Original Article

Understanding Fragmentation of Prostate Cancer Survivorship Care

Implications for Cost and Quality

Ted A. Skolarus, MD, MPH[1,2]; Yun Zhang, PhD[2]; and Brent K. Hollenbeck, MD, MS[1,2]

BACKGROUND: Cancer survivors are particularly prone to the effects of a fragmented health care delivery system. The implications of fragmented cancer care across providers likely include greater spending and worse quality of care. For this reason, the authors measured relations between increasing fragmentation of cancer care, expenditures, and quality of care among prostate cancer survivors. **METHODS:** A total of 67,736 patients diagnosed with prostate cancer between 1992 and 2005 were identified using Surveillance, Epidemiology, and End Results (SEER)-Medicare data. Using the Herfindahl-Hirschman Index and a measure of the average number of prostate cancer providers over time, patients were sorted into 3 fragmentation groups (low, intermediate, and high). The authors then examined annual per capita survivorship expenditures and a measure of quality (ie, repetitive prostate-specific antigen [PSA] testing within 30 days) according to their fragmentation exposure using multinomial logistic regression. **RESULTS:** Patients with highly fragmented cancer care tended to be younger, white, and of higher socioeconomic status (all $P < .001$). Prostate cancer survivorship interventions were most common among patients with the highest fragmentation of care across providers ($P < .001$). After adjustment for clinical characteristics and prostate cancer survivorship interventions, higher degrees of fragmentation continued to be associated with repetitive PSA testing (13.6% for high vs 7.0% for low fragmentation; $P < .001$) and greater spending, particularly among patients not treated with androgen deprivation therapy. **CONCLUSIONS:** Fragmented prostate cancer survivorship care is expensive and associated with potentially unnecessary services. Efforts to improve care coordination via current policy initiatives, electronic medical records, and the implementation of cancer survivorship tools may help to decrease fragmentation of care and mitigate downstream consequences for prostate cancer survivors. ***Cancer* 2012;118:2837-45.** © *2011 American Cancer Society.*

KEYWORDS: prostate cancer, survivorship, expenditures, quality.

INTRODUCTION

Fragmented health care fosters spending growth and compromises the quality of care.[1-4] As a result of poor care coordination, care fragmented among providers may manifest in the form of redundant services, decreased patient satisfaction, and even worse health outcomes.[5-7] Eliminating redundant testing, a potential by-product of fragmentation, could save the US health care system up to $8 billion annually.[8] Because of the complexity of cancer care, the implications of fragmented delivery may be exacerbated and fuel health care spending for patients, providers, and payers. Remedies for fragmentation focus on improving care coordination via electronic medical records[9] and better care planning,[10] with the hope of mitigating its consequences. For these reasons, efforts to improve the coordination of care are centerpieces of current health policy initiatives (eg, medical homes).[10-12]

Because there are over 2 million prostate cancer survivors, accounting for nearly $7 billion in annual spending, minimizing the fragmentation of care for these men has significant cost and quality implications.[13,14] In fact, prostate cancer survivors may be particularly prone to the effects of cancer care that is fragmented across providers. The variety of initial treatments, their long-term side effects (eg, incontinence and impotence), subsequent prostate cancer survivorship interventions (eg, androgen deprivation therapy [ADT]), and a prolonged natural history predispose survivors to fragmented

Corresponding author: Ted A. Skolarus, MD, MPH, Dow Division of Health Services Research, Division of Oncology, Department of Urology, The University of Michigan, 1500 E Medical Center Dr, 3875 Taubman Center, Ann Arbor, MI 48109-5330; Fax: (734) 232-2400; tskolar@med.umich.edu

[1]Division of Oncology, Department of Urology, University of Michigan, Ann Arbor, Michigan; [2]Dow Division of Health Services Research, Department of Urology, University of Michigan, Ann Arbor, Michigan

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cancer care.[15] In addition, having multiple providers (eg, urologists, radiation and medical oncologists, and primary care providers) with fluctuating roles renders patients susceptible to the downstream consequences of fragmentation,[16,17] the implications of which likely include greater spending for cancer care and worse quality of care.

