Care Fragmentation, Quality, and Costs Among Chronically Ill Patients

Brigham R. Frandsen, PhD; Karen E. Joynt, MD, MPH; James B. Rebitzer, PhD; and Ashish K. Jha, MD, MPH

ABSTRACT

Objectives: To assess the relationship between care fragmentation and both quality and costs of care for commercially insured, chronically ill patients.

Study Design: We used claims data from 2004 to 2008 for 506,376 chronically ill, privately insured enrollees of a large commercial insurance company to construct measures of fragmentation. We included patients in the sample if they had chronic conditions in any of the following categories: cardiovascular disease, diabetes, asthma, arthritis, or migraine.

Methods: We assigned each patient a fragmentation index based on the patterns of care of their primary care provider (PCP), with care patterns spread across a higher number of providers considered to be more fragmented. We used regression analysis to examine the relationship between fragmentation and both quality and cost outcomes.

Results: Patients of PCPs in the highest quartile of fragmentation had a higher chance of having a departure from clinical best practice (32.8%, vs 25.9% among patients of PCPs in the lowest quartile of fragmentation; $P < .001$). Similarly, patients of PCPs with high fragmentation had higher rates of preventable hospitalizations (9.1% in highest quartile vs 7.1% in lowest quartile; $P < .001$). High fragmentation was associated with $4542 higher healthcare spending ($10,396 in the highest quartile vs $5854 in the lowest quartile; $P < .001$). We found similar or larger effects on quality and costs among patients when we examined the most frequently occurring disease groups individually.

Conclusions: Chronically ill patients whose primary care providers offer highly fragmented care more often experience lapses in care quality and incur greater healthcare costs.

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The US healthcare system suffers from high costs that do not yield commensurately high levels of quality. Although there are many competing explanations for this inefficiency, one area of relatively broad consensus is care fragmentation. According to the fragmentation hypothesis, care delivery too often involves multiple providers and organizations with no single entity effectively coordinating different aspects of care.[1,2] Poor coordination across providers may lead to suboptimal care, including important healthcare issues being inadequately addressed, poor patient outcomes, and unnecessary or even harmful services that ultimately both raise costs and degrade quality. It is precisely this hypothesis that has spurred policy makers to make investments in care models that emphasize care coordination, such as the patient-centered medical home model and accountable care organizations.[3]

However, there is surprisingly little empirical evidence to either support or refute the fragmentation hypothesis. A key challenge to assessing the validity of the fragmentation hypothesis is determining whether higher costs and poorer outcomes are the result of fragmentation itself or simply a reflection of the fact that sicker patients see more providers—thus looking more "fragmented"—and have worse health outcomes at higher costs. Understanding the relationship between fragmentation and quality, as well as costs of care, is critical for policy makers and clinical leaders struggling to find ways to improve the value of healthcare, especially for chronically ill patients.

Given the central importance of understanding the role of fragmentation in healthcare delivery, and given the paucity of national data that directly address these issues, we sought to answer 3 key questions. First, is there a relationship between the degree to which a patient's care is fragmented and the quality of care he or she receives? Second, what is the relationship between the degree to which a patient's care is fragmented and their total costs of care? Finally, are the quality and cost consequences of fragmentation apparent in prespecified groups of patients with the most common chronic diseases?

Take-Away Points

Despite widespread consensus that fragmented care leads to higher costs and lower quality, there is little empirical evidence on the relationship between care fragmentation, quality, and costs. Our findings indicate that:

- Fragmentation is associated with increased costs of care, a higher chance of having a departure from clinical best practice, and higher rates of preventable hospitalizations.
- Even among patients with the same chronic condition, quality was lower and costs were higher in patients who received more fragmented care.
- Policy makers and clinical leaders may be able to reduce costs and improve quality by reducing fragmentation.

METHODS

Study Population and Data

Our patient sample consisted of 506,376 chronically ill enrollees in a major nationwide private health plan. We only included individuals who met the following criteria: received their insurance through a fully insured employer participating in this plan, had at least 1 insurance claim associated with a primary care provider (PCP), and had claims between 2004 and 2007 with a primary diagnostic code corresponding to any of 15 major common chronic conditions. The most frequent of these conditions included diabetes, hypertension, ischemic heart disease (IHD), congestive heart failure (CHF), and chronic obstructive pulmonary disease (COPD). The complete list of inclusion criteria, including the full list of conditions (and their associated *International Classification of Diseases, Ninth Revision, Clinical Modification* codes), is included in the online supplement **eAppendix Methods** (available at **www.ajmc.com**).

