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The Effects of Hospital Characteristics on Delays in Breast Cancer Diagnosis in Appalachian Communities: A Population-based Study

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Abstract

Purpose—Despite being generally accepted that delays in diagnosing breast cancer are of prognostic and psychological concern, the influence of hospital characteristics on such delays remains poorly understood, especially in rural and underserved areas. However, hospital characteristics have been tied to greater efficiency and warrant further investigation as they may have implications for breast cancer care in these areas.

Methods—Study data were derived from the Kentucky, North Carolina, Ohio, and Pennsylvania state central cancer registries (2006–2008). We then linked Medicare enrollment files and claims data (2005–2009), the Area Resource File (2006–2008), and the American Hospital Association Annual Survey of Hospitals (2007) to create an integrated data set. Hierarchical linear modeling was used to regress the natural log of breast cancer diagnosis delay on a number of hospital-level, demographic, and clinical characteristics.

Findings—The baseline study sample consisted of 4,547 breast cancer patients enrolled in Medicare that lived in Appalachian counties at the time of diagnosis. We found that hospitals with for-profit ownership ($P < .01$) had shorter diagnosis delays than their counterparts. Estimates for comprehensive oncology services, system membership and size were not statistically significant at conventional levels.

Conclusions—Some structural characteristics of hospitals (eg, for-profit ownership) in the Appalachian region are associated with having shorter delays in diagnosing breast cancer. Researchers and practitioners must go beyond examining patient-level demographic and tumor characteristics to better understand the drivers of timely cancer diagnosis, especially in rural and underserved areas.

Keywords

Appalachia; breast cancer; hospitals; Medicare; rural areas

Breast cancer is the most common form of non-skin cancer in US women, and it is estimated that more than 246,000 new cases will be diagnosed in 2016.¹ Delays in breast cancer diagnosis (defined as the number of days from a patient's initial breast screening or consultation until confirmed pathologic diagnosis)² have been generally accepted as being of prognostic concern and may negatively influence risk indicators, such as tumor stage³ and size⁴ at diagnosis, outcomes such as survival rates,^{5,6} and psychological issues for patients and families (eg, stress).⁷⁻¹³ Despite these implications, the role of hospitals and health systems in delays in breast cancer diagnosis remains poorly understood.¹⁴⁻¹⁹ In fact, the literature has vastly ignored macro-level organizational factors in evaluating the potential drivers of breast cancer diagnosis delays. Moreover, rural areas and regions that are characterized as medically underserved have not been the subject of prior research on breast cancer diagnosis delays.

Appalachia is a region of the US that is well-documented as having a medically underserved population,^{20,21} reduced access to cancer services,²² and inadequate cancer-control strategies.²³ This primarily rural region consists of 13 states stretching from New York to Mississippi and is also characterized as having a disproportionately high number of low-income families and high unemployment rates.²¹ Primarily for these reasons, The National Cancer Institute (NCI) designated Appalachia as a special population of interest.²⁴ However, despite this recognition by NCI, the organizational infrastructure in Appalachia has continued to suffer from a shortage of health care professionals,²⁵ a declining number of acute care hospitals,²⁶ and a small number of comprehensive cancer centers (n=3).²⁷

The relationship between organizational characteristics and improved health outcomes has been demonstrated across various disease types, including some cancers,²⁸ psychiatric diagnoses,²⁹ acute myocardial infarction,³⁰ congestive heart failure,³¹ and cardiac surgery.³² These relationships suggest that organizations play a critical role in determining the efficacy of health care delivery processes and point to the importance of a number of factors (eg, size, scale, ownership type, etc.) operating at the organizational level. In the present study, we examined the effect of hospital characteristics on delays in breast cancer diagnosis. The objective was to examine whether certain characteristics of the hospital where breast cancer was diagnosed—its ownership structure (eg, public or private), specialized capabilities, system membership, and size—were related to delays in diagnosis for patients living in Appalachian communities. Study findings advance our understanding of hospital variation in breast cancer diagnosis delays among the Appalachian population.