In light of the prevalence, cost, and protracted clinical course of prostate cancer, we performed a study to better understand fragmented cancer survivorship care. We first quantified the degree of fragmentation of prostate cancer care across providers and characterized clinical characteristics and prostate cancer survivorship interventions associated with increasing fragmentation. Next, we assessed the degree to which increasing fragmentation of cancer care across providers was associated with greater spending and potentially decreased quality of prostate cancer survivorship care.

MATERIALS AND METHODS

Study Population

We used Surveillance, Epidemiology, and End Results (SEER)-Medicare data for the years 1992 through 2005 to identify patients with prostate cancer (n = 423,908). The SEER-Medicare data combine population-based cancer registry data with the ability to perform longitudinal follow-up using Medicare claims.[18] For this study, we identified all Medicare patients ages 66 to 99 years who were at least 1 year removed from a diagnosis of prostate cancer (n = 79,826), as described in our prior work.[19] Because the initial treatment phase of prostate cancer may necessarily involve many different providers, we chose to examine the subsequent period to capture the effects of fragmentation during the protracted survivorship (ie, continuing care) phase of prostate cancer care. To ensure comparability of secular and geographic reimbursement trends over the study period, we limited this study to those patients diagnosed in the SEER 13 registries.[20] Patients in the fee-for-service program who were eligible for Medicare Parts A and B and did not participate in managed care were included. Moreover, the minority of patients without office visits associated with a prostate cancer diagnosis during survivorship were excluded. We observed patients until December 31, 2005 or until the beginning of the last year of life, whichever occurred first. Using these criteria, our study population was comprised of 67,736 patients who were followed through December 31, 2005.

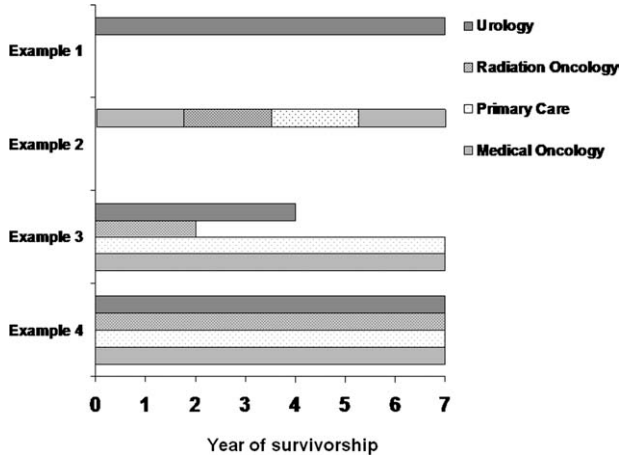

Figure 1. Various examples of fragmentation and prostate cancer survivorship care are shown. In Example 1, a single urologist is responsible for all prostate cancer-related claims during the survivorship period. This would represent the least fragmented care and the average number of providers would equal 1. In contrast, Example 4 represents a patient with multiple providers involved in his prostate cancer care for the entire survivorship period. This situation might represent the greatest potential for the consequences of fragmented cancer care (average number of providers: 4).

Measures of Fragmentation

An ideal measure of fragmentation or the potential for poor care coordination would capture the intensity of care within individual providers, as well as account for the breadth of care across providers, for a specific disease in a patient over time. We expect greater fragmentation of care among cancer survivors after their initial treatment (eg, care distributed across a greater number of providers) is associated with worse quality and greater survivorship expenditures. Unfortunately, to the best of our knowledge, there is no ideal single measure to account for these effects and therefore we operationalized fragmentation in 2 ways, as described below.

Average Number of Prostate Cancer Providers

Because an increasing number of prostate cancer providers after initial treatment fosters fragmented care, we enumerated the average number of prostate cancer providers per patient during the survivorship period. Clinical scenarios involving an average number of providers are illustrated in Figure 1. In Example 1, a single urologist is responsible for all prostate cancer-related care during the survivorship period. This would represent the least fragmented care, with the average number of providers equal to 1, and accounts for the duration of the survivorship period. In

contrast, Example 4 represents a patient with multiple providers involved in his prostate cancer care for the entire survivorship period. This situation represents the greatest potential for fragmented prostate cancer care (average number of providers: 4).

