

# Ambulatory Care Fragmentation and Hospitalization Among Veterans With Diabetes

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**F**ragmented care in the ambulatory setting occurs when an individual's care is distributed across multiple providers, with no single provider accounting for a substantial proportion of visits.<sup>1</sup> Having more fragmented ambulatory care has been found to be associated with costly and potentially avoidable subsequent care, including higher rates of emergency department visits,<sup>1-4</sup> higher rates of hospitalizations,<sup>1,2,5</sup> and more unnecessary tests and procedures,<sup>6,7</sup> compared with having less fragmented ambulatory care.

The Veterans Health Administration (VHA) offers an integrated system of care for eligible veterans, but even among VHA-enrolled veterans, most choose to receive health care outside the VHA. Among VHA patients 65 years and older, about 85% of total health care expenditures are paid for by private insurance, Medicare, or self-pay, with Medicare covering more than half the costs.<sup>8</sup> Veterans who use both VHA and non-VHA providers are at increased risk of poorer outcomes such as worse glycemic control<sup>9</sup> and hospitalizations and readmissions among veterans with congestive heart failure<sup>10</sup> and stroke.<sup>11</sup> However, such studies are often limited by the use of a dichotomous (VHA only vs both VHA and non-VHA) categorization. This oversimplification does not account for the extent of an individual patient's fragmentation of care across providers, which may have its own significant effect on a patient's outcomes.<sup>1</sup>

The objective of this study is to determine whether ambulatory care patterns are associated with the risk of subsequent hospitalization, considering 2 different measures of ambulatory care. We will consider the health system affiliation of the usual provider of care (UPC) (VHA or non-VHA), and we will also consider the extent to which care is spread (or fragmented) across all of a patient's providers, regardless of health system affiliation. Using both VHA medical records and Medicare claims from 2004 to 2010, we will assess UPC and fragmentation separately and also consider interactions between them.

## METHODS

### Overview

We conducted a retrospective dynamic cohort analysis of all veterans with diabetes 65 years and older enrolled nationally in

## ABSTRACT

**OBJECTIVES:** To determine whether having a usual provider of care (UPC) outside the Veterans Health Administration (VHA) and whether having highly fragmented care (regardless of the providers' health system affiliations) increased the risk of hospitalization among veterans with diabetes.

**STUDY DESIGN:** Retrospective dynamic cohort analysis of all veterans with diabetes 65 years and older enrolled nationally in both VHA and Medicare from 2005 to 2010, using VHA-Medicare linked data. We used 5 two-year study periods, assessing ambulatory care in the first year of each 2-year period and any hospitalization in the second year.

**METHODS:** We used longitudinal generalized estimating equation models to test the associations of the affiliation (VHA vs non-VHA) of the UPC and the extent of fragmentation with hospitalization, adjusting for potential confounders. Highly fragmented care was defined as a reversed Bice-Boxerman Index of at least 0.85, which was equivalent to the 75th percentile.

**RESULTS:** Having a UPC outside the VHA was associated with 11% increased odds of hospitalization (95% CI, 10%-12%). Having highly fragmented care was associated with 7% increased odds of hospitalization (95% CI, 6%-8%). Having both a UPC outside the VHA and highly fragmented care was associated with 19% increased odds of hospitalization (95% CI, 18%-20%).

**CONCLUSIONS:** Among veterans with diabetes enrolled in both VHA and Medicare, having both a UPC outside the VHA and highly fragmented care was associated with higher odds of hospitalization than either of these ambulatory patterns alone.

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## TAKEAWAY POINTS

In this national sample of veterans with diabetes:

- ▶ Having a usual provider of ambulatory care outside the Veterans Health Administration (VHA) was associated with 11% increased odds of hospitalization [95% CI, 10%-12%].
- ▶ Having highly fragmented care (spread across many ambulatory providers, regardless of health system affiliation) was associated with 7% increased odds of hospitalization (95% CI, 6%-8%).
- ▶ Having both a usual provider of ambulatory care outside the VHA and highly fragmented care was associated with higher (19% increased) odds of hospitalization than for either of these ambulatory patterns alone (95% CI, 18%-20%).

both VHA and Medicare fee-for-service from 2005 to 2010, using VHA-Medicare linked data. We used 5 two-year study periods, measuring ambulatory care in the first year of each 2-year period (2005, 2006, 2007, 2008, and 2009) and any hospitalization in the second year (2006, 2007, 2008, 2009, and 2010). The study protocol was approved by the Institutional Review Board at the East Orange Veterans Affairs Medical Center.

### Population

A veteran was considered to have diabetes if they had at least 1 inpatient or 2 outpatient diabetes *International Classification of Diseases, Ninth Revision* diagnosis codes (250.xx) in the prior 24-month look-back period in either VHA or Medicare.<sup>12</sup> To be included, veterans had to be enrolled in VHA, Medicare Part A, and Medicare Part B for both years in a given 2-year period. A veteran could contribute up to 5 two-year periods of data. Additional inclusion criteria included being alive on the first day of the outcome year and having at least 4 ambulatory care visits in the baseline year to ensure stability of the measure of fragmentation.<sup>5</sup> Non-community-dwelling veterans, as determined by having hospital stays longer than 180 days, any hospice stays, or any skilled nursing stays, were excluded from the cohort.

### Ambulatory Visits, UPC, and Fragmentation of Care

Ambulatory visits in VHA and Medicare were defined using a specific set of ambulatory evaluation and management (E&M) codes adapted from the Healthcare Effectiveness Data and Information Set (HEDIS).<sup>13</sup> Ambulatory visits were restricted to E&M visits for adults that took place in an office setting or hospital-based clinic, excluding home visits and nursing home visits.<sup>1,3,6</sup> Because the HEDIS definition of ambulatory visits does not include emergency department visits, we have not included it in our definition. We counted only 1 ambulatory visit per provider-beneficiary-date combination and excluded ambulatory visits for which the rendering provider was missing. Non-VHA providers are identified in Medicare claims using individual National Provider Index codes. In the VHA, providers are identified using clinic stop codes.

