

# Distinct Health Care Use Patterns of Patients With Chronic Gastrointestinal Diseases

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**H**ealth care is plagued by fragmentation, high costs, and low-value care both in the United States and globally.<sup>1</sup> The US patient-centered medical home (PCMH) model was designed to improve the individual experience of care, population health, and per capita cost of care through promotion of continuity of care (COC) with a primary care provider (PCP), who helps to coordinate other aspects of care. Continuity with a single PCP has been associated with lower health care costs and reduced care utilization in the general population.<sup>2</sup> However, the PCMH model, and measures designed to assess its benefits (such as measures of COC), are largely tailored to general primary care populations.

Complex chronic diseases are conditions with high morbidity that require care by multiple providers, such as diabetes complicated by kidney disease and peripheral neuropathy.<sup>3</sup> Patients with complex chronic conditions that require chronic specialty care are prone to fragmentation, which is often associated with poor health-related outcomes.<sup>4,5</sup> These patients often require care by a team composed of PCPs and specialists (including mental health providers), with a specialist often serving as central coordinator. In the setting of team-based care by multiple providers in multiple disciplines, COC measured across all providers declines, and claims-based care measures will inevitably appear more fragmented.<sup>6-8</sup> These patients have varying multidisciplinary care needs and utilization patterns, and it is unclear how conventional interventions and continuity measures should be applied to them.<sup>9,10</sup>

To better inform and tailor interventions to improve COC for patients with complex chronic conditions that require chronic specialty care and to reduce the consequences of fragmentation—including health care overutilization, information loss, and discordant plans of care—we aimed to understand the different patterns of outpatient care use and COC in this population, using 3 complex chronic conditions as case examples. Our overarching objective is to leverage these 3 conditions as a proof of concept, which could be extrapolated to other complex chronic conditions in future work. We hypothesized that we would find several different patterns of outpatient care and COC across outpatient primary, specialty, and mental health care.

## ABSTRACT

**OBJECTIVES:** Patients with complex chronic conditions have varying multidisciplinary care needs and utilization patterns, which limit the effectiveness of initiatives designed to improve continuity of care (COC) and reduce utilization. Our objective was to categorize patients with complex chronic conditions into distinct groups by pattern of outpatient care use and COC to tailor interventions.

**STUDY DESIGN:** Observational cohort study from 2014 to 2015.

**METHODS:** We identified patients whose 1-year hospitalization risk was in at least the 90th percentile in 2014 who had a chronic gastrointestinal disease (cirrhosis, inflammatory bowel disease, chronic pancreatitis) as case examples of complex chronic disease. We described frequency of office visits, number of outpatient providers, and 2 COC measures (usual provider of care, Bice-Boxerman COC indices) over 12 months. We used latent profile analysis, a statistical method for identifying distinct subgroups, to categorize patients based on overall, primary care, gastroenterology, and mental health continuity patterns.

**RESULTS:** The 26,751 veterans in the cohort had a mean (SD) of 13.3 (8.6) office visits and 7.2 (3.8) providers in 2014. Patients were classified into 5 subgroups: (1) high gastroenterology-specific COC with mental health use; (2) high gastroenterology-specific COC without mental health use; (3) high overall utilization with mental health use; (4) low overall COC with mental health use; and (5) low overall COC without mental health use. These groups varied in their sociodemographic characteristics and risk for hospitalization, emergency department use, and mortality.

**CONCLUSIONS:** Patients at high risk for health care utilization with specialty care needs can be grouped by varying propensity for health care continuity patterns.

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## TAKEAWAY POINTS

- ▶ Patients with complex chronic disease have varying multidisciplinary care needs and utilization patterns, which limit the effectiveness of initiatives designed to improve continuity of care and reduce utilization.
- ▶ Patients with cirrhosis, chronic pancreatitis, and inflammatory bowel disease (as case examples of complex chronic disease) can be grouped by varying propensity for health care continuity patterns.
- ▶ These varying patterns could be harnessed to personalize care coordination interventions to optimize health care utilization.

## METHODS

## Study Population

The US Department of Veterans Affairs (VA) Veterans Health Administration is a national integrated health system that has made substantial investments in improving the quality of health care and monitoring and improving COC on a population health level. We conducted a cross-sectional analysis of continuity patterns in VA patients with high levels of health care utilization using data from 2014 and 2015. The cohort for this analysis was drawn from an ongoing study of care continuity and fragmentation,<sup>11</sup> the population for which included VA patients at high risk for hospitalization (1-year hospitalization risk greater than or equal to 90th percentile in 2014, based on the VA's Care Assessment Needs score) and who were alive at the end of fiscal year 2014.