We calculated this measure in 3 steps to adjust for the duration of each patient's survivorship period. First, we identified all services with a primary diagnosis of prostate cancer (International Classification of Diseases [ICD] code 185 [prostate cancer]) for each patient in the carrier files. Each claim was assigned to a provider using a unique provider identification number. Second, we assigned a date for each provider's first and last claim to determine their coverage period within each patient's claims. If a substantial period of time had passed without a provider's involvement in a given patient's care (ie, no service claim for a period of $>$ 1.5 years), these claims were treated as a solitary coverage date, with the same start and end dates. Third, we enumerated the total number of provider days of coverage for each patient during the survivorship period. This number was then divided by the entire duration of the survivorship period for each patient to determine the average number of providers over time.

This measure has clinical relevance and is relatively simple to calculate; however, it may fall short in some cases because it does not account for the intensity of patient care by a given provider. For example, multiple prostate cancer providers may be involved in a survivor's care, yet the majority of visits might be with a single provider (eg, urologist) who coordinates their care, thereby limiting the effects of fragmentation (Fig. 1).

Concentration of Prostate Cancer Survivorship Care

To address the intensity of prostate cancer care across providers, we used the Herfindahl-Hirschman Index (HHI). The HHI is a commonly used instrument in the field of economics to measure market share, or the concentration of goods and services provided in a market among various firms.[21-24] In the same manner, we used the HHI to measure the "market share," or concentration of office visits, for prostate cancer care among a survivor's providers. To calculate this measure, the percentage of each patient's office visits for prostate cancer care was determined for each provider using unique provider identifiers. Next, we summed the squares of the percentages of prostate cancer office visits (ie, the share) provided by each provider. For example, less concentrated office visits dispersed across providers might correspond to an HHI of 0.42 (urology: 20% [$0.2^2 = 0.04$], radiation oncology: 60% [$0.6^2 = 0.36$], medical oncology: 10% [$0.1^2 = 0.01$], and primary care: 10% [$0.1^2 = 0.01$] = [0.04 + 0.36 + 0.01 + 0.01]), whereas concentration within a solitary provider would correspond to an HHI of 1.0 (urology: 100% [$1.0^2 = 1.0$]). This measure of fragmentation is relatively simple to calculate and identifies the degree of concentration of prostate cancer care within providers. However, it does not account for the changes over time captured with the average number of providers.

For the current study, we posited a priori that greater fragmentation (ie, a greater average number of providers and less concentrated care, or lower HHI) would be associated with increased cost and potentially decreased quality of prostate cancer survivorship care. For this reason, we categorized fragmentation into 3 groups using a combination of both measures: low ($<$ 50th percentile average number of providers and $>$ 50th percentile HHI), intermediate ($>$ 50th percentile average number of providers and $>$ 50th percentile HHI or $<$ 50th percentile average number of providers and $<$ 50th percentile HHI), and high ($>$ 50th percentile average number of providers and $<$ 50th percentile HHI).

Outcomes

Our primary outcome was annual per capita survivorship expenditures for prostate cancer care, assessed through December 31, 2005. All corresponding expenditures associated with a primary diagnosis of prostate cancer (ICD-9 code 185 [prostate cancer]) were tallied within the inpatient, outpatient, and carrier files until the end of the study period (December 31, 2005) or until the beginning of the last year of life, whichever occurred first. We specifically excluded all end-of-life spending (within 1 year of death). We used the methodology described by Brown et al to measure annual per capita survivorship (ie, continuing care phase) expenditures.[20] Payments were standardized to 2005 dollars using the Hospital Input Price Index for Medicare Part A[25] and the Medicare Economic Index for Medicare Part B claims[26] to account for changes in health care input price inflation. The geographic differences in Medicare payments were also adjusted for using the Capital Geographic Adjustment Factor for Medicare Part A[25] and the Geographic Practice Cost Index for Medicare Part B claims.[27]