For research purposes, the insurance company agreed to make available the complete insurance claims history of these individuals—anonymized to preserve confidentiality—as well as a broad set of internally generated quality measures associated with their care. The claims data set contains standard diagnostic and procedure codes as well as an anonymized, unique provider identifier associated with each claim. For providers, the data set contains specialty and a unique billing address and practice identifier. We assigned all patients to the PCP associated with their claims. PCPs were defined as physicians in 1 of the following specialties: family practice, internal medicine, general practice, and pediatrics. For patients with claims associated with more than 1 PCP, we assigned each patient to the PCP associated with the plurality of their healthcare costs.

Fragmentation Measure

There is no standard operational measure of fragmentation. Previous studies of fragmentation in a Medicare setting have added up the number of providers that a patient sees during the course of treatment for a single health episode[4,5] or during a year.[6,7] While the counting approach is helpful in assessing the degree to which a patient's care is fragmented, it is limited in its utility when assessing the degree to which fragmentation is associated with quality and costs of care.

An important limitation of the counting approach is that it does not reflect differences in the concentration of care. For example, a patient whose care is equally divided between 2 providers would be labeled as having the same level of fragmentation as a patient whose care is almost exclusively handled by 1 provider, but who briefly interacts with another. To address this problem, we measured care fragmentation in terms of a Herfindahl-Hirschman concentration index (HHI). The HHI is commonly used in economic studies of industrial structure and is usually a measure of the degree to which a market is concentrated among a small number of companies. We used the HHI to measure the degree to which a patient's care is concentrated among a set of providers; we constructed an HHI for each patient by first calculating each provider's share of the total costs associated with that patient's claims. We then summed the squares of the cost shares across all providers that a patient sees. A patient's care would be considered to be the least fragmented when all care was from a single provider (and corresponded to an HHI of 1). A patient's care would be considered maximally fragmented if their care was equally divided across a large number of providers (and corresponded to an HHI approaching zero as the number of providers increases).

To address the challenge that measured fragmentation may be higher among patients who are sicker or clinically more complex in ways that are not captured by our observed controls, we focused on the style of care of each patient's PCP as our marker for the patient's care fragmentation. Specifically, for each patient we calculated the fragmentation of their PCP's *other* patients, excluding that particular patient. That is, we defined a patient's fragmentation score to be the concentration of care for all the other patients in their PCP's panel, reflecting that PCP's practice style and not that patient's severity of illness directly. Of course, it may be that sicker patients cluster among certain PCPs—a possibility that we address below in our modeling approach. We define the fragmentation score as 1 minus this average HHI so that the score is increasing as fragmentation increases.

As a sensitivity analysis, we also estimate specifications with the unadjusted (individual-level) fragmentation measure.

Quality and Cost Outcomes

Our principal quality measure was derived from a proprietary algorithm the health plan uses to detect potential gaps in care. The algorithm analyzes patients' medical and drug claims, diagnostic history, and laboratory results for indications of departures from best clinical practice, and also triggers an alert that is sent to the provider. We refer to these alerts as potential gaps in care (PGCs). The algorithm generating the PGCs targets over 500 different potential clinical issues, the most frequent 20 of which are listed in **eAppendix Table 2**—these account for about two-thirds of the total alerts issued. These are very closely aligned to national quality measures such as those in the Healthcare Effectiveness Data and Information Set. The algorithm also generates measures of whether the detected issue was eventually resolved. Our 4 main quality outcomes are patient-level indicators for: 1) whether any PGC was generated; 2) number of PGCs generated; and 3) whether any PGC was left unresolved. Finally, 4) we examined hospitalizations that resulted from ambulatory care–sensitive conditions—conditions in which effective ambulatory care should prevent or reduce the need for hospitalization.[8,9] These potentially preventable hospitalizations are thus generally accepted as indicators of poor quality of ambulatory care. The measures were developed by the Agency for Healthcare Research and Quality as Prevention Quality Indicators (PQIs), and we used their definitions to construct our measures.[10] Most of the conditions underlying PQIs are targets of the PGC algorithms as well. We chose a priori to focus on whether any PGCs were generated as our primary quality measure of interest, but we examined all 4.

