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ORIGINAL REPORT

Association Between Geographic Access to Cancer Care, Insurance, and Receipt of Chemotherapy: Geographic Distribution of Oncologists and Travel Distance

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A B S T R A C T

Purpose

Geographic access to care may be associated with receipt of chemotherapy but has not been fully examined. This study sought to evaluate the association between density of oncologists and travel distance and receipt of adjuvant chemotherapy for colon cancer within 90 days of colectomy.

Patients and Methods

Patients in the National Cancer Data Base with stage III colon cancer, diagnosed between 2007 and 2010, and age 18 to 80 years were selected. Generalized estimating equation clustering by hospital service area was conducted to examine the association between geographic access and receipt of oncology services, controlling for patient sociodemographic and clinical characteristics.

Results

Of 34,694 patients in the study cohort, 75.7% received adjuvant chemotherapy within 90 days of colectomy. Compared with travel distance less than 12.5 miles, patients who traveled 50 to 249 miles (odds ratio [OR], 0.87; $P = .009$) or ≥ 250 miles (OR, 0.36; $P < .001$) had decreased likelihood of receiving adjuvant chemotherapy. Density level of oncologists was not statistically associated with receipt of adjuvant chemotherapy (low *v* high density: OR, 0.98; $P = .77$). When stratifying analyses by insurance status, non–privately insured patients who resided in areas with low density of oncologists were less likely to receive adjuvant chemotherapy (OR, 0.85; $P = .03$).

Conclusion

Increased travel burden was associated with a decreased likelihood of receiving adjuvant chemotherapy, regardless of insurance status. Patients with nonprivate insurance who resided in low-density oncologist areas were less likely to receive adjuvant chemotherapy. If these findings are validated prospectively, interventions to decrease geographic barriers may improve the timeliness and quality of colon cancer treatment.

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This study used the National Cancer Data Base (NCDB). The interpretation and reporting of these data are the sole responsibility of the authors. The data used in the study are derived from the limited data set of the NCDB file. The American College of Surgeons and the Commission on Cancer have not verified and are not responsible for the analytic or statistical methodology employed, or the conclusions drawn from these data by the authors.

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INTRODUCTION

Evidence-based guidelines[1-5] recommend the use of adjuvant chemotherapy in patients with stage III colon cancer within 90 days of colectomy to improve disease-free and overall survival; however, a substantial proportion of patients in the United State do not receive this treatment. Factors associated with not receiving chemotherapy after colectomy include nonwhite race,[6,7] older age,[6] low socioeconomic status (eg, low income[6,7] or lack of insurance[7-9]), comorbidity,[10] and surgical complications.[6,11] Geographic access to care is another factor that may also be associated with receipt of chemotherapy. Geographic access to care refers to the availability of oncologists in close proximity and/or travel burden (eg, travel distance, travel time). Studies have indicated that travel burden is associated with a reduction of preventive care services, delay in emergency treatment, and worse health outcomes.[12-17] Less is known, however, about the relationship between geographic access and quality of cancer care.

With regard to cancer diagnosis, greater availability of physicians seems to be associated with earlier stage of diagnosis and better survival outcomes.[18-21] Studies demonstrate that oncologists are unevenly distributed across the country with low or no representation in rural areas.[16,22,23] A previous study using the Surveillance, Epidemiology, and

Ends Results–Medicare data set found that patients older than age 65 years with stage III colon cancer who reside in areas with oncologists have a greater likelihood of receiving adjuvant chemotherapy compared with those in areas with no oncologists.[10] We sought to evaluate the relationship between geographic access to oncology care and receipt of adjuvant chemotherapy among patients with stage III colon cancer. We evaluate the association between density of oncologists and travel distance and cancer treatment, in particular, receipt of adjuvant colon cancer chemotherapy.

PATIENTS AND METHODS

Data Source

The primary data source for this study was the National Cancer Data Base (NCDB), which is a hospital-based cancer registry that is jointly sponsored by the American College of Surgeons and the American Cancer Society. Data are collected from more than 1,500 Commission on Cancer (CoC) – accredited facilities and capture approximately 70% of newly diagnosed cancer cases in the United States.[24] Patient demographic and clinical characteristics captured in the NCDB are comparable to those reported in the Surveillance, Epidemiology, and Ends Results population-based cancer registry.[25]

To identify number and location of oncologists, the Physician Compare data, created by the Centers for Medicare and Medicaid Services,[26] were used. These data provide the physicians and other health care professionals who have filed Medicare claims in the previous 12 months and identify physicians by National Provider Identifier, specialty designation, and multiple practice locations. Physician Compare data were selected because the majority of cancers occur in people older than age 65 years, so virtually all oncologists treat Medicare patients.[23] In addition, the data are updated monthly for providers who have practiced and billed to Medicare in the previous 12 months.

Study Population

Patients with first primary invasive American Joint Committee on Cancer stage III node-positive colon cancer (International Classification of Disease for Oncology, Third Edition, site codes: C18.0 to C18.9), diagnosed between 2007 and 2010, who were age 18 to 80 years at diagnosis, who underwent colectomy within 3 months of diagnosis, and who were diagnosed and/or treated at CoC-accredited facilities were selected as the study cohort. Patients with unknown chemotherapy data, or unknown chemotherapy administration date, or missing residence information were excluded. In addition, patients who survived less than 6 months after diagnosis were excluded to limit bias.

Outcomes and Covariates

The primary outcome of the study is receipt of adjuvant chemotherapy within 90 days of colectomy. Receipt of colectomy was identified from surgical procedure field in the NCDB (site-specific surgery codes: 30 to 80), including partial and total colectomy. Initiation of chemotherapy was defined from chemotherapy treatment field in the NCDB, including administration of single- or multiple-agent chemotherapy. Time to initiation of chemotherapy was calculated from the date of colectomy to the chemotherapy start date.