Methods

Data

The study design was a secondary data analysis which integrated 4 cross-sectional data sets. We began by linking 2 population-based data sources. State central cancer registry (CCR)

data on breast cancer incidence for the calendar years 2006-2008 were obtained for all patients living in the Appalachian counties of Kentucky (KY), North Carolina (NC), Ohio (OH), and Pennsylvania (PA). Patients included in the sample represented 167 of the 420 counties designated as Appalachian counties (40%). These states were selected based on data availability and cost. We linked the CCR data with Medicare enrollment files and claims data for the years 2005-2009, encompassing at least one year before and after the diagnosis date, using 3 unique identifiers: (1) social security number, (2) sex, and (3) date of birth. Across the 2 data sets, more than 98% of patients matched exactly on all 3 of these identifiers. Patients not matched on all 3 identifiers (<2%) were dropped from analysis. Medicare claims data have been used widely in cancer research because Medicare insures more than 97% of the US population 65 and older and has a high likelihood of having complete claims data for patients not belonging to a health maintenance organization.³³⁻³⁷ This linked data set was also used to identify diagnosis date and the patients' hospital provider. In some cases, patients had claims from multiple hospitals, so the hospital provider was identified as the one with the claim nearest to the diagnosis date.ⁱ We then joined data from the Area Resource File (ARF) for the years 2006-2008 using county Federal Information Processing Standard (FIPS) codes based on the patient's county of residence to include demographic and socioeconomic descriptors. Finally, we linked the 2007 American Hospital Association (AHA) Annual Survey of Hospitals data to incorporate hospital characteristics using the Medicare provider identification number. The 2007 survey data were selected because multi-year state CCR and Medicare data were used and the hospital characteristics reported in the AHA survey infrequently change from year-to-year.

Study Sample

Figure 1 depicts the inclusion and exclusion criteria for the present study.ⁱⁱ Continuous enrollment in a Medicare fee-for-service (FFS) health plan for the 12 months prior to a diagnosis of breast cancer was required for inclusion in this study. Excluding males (n=1), patients with a secondary tumor site that was reported to a state CCR (n=1,823), and those with missing data (eg, tumor characteristics, provider identification number) (n = 1,027), the number of Medicare patients who were diagnosed with breast cancer between January 1, 2006, and December 31, 2008, in the Appalachian counties of KY, NC, OH, and PA was 4,957. From this sample, we excluded patients who had a diagnosis delay greater than 180 days (n = 365).ⁱⁱⁱ This exclusion criteria was applied because it is possible that delays of more than 6 months may be related to unknown factors, such as a second primary tumor, that are not necessarily germane to the acute instance of breast cancer in question.³⁸ The final exclusion criteria was applied to breast cancer patients whose home address at the date of diagnosis was within an Appalachian county of KY, NC, OH, or PA, but who were diagnosed at an organization outside of one of those states (n = 45). Thus, the final study sample consisted of 4,547 breast cancer patients.

ⁱWe conducted a sensitivity analysis on the baseline regression model that included an independent variable, controlling for the number of providers a patient had claims for during the diagnostic process, and no notable differences were identified.

ⁱⁱThe study inclusion and exclusion criteria were adapted from McLaughlin et al.³⁸

ⁱⁱⁱWe conducted a subsequent outlier analysis of patients with a diagnosis delay greater than 180 days and no notable differences were identified.

Variables

Outcome Variable—The outcome variable of interest in this study was diagnosis delay. To calculate diagnosis delay, we constructed a time interval (in days) for each patient that began with a patient's initial breast-related consultation and ended with the date of pathology-confirmed diagnosis reported to the state CCR.^{2,39-43} The initial consultation date was defined as the date of the first claim for (1) a medical consultation for abnormal breast symptoms, (2) screening mammography, or (3) a diagnostic mammography. Abnormal breast symptoms were identified using *Internal Classification of Diseases, 9th Revision* (ICD-9) codes 611.71, 611.72, 611.79, and 611.9, while screening and diagnostic mammograms for years 2005 and 2006 were identified using *Current Procedural Terminology* (CPT) codes 76082, 76083, 76090, 76091, and 76092. Changes in mammography CPT codes for the years 2007–2009 prompted the use of codes 77051, 77052, 77055, 77056, and 77057 for those years. Moreover, in all years we searched for these mammography codes in conjunction with a corresponding diagnosis code of V76.11 or V76.12 to ensure the capture of all screening and diagnostic mammography claims. All patients included in the sample had a diagnosis date.

Hospital-Level Variables—Hospital characteristics (for-profit ownership, whether the hospital provides comprehensive oncology services, system membership, and hospital size) were derived from hospital responses to the 2007 AHA Annual Survey of Hospitals. We created binary variables for for-profit ownership (hospitals owned by private investors), hospitals that provide comprehensive oncology services (encompassing screening, diagnostic, and treatment modalities), and hospitals that are members of multi-hospital health systems (2 or more hospitals affiliated with the same parent organization). Hospital size, measured by the number of total inpatient admissions for a hospital, was included as a continuous variable.

