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Continuity of Care and Healthcare Cost among Community-Dwelling Older Adult Veterans Living with Dementia

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Abstract

Objectives: To estimate the causal impact of continuity of care (COC) on total, institutional and non-institutional cost among community-dwelling older veterans with dementia.

Data Sources: Combined Veterans Health Administration (VHA) and Medicare data in Fiscal Years (FYs) 2014-2015.

Study Design: FY 2014 COC was measured by the Bice-Boxerman Continuity of Care (BBC) index on a 0-1 scale. FY 2015 total combined VHA and Medicare cost, institutional cost of acute inpatient, emergency department [ED], long-/short-stay nursing home, and non-institutional long-term care (LTC) cost for medical (like skilled-) and social (like unskilled-) services were assessed controlling for covariates. An instrumental variable for COC (change of residence by more than 10 miles) was used to account for unobserved health confounders.

Data Collection: Community-dwelling veterans with dementia aged 66 and older, enrolled in Traditional Medicare (N=102,073).

Principal Findings: Mean BBC in FY 2014 was 0.32; mean total cost in FY 2015 was $35,425. A 0.1 higher BBC resulted in (1) $4,045 lower total cost; (2) $1,597 lower acute inpatient cost, $119 lower ED cost, $4,368 lower long-stay nursing home cost; (3) $402 higher non-institutional medical LTC and $764 higher non-institutional social LTC cost. BBC had no impact on short-stay nursing home cost.

Conclusions: COC is an effective approach to reducing total healthcare cost by supporting non-institutional care and reducing institutional care.

Key Words: Dementia; Health Care Cost; Primary Care; VA Health Care System; Aging/Elderly/Geriatrics; Instrumental Variables.

What This Study Adds

Better COC has been associated with cost savings in various populations. The relationship between COC and healthcare cost is not well understood among patients with dementia and the question of causality has not been addressed.

Findings show that better COC resulted in lower total combined VHA and Medicare cost due to its relationship with somewhat higher non-institutional cost and much lower institutional cost. Policymakers may wish to support efforts to improve COC as a means to reducing total healthcare cost for the growing population of community-dwelling older veterans living with dementia.

INTRODUCTION

With the aging population, the number of older Americans with dementia is expected to grow rapidly.[1,2] Patients with dementia are reported to have higher healthcare utilization compared to those without dementia, including higher hospitalization rate,[3-5] longer hospital stays,[6,7] more emergency department (ED) visits,[4] higher probability of nursing home admission,[8] and longer nursing home stays.[9] Consequently, the cost of caring for patients with dementia is higher than for patients without dementia,[3,6] including patients with heart disease and cancer.[1,10]

Although dementia is a complex neuropsychiatric illness often accompanied by other medical comorbidities, most care for patients with dementia is provided within primary care.[11] One of the tenets of primary care is continuity of care (COC) reflecting greater provider knowledge of patients including their medical and psychosocial conditions and greater commitment to their care. As a core attribute of primary care,[12] the Institute of Medicine and American College of Physicians recommended COC as a way to achieve

the best care at the lowest cost.[13,14] Previous literature has shown that better COC was associated with better communication between patients and their providers,[15-17] and better health management, e.g. better medication adherence,[18,19] more preventive care,[20-22] and better diabetes control,[23-25] which could all potentially reduce cost. Other literature has shown that fragmented care led to overuse of medical procedures,[26-29] potentially resulting in higher cost. Recent healthcare reforms promote COC through the Patient Protection and Affordable Care Act's Patient-Centered Medical Home,[30] accountable care organization,[31] and Veterans Health Administration (VHA) Patient-Aligned Care Team (PACT).[32]

Better COC has been shown to be associated with lower cost among various populations.[33-35] However, the relationship between COC and cost can simultaneously be influenced by unobserved health confounders. Evidence has shown that sicker patients with more healthcare needs valued COC more[36] and experienced greater COC.[37] No study had addressed the potential biases in the estimated effect of COC on cost arising from unobserved health confounders (i.e. endogeneity). Furthermore, no study explored the potential mechanisms that might be the drivers of the cost savings associated with better COC. We used an instrumental variable approach to address the endogeneity of COC and healthcare cost.