Geographic access to cancer care was defined as the density level of oncologists in a patient's area of residence and travel distance to cancer treatment. Through the Physician Compare data, oncologists were identified if their primary or secondary specialty was medical oncology, hematology/oncology, or hematology. Although Physician Compare data identify all locations from which a physician files Medicare claims, nearly one fourth (22%) of oncologists have submitted claims from multiple office locations. Each oncologist was counted only once per hospital service area (HSA). HSAs, defined by the Dartmouth Atlas of Health Care,[27] are geographic areas covering one or more zip codes where medical resources are distributed and used based on the analysis of travel patterns for routine hospital care. The density of oncologists was calculated by the number of unique oncologists available per 100,000 residents in each HSA to determine the ratio of oncologists to the population. A high density level of oncologists was defined as higher than the 95th percentile. The 95th percentile was selected because sensitivity analyses at multiple other cut points did not yield treatment variation. Each patient was assigned oncologist density according to the HSA in which the patient resided.

Travel distance to cancer treatment was defined as the driving distance between the geographic centroid of zip codes of the patient residence at diagnosis and the reporting facility by Google Maps and was categorized, based on literature,[16,28,29] as 0 to 12.49, 12.5 to 49.9, 50 to 249, and $\geq$ 250 miles. For patients who lived outside the U.S. continental 48 states but traveled back to seek cancer treatment, travel distance was calculated using the crow-fly method instead of driving distance. The majority of patients (90%) had surgical treatment in the facility that reported their diagnosis.

Other variables of interest included patient demographics, comorbidity, socioeconomic status, insurance status, facility type, and clinical characteristics (number of positive lymph nodes, tumor grade, and surgical margin). Patient insurance status was defined as private, uninsured, Medicaid, Medicare (age 18 to 64 years), and Medicare (age $\geq$ 65 years). Medicare (age $\geq$ 65 years) was further divided into Medicare with supplemental policy, Medicare without supplemental policy, Medicare Advantage, and Medicare-Medicaid. Race/ethnicity was categorized as non-Hispanic white, black, Hispanic, other, and missing. Comorbidity was measured using the Charlson-Deyo[30-34] comorbidity score, categorized as 0, 1, or $\geq$ 2. Facility type was assigned by CoC accreditation program as community cancer program, comprehensive community cancer program, teaching/research center, National Cancer Institute–designated program/network, and other. Median income level in the neighborhood of a patient's residence was derived from 2000 U.S. Census data (to match the study cohort diagnosed from 2007 to 2010) and categorized based on national quartiles by zip code level.

Statistical Analyses

Geographic distribution of oncologists nationwide was determined using ArcGIS software (version 10.2.2; esri, Redlands, CA). Descriptive analyses were performed to summarize patient characteristics. χ^2 tests were used to determine significance of differences in receipt of oncology services by density level of oncologists and by travel distance at $P = .05$ levels. Generalized estimating equations clustering by HSA was conducted to examine the association between geographic access and receipt of oncology services, controlling for patient sociodemographic and clinical characteristics. Two-sided P values were reported and were considered significant at $P = .05$.

We investigated the relationship between geographic access and receipt of chemotherapy by insurance status. Insurance status was collapsed into patients with private insurance and without private insurance (including uninsured, Medicaid, and Medicare). A sensitivity analysis was conducted including only Medicaid and Medicare in the nonprivate subset and another sensitivity analysis was conducted grouping Medicare with supplemental policy in the private subset to examine the relationship. In addition, to test whether the relationship between density level of oncologists and receipt of adjuvant chemotherapy is not affected by choice of clustering unit, sensitivity analyses were performed using Health Service Area as an alternative clustering unit. Health Service Areas are defined by the National Center for Health Statistics to include a single county or cluster of contiguous counties that are self-contained with respect to hospital care. All statistical analyses were performed using SAS 9.3 (SAS Institute, Cary, NC).

RESULTS

Geographic Distribution of Oncologists Nationwide

In total, 12,198 unique oncologists were identified through the Physician Compare data. The map in Figure 1 shows the geographic distribution of oncologists in quartiles at HSA level. Of 3,436 HSAs in the United States, 1,469 HSAs (42.75%) have at least one oncologist. The average density is 3.32 oncologists (interquartile range, 3.74 oncologists) per 100,000 residents. The 95th percentile of density is 12.65

