ORIGINAL RESEARCH

Interspecialty Communication Supported by Health Information Technology Associated with Lower Hospitalization Rates for Ambulatory Care–Sensitive Conditions

Ann S. O'Malley, MD, MPH, James D. Reschovsky, PhD, and Cynthia Saiontz-Martinez, ScM

Background: **Practice tools such as health information technology (HIT) have the potential to support care processes, such as communication between health care providers, and influence care for "ambulatory care–sensitive conditions" (ACSCs). ACSCs are conditions for which good outpatient care can potentially prevent the need for hospitalization. To date, associations between such primary care practice capabilities and hospitalizations for ambulatory care–sensitive conditions have been primarily limited to smaller, local studies or unique delivery systems rather than nationally representative studies of primary care physicians in the United States.**

Methods: **We analyzed a nationally representative sample of 1,819 primary care physicians who responded to the Center for Studying Health System Change's Physician Survey. We linked 3 years of Medicare claims (2007 to 2009) with these primary care physician survey respondents. This linkage resulted in the identification of 123,760 beneficiaries with one or more of 4 ambulatory care–sensitive chronic conditions (diabetes, chronic obstructive pulmonary disease, asthma, and congestive heart failure) for whom these physicians served as the usual provider. Key independent variables of interest were physicians' practice capabilities, including communication with specialists, use of care managers, participation in quality and performance measurement, use of patient registries, and HIT use. The dependent variable was a summary measure of ambulatory care–sensitive hospitalizations for one or more of these 4 conditions.**

Results: **Higher provider-reported levels of communication between primary care and specialist physicians were associated with lower rates of potentially avoidable hospitalizations. While there was no significant main effect between HIT use and ACSC hospitalizations, the associations between interspecialty communication and ACSC hospitalizations were magnified in the presence of higher HIT use. For example, patients in practices with both the highest level of interspecialty communication and the highest level of HIT use had lower odds of ambulatory care–sensitive hospitalizations than did those in practices with lower interspecialty communication and high HIT use (adjusted odds ratio, 0.70; 95% confidence limits, 0.59, 0.82).**

Conclusions: **Greater primary care and specialist communication is associated with reduced hospitalizations for ambulatory care–sensitive conditions. This effect was magnified in the presence of higher provider-reported HIT use, suggesting that coordination of care with support from HIT is important in the treatment of ambulatory care–sensitive conditions. (J Am Board Fam Med 2015;28:404–417.)**

Keywords: **Health Care Systems, Information Systems, Prevention & Control, Primary Health Care, Quality of Health Care**

Ambulatory care–sensitive conditions (ACSCs) such as diabetes, chronic obstructive pulmonary disease (COPD), asthma, and congestive heart failure (CHF) are conditions for which good outpatient care can potentially prevent the need for hos-

This article was externally peer reviewed.
Submitted 16 December 2013; revised 29 August 2014; accepted 11 September 2014.
From the Center for Studying Health System Change, Washington, DC (ASO, JDR); and Social and Scientific Systems, Silver Spring, MD (CS-M).

Funding: The survey was funded by the Robert Wood Johnson Foundation. Data analysis was funded by the National Institute for Health Care Reform (NIHCR).
Conflict of interest: none declared.
Corresponding author: Ann S. O'Malley, MD, MPH, Center for Studying Health System Change, 1100 1st St NE, 12th Floor, Washington, DC 20002-4221 (E-mail: aomalley@mathematica-mpr.com).

pitalization via early intervention to prevent complications and address exacerbations of the conditions.[1,2]

Medicare beneficiaries with these chronic conditions typically see numerous specialists,[3,4] making care coordination with their primary care physician (PCP) important to avoid duplicate testing, fragmentation of care, and mixed messages to patients, all of which risk worse outcomes. Unfortunately, interspecialty communication about referrals and consultations is poor,[5–8] in part because fee-for-service (FFS) payment lacks incentives for it.

New initiatives such as patient-centered medical homes (PCMH)[9] and accountable care organizations[10] create incentives for primary care practices to improve care processes (eg, care coordination), along with practice structures (eg, health information technology[11] [HIT] such as electronic health records and personnel such as care managers) to enable these processes. The ultimate goals are to improve quality and contain costs, but the extent to which specific practice structures and care processes are associated with these outcomes is still not well understood. Some demonstrations[10] will not yield results for some time and may be challenging to evaluate on a national scale given the heterogeneous way that their data are being collected.[12] Individually, some PCMH demonstrations may not have enough patients (be adequately powered) to capture outcomes such as ACSC hospitalization rates.

The most recent Center for Studying Health System Change (HSC) nationally representative Physician Survey[13] linked with Medicare claims presents a unique opportunity to provide evidence, at the national level across different types of practices and regions, on the extent to which physician-reported practice structures and care processes[14] are associated with hospitalizations for ACSCs (also referred to as prevention quality indicators).[1,2] The goal of this study was (1) to assess associations between practice structures and care processes and the dependent variable, ambulatory care–sensitive hospitalizations, as well as (2) to examine whether HIT use facilitated the practice care processes.

Methods

This study linked data from a nationally representative physician survey with claims data for the Medicare fee-for-service beneficiaries for whom the surveyed physicians provided care.

Data Sources and Study Populations

Physician Sample

The 2008 HSC Physician Survey[13] is the fifth in a series of nationally representative physician surveys conducted since 1996 by the Center for Studying HSC. The sampling frame of active, licensed allopathic and osteopathic physicians was drawn from the American Medical Association master file. Respondents must have completed medical training and provide direct patient care for at least 20 hours/week. A total of 4720 physicians completed the mailed survey (response rate, 62%; response rate = [completes + ineligibles]/total sample).[15] Characteristics of physicians who completed and refused to participate in the survey were similar. Survey statisticians took advantage of the availability of physician and practice characteristics from the sample frame to apply rigorous methods in constructing survey weights to account for survey nonresponse, minimizing the likelihood of nonresponse bias.[13] Additional survey information is available online (www.hschange.org/CONTENT/1085).

Survey items were previously validated and/or cognitively tested and included numerous items about specific practice supports and care processes. Approval for the survey was obtained from the Westat Institutional Review Board and for this study from the New England Institutional Review Board.

Medicare Beneficiary Sample

We included Medicare FFS beneficiaries in years 2007 to 2009; they were aged ≥65 years and had ≥1 of the following conditions: diabetes, COPD, asthma, and CHF. Patients with end-stage renal disease were removed before creating the analytic sample.