The provider with the highest proportion of ambulatory care visits was classified as the UPC.<sup>14</sup> UPC was further classified into 2 subcategories, based on whether the provider was inside or outside

the VHA. If a veteran had an equal proportion of visits with 2 providers (1 inside the VHA and 1 outside), the UPC was randomly assigned to 1 of them. Approximately 5% (between 4.8% and 5.6% over the 5 years) of patients had an equal number of VHA and non-VHA usual providers and needed to be randomly assigned. The UPC could be either a generalist or a specialist physician.

Fragmentation was defined using the Bice-Boxerman Index (BBI),<sup>15</sup> a validated<sup>1,2,5</sup> measure

of dispersion of ambulatory care that uses number of visits, number of unique providers, and the concentration of visits between providers in the following formula:

$$BBI = \frac{(\sum_{i=1}^p n_i^2) - n}{n(n-1)}$$

In this formula,  $n_i$  is the number of visits per individual  $i$ , and  $p$  is the number of unique providers. Although this index was originally labeled as a measure of “continuity,” it actually measures more than consistency of care with a single provider; it captures both “dispersion” (the spread of a patient’s care across multiple providers) and “density” (the relative share of visits by each provider).<sup>16</sup> It is highly correlated with other measures of continuity or fragmentation, such as the Herfindahl-Hirschman Index, the Usual Provider of Care Index, and the Sequential Continuity Index.<sup>14</sup> For ease of interpretation, we inverted the continuous scale so that higher values (ranging from 0 to 1) corresponded to more fragmentation (reversed BBI, or rBBI).

### Other Variables

Other measures during each baseline year included age, gender, comorbid condition burden measured using the Charlson-Deyo Comorbidity Index (CCI),<sup>17,18</sup> marital status (married, unmarried, and all other), and VHA priority status. The VHA assigns veterans to priority groups based on the extent of service-connected disability and income.<sup>19</sup> Diabetes severity was captured using the Diabetes Complications Severity Index (DCSI) score, which has been adapted for use with administrative data diagnosis codes.<sup>20</sup>

### Hospitalizations

A single binary dependent variable was used to represent the first acute hospitalization (yes/no) over 5 years (2006-2010), using data from VHA and Medicare inpatient files.

### Statistical Analysis

The 2 independent variables (UPC and fragmentation) were measured for each veteran for each baseline year (2005, 2006, 2007, 2008, and 2009). In each baseline year, we dichotomized fragmentation into high ( $\geq 0.85$ ) vs low ( $< 0.85$ ), using the 75th percentile of rBBI from the first baseline year as the cut point. We also combined UPC and fragmentation to divide veterans into 4 groups for each baseline

year: group 1 (low fragmentation with a VHA UPC), group 2 (high fragmentation with a VHA UPC), group 3 (low fragmentation with a non-VHA UPC), and group 4 (high fragmentation with a non-VHA UPC).

We used descriptive statistics to characterize veterans in each 2-year study period. We also summarized ambulatory utilization. We compared the characteristics of those with high vs low fragmentation using *t* tests for continuous variables and  $\chi^2$  tests for dichotomous variables.

We used generalized estimating equations (GEE) models to assess the association between the 2 variables of interest (high vs low fragmentation and whether the UPC was a VHA or a non-VHA provider) in the baseline year and hospitalization in the subsequent year. We generated 3 separate models. Model 1 used fragmentation (high vs low) as the exposure, without including UPC in the model. Model 2 used UPC (VHA vs non-VHA) as the exposure, without including fragmentation in the model. Model 3 used the 4-group variable as the exposure. All models adjusted for age, gender, marital status, VHA priority status, DCSI score, and CCI score and accounted for clustering because veterans could appear across multiple years. We chose an unstructured correlation structure for the models because we have 5 time points and guidelines suggest that with 5 or fewer time points, this option produces the most stable estimates.<sup>21</sup>

We conducted a sensitivity analysis using Cox proportional hazards models to assess time to first acute hospitalization as the outcome. Patients were censored if they died, or at the end of the outcome year. Proportional hazard assumptions were checked using Schoenfeld residuals. To confirm the robustness of our findings, we also conducted sensitivity analyses stratified by diabetes severity (DCSI score) and, separately, by comorbidity burden (CCI score).

## RESULTS

### Cohort Characteristics

The cohort of VHA enrollees with diabetes increased over the 5-year period from 492,479 veterans in 2005 to 532,123 in 2009. In 2005, 98% were male, as expected; 87% were White; 8%, Black; and 4%, of Hispanic ethnicity; the mean (SD) age was 75 (5.5) years. The mean (SD) CCI score was 3.4 (2.1), 86% had at least 1 diabetes complication, and 25% were moderately or severely disabled and 30% had very low income according to VHA priority group (Table 1).

As expected, the cohort was aging over time, with 10.0% being 85 years and older in 2009 compared with 4.6% in 2005. Diabetes severity increased slightly, with 32% having 3 or more complications in 2009 vs 30% in 2005. CCI scores decreased over time (31% with a score of 1 in 2009 compared with 22% in 2005), possibly because of the entry into the cohort of veterans with recently diagnosed diabetes and fewer comorbidities (Table 1).