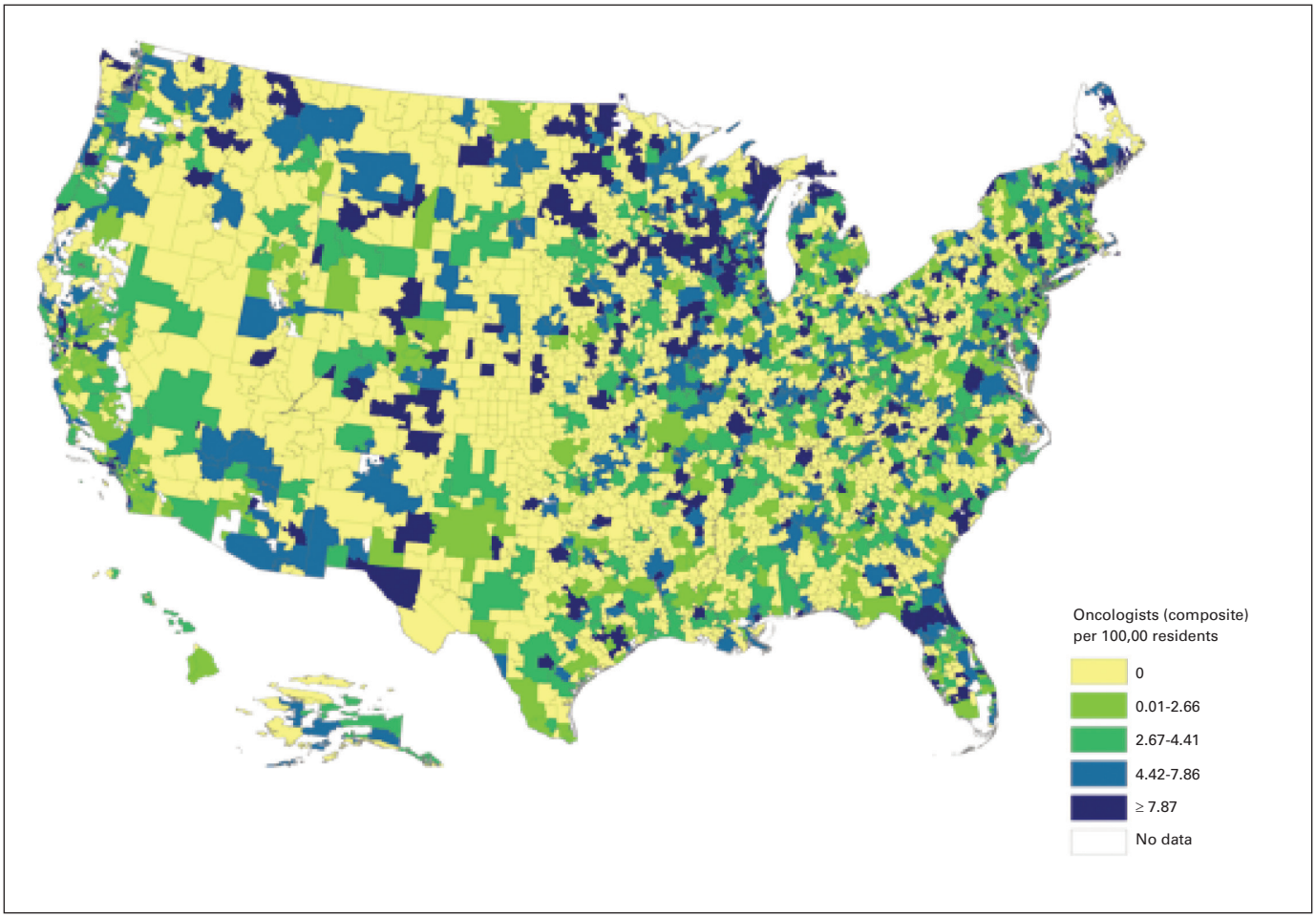

Fig 1. Oncologists per 100,000 residents by hospital service area.

oncologists per 100,000 residents. The HSAs with no oncologist were more likely to have a smaller population (average 32,000 residents) and be in the Midwest or South regions.

To understand whether the Physician Compare file is a reliable data source to identify oncologists, sensitivity analyses were conducted using deidentified American Society of Clinical Oncology (ASCO) membership data aggregated by zip code to identify oncologists and measure the density level of oncologists in each HSA. Overall, geographic distribution of ASCO-member oncologists was similar to that based on the Physician Compare data. However, the Physician Compare data captured higher numbers of oncologists in a majority of the HSAs.

Patient Characteristics

Of 34,694 patients with stage III node-positive colon cancer selected in the study, 75.7% of patients received adjuvant chemotherapy within 90 days of colectomy (Table 1). Median age was 63 years. Most patients were non-Hispanic white (68.6%) and had private insurance (44.9%) or Medicare (42.9%), a comorbidity score of 0 (70.0%), and less than four positive lymph nodes (63.2%). Overall, 44.9% of patients had private insurance; however, among patients younger than age 65 years, 71.9% had private insurance. Approximately half of the patients were diagnosed or treated at a comprehensive community cancer center and traveled less than 12.5 miles to the reporting facility for their cancer diagnosis and/or treatment, whereas 10.2% of patients traveled more than 50 miles. Approximately 7.2% of patients resided in areas with a high density level of oncologists. The proportion of patients receiving adjuvant chemotherapy was not significantly different between areas with different density levels of oncologists but was much lower among patients who traveled ≥ 250 miles to their reporting facility (0 to 12.5 miles *v* ≥ 250 miles: 75.3% *v* 59.4%, respectively; $P < .001$). Patients residing in low-density HSAs traveled a greater distance for medical services. One tenth of patients who resided in a low-density HSA traveled more than 50 miles for their medical services, whereas only 6% of patients residing in a high-density HSA traveled more than 50 miles ($P < .001$).

Factors Associated With Receipt of Adjuvant Chemotherapy

The adjusted associations between geographic access and receipt of adjuvant chemotherapy are listed in Table 2. Compared with travel distance less than 12.5 miles, patients who traveled 50 to 249 miles to the reporting facility had a lower likelihood of receipt of adjuvant chemotherapy (odds ratio [OR], 0.87; $P = .009$), as did patients who traveled more than 250 miles (OR, 0.36; $P < .001$). However, the

Table 1. Characteristics of Patients With Stage III Colon Cancer

Characteristic	No. of Patients (N = 34,694) (%)*
Receipt of adjuvant chemotherapy	
No	8,422 (24.3)
Yes	26,272 (75.7)
Age at diagnosis, years	
18-50	6,018 (17.4)
51-64	12,441 (35.9)
65-70	6,324 (18.2)
71-75	5,104 (14.7)
76-80	4,807 (13.9)
Race/ethnicity	
Non-Hispanic white	23,815 (68.6)
Hispanic	1,954 (5.6)
Black	5,053 (14.6)
Other	1,424 (4.1)
Unknown	2,448 (7.1)
Sex	
Male	17,488 (50.4)
Female	17,206 (49.6)
Insurance	
Uninsured	1,709 (4.9)
Medicaid	1,963 (5.7)
Medicare (age 18-64 years)	1,566 (4.5)
Medicare with supplement	8,140 (23.5)
Medicare without supplement	2,627 (7.6)
Medicare Advantage	1,600 (4.6)
Medicare/Medicaid	979 (2.8)
Private	15,578 (44.9)
Missing	532 (1.5)
Diagnosis year	
2007	8,826 (25.4)
2008	8,911 (25.7)
2009	8,486 (24.5)
2010	8,471 (24.4)
Median income level	
< $30,000	5,178 (14.9)
$30,000-$34,999	6,572 (18.9)
$35,000-$45,999	9,710 (28.0)
≥ $46,000	12,750 (36.8)
Missing	484 (1.4)
Facility type	
Community cancer program†	5,184 (14.9)
Comprehensive community cancer program‡	17,296 (49.9)
Teaching/research center§	6,676 (19.2)
NCI program/network‖	2,023 (5.8)
Other¶	3,515 (10.1)
Charlson-Deyo comorbidity score#	
0	24,288 (70.0)
1	7,285 (21.0)
2+	3,121 (9.0)
Travel distance, miles	
0-12.49	18,563 (53.5)
12.5-49.9	12,748 (36.7)
50-249	3,026 (8.7)
≥ 250	357 (1.0)
Density level of medical oncologist	
High	2,479 (7.2)
Low	32,215 (92.9)
No. of positive lymph nodes	
< 4	21,913 (63.2)
≥ 4	12,641 (36.4)
Unknown	140 (0.4)
Tumor grade	
Well differentiated	2,135 (6.2)
Moderately differentiated	22,996 (66.3)
Poorly differentiated	7,933 (22.9)
Undifferentiated	804 (2.3)
Unknown	826 (2.4)
Surgical margin	
Negative	31,502 (90.8)
Positive	2,708 (7.8)
Unknown	484 (1.4)