Linkage of Physician Survey Data with Medicare Claims and Identification of Beneficiaries' Usual Physician

Medicare beneficiaries were linked to physician survey respondents from whom they received any billed service during 2007 to 2009. Linkage occurred through the "performing physician" national provider identifier recorded on physician claims and available from the physician survey sample frame.

To ensure national representation, weights were assigned to the linked beneficiary sample by assigning and adjusting the weight assigned to the physician who brought the beneficiary into the sample. Because patients who saw a greater number of unique physi-

Table 1. Prevalence of Practice Supports Among Usual Primary Care Physician Respondents Caring for the Study Sample of Patients With One or More of Four Chronic Conditions, 2008*

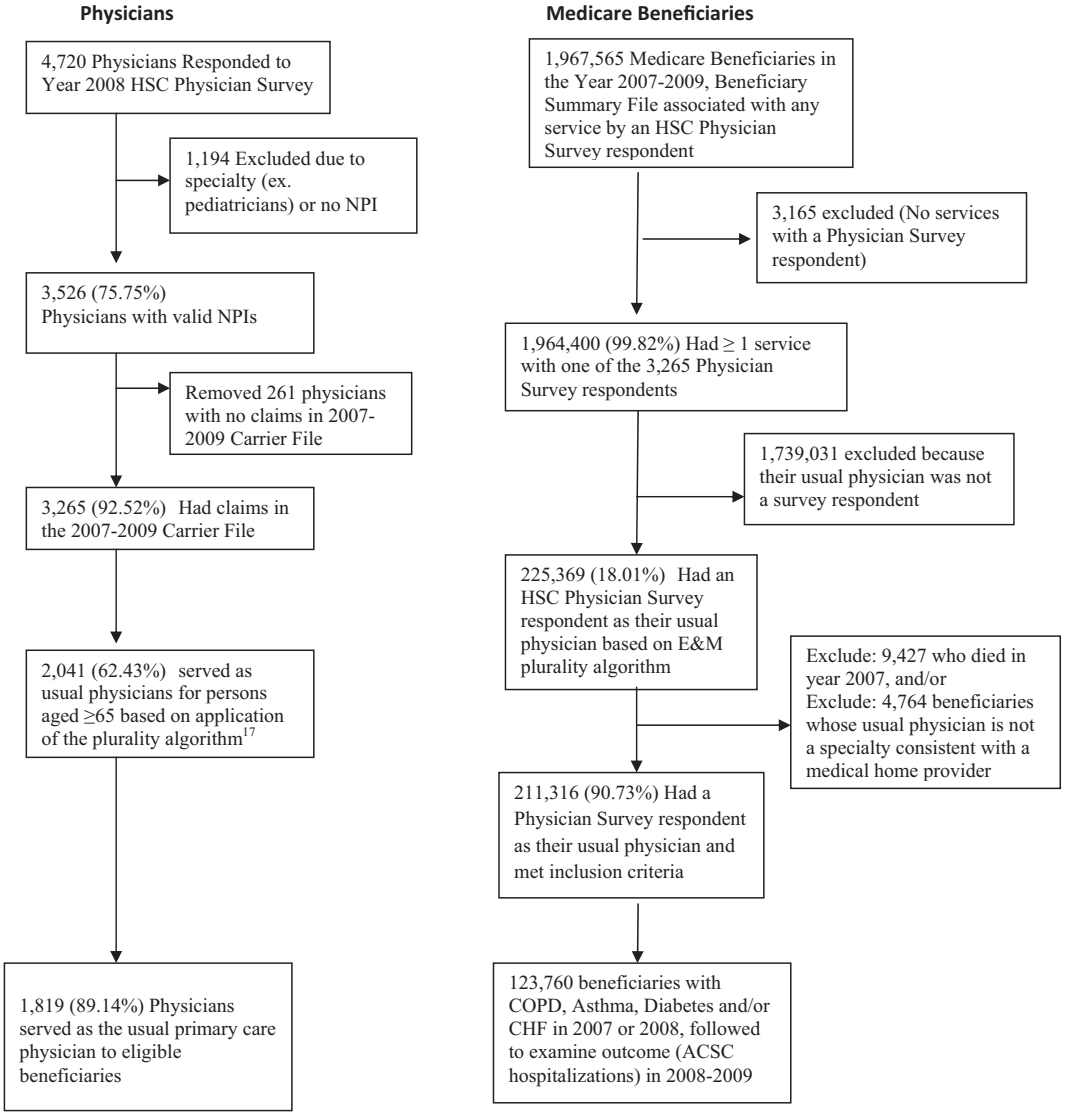
Practice Support	Beneficiaries Whose PCP Had the Practice Support (%)
PCP communication with patients and other specialists about specialist care received (% that said "Always" or "Most of the Time")	
1. How often do you know about all visits that your patients make to other physicians?	50.9
2. When you refer a patient to a specialist, how often do you send the specialist notification of patient's history and reason for consultation?	68.9
3. How often do you receive useful information about your referred patients from specialists?	66.5
4. After your patient has seen a specialist, how often do you talk with the patient or family members about the results of the visits(s) with the specialist?	61.8
Health information technology (extent of use)	
1. Physician's main practice uses an electronic health record	
Yes	44.2
No	55.8
2. Clinical information technology function is available in practice and used personally by respondent occasionally or routinely:	
a. To email patients	14.9
b. To provide reminders to clinicians of preventive services	35.2
c. To provide reminders to clinicians on follow-up	32.3
d. To generate reminders to patients about preventive services	35.2
e. To access patient notes, medication lists, or problem lists	48.4
f. To order lab or other diagnostic tests	49.8
g. To view test results	73.5
h. To access practice guidelines	80.4
i. For clinical decision support	65.1
j. To obtain information on formularies	42.3
k. To obtain information on potential drug interactions, allergies	67.4
l. To write prescriptions	38.4
m. To transmit prescriptions to pharmacy	36.4
Nurse and patient educator care management (% yes)	
1. Nurse care managers monitor and coordinate the care of patients with:	
Asthma	10.8
Diabetes	21.9
Congestive heart failure	15.7
2. Nonphysician staff educate patients in managing that condition	
Asthma	23.0
Diabetes	43.6
Congestive heart failure	21.4
Quality and performance measurement for your own patients (% yes)	
1. Receives reports on preventive care quality from practice/organization or health plan	59.5
2. Receives reports on quality of chronic care from practice/organization or health plan	65.0
3. How large of an effect do written practice guidelines have on your practice of medicine (% large or very large)	29.0
4. Participates in quality reporting programs sponsored by outside organizations like CMS	25.8
Registry	
Receives reports or patient lists of your own patients from your practice or health plan registry (% yes)	37.5

