

# Putting the Pieces Together: EHR Communication and Diabetes Patient Outcomes

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**D**elivering evidence-based, high-quality healthcare for patients with diabetes, a leading cause of morbidity and mortality, is a major public health challenge. The prevalence of diabetes is 9.3% in the US population,<sup>1</sup> and the economic cost of diagnosed diabetes in the United States was \$245 billion in 2012.<sup>2</sup>

Team-based diabetes care leads to better glycemic and blood pressure control, improved patient follow-up, increased patient satisfaction, lower risk of diabetes complications, better quality of life, and lower healthcare costs.<sup>3-10</sup> A meta-analysis of 66 diabetes intervention studies revealed that team-based interventions demonstrate the most robust improvements in patients' glycemic control.<sup>11</sup>

Electronic health record (EHR) communication is a salient aspect of team functioning as primary care teams collaborate in diabetes care delivery.<sup>12</sup> Prior research shows that communication networks in teams contribute to the development of a shared team vision of the team's goals and objectives, which in turn is linked to patient quality-of-care outcomes.<sup>13</sup> Team members need to be aware of who requires what information at what time, how information should be given, and whether the information should be reframed, evaluated, or summarized.<sup>14,15</sup> The delivery of EHR information should not overwhelm the team members, disrupt their workflow, or delay decision making. Evaluating EHR communication flow among team members is an important step in the assessment of diabetes care quality.<sup>16-18</sup>

Very limited evidence exists on how team EHR communication patterns are associated with diabetes-related patient outcomes in primary care. To fill this gap, this study uses social network analysis to determine configurations of team EHR communication flow in relation to diabetes patient panel outcomes. Social network analysis is a systematic analytical tool for examining relationships in a complex system (eg, EHR team communication in primary care).<sup>19-26</sup>

## METHODS

### Study Setting and Design

The study data were drawn from 4 primary care clinics associated with UW Health, a large healthcare system in southern Wisconsin

## ABSTRACT

**OBJECTIVES:** This study seeks to determine how changes in electronic health record (EHR) communication patterns in primary care teams relate to quality of care and costs for patients with diabetes.

**STUDY DESIGN:** EHR-extracted longitudinal observational study.

**METHODS:** A total of 83 health professionals in 19 care teams at 4 primary care clinics associated with a large Midwestern university participated in the study. Counts of messages routed between any 2 team members in the EHR in the past 18 months were extracted. Flow-betweenness, defined as the proportion of information passed indirectly within the team, was calculated. The analysis related changes in team flow-betweenness to changes in emergency department visits, hospital stays, and associated medical costs for the teams' patients with diabetes, while adjusting for team face-to-face communication, patient-level covariates, comorbidities, team size, and clinic fixed effects.

**RESULTS:** Patient hospital visits increased by 13% (standard error [SE] = 6%) for every increase of 1 percentage point in team EHR message forwarding (ie, higher team flow-betweenness). Medical costs increased by \$223 (SE = \$105) per patient with diabetes in the past 6 months for every increase of 1 percentage point in team flow-betweenness.

**CONCLUSIONS:** Primary care teams whose EHR communication reached more team members indirectly (ie, via message forwarding) had worse outcomes and higher medical costs for their patients with diabetes. EHR team communication flow patterns may be an important avenue to explore in raising quality of care and lowering costs for patients with diabetes in primary care.

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(see Mundt et al<sup>13</sup> for full details on study procedures and recruitment). The Institutional Review Board of the University of Wisconsin approved the study.

All physicians, physician assistants, nurse practitioners, registered nurses (RNs), medical assistants (MAs), licensed practical nurses (LPNs), laboratory technicians, radiology technicians, clinic managers, medical receptionists, and other patient care staff were invited to participate. A trained researcher conducted a 30-minute face-to-face structured survey about team communication in the clinic.

Using a clinic staff roster as an aid for memory recall, participants were asked to identify, for each other employee at their clinic, how frequently they communicated face-to-face about patient care.

### Clinical Participants

Eligibility criteria included being 18 years or older, able to read and understand English, and employed at the study site in a patient care or patient interaction capacity. More than 97% (83 of 85 invited) of eligible participants took part in the study.