(continued in next column)

Table 1. Characteristics of Patients With Stage III Colon Cancer (continued)

Abbreviation: NCI, National Cancer Institute.

*Because of rounding, percentages presented throughout this table may not add up to precisely 100%.

†Facilities report 101 to 499 patients with newly diagnosed cancer each year. A full range of diagnostic and treatment services is provided, but referral for a portion of diagnosis or treatment may occur.

‡Facilities report ≥ 500 patients with newly diagnosed cancer each year. A full range of diagnostic and treatment services is provided either on site or by referral.

§Facilities report ≥ 500 patients with newly diagnosed cancer each year and provide postgraduate medical education in at least four program areas. A full range of diagnostic and treatment services is provided either on site or by referral.

‖Facilities are designated a comprehensive cancer center by the NCI, with an NCI peer-reviewed cancer center support grant. A full range of diagnostic and treatment services is provided. No minimum caseload is required.

¶Facilities that are accredited as Integrated Network Cancer Program, Hospital Associate Cancer Program, or Free-Standing Cancer Center Program. Integrated Network Cancer Program is for facilities that are owned or operated by multiple facilities providing integrated cancer care. Hospital Associate Cancer Program is for facilities that report ≤ 100 patients with newly diagnosed cancer each year with limited range of diagnostic and treatment services. Free-Standing Cancer Center Program is for non–hospital-based facilities that offer at least one cancer-related treatment.

#Charlson-Deyo comorbidity score is a weighted score evaluating severe comorbidities that increase the risk of 1-year mortality. Fifteen noncancer comorbid conditions were identified and weighted to calculate Charlson-Deyo comorbidity scores.

density level of oncologists was not significantly associated with receipt of adjuvant chemotherapy (low density *v* high density: OR, 0.98; $P = .77$). Patients who were older than 50 years; were African American; were uninsured or insured by Medicaid, Medicare (age 18 to 64 years), Medicare without supplemental policy, or Medicare-Medicaid; and had one or more comorbidities were less likely to receive adjuvant chemotherapy.

Clinical factors that were associated with receipt of chemotherapy included ≥ four positive lymph nodes (OR, 1.21; $P < .001$) and high tumor grade (OR, 1.32; $P = .01$). In addition, female patients (OR, 1.08; $P = .007$) and patients treated in National Cancer Institute–designated facilities (OR, 1.32; $P < .001$) had increased likelihood of receiving adjuvant chemotherapy.

Factors Associated With Receipt of Adjuvant Chemotherapy by Insurance Status

Table 3 lists results of the analysis stratified by insurance status (private *v* without private insurance). Among privately insured patients, there was no significant association between oncologist density and receipt of adjuvant chemotherapy, but travel distance was linearly

Table 2. Likelihood of Receipt of Adjuvant Chemotherapy Among Patients With Stage III Colon Cancer

Factor	OR (95% CI)	*P*
Travel distance, miles		
0-12.49	1	
12.5-49.9	0.99 (0.92 to 1.06)	.73
50-249	0.87 (0.78 to 0.96)	.009
≥ 250	0.36 (0.28 to 0.45)	< .001
Density level of MO		
High	1	
Low	0.98 (0.84 to 1.14)	.77
Age at diagnosis, years		
18-50	1	
51-64	0.75 (0.69 to 0.82)	< .001
65-70	0.50 (0.44 to 0.56)	< .001
71-75	0.35 (0.31 to 0.39)	< .001
76-80	0.20 (0.17 to 0.22)	< .001
Race/ethnicity		
Non-Hispanic white	1	
Hispanic	0.94 (0.84 to 1.06)	.32
Black	0.79 (0.73 to 0.85)	< .001
Other	0.96 (0.84 to 1.11)	.62
Unknown	1.10 (0.99 to 1.23)	.07
Sex		
Male	1	
Female	1.08 (1.02 to 1.14)	.007
Insurance		
Private	1	
Uninsured	0.46 (0.41 to 0.52)	< .001
Medicaid	0.50 (0.44 to 0.57)	< .001
Medicare (age 18-64 years)	0.45 (0.40 to 0.51)	< .001
Medicare with supplement	1.10 (1.00 to 1.22)	.05
Medicare without supplement	0.76 (0.67 to 0.86)	< .001
Medicare Advantage	0.98 (0.84 to 1.13)	.75
Medicare/Medicaid	0.53 (0.45 to 0.63)	< .001
Missing	0.52 (0.39 to 0.69)	< .001
Diagnosis year		
2007	1	
2008	1.03 (0.96 to 1.12)	.39
2009	0.99 (0.92 to 1.08)	.90
2010	1.00 (0.92 to 1.08)	.92
Median income level		
< $30,000	1	
$30,000-$34,999	0.99 (0.91 to 1.09)	.91
$35,000-$45,999	1.05 (0.96 to 1.15)	.29
≥ $46,000	1.08 (0.99 to 1.19)	.10
Missing	0.97 (0.77 to 1.23)	.81
Facility type		
Community cancer program	0.96 (0.87 to 1.05)	.36
Comprehensive community cancer program	1	
Teaching/research center	0.92 (0.85 to 1.01)	.08
NCI program/network	1.32 (1.15 to 1.51)	< .001
Other	0.98 (0.88 to 1.09)	.73
Charlson-Deyo comorbidity score		
0	1	
1	0.88 (0.82 to 0.94)	< .001
≥ 2	0.59 (0.55 to 0.65)	< .001
No. of positive lymph nodes		
< 4	1	
≥ 4	1.21 (1.15 to 1.28)	< .001
Unknown	1.09 (0.70 to 1.68)	.70
Tumor grade		
Well differentiated	1	
Moderately differentiated	1.15 (1.03 to 1.27)	.009
Poorly differentiated	1.19 (1.06 to 1.34)	.003
Undifferentiated	1.32 (1.06 to 1.63)	.01
Unknown	0.94 (0.77 to 1.13)	.50
Surgical margin		
Negative	1	
Positive	0.90 (0.82 to 1.00)	.05
Unknown	1.25 (0.96 to 1.64)	.10
Region		
Northeast	1	
Midwest	1.28 (1.16 to 1.42)	< .001
South	1.03 (0.93 to 1.13)	.58
West	0.74 (0.66 to 0.83)	< .001

