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The influence of local area physician supply on the dispersion of care among Medicare patients with a consistent diagnosis

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THE INFLUENCE OF LOCAL AREA PHYSICIAN SUPPLY ON THE DISPERSION OF CARE AMONG MEDICARE PATIENTS WITH A CONSISTENT DIAGNOSIS

by

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MASTER'S THESIS

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To My Beloved Family: Long-Chang, Man-Li, and Chia-Chi

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INTRODUCTION

With healthcare costs increasing faster than inflation in the United States (Chernew, Hirth, & Cutler, 2003), it is expected that fewer people will be able to afford healthcare in the future without changes to the healthcare system. It has been argued that much of the healthcare utilization presently observed is unnecessary, and that a large portion of this wasteful spending can be attributed to the characteristics of local area physician supply and specialty mix (Baicker & Chandra, 2004a; Fisher, Wennberg, Stukel, Gottlieb, Lucas, & Pinder, 2003a; Fisher, Wennberg, Stukel, Gottlieb, Lucas, & Pinder, 2003b; Wennberg, Bronner, Skinner, Fisher, & Goodman, 2009). These arguments are based on observed positive correlations between local area health utilization and the local area supply of physicians and physician specialists (Fisher, Wennberg, Stukel, Gottlieb, Lucas, & Pinder, 2003a; Leonard, Stordeur, & Roberfroid, 2009). Commentators have suggested that greater local area physician supply leads to the use of more physicians by patients, resulting in diffuse, uncoordinated, and wasteful care (Wennberg, Brownlee, Fisher, Skinner, & Weinstein, 2008; Wennberg et al., 2009). Calls have been made for modifying the physician training system in the United States based on these correlations (Fisher, Wennberg, Stukel, Gottlieb, Lucas, & Pinder, 2003a; Fisher, Wennberg, Stukel, Gottlieb, Lucas, & Pinder, 2003b; Wennberg et al., 2008). However, we have found no studies that demonstrated direct relationships between local area physician supply and the use of physicians by individual patients. Studies in physician-induced demand theory have examined the relationships between physician supply and healthcare utilization (Dranove & Wehner, 1994a; McGuire TG, 2000; Wilensky & Rossiter, 1983), and physician referral studies have only investigated the effects of local supply on referral rates, and not actual number of physicians used by patients (Basu & Clancy, 2001; Shea, Stuart, Vasey, & Nag, 1999; Shortell S., 1972). To fill this gap, we isolated a set of patients with a consistent diagnosis and course of treatment (stage III colorectal cancer Medicare patients receiving surgery and chemotherapy but not radiation therapy) and investigated whether local area physician supply leads to the use of more physicians by these patients and care more dispersed across physicians during their first treatment course.

BACKGROUND

The cost of healthcare is increasing faster than inflation and reducing the number of people who can afford healthcare. After the projected change in population demographics, the Office of the Actuary, Centers for Medicare and Medicaid Services (CMS) said that healthcare spending will reach $4.3 trillion by 2017 in the United States (Becker, 2008). Meanwhile, CMS predicted that healthcare spending will reach 38 percent of Gross domestic product (GDP) by 2075, compared to 16.3 percent of GDP in 2007 (Chernew et al., 2003; Keehan et al., 2008). The high cost of Medicare and the impending bankruptcy of its trust fund have necessitated the need for reform to guarantee its continuance. Finding a more effective healthcare system that reduces cost and maintains quality is urgent. Some have suggested that high health care costs may partially stem from the dispersion of the care of individual patients across several physicians and physician specialists resulting poorly coordinated and inefficient care (Welch, Miller, Welch, Fisher, & Wennberg, 1993).

Some studies show that health care is highly dispersed in fee-for-service (Pham, Schrag, O'Malley, Wu, & Bach, 2007). Medical care dispersion as a concept refers to the extent that patient care is spread across physicians (Pham, Schrag, O'Malley, Wu, & Bach, 2007; Brazil et al., 2009; Coleman & Berenson, 2004). Medical care dispersion can be both beneficial and harmful to patients. Some studies suggested increased care dispersion can improve patient health if specialty care is needed and care is coordinated and information is exchanged among physicians (Casalino, Devers, Lake, Reed, & Stoddard, 2003). However, with higher care dispersion patients, information may become fragmented across providers resulting in higher costs, risks of medical errors, and inefficient healthcare (Coleman & Berenson, 2004; Pham et al., 2007); Jee & Cabana, 2006; Roos, Roos, Gilbert, & Nicol, 1980; Starfield, Simborg, Johns, & Horn, 1977).

The suggestion that high health expenditures result from highly dispersed care across physicians is based on positive correlations between physician supply and healthcare expenditures across geographic areas. Wennberg and his colleagues have shown that patients living in areas with greater specialist supply might have greater healthcare costs but no better outcomes (Fisher, Wennberg, Stukel, Gottlieb, Lucas, & Pinder, 2003a; Fisher, Wennberg, Stukel, Gottlieb, Lucas, & Pinder, 2003b; Wennberg et al., 2008; Welch et al., 1993; Wennberg, Fisher, & Skinner, 2002). Based on this evidence, Wennberg and colleagues suggest curtailing the use of specialists and returning care to the primary care physician is the key to a more effective health care system. One recent proposal encouraged medical students to be primary care physicians instead of pursuing specialty education (Pear, 2009; Wennberg et al., 2008). Other policy suggestions to promote primary care include boosting primary care physicians by increasing their Relative Value Units (RVUs) from the Medicare system (The war on specialists.2009).

It is believed that those strategies will maintain a consistent source of care and reduce care dispersion and thereby avoid unnecessary health service utilization (Pear, 2009; Wennberg et al., 2008). In Medicare, other studies have addressed the issue that areas with more specialists have higher expenditures on healthcare but no improved outcomes, such as quality of life and mortality (Baicker & Chandra, 2004a). However, yet other studies have suggested that this study “tested a hypothetical scenario that was based on manipulating statistical residuals, wherein fixed numbers of FP/GPs were mathematically replaced by the same numbers of specialists, holding the total number constant” (R. A. Cooper, 2009). We have found no studies demonstrating direct relationships between local area physician supply and the care dispersion by individual patients, or relationships between care dispersion and outcomes. It is possible that observed correlations between physician supply and healthcare expenditures may not be causal and that policies changing provider supply may have little effect healthcare costs and outcomes. In this study, as a first step to understand the relationship between local area provider supply and healthcare costs and outcomes, we will investigate the relationship between local area healthcare provider supply and the dispersion of patient care across providers.

A recent paper summarized the findings related to local area physician supply and healthcare utilization. Most of the thirteen studies reviewed found a positive association between the local area physician supply in general practitioners and healthcare consumption, which implies that greater physician supply in certain practitioners encourages more health service utilization (Leonard et al., 2009). Previously, the effects of physician supply on healthcare utilization had been studied according to two theories: physician-induced demand and referral pattern literature.

The physician-induced demand (PID) theory has often been used to explain these relationships about physician supply and healthcare utilization. PID suggests that the supply of physicians in an area affects the demand for healthcare, regardless of the best interests of the patient, as physicians attempt to reach their target income (McGuire TG, 2000). Greater local area physician supply reduces the number of patients per physician, which causes physicians to increase healthcare service utilization for each patient they treat to maintain income levels (Wilensky & Rossiter, 1983). Researchers who analyzed PID have found relationships between physician supply and elective surgical operations (Dranove & Wehner, 1994a), total surgery rate (Fuchs, 1978), and childbirth (Dranove & Wehner, 1994b). However, because PID studies focus primarily on the relationships between physician supply and specific procedures for health services, little attention has been given to whether the local area physician supply affects the number or physicians that treat individual patients, and the extent to which the care is dispersed across these physicians.

Furthermore, studies of physician referral patterns have also revealed relationships between local area physician supply and use of newly-established clinic visits, referral-sensitive procedures, or specific high-cost high-technology surgical procedures with necessary referring process from a primary care physician (Basu &

Clancy, 2001; Shea et al., 1999; Shortell S., 1972 ; Franks & Clancy, 1997; Gonzalez & Rizzo, 1991). However, these findings focused on the effects of physician supply on the rates of specific procedures that require referrals from primary care physicians to specialists. Few studies have identified the causes or clarified the mechanism between supply in different specialists and the extent of dispersed care among different specialists like exact number of unique physicians each patient had seen during a treatment period (Basu & Clancy, 2001; Shea et al., 1999; Shortell S., 1972 Franks & Clancy, 1997; Gonzalez & Rizzo, 1991; Shortell & Vahovich, 1975).

