTF) has released recommendations of medical interventions with usefulness ratings for primary care providers; they identify services which are of no benefit to the patient (or may even do more harm than good) as grade D services (on a scale from A to D).(10) Though there are hundreds of clinical-context definitions of low-value services in published medical journals, a proper methodology for the retrospective identification of these services has proven illusory until only recently.

As mentioned earlier, academic, peer-reviewed medical literature is replete with the criteria for defining constitutions of low-value services. Typically, a low value service is defined by some or all the following criteria: the type of service (procedure, or intervention); the age, sex, and medical history (chronic conditions, prior testing, etc.) of the patient; the frequency of service received by a patient; and the medical diagnosis of the patient, often in conjunction with the other criteria. In a present clinical context, it would be relatively simple for a medical professional to identify a service as low-value, however, the insurance claims data supplied to healthcare researchers for identifying low-value care is retrospective data originally intended for billing purposes, which presents researchers with various challenges.(11, 12) The criteria necessary to confidently detect a low-value service based on claims data is often either too detailed (and thus not found in the claims data), or too subjective in nature to identify the instance of a low-value service. A few studies have defined which low-value services could be identified based upon data available within Medicare claims. A seminal study of Medicare claims completed by Colla, et al. found that there was significant variation in usage of eleven low-value services (all from *Choosing Wisely*) across hospital referral regions in the United States.(13) The level of sensitivity for their low-value service detection rate is not estimated, but the selection methodology used to choose the eleven studied services was rigorous. Prior research from Schwartz, et al. has identified thirty-one low-value services which can be confidently identified in Medicare claims data with a high level of specificity.(14)

In recent years, the identification of physician referral networks, irrespective of formal healthcare delivery organizations, has been studied using social network theory and claims-based network detection modeling.(11, 15) These networks have shown meaningful variance in both healthcare quality and costs, though no variable has been identified as the driver of differentiation between networks (15, 16). Prior research lends strong credibility to the idea that physician referral networks may influence patterns of care delivery (12, 17), so investigating the relationship between physician referral networks and the usage of low value services is important to advance the understanding of wasteful medical care drivers.

Until recently, it was only speculated that low-value care delivery could be reduced through “pay-for-performance” (PFP) incentives programs; a study by

Schwartz, et al. measured the change in usage of low-value services before and after a an experimental group enrolled in a PFP contract with Medicare which either rewarded or penalized physicians based upon scores of cost and quality, etc. Their research, using difference in differences time series analysis has found that physician groups participating in the Medicare Pioneer ACO Program significantly reduced their usage of low-value care compared to groups of non-ACO physicians; we can say with some confidence that physicians, if prompted with an effective stimulus, can change clinical decision making practices—creating an impetus for further research upon the influence of care-delivery patterns, and the efficacy of health policy interventions and compensation packages seeking to reduce wasteful spending on low-value services(18).

It is our intention to elucidate the association or lack thereof between physician networks and the usage of low-value cancer screening services in this study so that physician organization leaders, payers, and researchers, amongst others, might develop a better understanding of what role physician networks play in their respective healthcare markets. In our study, we identify low-value service usage amongst a Medicare population, attribute those beneficiaries to their respective physician networks, and analyze econometric models to decipher variation of usage between physician networks and the potential drivers which might cause one network to deliver more low-value services than another. We hypothesize that there is variation in low-value cancer screening services amongst our study population of 417 networks.

Methods

Study Population

Building upon the work of Casalino, et al. we identified and attributed three "at-risk for low-value services" beneficiary populations to 417 physician practice communities for each of three low-value cancer screening services. The beneficiary population was drawn from a random sample of 987,000 Medicare fee-for-service enrolled beneficiaries from 5 states (Ohio, Pennsylvania, Tennessee, Washington, Wisconsin), alive at the end of the study-year, at least 65 years old, and not in the Medicare End-Stage Renal Disease Program in 2008. Amongst the three study populations, there is significant overlap of "at-risk" patient populations and physicians between Low-Value Service (LVS) #1 and LVS # 3, and between "at-risk" patient populations and physicians LVS #2 and #3, while patient populations #2 and #3 are exclusive of one another due to gender delineation. Networks vary amongst populations dependent upon the parameters for each respective "at-risk" populations defined by Schwartz, et al.(14, 18) Primary analysis was initially conducted based upon an aggregated population with "At-Risk for Low-Value Service #X", however due to the dissimilarity of physicians and beneficiaries analyzed for each of the three services; this study is more appropriately suited to test each population independently.