Abbreviations: MO, medical oncologist; NCI, National Cancer Institute; OR, odds ratio.

and negatively associated with the likelihood of receiving adjuvant chemotherapy. Among patients without private insurance, traveling ≥ 250 miles significantly reduced the likelihood of receipt of adjuvant chemotherapy (OR, 0.43; $P < .001$). Also in this subset of patients, those who resided in areas with a low density of oncologists were less likely to receive adjuvant chemotherapy within 90 days of colectomy (OR, 0.85; $P = .03$), compared with patients who lived in areas of high oncologist density.

The following three sensitivity analyses were conducted: separating uninsured patients from patients without private insurance; including Medicare with supplemental policy in the private subset; and replacing HSA with Health Service Area as the clustering unit to aggregate number of oncologists. In those sensitivity analyses, the results were similar to those from primary analyses (data not shown).

DISCUSSION

Using the NCDB, we found an association between distance to the initial treatment center and receipt of adjuvant colon cancer chemotherapy, but we did not observe an association between oncologist density and receipt of adjuvant treatment. However, in a subset analysis of patients without private insurance, patients who lived in areas with low oncologist density were less likely to receive adjuvant chemotherapy.

The majority of patients in this cohort received adjuvant chemotherapy within 90 days of colectomy.[1-5] The CoC requires that accredited facilities report concordance with this metric as a quality standard. We found that patients traveling more than 50 miles to their reporting facility were less likely to receive chemotherapy treatment compared with those traveling shorter distance.

We observed substantial variation in the density of oncologists across the country, which is consistent with the literature.[16,22,23] Onega et al[16] used the American Medical Association Masterfile to identify oncologists and their practice location. They reported that density of oncologists varied regionally and that density was greater in urban or suburban areas compared with rural areas.[22] In the attempt to improve the accuracy of this relationship, Kirkwood et al[23] examined the Masterfile database, American Board of Internal Medicine

Table 3. Likelihood of Receipt of Adjuvant Chemotherapy Among Patients With Stage III Colon Cancer by Insurance Status

Factor	Privately Insured		Without Private Insurance	
	OR (95% CI)	*P*	OR (95% CI)	*P*
Travel distance, miles				
0-12.49	1		1	
12.5-49.9	0.93 (0.84 to 1.03)	.18	1.01 (0.94 to 1.09)	.77
50-249	0.68 (0.57 to 0.82)	< .001	0.97 (0.86 to 1.10)	.61
≥ 250	0.26 (0.18 to 0.36)	< .001	0.43 (0.30 to 0.61)	< .001
Density level of MO				
High	1		1	
Low	1.26 (0.97 to 1.63)	.09	0.85 (0.73 to 0.98)	.03
Age at diagnosis, years				
18-50	1		1	
51-64	0.73 (0.66 to 0.81)	< .001	0.77 (0.67 to 0.90)	< .001
65-70	0.49 (0.41 to 0.58)	< .001	0.65 (0.50 to 0.84)	.001
71-75	0.30 (0.25 to 0.37)	< .001	0.46 (0.36 to 0.61)	< .001
76-80	0.16 (0.13 to 0.20)	< .001	0.26 (0.20 to 0.35)	< .001
Race/ethnicity				
Non-Hispanic white	1		1	
Hispanic	0.81 (0.66 to 1.00)	.04	0.95 (0.83 to 1.10)	.51
Black	0.77 (0.67 to 0.87)	< .001	0.81 (0.74 to 0.90)	< .001
Other	0.78 (0.62 to 0.97)	.02	1.07 (0.90 to 1.29)	.44
Unknown	1.13 (0.93 to 1.37)	.20	1.10 (0.96 to 1.25)	.16
Sex				
Male	1		1	
Female	1.12 (1.02 to 1.24)	.03	1.05 (0.99 to 1.12)	.13
Insurance				
Uninsured			0.51 (0.40 to 0.66)	< .001
Medicaid			0.55 (0.42 to 0.70)	< .001
Medicare (age 18-64 years)			0.52 (0.40 to 0.68)	< .001
Medicare with supplement			1	
Medicare without supplement			0.68 (0.61 to 0.75)	< .001
Medicare Advantage			0.88 (0.77 to 1.00)	.05
Medicare/Medicaid			0.47 (0.41 to 0.55)	< .001
Diagnosis year				
2007	1		1	
2008	1.05 (0.92 to 1.20)	.44	1.01 (0.92 to 1.11)	.82
2009	0.94 (0.82 to 1.08)	.39	1.02 (0.93 to 1.12)	.65
2010	0.95 (0.83 to 1.08)	.44	1.03 (0.93 to 1.13)	.59
Median income level				
< $30,000	1		1	
$30,000-$34,999	1.08 (0.91 to 1.28)	.38	0.96 (0.86 to 1.08)	.52
$35,000-$45,999	1.05 (0.90 to 1.24)	.53	1.05 (0.94 to 1.17)	.37
≥ $46,000	1.14 (0.96 to 1.35)	.13	1.04 (0.92 to 1.16)	.55
Missing	0.94 (0.65 to 1.37)	.76	1.00 (0.73 to 1.38)	.98
Facility type				
Community cancer program	1.01 (0.86 to 1.17)	.95	0.95 (0.86 to 1.06)	.36
Comprehensive community cancer program	1		1	
Teaching/research center	0.90 (0.78 to 1.03)	.13	0.93 (0.84 to 1.03)	.17
NCI program/network	1.53 (1.23 to 1.90)	< .001	1.05 (0.89 to 1.22)	.58
Other	1.18 (0.96 to 1.46)	.12	0.90 (0.80 to 1.01)	.08
Charlson-Deyo comorbidity score				
0	1		1	
1	0.88 (0.78 to 0.99)	.04	0.88 (0.81 to 0.95)	< .001
≥ 2	0.67 (0.56 to 0.81)	< .001	0.58 (0.52 to 0.64)	< .001
No. of positive lymph nodes				
< 4	1		1	
≥ 4	1.10 (1.00 to 1.21)	.04	1.28 (1.19 to 1.38)	< .001
Unknown	0.61 (0.34 to 1.09)	.10	1.63 (0.93 to 2.85)	.08