In this regard, there are important knowledge gaps relating physician supply to physician utilization and patient outcomes. It is unknown whether greater local area physician supply actually affects the number and mix of physicians use by individual patients and increases care dispersion for these patients. In this thesis we will investigate the extent to which local area physician supply affects the number of physicians used by patients and the dispersion of care across physicians for these patients. This research is a necessary first that is needed prior to implementing healthcare workforce policy changes.

To assess the relationship between local physician supply and care dispersion, we need to control for the patient diagnoses, disease severity, and major treatments to assure patients have similar health status. Health status is associated with health service utilization (Grossman, 1972). Studies not controlling for a diagnosis and treatment courses, could not conclude that additional physician use would vary in relation to increases in the local physician supply. By controlling for diagnosis and treatment by design we will be better able to isolate the effects of local area physician supply on the dispersion of patient care across physicians.

Our study focuses on cancer patients because cancer care is complex and often requires several physicians from different specialties. Experts have suggested that cancer care often requires primary care physicians, oncologists, surgeons, and other specialists (Muers, Holmes, & Littlewood, 1999; Wolpin, Meyerhardt, Mamon, & Mayer, 2007).

This study will measure how physician supply in different specialties may influence the dispersed care in physician use for patients with stage III colorectal cancer who have received surgery and chemotherapy, but not radiation in their first treatment course. Colorectal cancer is the fourth highest incidence of non-cutaneous malignancy in the United States, and the second most frequent cause of cancer deaths. In the United States, more than 100,000 patients have been diagnosed with this disease, and around 50% of them will die from it (Beretta, Milesi, Pessi, Mosconi, & Labianca, 2004). We measured physician supply as local area physician supply in different specialty groups according to colorectal cancer patients' clinical needs, specifically primary care physicians, oncology specialists, surgical specialists, and other specialists. The local area was defined as the travel distance within a 50-mile straight line from the ZIP code centroid of colorectal patients' resident areas; the median distance traveled by small rural cancer patients to urban area cancer care providers was around 50 miles (Baldwin et al., 2008). The concept of dispersion care was translated into two operational measures: the total number of unique physicians each patient saw and the Physician Visit Index derived from the Herfindahl index. The Physician Visit Index is used to estimate the concentration of care, i.e., physician visits, in four specialty groups to determine the extent of the coordination care for each patient (Franks, Clancy, & Nutting, 1997).

DATA AND METHOD

Data

This study uses two data resources: the National Cancer Institute's Surveillance, Epidemiology, and End Results (SEER)-Medicare-linked database, and the Unique Physician Identification Number (UPIN) Registry. The SEER-Medicare database provides clinical information about cancer patients, including their diagnosis information, tumor characteristics, and initial treatment, and it will be used in this study to select patients based upon consistent diagnosis and treatment courses. The SEER-Medicare-linked database is composed of several files. We will utilize the Patient Entitlement and Diagnosis Summary File (PEDSF), the Medicare Analysis and Procedure File (MEDPAR), the Hospital Outpatient File (Outpatient), and the Physician/Supplier Data (NCH). SEER-Medicare claims data contain specific information on providers' characteristics and healthcare services; specifically, physician services, inpatient care in short- and long-stay hospitals, skilled nursing facilities, home health, hospice care, outpatient care, and durable medical equipment (Warren, Klabunde, Schrag, Bach, & Riley, 2002). The providers' Unique Physician Identification Number (UPIN) from the Medicare claims will identify unique physicians and specialty codes. Specialty codes are used to categorize different specialty groups that detail the section of dependent variables, and the zip codes for their practice locations and will be applied to define the area and measure local physician supply.

The UPIN Registry also contains health providers' profiles, such as specialty code, and practice information for all providers who receive Medicare payments. Because the specialty code for the Multispecialty Practice Group does not specifically list what kinds of services are provided, it is potentially problematic to categorize the Multispecialty Practice Group into the other specialist groupings. It is necessary to get further details as to the kinds of specialties that are performed. To do this, we will take advantage of the primary specialty codes in the UPIN registry. By linking the UPIN numbers in the

Medicare database with the UPIN directory, each UPIN number will link to a primary specialty code. Physicians coded in a multispecialty practice group will then be recoded, via their primary specialty code in the UPIN registry, with a new specialty code. This procedure will be explained in greater detail in the section on dependent variables below.

Cohort Selection

The study cohorts are colorectal cancer patients who had at first colorectal cancer diagnosis during 1992 to 2001; according to the SEER cancer site recode variable (15-23, 25-26), any unknown months of diagnosis are excluded (n=195,339). In addition to the diagnosis as stage III colorectal cancer according to the American Joint Committee on Cancer (AJCC) modified version, patients are selected by having the recommended therapy of surgery, and chemotherapy remains the consistent diagnosis (n=40,595).

Patients were selected using the following criteria: 1) Enrolled for 12 months prior to diagnosis and 10 months after diagnosis to assure continuous enrollment in a Medicare program; 2) age 66 or older; 3) any adjuvant chemotherapy until four months after diagnosis (Temple, Hsieh, Wong, Saltz, & Schrag, 2004) (Adjuvant chemotherapy is defined as records with any procedure codes after primary surgery and also within the period of 4 months after diagnosis: ICD-9 procedure code as 99.25, ICD-9 diagnosis code as V581, V662, V672, HCPCS/CPT-4 codes as J8999-J9999, Q0083-Q0085, J7150, 96400-96599, or Revenue center codes 0331, 0332, 0335); 4) any record of recommended surgery which is conducted between diagnosis and the first date of chemotherapy (Birkmeyer, Sharp, Finlayson, Fisher, & Wennberg, 1998; G. S. Cooper et al., 2002; Temple et al., 2004) (ICD-9 procedure code of surgery as 45.7-45.79, 45.8, 48.4, 48.5, 48.6-48.69 or HCPCS/CPT-4 codes as 44140-44160, 45110-45119); 5) no adjuvant radiation therapy within a period of six months after the first date of surgery (Virnig et al., 2002) (Adjuvant radiation is defined as records with any radiation procedure code, 9221-9229, HCPCS/CPT-4 codes, 77401-77499, 77750-77799 or revenue center code, 0330, 0333 occurring within 6 months after the first surgery date); 6) a valid 5-digit zip code for available physician supply; 7) valid socioeconomic information from the 2000 Census; 8) at least one physician visit coded as Evaluation and Management services; and 9) exclusion of any patients' provider with an invalid 5-digit zip code. The final study cohort is 6539. (The patient number for each selection step is displayed at Table 1.)

Dependent Variables

The dependent variables measure the care dispersion for each patient during the study period. The study period is the time within the first course of treatment for each stage III colorectal patient, which is defined as 10 months. The period of the first 4 months is the average period from the patients' initial diagnoses to any operation and start of postoperative chemotherapy treatment; the next 6 months is the recommended chemotherapy treatment course for colorectal cancer and is calculated by the cycle length multiplied by the number of days per cycle for the entire treatment. Cycle length and the number of days per cycle will vary by regimens (Temple et al., 2004; Wolpin et al., 2007). To apply for the concept of care dispersion as the extent that patient care is spread across physicians we adopted two measures to approximate the extent of care dispersion (Franks et al., 1997; Jee & Cabana, 2006; Pham et al., 2007; Shortell, 1976): the sum of unique physicians each patient saw during the first treatment period; and the Physician Visit Index as an estimate of the concentration of physician care derived from the Herfindahl index (Franks et al., 1997).