Beneficiary Characteristics

We adjusted our analysis for commonly accepted beneficiary characteristics including: beneficiary age, sex, an indicator for Medicaid dual eligibility during 2008, and a socioeconomic status (SES) categorical variable. Zip code level per capita median income was used to develop a decile ranking of SES (excluded from descriptive statistics due to excessive volume of data). Beneficiary age, sex, and dual eligibility were derived from the Medicare annual beneficiary summary file.

Physician Network Characteristics

Physician practice community (PPC) characteristics which describe qualities of both commonly accepted physician quality measures and network composition were included. PPC Characteristics include the percentage of physicians in the age groups: <40, 40-50, 51-60, >60; percentage of female physicians; percentage of DO physicians (compared to MD); percentage of physicians trained in the U.S. (compared to foreign medical schools); percent of physicians board certified; primary care physician percentage of network; Mean-adjusted valued degree; and the betweeness-centrality ratio, amongst others. The mean adjusted-valued degree is a descriptor of the average strength of ties (computed based upon the number and frequency of beneficiaries shared between physicians in the network) within each network. The mean betweeness-centrality network variable is a measure of the average "centrality" (how central a physician is as a connector of beneficiaries to other network-assigned physicians) of all physicians in the network.

Identifying Low-Value Services

As described in the introduction, low-value services are medical services which deliver no clinical benefit to the beneficiary while increasing expenditure by payers (in this case, the payer is Medicare). Amongst the many low-value services listed and described by the literature, there is a subset which has been proven to be reliably identifiable from claims data—an intrinsically difficult data source to query for detailed clinical information.

In this study, we identify three low-value cancer screening services usage amongst physician practice communities: Prostate Specific Antigen testing amongst men over age 75, without a history of prostate cancer; Cervical Cancer Screening amongst women over age 65, without a history cervical and other relevant cancers or dysplasias; and Colon Cancer Screening for beneficiaries over the age of 85, without a history of colon cancer. The clinical definitions of these three cancer screens/tests are derived from the US Preventive Service Task Force and the Agency for Healthcare Research and Quality. (19-21) Patient Age, Sex, and Chronic Conditions History/Dates were accessed using the Chronic Conditions Warehouse.(22) HCPCS codes, diagnosis codes, and other clinical information were gathered from Outpatient claims, Inpatient claims, and the 2008 MEDPAR files. Physician characteristics (Age, Sex, certifications, etc.) were taken from the AMA Masterfile.

We conducted the detection of low-value service usage using SQL and SAS data mining techniques and conducted statistical analysis using STATA v.14. In order to capture all beneficiaries at risk for one of the three services, we applied population restriction criteria as defined by Schwartz, et al.(14, 18) which defines populations based on age, sex, chronic conditions, prior DRG codes. Amongst the three at-risk populations, we applied highly specific criteria to assign services as low-value based upon HCPCS codes, timing of service in relation to other services (using MEDPAR and Dates of Service in in/outpatient claims), and the setting of care (acute vs outpatient).

The three low-value cancer screening services as defined in this paper each include multiple procedures which qualify as the low-value service. There were 11 CPT codes qualifying as a Cervical Cancer Screenings; 38 CPT codes qualifying as a Colon Cancer Screening; and 4 CPT codes qualifying as a Prostate-Specific Antigen Screening. To calculate total costs for the three low-value services, we used a direct cost method, only including the cost of the screening test ordered.