(continued on following page)

Table 3. Likelihood of Receipt of Adjuvant Chemotherapy Among Patients With Stage III Colon Cancer by Insurance Status (continued)

Factor	Privately Insured		Without Private Insurance	
	OR (95% CI)	*P*	OR (95% CI)	*P*
Tumor grade				
Well differentiated	1		1	
Moderately differentiated	1.12 (0.93 to 1.34)	.24	1.18 (1.03 to 1.34)	.01
Poorly differentiated	1.14 (0.94 to 1.39)	.19	1.25 (1.09 to 1.44)	.002
Undifferentiated	1.29 (0.91 to 1.82)	.15	1.36 (1.03 to 1.79)	.03
Unknown	0.68 (0.51 to 0.93)	.01	1.24 (0.96 to 1.59)	.09
Surgical margin				
Negative	1		1	
Positive	0.91 (0.77 to 1.08)	.29	0.90 (0.80 to 1.02)	.11
Unknown	1.20 (0.79 to 1.81)	.40	0.81 (0.60 to 1.09)	.16
Region				
Northeast	1		1	
Midwest	1.36 (1.15 to 1.61)	< .001	1.25 (1.12 to 1.40)	< .001
South	1.01 (0.86 to 1.19)	.89	1.01 (0.91 to 1.12)	.88
West	0.76 (0.63 to 0.92)	.005	0.74 (0.64 to 0.84)	< .001

Abbreviations: MO, medical oncologist; NCI, National Cancer Institute; OR, odds ratio.

certification reports, the National Provider Identifier database, and Physician Compare data. In this analysis, the distribution of oncologists was skewed toward urban areas, whereas some rural areas had no oncologist at all.[23] In our study, we used Physician Compare data to identify oncologists and validated its accuracy through a comparison with ASCO membership data. Consistently, a substantial proportion of the population resides in areas without oncologists. Oncologists were more likely to cluster in areas with greater population density. Patients who reside in low-density HSAs might need to wait longer or travel farther to be seen by oncologists.

We found that patients without private insurance were more likely to receive chemotherapy closer to their area of residence compared with privately insured patients. This may be a result of a lack of resources available to travel a longer distance for cancer care. Therefore, accessibility to local oncologists has much more impact among patients without private insurance. Expanded coverage alone might not fully address the barriers to receive guideline-recommended treatment because patients who traveled ≥ 50 miles to medical services were less likely to receive adjuvant chemotherapy than those who traveled shorter distance. Rural states and regions extend care through visiting consulting clinics, as have been used in Iowa to improve access.[35] Additional research should examine how to extend care to areas that require long travel distances.

Despite whether cancer care is outpatient or inpatient, previous studies found that transportation and distance to medical care are factors in forgoing needed treatment, especially among underinsured minorities.[36,37] Depending on the regimen oncologists prescribe, adjuvant chemotherapy may involve visits every other week for 24 weeks.[38-40] Alternative approaches, such as telemedicine for cancer care consultations, have been developed, but the extent of their use in treatment delivery and impact on outcomes is uncertain. Volunteer-based transportation assistance (eg, the American Cancer Society Road to Recovery program) is another alternative to provide transportation. Also, enhancing patient navigators in facilities can help improve coordination of cancer services.[41]

We found that travel burden, as opposed to oncologist density, is a potentially modifiable factor that decreases utilization of adjuvant chemotherapy in patients with stage III colon cancer. Studies have reported that many rural patients travel great distances to receive their cancer care, even if providers are nearby.[15] It is possible that patients bypass local providers because of concerns about the quality of care[42] or experience level of providers[43] or because they need to see providers who have coverage in an insurance network. Although the oncologists we identified through Physician Compare data were actively engaged in clinical care, we have no information of their capability to accept new patients or accommodate patient demand.

Our study has several limitations inherent to observational registry studies. First, the NCDB is a hospital-based cancer registry that captures only patients who are diagnosed or treated in CoC-accredited facilities. Even though the NCDB captures approximately 70% of incident cancers each year, our results may not be fully generalizable. Second, the NCDB does not indicate location of chemotherapy treatment, if it is delivered outside of the COC facility; however, the majority of oncologists (approximately 90%) saw their patients at the same hospital where they had surgery.[6] Third, the Physician Compare data exclude oncologists who have not billed Medicare in the previous 12 months and do not provide information on the primary office location. However, we have previously shown that Physician Compare data provide better representation of the total number of oncologists than other databases.[23] Fourth, social support could also be associated with adherence to treatment guidelines; however, NCDB does not collect information on social support (eg, caregiver, spouse, or number of people in the household). Fifth, travel distance might be underestimated. However, further detail on location of patients or facilities is not available because of Health Insurance Portability and Accountability Act regulations for privacy. Sixth, the majority of patients in our study did not have severe comorbidities. Even though this is consistent with the literature,[44,45] our results may not be generalizable to patients with more severe comorbid conditions. Finally, this study does not include information on physician or patient preferences that might influence decisions regarding whether and where to initiate chemotherapy.