Counting the number of physicians actually treating and interacting with patients can show how care is dispersed across these physicians. To calculate the number of physicians treating each patient we first, we calculated the total unique physicians treating each patient during the first treatment period based on the Unique Physician Identification Number (UPIN) from the UPIN registry of the Centers for Medicare and Medicaid Services (CMS). The CMS has been issuing UPINs to all physicians since 1989 and to non-physician practitioners since 1994. The first letter of the UPIN classifies

Table 1. Cohort Selection Criteria

Inclusion/Exclusion criteria	Number of patients
Step 1) First colorectal diagnosis year 1992-2002	195339
Step 2) Modified AJCC stage III patients	40595
Step 3) Include enrolled in Medicare for 12 months prior to diagnosis, and the 10 months after diagnosis	16,138
Step 4) Exclude 65 and younger	15,582
Step 5) Exclude patients without adjuvant chemotherapy within four months of diagnosis	9,852
Step 6) Include any record of recommended surgery which is conducted between diagnosis and the first date of chemotherapy	8,382
Step 7) Exclude any patient who has adjuvant radiation therapy within period of 6 months after the first date of surgery	6,789
Step 8) Exclude patients with invalid 5-digit zip code	6,780
Step 9) Exclude patients with invalid socioeconomic information	6,611
Step 10) Exclude patients without at least one physician claim with an Evaluation and Management service	6,543
Step 9) Exclude patient if patient’s providers have an invalid 5-digit zip code to make sure he has correct supply information	6,539

Table 2. Definition of adjuvant chemotherapy

Field	Specific Code	File
ICD-9 procedure code	99.25	Medpar
ICD-9 diagnosis code	V581, V662, V672	Medpar
DRG code	410	Medpar
Level 1 HCPCS/CPT-4 codes	J8999-J9999, Q0083-Q0085, J7150, 96400-96599	Outpatient, Physician/supplier (NCH)
Revenue center codes	0331, 0332, 0335	Outpatient

Note:

- Adjuvant chemotherapy is defined as records with any procedure codes after primary surgery and also within the period of 4 months after diagnosis.
- DRG code of 410: Chemotherapy without Acute Leukemia As Secondary Diagnosis
- CPT-4 code of 7150: Oral chemotherapy prescription

Table 3. Definition of surgery

Field	Specific Code	File
ICD-9 procedure code	45.7-45.79, 45.8, 48.4, 48.5, 48.6-48.69	Medpar, Outpatient
Level 1 HCPCS/CPT-4 codes	44140-44160, 45110-45119	Physician/supplier (NCH)

Note: Surgery is defined as records with any surgery procedure occurring after diagnosis.

Table 4. Definition of adjuvant radiation

Field	Specific Code	File
ICD-9 procedure code	9221-9229	Medpar, Outpatient
Level 1 HCPCS/CPT-4 codes	77401-77499, 77750-77799	Outpatient, Physician/supplier (NCH)
Revenue center codes	0330, 0333	Outpatient

Note: Adjuvant radiation is defined as records with any radiation procedure code or revenue center code occurring within 6 months after the first surgery date.

provider types. Medical doctors have first UPIN letters ranging from A through M. In addition, physicians' healthcare treatment coded by the Evaluation and Management Services (E/M) in SEER-Medicare database contains recording patient history, physician examination information, and any medical decisions reached. By E/M services, we will gather the visit-based physician-conducted treatments. Because the E/M file notes physician visits and consultations, any attending physician, new or continuing, who bills Medicare for E/M services, should be documented in this file. Non-E/M physician claims may include hospital visits and claims for procedures and tests (Yu, McBean, & Virnig, 2007). Someone may doubt that E/M codes are not extremely reliable to record the real contact between physicians and patients. However, it is a good start trying to approach the measure of face-to-fact consultation.

Second, we created the Physician Visit Index to estimate the concentration of physician visits coded by E/M services by applying the concepts found in the Herfindahl Index, which measures the size of firms in relation to their industry and the amount of competition among them (Franks et al., 1997). It is also useful to measure the concentration of the market share for each firm. We arrived at our measures by summing the squared shares of the patient's total physician visits for each physician visited during the first course treatment period. One physician visit is understood as the present UPIN number per day. The range of the Physician Visit Index is also from zero to one. The closer to zero the index is, the higher the care dispersion (Franks et al., 1997).

In this study, Physician Visit Index is estimated not only among all individual physicians but also across four specialty groups (See Table 5).The formula of the Physician Visit Index among all individual physicians is displayed as the following: In the formula, α represents one (the i^{th}) physician's visit share in total physician visits each patient received; n is the number of unique physicians each patient saw.

$$\text{Physician Visit Index among all individual physicians} = \sum_{i=1}^{n} (\alpha_i)^2$$

Physician visit index is between 0 and 1. If the index is closer to 0, there is more care dispersion for the individual patient. Physician visit index can be closer to zero either through more physicians or same number of physician but visits dispersed more evenly across different physicians. For example, patient A had 12 physician visits during his/her first treatment course that were distributed evenly across 6 unique physicians (n = 6), in other words, patient A went to see 2 times for each physician. Patient A' Physician Visit Index among all individual physicians will be sum of squared visit shares for each unique physician: Physician visit index = $(2/12)^2 + (2/12)^2 + (2/12)^2 + (2/12)^2 + (2/12)^2 + (2/12)^2 = 0.1734$.

On the other hand, suppose patient B had 8 physician visits that were distributed evenly across 4 unique physicians (n = 4), in other words, patient B also went to see 2 times for each physician during the first treatment course.. The patient B' Physician Visit Index among all individual physicians will be sum of squared visit shares for each unique physicians: Physician visit index = $(2/8)^2 + (2/8)^2 + (2/8)^2 + (2/8)^2 = 0.25$. Patient A saw more physicians with equal distribution with Patient B. As a result, patient A with lower physician visit index gets more care dispersion due to seeing more unique physicians.

Another example is to explain the less care dispersion caused by seeing physicians less evenly when patients have the same number of physicians. Patient C saw the same number of unique physicians with patient B but with unevenly distribution across four physicians. For example during the first treatment course, patient C saw one primary care physician three times, one oncology specialists once, surgical specialist once, and other specialist three times. The patient C' Physician Visit Index among all individual physicians will be sum of squared visit shares for each unique physicians: Physician visit index = $(3/8)^2 + (1/8)^2 + (1/8)^2 + (3/8)^2 = 0.3125$. Patient C saw the same number of doctors with different distribution with Patient B whereas Patient C has more concentrated visit for primary care physicians and other specialists. In this regard, Patient C has less care dispersion then Patient B even though the saw the same number of physicians.

Second, the formula of the Physician Visit Index across four specialists is displayed as the following: In this formula, j represents the categories of specialty groups (according to Table 4): j = 1 as primary care physicians; j = 2 as oncology specialists; j = 3 as surgical specialists; and j = 4 as other specialists.

$$\sum_{j=1}^{4}\left(\frac{\text{Number of visits conducted by physicians in each specialty group j}}{\text{Total physician visits each patient had}}\right)^2$$

Because colorectal cancer care requires sophisticated surgical and medical resources, including medical, surgical chemotherapy, and other specialists, this study places physicians into four categories according to their Healthcare Financing Administration (HCFA) specialty codes from CMS: Primary care physicians (General practice: 01, Internal Medicine: 11, Family Practice: 08, Obstetrics/Gynecology: 16, and Geriatric Medicine: 38), oncology specialists (Medical oncology: 90, and Hematology/Oncology: 83), surgical specialists (General surgeons: 02, Colorectal surgery: 28, and Surgical Oncology: 91), and other specialists (all specialties other than the above). Multispecialty Group Practice is composed of different types of specialties. After finding the distribution of health services in terms of HCPCS codes, we found that the services conducted by Multispecialty Group Practice could not be easily and directly categorized into the four groups below. We decided to follow the specialty of the one who billed Medicare to track the major care giver's primary specialty code. Because the primary specialty codes should refer to each physician's main specialized field, it is more appropriate to assign those multispecialty group practitioners by their primary specialty code. We then linked the UPIN directory to the UPIN number and recoded their specialty codes to match their primary specialty, shown in Table 5.

Table 5. The physician-categorized groups

Category	**Specialty identification**	**HCFA-CMS specialty code**
Primary care physicians	General Practice	01
	Internal Medicine	11
	Family Practice	08
	Obstetrics/Gynecology	16
	Geriatric Medicine	38
Oncology specialists	Medical oncology	90
	Hematology/Oncology	83
Surgical specialists	General Surgeons	02
	Colorectal Surgery	28
	Surgical Oncology	91
Other specialists	Specialists other than the above lists	

Note: Multispecialty Group Practice uses the UPIN directory to recode by the categories shown above.