Cirrhosis, chronic pancreatitis, and inflammatory bowel disease (IBD) are prototypical examples of complex chronic conditions. They have high morbidity and propensity for health care overuse, necessitate high-intensity self-management by patients, and require multidisciplinary management by both primary care and gastroenterology providers. They are also not supported within existing medical home programs. Our analyses focused on patients with 1 of these 3 chronic gastrointestinal (GI) conditions. We selected these GI conditions to minimize heterogeneity in COC among different specialty care disciplines. Patients with IBD, cirrhosis, and chronic pancreatitis were identified using previously validated algorithms (eAppendix Figure 1 [eAppendix available at [ajmc.com](http://ajmc.com)]).<sup>12-16</sup>

Patients were required to have at least 1 VA office visit in 2014 and have a minimum of 4 total office visits that were either in the VA or in the community but covered by the VA. A minimum of 4 office visits is required to calculate the usual provider of care index (UPC) and Bice-Boxerman COC index (COCI) with a desirable level of variation.<sup>17</sup> This threshold of a minimum of 4 visits is standard in previous studies and addresses the bias toward reporting minimal variation in care fragmentation patterns when patients have low-volume care, while representing patients with a high burden of care.<sup>6,17-19</sup>

## Variables of Interest

Outpatient VA visits and VA-covered community visits with physicians, nurse practitioners, physician assistants, residents, psychologists,

and licensed clinical social workers with a national provider identifier were collected.<sup>20</sup> PCPs included general practice, family practice, internal medicine, pediatric medicine, geriatric medicine, and preventive medicine providers. Mental health providers included specialists in psychiatry/neuropsychiatry, addiction medicine, psychology, and clinical social work.

Health care continuity patterns were characterized using several distinct measures: the frequency of office visits, the total number of outpatient providers, and 2 claims-based COC measures. The 2 COC measures were (1) the UPC and (2) the COCI (eAppendix Table 1). The UPC is a measure of care density and captures the proportion of all visits that are attributed to a patient's most frequently visited provider, whereas the COCI measures the extent to which a given individual's total number of visits for an episode of illness or a specific time period are with a single provider.<sup>21</sup> The indices range from 0 to 1, where 0 represents a scenario in which each visit is made to a different provider and 1 represents a scenario in which all visits are made to a single provider. We developed variants of each of the continuity measures as applied to outpatient care overall, as well as PCP-specific, gastroenterology-specific, and mental health-specific outpatient care. Provider-specific UPC and COCI measures were considered for patients with at least 2 visits with a PCP, mental health provider, or gastroenterologist so that our findings would be generalizable to patients who saw a specific provider type twice yearly, which is relatively common.

We reported patient-level covariates including age, gender, race, ethnicity, rural-urban commuting area designation, marital status, and homelessness status. These classifications are all specified in VA Corporate Data Warehouse files. We identified the number of chronic conditions and Charlson Comorbidity Index score for each patient using *International Classification of Diseases, Ninth Revision, Clinical Modification* codes.<sup>22-24</sup> We also examined outcome measures in fiscal year 2015, which included hospitalization or death, emergency department (ED) visits, and number of outpatient visits.

## Statistical Analysis

We used latent profile analysis, which is a model-based method of clustering. Latent profile analysis is a strategy used to identify unobserved subgroups in a population, using a specified set of variables from observed data and assuming population heterogeneity.<sup>25</sup> We fit a latent profile model using the *gsem* command in Stata (StataCorp) for a prespecified combination of observed continuous and count variables. We estimated the expected proportions of the population in each group. These classes, or subgroups, were then labeled with the marginal means of each observed variables based on subgroup. To examine goodness of fit, we evaluated models with 3 to 10 subgroups, using the Akaike information criterion (AIC) and Bayesian information criterion (BIC).<sup>26</sup> The model with the smallest

values for AIC and BIC was considered the model with the best fit. The predicted probabilities of preselected patient characteristics and health care utilization values were reported by class membership.

**Sensitivity Analyses**

The frequency of PCP-, mental health-, and gastroenterology-specific visits is overall low, and therefore there was concern that patients with perfect provider-specific continuity may bias the derivation and interpretation of the UPC and COCI measurements. Therefore, we performed a sensitivity analysis, redefining the PCP-, mental health-, and gastroenterology-specific COC measures as a dichotomous variable, where a provider-specific UPC and COCI of 1 was labeled as “single provider.” In a second sensitivity analysis we extended the previous analysis to include an indicator variable to identify whether a PCP or mental health or gastroenterology provider was the usual provider of care. Associations among patient characteristics, health care utilization, and subgroup membership were analyzed using a  $\chi^2$  test and one-way analysis of variance for categorical and continuous variables, respectively. All analyses were performed in Stata/MP version 15 (StataCorp). This study was approved by the Palo Alto VA (affiliated with Stanford University) and Ann Arbor VA Institutional Review Boards.