RESULTS

Study Population

Three separate at-risk populations were calculated based upon the at-risk for low-value service (LVS) criteria explained in the Methods section. Population 1 (At-Risk for PSA LVS) contains 113,811 beneficiaries and 28,925 physicians attributed to 416 networks; Population 2 (At-Risk for Cervical Screening LVS) contains 409,786 beneficiaries and 44,867 physicians within 417 networks; and Population 3 (At-Risk for Colorectal Screening LVS) contains 100,690 beneficiaries and 26,538 physicians within 416 networks. Total LVS usage across all three populations were calculated; we detected 15,087 instances of LVS #1, 15,323 instances of LVS #2, and 3,167 instances of LVS #3 (Table 1). Total costs for each LVS were computed using the direct cost of the screening service used; LVS #1 usage generated $452,610 in wasteful spending, LVS #2 usage generated $386,752 in wasteful spending, and LVS #3 generated $1,337,311 in wasteful spending (Table 1). Amongst the three populations, patients at risk for LVS #1 had the highest risk of receiving the LVS, as 13.26% of all at-risk beneficiaries received the LVS (table 1).

Table 1: Low Value Service Prevalence Amongst Each "At-Risk Population"

Low-Value Service	Beneficiaries At-Risk for Service	Beneficiaries Who Received LVS (Count, %)	Total LVS	Total Direct Cost
LVS 1 (PSA)	113,811	14,369 (13.26%)	15,087	$ 452,610.00
LVS 2 (Cervical)	409,786	14,786 (3.74%)	15,323	$ 386,752.52
LVS 3 (Colon)	100,690	3,167 (3.60%)	3,627	$1,337,311.17

Further descriptive statistics for each of the three at-risk patient populations are provided in Tables 2-4.

Table 2: Descriptive Statistics for "At-Risk for LVS#1" Beneficiaries and Physicians Assigned to a PPC

	Mean	SD	Minimum	Maximum
Patient Level Characteristics (n=113,811)				
Age	81.7	4.74	75.05	107.7
Female (%)	0	NA	NA	NA
Dual Eligible (min 1 mo.) (%)	8.42	NA	NA	NA
Race				
White	95.42	NA	NA	NA
Black	3.12	NA	NA	NA
Hispanic	0.34	NA	NA	NA
Asian/Pacific Islander	0.67	NA	NA	NA
American Indian/Alaska Native	0.32	NA	NA	NA
Other Race/Ethnicity	0.14	NA	NA	NA
Mean LVS (#1) Per Beneficiary	0.1326	0.359	0	8
Physician-Level Characteristics (n=28,925)				
Female (%)	10.08	NA	NA	NA
Age (%)				
Under 40 Years	13.41	NA	NA	NA
40-50 Years	28.70	NA	NA	NA
51-60 Years	36.87	NA	NA	NA
Over 60 Years	21.02	NA	NA	NA
US Trained (%)	82.24	NA	NA	NA
Doctor of Osteo. (%)	10.31	NA	NA	NA
Network Characteristics (n=416)				
Physician Female (%)	23.29	8.57	0	61.54
Physician US Trained (%)	76.64	11.2	30.43	100
Physician DO (%)	11.14	10.4	0	70.32
Physician Board Certified (%)	80.4	11.41	21.68	100
PCP (%)	42.5	11.56	6.3	90.32
"At-Risk" Beneficiaries Per PPC	273.58	226.53	2.00	2084.00
Physicians Per PPC (w/at-risk bene.)	69.53	48.72	2.00	285.00
Mean Adjusted Valued Degree	3.69	2.27	0.72	15.07
Betweeness-Centrality Ratio	1.18	1.28	0	14.76

Table 3: Descriptive Statistics for "At-Risk for LVS#2" Beneficiaries and Physicians Assigned to a PPC