Data source: Medicare claims from years 2007 to 2009 and linked Center for Studying Health System Change (HSC) nationally representative Physician Survey (2008).
*Analytic sample is the 123,760 (unweighted frequency; weighted count, N = 1,359,053) Medicare fee-for-service beneficiaries with any one or more of 4 chronic conditions (asthma, diabetes, congestive heart failure) whose usual primary care physician (PCP) was a respondent to the HSC nationally representative physician survey (2008).
CMS, Centers for Medicare & Medicaid Services; PCP, primary care physician.

cians during the 3-year period had a greater probability of sample inclusion, we adjusted the beneficiary weight to account for this.

We examined associations between beneficiaries' ambulatory care–sensitive hospitalization rates and their usual physician's characteristics and practice environment. We attributed beneficiaries to their usual physician by identifying the physician who provided the plurality of their outpatient evaluation and management physician visits[16] over all 3 years (2007 to 2009). This approach is analogous to that of Weiner et al.[17] Emergency physicians, hospitalists, surgeons, and certain medical subspecialties unlikely to serve as a patient's usual primary care providers were excluded after applying the attribution algorithm. After these exclusions, the >85% of beneficiaries in the resulting analytic sample had a PCP (general internal medicine, family medicine, geriatrics, or general practitioner) as their usual provider based on the plurality attribution algorithm. Remaining plurality providers were mostly cardiologists (6.4% of beneficiaries), oncologists (2.1%), pulmonologists (1.4%), rheumatologists (1.3%), and endocrinologists (0.9%).

Figure 1. Unweighted frequencies and weighted percentages of the study populations of physicians (left) and Medicare beneficiaries (right), based on the Center for Studying Health System Change Physician Survey linked with Medicare claims, 2007 to 2009. ACSC, ambulatory care–sensitive condition; CHF, congestive heart failure; COPD, chronic obstructive pulmonary disease; E&M, evaluation and management visit; HSC, Center for Studying Health System Change; NPI, National Provider Identifier.



Dependent Variable: Ambulatory Care–Sensitive Hospitalizations

We examined ambulatory care–sensitive hospitalizations for any 1 of 4 chronic conditions: diabetes, COPD, asthma, or CHF. Hospitalizations for these ACSCs, calculated using the denominator of beneficiaries with the underlying chronic condition, are validated quality indicators for populations at risk.[2] We chose these conditions because of their prevalence among Medicare beneficiaries and because the physician survey specifically asked about practices' use of nurse care managers and health educators for these conditions. We used *International Classification of Diseases, Ninth Revision, Clinical Modification* diagnosis codes and algorithms used by the Agency for Healthcare Research and Quality to identify hospitalizations for these ACSCs (Table A1 in the Appendix).

Table 2. Characteristics of Study Sample of Medicare Beneficiaries with One or More of Four Key Chronic Conditions

Beneficiary Characteristics	Beneficiaries in Sample*
Age (years)	
65–74	51.0
75–84	33.7
≥85	15.3
Female sex	57.9
Median income in ZIP code area ($)	
0–43,541	33.2
43,541–58,773	33.1
≥58,773	33.7
Medicaid dual eligibles	11.4
Patients with chronic condition of interest	
Asthma/COPD	56.6
Diabetes	54.6
Congestive heart failure	21.8
Prior ambulatory care–sensitive hospitalization in 2007†	2.0
HCC score‡	
Mean	1.18
Median	0.89
Mode	0.30
Range	0.29–13.59

Data are percentages unless otherwise indicated.
Data sources: Medicare claims from years 2007 to 2009 for 123,760 beneficiaries whose usual physician was a respondent to the Center for Studying Health System Change Physician Survey 2008 and whose specialty could plausibly be a "medical home," that is, family medicine, general internal medicine, geriatrics, medicine/pediatrics.
*These 123,760 beneficiaries represent a weighted sample of 1,359,053 Medicare beneficiaries.
†Ambulatory care–sensitive conditions of interest for this analysis were diabetes, chronic obstructive pulmonary disease (COPD), asthma, and congestive heart failure.
‡HCC is the hierarchical coexisting conditions score (for the analytic sample, which is sicker than the general Medicare population) based on community-dwelling Medicare beneficiaries. A higher score indicates more severe comorbidity.

Key Independent Variables

Practice Structures and Care Processes

We constructed 5 measures of primary care practice structures and care processes to capture domains consistent with the PCMH concept and the primary and chronic care models[18–20] on which it is built (items used to create each measure are presented in Table 1). We focused on 2 structural elements (HIT use and personnel for care management/patient education) and 3 process elements: communication between primary care and specialist physicians, which is an aspect of care coordination; use of quality and performance feedback reports; and use of registry reports about a physician's own patients. Before creating indices for each of these items, we assessed the correlation of responses to the individual items. Based on this we combined into a single index items that were highly correlated and captured similar ideas (eg, use of nurse care managers and non-nurse staff for patient education were highly correlated and thus combined into a single index.) We then added the items pertaining to each element to create a summed score for each element. Indices were divided into weighted terciles. The fifth measure was an indicator of whether the physician received reports from a patient registry (yes/no). Of note, use of patient registries was not highly correlated with use of electronic health records (EHRs) in these data; thus these were kept as separate measures.