### Ambulatory Care Utilization and Provider Characteristics

In unadjusted analysis, 167,286 (34%) of the veterans in 2005 had high fragmentation ( $rBBI \geq 0.85$ ). The majority (70%) of veterans had a non-VHA UPC. In 2005, veterans had an average of 15 visits

**TABLE 1.** Profile of Veterans With Diabetes Included in the Analysis for Each Baseline Year

Characteristic	2005	2006	2007	2008	2009
N	492,479	519,173	524,739	529,368	532,123
Sex					
Male	98.5%	98.4%	98.4%	98.4%	98.4%
Female	1.5%	1.6%	1.6%	1.6%	1.6%
Age categories					
65-69 years	19.5%	18.7%	18.0%	17.6%	17.7%
70-74 years	30.9%	29.8%	28.6%	27.0%	25.3%
75-79 years	27.2%	26.5%	26.2%	26.5%	27.1%
80-84 years	17.8%	19.1%	19.9%	20.3%	20.0%
≥85 years	4.6%	5.9%	7.2%	8.7%	10.0%
Race/ethnicity					
White	87.2%	87.4%	87.3%	87.0%	86.6%
Black	7.4%	7.2%	7.2%	7.5%	7.8%
Hispanic	4.1%	4.0%	4.0%	4.0%	4.1%
Other	1.3%	1.3%	1.4%	1.5%	1.6%
Marital status					
Unknown	25.9%	27.6%	29.0%	30.4%	31.2%
Married	55.3%	53.7%	52.4%	51.0%	50.1%
All other	18.7%	18.7%	18.6%	18.5%	18.7%
Medicaid enrollment					
Yes	5.3%	4.5%	4.6%	4.6%	4.7%
No	94.7%	95.5%	95.4%	95.4%	95.3%
Diabetes severity (according to Diabetes Complications Severity Index)					
No complication	14.9%	14.6%	14.2%	13.9%	13.8%
1 complication	29.0%	28.9%	28.4%	28.0%	27.6%
2 complications	26.2%	26.3%	26.4%	26.5%	26.6%
≥3 complications	29.9%	30.3%	31.0%	31.6%	32.1%
VHA priority status					
Unknown	5.1%	3.5%	2.4%	2.4%	2.4%
Low income	29.6%	28.1%	26.4%	24.6%	23.7%
Severely disabled	10.9%	11.5%	12.0%	12.7%	13.4%
Moderately disabled	14.3%	14.5%	14.8%	15.2%	15.5%
Co-pays required	40.1%	42.4%	44.4%	45.2%	45.0%
Charlson-Deyo Comorbidity Index score category					
Score 1	22.0%	26.8%	29.4%	30.4%	30.9%
Score 2-4	51.8%	52.5%	53.8%	53.3%	53.2%
Score ≥5	26.2%	20.7%	16.8%	16.3%	15.9%

VHA, Veterans Health Administration.

(4 [27%] of which were in VHA) among 6 providers (2 [33%] in VHA), with the UPC accounting for an average of 44% of all visits. Patterns differed significantly between veterans with high and low fragmentation. Veterans with high fragmentation had an average of 17 visits (5 [29%] in VHA) among 8 providers (3 [38%] in VHA), with the UPC accounting for only 27% of total visits, compared with those with low fragmentation, who had an average of 14 visits

## CLINICAL

**TABLE 2.** Ambulatory Care and Hospitalizations by Fragmentation and UPC Categories Among Veterans With Diabetes for Each 2-Year Period

Years	Total	Low fragmentation scores (rBBI < 0.85)	High fragmentation scores (rBBI ≥ 0.85)
<b>First 2-year period</b>			
Ambulatory care, 2005			
n	492,479	325,193	167,286
n (%) with non-VHA UPC	347,346 (70.5%)	230,128 (70.8%)	117,218 (70.1%)
n (%) with VHA UPC	145,133 (29.5%)	95,065 (29.2%)	50,068 (29.9%)
Hospitalizations, 2006			
n (%) with at least 1 hospitalization	142,359 (28.9%)	90,025 (27.7%)	52,334 (31.3%)
Among non-VHA UPC	104,006 (29.9%)	66,305 (28.8%)	37,701 (32.2%)
Among VHA UPC	38,353 (26.4%)	23,720 (25.0%)	14,633 (29.2%)
<b>Second 2-year period</b>			
Ambulatory care, 2006			
n	519,173	339,025	180,148
n (%) with non-VHA UPC	374,311 (72.1%)	244,988 (72.3%)	129,323 (71.8%)
n (%) with VHA UPC	144,862 (27.9%)	94,037 (27.7%)	50,825 (28.2%)
Hospitalizations, 2007			
n (%) with at least 1 hospitalization	147,150 (28.3%)	91,688 (27.0%)	55,462 (30.8%)
Among non-VHA UPC	109,240 (29.2%)	68,491 (28.0%)	40,759 (31.5%)
Among VHA UPC	37,900 (26.2%)	23,197 (24.7%)	14,703 (28.9%)
<b>Third 2-year period</b>			
Ambulatory care, 2007			
n	524,739	337,030	187,709
n (%) with non-VHA UPC	384,272 (73.2%)	247,563 (73.5%)	136,709 (72.8%)
n (%) with VHA UPC	140,465 (26.8%)	89,465 (26.6%)	51,000 (27.2%)
Hospitalizations, 2008			
n (%) with at least 1 hospitalization	147,615 (28.1%)	90,650 (26.9%)	56,965 (30.3%)
Among non-VHA UPC	110,718 (28.8%)	68,507 (27.7%)	42,211 (30.9%)
Among VHA UPC	36,897 (26.3%)	22,143 (24.8%)	14,754 (28.9%)
<b>Fourth 2-year period</b>			
Ambulatory care, 2008			
n	529,368	335,204	194,164
n (%) with non-VHA UPC	391,100 (73.9%)	248,486 (74.1%)	142,614 (73.5%)
n (%) with VHA UPC	138,268 (26.1%)	86,718 (25.9%)	51,550 (26.6%)
Hospitalizations, 2009			
n (%) with at least 1 hospitalization	144,609 (27.3%)	87,079 (26.0%)	57,530 (29.6%)
Among non-VHA UPC	109,335 (28.0%)	66,462 (26.7%)	42,873 (30.1%)
Among VHA UPC	35,274 (25.5%)	20,617 (23.8%)	14,657 (28.4%)
<b>Fifth 2-year period</b>			
Ambulatory care, 2009			
n	532,123	331,609	200,514
n (%) with non-VHA UPC	393,465 (73.9%)	245,654 (74.1%)	147,811 (73.7%)
n (%) with VHA UPC	138,658 (26.1%)	85,955 (25.9%)	52,703 (26.3%)
Hospitalizations, 2010			
n (%) with at least 1 hospitalization	143,013 (26.9%)	84,548 (25.5%)	58,465 (29.2%)
Among non-VHA UPC	108,355 (27.5%)	64,483 (26.2%)	43,872 (29.7%)
Among VHA UPC	34,658 (25.0%)	20,065 (23.3%)	14,593 (27.7%)

rBBI, reversed Bice-Boxerman Index; UPC, usual provider of care; VHA, Veterans Health Administration.