**RESULTS**

**Cohort Description**

We identified 26,751 patients with chronic gastroenterology disease with a hospitalization risk score in the top 10% and a minimum of 4 VA or VA-covered office visits in fiscal year 2014 (eAppendix Figure 2). Among these patients, 4450 (16.7%) carried a diagnosis of IBD, 17,568 (65.7%) had cirrhosis, and 5536 (20.7%) had chronic pancreatitis. A majority were White (72.1%) and male (95.3%), and they had a mean (SD) age of 62 (9.35) years and a mean (SD) Charlson Comorbidity Index score of 4.5 (3.02). Overall, 28.5% (n = 7623) of patients resided in rural areas, and 13.1% had a history of homelessness. Comorbid conditions were common in this cohort, with more than half (56.3%) having 8 or more chronic conditions—among them, mental health conditions, cancer, obesity, and alcohol use disorder were common (Table 1). Baseline health care utilization in 2014 was high, with a mean (SD) of 1.3 (1.85) hospitalizations and 2.6 (3.47) ED visits per person.

A high volume of care was common often with multiple providers, with an overall mean (SD) of 13.3 (8.63) office visits and 7.2 (3.83) providers per patient (Table 2). The overall mean (SD) UPC was 0.36 (0.16), indicating that 36% of visits were with the most frequently seen provider, and the overall mean (SD) COCI was 0.17 (0.14) on a scale from 0 to 1. PCP-specific care had higher continuity, with a mean (SD) PCP-specific UPC of 0.81 (0.23) and COCI of 0.67 (0.38). The mean (SD) gastroenterology-specific UPC and COCI were 0.72 (0.26) and 0.52 (0.42), respectively. The mean (SD) mental health-specific UPC and COCI were 0.72 (0.24) and 0.56 (0.37), respectively.

**TABLE 1.** Cohort Demographics and Health Care Utilization in 2014 and 2015

Patient demographics	N = 26,751
Age in years, mean (SD)	62.0 (9.35)
65 years and older, n (%)	10,966 (41.0%)
Male gender, n (%)	25,488 (95.3%)
Race, n (%)	
White	19,303 (72.1%)
Black	5855 (21.9%)
Other	585 (2.2%)
Unknown	1008 (3.8%)
Ethnicity, n (%)	
Hispanic	1975 (7.4%)
Non-Hispanic	23,937 (89.5%)
Unknown	839 (3.1%)
Charlson Comorbidity Index score, mean (SD)	4.5 (3.02)
Rural place of residence, n (%)	7623 (28.5%)
Married, n (%)	9723 (36.4%)
History of homelessness, n (%)	3511 (13.1%)
Number of chronic conditions, mean (SD)	8.4 (3.58)
Mental health condition, n (%)	18,045 (67.5%)
Cancer diagnosis, n (%)	5900 (22.1%)
Obesity diagnosis, n (%)	4289 (16.0%)
Alcohol use disorder, n (%)	8962 (33.5%)
Opioid use disorder, n (%)	1716 (6.4%)
Health care utilization in 2014	
Any hospitalization, n (%)	15,747 (58.9%)
Number of hospitalizations, mean (SD)	1.34 (1.85)
Any ED visit, n (%)	19,946 (74.6%)
Health care utilization in 2015	
Any hospitalization or death, n (%)	12,978 (48.5%)
Number of hospitalizations, mean (SD)	1.0 (1.73)
Any hospitalization, n (%)	11,259 (42.1%)
Hospital days, mean (SD)	6.0 (15.47)
Any ED visit, n (%)	16,167 (60.4%)
Number of ED visits, mean (SD)	2.0 (3.34)

ED, emergency department.

**Latent Profile Analysis**

A 5-class model was chosen as the final model based on domain usefulness and goodness of fit (eAppendix Table 2), and so that no class had less than 5% of the cohort. Each of these 5 subgroups are described by specific health care utilization (based on frequency of office visits and number of providers) and COC (based on the UPC and COCI measurements) patterns (Table 3). Among the 5 subgroups, 2 of these groups could be classified by high gastroenterology-specific COC (subgroup 1, subgroup 2) but distinguished by the presence or absence of mental health use. Two groups could be classified by

## CLINICAL

**TABLE 2.** Outpatient Continuity Patterns

Measures in fiscal year 2014	Overall (N = 26,751)	PCP specific (n = 22,358)	Gastroenterology specific (n = 12,850)	Mental health specific (n = 11,217)
Number of visits, mean (SD)	13.3 (8.63)	3.5 (2.64)	3.0 (2.69)	3.0 (5.50)
Number of providers, mean (SD)	7.2 (3.83)	1.6 (1.04)	1.7 (1.09)	1.1 (1.50)
Usual provider of care index, mean (SD)	0.36 (0.16)	0.81 (0.23)	0.72 (0.26)	0.72 (0.24)
Bice-Boxerman continuity of care index, mean (SD)	0.17 (0.14)	0.67 (0.38)	0.52 (0.42)	0.56 (0.37)

PCP, primary care provider.