Because interventions during prostate cancer survivorship are not uncommon[28] and may serve as a measure of patient complexity that might warrant the involvement of multiple providers and increase spending, we also

examined the use of prostate cancer survivorship interventions across fragmentation groups. These included ADT, radiotherapy, chemotherapy, cystoscopic procedures, and placement of artificial urinary sphincters and penile prostheses during the survivorship period. We used the appropriate Healthcare Common Procedure Coding System (HCPCS) codes in the carrier and outpatient files to determine whether each patient had a claim for any of these interventions, regardless of the associated diagnosis, during the survivorship period.

As a secondary outcome, we measured the effects of fragmented prostate cancer care on quality. Because repetitive (ie, redundant) testing is usually unnecessary, it may represent suboptimal quality of care. For this reason, we chose repeat PSA testing within 30 days among prostate cancer survivors at least 1 year removed from diagnosis as our measure of repetitive care (yes/no). Although there may be some clinical scenarios that might require this, we posited that increasing fragmentation of cancer care would be associated with the greater potential for repetitive testing even after adjustment for clinical characteristics, disease severity, and prostate cancer survivorship interventions. At least 2 PSA claims during survivorship were necessary to determine this measure (n = 33,447 patients). We used the appropriate HCPCS codes in the carrier files to determine the frequency of repeat PSA testing.

Statistical Analysis

First, we examined differences in the clinical characteristics of patients across our measure of fragmentation (low, intermediate, and high) using the Mantel-Haenszel chi-square test. Patients were categorized according to age (ages 66-69 years, then in 5-year intervals thereafter), race (white, black, and other), socioeconomic status, comorbidity, tumor grade (low, medium, high, and unknown), tumor stage (local/regional, distant, and unstaged), rural status, initial treatment, and prostate cancer survivorship interventions. To measure comorbidity, Medicare claims made 12 months before a diagnosis of prostate cancer were evaluated using the methods described by Klabunde et al.[29] We used the approach of Diez Roux et al to ascertain socioeconomic status at the level of the patient's ZIP code.[30] Any missing values for these variables were coded as unknown. We categorized each patient's initial treatment (within 1 year of diagnosis) using appropriate procedure codes (ICD-9 and HCPCS codes).

Next, we compared the annual per capita survivorship expenditures according to our fragmentation exposure using the analysis of variance test. We used the Mantel-Haenszel chi-square test to compare the percentage of patients with repetitive PSA tests across our fragmentation categories. We then rank-ordered and sorted annual per capita survivorship expenditures into 3 groups: low, intermediate, and high. Finally, we used multinomial logistic regression models to examine whether fragmentation was associated with low, intermediate, and high annual per capita survivorship expenditures and worse quality of survivorship care in terms of repetitive PSA within 30 days. Each of the models was adjusted for the covariates described above (age, race, comorbidity, socioeconomic status, rural status, tumor grade, tumor stage, initial treatment, and prostate cancer survivorship interventions). The adjusted models were then used to predict how our cost and quality outcomes varied according to the degree of fragmentation. Because of its overbearing effect on the cost of survivorship care, we also stratified patients by whether they had received ADT injections during survivorship in our cost models.

All analyses were performed using computerized software (SAS 9.2, SAS Institute Inc, Cary, NC; R Version 2.9) and all testing was 2-sided. The probability of a type I error was set at 0.05. The University of Michigan Institutional Review Board approved the study protocol.