Independent Variables

Explanatory variables

Local Area Physician Supply (crcon1, crcon2, crcon4, crcon8)

The local area physician supply is the concept of the number of unique physicians per 1,000 patients within certain areas. The ideal measure of the local area physician supply is the ratio of the actual number of all physicians over all cancer patients within each local area. However, those files are not available. As a result, we tried to compile as many cancer patients as possible to derive the most extensive cancer patient pool available. In this pool, we approximated the local area physician supply by aggregating data from NCH’s Physician/Supplier Data files, which consisted of four kinds of cancer (colorectal, breast, lung, and prostate) treatment information to assess the numbers of real and relevant practitioners. The measure of the local area physician supply per 1,000 patients is the ratio of the number of local physicians (numerator) versus per 1,000 cancer patients in each area (denominators).

The numerator is extracted from the four-cancer patient pool, patients who live within a 50-mile radius from each of the four-cancer patients’ residence zip codes during their first diagnosis year. On average, the median distance traveled by rural cancer patients who traveled to urban cancer care givers was 47.8 miles or more (Baldwin et al., 2008). In this regard, we decide to use 50-miles as radius to define each local area. We then found the sum of the unique medical physicians in the four specialty categories within certain areas in which they had treated any four-cancer patients. The straight-line distance of 50 miles is calculated using latitude and longitude data for the zip code centroids. Patient residence location is defined as the ZIP code on the SEER-Medicare claims in the calendar month of the colorectal cancer diagnosis. The physician/supplier file contains a performing-provider ZIP code, which could represent the ZIP code of the office where the service is provided and the physician practices (Baldwin et al., 2002). Physician practice location was defined as the first listed ZIP code on claims submitted on behalf of colorectal cancer patients diagnosed between 1992 and 2002 and reported to the SEER program. The denominator is from the same pool of the recruited four-cancer patients, within 50 miles from each four-cancer patient’s ZIP code centroid, according to their first diagnosis year, then finding the sum of four-cancer patients treated by medical physicians in four categories within certain areas.

Lastly, we calculated the ratio of local physician numbers (numerator) over per 1,000 cancer patients in each area (denominator) to arrive at four measures of local physician supply: local area primary care physician supply (crcon1), local area oncology specialty supply (crcon2), local area surgical supply (crcon4), and local area other specialist supply (crcon8). However, concern was expressed over the problem of bias in estimating physician supply from only the four-cancer pool. Specifically, the four-cancer pool is easy for capturing oncologists but not primary care physicians. Some may argue that the UPIN registry file, which contains the physicians' original information, was a more comprehensive tool. However, our measurements showed little difference between the four-cancer pool and the UPIN file. Therefore, we treated the measurement taken from the four-cancer pool as the local area physician supply.[1]

Control variables

Age at Diagnosis (age dx)

This variable, the age at the time of diagnosis of each patient (age_dx), was calculated by subtracting the patients' year of birth from the year of diagnosis. This variable is treated as a continuous variable. Besides, we add the squared term of age at diagnosis to see if there is any nonlinear relationship between age and care dispersion of physician use.

Socioeconomic status (ZPMED00, ZPWHT00, ZPNON00)

Socioeconomic status included information about income, ethnicity, and education level for each zip code from the 2000 Census integrated into the SEER-

[1] By comparing the four measures of physician supply from the four-cancer pool with the measures from the UPIN registry file, the measures from the four-cancer pool are all highly correlated with measures from UPIN registry files. It means that the distribution of these measures is similar. To decide which measure is better for approximating the real local area physician supply, we consider the problem that the UPIN file may possibly contain physicians who are no longer in practice. We eventually adopted the supply measure from the four-cancer pool to approximate the real practitioners.

Medicare database: The Median income of each zip code as ZPMED00; the Percentage of Caucasians within each zip code area as ZPWHT00; and the percentage of non-high school graduates within each zip code area as ZPNON00. Those variables are continuous variables.

Tumor grade (grade1, grade2, grade3, grade4, grade9)

The tumor grade variables show the progress of the tumors, which are categorized into five groups: Tumor grade 1 as well differentiated (grade1), tumor grade 2 as moderately differentiated (grade2), tumor grade 3 as poorly differentiated (grade3), tumor grade 4 as undifferentiated (grade4), and tumor grade 9 as unknown status of differentiation. The reference group is tumor grade 1.

Tumor site (grpsite1, grpsite2, grpsite3)

For colorectal cancer, the three possible tumor sites are colon (grpsite1), rectosigmoid (grpsite2), and rectum (grpsite3). The tumor site at the colon (grpsite1) is the reference group.

Surgery type (surg_type2, surg_type3)

The main surgery procedures for treating colorectal cancer vary. In this study, we categorize the surgery procedure into two types: one is local tumor excision (surg_type2), and another is colectomy, hemicolectomy, protocolectomy, etc. (surg_type3). The reference group is colectomy, hemicolectomy, protocolectomy, etc. (surg_type3).

Comorbidity (PCHRLSON_OP, PCHRLSON_INP)

Originally, The Charlson Index was counted for the comorbidity of the inpatient claims file. However, for SEER-Medicare databases, the information for inpatient files could not cover the whole profile of each patient. The way to improve this insufficient measure is to have another Charlson index for comorbidity in the outpatient claims file. In this regard, this study contains two of the control variables that are the measures of co-morbidity: one is for inpatient (PCHRLSON_INP), and another is for outpatient (PCHRLSON_OP) (Klabunde, Warren, & Legler, 2002). We adopt The Charlson Index, perhaps the most well-known and widely used comorbidity measure. It is a summary that measures 19 comorbid conditions, each of which is assigned a weight according to its potential to influence mortality. In the study, the Charlson comorbidity index is based on the period of one year before the diagnosis year from both inpatient and outpatient claims files.

Statistical methods

We estimated an empirical regression model by ordinary least square regression that described the effect of area physician supplies in four categories of specialties on unique physician use and on the Physician Visit Index for physician care among the colorectal cancer patients.

Empirical model 1:

We estimated an empirical regression model by ordinary least square regression that described the effect of area physician supplies in four categories of specialties on unique physician use (U_{ji}) among the colorectal cancer patients:

$$U_{ji} = \beta_0 + \beta_1 \text{ crcon1} + \beta_2 \text{ crcon2} + \beta_3 \text{crcon4} + \beta_4 \text{ crcon8} + \beta_5 \text{ age\_dx} + \beta_6 (\text{age\_dx})^2 + \beta_7 \text{ PCHRLSON\_OP} + \beta_8 \text{ PCHRLSON\_INP} + \beta_9 \text{ ZPMED00} + \beta_{10} \text{ ZPWHT00} + \beta_{11} \text{ ZPNON00} + \beta_{12} \text{ grade2} + \beta_{13} \text{ grade3} + \beta_{14} \text{ grade4} + \beta_{15} \text{grade9} + \beta_{16} \text{grpsite2} + \beta_{17} \text{ grpsite3} + \beta_{18} \text{ surg\_type2} + \varepsilon_i$$

where i stands for each individual patient and j refers to specialty categories. For example, j = 0 as = total unique physician; j = 1 as primary care physicians; j = 2 as oncology specialists; j = 3 as surgical specialists; and j = 4 as the other specialists. In that way, U_{1j} - U_{5j} represent unique physician use in overall physicians and four specialty groups; ε_i : is a patient-level error term.

Empirical model 2:

We estimated an empirical regression model by ordinary least square regression that described the effect of area physician supplies in four categories of specialties on the Physician Visit Index (H_{ki}) among the colorectal cancer patients:

$$H_{ki} = \beta_0 + \beta_1 \text{ crcon1} + \beta_2 \text{ crcon2} + \beta_3 \text{crcon4} + \beta_4 \text{ crcon8} + \beta_5 \text{ age\_dx} + \beta_6 (\text{age\_dx})^2 + \beta_7 \text{ PCHRLSON\_OP} + \beta_8 \text{ PCHRLSON\_INP} + \beta_9 \text{ ZPMED00} + \beta_{10} \text{ ZPWHT00} + \beta_{11} \text{ ZPNON00} + \beta_{12} \text{ grade2} + \beta_{13} \text{ grade3} + \beta_{14} \text{ grade4} + \beta_{15} \text{grade9} + \beta_{16} \text{grpsite2} + \beta_{17} \text{ grpsite3} + \beta_{18} \text{ surg\_type2} + \varepsilon_i$$

where i stands for each individual patient and k refers to the Physician Visit Index for each individual physician (k=1) or across the four specialty groups (k=2).