Patient-Level Variables—Patient socio-demographic characteristics (race, age, marital status, diagnosis year, diagnosis quarter, diagnosis state, patient ZIP code of residence at diagnosis date, median income of county of residence) were derived from state CCRs, Medicare enrollment files and claims data, and the ARF. Race was categorized into white and African American. Very small sample sizes (<1%) for all other races (eg, Alaska Native, American Indian, Asian Americans, or Pacific Islanders) and ethnicities (eg, Hispanic) prevented analysis in the present study.³⁸ Marital status was categorized into married (or member of a domestic partnership) and not married (single, divorced/separated, or widowed). Diagnosis quarter, or the quarter of the calendar year when a diagnosis was made, was included to account for seasonal variation as Appalachia's mountainous terrain and periods of prolonged inclement weather may be a contributing factor to diagnosis delay. We also categorized a patient's ZIP code of residence at the date of diagnosis into metropolitan and non-metropolitan based on the US Office of Management and Budget (OMB) designations.⁴⁴ Median income for the patient's county of residence at the date of diagnosis was included as a continuous variable.

Tumor-specific characteristics (American Joint Committee on Cancer consolidated cancer stage, lymph node involvement, presence of a sentinel lymph node, hormone receptor status)

were obtained from state CCR data. Breast cancer stage at diagnosis was segmented into 4 categories: *in situ* (tumor confined to its site of origin), localized (primary site only with no lymph node involvement), regional (regional lymph node involvement or directly beyond the primary tumor site), or distant (metastasized). Lymph node involvement was categorized into no level I/II AD and level I/II AD. The presence of a sentinel lymph node was also accounted for (No/Yes). Hormone receptor status (based on data for estrogen receptor (ER) and progesterone receptor (PR) statuses) of a tumor was categorized into 1 of 4 groups: (1) positive, if ER or PR positive, (2) negative, if ER and PR negative, (3) borderline, and (4) undetermined/unknown. Human epidermal growth factor receptor 2 (HER2) status data were not available. Tumor size was omitted from the analysis due to missing data.

A Deyo-version⁴⁵ of the Charlson co-morbidity index was calculated for each patient using Medicare claims data. This 18-comorbidity index assesses the extent to which patients diagnosed with cancer are affected by other diseases as well and counts how many comorbid conditions (based on specific diagnosis codes) are present. Since cancer was the disease of interest in this study, it was not included in the co-morbidity index. Co-morbidity burden was assessed for the period of 1 year prior to the date of breast cancer diagnosis through 1 month prior to the diagnosis date.

Statistical Analyses

Descriptive statistics were provided to assess the distribution of patients within the study sample in terms of the covariates. Estimation of a linear mixed model was used to identify both patient- and hospital-level variables with an influence on diagnosis delay. We took the natural log of the outcome variable, diagnosis delay, to ensure that the error term of the model was more likely to approximate a normal distribution. Moreover, we accounted for heteroscedasticity by clustering the patients treated at each hospital. Tests for co-linearity revealed no problematic relationships between independent variables. Statistical significance of regression coefficients was assessed using *t*-tests.

Because statistically significant differences were detected in the baseline regression model and the sample size of for-profit hospitals was relatively small, we elected to test the robustness of the findings with respect to ownership. A propensity score analysis using the nearest neighbor matching methodology was conducted in order to ensure comparability between treated observations (ie, patients diagnosed with breast cancer in for-profit hospitals) and controls.⁴⁶ More specifically, each patient diagnosed with breast cancer at a for-profit hospital was matched (1:1 matching) with a patient having similar hospital (system membership, hospital size) and demographic (race, age, marital status, diagnosis year, diagnosis quarter, diagnosis state, patient ZIP code of residence at diagnosis date, median income in county of patient residence, number of co-morbid conditions, cancer stage at diagnosis, lymph node involvement, presence of a sentinel lymph node, hormone receptor status) characteristics, but who was diagnosed at a non-profit hospital. For the model that generated the propensity score the random effect was at the facility level. For the matched models, the random effect was the matched pair. We then re-ran the baseline linear mixed model using the matched sample and assessed statistical significance of the regression coefficients with *t*-tests. Sensitivity analyses were conducted to match each patient in a for-

profit hospital with 2, then 3 similar patients at non-profit hospitals. These sensitivity analyses showed no substantive change in our findings. Moreover, we compared covariate balance between for-profit patients and non-profit patients using standardized biases (results not shown). No significant covariate imbalance was found after matching.⁴⁷ Analyses were carried out using Stata statistical software.⁴⁸