**TABLE 3.** Marginal Means of Health Care Continuity Patterns by Phenotype

Class		Subgroup 1	Subgroup 2	Subgroup 3	Subgroup 4	Subgroup 5
		High gastroenterology-specific COC with mental health use	High gastroenterology-specific COC without mental health use	High overall utilization with mental health use	Low overall COC with mental health use	Low overall COC without mental health use
Proportion of cohort		16.3%	35.6%	8.1%	19.1%	20.9%
Overall	Number of visits	9.65	8.05	31.91	13.48	17.85
	Number of providers	4.92	4.79	11.80	7.89	10.49
	UPC	0.43	0.42	0.37	0.30	0.26
	COCI	0.22	0.20	0.20	0.12	0.10
PCP specific	Number of visits	2.76	2.91	5.18	3.28	4.44
	Number of providers	1.26	1.35	2.11	1.60	2.07
	UPC	0.80	0.85	0.74	0.80	0.73
	COCI	0.78	0.73	0.59	0.64	0.55
Mental health specific	Number of visits	2.97	0.00	16.31	5.02	0.91
	Number of providers	1.07	0.00	3.51	2.74	0.40
	UPC	0.98	0.79	0.65	0.54	1.00
	COCI	0.95	0.35	0.49	0.25	1.00
GI specific	Number of visits	2.36	2.47	3.91	2.64	4.11
	Number of providers	1.32	1.46	2.03	1.59	2.28
	UPC	0.82	0.77	0.68	0.73	0.62
	COCI	0.66	0.59	0.48	0.53	0.38

COC, continuity of care; COCI, Bice-Boxerman COC index; PCP, primary care provider; UPC, usual provider of care index.

low overall COC (subgroup 4 and subgroup 5), although one group involves mental health utilization whereas the other does not. Three of the groups could be classified by the presence of mental health visits (subgroup 1, subgroup 3, and subgroup 4), although these groups could be differentiated by degree of overall health care utilization. PCP-specific COC was high across groups, although GI- and mental health-specific COC varied by group.

### Subgroup Characteristics

Demographic characteristics varied by subgroup (Table 4). Patients in the 2 subgroups with low COC (subgroup 3 and subgroup 4) and those in 1 subgroup with high outpatient care utilization (subgroup 2) were more likely to be non-White, were more likely to reside in a rural area, and tended to have fewer chronic conditions. Patients in the 2 subgroups characterized by low COC (subgroup 3 and subgroup 4) also

tended to have a higher baseline proportion of hospitalization and ED utilization. Patients classified by the presence of substantial mental health care use (subgroup 1, subgroup 2, and subgroup 3) tended to be younger and were more likely to be female and married. They were also less likely to have a history of homelessness. The subgroups with mental health use (subgroup 1, subgroup 2, and subgroup 3) also had the highest proportions of patients with chronic pancreatitis.

In the subsequent year (fiscal year 2015), patients had a mean (SD) of 11.8 (9.05) office visits, and 11,259 (42.1%) had a hospitalization, 16,167 (60.4%) had an ED visit, and 1719 (6.4%) died. Fiscal year 2015 health care utilization varied across subgroups, with a higher proportion of subsequent hospitalizations and ED visits among 3 subgroups—the group with high outpatient care utilization and mental health care use (subgroup 2) and the 2 groups with low overall COC (subgroup 3 and subgroup 4) (Table 5).