Health Information Technology

The survey assessed the extent of HIT use by a physician in terms of both EHR use and specific functionalities. In addition to being asked whether the physician's main practice used an EHR (yes/no), physicians were asked a series of questions on the extent of use of 13 clinical information technology functions (outlined in Table 1). For each of the 13 information technology functions, physicians first were asked whether the function was available in their practice; if available, they were

asked whether they used it occasionally, routinely, or not at all. We then created 3 mutually exclusive categories for each HIT item (not available, available but not used, available and used occasionally or routinely.) We assigned points of 0, 1, and 2 to each of these responses, respectively, for the 13 items

Table 3. Ambulatory Care–Sensitive Condition Hospitalizations for Medicare Beneficiaries With Chronic Conditions, According to Practice Supports and Patient and Practice Characteristics (Main Effects Model)

	ACSC Hospitalization, 2008–2009
Primary care practice supports (extent of use)	
PCP communicates with patient and with other specialists about specialist care received	
Lower tercile (reference)	1
Middle tercile	0.88 (0.80, 0.96)*
Upper tercile	0.81 (0.74, 0.89)†
Extent of HIT use	
Lower tercile (reference)	1
Middle tercile	1.08 (0.99, 1.18)
Upper Tercile	1.07 (0.98, 1.18)
Registry or patient list (vs none)	1.00 (0.92, 1.09)
Nurse and patient educator care management	
Lower tercile (reference)	1
Middle tercile	1.03 (0.94, 1.13)
Upper tercile	1.02 (0.93, 1.12)
Quality and performance measurement	
Lower tercile (reference)	1
Middle tercile	0.98 (0.83, 1.16)
Upper tercile	1.00 (0.83, 1.22)
Patient characteristics	
HCC score (already adjusted for age, sex, and dual Medicaid eligibility)	
Lower tercile (reference)	1
Middle tercile	2.18 (1.89, 2.51)†
Upper tercile	5.30 (4.66, 6.04)†
ACSC hospitalization in prior year (vs none)‡	5.78 (5.05, 6.62)†
Income (median) in ZIP code	
Lower tercile	1.28 (1.16, 1.40)*
Middle tercile	1.11 (1.02, 1.22)§
Upper tercile (reference)	1
Patient race/ethnicity	
White	1
Black	1.13 (0.97, 1.30)
Hispanic	1.09 (0.85, 1.41)
Other	0.87 (0.65, 1.16)
Practice characteristics	
Revenue from Medicare (%)	
0–30 (reference)	1
31–50	1.16 (1.05, 1.27)*
51–100	1.17 (1.07, 1.29)†
Practice size (no. of physicians)	
1–2	1
3–10	1.04 (0.95, 1.14)
11–49	1.04 (0.93, 1.17)
≥50	0.97 (0.85, 1.11)

Continued

Table 3. Continued

	ACSC Hospitalization, 2008–2009
Practice type	
Independent practice (physician owned)	1
Community health center	0.74 (0.50, 1.08)
Hospital-based outpatient practice/clinic†	0.96 (0.77, 1.19)

Data are odds ratio (95% confidence limits). All estimates are adjusted for all the other variables listed in the first column as well as for the urban influence codes (large metro, small metro, micropolitan, rural). All analyses were conducted in SUDAAN and accounted for clustering of patients within physicians.
Data Source: Linked data from the nationally representative Center for Studying Health System Change (HSC) Physician Survey (2008) and Medicare fee-for-service claims for the years 2007 to 2009 for all beneficiaries for whom a physician from the HSC national survey was their usual source of care. Usual source of care was determined by the plurality algorithm for evaluation and management visits.
*$P < .01$ vs reference group, two-sided test.
†$P < .001$ vs reference group, two-sided test.
‡Ambulatory care–sensitive conditions (ACSCs) examined included congestive heart failure, chronic obstructive pulmonary disease, asthma and diabetes. ACSC hospitalizations for any one or more of these conditions (combined rate) were calculated using claims for 2008 and 2009 (the numerator). The denominator for all analyses is 123,760 patients with one or more of these chronic conditions (identified in 2007–2008 claims).
§$P < .05$ vs reference group, two-sided test.
HCC, hierarchical condition category score; HIT, health information technology; PCP, primary care physician.

and created a summary score to capture overall HIT use. To this we added whether the practice had an EHR; if so, fully electronic users received an additional 8 points to their HIT score, those with partial paper/electronic EHR use received 4 points, and those without an EHR received zero additional points. The total HIT score, which ranged from 0 to 34, then was categorized into terciles.

Care Managers

For each of the chronic conditions of interest (diabetes, COPD, asthma, and CHF), respondents were asked whether they had access to nurse care managers to monitor and coordinate care and whether "nonphysician" staff were available to educate patients about managing the condition.

Interspecialty Communication

Important elements of care coordination include knowing about visits one's primary care patients make to other specialists to ensure communication and care integration between the PCP and specialists. Such communication includes PCPs transferring to specialists the reason for the referral and relevant patient information, and specialists communicating findings and recommendations back to the PCP. Equally important is the receipt and recognition of this information by the respective parties and discussion of this information with the patient/caregivers. The HSC Physician Survey included 4 questions on interspecialty communication, which were originally developed as part of a well-validated primary care provider survey.[21] These items were used to create an index on interspecialty communication.

Quality and Performance Measurement

Via 4 survey items, physicians were asked (1) whether they receive reports on preventive care quality from their practice, practice organization, or a health plan; (2) whether they receive reports on the quality of chronic care from their practice, practice organization, or a health plan; (3) how large of an effect written practice guidelines have on their practice of medicine; and (4) whether they participate in quality reporting programs sponsored by outside organizations such as the Centers for Medicare & Medicaid Services.

Patient Registry

Respondents were asked whether they received reports or lists of their own patients from a practice or health plan registry. This item did not distinguish between registry reports created by the practice itself versus those created by an outside source such as a health plan.

Other Covariates

All estimates reported from the regressions control for patient characteristics: patient health status, measured using a hierarchical condition category (HCC) score[22]; presence of an ACSC hospitalization in the prior year (demonstrated in previous

Table 4. Ambulatory Care–Sensitive Condition Hospitalizations for Medicare Beneficiaries With Chronic Conditions, Stratified by Usual Primary Care Physician's Level of Health Information Technology Use According to Practice Supports and Patient and Practice Characteristics