(4 [29%] in VHA) among 5 providers (2 [40%] in VHA), with the UPC accounting for more than 50% of total visits. **eAppendix Table 1**, **eAppendix Figure 1**, and **eAppendix Figure 2** show ambulatory patterns for all years from 2005 to 2009 (eAppendix available at [ajmc.com](http://ajmc.com)).

Of the total veterans in 2005, 19% were in group 1 (low fragmentation with a VHA UPC), 10% were in group 2 (high fragmentation with a VHA UPC), 47% were in group 3 (low fragmentation with a non-VHA UPC), and 24% were in group 4 (high fragmentation with a non-VHA UPC).

### Rates of Hospitalization

**Table 2** shows that between 27% and 29% of veterans had at least 1 hospitalization in the outcome year between 2005 and 2009. There was a significantly higher proportion of veterans hospitalized in the high vs low fragmentation groups in all years. Separately, having a non-VHA UPC was associated with significantly higher rates of hospitalization compared with having a VHA UPC (**Table 2**).

### Association Between Fragmentation and Hospitalization

Using the GEE models, model 1 revealed that veterans with high fragmentation had 7% higher odds (adjusted odds ratio [AOR], 1.07; 95% CI, 1.06-1.08) of being hospitalized compared with those with low fragmentation, after adjustment for age, gender, marital status, VHA priority status, DCSI score, and CCI score (**Table 3**). This model did not include UPC as a variable.

### Association Between Location of UPC and Hospitalization

Model 2 revealed that veterans with a non-VHA UPC had 11% higher odds of hospitalization (AOR, 1.11; 95% CI, 1.10-1.12) compared with those with a VHA UPC, after adjustment for age, gender, marital status, VHA priority status, DCSI score, and CCI score. This model did not include fragmentation as a variable.

### Impact of Interaction of Fragmentation and UPC on Hospitalization

The interaction between the extent of fragmentation and the location of the UPC was significant ( $P < .0001$ ).

Model 3, which included the 4-level exposure variable of high and low fragmentation and VHA vs non-VHA UPC, demonstrated a statistically significant incremental increase in odds of hospitalization compared with the reference group (veterans with a VHA UPC and low fragmentation). Compared with the reference group (group 1), the odds of hospitalization increased to an AOR of 1.11 (95% CI, 1.10-1.13) for those with high fragmentation index and VHA UPC (group 2), AOR of 1.13 (95% CI, 1.12-1.14) for those with low fragmentation and a non-VHA UPC (group 3), and AOR of 1.19 (95% CI, 1.18-1.20) for those with both high fragmentation index and non-VHA UPC (group 4) (Table 3).

**Sensitivity Analyses**

Applying Cox proportional hazard models (eAppendix Table 2) corroborated the findings described above, with high fragmentation associated with an increased adjusted hazard of hospitalization (HR, 1.06; 95% CI, 1.05-1.07). Having a non-VHA provider as the UPC resulted in an increased hazard of hospitalization (HR, 1.10; 95% CI, 1.09-1.10). Using the combined 4-category variable, the results were similar. However, because the sensitivity analyses using Cox models did not satisfy the proportional hazards assumption, these results can only be interpreted as an “average hazard ratio” over a 1-year follow up period.

When we stratified results by diabetes severity, the main findings of the study were observed within each level of diabetes severity (eAppendix Table 3). Separately, when we stratified results by CCI scores, the main findings were observed within each level of CCI scores (eAppendix Table 4).

**DISCUSSION**

In this cohort of veterans 65 years and older with diabetes who use VHA and Medicare, high fragmentation of ambulatory care and having a non-VHA UPC in the baseline year were each associated with higher odds of hospitalization. Veterans with both high fragmentation and a non-VHA UPC had the highest odds of hospitalization compared with all other combinations of fragmentation level and UPC affiliation. These results suggest that the extent of ambulatory care fragmentation and the setting of the UPC each make independent contributions to the odds of hospitalization.

Some literature has focused on the differences between users who use both VHA and non-VHA providers (mainly Medicare) compared with those who use the VHA only; however, the results are mixed for the different types of outcomes studied.<sup>9,22,23</sup> Another study looked at VA/private dual use among veterans with diabetes, stratified by whether care by private providers was for specialty care or for primary care; that study showed a beneficial effect on preventable hospitalizations when care by private providers was

**TABLE 3.** Association Between Fragmentation and Any Hospital Admission in the Subsequent Year From 2006 to 2010\*

Outcome: hospital admissions	Odds ratio (95% CI)
Model 1: fragmentation score (high vs low)	1.07 (1.06-1.08)
Model 2: UPC (non-VHA vs VHA)	1.11 (1.10-1.12)
Model 3: analysis using a 4-level variable that incorporates fragmentation score and UPC	
Group 1: veterans with low fragmentation and a VHA UPC	Reference
Group 2: veterans with high fragmentation and a VHA UPC	1.11 (1.10-1.13)
Group 3: veterans with low fragmentation and a non-VHA UPC	1.13 (1.10-1.14)
Group 4: veterans with high fragmentation and a non-VHA UPC	1.19 (1.18-1.20)

UPC, usual provider of care; VHA, Veterans Health Administration.

\*All models adjusted for age, gender, marital status, VHA priority status, Diabetes Complications Severity Index score, and Charlson-Deyo Comorbidity Index score. Models also adjusted for clustering by patient.

for specialty services and no effect when they were for primary care services.<sup>24</sup> To our knowledge, our study is the first to tease apart the affiliation of the UPC from the extent of fragmentation overall.