VHA provides more complete services than Medicare,[38] allowing a more comprehensive examination of the mechanisms by which COC might impact cost. However, many veterans with dementia do rely on Medicare.[39] Thus, examining the combined VHA and Medicare utilization and cost is imperative to comprehensively measure COC and to understand its impact on total combined government cost.

Higher government expenditures associated with dementia are in large part due to expensive institutional care such as hospitalization and nursing home care.[3,40] Non-institutional care (e.g. home-based primary care [HBPC] and adult day health care) might ameliorate the need for expensive institutional care;[41-43] however, it comes at its own cost. We examined the mechanism driving the relationship between COC and total cost by studying the impact of COC on institutional cost (acute inpatient, emergency department [ED], long-/short-stay nursing home care) and non-institutional medical and

social long-term care (LTC) cost. We hypothesize that greater COC resulted in: (1) lower total combined VHA and Medicare cost; (2) lower institutional cost of acute inpatient, ED and nursing home; and (3) higher non-institutional medical LTC and social LTC cost.

METHODS

In this study we used data from FY 2014 to measure COC and tested the FY 2014 COC on outcomes measured in FY 2015.

Data

We used VHA Office of Geriatrics & Extended Care Data Analysis Center (GECDAC) Core Files in Fiscal Years (FYs) 2014-2015 which aggregate VHA (enrollment, inpatient and outpatient records, purchased care claims) and Medicare (enrollment and all claims) data at the veteran level using Veterans Affairs' (VA's) Scrambled Social Security Number.[44] Veteran's residential information, updated quarterly, was obtained from the VHA Planning Systems Support Group data. Minimum Data Set resident assessments from community living centers, state veterans homes and nursing homes in the community were used to identify long-term institutionalization.[45] VHA staff data and Medicare Carrier Standard Analytic Files were used to identify providers through their National Provider Identification (NPI) and specialty. Population and market characteristics were obtained by linking veterans' residential information to 2015 US Census data and 2014 Area Health Resource Files.

Study Cohort

Dementia diagnoses were identified from VHA and Medicare claims with ICD-9-CM codes in a VHA sanctioned list (046xx, 290xx, 291.2, 292.82, 294xx, and 331xx), and from VHA pharmacy and Medicare part D prescriptions with medications commonly used to treat dementia (Donepezil, Galantamine, Rivastigmine and Memantine).[40,46,47] Veterans with ≥1 inpatient or ≥2 outpatient diagnoses or with 1 outpatient diagnosis and ≥1 medication prescription in FYs 2007-2014 were identified with dementia.

Among veterans with dementia ≥66 years old who used VHA in FYs 2014 and 2015 (n=190,672), we excluded those not enrolled in Medicare (n=2,804) or enrolled in Medicare Advantage (n=38,504) due to incomplete data, and excluded those with end-stage renal disease or spinal cord injury due to their extremely high cost (n=5,144). We excluded veterans continually in nursing home for >90 days in FY 2014 (long-term institutionalized; n=22,061), veterans residing in Puerto-Rico and the Virgin-Islands (n=1,974) and veterans with <3 selected outpatient visits because COC measures tended to be unstable with fewer than 3 visits (n=18,112).[48] The final cohort included 102,073 veterans.

Continuity of Care (COC)

COC was measured by the Bice-Boxerman Continuity of Care (BBC) index,[18,27-29,33,34] reflecting the relative share of the veteran's total visits to distinct providers in FY 2014. BBC measured the dispersion of care across various providers, which was the primary focus of this study. The BBC ranges from zero (each visit involves a different provider) to one (all visits to the same provider) with higher scores indicating better COC. In constructing the BBC, we included outpatient evaluation and management visits, defined by Berenson-Eggers Type of Service codes M1A, M1B, M4A, M5B, M5C, M5D and M6.[27,34] In addition, we counted only visits to primary care providers (physicians with general, family, internal, preventive and geriatric medicine, nurse practitioner and physician assistant) and dementia related specialists (neurologist, psychiatrist, psychologist, and social worker) because these providers were most likely to provide long-term outpatient management for these veterans and to coordinate their care with other physicians. We did not include visits to other specialists in the BBC measure because whether veterans had any visits to other specialists is likely related to their comorbidities, and therefore would confound COC with complexity of care. Examples of BBC are provided in Online Appendix Table S1.