**TABLE 4.** Patient Characteristics by Class Membership

Class	Subgroup 1	Subgroup 2	Subgroup 3	Subgroup 4	Subgroup 5	P
	High gastroenterology-specific COC with mental health use	High gastroenterology-specific COC without mental health use	High overall utilization with mental health use	Low overall COC with mental health use	Low overall COC without mental health use	
<b>Demographics</b>						
Age in years, mean (SD)	60.9 (8.9)	63.8 (9.2)	58.6 (9.8)	59.2 (9.3)	63.7 (8.7)	<.001
Male gender, n (%)	4149 (94.9%)	9365 (97.0%)	1955 (90.8%)	4674 (93.8%)	5345 (95.6%)	<.001
Race, n (%)						<.001
White	3195 (73.1%)	7072 (73.3%)	1543 (71.6%)	3473 (69.7%)	4020 (71.9%)	
Black	944 (21.6%)	1941 (20.1%)	502 (23.3%)	1213 (24.3%)	1255 (22.4%)	
Other	95 (2.2%)	203 (2.1%)	58 (2.7%)	113 (2.3%)	116 (2.1%)	
Unknown	136 (3.1%)	436 (4.5%)	51 (2.4%)	183 (3.7%)	202 (3.6%)	
Ethnicity, n (%)						<.001
Hispanic	311 (7.1%)	636 (6.6%)	185 (8.6%)	375 (7.5%)	468 (8.4%)	
Non-Hispanic	3911 (89.5%)	8686 (90.0%)	1931 (89.6%)	4456 (89.5%)	4953 (88.5%)	
Unknown	148 (3.4%)	330 (3.4%)	39 (1.8%)	151 (3.0%)	172 (3.1%)	
Charlson Comorbidity Index score, mean (SD)	3.9 (2.7)	4.5 (2.9)	4.3 (3.2)	4.0 (2.9)	5.5 (3.4)	<.001
Rural place of residence, n (%)	3090 (70.7%)	6565 (68.0%)	1683 (78.1%)	3709 (74.5%)	4081 (73.0%)	<.001
Married, n (%)	2937 (67.2%)	6125 (63.5%)	1469 (68.2%)	3361 (67.5%)	3136 (56.1%)	<.001
History of homelessness, n (%)	3765 (86.2%)	9016 (93.4%)	1582 (73.4%)	3735 (75.0%)	5142 (91.9%)	<.001
Number of chronic conditions, mean (SD)	8.10 (3.33)	7.10 (3.19)	10.52 (3.72)	9.65 (3.57)	8.93 (3.48)	<.001
Type of chronic gastrointestinal disease, n (%)						<.001
Inflammatory bowel disease	645 (14.8%)	1641 (17.0%)	385 (17.9%)	712 (14.3%)	1067 (19.1%)	
Cirrhosis	2870 (65.7%)	6415 (66.5%)	1349 (62.6%)	3203 (64.3%)	3731 (66.7%)	
Chronic pancreatitis	991 (22.7%)	1852 (19.2%)	479 (22.2%)	1247 (25.0%)	967 (17.3%)	
Other chronic conditions, n (%)						
Mental health condition	3953 (90.5%)	3967 (41.1%)	2118 (98.3%)	4845 (97.3%)	3162 (56.5%)	<.001
Cancer diagnosis	629 (14.4%)	2145 (22.2%)	442 (20.5%)	748 (15.0%)	1936 (34.6%)	<.001
Obesity diagnosis	599 (13.7%)	1336 (13.8%)	488 (22.7%)	834 (16.7%)	1032 (18.4%)	<.001
Alcohol use disorder	1709 (39.1%)	2356 (24.4%)	1023 (47.5%)	2652 (53.2%)	1222 (21.8%)	<.001
Opioid use disorder	303 (6.9%)	230 (2.4%)	330 (15.3%)	642 (12.9%)	211 (3.8%)	<.001
Health care utilization in 2014						
Any hospitalization, n (%)	2262 (51.8%)	5396 (55.9%)	1325 (61.5%)	3130 (62.8%)	3634 (65.0%)	<.001
Number of hospitalizations, mean (SD)	1.08 (1.62)	1.09 (1.49)	1.78 (2.56)	1.60 (2.11)	1.58 (1.92)	<.001
Any ED visit, n (%)	3053 (69.9%)	6890 (71.4%)	1699 (78.9%)	3932 (78.9%)	4372 (78.2%)	<.001
Number of ED visits, mean (SD)	2.15 (3.12)	1.99 (2.62)	3.75 (5.02)	3.23 (4.14)	2.85 (3.40)	<.001

COC, continuity of care; ED, emergency department.

### Sensitivity Analyses

In a sensitivity analysis with dichotomized gastroenterology-, PCP-, and mental health-specific UPC and COCI variables (based on whether all care took place with a single provider), 39.2%, 34.7%, and 52.7% of patients had a single PCP, mental health provider, and gastroenterologist, respectively. Using these dichotomized variables, we were able to classify patients into similar phenotypes (eAppendix Table 3). In a second sensitivity analysis, we analyzed the provider type for the UPC measure and found that the usual provider of care was a PCP for 51.4% of patients, whereas mental health providers and gastroenterology providers were the usual

providers for 19.9% and 13.7% of patients, respectively. With addition of these indicator variables, patients were classified into similar subgroups (eAppendix Table 3).