RESULTS

As shown in Table 1, patients with highly fragmented prostate cancer care tended to be younger, white, of higher socioeconomic status (all $P < .001$) and were observed for longer intervals (high fragmentation, median of 64.7 months; intermediate fragmentation, median of 57.3 months; and low fragmentation, median of 39.6 months). In terms of initial treatment, fragmentation was more common among patients undergoing radiotherapy. For example, a greater percentage of patients with the most fragmented care underwent radiotherapy as their initial treatment compared with patients with the least fragmented care (44.4% for high fragmentation vs 32.2% for low fragmentation; $P < .001$). Moreover, greater fragmentation care was also associated with the increased use of prostate cancer survivorship interventions ($P < .001$), including cystoscopic procedures (38.2% for high fragmentation vs 22.6% for low fragmentation) and ADT (49.8% for high fragmentation vs 34.2% for low fragmentation).

As fragmentation of prostate cancer survivorship care increased, so did unadjusted annual survivorship

Table 1. Patient and Disease Characteristics According to the Degree of Fragmented Survivorship Care

Characteristic	Fragmentation of Care			*P*
	Low	Intermediate	High	
No. of patients	25,405	18,115	24,216	
Median follow-up, mo	39.6	57.3	64.7	
Age, %				<.001
66-69 y	23.6	23.8	25.8	
70-74 y	30.1	33.1	35.6	
75-79 y	25.4	26.2	25.1	
80-84 y	14.3	12.1	10.2	
≥85	6.6	4.8	3.3	
Race, %				<.001
White	70.1	74.6	75.2	
Black	4.7	6.8	8.3	
Other/unknown	25.2	18.6	16.5	
Socioeconomic status, %				<.001
Low	24.1	26.1	25.5	
Medium	29.6	30.3	30.9	
High	25.2	30.0	33.6	
Unknown	21.1	13.6	10.0	
Rural, %	1.9	1.4	1.4	<.001
Comorbidity, %				<.001
0	81.4	81.3	82.0	
1	13.1	13.5	13.5	
2	3.7	3.5	3.2	
≥3	1.8	1.7	1.3	
Tumor grade, %				<.001
Well differentiated	8.9	8.6	8.2	
Moderately differentiated	51.0	55.2	56.3	
Poorly differentiated	15.7	18.5	21.5	
Unknown	24.4	17.7	14.0	
Tumor stage, %				<.001
Localized/regional	70.5	76.9	87.2	
Distant	2.4	2.6	3.1	
Unknown	27.1	20.5	9.7	
Initial treatment, %				<.001
Observation	21.4	19.1	18.4	
Surgery	23.1	19.8	17.1	
Radiotherapy	32.2	39.5	44.4	
Surgery and radiotherapy	0.9	1.7	1.9	
ADT	22.4	19.9	18.2	
Prostate cancer survivorship interventions, %				<.001
ADT	34.2	43.6	49.8	
Radiotherapy	3.4	7.4	17.2	
Chemotherapy	17.3	22.7	25.6	
Cystoscopic procedures	22.6	31.7	38.2	
Artificial urinary sphincter	0.8	1.2	1.2	
Penile prosthesis	2.2	3.2	3.7	

Abbreviation: ADT, androgen deprivation therapy.

expenditures. Annual, unadjusted, per capita expenditures for prostate cancer survivorship care were > 3-fold higher among patients with the most fragmented care compared with those with the least fragmented care (median annual per capita expenditures, $453 for high fragmentation vs $142 for low fragmentation; $P < .001$) (Table 2). In addition, fragmented care was associated with higher unadjusted rates of repetitive PSA testing (14.7% for high fragmentation vs 5.7% for low fragmentation; $P < .001$) (Table 2).

Table 2. Unadjusted Annual Prostate Cancer Survivorship Spending and Repetitive PSA Testing According to the Degree of Fragmented Care

Unadjusted Quality and Cost Measures	Fragmentation of Care			*P*
	Low	Intermediate	High	
Repetitive PSA testing within 30 d, % of patients	5.7%	9.2%	14.7%	<.001
Annual per capita survivorship expenditures (2005 dollars, median)	$142	$228	$453	<.001

Abbreviation: PSA, prostate-specific antigen.