Findings

Descriptive Findings

Table 1 reports hospital-level, demographic, tumor, and morbidity characteristics for the patients included in the study (n=4,547). In terms of the hospital where breast cancer was diagnosed, two percent of patients were diagnosed at a for-profit hospital. This relatively small number of patients is consistent with the overall ratio of for-profit hospitals to non-profit hospitals during the time of this research.²⁶ Seventy-nine percent of patients were diagnosed at a hospital that reported providing comprehensive oncology services and 42% were diagnosed at a hospital that was a member of a health system. The mean hospital size in the study had an inpatient admission total of 10,760 during 2007. Table 1 also demonstrates that the majority (96%) of women in this study were white. This high proportion of white women with breast cancer is consistent with prior Appalachia research.⁴⁹ Sixty-three percent of women lived in a metropolitan area. Thirty-nine percent of women had 3 or more co-morbid conditions, while slightly more than half (53%) were diagnosed with local stage breast cancer.

Mean Diagnosis Delay by Covariate

Table 2 reports the mean, median, and interquartile range for each of the variables included in our study. Patients that received a breast cancer diagnosis at a for-profit hospital were, on average, diagnosed in about two-thirds the time of patients diagnosed at non-profit hospitals (20 days vs 29 days, $P < .05$). In terms of the demographic variables, African American women had a shorter diagnosis delay on average than white women (24 days vs 29 days, $P < .05$). Moreover, women 75-84 had the shortest mean diagnosis delay (25 days vs 28-34 days for other age groups) of all age groups in the study ($P < .0001$). We also found that hormone receptor status was significantly longer, on average, for borderline patients (43 days vs 28-31 days for other hormone receptor statuses, $P < .05$).

Baseline Regression Results

Table 3 reports the coefficients and standard errors from the baseline linear regression model (n=4,547). Based on the coefficients for the hospital-level variables, the estimates suggest that relative to patients diagnosed at non-profits, patients diagnosed with breast cancer at for-profit hospitals ($P < .01$) had shorter diagnosis delays. Moreover, patients diagnosed at hospitals that provided comprehensive oncology services displayed only a trend toward significance when compared to hospitals not providing comprehensive oncology services. No statistically significant differences were noted among the other key hospital variables: system membership and hospital size. In terms of the demographic variables included in the model, the estimates suggest that women 75-84 had the shortest diagnosis delay ($P < .01$), followed by women 85+ ($P < .05$). Moreover, coefficients for the quarterly indicators

suggest some seasonality in diagnosis delay. Specifically, women diagnosed in April-June had the shortest diagnosis delays ($P < .05$). Among tumor characteristics, cancer stage at diagnosis was associated with longer diagnosis delays for women with local ($P < .05$) and regional ($P < .05$) disease.

Regression Results Using Propensity Score Matched Sample

Table 4 reports the coefficients and standard errors from the regression results using the propensity score matched sample ($n=214$), carried out as a robustness check on the for-profit ownership finding in Table 3. One patient diagnosed at a for-profit hospital could not be matched. Based on the coefficients, the estimates from the propensity score model suggest that relative to non-profits, patients diagnosed with breast cancer at for-profit hospitals had a statistically significant shorter diagnosis delay (20 days vs 28 days, $P < .01$). Also, hospitals that provided comprehensive oncology services ($P < .05$) demonstrated a statistically significant shorter diagnosis delay in the matched sample.^{iv} Consistent with the base analysis, statistically significant differences were not detected for system membership or hospital size. In terms of the demographic variables included in the model, the estimates suggest that women ages 75-84 ($P < .05$) and 85+ ($P < .05$) had a shorter diagnosis delay. Further, women with co-morbid conditions in this model had a statistically significant shorter diagnosis delay than those without a co-morbid condition. Specifically, women with 1 co-morbid condition ($P < .01$) and 3 or more co-morbid conditions ($P < .01$) had statistically significant shorter diagnosis delays than women with no co-morbid conditions, while women with 2 comorbidities displayed a trend toward significance.

Several differences were noted between the baseline regression model and the propensity score matching regression model. Following analysis using the reduced data sample, we observed changes in the level of significance and/or direction among some of the hospital and demographic variables including ownership status, hospitals providing comprehensive oncology services, age, marital status, diagnosis quarter, the number of co-morbid conditions, and cancer stage.