In summary, this study observed that increased travel burden was associated with a decreased likelihood of receiving adjuvant chemotherapy for patients with stage III colon cancer, regardless of insurance status. We also found that patients who were not privately

insured and resided in areas with a low density of oncologists were less likely to receive adjuvant chemotherapy. More in-depth analysis to focus on low-density areas would help analyze how interventions to decrease geographic barriers may improve the access to colon cancer treatment. Understanding how insurance can be a barrier to quality cancer care is increasingly important because the number of people with Medicaid coverage has expanded under the Affordable Care Act.

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Disclosures provided by the authors are available with this article at www.jco.org.

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Association Between Geographic Access to Cancer Care, Insurance, and Receipt of Chemotherapy: Geographic Distribution of Oncologists and Travel Distance

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Appendix

Table A1. Characteristics of Patients With Stage III Colon Cancer by Density Level of Oncologists

Characteristic	No. of Patients (%)*		*P*
	Low Density Level of MO	High Density Level of MO	
Total	32,215 (92.9)	2,479 (7.2)	
Receipt of adjuvant chemotherapy			.44
No	7,836 (24.3)	586 (23.6)	
Yes	24,379 (75.7)	1,893 (76.4)	
Age at diagnosis, years			.35
18-50	5,597 (17.4)	421 (17.0)	
51-64	11,579 (35.9)	862 (34.8)	
65-70	5,850 (18.2)	474 (19.1)	
71-75	4,750 (14.7)	354 (14.3)	
76-80	4,439 (13.8)	368 (14.8)	
Race/ethnicity			< .001
Non-Hispanic white	22,311 (69.3)	1,504 (60.7)	
Hispanic	1,791 (5.6)	163 (6.6)	
Black	4,558 (14.2)	495 (20.0)	
Other	1,292 (4.0)	132 (5.3)	
Unknown	2,263 (7.0)	185 (7.5)	
Sex			.99
Male	16,238 (50.4)	1,250 (50.4)	
Female	15,977 (49.6)	1,229 (49.6)	
Insurance			.02
Uninsured	1,603 (5.0)	106 (4.3)	
Medicaid	1,800 (5.6)	163 (6.6)	
Medicare (age 18-64 years)	1,460 (4.5)	106 (4.3)	
Medicare with supplement	7,545 (23.4)	595 (24.0)	
Medicare without supplement	2,424 (7.5)	203 (8.2)	
Medicare Advantage	1,506 (4.7)	94 (3.8)	
Medicare/Medicaid	894 (2.8)	85 (3.4)	
Private	14,480 (45.0)	1,098 (44.3)	
Missing	503 (1.6)	29 (1.2)	
Diagnosis year			.13
2007	8,186 (25.4)	640 (25.8)	
2008	8,323 (25.8)	588 (23.8)	
2009	7,855 (24.4)	631 (25.5)	
2010	7,851 (24.4)	620 (25.0)	
Median income level			< .001
< $30,000	4,755 (14.8)	423 (17.1)	
$30,000-$34,999	6,227 (19.3)	345 (13.9)	
$35,000-$45,999	9,024 (28.0)	686 (27.7)	
≥ $46,000	11,743 (36.5)	1,007 (40.6)	
Missing	466 (1.5)	18 (0.7)	
Facility type			< .001
Community cancer program	4,890 (15.2)	294 (11.9)	
Comprehensive community cancer program	16,370 (50.8)	926 (37.4)	
Teaching/research center	6,084 (18.9)	592 (23.9)	
NCI program/network	1,647 (5.1)	376 (15.2)	
Other	3,224 (10.0)	291 (11.7)	

(continued on following page)

Table A1. Characteristics of Patients With Stage III Colon Cancer by Density Level of Oncologists (continued)

Characteristic	No. of Patients (%)*		*P*
	Low Density Level of MO	High Density Level of MO	
Charlson-Deyo comorbidity score			.54
0	22,568 (70.1)	1,720 (69.4)	
1	6,764 (21.0)	521 (21.0)	
≥ 2	2,883 (9.0)	238 (9.6)	
Travel distance, miles			< .001
0-12.49	16,880 (52.4)	1,683 (67.9)	
12.5-49.9	12,101 (37.6)	647 (26.1)	
50-249	2,904 (9.0)	122 (4.9)	
≥ 250	330 (1.0)	27 (1.1)	
No. of positive lymph nodes			.08
< 4	20,318 (63.1)	1,595 (64.3)	
≥ 4	11,761 (36.5)	880 (35.5)	
Unknown	136 (0.4)	4 (0.2)	
Tumor grade			< .001
Well differentiated	1,996 (6.2)	139 (5.6)	
Moderately differentiated	21,435 (66.5)	1,561 (63.0)	
Poorly differentiated	7,309 (22.7)	624 (25.2)	
Undifferentiated	715 (2.2)	89 (3.6)	
Unknown	760 (2.4)	66 (2.7)	
Surgical margin			.05
Negative	29,270 (90.9)	2,232 (90.0)	
Positive	2,488 (7.7)	220 (8.9)	
Unknown	457 (1.4)	27 (1.1)	

Abbreviations: MO, medical oncologist; NCI, National Cancer Institute.
*Because of rounding, percentages presented throughout this table may not add up to precisely 100%.