RESULTS

Univariate statistical results

In this study, as seen in Table 6, patients on average saw 7.48 physicians on average during their first course of treatment (2.49 for local primary care physicians, 0.98 for local oncology specialists, 1.02 local surgical specialists, and 3.05 for local other specialists). The mean for seeing primary care physicians and total unique physicians from this cohort is similar but a little higher than for the lung cancer beneficiaries in Medicare (3 for primary care physicians and 11 for total unique physicians) (Pham et al., 2007).

For another measurement, the Physician Visit Index, the effects of the physician supply in the four specialty categories are displayed in Table 7. In this study, patients had an average Physician Visit Index of physician E/M visits of 0.37, and the Physician Visit Index across the four specialty groups of 0.55 during their first course of treatment.

Table 6. Distribution of unique medical physicians seen by each patient in four categories in the study population

Categories	Mean	Std Dev	Min	5%	25%	50%	75%	95%	Max
Primary care physicians	2.49	1.82	0	0	1	2	3	6	15
Oncology specialist	0.98	1.13	0	0	0	1	1	3	8
Surgeon specialist	1.02	0.63	0	0	1	1	1	2	7
Other specialists	3.05	2.88	0	0	1	2	4	9	33
All of the above	7.48	4.23	1	2	5	7	9	15	45

As for measuring the numerator of the local area physician supply per patient, we find that within 50 miles from each patient's residence (Table 8). In addition, the average of denominator of the local area physician supply per patient from the same pool as the aggregated patient number within 50 miles from each patient's residence is 35,879.43 (Table 9).

Table 7. Distribution of Physician Visit Index for each patient in the study population

Categories	Mean	Std Dev	Min	5%	25%	50%	75%	95%	Max
Physician Visit Index from each individual physician	0.37	0.19	0.05	0.13	0.23	0.33	0.49	0.74	1.00
Physician Visit Index across the four specialtygroups	0.55	0.17	0.25	0.32	0.41	0.51	0.66	0.88	1.00

Using a multivariate linear regression from the empirical model 1-2, which takes the total numbers of all unique physicians seen or the Physician Visit Index by each patient as the dependent variables and controls patient age, ethnicity, cancer grade, surgery type, and socioeconomic status, the parameters for the explanatory variables are displayed in Tables 10-11.

Table 8. Number of physicians in the four specialty groups within 50 miles from each patient's zip code centroid (The numerator of the local physician supply measurements)

Label	Mean	Std Dev	Min	5^{th} Pctl	25^{th} Pctl	50^{th} Pctl	75^{th} Pctl	95^{th} Pctl	Max
Number of primary care physicians	2639.13	1867.78	12	169	606	2927	4586	4785	6023
Number of oncologists	90.12	76.15	0	1	14	88	143	224	418
Number of surgeons	328.09	237.92	1	17	72	377	538	614	939
Number of other specialties	4098.84	3054.84	7	155	836	4796	6735	7462	13683

Table 9. Number of patients treated by all medical physicians within 50 miles from each patient's zip code centroid (The denominator of the local physician supply measurements)

Mean	Std Dev	Min	5^{th} Pctl	25^{th} Pctl	50^{th} Pctl	75^{th} Pctl	95^{th} Pctl	Max
35879.43	23354.56	25	3375	9296	41015	57128	65298	65628

Table 10. The distribution of the explanatory variables across four models

Independent variables (Explanatory variables)	Mean	Std Dev	Min	25^{th} Pctl	50^{th} Pctl	75^{th} Pctl	Max
Numbers of Primary care physicians per 1,000 four-cancer patients within 50 miles from each patient's zip code centroid	69.63	36.06	0	57.4	70.3	80.0	1058.3
Numbers of Oncology specialists per 1,000 four-cancer patients within 50 miles from each patient's zip code centroid	2.28	1.63	0	1.4	2.0	2.9	29.1
Numbers of Surgeon specialists per 1,000 four-cancer patients within 50 miles from each patient's zip code centroid	8.55	3.78	0	4.0	6.9	8.7	145.6
Numbers of Other specialists per 1,000 four-cancer patients within 50 miles from each patient's zip code centroid	105.27	54.43	0	79.9	102.2	120.0	1873.8

Multivariate regression results

Dependent variables as unique physician use

The unit effects from the physician supply per 1,000 patients on the total physician use are displayed in Tables 12, if the numbers of primary care physicians per 1,000 patients in a certain area increased one unit, then the number of unique physicians used by each patient would increase by 0.03156 ($p<.0001$). If the number of oncology specialists per 1,000 patients in a certain area increases one unit, then the number of unique physicians used by each patient would increase by 0.4254 ($p<.0001$). If the

Table 11. The distribution of the control variables across four models

	Mean	Std Dev	Min	25th Pctl	50th Pctl	75th Pctl	Max
Independent variables (Control, continuous variables)							
Prior Charlson comorbidity score for outpatient	0.253	0.568	0	0	0	0	5
Prior Charlson comorbidity score for inpatient	0.191	0.623	0	0	0	0	6
Age	76.40	6.56	66.00	71.00	76.00	81.00	100.00
Zip Code Median Income (Census 2000)	48614.08	17875.77	10212	36454	44931	56984	146762
Zip Code Percent of Whites (Census 2000)	79.22	28.23	0	80.04	92.81	96.22	100.00
Zip Code Percent of non-high school grades (Census 2000)	16.57	8.33	0	11.03	15.01	19.92	56.3
Independent variables (Control, categorical variables)							
Tumor grade 1: Well differentiated (Reference group)	0.051	0.221	0	0	0	0	1
Tumor grade 2: Moderately differentiated	0.655	0.476	0	0	1	1	1
Tumor grade 3: Poorly differentiated	0.246	0.430	0	0	0	0	1
Tumor grade 4: Undifferentiated	0.009	0.095	0	0	0	0	1
Tumor grade 9: Unknown	0.039	0.195	0	0	0	0	1
Tumor site: colon (Reference group)	0.765	0.424	0	1	1	1	1
Tumor site: Rectosigmoid	0.0997	0.2996	0	0	0	0	1
Tumor site: Rectum	0.135	0.342	0	0	0	0	1
Surgery type: Local tumor excision	0.003	0.055	0	0	0	0	1
Surgery type: Colectomy, hemicolectomy, protocolectomy, etc. (Reference group)	0.997	0.055	0	1	1	1	1

number of surgeon specialists per 1,000 patients in a certain area increases one unit, then the number of unique physicians used by each patient would decrease by 0.30562 ($p<.0001$). If the numbers of surgeon specialists per 1,000 patients in a certain area increases one unit, then the number of unique physicians used by each patient would decrease by 0.0009. However, the supply of the other specialists does not have a significant effect on the number of unique physicians used.

Furthermore, we use other multivariate linear regressions to investigate the effect of the number of physicians in four specialty categories per patient (in a four-cancer pool) on the number of the unique physicians used across the four categories of specialties for each patient, respectively. The results show that the local physician supply per patient from primary care physicians and oncology specialties have a positive influence on the four categories of unique physician use; both the local physician supply per patient from surgical specialists and the other specialists have a negative influence on the four categories of unique physician use, except the case that the other specialist supply increases the unique physician use in other specialist groups. Those results are displayed in Tables 13-16. The trend of effects from the four groups of specialties on the physician use of the four specialty groups is displayed in Table 17.