	Mean	SD	Minimum	Maximum
Patient Level Characteristics (n=409,786)				
Age	77.64	7.75	66	112
Female (%)	100	NA	NA	NA
Dual Eligible (min 1 mo.) (%)	15.46	NA	NA	NA
Race				
White	93.38	NA	NA	NA
Black	4.99	NA	NA	NA
Hispanic	0.53	NA	NA	NA
Asian/Pacific Islander	0.7	NA	NA	NA
American Indian/Alaska Native	0.23	NA	NA	NA
Other Race/Ethnicity	0.18	NA	NA	NA
Mean LVS (#2) Per Beneficiary	0.0374	0.197	0	4
Physician-Level Characteristics (n=44,867)				
Female (%)	22.64	NA	NA	NA
Age (%)				
Under 40 Years	18.57	NA	NA	NA
40-50 Years	28.33	NA	NA	NA
51-60 Years	28.63	NA	NA	NA
Over 60 Years	24.47	NA	NA	NA
US Trained (%)	83.19	NA	NA	NA
Doctor of Osteo. (%)	9.7	NA	NA	NA
Network Characteristics (n=417)				
Physician Female (%)	23.32	8.58	0	61.53
Physician US Trained (%)	76.61	11.15	30.43	100
Physician DO (%)	11.12	10.39	0	70.32
Physician Board Certified (%)	80.41	11.58	21.74	100
PCP (%)	43.82	0.14	4.54	100
"At-Risk" Beneficiaries Per PPC	982.7	715.21	6.00	3689
Physicians Per PPC (w/at-risk bene.)	107.62	79.53	6.00	473
Mean Adjusted Valued Degree	3.69	2.27	0.713	15.07
Betweeness-Centrality Ratio	0.717	0.23	0.069	1.915

Table 4: Descriptive Statistics for the "At-Risk for LVS#3" Beneficiaries and Physicians Assigned to a PPC

	Mean	SD	Minimum	Maximum
Patient Level Characteristics (n=100,690)				
Age	89.49	3.25	86	112
Female (%)	70.95	NA	NA	NA
Dual Eligible (min 1 mo.) (%)	19.51	NA	NA	NA
Race				
White	95	NA	NA	NA
Black	3.76	NA	NA	NA
Hispanic	0.21	NA	NA	NA
Asian/Pacific Islander	0.54	NA	NA	NA
American Indian/Alaska Native	0.19	NA	NA	NA
Other Race/Ethnicity	0.1	NA	NA	NA
Mean LVS (#3) Per Beneficiary	0.0361	0.216	0	9
Physician-Level Characteristics (n=26,538)				
Female (%)	20.24	NA	NA	NA
Age (%)				
Under 40 Years	17.41	NA	NA	NA
40-50 Years	29.36	NA	NA	NA
51-60 Years	31.51	NA	NA	NA
Over 60 Years	21.73	NA	NA	NA
US Trained (%)	82.35	NA	NA	NA
Doctor of Osteo. (%)	89.28	NA	NA	NA
Network Characteristics (n=416)				
Physician Female (%)	23.31	8.59	0	61.54
Physician US Trained (%)	76.62	11.15	30.43	100
Physician DO (%)	11.15	10.39	0	70.32
Physician Board Certified (%)	80.42	11.6	21.74	100
PCP (%)	43.88	14.1	4.55	100
"At-Risk" Beneficiaries Per PPC	242.04	175.31	2.00	919
Physicians Per PPC (w/at-risk bene.)	63.8	43.77	2.00	241
Mean Adjusted Valued Degree	3.679	2.26	0.713	15.07
Betweeness-Centrality Ratio	0.743	0.22	0.688	1.915

Analysis

To answer our research question, we first tested for variation of LVS usage amongst physician networks, and furthermore, conducted multivariate regression analysis to test network-level characteristics for significant association with the dependent variable. In order to test for variance of low-value cancer screening service usage across networks for each of the three at-risk populations, we tested for joint-significance of network fixed effects in a negative binomial regression model (multiple variations of models tested to adjust for the distribution of outcome variable "LVS Count" for each beneficiary), adjusting for both patient and physician characteristics. The unit of analysis was at the beneficiary level, where each beneficiary was assigned a count (0-x) for the number of low-value services they received in each respective population group. A statistically significant result ($p<.01$) of joint-significance was found for networks amongst populations 1 and 2, suggesting that physician networks matter and are associated with the usage of these two cancer screening services. We did not find statistical significance for population 3, which we hypothesize might be due to the clinical nature of the screening service; those networks with a greater proportion of gastroenterologists were more likely to deliver LVS #3 at an aggregated network level but not at the beneficiary level analysis we are interested in.