### Diabetes Patient Panel Sample

An EHR search linked primary care teams to patients with diabetes (type 1 and type 2) 18 years or older who were seen by the team over the 18-month study period (July 1, 2013, to December 31, 2014). Diabetes diagnoses were determined by the presence of 2 validated *International Classification of Diseases, Ninth Revision* diabetes codes (250.00-250.03, 250.10-250.13, 250.20-250.23, 250.30-250.33, 250.40-250.43, 250.50-250.53, 250.60-250.63, 250.70-250.73, 250.80-250.83, 250.90-250.93, 357.2, 362.01, 362.02, 366.41) on 2 separate occasions within the previous 3 years.

### Data

**Team membership survey.** To determine team membership, health professionals were asked to consider a team definition and indicate on a full clinic staff roster who is on their care team. The care team was defined as “the smallest unit of individuals within the clinic that cares for a specific patient panel.”

The initial sample included 24 care teams. A total of 5 teams were excluded due to significant turnover during the study period.

**Team EHR communication.** Electronic communication about patient care between team members is sent and received through the secure Epic (Epic Systems Corp; Madison, Wisconsin) EHR system employed at each study clinic. We extracted counts of EHR messages sent from each member to every other team member through the secure electronic messaging function (inbox) of the EHR. These established communication connections created an EHR communication network, which was presented as a sociomatrix for the study analysis.<sup>27</sup> Due to Health Insurance Portability and Accountability Act constraints, other forms of electronic communication, such as

## TAKEAWAY POINTS

This article analyzes the associations between indirect electronic health record (EHR) communication in primary care teams and outcomes and costs for patients with diabetes.

- ▶ More frequent indirect EHR communication (eg, message forwarding) in primary care teams is associated with worse outcomes and higher medical costs for patients with diabetes.
- ▶ Patient hospital visits increased by 13% for every increase of 1 percentage point in team EHR message forwarding.
- ▶ Medical costs increased by \$223 per patient with diabetes for every increase of 1 percentage point in message forwarding.
- ▶ Team EHR communication flow patterns may be an important avenue to explore in raising quality of care and lowering costs for patients with diabetes.

email, Skype for Business, alerts/notes, and forwarded messaging to/from patients, were not available for the analysis and were not analyzed in the study; as such, they are left to future research.

Message counts between team members were totaled for three 6-month time periods: (1) July 1, 2013, to December 31, 2013; (2) January 1, 2014, to June 30, 2014; and (3) July 1, 2014, to December 31, 2014. The sum of dyadic pair messages was used to create a square sociometric matrix for each team and each time period.

The analysis calculated the following measures: (1) the total number of messages sent within the team for each 6-month period, (2) the percentage of the team’s messages sent to the study team primary care provider (PCP), and (3) the social network analysis measure of flow-betweenness<sup>28,29</sup> for the EHR team message network. Flow-betweenness is the amount of information that travels between team members indirectly, by going through another team member within the team, as opposed to being sent directly from person to person.

To calculate flow-betweenness for the whole network, the analysis began by computing the flow-betweenness for each vertex in the network. Vertex flow-betweenness is the amount of message information transferred through the vertex *i* when the maximum flow of information is averaged over all pairs *a* and *b* in the network.<sup>30,31</sup> Normalizing the individual flow-betweenness in the network by the total number of messages transmitted yielded the team-based measure of flow-betweenness, which can be expressed as a percentage.

### EHR healthcare utilization data for patients with diabetes.

The numbers of emergency department (ED) visits and hospital visit days were extracted from the EHR as utilization counts over the 18-month study period. Healthcare costs were calculated by applying average healthcare costs derived from published reports to healthcare utilization counts.<sup>32,33</sup> An average cost of \$664 per ED visit and \$1628 per hospital day was applied to each recorded visit.