## DISCUSSION

Patients with chronic GI conditions who are at risk for high utilization have varying health care continuity patterns that can be described beyond a single COC index. We were able to classify these individuals into 1 of 5 subgroups based on PCP-specific, gastroenterology-specific, mental health-specific, and overall

**TABLE 5.** Health Care Utilization in 2015 by Class Membership

Class	Subgroup 1	Subgroup 2	Subgroup 3	Subgroup 4	Subgroup 5	P
Health care utilization in 2015	High gastroenterology-specific COC with mental health use	High gastroenterology-specific COC without mental health use	High overall utilization with mental health use	Low overall COC with mental health use	Low overall COC without mental health use	
Any hospitalization or death, n (%)	1956 (44.8%)	4371 (45.3%)	1118 (51.9%)	2541 (51.0%)	2992 (53.5%)	<.001
Number of hospitalizations, mean (SD)	0.87 (1.70)	0.79 (1.50)	1.29 (2.18)	1.15 (1.96)	1.06 (1.68)	<.001
Any hospitalization, n (%)	1695 (38.8%)	3624 (37.6%)	1031 (47.9%)	2280 (45.8%)	2629 (47.0%)	<.001
Hospital days, mean (SD)	5.78 (16.63)	4.72 (13.72)	8.52 (19.63)	7.49 (16.19)	6.18 (14.66)	<.001
Any ED visit, n (%)	2481 (56.8%)	5309 (55.0%)	1474 (68.4%)	3259 (65.4%)	3644 (65.2%)	<.001
Number of ED visits, mean (SD)	1.82 (2.99)	1.62 (2.78)	2.84 (4.37)	2.51 (4.02)	2.16 (3.23)	<.001

COC, continuity of care; ED, emergency department.

frequency of office visits; number of providers; and UPC and COCI measurements. These were (1) high gastroenterology-specific COC with mental health use; (2) high gastroenterology-specific COC without mental health use; (3) high overall utilization with mental health use; (4) low overall COC with mental health use; and (5) low overall COC without mental health use. These classifications reflect subpopulations with varying characteristics and risk for subsequent health care utilization.

Overall COC as determined by the UPC and COCI was low but varied by subgroup, similar to other disease states and findings of studies of COC in other health care systems.<sup>5,6,27,28</sup> Patients classified as having the lowest overall COC or highest outpatient care utilization also had more subsequent hospitalizations and ED visits. This is similar to prior findings.<sup>2,6,29</sup> A recent systematic review examining hospitalizations for ambulatory care-sensitive conditions demonstrated a significant increase in likelihood of hospitalizations among patients with low COC, with odds ratios ranging from 1.34 to 8.69.<sup>30</sup> This needs to be considered in the context of disease severity, as sicker patients may be more likely to be seen by a greater number of providers. However, we selected for patients who were at high risk for hospitalization based on an established risk score.

Use of mental health care services also played an important role in classifying patients, with mental health utilization and fragmentation characterizing certain subgroup phenotypes, yet a distinct absence of mental health care occurred among other subgroups with both high and low COC. Although mental health care use patterns played a substantial role in classifying patients, they did not align with high or low subsequent health care utilization. This has implications for mental health care.

Although existing PCMH models in the United States are not tailored to patients with high-intensity specialty care needs, classifying high-risk patients may aid in further personalizing care coordination strategies for effectiveness and sustainability. For example, patients with a need for frequent mental health services may benefit from a collaborative care model centered around mental health providers.<sup>31,32</sup> It may also be beneficial to include participation

of mental health providers in interventions designed to improve COC or coordination, such as multidisciplinary meetings or the addition of care manager roles. Patients with complex chronic conditions that require more specialized care, such as individuals with advanced heart failure or chronic obstructive pulmonary disease, may also benefit more from interprofessional case conferences or structured communication about specialist-recommended care plans.<sup>33</sup> In addition, identifying subpopulations with varying risk for subsequent health care utilization can help prioritize targets for improvement. Tailored interventions need to be further evaluated as part of future efforts to optimize health care utilization and COC.

This study offers important insight into the use of claims-based COC measurements in understanding patterns of care. Measures such as the UPC and COCI provide us with a quantitative method of describing the concentration and dispersion of care. However, these measures are influenced by the frequency of office visits, number of providers, and number of visits with each provider from which these indices are derived. If patients only have a couple of visits in a specialty care clinic, this limits the possible values for the continuity measures, and the limited variation may have implications for population-based studies. In addition, these measures can be skewed if patients tend to have most of their care with one provider, as occurred in this study, in which most patients received all their care from a single PCP, mental health provider, or gastroenterologist.