Finally, we examined total costs of care by assigning each claim a standardized Medicare payment rate—we did this both because we did not have the proprietary reimbursement amounts from the health plan and because we wanted the results to be broadly generalizable. The standard rate was using the Medicare allowable payments, adjusted for the geographical pricing cost index to standardize across locations.

Covariates of Interest

Because we were concerned that sicker patients might cluster together among certain PCPs, we included covariates to account for underlying patient characteristics that might otherwise confound the relationship between fragmentation and our outcomes of interest. We used the hierarchical condition categories (HCCs) created and used by CMS[11] as a risk-adjustment tool in our analyses to account for differences in patient severity.

Statistical Analysis

We divided our population of patients by quartile of the fragmentation measure and compared key demographic and clinical characteristics of patients across these 4 groups. Next, we estimated the relationship between the fragmentation measure and our outcomes using regression models that accounted for age, gender, and the HCC risk-adjustment variables, clustering to account for correlation among patients assigned to a given provider. For each outcome we estimated a model specifying a linear effect of fragmentation scaled in units of a standard deviation. We also estimated a more flexible nonlinear specification using indicators for fragmentation quartile.

In our subgroup analyses we estimated the same set of models separately for patients in each of the 5 disease categories we chose a priori: diabetes, hypertension, IHD, CHF, and COPD. Using the results of the regression analysis, we calculated regression-adjusted means for each of our cost and quality measures for each quartile of the fragmentation measure.

This study was approved by the Office of Human Research Administration at the Harvard T.H. Chan School of Public Health, the Harvard University Committee on the Use of Human Subjects in Research, and the Boston University Institutional Review Board.

RESULTS

Patient and Provider Characteristics

Patients whose PCPs exhibited a more fragmented style were, on average, older, more likely to be female, and more likely to suffer from diabetes, IHD, hypertension, CHF, or COPD than patients whose PCPs practiced in a less fragmented style (**Table 1**). The patients of PCPs with a more fragmented style of practice had a greater number of primary care visits in a given year (24 in the highest quartile vs 10 in the lowest; P <.001 for trend) as well as more specialist visits (24 in the highest quartile vs 4 in the lowest; P <.001 for trend). Further, we found that patients of PCPs with the most fragmented practice style saw, on average, more PCPs (4.0 in highest quartile vs 2.3 in lowest quartile) as well as common types of specialists (Table 1) than patients whose PCPs practiced in a less fragmented style.

Table 1. Patient Characteristics by Fragmentation Quartile

Fragmentation	1 (least fragmented)	2	3	4 (most fragmented)
N	126,440	126,748	126,568	126,620
Age (mean, years)	43	45	48	49
Female	52%	56%	62%	62%
Diabetes	16%	17%	20%	23%
Hypertension	41%	43%	48%	52%
IHD	8%	11%	16%	18%
CHF	2%	3%	4%	5%
COPD	5%	6%	7%	8%
2 or more chronic conditions	16%	19%	25%	29%
Median PCP visits	10	13	22	24
Median specialist visits	4	9	19	24
Number of different physicians seen, by specialty				
Primary care	2.28	2.81	3.64	3.95
Cardiology	1.82	2.08	2.63	2.91
Gastroenterology	1.36	1.44	1.68	1.77
Orthopedics	1.60	1.74	1.98	2.11
Dermatology	1.48	1.62	1.89	1.97
Fragmentation index	0.593	0.738	0.821	0.849

CHF indicates congestive heart failure; COPD, chronic obstructive pulmonary disease; IHD, ischemic heart disease; PCP, primary care physician. The table contains sample sizes and means of the variables in the left-hand column by quartile of the fragmentation index. The sample contains commercial insurance members whose employers are fully insured, and who have evidence of chronic illness as described in the text. The fragmentation measure is 1 minus the Herfindahl-Hirschman index of concentration of providers' care of a patient in terms of costs, as described in the text. Number of different physicians seen by specialty are averages conditional on seeing at least 1 of the given specialty type. Overall averages and a broader set of specialties are reported in **eAppendix Table 1**.

Quality and Patient Outcomes

We found that a higher degree of fragmentation was associated with a higher number of PGCs generated (Table 2). A standard deviation increase in fragmentation was associated with a 3.9% absolute increase in the likelihood of having at least 1 PGC. Across quartiles, this relationship held: 25.9% of patients in the lowest quartile of fragmentation had a PGC, compared with 32.8% of patients in the highest quartile (P <.001 across quartiles) (Figure). The patterns were similar for the number of PGCs (higher among patients in more fragmented practices), the likelihood of having any unresolved PGC, and the total number of unresolved PGCs (Table 2).