### Statistical Analysis

Flow-betweenness changes were calculated as the difference in team flow-betweenness between time period 3 and time period 2 and the difference in team flow-betweenness between time period 2 and time period 1. Changes in flow-betweenness were then modeled

**TABLE 1.** Study Sample

Clinician Sample Characteristics (N = 83 employees at 4 clinics)		n (%)
Job position in clinic		
Physician (MD/DO)	14	(16.9)
Nurse practitioner/physician assistant	5	(6.0)
Clinic manager	4	(4.8)
Registered nurse	19	(22.9)
Licensed practical nurse/medical assistant	21	(25.3)
Laboratory/radiology technician	10	(12.0)
Medical receptionist	10	(12.0)
Gender		
Female	79	(95.2)
Years at clinic		
≤1	12	(14.4)
>1-3	28	(33.7)
>3-6	17	(20.4)
>6-10	8	(9.6)
>10	18	(21.7)
Employment, as % of full-time equivalent		
≤50%	9	(10.8)
>50%-75%	12	(14.4)
>75%	62	(74.7)
Patient Sample Characteristics (N = 2242 patients)		Mean (SD)
Diabetes, %	100.0	(0)
Age, years	59.8	(13.0)
Female, %	48.0	(0.5)
Race/ethnicity, %		
Non-Hispanic white	89.7	(0.3)
Black	2.9	(0.2)
White Hispanic	3.6	(0.2)
Asian	1.6	(0.1)
Other/missing	2.2	(0.1)
Insurance, %		
Commercial	49.8	(0.5)
Medicare	44.4	(0.5)
Medicaid	3.9	(0.2)
Uninsured	1.9	(0.1)
Chronic conditions, %		
Acute myocardial infarction	4.9	(0.2)
Asthma	12.7	(0.3)
Atrial fibrillation	12.1	(0.3)
Cancer	7.9	(0.3)
Cerebrovascular disease	7.0	(0.3)
Chronic kidney disease	27.1	(0.4)
Chronic obstructive pulmonary disease	8.0	(0.3)
Congestive heart failure	5.7	(0.2)
Dementia	2.2	(0.1)

(continued)

as predictors of changes in patient healthcare utilization and costs for the teams' patients with diabetes using multilevel mixed-effects modeling (MLME).<sup>34</sup> The MLME analysis used a log link function for count outcomes (ED visits, hospital days) and a normal link function for medical costs while adjusting for team-level confounders, such as team face-to-face communication density, and clinic-level clustering. Density is the ratio of communication ties observed to the total number of possible network connections.

To control for differences in patient panel characteristics across teams, the study adjusted for patient age, gender, race/ethnicity, insurance status, and available EHR diagnoses of chronic conditions referenced in the CMS Chronic Condition Warehouse (eg, acute myocardial infarction, asthma, atrial fibrillation, cancer, chronic kidney disease, chronic obstructive pulmonary disease, depression, hyperlipidemia, hypertension, ischemic heart disease, osteoarthritis, osteoporosis, rheumatoid arthritis) or in the Charlson Comorbidity Index (CCI; eg, cerebrovascular disease, congestive heart failure, dementia, peptic ulcer disease). The CCI was also included to adjust for potential confounding by multiple simultaneous chronic conditions.<sup>35</sup>

## RESULTS

This study included 19 primary care teams from 4 primary care clinics. A total of 83 health professionals participated in the study (Table 1). Study participants included 19 PCPs (14 physicians, 2 nurse practitioners, and 3 physician assistants), 19 RNs, 14 MAs, 7 LPNs, 10 medical receptionists, 10 laboratory or radiology technicians, and 4 clinic managers.

Study participants were 95% female, which is in line with US Census Bureau data indicating that 91% of all nurses, nurse practitioners, and LPNs, as well as 97% of all medical receptionists, are female.<sup>36</sup> Fourteen percent of the participants had worked at their practice for 1 year or less, and one-fourth worked 75% of full-time equivalent or less. Care teams ranged in size from 11 to 28 individuals, averaging 18 team members (Table 2).

The teams' panels of patients with diabetes consisted of 2242 patients. Just under half of the patients were women (48%), most were non-Hispanic white (90%), and most had private insurance (50%) or Medicare (44%). Comorbidities were common among the patients, with 79% diagnosed with hypertension and 81% diagnosed with hyperlipidemia. EHR records showed that patients had, on average, 0.2 ED visits and 0.6 hospital visit days per 6 months. Acute medical care costs averaged \$1075 per patient per 6 months.