Dependent Variables as the Physician Visit Index

The parameters of unit effects from the physician supply per 1,000 patients on the Physician Visit Index are displayed in Table 18. If the number of primary care physicians per 1,000 patients in a certain area increases one unit, then the Physician Visit Index for each patient would decrease by 0.00066 ($p<.01$). If the number of oncology specialists per 1,000 patients in a certain area increases one unit, then the Physician Visit Index for each patient would decrease by 0.01102 ($p<.0005$). If the number of surgeon specialists per 1,000 patients in a certain area increases one unit, then the Physician Visit Index for

Table 12. The effect of local area physician supply in four specialty categories on the number of unique physicians used per patient

Dependent variable: The total number of all unique physicians seen by each patient			
Independent (Explanatory) variables	Parameter Estimate	Standard Error	Pr>| t |
Number of Primary care physicians per 1,000 four-cancer patients within 50 miles from each patient's zip code centroid	0.03156	0.00528	<.0001
Number of Oncology specialists per 1,000 four-cancer patients within 50 miles from each patient's zip code centroid	0.42540	0.00621	<.0001
Number of Surgical specialists per 1,000 four-cancer patients within 50 miles from each patient's zip code centroid	-0.30562	0.04712	<.0001
Number of Other specialists per 1,000 four-cancer patients within 50 miles from each patient's zip code centroid	-0.0009317	0.00319	0.8116

Note:
1. All other undisplayed regressors are listed in Tables 10-11.
2. $R^2 = 0.0795$

Table 13. The effect of local area physician supply in four specialty categories on the number of unique physicians used in primary care physicians in the four categories per patient

Dependent variable: The total number of unique Primary care physicians seen by each patient			
Independent (Explanatory) variables	Parameter Estimate	Standard Error	Pr>| t |
Number of Primary care physicians per 1,000 four-cancer patients within 50 miles from each patient's zip code centroid	0.00753	0.00233	0.0012
Number of Oncology specialists per 1,000 four-cancer patients within 50 miles from each patient's zip code centroid	0.09322	0.02925	0.0014
Number of Surgical specialists per 1,000 four-cancer patients within 50 miles from each patient's zip code centroid	-0.00208	0.02082	0.9205
Number of Other specialists per 1,000 four-cancer patients within 50 miles from each patient's zip code centroid	-0.00561	0.00173	0.0012

Note:
1. All other undisplayed regressors are listed in Tables 10-11.
2. $R^2 = 0.0285$

Table 14. The effect of the local area physician supply in four specialty categories on the number of unique physicians used in oncology specialists in the four categories per patient

Dependent variable: The total number of unique Oncology specialists seen by each patient			
Independent (Explanatory) variables	Parameter Estimate	Standard Error	Pr>| t |
Number of Primary care physicians per 1,000 four-cancer patients within 50 miles from each patient's zip code centroid	0.00676	0.00139	<.0001
Number of Oncology specialists per 1,000 four-cancer patients within 50 miles from each patient's zip code centroid	0.18130	0.01746	<.0001
Number of Surgical specialists per 1,000 four-cancer patients within 50 miles from each patient's zip code centroid	-0.06686	0.01242	<.0001
Number of Other specialists per 1,000 four-cancer patients within 50 miles from each patient's zip code centroid	-0.00290	0.00103	0.0049

Note:
1. All other undisplayed regressors are listed in Tables 10-11.
2. $R^2 = 0.0947$

Table 15. The effect of local area physician supply in four specialty categories on the number of unique physicians used in surgical specialists in the four categories per patient

Dependent variable: The total number of unique Surgical specialists seen by each patient			
Independent (Explanatory) variables	Parameter Estimate	Standard Error	Pr>| t |
Number of Primary care physicians per 1,000 four-cancer patients within 50 miles from each patient's zip code centroid	0.00376	0.00080898	<.0001
Number of Oncology specialists per 1,000 four-cancer patients within 50 miles from each patient's zip code centroid	0.00816	0.01015	0.4216
Number of Surgical specialists per 1,000 four-cancer patients within 50 miles from each patient's zip code centroid	-0.02847	0.00723	<.0001
Number of Other specialists per 1,000 four-cancer patients within 50 miles from each patient's zip code centroid	0.00023624	0.00059927	0.6934

Note:
1. All other undisplayed regressors are listed in Tables 10-11.
2. $R^2 = 0.0180$

Table 16. The effect of local area physician supply in four specialty categories on the number of unique physicians used in other specialists in the four categories per patient

Dependent variable: The total number of unique Other specialists seen by each patient			
Independent (Explanatory) variables	Parameter Estimate	Standard Error	Pr>| t |
Number of Primary care physicians per 1,000 four-cancer patients within 50 miles from each patient's zip code centroid	0.01251	0.00357	0.0005
Number of Oncology specialists per 1,000 four-cancer patients within 50 miles from each patient's zip code centroid	0.14798	0.04479	0.0010
Number of Surgical specialists per 1,000 four-cancer patients within 50 miles from each patient's zip code centroid	-0.18694	0.03188	<.0001
Number of Other specialists per 1,000 four-cancer patients within 50 miles from each patient's zip code centroid	0.00620	0.00264	0.0190

Note:
1. All other undisplayed regressors are listed in Tables 10-11.
2. $R^2 = 0.0903$

Table 17. Trends of effects of local physician supply on the unique physician use in the four specialty groups.

Physician supply	Unique physician use in four specialty groups			
Specialty groups	Primary care	Oncology	Surgical	Other
Primary care	Increase***	Increase***	Increase ***	Increase***
Oncology	Increase ***	Increase***	Increase	Increase***
Surgical	Decrease	Decrease***	Decrease ***	Decrease***
Other	Decrease ***	Decrease***	Increase	Increase**

Significance level: *, ** and *** indicate significance at p<0.1, p<0.05, and p<0.01, respectively.

each patient would increase by 0.01068 (p<.0001). If the number of the other specialists per 1,000 patients in the certain area increases one unit, then the Physician Visit Index would decrease by 0.00017. However, the supply of other specialists does not have a significant effect on the Physician Visit Index.

For the measure of the Physician Visit Index across four specialists, Tables 19 shows the unit effects from the physician supply per patient on the Physician Visit Index. These results show a similar trend of unit effect of the local area physician supply on dispersed physician visits across the four specialty groups. Primary care physicians and Oncology specialists significantly tend to increase care dispersion by lowering the Physician Visit Index across the four specialty groups, whereas surgical specialists and the other specialists both significantly decrease care dispersion by increasing the Physician Visit Index across the four specialty groups.

We also tried to measure physician use using a broader measure as the total physician use without E/M service definition. In contrast we found the great increase from the average physician use number between the average physician use number without E/M service definition physicians used is from 7.48 to 17.10, as well as the high increase from the average visits of the other specialty group, from 3.05 to 11.82. Meanwhile, another great jump takes place from the average overall physician use between physicians use and the physician uses without E/M service definition (displayed in Appendix). However, the other three specialty groups did not increase a great deal. These results might imply that the use of primary care, oncology specialists, and surgeon specialists could not be inflated by non-personal-visit physician visits, but the other specialists could be. In this regard, the physician use coded as E/M services could be more reliable for measuring visit-based utilization. As a result, we adopt the physician use coded as E/M services as one main measure of care dispersion. Other multivariates analysis results are also displayed at Appendix. The trend effects of local physician supply on physician use without E/M codes are consistent with which of local physician supply on physician use with E/M codes.