After adjusting for measured patient and disease characteristics as well as the use of prostate cancer survivorship interventions, higher degrees of fragmentation were associated with more repetitive PSA testing within 30 days and greater survivorship spending in some cases (Figs. 2A and 2B) (Table 3). Compared with patients with the highest degree of fragmented care, patients with the least fragmented care were nearly half as likely to undergo repetitive PSA testing within 30 days (13.6% repetitive PSA testing in those with high fragmentation vs 7.0% repetitive PSA testing in those with low fragmentation). Although increasing fragmentation of care was associated with increased annual spending among patients who were not treated with ADT injections, the relation did not persist when examining patients who were treated with ADT injections. For example, among those not receiving ADT, 5.5% of survivors with the highest degree of fragmented care would be expected in the highest spending group compared with 2.3% in the least fragmented group when adjusted for age, race, comorbidity, socioeconomic status, rural status, tumor grade, tumor stage, initial treatment, and prostate cancer survivorship interventions. Not surprisingly, patients treated with ADT during survivorship had greater annual prostate cancer expenditures. However, the relations between fragmentation and spending were found to be less direct among this group of survivors, in which 8.0% of patients in the least fragmented group, 9.1% of those in the intermediate fragmentation group, and 8.7% of patients in the high fragmentation group would be predicted to be high-cost survivors.

We also performed a sensitivity analysis to examine whether using concentration of prostate cancer survivorship care (HHI) as our measure of fragmentation would produce similar findings. We sorted patients into 3 fragmentation groups according to their HHI. After adjustment, the results again indicated that higher degrees of fragmentation (ie, a lower HHI) were associated with more repetitive PSA testing within 30 days and greater survivorship spending among patients not receiving ADT

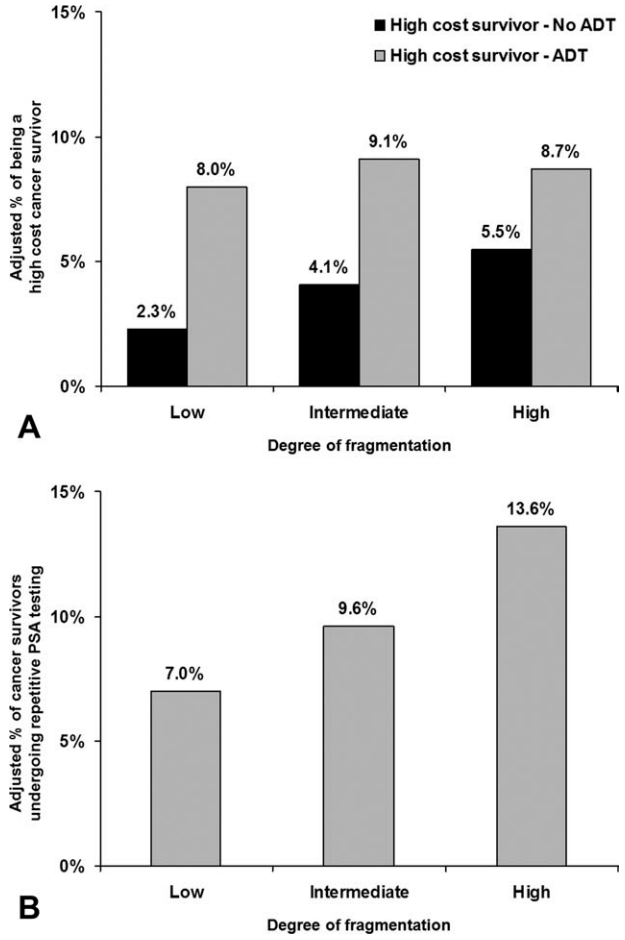

Figure 2. Relationship between degree of fragmentation, (A) survivorship spending, stratified by whether patients underwent androgen deprivation injection therapy (ADT), and (B) repetitive prostate-specific antigen (PSA) testing. Patients with higher fragmentation of care were more likely to undergo repetitive PSA testing within 30 days, independent of clinical characteristics and prostate cancer survivorship interventions ($P < .05$ for all comparison groups). In addition, patients with higher fragmentation of care who were not treated with ADT were more likely to have greater annual spending. For example, among those not receiving ADT, 5.5% of survivors with the highest degree of fragmented care would be in the highest spending group compared with 2.3% in the least fragmented group (adjusted for age, race, comorbidity, socioeconomic status, rural status, tumor grade, tumor stage, initial treatment, and prostate cancer survivorship interventions).