In an effort to further explore the association of physician networks and the usage of cancer screening LVS, we ran a multivariate regression analysis with state-fixed effects and included physician network-level characteristics (replacing the network-level fixed effects from the prior model). To control for the high variation in

LVS usage amongst networks with a low proportion of beneficiaries at-risk for a LVS, we restricted our analysis population to only those networks with at least 100 beneficiaries at risk for each respective LVS population, which did not substantially alter the descriptive statistics of Tables 2-4. Population 3 network characteristics were not significantly related to the dependent variable (Count LVS #3 for each beneficiary), which while unexplained in our analysis might be the result of: A.) a low prevalence of these services; and B.) an abnormal distribution of gastroenterologists (and generally a low population of gastroenterologists) amongst networks in this study.

Results from our multivariate regression analysis (tables 5-7) for populations 1 and 2 suggest that the percentage of US trained physicians (vs. Foreign) and the percentage of MD physicians (vs. DO) in a network are both inversely related to the amount of low-value cancer screening services delivered by the network. Population 1 and Population 2 results indicate that physician networks with a one standard deviation greater than average US trained physician percentage, delivered LVS 1 and LVS 2, 9.05% and 1.22% less than the population mean, respectively. Further, Population 1 and population 2 results indicate that physician networks with a one standard deviation greater than the mean percentage of DO's, delivered LVS 1 and LVS 2 11.09% and 32.26% more than the population mean, respectively. Statistical significance of Mean Adjusted-Valued Degree ($p<.01$) was found in population 1, and statistical significance of the betweeness-centrality ratio ($p<.01$) was found in population 2, suggesting that measures of network patient-sharing and network "closeness" might be associated with LVS usage. The percentage of Board-certified physicians amongst networks delivering LVS #2 was associated (p<.01), such that an increase of one standard deviation in Board-Certified physicians compared to the mean resulted in a 17% increase of LVS delivery compared to the population mean.

Table 5: Multivariate Analysis of Variables Association with LVS #1 (PSA Testing)

Beneficiaries (N= 113,811)	**Marginal Effect †**	**SD (ME)**	**Change in LVS Usage Per 100 Beneficiaries Per Year ‡**	**Change in LVS Usage Per 100 Beneficiaries Per Year as a % of Mean LVS Per 100 Bene. Per Year (%) ¥**
Patient Level Characteristics				
Age	-0.0064***	4.7280	-3.03	-22.86%
Female	NA	NA	NA	
Dual Eligible (min 1 mo.)	-0.0493***	NA	-4.93	-37.19%
Race				
Black	0.0122	NA	1.22	9.20%
Hispanic	-0.0054	NA	-0.54	-4.07%
Asain/Pacific Islander	0.01	NA	1	7.54%
American Indian/Alaska Native	-0.0194	NA	-1.94	-14.63%
Other Race/Ethnicity	-0.0240	NA	-2.4	-18.10%
Physician-Level Characteristics				
Female	0.0103*	NA	1.03	7.77%
Age**				
40-50 Years	-0.0078	NA	-0.78	-5.88%
51-60 Years	-0.0122**	NA	-1.22	-9.20%
Over 60 Years	0.0014	NA	0.14	1.06%
ForeignTrained	0.0144***	NA	1.44	10.86%
Doctor of Osteo.	0.0173***	NA	1.73	13.05%
Network Characterisitcs				
Physician Female (%)	0.1477**	0.0600	0.89	6.71%
Physician US Trained (%)	-0.1187**	0.1010	-1.2	-9.05%
` Physician DO (%)	0.1636*	0.0900	1.47	11.09%
Physician Board Certified (%)	-0.0678	0.0960	-0.65	-4.90%
PCP (%)	-0.1178	0.0910	-1.07	-8.07%
Physicians Per PPC	0	147.3410	~	
Mean Adjusted Valued Degree	-0.0069***	2.0350	-1.40	-10.56%
Betweeness-Centrality Ratio	0.5526	0.0100	0.55	4.15%

*p<.10; **p<.05; ***p<.01.