Discussion

These findings indicate that organizations may play an important role in diagnosis delay among women with breast cancer in the Appalachian region. The findings support the idea that for-profit hospitals in this region may be more efficient in diagnosing patients than their not-for-profit counterparts. Prior work on hospital ownership suggests that these findings may reflect a unique institutional logic specific to for-profit hospitals.^{50,51} In particular, the market-oriented logic of for-profit hospitals may function as a driver of efficiency, productivity, and increased sensitivity to customer demand, while non-profit and government hospitals may place greater emphasis on community-based or politically oriented objectives that do not equate to operational efficiencies. Prior research on hospital efficiency supports this idea and has identified a strong relationship between investor-owned hospitals and greater efficiency.⁵²⁻⁵⁴

^{iv}The number of days for this variable is not reported in a separate table as the propensity score analysis was performed as a robustness check on the for-profit variable.

The findings with respect to for-profit ownership status may also reflect, to some degree, the resources of large for-profit health systems that own hospitals in Appalachian communities. In a more detailed examination of the for-profit hospitals in this study that stemmed from our principal finding, we observed that the vast majority are members of multi-state health systems comprising more than 48 hospitals. More specifically, of the 28 for-profit hospitals in this study, 22 (79%) were members of health systems with more than 48 hospitals. By contrast, 54% of the non-profit hospitals in this study were not members of a health system, and of those non-profit hospitals that were part of a health system, 78% were in systems with fewer than 15 hospitals. The implication of this finding is that large, nationally integrated health systems may come with advantages not typically available to stand-alone facilities or even small local systems commonly found in many underserved communities, such as Appalachia. Such advantages may include access to capital, management expertise, and the learning benefits associated with in-system information sharing and knowledge transfer. Yet, future research is needed to examine how these issues, specifically the benefits of large health systems, relate directly to diagnosis delays and other process measures.

Our for-profit hospital finding is also of broader national importance in that the number of for-profit hospitals has risen sharply since the time this research began. Specifically, the number of for-profit hospitals in the US increased from 890 to 1,060 from 2006-2013. Meanwhile, the number of non-profits declined from 2,919 to 2,904 and government-owned hospitals declined from 1,119 to 1,010 during the same period.²⁶ These statistics indicate that government-owned hospitals are being acquired by for-profit owners in many underserved communities, where state and county ownership is common. For example, LifePoint Health (Brentwood, Tennessee), a for-profit health system, recently purchased Fleming County Hospital (FCH), a financially distressed government-owned hospital in Flemingsburg, KY.⁵⁵ Transactions of this nature are significant in strengthening underserved, rural communities for reasons of efficiency (eg, shorter diagnosis delays) and increased access (eg, service line expansions), as well as financial stability (eg, new sources of tax revenue supporting local schools, projects). However, for patients with Medicaid and charity care, for-profit hospitals tend to shift non-emergent care to other providers, potentially reducing those residents' access to certain services, including mammography. Related to this topic, a recent spate of hospital closures in rural America (71 nationwide since January 2010), with at least 1 in our study area (Nicholas County Hospital in KY), raises concerns for access to care.⁵⁶ Furthermore, more than 600 other rural US hospitals are considered "at-risk."⁵⁷ Nonetheless, further research is needed to determine whether this increase in the number of for-profit hospitals has translated into improved access to health care services without negative impacts on the price of care in these rural and underserved communities. As it stands, this analysis suggests only that for-profit hospitals achieve a "faster" breast cancer diagnosis, which is merely one factor patients should consider when selecting a hospital for care.

Another interesting topic that arose through our regression analyses, although only displaying a trend toward significance in the baseline model, suggests that hospitals providing comprehensive oncology services may achieve slightly shorter diagnosis delays. Two related issues may be noteworthy here: (1) the organizational integration of specialized, yet interdependent tasks, and (2) the level of experience the organization has in performing

this set of interrelated tasks (eg, prevention, breast cancer screening, diagnosis, treatment). The organizational integration of the necessary components of oncology care (including the required use of cancer patient navigators for hospitals accredited by the American College of Surgeons Commission on Cancer) may facilitate more rapid progression through each phase of the care continuum, including the diagnostic phase. Moreover, the visible presence of these specialized capabilities within the organization may direct greater organizational attention to the resources, rules, and relationships involved in diagnosing breast cancer⁵⁸ and result in better cross-unit coordination.⁵⁹ From a policy perspective, if further research supports this idea, a consideration could be initiated from government hospitals to request specific tax funding for providing specific services that constitute comprehensive breast cancer care. However, we exercise caution in interpreting these results and believe that further research is warranted to substantiate them on a broader level.