Healthcare Cost

We examined total combined VHA and Medicare cost in FY 2015 and six cost categories including institutional cost of acute inpatient, ED, long-stay and short-stay nursing home (>90 vs ≤90 days), and non-institutional medical LTC and social LTC

cost. Non-institutional medical LTC services included VHA HBPC (comprehensive interdisciplinary care),[49] geriatric PACT (team-based geriatric primary care),[50] dementia clinic, purchased skilled home care as well as Medicare skilled home health care. Non-institutional social LTC services included VHA personal care services (home health aide, veteran-directed home and community-based services, adult day health care and respite), and Medicare home health aide. Detailed data sources for each cost outcome are provided in Online Appendix Table S2. Cost was adjusted by consumer price index to 2018 dollars and by medical area wage index to account for geographic variation in the value of the Dollar.[39] To eliminate the impact of outliers on the estimates we truncated all non-zero cost measures at the 99th percentile.

Covariates

We adjusted for potential confounders of cost including socio-demographics (age, gender, race and marital status), socio-economic variables (priority group, rurality, Medicaid indicator and median household income in the ZIP code area) and market characteristics (number of active physicians, nursing home beds and hospital beds per 1,000 population in the county). Priority group is determined by service-connected disabilities and income and determines the degrees of VHA benefit coverage.[51] There are eight priority groups with lower priority scores indicating higher VHA commitment and lower veteran copays. Baseline risk factors included years living with dementia, JEN Frailty Index (JFI; a sum of twelve condition categories related to a greater need for long-term nursing home care), thirty-three comorbidity indicators associated with cost,[39] indicators of geriatric PACT and HBPC PACT enrollment, and total number of visits to primary care, total number of visits to dementia related and total number of visits to other specialists since sicker patients generally need more visits. JFI was categorized into four groups (0-2, 3-5, 6-8 and ≥9) which have been shown to reflect the number of activities of daily living with difficulties (0, 1, 2, and ≥3, respectively).[52]

Instrumental Variable

We used an instrumental variable approach to address the endogeneity problem and identify the causality between COC and cost. The instrument was whether the veteran changed residence (longitude/latitude) by more than 10 miles in FY 2014 (5.4% of

cohort). A change in residence was highly correlated with COC (partial $F_{1,139}$=373, p<0.01; Online Appendix Table S4). Because veterans who moved more than 10 miles may have needed to change their "usual" providers, resulting in lower COC. We confirmed that the instrumental variable approach was necessary as the Durbin-Wu-Hausman test of endogeneity was significant for the instrumental variable model, indicating that standard multivariate regression resulted in biased estimates compared with instrumented results. The instrumental variable approach also assumes that a change in residence was not correlated with the cost outcomes, except through COC. This assumption would be invalidated if veterans moved due to worse health conditions. In addition, there should not be any mutual confounders between the instrument and outcomes. We checked the balance in risk factors and other baseline characteristics between veterans who moved more than 10 miles and those who did not[53] and found that the majority were balanced (Online Appendix Table S3). Age (66-74), marital status, Medicaid, years living with dementia (<1), JFI (0-2), number of visits (to other specialists), substance dependence (alcohol, tobacco and drug) and several mental health conditions (schizophrenia, manic depression and personality disorder) were not balanced. To deal with such imbalances, we performed sensitivity analyses stratified by these variables to rule out an association of change in residence with outcomes.[54,55]

Statistical Analyses

We used a linear model of total combined VHA and Medicare cost in FY 2015 explained by BBC and other covariates that were measured in FY 2014. This approach addresses the problem of reverse causality that could arise by modelling BBC and cost in the same year.[25,27,56,57] We used a linear model of total cost to directly estimate the marginal effect of BBC in terms of dollars; we considered using a log-linear model, but decided against it on account of the retransformation problem.[58] We multiplied the BBC score by 10 to estimate the impact of 0.1-unit BBC increments on cost.[59]

Since not every veteran had a cost for each of the sub-cost categories we ran two-part models, first estimating the impact of BBC on any cost using a probit model, and then, among veterans with a positive cost, estimating the impact of BBC on cost using a

linear model, controlling for covariates. The two models were combined to calculate the marginal effect of BBC on each cost category.[60]