We found a similar relationship between fragmentation and rates of preventable hospitalizations: a standard deviation increase in fragmentation was associated with a 1.4% absolute increase in the likelihood of having a preventable hospitalization (Table 2). The analyses examining fragmentation in quartiles gave similar results: approximately 7.1% of patients in the lowest fragmentation quartile had a preventable hospitalization in a given year compared with approximately 9.1% in the highest quartile (P <.001 for difference across quartiles) (Figure).

Finally, we found that fragmentation was associated with substantial increases in costs of care (Table 3). An increase of 1 standard deviation in the fragmentation measure was associated with a $2642 increase in costs over a median period of 35 months. In examining quartiles, we found that patients in the most fragmented quartile had an average total cost of $10,396, compared with just $5854 among those in the least fragmented quartile (Figure).

Fragmentation, Costs, and Quality by Individual Diseases

When we examined each of the 5 prespecified chronic disease groups independently, we found relatively similar effects across each. In each of the 5 conditions, the likelihood of having any PGC (our measure of a quality gap) increased with increasing fragmentation, and as did the likelihood of having a preventable hospitalization. Finally, we found that costs were, in each of the 5 conditions, highest in the 2 quartiles with the most fragmentation and substantially lower in the quartiles with the least fragmentation (Table 3).

Sensitivity Analysis

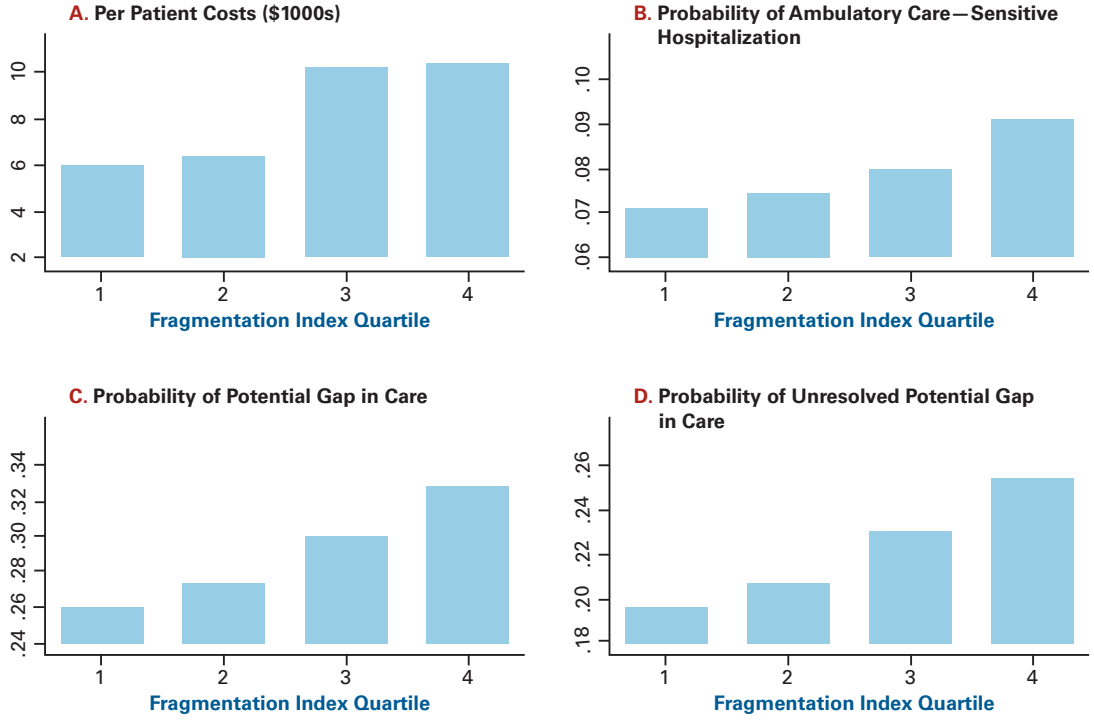
We repeated the analyses above using the unadjusted,