The 2 groups with the lowest odds of hospitalization both had a UPC at the VHA. This finding could be because the VHA is an integrated delivery system<sup>25</sup> with a single electronic health record that enables information continuity across providers and sites.<sup>26,27</sup> However, the finding that, among those with a VHA UPC, having more fragmented care was associated with a higher risk of hospitalization compared with having less fragmented care is novel.

**Strengths and Limitations**

The study has numerous strengths. It uses the entire population of older Medicare-enrolled VHA users with diabetes over a 6-year period, representing one of the largest samples of patients with diabetes. Our use of the VHA and Medicare data ensures the most complete administrative data set possible and captures all hospitalizations. By utilizing 5 cohorts over the 6-year period, we were able to show consistency of our results over time. We also used previously validated measures of fragmentation of care and applied robust statistical analysis.

This study has several limitations. First, because it is observational, we cannot infer causality and cannot rule out the presence of unmeasured confounders. It uses administrative data records, which could result in incomplete recording or miscoding of comorbidities. Second, we cannot determine the appropriateness of the hospital admissions. Third, although we excluded individuals with prolonged hospitalizations (> 180 days), we did not account for prior hospitalization, in part because of the dynamic cohort design. Fourth, for VHA services, fragmentation was potentially partially obscured by the use of clinic stop codes to capture providers, which may have the effect of counting multiple providers in the same clinic as 1 “provider” for this analysis. This limitation would cause us to underestimate the extent of fragmentation. Finally, this study uses data through 2010, which preceded the passage of the Choice Act of 2014<sup>28,29</sup> and the MISSION Act of 2018,<sup>30,31</sup> which are legislative initiatives designed to make it easier for veterans

to seek care outside the VHA at the VHA's expense. From fiscal year (FY) 2014 to FY 2018, the number of individual veterans using community care increased from 1.3 million to 1.8 million, with the latter number equivalent to 30% of all veterans accessing VHA health care services that year.<sup>32</sup> From FY 2014 to FY 2018, VHA spending on community care increased from \$8.2 billion to \$14.9 billion (an 82% increase), and that figure is expected to reach \$17.8 billion in FY 2021.<sup>32</sup> Although we cannot be sure that this represents an overall increase in the number of providers engaged in the care of these veterans, the magnitude of the increases suggests this and, from the perspective of the VHA, highlights the issue of fragmentation of care. Thus, it will be important for the VHA to continue to monitor the impact of fragmentation of care on hospitalization and cost in the era of the Choice and MISSION Acts, and our results can serve as a baseline for those future analyses.

## CONCLUSIONS

Among veterans with diabetes, having highly fragmented health care in one year was associated with 11% increased odds of hospitalization in the following year. Separately, having a non-VHA UPC one year was associated with 7% increased odds of hospitalization in the following year. Having both highly fragmented care and a non-VHA UPC one year was associated with 19% increased odds of hospitalization in the following year. The magnitude of this effect and the presence of this interaction indicate that where veterans seek care and how diffusely their care is delivered both matter. Future studies should apply the methods used in this study to understand whether this problem is exacerbated in the context of legislative initiatives that are likely to increase the fragmentation of care for veterans. ■

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**eAppendix Table 1.** Ambulatory Care Utilization Among Veterans With Diabetes for Each Period From 2005 to 2009

	<b>Total</b>	<b>Low Fragmentation rBBI Scores below 0.85</b>	<b>High Fragmentation rBBI Scores &gt;= 0.85</b>
<b>Ambulatory Utilization - 2005</b>			
N	492,479	325,193	167,286
Number of ambulatory visits per patient			
Total Mean (SD), Median (IQR)	15.0 (9.8), 13 (11)	14.0 (9.7), 11 (10)	16.8 (9.8), 15 (11)
VHA	4.3 (6.4), 2 (6)	4.0 (6.6), 2 (5)	4.7 (6.1), 3 (5)
Non- VHA	10.7 (9.7), 9 (11)	10.0 (9.6), 8 (11)	12.0 (9.8), 10 (12)
Number of unique ambulatory providers per patient			
Total Mean (SD), Median (IQR)	5.8 (2.9), 5 (3)	4.7 (2.2), 4 (3)	8.0 (3.0), 7 (4)
VHA	1.8 (2.1), 1 (3)	1.5 (1.8), 1 (2)	2.5 (2.5), 2 (2)
Non- VHA	4.0 (3.0), 4 (4)	3.2 (2.4), 3 (4)	5.6 (3.5), 5 (5)
Proportion of visits with the most frequently seen ambulatory provider			
Total Mean (SD)	44% (18%)	52% (16%)	27% (6%)
Median (IQR)	40% (24%)	50% (20%)	27% (9%)
Fragmentation score (rBBI)			
Total Mean (SD)	0.75 (0.18)	0.67 (0.18)	0.89 (0.03)
Median (IQR)	0.80 (0.19)	0.73 (0.19)	0.89 (0.04)
<b>Ambulatory Utilization - 2006</b>			
N	519,173	339,025	180,148
Number of ambulatory visits per patient			
Total Mean (SD), Median (IQR)	15.2 (10.0), 13 (11)	14.2 (9.9), 12 (10)	17.0 (10.0), 15 (12)
VHA	4.1 (6.3), 2 (5)	3.8 (6.5), 2 (5)	4.6 (6.0), 3 (5)
Non- VHA	11.1 (10.0), 9 (11)	10.3 (9.8), 8 (10)	12.4(10.1), 10 (12)
Number of unique ambulatory providers per patient			
Total Mean (SD), Median (IQR)	1.9 (3.0), 5 (3)	4.7 (2.2), 4 (3)	8.1 (3.0), 8 (4)
VHA	1.8 (2.1), 1 (3)	1.5 (1.8), 1 (2)	2.4 (2.5), 2 (2)
Non- VHA	4.1 (3.1), 4 (4)	3.3 (2.4), 3 (3)	5.7 (3.5), 6 (5)
Proportion of visits with the most frequently seen ambulatory provider			
Total Mean (SD)	44% (18%)	52% (16%)	27% (6%)
Median (IQR)	40% (23%)	50% (20%)	27% (9%)
Fragmentation score (rBBI)			
Total Mean (SD)	0.75 (0.17)	0.68 (0.17)	0.89 (0.03)
Median (IQR)	0.80 (0.18)	0.73 (0.19)	0.89 (0.04)
<b>Ambulatory Utilization - 2007</b>			