Claims-based COC measures provide limited insight into informational continuity, or reasons for fragmentation patterns, such as the strength of the patient-provider relationship, provider-provider comanagement relationships, access to care, incomplete evaluations, and patient engagement. Overall COC, although commonly used, is challenging to interpret in the context of varying disease severity, which may require different numbers of providers for optimal care. For example, a patient with mild IBD may need only a PCP and gastroenterologist, whereas a more severely ill patient with IBD may also require care by a surgeon, yet the latter patient will appear to have lower COC by the measure. Finally, it is important to note that the original COCI identified continuity

with a single provider or group of referred providers. Subsequent operationalizations of this measure have ignored referral patterns among providers given that these are difficult to establish in claims data. However, as a result, existing measures cannot measure the continuity of a multispecialty group of physicians caring for a patient with a complex disease. It may be that to fully understand patterns of health care use, we must develop measures of the COC with a multispecialty care team.

### Strengths and Limitations

The strengths of this study include a large sample size and national data set. The study also has its limitations, including limited descriptors of cirrhosis or IBD severity or related medication use, although as a group of high utilizers the impact of disease severity on utilization is less relevant. The study findings do not represent patients with fewer than 4 visits per year, although any potential interventions that could be derived using the study findings are focused on patients with high baseline utilization. Future research could consider whether measuring fragmentation over a longer period might yield different findings due to an increased number of visits per specialty. Provider-specific UPC and COCI measures were considered for patients with at least 2 visits with a PCP, mental health provider, or gastroenterologist so that our findings would be generalizable to patients who saw a specific provider type twice yearly, which is relatively common. The limitations of this methodology need to be considered, as perfect continuity with a provider may skew the UPC and COCI in this context. Therefore, we performed analyses in which provider-specific UPC and COCI were treated as continuous variables and another in which these variables were dichotomized and defined by the presence or absence of perfect continuity with a single provider to capture whether this would influence our study findings. Any care that veterans received outside the VA that was not a VA-covered service was not considered. We also need to consider the limited generalizability of these data to a nonveteran population. We plan to address this limitation by externally validating our findings in other populations in future work. We also need to consider potential limited generalizability to other complex chronic conditions managed by other specialties. We plan to extend these methods to other conditions and specialties in future work. Finally, given the limitations of the data, disease-specific characteristics and outcomes (eg, IBD severity or duration) were not examined.

## CONCLUSIONS

Patients with high-intensity GI care needs and a high risk for health care utilization can be grouped by varying propensity for health care continuity patterns. These findings are relevant as a proof of concept for complex chronic conditions that require management with a specialist. They also more specifically inform efforts within the PCMH setting to improve COC for patients with chronic GI conditions and to reduce the consequences of fragmentation for these patients. Future studies should extend this analysis to

other national health systems and other conditions with complex specialty care needs and compare these findings with those of a general population of patients at risk for increased utilization. An in-depth qualitative evaluation of patients in each classification would also help to better understand these patterns of care and associated influences, including the role of informational and interpersonal continuity among providers. These varying patterns could be harnessed to personalize care coordination interventions to optimize health care utilization. ■

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**eAppendix Table 1. Derivation of COC Measures**

<b>Measure</b>	<b>Formula</b>
Usual provider of care (UPC)	$\max\left(\frac{n_i}{n}\right)$
Continuity of care index (COCI)	$\frac{\sum_{i=1}^P n_i^2 - n}{n(n - 1)}$

**eAppendix Table 2. Goodness of Fit and Number of Classes**

Number of classes in model	ll(model)	DF	AIC	BIC
Three class	-402,644.5	58	805404.9	805880.2
Four class	-385,578.8	75	771307.6	771307.6
Five class	-376,559.6	90	753299.3	753299.3
Six class	-361,875.6	109	723969.2	724862.4
Seven class	-358,587.8	125	717425.7	718450.0
Eight class	-348,271.4	140	696822.9	697970.1
Nine class	-342,986.3	161	686294.6	687613.9
Ten class	-335,597.4	180	671554.8	673029.8

\*A lower BIC and AIC is representative of a more favorable model with better model fit parameters

**eAppendix Table 3. Sensitivity Analyses (a) dichotomous provider-specific continuity measures, (b) designation of UPC**