	ACSC Hospitalizations, 2008 to 2009		
	Low HIT	Medium HIT	High HIT
	OR (95% CL)	OR (95% CL)	OR (95% CL)
Primary care Practice Supports (extent of use)			
PCP communicates with patient and with other specialists about specialist care received			
Lower tercile (reference)	1	1	1
Middle tercile	0.92 (0.79, 1.07)	0.98 (0.84, 1.14)	0.79 (0.67, 0.92)*
Upper tercile	1.00 (0.85, 1.18)	0.75 (0.65, 0.88)†	0.70 (0.59, 0.82)†
Registry or patient list (vs none)	0.91 (0.77, 1.07)	1.00 (0.87, 1.16)	1.08 (0.94, 1.25)
Nurse and patient educator care management			
Lower tercile (reference)	1	1	1
Middle tercile	0.94 (0.80, 1.10)	0.83 (0.71, 0.98)‡	1.40 (1.18, 1.67)*
Upper tercile	1.06 (0.90, 1.24)	0.97 (0.81, 1.16)	1.11 (0.93, 1.32)
Quality and performance measurement			
Lower tercile (reference)	1	1	1
Middle tercile	0.98 (0.83, 1.16)	0.97 (0.83, 1.12)	0.90 (0.76, 1.07)
Upper tercile	1.00 (0.83, 1.22)	1.01 (0.84, 1.23)	0.88 (0.74, 1.05)
Patient characteristics			
HCC score (already adjusted for age, sex, and dual Medicaid eligibility)			
Lower tercile (reference)	1	1	1
Middle tercile	2.16 (1.65, 2.81)†	2.08 (1.64, 2.63)†	2.33 (1.84, 2.95)†
Upper tercile	5.30 (4.12, 6.83)†	5.07 (4.12, 6.22)†	5.44 (4.38, 6.77)†
ACSC hospitalization in prior year (vs none)§	5.35 (4.17, 6.87)†	5.55 (4.45, 6.92)†	6.52 (5.12, 8.28)†
Income (median) in zip code			
Lower tercile	1.26 (1.06, 1.47)*	1.24 (1.06, 1.45)*	1.21 (1.02, 1.43)‡
Middle tercile	1.16 (1.00, 1.38)	1.03 (0.89, 1.19)	1.04 (0.89, 1.23)
Upper tercile (ref)	1	1	1
Patient race/ethnicity			
White	1	1	1
Black	1.16 (0.90, 1.47)	1.18 (0.93, 1.52)	1.04 (0.80, 1.36)
Hispanic	1.03 (0.65, 1.61)	1.23 (0.79, 1.90)	1.09 (0.71, 1.65)
Other	0.79 (0.44, 1.40)	1.12 (0.75, 1.65)	0.70 (0.46, 1.06)
Practice characteristics			
Revenue from Medicare (%)			
0–30 (reference)	1	1	1
31–50	1.12 (0.94, 1.33)	1.58 (1.28, 1.94)†	1.04 (0.89, 1.22)
51–100	1.25 (1.06, 1.47)*	1.25 (1.06, 1.48)*	1.18 (0.98, 1.40)
Practice size (no. physicians)			
1–2	1	1	1
3–10	1.01 (0.87, 1.16)	1.29 (1.09, 1.53)	0.98 (0.83, 1.16)
11–49	1.11 (0.88, 1.39)	1.17 (0.94, 1.46)	0.90 (0.74, 1.09)
≥50	1.28 (0.96, 1.72)	0.96 (0.73, 1.24)	0.83 (0.67, 1.03)

Continued

Table 4. Continued

	ACSC Hospitalizations, 2008 to 2009		
	Low HIT	Medium HIT	High HIT
Practice type			
Independent practice (physician owned)	1	1	1
Community health center	0.62 (0.30, 1.27)	1.22 (0.67, 2.21)	0.66 (0.29, 1.50)
Hospital-based outpatient practice/clinic[†]	0.71 (0.46, 1.08)	1.06 (0.69, 1.63)	1.17 (0.90, 1.51)

Data are odds ratio (95% confidence limits). The first data column is the subgroup of beneficiaries whose usual physician has low HIT use, the middle column has medium HIT use, and the right-hand column has high HIT use. All estimates are adjusted for all the other variables listed in the first column as well as for the urban influence codes (large metro, small metro, micropolitan, rural). All analyses were conducted in SUDAAN and accounted for clustering of patients within physicians.

Data source: Linked data from the nationally representative Center for Studying Health System Change (HSC) Physician Survey (2008) and Medicare fee-for-service claims for the years 2007 to 2009 for all beneficiaries for whom a physician from the HSC national survey was their usual source of care. Usual source of care was determined by the plurality algorithm for evaluation and management visits.

[*]$P < .01$, vs reference group, two-sided test.

[†]$P < .001$, vs reference group, two-sided test.

[‡]$P < .05$, vs reference group, two-sided test.

[§]Ambulatory care–sensitive conditions (ACSCs) examined included congestive heart failure, chronic obstructive pulmonary disease, asthma and diabetes. ACSC hospitalizations for any one or more of these conditions (combined rate) were calculated using claims for 2008 and 2009 (the numerator). The denominator for all analyses is the 123,760 patients with one or more of these chronic conditions (identified in 2007–2008 claims).

CL, confidence limit; HCC, hierarchical condition category; HIT, health information technology; OR, odds ratio; PCP, primary care physician.

work to be highly predictive of future ACSC hospitalizations); median household income in the patient's ZIP code; and race/ethnicity. The HCC score incorporates age, sex, Medicaid dual eligibility, and prior-year conditions. We also included controls for physician and practice factors that might potentially be confounded with practice structures and care processes, including physician age and sex, practice size (1 to 2, 3 to 10, 11 to 49, ≥50 physicians); practice type (solo/group practice, community health center, staff model health maintenance organization, and hospital-based outpatient practice/clinic but excluding emergency departments); physician ownership of the practice; percentage of practice revenue from Medicare (≤30%, 31% to 50%, 51% to 100%); and urban influence codes.

The beneficiary's months under observation (ie, months of claims available) also are included as a covariate. Physician age, sex, and practice ownership were not significant in unadjusted or adjusted analyses and thus were not included in the final models.

Statistical Analyses

We examined univariate frequencies of all variables, correlations among independent variables, and the bivariate and stratified associations between independent variables and dependent variables. We also assessed for interactions between the practice structures (eg, HIT use, care managers) and each of the key care processes (eg, interspecialty communication, use of quality and performance reports, and use of registry reports) that might complement one another. Multiple comparisons of the bivariate proportions were tested, and they did not differ significantly from the raw *P* values. Based on these analyses and the clinical and policy relevance of the measures, we built regression models to examine associations between key modifiable independent variables and the dependent variable (ACSC hospitalizations), adjusting for all other practice factors and potential confounders.