Table 2. Impact of Fragmentation on Care Quality and Cost Measures

Quality and Cost Measures	Overall Mean	Regression Coefficient for 1 SD Change in Fragmentation (robust standard errors in parentheses)	Regression-Adjusted Mean by Fragmentation Index Quartile			
			1 (least fragmented)	2	3	4 (most fragmented)
Any PGC	29%	3.9% (0.22%)	26%	27%	30%	33%
Number of PGCs	0.67	0.12 (0.008)	0.58	0.61	0.71	0.80
Any unresolved PGC	22%	3.2% (0.21%)	20%	21%	23%	25%
Number of unresolved PGCs	0.43	0.08 (0.005)	0.37	0.39	0.45	0.56
Any ACSC hospitalization	7.8%	1.4% (0.11%)	7.1%	7.4%	8.0%	9.1%
Cost	$8008	$2642 ($127)	$5854	$6403	$10,163	$10,396

ACSC indicates ambulatory care–sensitive condition; PGC, potential gap in care.
The regression coefficient is the coefficient for each standard deviation change in our fragmentation measure in a regression that also controls for age, gender, and hierarchical clinical conditions as described in the text. Standard errors allowing for arbitrary correlation at the provider level are in parentheses below the coefficient estimates. Regression-adjusted means by fragmentation index quartile are predicted values for each fragmentation quartile from a regression of the dependent variable on dummies indicating fragmentation quartile and the controls used in the linear regressions, holding other characteristics fixed at the mean.

Figure. Regression-Adjusted Cost and Quality Outcomes by Fragmentation Quartile



individual-level fragmentation score. The results are reported in Table 4, and they show that the results are qualitatively and quantitatively similar to the main results achieved with the adjusted fragmentation score.

DISCUSSION

We examined the relationship between fragmentation and both quality and costs of care among a chronically ill, commercially insured population and found that greater fragmentation was consistently associated with worse quality and higher costs. Even among select subgroups of patients with common chronic diseases, receiving care from a primary care physician who exhibits a more fragmented style of practice was associated with greater gaps in quality, more preventable hospitalizations, and higher healthcare spending. Taken together, these findings offer new evidence that national policy efforts may benefit

Table 3. Impact of Fragmentation on Care Quality and Cost Measures by Chronic Condition

Condition	Overall Mean	Regression-Adjusted Mean by Fragmentation Index Quartile	Regression Coefficient for 1 SD Change in Fragmentation (robust standard errors in parentheses)			
			1 (least fragmented)	2	3	4 (most fragmented)
Diabetes						
Any potential gap in care	61%	4.5% (0.53%)	58%	59%	62%	64%
Any ACSC hospitalization	19%	3.5% (0.35%)	18%	18%	20%	21%
Cost	$12,125	$4219 (241)	$9095	$9429	$14,687	$14,607
Hypertension						
Any potential gap in care	40%	6.0% (0.28%)	36%	38%	41%	45%
Any ACSC hospitalization	12%	2.2% (0.18%)	11%	11%	12%	13%
Cost	$10,422	$3489 (177)	$7636	$8166	$12,927	$12,869
Ischemic heart disease						
Any potential gap in care	48%	6.0% (0.50%)	44%	44%	48%	51%
Any ACSC hospitalization	19%	4.2% (0.36%)	17%	17%	19%	21%
Cost	$17,735	$6434 (313)	$13,633	$14,017	$20,852	$19,712
Congestive heart failure						
Any potential gap in care	59%	5.8% (0.82%)	56%	56%	59%	62%
Any ACSC hospitalization	37%	5.1% (0.77%)	35%	35%	38%	39%
Cost	$25,868	$7610 (456)	$21,163	$20,572	$29,415	$28,304
COPD						
Any potential gap in care	43%	6.4% (0.45%)	38%	41%	45%	51%
Any ACSC hospitalization	27%	3.8% (0.42%)	25%	27%	28%	29%
Cost	$16,885	$4720 (302)	$12,702	$13,438	$20,093	$19,368

ACSC indicates ambulatory care–sensitive condition; COPD, chronic obstructive pulmonary disease.
The regression coefficient is the coefficient for each standard deviation change in our fragmentation measure in a regression that also controls for age, gender, and hierarchical clinical conditions as described in the text. Standard errors allowing for arbitrary correlation at the provider level are in parentheses below the coefficient estimates. Regression-adjusted means by fragmentation index quartile are predicted values for each fragmentation quartile from a regression of the dependent variable on dummies indicating fragmentation quartile and the controls used in the linear regressions, holding other characteristics fixed at the mean.

from a greater effort toward reducing the fragmentation of care that chronically ill patients often experience. Methodologically, our study introduces a new measure of care fragmentation, and analyzes commercially insured patients, a relatively under-studied population.