† The marginal effect is the change in Low-Value Service (#1) per beneficiary per year for a 1 unit change in the variable, when the variable is continuous, or for a change from the reference category to the category listed, when the variable is categorical.

‡ This is the change in Low-Value Service (#1) usage per 100 beneficiaries for a 1 SD change in continuous variables, or for a change from the reference category to the category listed for categorical variables. Continuous variables are multiplied by the SD and expressed on a per 100 beneficiaries basis.

¥The mean LVS(#1) per 100 beneficiaries per year amongst the total "at-risk" population is 13.256

"Race" reference group is White

"Foreign Trained" reference group is "U.S. Trained"

"Doctor of Osteo." reference group is MD

Table 6: Multivariate Analysis of Variables Association with LVS #2 (Cervical Cancer testing)

Beneficiaries (N= 409,786)	Marginal Effect †	SD	Change in LVS Usage Per 100 Beneficiaries Per Year ‡	Change in LVS Usage Per 100 Beneficiaries Per Year as a % of Mean LVS Per 100 Bene. Per Year (%) ¥
Patient Level Characteristics				
Age	-0.0027***	0.0002	0.0001	0.00%
Female	~	~	~	~
Dual Eligible (min 1 mo.)	-0.0164***	NA	-1.64	-45.45%
Race				
Black	-0.0093***	NA	-0.93	-25.78%
Hispanic	-0.0024	NA	-0.24	-6.65%
Asain/Pacific Islander	-0.0009	NA	-0.09	-2.49%
American Indian/Alaska Native	0.0036	NA	0.36	9.98%
Other Race/Ethnicity	-0.0157**	NA	-1.57	-43.51%
Physician-Level Characteristics				
Female	0.0069***	NA	0.69	19.12%
Age**				
40-50 Years	0.0014	NA	0.14	3.88%
51-60 Years	0.0023	NA	0.23	6.37%
Over 60 Years	0.0082***	NA	0.82	22.73%
ForeignTrained	0.0052***	NA	0.52	14.41%
Doctor of Osteo.	-0.0020	NA	-0.20	-5.54%
Network Characterisitcs				
Physician Female (%)	-0.1040	0.0318	-0.33072	-9.17%
Physician US Trained (%)	-0.0226***	0.0194	-0.0438	-1.22%
Physician DO (%)	0.3604***	0.0323	1.1641	32.26%
Physician Board Certified (%)	0.2005***	0.0306	0.6135	17.00%
PCP (%)	-0.0374	0.0231	-0.0864	-2.39%
Bene. Per PPC	~	~	~	
Mean Adjusted Valued Degree	-0.0015	0.0011	0.00	0.00%
Betweeness-Centrality Ratio	0.0353***	0.0120	0.04236	1.17%

*p<.10; **p<.05; ***p<.01.

† The marginal effect is the change in Low-Value Service (#1) per beneficiary per year for a 1 unit change in the variable, when the variable is continuous, or for a change from the reference category to the category listed, when the variable is categorical.

‡ This is the change in Low-Value Service (#1) usage per 100 beneficiaries for a 1 SD change in continuous variables, or for a change from the reference category to the category listed for categorical variables. Continuous variables are multiplied by the SD and expressed on a per 100 beneficiaries basis.

¥The mean LVS(#2) per 100 beneficiaries per year amongst the total "at-risk" population is 3.608

"Race" reference group is White

"Foreign Trained" reference group is "U.S. Trained"

"Doctor of Osteo." reference group is MD

Table 7: Multivariate Analysis of Variables Association with LVS #3 (Colon Cancer Screening)