All analyses used SUDAAN (version 11.0.0; RTI International, Research Triangle Park, NC) and accounted for clustering of patients within physicians. Beneficiary weights were constructed by assigning the survey weight associated with the physician through whom they were included in the sample, divided by the number of unique physicians seen. Beneficiary characteristics closely match beneficiary characteristics from Medicare administrative data.[23,24]

Of all the interaction testing described above, the only significant interaction was between HIT use and interspecialty communication. Running separate regressions for the beneficiaries of PCPs with low versus medium versus high HIT use was necessary because of this interaction.[25] Hosmer-Lemeshow χ^2 goodness of fit tests indicated adequate fit of the data in these models of the binary dependent variable. Additional description of the subgroup and sensitivity analyses, which did not change the results, can be found in the Appendix.

Results

Patient and Physician Characteristics

Among the 123,760 beneficiaries in the analytic cohort (ie, patients aged ≥65 years with COPD, asthma, diabetes, and/or CHF), 58% were women, 51% were between the ages of 65 and 74, and 11.4% were dually eligible for Medicaid (Figure 1 and Table 2).

Of the 4720 physicians who responded to the survey, 1819 served as the usual PCP to eligible beneficiaries (Figure 1) with any of the 4 chronic conditions. Of these physicians, 44% were full owners of their practices, 27% were part owners, and the rest were employees. In terms of practice size, 46% worked in solo or 2-physician practices, 17% in groups of 3 to 5 physicians, 10% in groups of 6 to 10 physicians, and 12% in groups of 11 to 50 physicians; the remainder were in groups of ≥50 physicians.

Practice Supports and Care Processes

Table 1 presents the degree of variability in practice capabilities. Between 60% and 70% of physicians reported that they "always" or "most of the time" sent communications concerning referrals to specialists, received specialist reports, and followed up with patients about specialist visit results. Physician use of specific HIT clinical functions varied considerably. Among physicians in the analytic sample, 37.5% received registry reports on their patients and 44.2% had an EHR. Nurse care managers and patient educators were used most often for patients with diabetes, although only a minority of physician used these supports.

Unadjusted analyses for associations between each of the practice structures and care processes and the dependent variable were largely consistent with the multivariate logistic regression results and thus are not presented. For example, higher levels of interspecialty communication were associated with lower ACSC hospitalization rates.

Table 3 presents the main effects model. The greatest variation in ACSC hospitalizations was a result of patient health status as measured by HCC scores and history of ACSC hospitalization. In terms of practice care processes and supports, higher levels of interspecialty communication were associated with lower ACSC rates. HIT alone did not have significant main effects on ACSC rates. HIT findings were robust across numerous different methods of organizing and specifying the HIT score from the survey items and were not affected by the number of points we assigned to having (vs not having) an EHR.

Because there was a strong interaction between interspecialty communication and HIT use (unadjusted interaction results are presented in Table A2 of the Appendix), we present the patient and physician practice characteristics in relation to the odds of an ACSC hospitalization, stratified by level of HIT use (Table 4**)**. In these 3 regression models (1 each for low, medium, and high HIT users), the interspecialty communication effects were magnified in the presence of higher HIT use. For example, physicians with high interspecialty communication and high HIT use had a 30% lower adjusted likelihood of ACSC hospitalizations for beneficiaries with the 4 conditions than did physicians with high HIT use but low interspecialty communication.

Other covariates describing the physicians and their practices were not consistently associated with outcomes. Similarly, use of patient registries, nurse care managers and patient educators, and quality and performance measurement were not consistently significantly associated with ACSC hospitalizations. As indicated below, these insignificant relationships may reflect the fact that we are dealing with Medicare FFS patients, for whom many of the care management tools were unlikely to be available in 2008.

Discussion

The fragmented health care system, including the large number of different specialists involved in the care of Medicare beneficiaries, makes the PCP's ability to reliably communicate and coordinate care

with specialists both challenging and important.[4–7] Our findings suggest that when more consistent communication occurs, particularly with the support of HIT, rates of hospitalizations are lower among patients with ACSCs.

Previous work has demonstrated that physicians and staff find 2 aspects of EHRs, as they currently exist, particularly supportive of interspecialty communication: (1) the immediate access to patient data, allowing them to answer questions raised by outside providers regarding referrals and consultations, and (2) electronic messaging among office staff to arrange for tasks related to referrals and consultations. However, interoperability between EHRs continues to be poor.[26–27] Looking forward, improved interoperability as well as additional capabilities, such as electronic referrals, referral tracking systems, and care coordination agreements, have the potential to enhance how HIT supports communication among physicians caring for the same patients.[29,30]

To date, HIT has been demonstrated to help care delivery in other ways (eg, increased adherence to guideline-concordant care, decreased medication errors, decreased testing redundancy, and enhanced surveillance and monitoring).[31–34] But some also have raised concerns about potential harms if HIT is not designed or used in a way that maximizes clinical information and patient safety.[35] To our knowledge, our study is the first to use nationally representative data at the individual physician level to examine whether EHR use in ambulatory settings is associated with potentially preventable hospitalizations. Evidence from within specific health organizations suggests EHR use, in conjunction with other advanced care processes, have beneficial effects on patients.[32–34,36] Our study's findings add to that literature by examining HIT, interspecialty communication, and care management supports not just in integrated health systems but in a nationally representative sample of more typical PCPs and their patients. Indeed, one of this study's strengths is the very descriptive battery of items on HIT/EHR functionalities used by physicians. The survey went beyond other national surveys of its time to ask about actual use by physicians (not just the presence of the systems in their practice) of a wide range of clinical HIT functions.

The lack of association between the use of care managers/patient educators and ACSC hospitalizations was not entirely surprising. In 2008, other than a few demonstrations, care managers—if used at all in typical practices—were likely focused on care for high-cost, commercially insured patients and were employed by and located at the offices of health plans rather than within primary care practices. Current demonstrations of PCMHs (advanced primary care) in Medicare may shed more light on the effectiveness of care managers among Medicare patients.

Study limitations include the observational, cross-sectional nature of the data. In addition, given the scope of topics this survey covers, delving into more detail on some of the practice structures and care processes and the degree to which they extend to Medicare patients was not possible. For example, whether registries included all a physician's patients or only some subset is unknown. Similarly, 2 important components of a PCMH—accessibility of care and teamwork—were not measured in the survey. In addition, rates of HIT adoption and the nature of use of care managers in practices have changed somewhat since 2008.[37] We attempted to control for potential confounding by beneficiary characteristics, especially for beneficiary health and socioeconomic status, as well as physician and practice characteristics, but there are likely potential unmeasured confounders that we could not capture. Thus, additional studies (eg, measuring the care structures and processes in ways other than purely by provider self-report) could explore and confirm (or refute) the findings.