We could not directly examine why fragmentation was associated with worse quality and higher costs, although there are several potential explanations. One possibility is that with multiple providers each heavily involved in a patient's care, no single provider is able to ensure that the entirety of a patient's clinical needs are taken into account, leading to gaps in care as important issues go unaddressed.[12] The substantial coordination costs of managing input from specialists drives another possible explanation. Among PCPs with a fragmented style of care delivery, the time spent managing multiple specialists may be crowding out primary care physicians' direct efforts to provide optimal care to their patients.

The higher costs associated with fragmentation may be driven by unnecessary duplication of services, or additional testing that results as patients see more and more providers, consistent with the findings here that patients with higher fragmentation saw a greater number of different providers of a given specialty type. Given the relatively poor exchange of clinical data among providers,[13] it is possible that each additional visit with a new provider led to more tests, especially as patients saw more specialists. Finally, it is possible that that differences in costs may have been driven by poor care coordination leading to more preventable hospitalizations.

Our study adds to prior literature on the issue of fragmentation in medical care. Pham and colleagues demonstrated that the average Medicare patient sees a median of 2 primary care physicians and 5 specialists over a 2-year time period.[6] Schrag found that 17% of patients in New York experienced fragmented inpatient care, and that this

Table 4. Impact of Fragmentation on Care Quality and Cost Measures (unadjusted fragmentation measure)

Quality and Cost Measures	Overall Mean	Regression Coefficient for 1 SD Change in Fragmentation (robust standard errors in parentheses)	Regression-Adjusted Mean by Fragmentation Index Quartile			
			1 (least fragmented)	2	3	4 (most fragmented)
Any PGC	29%	4.2% (0.11%)	24%	27%	30%	35%
Number of PGCs	0.67	0.11 (0.004)	0.54	0.62	0.70	0.86
Any unresolved PGC	22%	3.1% (0.09%)	19%	21%	23%	27%
Number of unresolved PGCs	0.43	0.07 (0.002)	0.35	0.40	0.44	0.53
Any ACSC hospitalization	7.8%	1.8% (0.05%)	6.4%	6.8%	8.0%	10.8%
Cost	$8008	$1910 ($78)	$5732	$6429	$7814	$12,762

ACSC indicates ambulatory care–sensitive condition; PGC, potential gap in care.
The regression coefficient is the coefficient for each standard deviation change in our fragmentation measure in a regression that also controls for age, gender, and hierarchical clinical conditions as described in the text. Standard errors allowing for arbitrary correlation at the provider level are in parentheses below the coefficient estimates. Regression-adjusted means by fragmentation index quartile are predicted values for each fragmentation quartile from a regression of the dependent variable on dummies indicating fragmentation quartile and the controls used in the linear regressions, holding other characteristics fixed at the mean.

was particularly common among Medicaid recipients.[14] Liu and colleagues showed that in a population of patients with diabetes and chronic kidney disease, increasing fragmentation was associated with higher rates of emergency department (ED) use.[15] Others have focused on the opposite phenomenon—that is, continuity of care—and have demonstrated that high levels of continuity are associated with better preventive care, lower likelihood of hospitalization, and better patient experience,[16,17] though others have still failed to find the same association.[18] Most recently, Hussey and colleagues found that chronically ill Medicare beneficiaries who had more continuous care were less likely to experience complications, visit the ED, or be admitted to the hospital.[19]

Limitations

First, some patients may have unobserved underlying health issues that make care more complex and that require more specialized services. It may be that it is the need for specialized services, rather than fragmentation per se, that leads to higher costs and lower quality. We attempted to address this in 3 ways: first, we used a fragmentation measure that is based on the *other* patients a physician sees, which removes a patient's own clinical conditions from the fragmentation measure; second, we included detailed covariates in the regression models; and finally, we used 5 relatively homogeneous populations (those with specific chronic diseases). However, none of these techniques is perfect, and residual confounding remains a possibility.