<b>(a) Class</b>		<b>Subgroup 1</b>	<b>Subgroup 2</b>	<b>Subgroup 3</b>	<b>Subgroup 4</b>	<b>Subgroup 5</b>
		<b>High gastroenterology specific COC with mental health use</b>	<b>High gastroenterology specific COC without mental health use</b>	<b>High overall utilization with mental health use</b>	<b>Low overall COC with mental health use</b>	<b>Low overall COC without mental health use</b>
<b>Proportion of cohort</b>		36.0%	8.9%	8.5%	28.8%	17.7%
Overall	Number of visits	9.58	7.20	29.55	10.30	21.06
	Number of providers	6.11	2.75	10.69	5.87	11.88
	UPC	0.34	0.68	0.38	0.36	0.25
	COCI	0.13	0.47	0.20	0.15	0.10
PCP-specific	Number of visits	2.94	3.73	4.48	2.75	5.04
	Number of providers	1.51	1.14	1.87	1.37	2.21
	Single PCP*	0.44	0.68	0.37	0.47	0.32
Mental health-specific	Number of visits	0.00	0.34	16.80	3.58	2.56
	Number of providers	0.00	0.19	3.82	1.73	1.26
	Single MH provider*	0.00	0.01	0.07	0.33	0.23
GI-specific	Number of visits	2.58	3.30	3.21	2.26	4.54
	Number of providers	1.65	1.23	1.77	1.41	2.32
	Single GI*	0.19	0.22	0.19	0.18	0.17

<b>(b) Class</b>		<b>Subgroup 1</b>	<b>Subgroup 2</b>	<b>Subgroup 3</b>	<b>Subgroup 4</b>	<b>Subgroup 5</b>
		<b>High gastroenterology specific COC with mental health use</b>	<b>High gastroenterology specific COC without mental health use</b>	<b>High overall utilization with mental health use</b>	<b>Low overall COC with mental health use</b>	<b>Low overall COC without mental health use</b>
Proportion of cohort		35.7%	8.7%	9.5%	28.5%	17.6%
Overall	Number of visits	9.61	7.17	28.06	10.10	21.11
	Number of providers	6.15	2.80	10.39	5.78	11.78
	UPC	0.34	0.67	0.37	0.36	0.26
	COCI	0.12	0.46	0.20	0.16	0.10
	PCP is UPC*	0.62	0.72	0.08	0.47	0.51
	MH is UPC*	0.00	0.00	0.89	0.36	0.07
	GI is UPC*	0.16	0.17	0.02	0.09	0.22
PCP-specific	Number of visits	2.93	3.81	4.03	2.74	5.19
	Number of providers	1.51	1.16	1.78	1.37	2.20
	Single PCP*	0.43	0.69	0.38	0.47	0.33
Mental health-specific	Number of visits	0.00	0.13	15.92	3.46	2.41
	Number of providers	0.00	0.12	3.55	1.69	1.27
	Single MH provider*	0.00	0.00	0.10	0.35	0.21
GI-specific	Number of visits	2.57	3.18	3.14	2.22	4.67
	Number of providers	1.65	1.23	1.75	1.41	2.31
	Single GI*	0.19	0.24	0.19	0.18	0.18

\*Reported as predicted probabilities rather than marginal means; COC, continuity of care; UPC: usual provider of Care index; COCI, Bice-Boxerman COC Index

**eAppendix Figure 1. Inpatient and outpatient International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM) codes**

**Patients with IBD:** Crohn's disease (555.x), and ulcerative colitis (556.x).<sup>9</sup> Patients were selected for inclusion if they had two or more of these ICD-9-CM codes during at least two clinical encounters in 2014, with at least one of these encounters being an outpatient visit. This approach has an established positive predictive value for Crohn's disease of 0.84 and a positive predictive value for ulcerative colitis of 0.91 in the VA.

**Patients with cirrhosis:** Patients were selected for inclusion if they had these ICD-9-CM codes recorded at least twice in inpatient or outpatient medical records: 571.2 (cirrhosis with alcoholism), 571.5 (cirrhosis no mention of alcohol), 456.0-456.21 (esophageal varices with or without bleeding), 567.23 (spontaneous bacterial peritonitis), 572.2 (hepatic encephalopathy), and 572.4 (hepatorenal syndrome).<sup>10,11</sup> These diagnostic definitions of cirrhosis and hepatocellular carcinoma based on ICD-9 codes derived from VA electronic medical datasets have been shown to have high agreement with review of the medical records by a physician (cirrhosis: positive predictive value of 88%; negative predictive value of 92%; hepatocellular carcinoma: positive predictive value of 94%; negative predictive value of 100%) and have been extensively used in epidemiological studies.

**Patients with chronic pancreatitis:** Patients were selected for inclusion based on presence of an ICD-9 code of 577.1. Use of ICD-9 code for chronic pancreatitis has a sensitivity of 87% and a specificity of 86%.<sup>15,16</sup>

## eAppendix Figure 2. Study Cohort