Study findings advance the literature on breast cancer diagnosis delays by providing an organizational perspective on the diagnostic process within underserved communities. Specifically, they support the notion that some hospital characteristics are related to differences in diagnosis delays. Wujcik & Malin-Fair examined the literature on barriers to diagnostic resolution after abnormal breast symptoms and found that very few studies have evaluated provider and system influences.¹⁹ In our review of scholars that studied provider and system delays, we concluded that past studies were focused primarily on communication (eg, physician-to-physician, physician-to-patient) and process (eg, delays in scheduling, lack of operating room access) barriers. Thus, our study contributes a needed perspective by shedding light on the broader context within which diagnosis delays occur, while focusing on an underserved population as a study setting.

Study Limitations

This study has several limitations. First, we may be limited in our ability to generalize the results of this study to the broader US population of women with breast cancer as it includes only the Appalachian counties of 4 states. Given Appalachia's distinct characteristics, it exhibits some attributes that may differentiate it from other areas of the US. However, since this study incorporates approximately 40% of the Appalachian counties and is population-based, we argue that these findings are likely generalizable to the 420 federally designated Appalachian counties that stretch across 13 states. A second limitation stems from the use of Medicare claims data. This data source includes predominantly patients 65 and older, and thus it may not represent breast cancer diagnosis delay among younger patients, those with no or few co-morbidities, or those covered by different insurance types. Nevertheless, from 2006-2008 nearly half (42.4%) of US women with breast cancer were 65 and older¹ and prior scholars have demonstrated that Medicare volumes are highly correlated with overall volumes.⁶⁰⁻⁶³ Third, this study may be limited in that while we focused on hospital providers, there may be other outpatient facilities or individuals involved in the diagnostic process, the characteristics of which we are unable to measure. However, the existence of these providers may reflect the ability of hospitals to coordinate care with each of these other entities. For example, consider that a patient may elect to use a freestanding outpatient imaging center for mammography and ultrasound testing, while opting to have the more complex diagnostic testing (eg, biopsy, pathology) performed at a hospital. In this scenario,

the hospital must lead and coordinate a process for retrieving the results of all imaging studies conducted at the outpatient imaging center prior to proceeding with a biopsy or other testing. Finally, while there is interest in understanding causal processes related to delays in breast cancer diagnosis, the statistical analysis used in this study is limited to making inferences about association. Nonetheless, the relationships identified in this study provide an evidence base that can be used to create studies using primary data that may more definitively determine causality.

Conclusion

Despite these limitations, the findings of this study are novel and improve our understanding of the underlying issues related to breast cancer diagnostic delays in underserved communities. Specifically, this study points to the importance of hospital characteristics (specifically, for-profit ownership) and advances our conceptual and empirical understanding of the role these characteristics play in diagnostic delays. This study also supports the notion that the breast cancer research community must go beyond examining demographic and clinical characteristics to understand why some patients are diagnosed more expeditiously than others. Diagnosis is a process of allocating resources to patients, and hospitals and health systems are at the center of that process. These findings suggest that improving our understanding of how such resources are organized, in order to improve process efficiency, may provide helpful insights in minimizing diagnosis delays.

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Figure 1.
Study Inclusion and Exclusion Criteria

Table 1

Descriptive Characteristics of the Study Sample

n=4,547

Characteristic	N	(%)
Hospital Characteristics		
For-profit Ownership	108	2.4
Non-profit Ownership	4,439	97.6
Hospital Provides Comprehensive Oncology Services	3,571	78.5
Hospital Does Not Provide Comprehensive Oncology Services	976	21.5
System Membership	1,910	42.0
Not a System Member	2,637	58.0
Hospital Size (Number of Admissions), ^a IQR (Q1,Q3)	10,760 (5,961,18,215)	
Patient Demographic Characteristics		
Race		
White	4,377	96.3
African American	170	3.7
Age		
< 65	393	8.7
65-74	1,847	40.6
75-84	1,734	38.1
85+	573	12.6
Marital Status		
Married	2,058	45.3
Not Married	2,489	54.7
Diagnosis Year		
2006	1,577	34.7
2007	1,526	33.7
2008	1,444	31.8
Diagnosis Quarter		
January-March	1,092	24.0
April-June	1,132	24.9
July-September	1,178	25.9
October-December	1,145	25.2
Diagnosis State		
Kentucky	128	2.8
North Carolina	1,036	22.8
Ohio	325	7.1
Pennsylvania	3,058	67.3
Patient ZIP Code of Residence at Diagnosis Date		
Metropolitan	2,845	62.6
Non-metropolitan	1,702	37.4
Median Income in County of Patient Residence (in \$), IQR (Q1,Q3)	41,594 (37,949, 43,889)	