We performed sensitivity analyses stratified by BBC to examine the potential nonlinear impact of BBC on cost, and by excluding deceased veterans due to their high cost compared to those alive ($47,957 vs $32,817). We further tested the validity of the instrumental variable by modelling only veterans who had any change in residence, because veterans who moved and those who did not may have different outcome distributions. We also excluded veterans with assisted living residence identified in Medicare part B claims,[61] because veterans might move to assisted living on account of worse health conditions. In a sensitivity analysis, we also tested other cut-offs for the instrument (change in residence by more than 5 miles [7% of the total sample] and change in residence by more than 15 miles [4.6% of the total sample]) since we were concerned about the variability of change in residence by more than 10 miles (5.4%). We tested the validity of the COC measure using a BBC measure of only primary care visits (i.e. continuity of primary care), excluding visits by dementia-related specialists to test the possibility that BBC was unnecessarily lower for veterans who may have been referred to a dementia related specialist. Sensitivity to the construction of BBC with only primary care and dementia-related specialist visits was also tested by using a BBC measure of all primary care and all specialist visits, regardless of specialty, and many studies used all outpatient visits to measure COC.[28,33] Finally we tested the sensitivity to the selection of BBC as the measure of COC by using a density measure of COC, the Usual Provider of Care (UPC) measure,[15,62-66] which reflects the proportion of veteran's total visits to the most frequently visited provider.

We used two-stage least square for the instrumental variable analysis with IV-probit at part I models. For all estimates, we used bootstrapping with 1,000 replications to generate 95% normal-based confidence intervals (CIs); draws were made at the VA medical center level (n=140) to deal with clustering. All statistical analyses were conducted using Stata version 15.1 (StataCorp).

STUDY RESULTS

Summary Statistics

Table 1 presents descriptive statistics for variables of interest. The mean BBC in FY 2014 was 0.32 (SD, 0.23); mean total combined VHA and Medicare cost in FY 2015 was $35,425 (SD, $39,834). Table 2 lists baseline cohort characteristics. Seventy-seven percent of veterans were older than 75 years, 98% were male, 65% were married, 6.9% were Medicaid recipients, and 94% had a JFI ≥3.

COC and Total Combined VHA and Medicare Cost

Multivariate regression estimates indicated that a 0.1 higher BBC in FY 2014 (about 1/2 SD) was associated with $557 (95% CI, $431-$684) lower total cost in FY 2015 (Table 3 and Online Appendix Table S4 for full regression results). Instrumental variable estimates indicated that a 0.1 higher BBC resulted in $4,045 (95% CI, $2,171-$5,919) lower total cost. Instrumental variable estimates were much larger than multivariate regression estimates, indicating that the endogeneity arising from unobserved confounders led to an underestimation of the impact of COC on cost. We therefore continue to present only instrumented results.

COC and Cost Categories

The impact of COC on each cost category using instrumental variable analyses are presented in Table 4 (Online Appendix Table S5-S6 for full regression results in part I and part II models). The marginal effect indicated that 0.1 higher BBC resulted in $1,597 (95% CI, $688-$2,506) lower acute inpatient cost, $119 (95% CI, $64-$174) lower ED cost, $4,368 (95% CI, $643-$8,093) lower long-stay nursing home cost, $402 (95% CI, $113-$691) higher medical LTC cost, and $764 (95% CI, $460-$1,067) higher social LTC cost. BBC had no impact on short-stay nursing home cost.

Sensitivity analyses in Table 5 demonstrated consistent results in the estimated impact of COC on total cost across age, marital status, JFI, substance dependence, mental health conditions or number of visits, among veterans without Medicaid, veterans not deceased, veterans with any change in residence, or veterans not moving to assisted

living facility, and when using other cut-offs for the instrument (change in residence by more than 5 miles and change in residence by more than 15 miles). Using other COC measures including BBC with only primary care visits, BBC with all primary care and all specialist visits and UPC with primary care and dementia-related specialist visits, the estimated impacts of COC on total cost were consistent with the main findings (impacts on cost categories were also consistent with the main findings and are presented in Online Appendix Table S7). The impact of COC on total cost was larger among veterans who were younger (66-74), unmarried, with higher frailty levels, with substance dependence and with mental health conditions. When stratified by level of BBC, the impact of BBC was much larger among veterans with BBC below the median than the full cohort ($14,556 [95% CI, $6,675-$22,437] vs $4,045). BBC was not associated with cost among veterans with BBC above the median, or veterans with Medicaid, possibly due to missing Medicaid cost data.