Another potential limitation is that our sample comes from a single large health plan, and for this reason likely includes only a subset of any provider's panel of patients. This feature of our data introduces measurement error into our fragmentation measure and this, in turn, likely reduces the magnitude and precision of our estimates. Thus, our results may represent a conservative estimate of the relationship between fragmentation and care and quality outcomes. Next, to the extent that the alerts triggered by the identified PGCs altered providers' behavior, the impacts we measured on other quality and cost outcomes are net of the potentially ameliorating effect of the PGC alerts, which would decrease the magnitude of any relationship we find between increasing fragmentation and worse quality. Because our data are limited to a commercially insured population, whether other patients, such as the elderly on Medicare, experience similar effects is unclear.

Finally, our fragmentation measure focuses on a specific dimension of fragmentation: the dispersion of care across multiple providers. Another important dimension of fragmentation captures information flow disruptions among the providers involved in a patient's care,[14] as measured perhaps by the presence of a cohesive information system linking the providers. Our data could not directly examine information flows among physicians, but this dimension of fragmentation is likely to be highly correlated with our notion of care dispersion, and their effects are likely to be complementary: a pattern of care that is dispersed over several physicians is likely to be particularly susceptible to the consequences of information discontinuities, and vice versa.

CONCLUSIONS

In summary, we found that more fragmented care is associated with lower quality and higher costs among nonelderly, chronically ill patients. The effects were sizable,

and suggest that policy makers and clinical leaders may need to pay greater attention to reducing fragmentation in order to improve care and reduce healthcare spending.

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Author Affiliations: Department of Economics, Brigham Young University (BRF), Provo, UT; Department of Health Policy and Management, Harvard T.H. Chan School of Public Health (KEJ, AKJ), Boston, MA; Department of Markets, Public Policy, and Law, Boston University School of Management (JBR), Boston, MA.

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Address correspondence to: Ashish K. Jha, MD, MPH, Harvard T.H. Chan School of Public Health, 677 Huntington Ave, Boston, MA 02115. Email: ajha@hsph.harvard.edu.

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eAppendix supporting material for:

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Contents

eAppendix Methods. Patient Inclusion Criteria

The analysis population includes all patients receiving insurance through fully insured clients of the insurance company who had at least 1 claim between January 2004 and June 2007 with an *International Classification of Diseases, Ninth Revision, Clinical Modification* diagnostic code in 1 of the following categories:

- Coronary artery disease: 410.xx-414.xx
- Cerebrovascular disease: 433.xx-438.xx, 441.xx-442.xx
- Peripheral arterial disease: 443.xx-445.xx
- Mesenteric vascular disease: 557.xx
- Other ischemic vascular disease or conduction disorders: 391.xx, 394.xx-398.xx, 426.xx-427.xx, 440.xx
- Heart failure: 402.01, 402.11, 402.91, 404.01, 404.03, 404.11, 404.13, 404.91, 404.93, 428.xx
- Migraine and cluster headache: 339.xx, 346.xx
- Hypertension: 401.xx-405.xx
- Hyperlipidemia: 272.xx
- Diabetes mellitus: 249.xx-250.xx, 362.0x
- Asthma: 493.xx
- Chronic obstructive pulmonary disease: 416.xx, 491.xx-492.xx, 494.xx, 496.xx
- Hypercoagulability disorders: 415.xx, 451.xx-454.xx
- Osteoarthritis: 715.xx, 717.xx, 721.xx, 726.xx
- Rheumatoid arthritis: 714.xx, 720.xx

eAppendix Table 1. Average Number of Different Physicians Seen, by Specialty

Fragmentation Quartile	1 (least fragmented)	2	3	4 (most fragmented)
A. Conditional on seeing at least 1				
Primary care	2.28	2.81	3.64	3.95
Cardiology	1.82	2.08	2.63	2.91
Ophthalmology	1.44	1.62	1.92	2.04
Dermatology	1.48	1.62	1.89	1.97
Gastroenterology	1.36	1.44	1.68	1.77
Neurology	1.60	1.72	2.00	2.12
Otolaryngology	1.38	1.46	1.63	1.70
Urology	1.44	1.59	1.83	1.94
Pulmonology	1.50	1.62	1.88	1.99
Immunology	1.59	1.73	1.95	1.89
Rheumatology	1.52	1.63	1.91	1.91
Orthopedics	1.60	1.74	1.98	2.11
Metabolism and diabetes	1.44	1.57	1.81	1.82
Hematology	1.55	1.67	2.03	2.10
Endocrinology	1.42	1.56	1.73	1.75
Nephrology	1.76	1.94	2.28	2.42
B. Overall				
Primary care	2.28	2.81	3.64	3.95
Cardiology	0.39	0.61	1.03	1.30
Ophthalmology	0.21	0.33	0.55	0.70
Dermatology	0.23	0.35	0.62	0.69
Gastroenterology	0.21	0.31	0.56	0.67
Neurology	0.14	0.21	0.37	0.45
Otolaryngology	0.12	0.18	0.29	0.35
Urology	0.10	0.16	0.26	0.32
Pulmonology	0.09	0.13	0.23	0.27
Immunology	0.07	0.09	0.13	0.14
Rheumatology	0.05	0.07	0.13	0.15
Orthopedics	0.25	0.39	0.59	0.71
Metabolism and diabetes	0.04	0.06	0.10	0.12
Hematology	0.03	0.05	0.09	0.12
Endocrinology	0.03	0.05	0.09	0.10
Nephrology	0.03	0.04	0.07	0.10