Table A2. Characteristics of Patients With Stage III Colon Cancer by Travel Distance

Characteristic	No. of Patients (%)*				*P*
	0-12.49 Miles	12.5-49.9 Miles	50-249 Miles	≥ 250 Miles	
Total	18,563 (53.5)	12,748 (36.7)	3,026 (8.7)	357 (1.0)	
Receipt of adjuvant chemotherapy					< .001
No	4,589 (24.7)	2,919 (22.9)	769 (25.4)	145 (40.6)	
Yes	13,974 (75.3)	9,829 (77.1)	2,257 (74.6)	210 (59.4)	
Age at diagnosis, years					< .001
18-50	3,125 (16.8)	2,316 (18.2)	512 (16.9)	65 (18.2)	
51-64	6,531 (35.2)	4,735 (37.1)	1,033 (34.1)	142 (39.8)	
65-70	3,255 (17.5)	2,398 (18.8)	612 (20.2)	59 (16.5)	
71-75	2,841 (15.3)	1,739 (13.6)	476 (15.7)	48 (13.5)	
76-80	2,811 (15.1)	1,560 (12.2)	393 (13.0)	43 (12.0)	
Race/ethnicity					< .001
Non-Hispanic white	11,968 (64.5)	9,254 (72.6)	2,330 (77.0)	263 (73.7)	
Hispanic	1,196 (6.4)	639 (5.0)	102 (3.4)	17 (4.8)	
Black	3,377 (18.2)	1,383 (10.9)	264 (8.7)	29 (8.1)	
Other	917 (4.9)	417 (3.3)	72 (2.4)	18 (5.0)	
Unknown	1,105 (6.0)	1,055 (8.3)	258 (8.5)	30 (8.4)	
Sex					< .001
Male	9,134 (49.2)	6,572 (51.6)	1,593 (52.6)	189 (52.9)	
Female	9,429 (50.8)	6,176 (48.5)	1,433 (47.4)	168 (47.1)	
Insurance					< .001
Uninsured	917 (4.9)	636 (5.0)	143 (4.7)	13 (3.6)	
Medicaid	1,216 (6.6)	590 (4.6)	150 (5.0)	7 (2.0)	
Medicare (age 18-64 years)	826 (4.5)	574 (4.5)	157 (5.2)	9 (2.5)	
Medicare with supplement	4,257 (22.9)	2,958 (23.2)	845 (27.9)	80 (22.4)	
Medicare without supplement	1,459 (7.9)	893 (7.0)	249 (8.2)	26 (7.3)	
Medicare Advantage	944 (5.1)	532 (4.2)	118 (3.9)	6 (1.7)	
Medicare/Medicaid	560 (3.0)	326 (2.6)	90 (3.0)	3 (0.8)	
Private	8,122 (43.8)	6,053 (47.5)	1,226 (40.5)	177 (49.6)	
Missing	262 (1.4)	186 (1.5)	48 (1.6)	36 (10.1)	
Diagnosis year					.300
2007	4,797 (25.8)	3,210 (25.2)	749 (24.8)	70 (19.6)	
2008	4,764 (25.7)	3,270 (25.7)	781 (25.8)	96 (26.9)	
2009	4,513 (24.3)	3,146 (24.7)	736 (24.3)	91 (25.5)	
2010	4,489 (24.2)	3,122 (24.5)	760 (25.1)	100 (28.0)	
Median income level					< .001
< $30,000	2,673 (14.4)	1,449 (11.4)	1,006 (33.3)	50 (14.0)	
$30,000-$34,999	3,037 (16.4)	2,391 (18.8)	1,053 (34.8)	91 (25.5)	
$35,000-$45,999	5,378 (29.0)	3,629 (28.5)	597 (19.7)	106 (29.7)	
≥ $46,000	7,216 (38.9)	5,105 (40.1)	330 (10.9)	99 (27.7)	
Missing	259 (1.4)	174 (1.4)	40 (1.3)	11 (3.1)	
Facility type					< .001
Community cancer program	3,132 (16.9)	1,806 (14.2)	212 (7.0)	34 (9.5)	
Comprehensive community cancer program	9,007 (48.5)	6,526 (51.2)	1,635 (54.0)	128 (35.9)	
Teaching/research center	3,690 (19.9)	2,337 (18.3)	596 (19.7)	53 (14.9)	
NCI program/network	664 (3.6)	826 (6.5)	412 (13.6)	121 (33.9)	
Other	2,070 (11.2)	1,253 (9.8)	171 (5.7)	21 (5.9)	
Charlson-Deyo comorbidity score					< .001
0	12,854 (69.3)	9,024 (70.8)	2,129 (70.4)	281 (78.7)	
1	3,941 (21.2)	2,654 (20.8)	633 (20.9)	57 (16.0)	
≥ 2	1,768 (9.5)	1,070 (8.4)	264 (8.7)	19 (5.3)	
Density level of MO					< .001
Low	16,880 (90.9)	12,101 (94.9)	2,904 (96.0)	330 (92.4)	
High	1,683 (9.1)	647 (5.1)	122 (4.0)	27 (7.6)	
No. of positive lymph nodes					.330
< 4	11,786 (63.5)	8,026 (63.0)	1,892 (62.5)	209 (58.5)	
≥ 4	6,708 (36.1)	4,663 (36.6)	1,124 (37.1)	146 (40.9)	
Unknown	69 (0.4)	59 (0.5)	10 (0.3)	2 (0.6)	

(continued on following page)

Table A2. Characteristics of Patients With Stage III Colon Cancer by Travel Distance (continued)

Characteristic	No. of Patients (%)*				*P*
	0-12.49 Miles	12.5-49.9 Miles	50-249 Miles	≥ 250 Miles	
Tumor grade					< .001
Well differentiated	1,171 (6.3)	783 (6.1)	169 (5.6)	12 (3.4)	
Moderately differentiated	12,268 (66.1)	8,536 (67.0)	1,991 (65.8)	201 (56.3)	
Poorly differentiated	4,296 (23.1)	2,807 (22.0)	707 (23.4)	123 (34.5)	
Undifferentiated	407 (2.2)	307 (2.4)	79 (2.6)	11 (3.1)	
Unknown	421 (2.3)	315 (2.5)	80 (2.6)	10 (2.8)	
Surgical margin					< .001
Negative	16,879 (90.9)	11,556 (90.7)	2,763 (91.3)	304 (85.2)	
Positive	1,498 (8.1)	996 (7.8)	195 (6.4)	19 (5.3)	
Unknown	186 (1.0)	196 (1.5)	68 (2.3)	34 (9.5)	

Abbreviations: MO, medical oncologist; NCI, National Cancer Institute.
*Because of rounding, percentages presented throughout this table may not add up to precisely 100%.