Table 3. Adjusted Probability of Annual Prostate Cancer Survivorship Spending and Repetitive PSA Testing According to the Degree of Fragmented Care[a]

Adjusted Quality and Cost Measures	Fragmentation of Care		
	Low	Intermediate	High
Adjusted probability of repetitive PSA testing within 30 d, % of patients	7.0	9.6	13.6
Annual prostate cancer survivorship spending among patients with no ADT during survivorship, % of patients			
Low cost (<$1179)	96.0	93.2	89.6
Intermediate cost ($1179-$2351)	1.7	2.7	4.9
High cost (>$2351)	2.3	4.1	5.5
Annual prostate cancer survivorship spending among patients treated with ADT during survivorship, % of patients			
Low cost (<$3178)	69.5	66.4	69.9
Intermediate cost ($3178-$6326)	22.5	24.5	21.4
High cost (>$6326)	8.0	9.1	8.7

Abbreviations: ADT, androgen deprivation therapy; PSA, prostate-specific antigen.
[a] Adjusted for age, race, comorbidity, socioeconomic status, rural status, tumor grade, tumor stage, initial treatment, and prostate cancer survivorship interventions.

injections, which was similar to our primary analysis. The relation between fragmentation and annual spending among patients treated with ADT injections suggested negligible differences (approximately 1%) in the probability of being a high-cost survivor among the HHI groups.

DISCUSSION

Fragmented prostate cancer survivorship care is expensive and is associated with potentially unnecessary services. Among prostate cancer survivors, highly fragmented care was > 3 times more costly than the least fragmented care due, in part, to the greater use of prostate cancer survivorship interventions. As fragmentation of cancer care increased, spending also increased independent of clinical characteristics and the use of survivorship interventions, particularly among patients not treated with ADT. In relative terms, repetitive PSA testing within 30 days was also more common with higher levels of fragmentation. With > 2 million prostate cancer survivors, the cost and quality implications of fragmentation are nontrivial. Efforts to improve care coordination via current policy initiatives, electronic medical records, and the implementation of cancer survivorship tools may help decrease fragmentation of care and mitigate its downstream consequences for prostate cancer survivors.

As demonstrated in the current study, cancer patients subjected to fragmented care are at risk for worse quality of care as measured by repetitive PSA testing. Communication breakdowns may lead to unnecessary venipunctures, additional uncertainty surrounding PSA levels,[31] and even compromise patients' confidence in their providers.[32] There are at least 2 scenarios in which intense PSA testing among prostate cancer survivors might occur. First, a lack of care coordination could prompt PSA tests from different providers (ie, redundant testing). Different providers may also use different PSA assays, resulting in clinically insignificant differences in PSA values[33] that prompt patient anxiety and further testing and health care use. This may be particularly true for patients undergoing radiotherapy, the initial treatment found to be most prone to fragmented care in the current study. These survivors have both urologists and radiation oncologists to contend with, making adequate role identification and the coordination of care essential for the efficient delivery of survivorship care. Second, concerns about disease recurrence or progression may drive such a phenomenon. Better understanding of the value of intensive PSA surveillance to detect and guide treatment for biochemical disease recurrence and metastatic disease is warranted. However, even after adjustment for the receipt of ADT, we observed intense PSA testing patterns with increasing fragmentation of care, suggesting redundancy. Such PSA testing may have associated opportunity costs for providers who are ultimately responsible for the results and for patients subjected to additional visits and testing.[34] Perhaps more consolidation of care and better delineation of provider roles after initial treatment are

necessary to decrease fragmentation of prostate cancer care, regardless of disease recurrence and even in the setting of metastatic disease. Moreover, the Institute of Medicine[35] and the 2004 President's Cancer Panel[36] proposed prostate cancer survivorship care plans and guidelines as tools with which to improve the delivery of cancer care.