eAppendix Table 2. Frequencies and Distributions for the 20 Most Frequently Occurring Potential Gaps in Care

Description	Severity	Issued PGCs			Physicians		Patients		
					All	Primary Care	All	Female	Aged ≥50 Years
		No.	%	Cum.	Any	Any	Any	Any	Any
All		3,566,548	100	100	0.438	0.527	0.240	0.243	0.316
Diabetes—consider eye exam	3	328,533	9.2	9.2	0.089	0.138	0.051	0.042	0.071
Heart Protection Study—consider adding a statin	2	277,372	7.8	17.0	0.101	0.146	0.040	0.035	0.059
Breast cancer screening—females 50 years and older	5	207,730	5.8	22.8	0.000	0.000	0.016	0.029	0.033
Diabetes—consider A1C monitoring	2	180,044	5.1	27.9	0.050	0.076	0.026	0.022	0.037
Cervical cancer screening—females 21 years and older	5	170,148	4.8	32.6	0.000	0.000	0.010	0.019	0.015
Diabetes—consider screening for microalbuminuria	2	153,797	4.3	36.9	0.054	0.084	0.022	0.021	0.029
Breast cancer screening—females 50 years and older	3	127,077	3.6	40.5	0.056	0.078	0.007	0.012	0.013
Hyperlipidemia—primary prevention - consider lifestyle changes and/or lipid-lowering therapy	3	119,850	3.4	43.9	0.094	0.142	0.026	0.024	0.033
Colorectal cancer screening—adults 50 years and older	5	105,835	3.0	46.8	0.000	0.000	0.008	0.008	0.016
Diabetes mellitus—consider pneumococcal vaccine	5	88,127	2.5	49.3	0.000	0.000	0.010	0.009	0.014

Breast cancer screening—females aged 40-49 years	5	85,795	2.4	51.7	0.000	0.000	0.005	0.008	0.000
Diabetes—consider lipid panel monitoring	2	76,969	2.2	53.9	0.025	0.035	0.011	0.010	0.014
High-Risk Diabetic (HOPE Trial)—consider adding an ACE inhibitor	2	76,513	2.2	56.0	0.026	0.041	0.010	0.008	0.020
Levothyroxine—consider TSH monitoring	2	65,323	1.8	57.9	0.004	0.007	0.008	0.011	0.012
Metabolic syndrome—consider treatment	2	63,511	1.8	59.6	0.015	0.025	1.127	0.011	0.020
Concomitant use of SSRIs and NSAIDs increases the risk of GI bleeding	2	63,022	1.8	61.4	0.004	0.007	0.009	0.012	0.010
Diabetes and LDL greater than 100—consider adding a lipid-lowering agent	2	47,800	1.3	62.7	0.010	0.016	0.012	0.012	0.018
Hyperlipidemia (primary prevention)—candidate for a lipid-lowering agent	2	39,693	1.1	63.9	0.035	0.054	0.009	0.009	0.013
Children aged 6 to 59 months—consider influenza vaccine	5	39,161	1.1	65.0	0.000	0.000	0.000	0.000	0.000
Statin use—consider LFT monitoring	3	36,163	1.0	66.0	0.003	0.004	0.004	0.002	0.006

ACE indicates angiotensin-converting enzyme; cum, cumulative; GI, gastrointestinal; HOPE, Heart Outcomes Prevention Evaluation; LDL, low-density lipoprotein cholesterol; LFT, liver function test; NSAID, nonsteroidal anti-inflammatory drug; SSRI, selective serotonin reuptake inhibitor; TSH, thyroid-stimulating hormone.