DISCUSSION

Better COC has been reported to improve primary care such as faster problem identification, better adherence to treatment, and less medical errors or waste,[26-28,67] directly serving to reduce institutional care (e.g. hospitalization and ED).[68,69] Better COC might indirectly reduce institutional care (e.g. hospitalization and nursing home care) by providing more referrals to non-institutional care (e.g. HBPC and adult day health care).[41-43] In total, higher non-institutional cost resulting from better COC were more than offset by lower institutional care cost; resulting in lower total cost. To provide some perspective of the magnitude of the impacts, if the BBC of veteran in the 1st quartile (0.17) improved to the median (0.28), the model estimates that there would be a cost saving of at least $4,450 in total annual combined VHA and Medicare cost. Since the impacts of BBC were much larger at lower levels of BBC, interventions to improve COC may be more productive if targeted to veterans with lower COC.

COC is important for patients with dementia due to the complexity of their conditions and the long duration of illness which requires ongoing knowledge of patients' medical and psychosocial conditions. The instrumental variable approach used in this study resulted in a similar finding to that reported by Amjad et al. using propensity score

methods,[33] supporting the evidence that COC makes a difference in total cost of care for patients with dementia. We extended the prior results by examining the mechanisms driving this relationship.

Better COC resulted in lower institutional cost (acute inpatient, ED and long-stay nursing home care), consistent with the literature that better COC was associated with lower hospitalization rate,[48,56,63,65,70-72] and lower ED rate.[56,64-66,71,73-77] The findings that COC lowered long-stay nursing home cost with no impact on short-stay cost have not been previously examined. Short-term, post-acute nursing home stays (e.g. post-stroke rehabilitation) may not be sensitive to continuity of care in the community.

Better COC resulted in higher non-institutional medical and social LTC cost. If better COC was related to closer knowledge of veterans, including knowledge of their living conditions and social support, providers of veterans with better COC may have been able to better understand their needs and to refer them to appropriate resources. HBPC in Medicare (through the independence at home demonstrations) were proven successful in reducing cost.[78-80] However, we could not test this due to unavailability of data from managed care programs. Our findings about the impact of COC on medical LTC cost might be conservative. Due to lack of Medicaid data we could not capture home and community-based services paid by Medicaid, which may have increased the social LTC cost. Our findings about the impact of COC on social LTC cost might therefore be conservative.

To address patient's complex care needs new healthcare delivery reforms have emerged including telemedicine, team care models (e.g. Patient-Aligned Care Team [PACT] and Patient-Centered Medical Home), care coordination, and clinical decision support tools. This study captured the impact of individual-level COC following system-wide implementation of the PACT model across the VHA healthcare system (which began in 2010) with virtually all veterans assigned to a PACT team by FY 2014. Moreover, telemedicine visits accounted for 13% of all visits to primary care providers and dementia-related specialists in FY 2014. However, these reforms might change the way primary care is provided, requiring future work to devise more appropriate measure

of COC, evaluate how COC is achieved and its impact on healthcare utilization and cost.

There are several limitations to this study. First, the study population was primarily male veterans making generalizations to the US population difficult. Second, under-diagnosis and under-recording of dementia in claims data has been well documented in the literature.[81,82] However, a recent study linking Health and Retirement Study with Medicare claims data showed that the reported ratio of the number of individuals with dementia identified from clinical assessment of cognitive impairment to those identified from diagnoses in claims data continuously declined from 2.5 in 2000 to 1.3 in 2010.[83] Third, the BBC does not reflect patient-provider relationships directly. However previous studies have shown that better COC was associated with better communication.[15-17] Fourth, The instrument did not attain balance of several key measured covariates (e.g. substance use and mental health conditions) and likely unmeasured covariates as well. The instrument may not have fully satisfied the "ignorable treatment assignment assumption". To deal with such imbalances we performed sensitivity analyses stratified by these imbalanced variables and found results to be consistent with the main study findings. Fifth, we did not measure severity of dementia, which might be an important contributor to cost, and a lower BBC score might be an indicator of greater care complexity (unmeasured by frailty and comorbidity variables). We did, however, control for years living with dementia which is likely to be related to dementia severity.[84] Unmeasured dementia severity may further confound the instrument-outcome relationship if veterans with more severe dementia were more likely to move (e.g. be to closer to a caregiver or to specialized care). However, the balance table (Online Appendix Table S3) showed that veterans newly diagnosed with dementia were more likely to move by more than 10 miles. We performed sensitivity analyses stratified by years living with dementia and results were consistent with those from the main findings. Sixth, our analyses pooled VHA and Medicare utilization and cost leaving the question of whether COC impacted the systems differently unanswered. Seventh, we did not have Medicaid cost. VHA and Medicare cost for the seven percent of veterans enrolled in Medicaid does not include the cost of services provided by Medicaid, which are likely to be for long-stay nursing home care and social LTC. These services are not