N	524,739	337,030	187,709
Number of ambulatory visits per patient			
Total Mean (SD), Median (IQR)	15.2 (10.0), 13 (11)	14.2 (9.8), 12 (10)	17.0 (10.1), 15 (12)
VHA	4.0 (6.2), 2 (5)	3.7 (6.3), 1 (5)	4.4 (6.0), 2 (5)
Non- VHA	11.3 (10.0), 9 (12)	10.5 (9.8), 8 (11)	12.6(10.2), 11 (12)
Number of unique ambulatory providers per patient			
Total Mean (SD), Median (IQR)	5.9 (3.0), 5 (4)	4.8 (2.2), 4 (3)	8.1 (3.0), 8 (4)
VHA	1.7 (2.1), 1 (2)	1.4 (1.8), 1 (2)	2.3 (2.5), 1 (2)
Non- VHA	4.2 (3.1), 4 (4)	3.3 (2.4), 3 (3)	5.8 (3.5), 6 (5)
Proportion of visits with the most frequently seen ambulatory provider			
Total Mean (SD)	43% (18%)	52% (16%)	27% (6%)
Median (IQR)	40% (23%)	50% (20%)	27% (9%)
Fragmentation score (rBBI)			
Total Mean (SD)	0.76 (0.17)	0.68 (0.17)	0.89 (0.03)
Median (IQR)	0.81 (0.17)	0.73 (0.19)	0.89 (0.04)
<b>Ambulatory Utilization - 2008</b>			
N	529,368	335,204	194,164
Number of ambulatory visits per patient			
Total Mean (SD), Median (IQR)	15.4 (10.3), 13 (12)	14.3 (10.1), 12 (10)	17.3 (10.2), 15 (12)
VHA	3.9 (6.4), 2 (5)	3.6 (6.5), 1 (5)	4.4 (6.2), 2 (5)
Non- VHA	11.5 (10.2), 9 (12)	10.7 (10.0, 9 (11)	12.9(10.4), 11 (13)
Number of unique ambulatory providers per patient			
Total Mean (SD), Median (IQR)	6.0 (3.1), 5 (4)	4.8 (2.2), 4 (3)	8.2 (3.1), 8 (4)
VHA	1.7 (2.2), 1 (2)	1.4 (1.8), 1 (2)	2.3 (2.6), 1 (2)
Non- VHA	4.3 (3.2), 4 (4)	3.4 (2.5), 3 (3)	5.9 (3.6), 6 (4)
Proportion of visits with the most frequently seen ambulatory provider			
Total Mean (SD)	43% (18%)	52% (16%)	27% (6%)
Median (IQR)	40% (23%)	50% (20%)	27% (9%)
Fragmentation score (rBBI)			
Total Mean (SD)	0.76 (0.17)	0.68 (0.17)	0.89 (0.03)
Median (IQR)	0.81 (0.17)	0.73 (0.18)	0.89 (0.04)
<b>Ambulatory Utilization - 2009</b>			
N	532,123	331,609	200,514
Number of ambulatory visits per patient			
Total Mean (SD), Median (IQR)	15.5 (10.3), 13 (12)	14.4 (10.2), 12 (10)	17.5 (10.3), 15 (12)
VHA	3.9 (6.5), 2 (5)	3.6 (6.6), 1 (5)	4.4 (6.3), 2 (6)
Non- VHA	11.6 (10.3), 9 (12)	10.8 (10.1, 9 (11)	13.1(10.5), 11 (12)
Number of unique ambulatory providers per patient			

Total Mean (SD), Median (IQR)	6.1 (3.1), 6 (4)	4.8 (2.3), 4 (3)	8.2 (3.1), 8 (4)
VHA	1.7 (2.2), 1 (2)	1.4 (1.8), 1 (2)	2.3 (2.6), 1 (3)
Non- VHA	4.4 (3.2), 4 (4)	3.4 (2.5), 3 (3)	5.9 (3.6), 6 (4)
Proportion of visits with the most frequently seen ambulatory provider			
Total Mean (SD)	42% (18%)	52% (16%)	27% (6%)
Median (IQR)	40% (21%)	50% (20%)	27% (10%)
Fragmentation score (rBBI)			
Total Mean (SD)	0.76 (0.17)	0.68 (0.17)	0.89 (0.03)
Median (IQR)	0.81 (0.17)	0.73 (0.18)	0.89 (0.04)

VHA = Veterans Health Administration. UPC = usual provider of care. rBBI = reversed Bice-Boxerman Index.

**eAppendix Table 2.** Association Between Fragmentation Scores in the Baseline Year and Hospital Admissions in the Subsequent Year Using Proportional Hazard (PH) Models From 2006 to 2010

	Crude model	Overall Model
Fragmentation score (High vs. Low)*	1.17 (1.16 – 1.17)	1.06 (1.05 – 1.07)
Gender (Male vs. Female)	---	0.95 (0.92 – 0.97)
Age (for every 1-year increase)	---	1.02 (1.02 – 1.02)
Diabetes Severity		
No Complication	---	Ref
1 complication	---	1.31 (1.30 – 1.33)
2 complications	---	1.54 (1.52 – 1.55)
3 or more complications	---	1.89 (1.87 – 1.91)
Marital Status		
Unknown	---	Ref
Married	---	1.06 (1.06 – 1.07)
Widowed/Divorced/Single/Never Married	---	1.02 (1.02 – 1.03)
Charlson Comorbidity index		
Score of 1	---	Ref
Score 2 to 4	---	1.24 (1.23 – 1.25)
Score 5 and above	---	1.62 (1.60 – 1.63)

\*High fragmentation is defined as rBBI Scores  $\geq 0.85$ . Low fragmentation as rBBI Scores  $< 0.85$

**eAppendix Table 3.** Association Between Fragmentation Scores and Any Hospital Admission in the Subsequent Year From 2006 to 2010, Stratified by Diabetes Severity