Beneficiaries (N= 100,690)	Marginal Effect †	SD	Change in LVS Usage Per 100 Beneficiaries Per Year ‡	Change in LVS Usage Per 100 Beneficiaries Per Year as a % of Mean LVS Per 100 Bene. Per Year (%) ¥
Patient Level Characteristics				
Age	-0.003***	0.0020	-0.0006	-0.02%
Female	-0.0138	0.0017	0.002346	0.08%
Dual Eligible (min 1 mo.)	-0.0027	NA	-0.2700	-8.95%
Race				
Black	0.0056	NA	0.5625	18.64%
Hispanic	0.0200	NA	2.0014	66.32%
Asain/Pacific Islander	-0.0136**	NA	-1.3610	-45.10%
American Indian/Alaska Native	0.0212	NA	2.1239	70.37%
Other Race/Ethnicity	0.0094	NA	0.9421	31.22%
Physician-Level Characteristics				
Female	-0.0008	NA	-0.0763	-2.53%
Age**				
40-50 Years	0.001	NA	0.1072	3.55%
51-60 Years	0.0024	NA	0.2419	8.02%
Over 60 Years	-0.0025	NA	-0.2493	-8.26%
ForeignTrained	0.006***	NA	0.5969	19.78%
Doctor of Osteo.	-0.0019	NA	-0.1944	-6.44%
Network Characterisitcs				
Physician Female (%)	-0.0032	0.0205	-0.0061	-0.20%
Physician US Trained (%)	-0.0110	0.0142	-0.0157	-0.52%
Physician DO (%)	-0.0051	0.0120	-0.0100	-0.33%
Physician Board Certified (%)	-0.0031	0.0209	-0.0065	-0.22%
PCP (%)	0.0174	0.0173	0.0299	0.99%
Bene. Per PPC	~	~	~	~
Mean Adjusted Valued Degree	-0.0001	0.0006	0	0.00%
Betweeness-Centrality Ratio	0.0128	0.0102	0.0131	0.43%

*p<.10; **p<.05; ***p<.01.

† The marginal effect is the change in Low-Value Service (#1) per beneficiary per year for a 1 unit change in the variable, when the variable is continuous, or for a change from the reference category to the category listed, when the variable is categorical.

‡ This is the change in Low-Value Service (#1) usage per 100 beneficiaries for a 1 SD change in continuous variables, or for a change from the reference category to the category listed for categorical variables. Continuous variables are multiplied by the SD and expressed on a per 100 beneficiaries basis.

¥The mean LVS(#3) per 100 beneficiaries per year amongst the total "at-risk" population is 3.018

"Race" reference group is White

"Foreign Trained" reference group is "U.S. Trained"

"Doctor of Osteo." reference group is MD

DISCUSSION

In agreement with prior research on physician practice communities (referred to as physician networks in this paper), we found that networks have an association with the cost of healthcare—in this case specifically we found that networks vary significantly in their usage of low-value cancer screening services when adjusting for patient and physician characteristics. Amongst a total study population of 987,000 Medicare beneficiaries, we identified three populations of beneficiaries who were at-risk for receiving at least one of three low-value cancer screening services (as defined by the literature) and were assigned to a physician network as defined by Casalino, et al.. Our findings strongly suggest that there is an association between a physician network's physician composition in predicting its' usage of low-value cancer screening services. The percentage of physicians practicing in a network with an MD, and those who were trained in the United States was significantly related to a reduced usage from the population mean of two of the three low-value cancer screening services we studied (Prostate-Specific Antigen testing, and Cervical Cancer Screening amongst at-risk populations). We also conclude that certain measures of physician networks, such as the closeness of physicians (patient sharing frequency) and the centrality of the average physician in a network (how many physicians the average physician refers patients to) may be a key to understanding the patterns of low-value care across networks.

The field of social network theory suggests that social networks may underpin certain physician practice patterns, resulting in differences in the cost and quality of care even if we control for individual patient and physician characteristics. Although our findings lend credence to this theory, we cannot claim that there is a causal relationship between the composition and characteristics of a physician network with the delivery of low-value services without further research. Furthermore, our data are derived from 2008 Medicare claims, so the patterns discovered in this research may not be representative of today's healthcare market practice patterns which have notably progressed in response to pay-for-performance initiatives and alternative payment models introduced by both commercial and public payers. We recommend further study of low-value service patterns of delivery, as the results may arm payers, physician practices, and policymakers with important information which results in precisely targeted policy initiatives which reduce wasteful spending on low-value services.

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