provided by Medicare and the VA might rely on Medicaid to provide them, especially for non-service-connected veterans. Sensitivity analyses showed consistent results in the estimated effect of COC on total healthcare cost among veterans without Medicaid with similar but insignificant estimates among veterans with Medicaid. The impact of COC on total healthcare cost might be underestimated among veterans enrolled in Medicaid due to our inability to account for Medicaid costs. Last, we did not have informal caregiver cost. Lower government cost might increase burden to informal caregivers. Since spouses may lower formal cost by providing informal support we conducted sensitivity analyses stratified by marital status with findings consistent among married and unmarried veterans.

In conclusion, among community-dwelling older veterans with dementia continuity of care (COC) was an effective approach to reducing total healthcare cost. Higher non-institutional medical LTC and social LTC cost and lower institutional cost (acute inpatient, ED and long-stay nursing home care) resulting from better COC explained the mechanism by which COC lowered total cost. These results provide empirical support for efforts to improve COC as a means to reducing healthcare cost for the growing population of community-dwelling older adult veterans living with dementia.

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Table 1. Summary Statistics of Variables of Interest (N=102,073)

Variables	Mean (SD)/%
BBC in FY 2014	0.32 (0.23)
Total combined VHA and Medicare cost in FY 2015, $	35,425 (39,834)
Whether have positive cost for each category in FY 2015, %	
Acute inpatient cost	41.4
ED cost	51.6
Long-stay nursing home cost	3.1
Short-stay nursing home cost	20.5
Medical LTC cost	45.8
Social LTC cost	25.2
Average cost among veterans with any cost for each category in FY 2015, $	
Acute inpatient cost	22,035 (25,542)
ED cost	1,232 (1,402)
Long-stay nursing home cost	58,459 (66,129)
Short-stay nursing home cost	19,861 (19,652)
Medical LTC cost	7,339 (7,408)
Social LTC cost	6,681 (7,949)

Notes: BBC, Bice-Boxerman Continuity of Care; VHA, Veteran Health Administration; ED, emergency department; LTC, long-term care; FY, fiscal year.

Table 2. Descriptive statistics of baseline characteristics (N=102,073)

Characteristics	Mean (SD)/%
Socio-demographics, %	
66-74	22.8
75-84	41.3
85+	36.0
Male	97.9
Non-Hispanic white	76.0
Married	64.9
Priority group, %	
1	25.5
2	5.6
3	9.5
4	9.0
5	20.3

Characteristics	Mean (SD)/%
6	1.2
7	3.7
8	24.9
Unknown	0.4
Rurality of residence, %	
Highly urban	47.3
Urban	17.9
Rural	33.5
Highly rural	1.3
Medicaid recipient, %	6.9
Median household income among household owner ≥65 in the ZIP code area, mean (SD)	$39,296 (12,528)
Years living with dementia, %	
0-1	24.9
2-3	32.7
4-5	20.9
6-7	14.3
8+	7.2
JFI, %	
0-2	5.6
3-5	39.3
6-8	41.9
9+	13.3
Special PACT enrollment, %	
Geriatric PACT	7.0
HBPC PACT	7.7
Comorbidities, %	
Cancer	19.9
Multiple sclerosis	0.3
HIV/AIDS	0.2
Diabetes	38.3
Thyroid diseases	17.8
Chronic kidney disease	27.8
Anemia	28.6
Chronic obstructive pulmonary disease	24.4
Asthma	5.5