<b>Diabetes Severity Level</b>	<b>Study Group</b>	<b>Model 4* Odds Ratio (95% Confidence Levels)</b>
No diabetes complications	Group 1: Veterans with low fragmentation and a VHA UPC	Reference
	Group 2: Veterans with high fragmentation and a VHA UPC	1.13 (1.09 - 1.17)
	Group 3: Veterans with low fragmentation and a non-VHA UPC	1.13 (1.10 - 1.16)
	Group 4: Veterans with high fragmentation and a non-VHA UPC	1.21 (1.17 - 1.25)
One diabetes complication	Group 1: Veterans with low fragmentation and a VHA UPC	Reference
	Group 2: Veterans with high fragmentation and a VHA UPC	1.14 (1.11 - 1.17)
	Group 3: Veterans with low fragmentation and a non-VHA UPC	1.15 (1.13 - 1.17)
	Group 4: Veterans with high fragmentation and a non-VHA UPC	1.24 (1.21 - 1.26)
Two diabetes complications	Group 1: Veterans with low fragmentation and a VHA UPC	Reference
	Group 2: Veterans with high fragmentation and a VHA UPC	1.09 (1.06 - 1.12)
	Group 3: Veterans with low fragmentation and a non-VHA UPC	1.12 (1.10 - 1.14)
	Group 4: Veterans with high fragmentation and a non-VHA UPC	1.16 (1.14 - 1.19)
Three or more diabetes complications	Group 1: Veterans with low fragmentation and a VHA UPC	Reference
	Group 2: Veterans with high fragmentation and a VHA UPC	1.09 (1.06 - 1.11)
	Group 3: Veterans with low fragmentation and a non-VHA UPC	1.10 (1.08 - 1.12)
	Group 4: Veterans with high fragmentation and a non-VHA UPC	1.16 (1.14 - 1.18)

VHA = Veterans Health Administration. UPC = Usual provider of care.

\*All models adjusted for age, gender, marital status, VHA priority status, diabetes severity index and Charlson Comorbidity Index. Models also adjusted for clustering by patient.

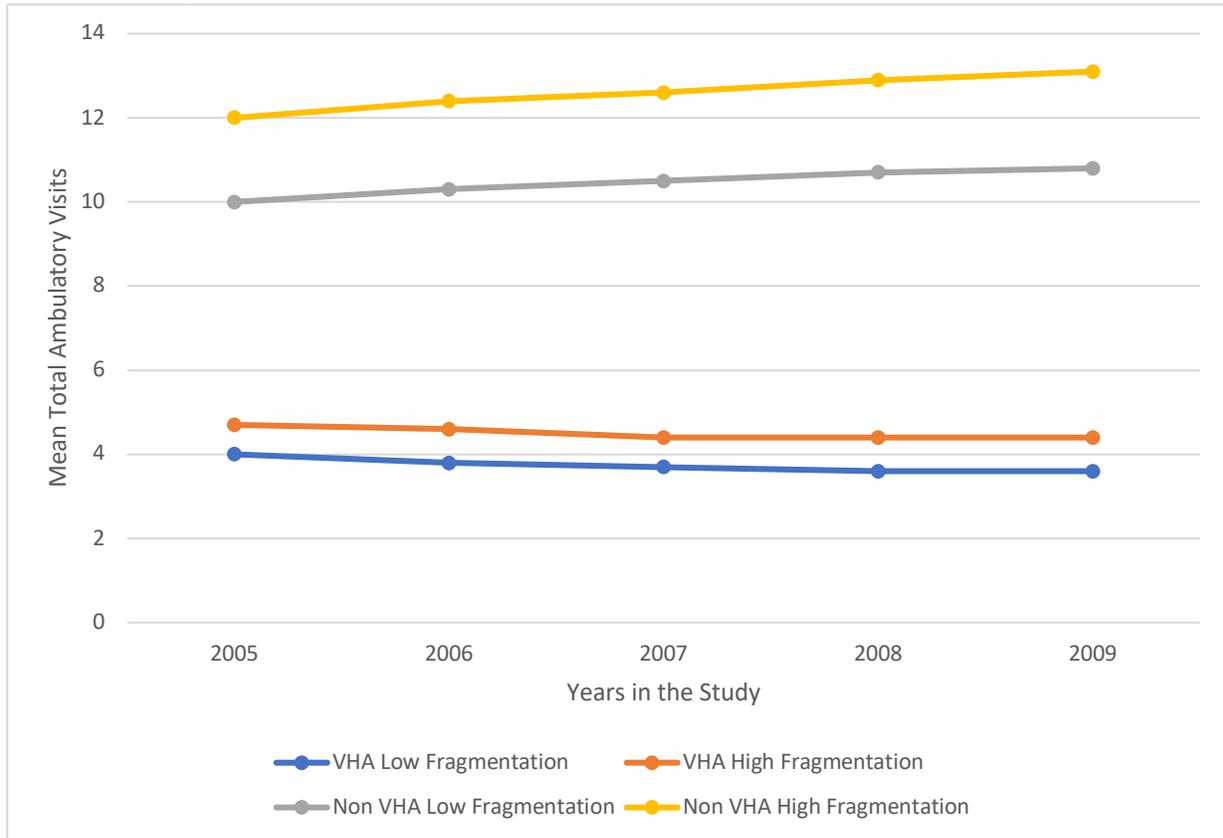
**eAppendix Table 4.** Association Between Fragmentation Scores and Any Hospital Admission in the Subsequent Year From 2006 to 2010, Stratified by Comorbidity Burden\*