Table 18. The effect of the local area physician supply in four categories on the Physician Visit Index per 1,000 patients

Dependent variable: The Physician visit index for each patient			
Independent (Explanatory) variables	Parameter Estimate	Standard Error	Pr>| t |
Number of Primary care physicians per 1,000 four-cancer patients within 50 miles from each patient's zip code centroid	-0.00066	0.00024468	0.0069
Number of Oncology specialists per 1,000 four-cancer patients within 50 miles from each patient's zip code centroid	-0.01102	0.00307	0.0003
Number of Surgeon specialists per 1,000 four-cancer patients within 50 miles from each patient's zip code centroid	0.01068	0.00219	<.0001
Number of Other specialists per 1,000 four-cancer patients within 50 miles from each patient's zip code centroid	-0.00016832	0.00018126	0.3531

Note:
1. All other undisplayed regressors are listed in Tables 10-11.
2. $R^2 = 0.0446$

Table 19. The effect of the local area physician supply in four categories on the Physician Visit Index across four specialty groups per 1,000 patients

Dependent variable: The Herfindahl visit index for each patient			
Independent (Explanatory) variables	Parameter Estimate	Standard Error	Pr>| t |
Number of Primary care physicians per 1,000 four-cancer patients within 50 miles from each patient's zip code centroid	-0.00127	0.00022	<.0001
Number of Oncology specialists per 1,000 four-cancer patients within 50 miles from each patient's zip code centroid	-0.01495	0.00278	<.0001
Number of Surgeon specialists per 1,000 four-cancer patients within 50 miles from each patient's zip code centroid	0.01539	0.00198	<.0001
Number of Other specialists per 1,000 four-cancer patients within 50 miles from each patient's zip code centroid	-0.00013	0.00016416	0.4188

Note:
1. All other undisplayed regressors are listed in Tables 10-11.
2. $R^2 = 0.0365$

DISCUSSION

Measuring care dispersion by unique physician use and the Physician Visit Index, the impact of physician supply per patient in the local area around patients' residence on care dispersion varied across the four specialty groups. Increasing unique physician use and decreasing Physician Visit Index shows higher care dispersion. By using multivariate linear regression models, both local physician supplies from primary care physicians and oncology specialties have a positive influence on care dispersion, such as increasing unique physician use and decreasing the Physician Visit Index. This finding is consistent with previous studies that showed a positive association between physician density and healthcare consumption when focusing on the group of primary care physicians (Baicker & Chandra, 2004b). On the other hand, the two other specialty groups—surgical specialists and other specialists—have a negative influence on care dispersion, such as decreasing unique physician use and increasing the Physician Visit Index. We are convinced that local area physician supply per patient significantly affects physician use across the four different specialty groups. The strength and trend of the effect are varied across the four specialty groups.

Furthermore, the local primary care physician and oncology specialist supply have a positive impact not only on care dispersion of total physician use, but also specifically on the four categories of unique physician use. However, both the local surgical and other specialty supply per patient negatively influenced the unique physician use for each patient. Simply put, the local area supply of physicians in the four specialty groups could affect the specialty mix of physicians treating cancer patients. For example, care dispersion of unique physician use decreased by the surgical specialists significantly but increased by the primary care physicians. The possible explanation of the local area supply of physicians affecting the specialty mix differently is due to the characteristics of different specialists. Involving more than one physician in the care system has strong demands for coordination of the providers in the networks (Shortell S., 1972). When the number of physicians within an area increases, how a physician identifies her/himself will determine whether other physicians are called upon for additional services. More specifically, it is possible that the role of "continuous care giver" determines whether outside physicians/specialists are requested.

Continuous care givers tend to refer their patients to other specialists, whereas non-continuous care givers focus only on their specialty fields (Shea et al., 1999; Shortell S., 1972). For example, some research has found that primary care physicians and specialists have very different practice technique areas. Primary care physicians who regard themselves as continuous care givers provide care for a broad and diverse spectrum of conditions by cooperating with other specialists, whereas medical and surgical specialists spend most of their time treating diseases within areas where the specialties are organized. Moreover, some specialists even provide healthcare for their patients similar to what oncology specialists or primary care physicians do to take over their patients' needs for seeing a primary care physician. In this regard, the use of primary care physicians will be decreased, and therefore, physician supply in different specialties could have mixed positive and negative effects on physician use (Rosenblatt, Hart, Baldwin, Chan, & Schneeweiss, 1998).

Previous studies demonstrated that in a Medicare population, referral physician visits were generally more common from generalist to specialist than from specialist to specialist (Forrest & Reid, 1997). Because primary care physicians have a continuous-care relationship with their patients, it is no wonder that a local supply of primary care physicians could have a positive influence on dispersed physician visits of the total unique physicians used, as well as the other three types of specialty groups. Primary care physicians will refer their patients to other specialists to conduct further diagnostic services, so that primary care supply could spur other specialist uses. Moreover, the oncology specialists maintain a similar pattern with primary care physicians because the oncology specialists are regarded as both the malignant neoplasm curers and the continuous-care givers for the colorectal cancer patients. Some oncologists become general care providers and build a long-term care relationship with their patients. As a result, the oncology specialists need to refer their colorectal patients to other specialists or primary care physicians for comprehensive healthcare.

Conversely, surgical specialists have a different practice philosophy. Most surgical specialists appear to function primarily as specialists. They are less likely to form a long-term care relationship with their patients, render care for a specific diagnosis group, and seldom use treatment outside the traditional domain of their specialty. However, surgical specialists do bond with their patients for certain office services. For example, they might prescribe chemotherapy drugs that are otherwise prescribed by an oncologist. Besides, they also tend to be more aggressive than other specialists and provide broader services to their patients and might not refer patients to other physicians, either. This scenario could be used to help interpret the results of the effects of surgical specialists on care dispersion in unique physician use. Surgical specialists do not often refer service and tend to perform services that other specialists typically give. The supply of surgical specialists, the most frequent first source of contact with the healthcare system after a colorectal cancer diagnosis, ultimately decreases the total unique physician use.

In conclusion, our results show that not only the specialists' characteristics but also the market level variable as the local physician supply affect the care dispersion in terms of numbers and specialty mix of physicians treating colorectal cancer patients with the same condition. According to these findings, it is suggested that the local physician supply has a causal relationship between the patterns of care dispersion. Supply of primary care physicians and oncology specialists tends to spur the physician utilization across the four specialty groups, which are more likely to have discretionary utilization. In this regard, it is significant to investigate the effects of care dispersion from four specialists on patients' outcomes to justify whether shifting the supply of specialists to primary care physicians could curtail the visits of physician consultation, thus saving great expenditure on health.

All in all, for future study, the local physician supply in the four specialist areas could be used as predictors to help study the causal relationships between care dispersion in terms of number and mix of physicians used by cancer patients, and outcomes such as patient survival and costs. Further investigation could help health policy makers examine the justification of policy that intends to maintain health expenditures by encouraging primary care physicians in the local areas.

STUDY LIMITATIONS

The first limitation for this study is to estimate the physician supply precisely. People travel for medical care around different areas, especially those who reside in remote and non-urban areas. It is hard to define where the local area physician supply for each area exists across urban and suburban areas. The definition of a supply area is crew-fly distance, but not the real driving distances. There may be a much more time-consuming drive to the east side within a 50-mile radius distance, but less to the west side. If that is the case, the measure of the supply would be imprecise and would need to be recalculated. Moreover, the supply areas for each specialty group might be different according to patients' needs and physicians' networks.

Physician use in a multispecialty practice group could be another limitation. This measure does not represent the individual practice pattern, but rather the aggregate effects from the group members after treatments. In this study, we recode the multispecialty practice group into the physician who billed Medicare, to try to find the major care giver's specialty. However, this recoded measure of physician uses in a multispecialty practice group still has the limitation of representing the effect of any specific specialty group.

The geographic generalization for the results in this study is limited. The registry areas for collecting data for the SEER database are approximately 10% of the United States population since 1973, which included the states of Connecticut, Hawaii, Iowa, New Mexico, and Utah, as well as the metropolitan areas of Detroit, San Francisco-Oakland, Atlanta, and Seattle-Puget Sound. The inclusion of these areas has expanded year by year. The most updated SEER database represented around 25% of the U.S. population in 2000. However, the SEER registry areas have not been randomly selected, so the generalization for the results from the SEER database is still limited. Those results below refer to the elderly population included in the SEER registry areas.

Another limitation is missing data. Because the SEER-Medicare data contain claims only for fee-for-service (FFS) care, or patients whose services were within HMOs, there would be a lack of claims data for HMO enrollees. As of the end of 2001, only 4% of HMO enrollees were registered in the Medicare system, with significant variation by geographic areas. We intend to exclude those people who were recorded to have enrolled in HMOs 12 months prior to diagnosis and 12 months after diagnosis to assure the validity of record completeness.

Variation still exists between each of the SEER registries in terms of demographic factors. As for age and gender distributions, similar patterns can be seen across all registry areas. However, significant variation exists between SEER registry areas in the racial composition of persons elder than 65 years old. Some states' populations are exclusively white, whereas some metropolitan areas have greater proportions of minority populations. In our study, the racial distribution might refer to the access to physicians. In other words, Caucasian people might feel they have more access to seeing doctors than other ethnicity groups might feel. This factor might lower the effects on the care dispersion.