Characteristics	Mean (SD)/%
Lower back pain	26.5
Osteoporosis	4.9
Arthritis	33.9
Cardiac arrhythmia	33.2
Congestive heart failure	20.0
Ischemic heart disease	45.6
Peripheral vascular disease	16.0
Hyperlipidemia	68.2
Hypertension	82.4
Parkinson's disease	9.7
Cerebrovascular disease/Stroke	13.9
Alcohol dependence/abuse	3.3
Tobacco dependence	9.3
Drug dependence/abuse	1.1
Post-traumatic stress disorder	9.7
Schizophrenia	2.2
Manic depressive	3.1
Personality disorders	0.8
Other psychotic conditions	28.4
Depression	31.4
Hepatitis C	0.7
Cataract	26.9
Glaucoma	18.7
Benign prostatic hypertension	36.5
Number of visits to, mean (SD)	
Primary care providers	7.2 (5.7)
Dementia related specialists	3.2 (6.8)
Other specialists	6.4 (7.0)
Market characteristics, mean (SD)	
# NH beds / 1,000 population ≥ 75 in the county	92.4 (39.7)
# hospital beds / 1,000 population in the county	3.1 (2.4)
# physicians / 1,000 population in the county	2.6 (2.0)

Notes: JFI, JEN Frailty Index; PACT, patient-aligned care team; HBPC, home-based primary care; NH, nursing home.

Table 3. COC and Total Healthcare Cost

Model	Estimates	*p* Value
Total combined VHA and Medicare cost, $		
Multivariate linear model[a]	-557 (-684 to -431)	<.01
Instrumental variable model[b]	-4,045 (-5,919 to -2,171)	<.01

Notes: COC, continuity of care; VHA, Veteran Health Administration.

Both models controlled for the socio-demographics, socio-economic variables, risk factors and market characteristics. The independent variable was the Bice-Boxerman Continuity of Care (BBC) index. Estimates reported were marginal effects of a 0.1 increment in BBC score on change of total combined VHA and Medicare cost. The 95% confidence intervals reported in brackets were generated using bootstrap with 1,000 replications.

[a] Multivariate linear model was estimated by ordinary least square.

[b] Instrumental variable model was estimated by two-stage least square. Sample size: 102,073.

Table 4. COC and Cost for Each Category – Two-part Model

	Part I: Probability of Having Any Cost[a], %		Part II: Among Veterans with Any Cost, Impact of BBC on Cost[b], $		Marginal Effect[c], $	
Outcome	Estimates	*p* Value	Estimates	*p* Value	Estimates	*p* Value
Acute inpatient cost	-3.1 (-4.9 to -1.2)	<.01	-1,968 (-3,822 to -115)	.04	-1,597 (-2,506 to -688)	<.01
ED cost	-3.6 (-5.4 to -1.8)	<.01	-140 (-232 to -49)	<.01	-119 (-174 to -64)	<.01
Long-stay NH cost	-6.5 (-8.3 to -4.8)	<.01	2,173 (-11,763 to 16,110)	.76	-4,368 (-8,093 to -643)	.03
Short-stay NH cost	-1.0 (-2.8 to 0.9)	.30	484 (-1,283 to 2,250)	.59	-98 (-742 to 546)	.77
Medical LTC cost	3.6 (1.6 to 5.6)	<.01	313 (-89 to 715)	.13	402 (113 to 691)	<.01
Social LTC cost	5.3 (3.8 to 6.8)	<.01	1,137 (292 to 1,982)	<.01	764 (460 to 1,067)	<.01

Notes: COC, continuity of care; ED, emergency department; NH, nursing home; LTC, long-term care.

All instrumental variable models controlled for the socio-demographics, socio-economic variables, risk factors and market characteristics. The independent variable was the Bice-Boxerman Continuity of Care (BBC) index.

[a] Instrumental variable models for the impact of BBC on the probability of having any cost for each category were estimated by IV-Probit. Estimates reported were marginal effects of a 0.1 increment in BBC score on change of probability of having any cost for each category and were calculated by the formula, $\varphi(\gamma_1 BBC + \gamma_2 Cov) * \gamma_1$, where $\varphi(\cdot)$ is the standard normal density function, γ is coefficients of variables, and Cov represents all the covariates in part I model. The 95% confidence intervals reported in brackets were generated using bootstrap with 1,000 replications. Sample size: 102,073.

[b] Instrumental variable models for the effect of BBC on cost among veterans with positive cost for each category were estimated by two-stage least square. Estimates reported were marginal effects of a 0.1 increment in BBC score on change of cost for each category among veterans with a positive cost. The

95% confidence intervals reported in brackets were generated using bootstrap with 1,000 replications. Sample size: 42,299 for acute inpatient cost, 52,713 for ED cost, 3,183 for long-stay nursing home cost, 20,905 for short-stay nursing home cost, 46,719 for medical LTC cost and 40,860 for social LTC cost.