Nonetheless, this study included numerous items on HIT use, and when added to the work of others,[32,33,38] it suggests that HIT alone is not sufficient to create the conditions necessary to avoid potentially avoidable hospitalizations. Reliable communication among primary care and specialist physicians about referrals and consultations, particularly in the presence of HIT, is associated with lower rates of potentially avoidable hospitalizations.

References

1. Prevention quality indicators overview. Rockville, MD: Agency for Healthcare Research and Quality. Available from: http://www.qualityindicators.ahrq.gov/modules/pqi_resources.aspx. Accessed March 11, 2015.
2. Davies SM, McDonald KM, Schmidt E, Schultz E, Geppert J, Romano PS. Expanding use of the AHRQ prevention quality indicators. Report on the Clinical Expert Review Panel. November 7, 2009. Available

from: http://www.qualityindicators.ahrq.gov/Downloads/Modules/PQI/PQI_Summary_Report.pdf. Accessed March 11, 2015.

3. Centers for Medicare and Medicaid Services. Chronic Conditions Among Medicare Beneficiaries, Chartbook, 2012 Edition. Baltimore, MD 2012. Available at: http://www.cms.gov/Research-Statistics-Data-and-Systems/Statistics-Trends-and-Reports/ChronicConditions/Downloads/2012Chartbook.pdf. Accessed August 28, 2013.
4. Pham HH, Schrag D, O'Malley AS, Wu B, Bach PB. Care patterns in Medicare and their implications for pay for performance. N Engl J Med 2007;356:1130–9.
5. Pham HH, O'Malley AS, Bach PB, Saiontz-Martinez C, Schrag D. Primary care physicians' links to other physicians through medicare patients: the scope of care coordination. Ann Intern Med 2009;150:236–42.
6. Kripalani S, LeFevre F, Phillips CO, Williams MV, Basaviah P, Baker DW. Deficits in communication and information transfer between hospital-based and primary care physicians: implications for patient safety and continuity of care. JAMA 2007;297:831–41.
7. Cummins RO, Smith RW, Inui TS. Communication failure in primary care. Failure of consultants to provide follow-up information. JAMA 1980;243:1650–2.
8. O'Malley AS, Reschovsky JD. Referral and consultation communication between primary care and specialist physicians: finding common ground. Arch Intern Med 2011;171:56–65.
9. The Patient Centered Medical Home (PCMH). Available from: http://www.aafp.org/practice-management/transformation/pcmh.html. Accessed March 19, 2015.
10. Accountable Care Organizations. Available from: https://www.cms.gov/Medicare/Medicare-Fee-for-Service-Payment/ACO/index.html?redirect=/ACO. Accessed March 19, 2015.
11. Health Information Technology for Economic and Clinical Health Act, part of the American Recovery and Reinvestment Act (ARRA) of 2009, Pub. L. No. 111–5, 123 Stat. 115 (February 27, 2009).
12. Peikes D, Dale S, Lundquist E, Genevro J, Meyers D. Building the evidence base for the medical home: what sample and sample size do studies need? AHRQ publication no. 11-0090-EF. Rockville, MD: Agency for Healthcare Research and Quality; 2011. Available from: http://pcmh.ahrq.gov/sites/default/files/attachments/Building%20Evidence%20Base%20PCMH%20White%20Paper.pdf. Accessed August 28, 2013.
13. 2008 Health Tracking Physician Survey methodology report. Technical publication no. 77. Washington, DC: Center for Studying Health System Change; 2009. Available from: http://www.hschange.com/CONTENT/1085/. Accessed August 28, 2013.
14. Donabedian A. Evaluating the quality of medical care. Milbank Mem Fund Q 1966;44(Suppl):166–206.
15. Standard definitions: final dispositions of case codes and outcome rates for surveys. 6th ed. Lenexa, KS: American Association for Public Opinion Research; 2009. Available from: http://www.aapor.org/AAPORKentico/Communications/AAPOR-Journals/Standard-Definitions.aspx. Accessed March 19, 2015.
16. Berenson-Eggers type of service (BETOS). Baltimore: Centers for Medicare and Medicaid Services. Available from: http://www.cms.gov/Medicare/Coding/HCPCSReleaseCodeSets/BETOS.html. Accessed October 23, 2013.
17. Weiner JP, Parente ST, Garnick DW, Fowles J, Lawthers AG, Palmer RH. Variation in office-based quality. A claims-based profile of care provided to Medicare patients with diabetes. JAMA 1995;273:1503–8.
18. Starfield B. Primary care: balancing health needs, services and technology. New York: Oxford University Press; 1998.
19. Wagner EH, Austin BT, Davis C, Hindmarsh M, Schaefer J, Bonomi A. Improving chronic illness care: translating evidence into action. Health Aff (Millwood) 2001;20:64–78.
20. Joint principles of a patient-centered medical home released by organizations representing more than 300,000 physicians. Press release, March 5, 2007. Philadelphia: American College of Physicians. Available from: http://www.acponline.org/pressroom/pcmh.htm. Accessed August 28, 2013.
21. Starfield B, Cassidy C. Adult Primary Care Assessment Tool. 1998. Available from: http://www.jhsph.edu/research/centers-and-institutes/johns-hopkins-primary-care-policy-center/pca_tools.html. Accessed March 13, 2015.
22. Pope GC, Kautter J, Ingber MJ, Freeman S, Sekar R, Newhart C. Evaluation of the CMS-HCC risk adjustment model. Final report. Research Triangle Park, NC: RTI International; 2011. Available from: https://www.cms.gov/Medicare/Health-Plans/MedicareAdvtgSpecRateStats/downloads/evaluation_risk_adj_model_2011.pdf. Accessed March 11, 2015.
23. Medicare & Medicaid statistical supplement, 2009 edition. Baltimore: Centers for Medicare & Medicaid Services; 2014. Available from: http://www.cms.gov/Research-Statistics-Data-and-Systems/Statistics-Trends-and-Reports/MedicareMedicaidStatSupp/2009.html. Accessed March 11, 2015.
24. Medicare Advantage rates & statistics. FFS Data (2008–2012). Available from: http://www.cms.gov/