APPENDIX

Table A1. Distribution of total unique medical physicians seen by each patient in four categories in the study population without E/M definition

Categories	Mean	Std Dev	Min	5%	25%	50%	75%	95%	Max
Primary care physicians	2.91	2.03	0	1	1	2	4	7	18
Oncology specialist	1.00	1.16	0	0	0	1	1	3	8
Surgeon specialist	1.46	0.77	0	1	1	1	2	3	7
Other specialists	11.82	7.15	0	3	7	11	15	25	74
All of the above	17.10	8.61	1	7	11	16	21	33	88

Table A2. Distribution of Physician Visit Index for each patient in the study population without E/M definition

Categories	Mean	Std Dev	Min	5%	25%	50%	75%	95%	Max
Physician Visit Index from each individual physician (cnt_HI)	0.21	0.13	0.02	0.07	0.12	0.18	0.27	0.46	1.00
Physician Visit Index across the four specialty groups	0.46	0.12	0.25	0.31	0.37	0.44	0.51	0.71	1.00

Table 20. The effect of local area physician supply in four specialty categories on the number of unique physicians used per patient without E/M definition

Dependent variable: The total number of all unique physicians seen by each patient			
Independent (Explanatory) variables	Parameter Estimate	Standard Error	Pr>| t |
Number of Primary care physicians per 1,000 four-cancer patients within 50 miles from each patient's zip code centroid	0.09350	0.61066	<.0001
Number of Oncology specialists per 1,000 four-cancer patients within 50 miles from each patient's zip code centroid	1.0116	0.13380	<.0001
Number of Surgical specialists per 1,000 four-cancer patients within 50 miles from each patient's zip code centroid	-0.89412	0.09523	<.0001
Number of Other specialists per 1,000 four-cancer patients within 50 miles from each patient's zip code centroid	-0.00243	0.00790	0.7586

Note:
1. All other undisplayed regressors are listed in Tables 10-11.
2. $R^2 = 0.0943$

Table A4. The effect of local area physician supply in four specialty categories on the number of unique physicians used in primary care physicians in the four categories per patient without E/M definition

Dependent variable: The total number of unique Primary care physicians seen by each patient			
Independent (Explanatory) variables	Parameter Estimate	Standard Error	Pr>| t |
Number of Primary care physicians per 1,000 four-cancer patients within 50 miles from each patient's zip code centroid	0.01081	0.00261	<.0001
Number of Oncology specialists per 1,000 four-cancer patients within 50 miles from each patient's zip code centroid	0.08344	0.03270	0.0108
Number of Surgical specialists per 1,000 four-cancer patients within 50 miles from each patient's zip code centroid	-0.04892	0.02327	0.0356
Number of Other specialists per 1,000 four-cancer patients within 50 miles from each patient's zip code centroid	-0.00389	0.00193	0.0439

Note:
1. All other undisplayed regressors are listed in Tables 10-11.
2. $R^2 = 0.0288$

Table A5. The effect of the local area physician supply in four specialty categories on the number of unique physicians used in oncology specialists in the four categories per patient without E/M definition

Dependent variable: The total number of unique Oncology specialists seen by each patient			
Independent (Explanatory) variables	Parameter Estimate	Standard Error	Pr>| t |
Number of Primary care physicians per 1,000 four-cancer patients within 50 miles from each patient's zip code centroid	0.00769	0.00143	<.0001
Number of Oncology specialists per 1,000 four-cancer patients within 50 miles from each patient's zip code centroid	0.19596	0.01799	<.0001
Number of Surgical specialists per 1,000 four-cancer patients within 50 miles from each patient's zip code centroid	-0.07359	0.01280	<.0001
Number of Other specialists per 1,000 four-cancer patients within 50 miles from each patient's zip code centroid	-0.00331	0.00106	0.0018

Note:
1. All other undisplayed regressors are listed in Tables 10-11.
2. $R^2 = 0.1014$

Table A6. The effect of local area physician supply in four specialty categories on the number of unique physicians used in surgical specialists in the four categories per patient without E/M definition

Dependent variable: The total number of unique Surgeon specialists seen by each patient			
Independent (Explanatory) variables	Parameter Estimate	Standard Error	Pr>| t |
Number of Primary care physicians per 1,000 four-cancer patients within 50 miles from each patient's zip code centroid	0.00256	0.00098686	0.0094
Number of Oncology specialists per 1,000 four-cancer patients within 50 miles from each patient's zip code centroid	0.01750	0.01239	0.1576
Number of Surgical specialists per 1,000 four-cancer patients within 50 miles from each patient's zip code centroid	-0.00017620	0.00882	0.9841
Number of Other specialists per 1,000 four-cancer patients within 50 miles from each patient's zip code centroid	-0.00167	0.00073104	0.0244

Note:
1. All other undisplayed regressors are listed in Tables 10-11.
2. $R^2 = 0.0269$

Table A7. The effect of local area physician supply in four specialty categories on the number of unique physicians used in other specialists in the four categories per patient without E/M definition

Dependent variable: The total number of unique Other specialists seen by each patient			
Independent (Explanatory) variables	Parameter Estimate	Standard Error	Pr>| t |
Number of Primary care physicians per 1,000 four-cancer patients within 50 miles from each patient's zip code centroid	0.07129	0.00882	<.0001
Number of Oncology specialists per 1,000 four-cancer patients within 50 miles from each patient's zip code centroid	0.71663	0.11069	<.0001
Number of Surgical specialists per 1,000 four-cancer patients within 50 miles from each patient's zip code centroid	-0.75399	0.07878	<.0001
Number of Other specialists per 1,000 four-cancer patients within 50 miles from each patient's zip code centroid	0.00564	0.00653	0.3884

Note:
1. All other undisplayed regressors are listed in Tables 10-11.
2. $R^2 = 0.0983$

Table A8. Trends of effects of local physician supply on the unique physician use in the four specialty groups without E/M definition

Physician supply	Unique physician use in all services in four specialty groups			
Specialty groups	Primary care	Oncology	Surgical	Other
Primary care	Increase***	Increase***	Increase***	Increase***
Oncology	Increase **	Increase***	Increase	Increase***
Surgical	Decrease**	Decrease***	Decrease	Decrease***
Other	Decrease **	Decrease***	Decrease**	Increase

Significance level: *, ** and *** indicate significance at p<0.1, p<0.05, and p<0.01, respectively.

Table A9. The effect of the local area physician supply in four categories on the Physician Visit Index per 1,000 patients without E/M definition

Dependent variable: The physician visit index seen by each patient			
Independent (Explanatory) variables	Parameter Estimate	Standard Error	Pr>| t |
Number of Primary care physicians per 1,000 four-cancer patients within 50 miles from each patient's zip code centroid	-0.00048396	0.00017	0.0034
Number of Oncology specialists per 1,000 four-cancer patients within 50 miles from each patient's zip code centroid	-0.00362	0.00208	0.0812
Number of Surgeon specialists per 1,000 four-cancer patients within 50 miles from each patient's zip code centroid	0.01074	0.00148	<.0001
Number of Other specialists per 1,000 four-cancer patients within 50 miles from each patient's zip code centroid	-0.000436	0.00012	0.0004

Note:
1. All other undisplayed regressors are listed in Tables 10-11.
2. R^2= 0.0653

Table A10. The effect of the local area physician supply in four categories on the Physician Visit Index of across four specialty groups per 1,000 patients without E/M definition

Dependent variable: The Herfindahl visit index coded as E/M services seen by each patient			
Independent (Explanatory) variables	Parameter Estimate	Standard Error	Pr>| t |
Number of Primary care physicians per 1,000 four-cancer patients within 50 miles from each patient's zip code centroid	-0.00133	0.00016	<.0001
Number of Oncology specialists per 1,000 four-cancer patients within 50 miles from each patient's zip code centroid	-0.01373	0.00201	<.0001
Number of Surgeon specialists per 1,000 four-cancer patients within 50 miles from each patient's zip code centroid	0.00719	0.00143	<.0001
Number of Other specialists per 1,000 four-cancer patients within 50 miles from each patient's zip code centroid	0.000514	0.00012	<.0001

Note:
1. All other undisplayed regressors are listed in Tables 10-11.
2. R^2 = 0.0339

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