n=4,547

Characteristic	N	(%)
Tumor/Cancer Characteristics		
Cancer Stage at Diagnosis		
in situ	709	15.6
Local	2,398	52.8
Regional	1,166	25.6
Distant	274	6.0
Lymph Node Involvement		
No level I/II AD	1,558	34.3
Level I/II AD	2,989	65.7
Sentinel Lymph Node		
No	4,485	98.6
Yes	62	1.4
Hormone Receptor Status		
Positive	3,486	76.7
Negative	654	14.4
Borderline	23	0.5
Undetermined/Unknown	384	8.4
Morbidity Indicators		
Number of Co-morbid Conditions		
0	955	21.0
1	1,041	22.9
2	767	16.9
3+	1,784	39.2

^aThe median is reported for this variable.

Table 2

Mean Diagnosis Delay by Covariate

n=4,547

Characteristic	Mean	Median	IQR	Q1	Q3	P value
Hospital Characteristics						
For-profit Ownership	20	16	28	1	29	.01
Non-profit Ownership	29	18	29	7	36	
Hospital Provides Comprehensive Oncology Services	28	18	29	6	36	.70
Hospital Does Not Provide Comprehensive Oncology Services	29	19	30	7	36	
System Membership	29	18	32	6	38	.21
Not a System Member	28	18	29	7	36	
Hospital Size (Number of Admissions, Above Median)	28	19	30	6	36	.83
Hospital Size (Number of Admissions, Below Median)	29	18	29	7	36	
Patient Demographic Characteristics						
Race						
White	29	18	29	5	32	.048
African American	24	17	27	5	32	
Age						
< 65	34	24	37	6	43	< .0001
65-74	31	20	32	7	39	
75-84	25	15	26	6	32	
85+	28	18	32	6	38	
Marital Status						
Married	29	19	30	7	37	.24
Not Married	28	17	30	6	36	
Diagnosis Year						
2006	28	17	30	6	36	.82
2007	28	18	29	7	36	
2008	29	19	31	7	38	
Diagnosis Quarter						
January-March	30	19	34	7	41	.07
April-June	26	16	26	6	32	
July-September	29	20	31	6	37	
October-December	29	20	31	7	38	
Diagnosis State						
Kentucky	31	21	36	8	43	.83
North Carolina	28	19	30	7	37	
Ohio	28	15	31	4	35	
Pennsylvania	28	18	29	7	36	
Patient ZIP Code of Residence at Diagnosis Date						
Metropolitan	28	18	30	6	36	.32
Non-metropolitan	29	19	29	7	36	

n=4,547

Characteristic	Mean	Median	IQR	Q1	Q3	P value
Income in County of Patient Residence						
Above Median	29	19	29	7	36	.52
Below Median	28	17	30	6	36	
Tumor/Cancer Characteristics						
Cancer Stage at Diagnosis						
in situ	28	16	29	6	35	
Local	29	18	32	6	38	.11
Regional	29	20	29	7	36	
Distant	24	15	25	5	30	
Lymph Node Involvement						
No level I/II AD	29	18	30	6	36	.81
Level I/II AD	28	19	29	7	36	
Sentinel Lymph Node						
No	29	18	30	6	36	.86
Yes	28	21	33	9	42	
Hormone Receptor Status						
Positive	28	18	30	6	36	
Negative	31	19	31	7	38	.049
Borderline	43	21	78	15	93	
Undetermined/Unknown	28	17	28	6	34	
Morbidity Indicators						
Number of Co-morbid Conditions						
0	30	20	31	7	38	
1	29	17	31	6	37	.13
2	29	19	30	6	36	
3+	27	18	29	7	36	