<b>Charlson Comorbidity Category</b>	<b>Study Group</b>	<b>Odds Ratio (95% Confidence Levels)</b>
Comorbidity Score 1	Group 1: Veterans with low fragmentation and a VHA UPC	Reference
	Group 2: Veterans with high fragmentation and a VHA UPC	1.12 (1.09 - 1.15)
	Group 3: Veterans with low fragmentation and a non-VHA UPC	1.08 (1.06 - 1.11)
	Group 4: Veterans with high fragmentation and a non-VHA UPC	1.19 (1.16 - 1.22)
Comorbidity Score 2 or 3	Group 1: Veterans with low fragmentation and a VHA UPC	Reference
	Group 2: Veterans with high fragmentation and a VHA UPC	1.13 (1.10 - 1.15)
	Group 3: Veterans with low fragmentation and a non-VHA UPC	1.14 (1.12 - 1.15)
	Group 4: Veterans with high fragmentation and a non-VHA UPC	1.19 (1.17 - 1.21)
Comorbidity score 4 or 5	Group 1: Veterans with low fragmentation and a VHA UPC	Reference
	Group 2: Veterans with high fragmentation and a VHA UPC	1.09 (1.07 - 1.12)
	Group 3: Veterans with low fragmentation and a non-VHA UPC	1.12 (1.09 - 1.14)
	Group 4: Veterans with high fragmentation and a non-VHA UPC	1.16 (1.13 - 1.18)
Comorbidity score of 6 or more	Group 1: Veterans with low fragmentation and a VHA UPC	Reference
	Group 2: Veterans with high fragmentation and a VHA UPC	1.07 (1.03 - 1.11)
	Group 3: Veterans with low fragmentation and a non-VHA UPC	1.15 (1.11 - 1.18)
	Group 4: Veterans with high fragmentation and a non-VHA UPC	1.16 (1.13 - 1.20)

VHA = Veterans Health Administration. UPC = Usual provider of care.

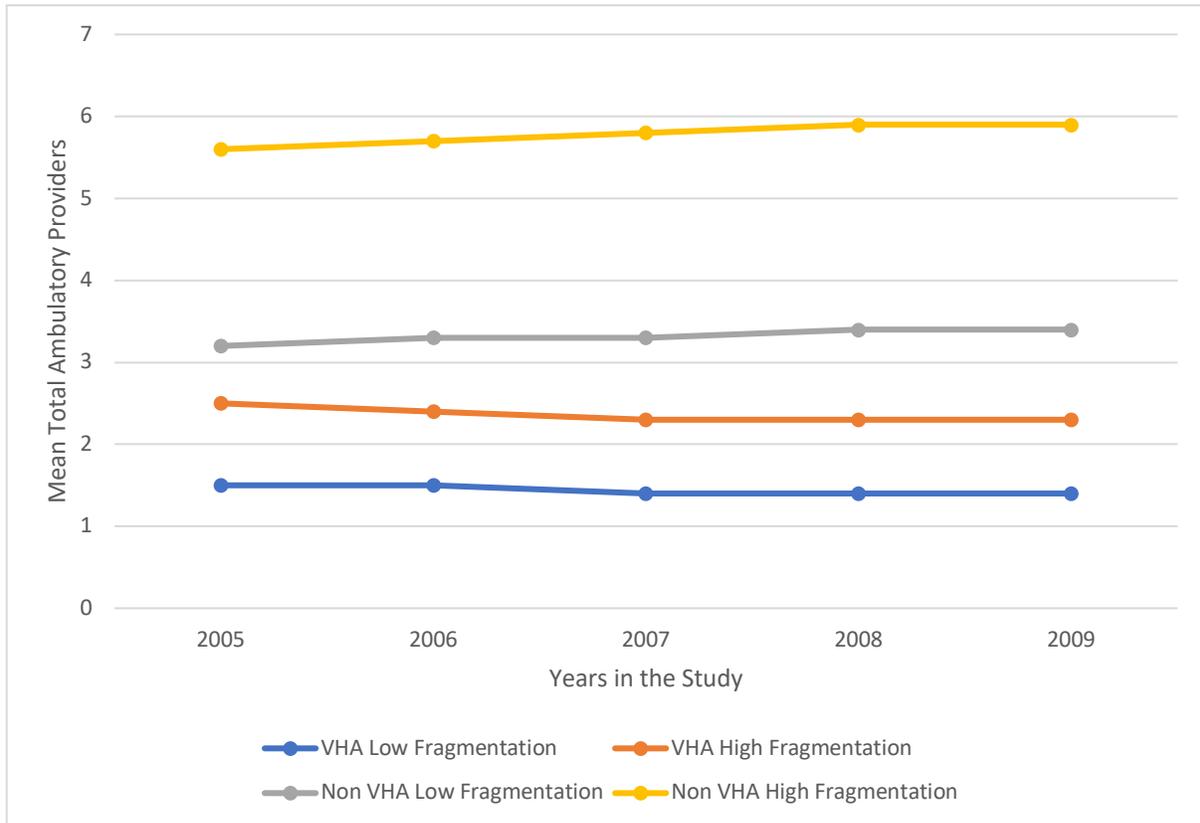
\*All models adjusted for age, gender, marital status, VHA priority status, diabetes severity index and Charlson Comorbidity Index. Models also adjusted for clustering by patient.

**eAppendix Figure 1.** Mean Total Ambulatory Visits Over Time, Stratified by Usual Provider of Care and Fragmentation Groups



VHA = Veterans Health Administration. VHA and non-VHA refer to the health system affiliation of the usual provider of care. High and low fragmentation refer to the extent of the dispersion of care across providers, regardless of health system affiliation. Thus, the four groups are: VHA usual provider of care with low fragmentation (blue), VHA usual provider of care with high fragmentation (orange), non-VHA usual provider of care with low fragmentation (grey), and non-VHA usual provider of care with high fragmentation (yellow).

**eAppendix Figure 2.** Mean Total Ambulatory Providers Over Time, Stratified by Usual Provider of Care and Fragmentation Groups



VHA = Veterans Health Administration. VHA and non-VHA refer to the health system affiliation of the usual provider of care. High and low fragmentation refer to the extent of the dispersion of care across providers, regardless of health system affiliation. Thus, the four groups are: VHA usual provider of care with low fragmentation (blue), VHA usual provider of care with high fragmentation (orange), non-VHA usual provider of care with low fragmentation (grey), and non-VHA usual provider of care with high fragmentation (yellow).