[c] Estimates reported were marginal effects of a 0.1 increment in BBC score on change of cost for each category combining estimates from part I and part II models. The 95% confidence intervals reported in brackets were generated using bootstrap with 1,000 replications.

Table 5. Subgroup and sensitivity analyses – COC and total healthcare cost

Model	Total Combined VHA and Medicare Cost, $		
	N	Estimates	*P* Value
Original instrumented results (from Table 3)	102,073	-4,045 (-5,919 to -2,171)	<.01
BBC			
Below median	51,096	-14,556 (-22,437 to -6,675)	<.01
Above median	50,977	-3,755 (-10,255 to 2,746)	.26
Age			
66-74	23,223	-7,685 (-12,721 to -3,010)	<.01
>=75	78,850	-2,898 (-4,834 to -961)	<.01
Marital status			
Married or in long-term relationship	66,205	-3,370 (-5,848 to -892)	<.01
Single, divorced or widowed	35,868	-4,705 (-7,409 to -2,002)	<.01
Medicaid indicator			
Yes	6,994	-4,150 (-12,217 to 3,917)	.31
No	95,079	-4,110 (-6,048 to -2,172)	<.01
Years living with dementia			
<1	23,189	-4,716 (-7,953 to -1,479)	<.01
≥1	78,884	-3,766 (-6,122 to -1,410)	<.01
JFI			
0-2	5,683	560 (-5,366 to 6,486)	.85
3-5	40,101	-2,955 (-5,467 to -443)	.02
6-8	42,749	-4,835 (-8,106 to -1,563)	<.01
9+	13,540	-5,305 (-10,638 to 28)	.05
Substance dependence[a]			
Yes	11,981	-10,587 (-16,662 to -4,512)	<.01
No	90,092	-2,622 (-4,664 to -581)	.01
Mental health conditions[b]			

Model	Total Combined VHA and Medicare Cost, $		
	N	Estimates	*P* Value
Yes	31,634	-7,624 (-11,510 to -3,738)	<.01
No	70,439	-1,809 (-3,774 to 156)	.07
Number of visits			
Below median	50,794	-3,968 (-6,728 to -1,208)	<.01
Above median	51,279	-4,027 (-6,940 to -1,115)	<.01
Excluding deceased veterans	84,430	-4,658 (-7,325 to -1,991)	<.01
With any change in residence	11,332	-3,529 (-7,064 to 5)	.05
Excluding veterans in assisted living facility	97,823	-3,980 (-5,983 to -1,977)	<.01
Other cut-offs for the instrument			
Change in residence ≥5 miles (7%)	102,073	-5,515 (-7,401 to -3,629)	<.01
Change in residence ≥15 miles (4.6%)	102,073	-3,372 (-5,132 to -1,611)	<.01
Other COC measures			
Measuring BBC with primary care visits[c]	91,624	-2,849 (-5,235 to -463)	.02
Measuring BBC with all primary care and all specialist visits[d]	102,073	-7,591 (-11,186 to -3,996)	<.01
Usual Provider of Care (UPC)[e]	102,073	-4,508 (-6,620 to -2,395)	<.01

Notes: COC, continuity of care; BBC, Bice-Boxerman Continuity of Care; JFI, JEN Frailty Index.
All instrumental variable models controlled for the socio-demographics, socio-economic variables, risk factors and market characteristics and were estimated by two-stage least square. The independent variable was BBC. Estimates reported were marginal effects of a 0.1 increment in BBC score on change of total combined VHA and Medicare cost. The 95% confidence intervals reported in brackets were generated using bootstrap with 1,000 replications.

[a] Substance dependence included alcohol, tobacco and drug dependence.

[b] Mental health conditions included schizophrenia, manic depression, personality disorder and other psychotic conditions.

[c] Mean, 0.43; SD, 0.28.

[d] Mean, 0.19; SD, 0.15.

[e] UPC measures proportion of veteran's total primary care and dementia-related specialist visits with the most frequently visited provider. Mean, 0.53; SD, 0.20. Estimates reported was marginal effect of a 0.1 increment in UPC score on change of total combined VHA and Medicare cost.