Table 3

Baseline HLM Regression Results

n=4,547

Characteristic	Coefficient	Standard Error	P value
Hospital Characteristics			
For-profit Ownership	−0.51	0.14	< .01
Hospital Provides Comprehensive Oncology Services	−0.10	0.06	.10
System Membership	0.03	0.05	.51
Hospital Size (Number of Admissions)	0.01	0.02	.73
Demographic Characteristics			
Race			
White	0.18	0.11	.10
African American	Referent		
Age			
< 65	0.10	0.08	.21
65-74	Referent		
75-84	−0.24	0.05	< .01
85+	−0.19	0.07	.01
Marital Status			
Married	Referent		
Not Married	−0.05	0.04	.21
Diagnosis Year			
2006	Referent		
2007	0.05	0.05	.34
2008	0.10	0.05	.06
Diagnosis Quarter			
January-March	Referent		
April-June	−0.15	0.06	.01
July-September	−0.02	0.06	.70
October-December	0.02	0.06	.73
Diagnosis State			
Kentucky	Referent		
North Carolina	−0.10	0.14	.49
Ohio	−0.25	0.15	.11
Pennsylvania	−0.08	0.14	.56
Patient ZIP Code of Residence at Diagnosis Date			
Metropolitan	Referent		
Non-metropolitan	0.02	0.05	.71
Median Income in County of Patient Residence (per \$10,000)	0.02	0.05	.72
Tumor/Cancer Characteristics			
Cancer Stage at Diagnosis			
in situ	0.14	0.10	.15

n=4,547

Characteristic	Coefficient	Standard Error	P value
Local	0.19	0.09	.04
Regional	0.23	0.09	.01
Distant	Referent		
Lymph Node Involvement			
Level I/II AD	Referent		
No Level I/II AD	0.02	0.05	.60
Sentinel Lymph Node			
No	Referent		
Yes	0.13	0.18	.47
Hormone Receptor Status			
Positive	−0.37	0.29	.21
Negative	−0.29	0.30	.34
Borderline	Referent		
Undetermined / Unknown	−0.40	0.30	.18
Morbidity Indicators			
Number of Co-morbid Conditions			
0	Referent		
1	−0.07	0.06	.24
2	−0.06	0.07	.38
3+	−0.06	0.06	.29

Notes: Regression includes a constant, which is not reported.

Number of hospital clusters (303), Mean = 15 patients (range: 1-234); SE of the random effect = .009; SE of the residual = .04; ICC (rho) $P < .01$

Table 4

Regression Results Using Propensity Score Matched Sample (1:1 Matching)

n=214 (107 for-profit patients^a)

Characteristic	Coefficient	Standard Error	P value
Hospital Characteristics			
For-profit Ownership	−0.54	0.19	.01
Hospital Provides Comprehensive Oncology Services	−0.54	0.25	.03
System Membership	−0.20	0.34	.55
Hospital Size (Number of Admissions)	0.00	0.27	.99
Demographic Characteristics			
Race			
White	−0.10	0.38	.80
African American	Referent		
Age			
< 65	−0.19	0.38	.61
65-74	Referent		
75-84	−0.65	0.23	.01
85+	−0.60	0.28	.03
Marital Status			
Married	Referent		
Not Married	0.25	0.20	.23
Diagnosis Year			
2006	Referent		
2007	0.10	0.26	.69
2008	0.33	0.25	.20
Diagnosis Quarter			
January-March	Referent		
April-June	−0.30	0.29	.30
July-September	−0.20	0.29	.49
October-December	0.20	0.27	.47
Diagnosis State			
Kentucky	Referent		
North Carolina	0.28	0.48	.57
Ohio	−0.62	0.65	.34
Pennsylvania	0.13	0.51	.80
Patient ZIP Code of Residence at Diagnosis Date			
Metropolitan	Referent		
Non-metropolitan	0.07	0.24	.79
Median Income in County of Patient Residence (per \$10,000)	0.05	0.27	.87
Tumor/Cancer Characteristics			
Cancer Stage at Diagnosis			
in situ	−0.27	0.43	.54

n=214 (107 for-profit patients^a)

Characteristic	Coefficient	Standard Error	P value
Local	−0.35	0.40	.38
Regional	0.08	0.43	.86
Distant	Referent		
Lymph Node Involvement			
Level I/II AD	Referent		
No Level I/II AD	−0.30	0.21	.16
Sentinel Lymph Node			
No	Referent		
Yes	(omitted) ^b		
Hormone Receptor Status			
Positive	0.51	0.40	.21
Negative	0.29	0.44	.51
Borderline	Referent		
Undetermined / Unknown	(omitted) ^a		
Morbidity Indicators			
Number of Co-morbid Conditions			
0	Referent		
1	−1.37	0.33	< .01
2	−0.59	0.31	.07
3+	−0.87	0.27	< .01

Note: Regression includes a constant, which is not reported.

^aOne patient diagnosed at a for-profit hospital could not be matched.

^bThis variable was omitted from this model because there was no variation across observations in the matched sample.