Medicare/Health-Plans/MedicareAdvtgSpecRateStats/FFS-Data.html. Accessed March 11, 2015.
25. Hosmer DW, Lemeshow S. Applied Logistic Regression. John Wiley and Sons, 1989, New York.
26. O'Malley AS, Grossman JM, Cohen GR, Kemper NM, Pham HH. Are electronic medical records helpful for care coordination? Experiences of physician practices. J Gen Intern Med 2010;25:177–85.
27. Kuperman GJ. Health-information exchange: why are we doing it, and what are we doing? J Am Med Inform Assoc 2011;18(5):678–82.
28. Knaup P, Bott O, Kohl C, Lovis C, Garde S. Electronic patient records: moving from islands and bridges towards electronic health records for continuity of care. Yearb Med Inform 2007:34–46.
29. Chen AH, Murphy EJ, Yee HF Jr. eReferral–a new model for integrated care. N Engl J Med 2013;368:2450–3.
30. Carrier E, Dowling MK, Pham HH. Care coordination agreements: barriers, facilitators, and lessons learned. Am J Manag Care 2012;18:e398–404.
31. Kern LM, Barrón Y, Dhopeshwarkar RV, Edwards A, Kaushal R; HITEC Investigators. Electronic health records and ambulatory quality of care. J Gen Intern Med 2013;28:496–503.
32. Chaudhry B, Wang J, Wu S, et al. Systematic review: impact of health information technology on quality, efficiency, and costs of medical care. Ann Intern Med 2006;144:742–52.
33. Payne TH, Bates DW, Berner ES, et al. Healthcare information technology and economics. J Am Med Inform Assoc 2013;20:212–7.
34. Friedberg MW, Coltin KL, Safran DG, Dresser M, Zaslavsky AM, Schneider EC. Associations between structural capabilities of primary care practices and performance on selected quality measures. Ann Intern Med 2009;151:456–63.
35. Institute of Medicine. Health IT and patient safety: building safer systems for better care. Washington, DC: National Academies Press; 2012. Available from: http://www.nap.edu/openbook.php?record_id=13269&page=R1. Accessed March 11, 2015.
36. AHRQ Health Care Innovations Exchange. Intermountain healthcare experience, Dorr DA et al. Available from: http://www.innovations.ahrq.gov/content.aspx?id=264. Accessed August 28, 2013.
37. Hsiao CJ, Hing E, Socey TC, Cai B. Electronic Health Record Systems and Intent to Apply for Meaningful Use Incentives Among Office-based Physician Practices: United States, 2001–2011. NCHS Data Brief: No. 79, November 2011. Available from: http://www.cdc.gov/nchs/data/databriefs/db79.htm. Accessed March 19, 2015.
38. Bates DW, Bitton A. The future of health information technology in the patient-centered medical home. Health Aff (Millwood) 2010;29:614–21.

Appendix

Inpatient claims were searched for the International Classification of Diseases, Ninth Revision, Clinical Modification, diagnosis codes listed in Table A1 to identify the numerator for ambulatory care–sensitive admissions.

Description of Subgroup and Sensitivity Analyses

Subgroup and sensitivity analyses included excluding beneficiaries with any skilled nursing facility (SNF) or hospice claim in any of the years (2007–2009) and limiting the analysis to beneficiaries attributed to family medicine, general internal medicine, general practice or geriatric medicine physicians (which excluded the 12% of specialist physicians represented in the analytic sample). Even though HCC scores already adjust for age, sex and dual Medicaid eligibility, we also ran the regressions with these variables as additional covariates. Finally, we checked whether alternative approaches to generate domain scores affected results. None of these sensitivity tests changed the results.

We also ran a single model where we entered several interaction terms for each of the combinations of HIT levels and inter-specialty com-

Table A1. International Classification of Diseases, Ninth Revision, Clinical Modification, Diagnosis Codes Used in Search

Diabetes (short- and long-term complications and uncontrolled diabetes)	25010–25013, 25020–25023, 25030–25033
	25040–25043, 25050–25053, 25060–25063, 25070–25073, 25080–25083, 25090–25093
	8410–8419
	25000–25003, 25010–25013, 25020–25023, 25030–25033, 25040–25043, 25050–25053, 25060–25063, 25070–25073, 25080–25083, 25090–25093
Chronic obstructive pulmonary disease/adult asthma	490* 4660* 4910 4911 49120 49121 4918 4919 4920 4928 494 4940 4941 496
	49300–49302, 49310–48312, 49320–49322, 49381–49382, 49390–49392
Congestive heart failure	39891, 40201, 40211, 40291, 40401, 40403, 40411, 40413, 40491, 40493, 4280, 4281, 42820, 42821–42823, 42830–42833, 42840–42843, 4289

*Qualifies only if accompanied by secondary diagnosis of any other code on this list.

Table A2. Interaction Between Interspecialty Communication and Ambulatory Care–Sensitive Hospitalizations for Patients With Chronic Conditions, Stratified by Personal Primary Care Physician's Level of Health Information Technology Use (Unadjusted Percentages)

	PQI Hospitalizations in 2008 or 2009 (%)		
	Low HIT	Medium HIT	High HIT
PCP communicates with patient and with other specialists about specialist care received			
Lower tercile (reference)	2.47	2.82	2.78
Middle tercile	2.09	2.50	2.45
Upper tercile	2.50	2.04	1.90
P value	<.0001	<.0001	<.0001

The first column is the subgroup of beneficiaries in practices whose usual physician has low health information technology (HIT) use, the middle column has medium HIT use and the far right column has high HIT use.
Data source: Linked data from the nationally representative Center for Studying Health System Change (HSC) Physician Survey (2008) and Medicare fee-for-service claims for the years 2007 to 2009 for all beneficiaries for whom a physician from the HSC national survey was their usual source of care. Usual source of care was determined by the plurality algorithm for evaluation and management visits.
Ambulatory care–sensitive conditions (ACSCs) examined included congestive heart failure, chronic obstructive pulmonary disease, asthma, and diabetes. ACSC hospitalizations for any one or more of these conditions (combined rate) were calculated using claims for 2008 and 2009 (the numerator). The denominator for all analyses is the 123,760 patients with one or more of these chronic conditions (identified in 2007–2008 claims).
PCP, primary care physician; PQI, prevention quality indicators.

munication levels, but that created significant challenges for presentation of the data and did not change the findings. Thus the results are presented as three separate regressions for the beneficiaries of physicians with low, medium and high HIT use (Table 4).