Most studies agree that poor coordination of care (ie, fragmentation) is associated with worse quality in terms of patient satisfaction and outcomes for chronic disease.[3-7,32] In fact, the medical home model and accountable care organizations are both current health reform efforts to improve the coordination of chronic disease care.[3,4,6,10-12] One obstacle facing improvements in care coordination, at least in terms of cancer care, is a lack of clearly defined roles for the surgeons, radiation and medical oncologists, and primary care providers caring for cancer survivors.[15] Specialty and primary care organizations might be well served to define provider roles and responsibilities over the disease course so that patients have a consistent message regarding who is in charge of their care. Electronic medical records and integrated delivery systems, as in the Veterans Affairs and Kaiser Permanente systems, may also hasten improvements in the coordination of care by enabling increased communication and providing guidance to providers of prostate cancer and other chronic disease care.[37,38]

Several considerations should be noted when interpreting the results of the current study. First, we were only able to account for measured patient and disease characteristics in our models. Significant selection bias (ie, unmeasured confounding) may exist such that more complicated patients received more treatment, were more expensive, and necessarily had more fragmented care. However, there were minimal differences noted with regard to measured comorbidity burden across the fragmentation groups, thereby lowering our suspicion of significant unmeasured differences in health status. We also took prostate cancer survivorship interventions into consideration in our models and interpretation of the results to account for patient complexity and possible referral bias. In some cases, complicated prostate cancer patients might need to see different specialists (ie, less concentrated care) to obtain the best quality of care. This may or may not be true for patients with ongoing treatment-related side effects and recurrent disease. However, repetitive PSA testing and spending (at least among patients not treated with ADT) increased with increasing fragmentation of cancer care, even after adjustment. In addition, all patients were at least 1 year removed from their diagnosis so the acute side effects (eg, incontinence) from primary interventions should have stabilized, thereby decreasing the need for fragmented care among multiple providers for the majority of patients. Being aware that the potential for poor care coordination and the consequences of fragmented care increase with patient complexity may guide future efforts to better coordinate prostate cancer care.

Second, patients included the current study were aged $>$ 66 years and experienced decreased fragmentation of prostate cancer care with increasing age. However, $>$ 33% of men with newly diagnosed prostate cancer are aged $<$ 65 years.[13] The cost and quality implications of fragmented cancer care are likely greater for these men given their longer life expectancy and increased exposure to multiple providers. Third, to understand whether fragmentation of care relied solely on the concentration of care among providers, we performed a sensitivity analysis using the HHI. Although we discovered similar trends, because of the limitations of this approach with respect to time spent in survivorship and the number of providers as we describe above, we pursued the composite measure of fragmentation. Moreover, although our cost outcomes for patients not treated with ADT were consistent in the primary and sensitivity analyses, there did not appear to be a clear relation between fragmentation and annual spending for the more expensive survivors who were treated with ADT injections (Fig. 2). One explanation might be that the magnitude of spending for ADT masks the effects of fragmentation on annual prostate cancer survivorship expenditures. Further study is needed to understand the limitations and validity of these measures of fragmented health care delivery and their downstream implications. Last, it is unclear how fragmented care across specialties rather than providers as in this study may be associated with our prostate cancer survivorship outcomes. Further efforts are needed examining provider-, specialty-, and system-level fragmentation effects and their impact on outcomes.

Fragmented prostate cancer survivorship care is expensive and associated with potentially unnecessary services. Among prostate cancer survivors, highly fragmented care was found to be $>$ 3 times more costly than the least fragmented care due, in part, to the greater use of prostate cancer survivorship interventions. Higher degrees of fragmentation were also associated with increased rates of repetitive PSA testing within 30 days. Efforts to improve care coordination via current policy initiatives, electronic medical records, and the implementation of cancer survivorship tools may help to decrease fragmentation of care and mitigate some of its downstream consequences for prostate cancer survivors.

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CONFLICT OF INTEREST DISCLOSURES

The authors made no disclosures.

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