As seen in Table 2, the number of EHR messages sent between team members averaged 4099 messages in a 6-month period. More than 80% of EHR messages were sent from a team member to the PCP. Team flow-betweenness averaged 4.6%, indicating that just under 5% of information in the EHR network was passed indirectly (eg, forwarded message) from one team member to another before reaching its final destination.

The Figure visually represents the EHR interaction networks in 2 study teams. The team with the lowest quartile of healthcare

utilization and costs in panel A of the Figure has a less dense communication network than the team with the highest quartile of healthcare utilization and costs in panel B of the Figure, which has visibly more EHR communication connections among more team members. Team A, with the lowest quartile of healthcare utilization and costs, demonstrates flow-betweenness of 2.3%, which was in the lowest quartile of team flow-betweenness. Team B, on the other hand, was in the highest quartile of healthcare utilization and costs and had the highest quartile of team flow-betweenness, at 10.6%. As evidenced in the Figure, Team B, which had more information passed indirectly by more team members (eg, message forwarding) in the EHR network, had higher healthcare utilization and associated medical costs for their patient panels with diabetes.

**Table 3** presents results from the multilevel modeling evaluation of change in EHR team communication flow (ie, change in flow-betweenness) in relation to change in frequencies of EHR-documented patient ED visits, hospital days, and costs. The results show that increases in team EHR flow-betweenness (ie, message forwarding) were associated with increased patient hospital days and higher associated medical costs. For every increase of 1 percentage point in team EHR flow-betweenness, there was a corresponding increase of 13% (standard error [SE] = 6%) in hospital days per patient per 6 months and of \$226 (SE = \$104) in medical costs per patient per 6 months.

## DISCUSSION

Our findings demonstrate that teams' variations in EHR communication patterns are associated with statistically significant differences in hospital stay days and medical costs for their patients with diabetes.

For every increase of 1 percentage point in EHR team flow-betweenness, healthcare costs increased by \$226 per patient per 6 months (\$452 annually) in our study. These results are not trivial. If the causality pathway between EHR communication patterns and patient outcomes could be firmly established, with close to 9.3% of all patients seen in primary care treated for diabetes,<sup>1</sup> potentially \$19.2 million in healthcare costs could be saved for patients with diabetes at UW Health, the healthcare system of the University of Wisconsin, annually (\$452 per patient × 42,500 patients with diabetes). Furthermore, if the causal connections between EHR communication patterns and patient outcomes are fully confirmed, with the costs of hospital visits for patients with diabetes nationwide at \$75 billion per year,<sup>37</sup> the savings would possibly approach \$10 billion (13% of \$75 billion) nationwide, affecting the 23.1 million patients with diabetes. Future studies are needed to test this causal pathway.

The results show that patients with diabetes fared better if their care team relied on fewer indirect EHR connections to pass patient care information. Teams that use EHR communication purposefully, with well-established, frequently used EHR connections among fewer team members, may have fewer opportunities to pass information indirectly or in an untimely fashion. To point to the value of direct face-to-face communication connections rather than indirect EHR interactions, a study key informant reported: "I think face-to-face

**TABLE 1.** (Continued) Study Sample

Patient Sample Characteristics (N = 2242 patients)	Mean (SD)
Depression	31.9 (0.5)
Hyperlipidemia	81.0 (0.4)
Hypertension	79.3 (0.4)
Ischemic heart disease	13.8 (0.3)
Osteoarthritis	21.0 (0.4)
Osteoporosis	3.3 (0.2)
Peptic ulcer	1.6 (0.1)
Rheumatoid arthritis	2.9 (0.2)
Charlson Comorbidity Index score, mean	2.8 (1.8)
Healthcare Use, Past 6 Months	Mean (SD)
ED visits (per patient per 6 months)	0.17 (1.21)
Hospital days (per patient per 6 months)	0.59 (3.58)
Medical costs (per patient per 6 months)	\$1075 (\$7037)

DO indicates doctor of osteopathic medicine; ED, emergency department; MD, doctor of medicine.

**TABLE 2.** EHR Communication Networks in Primary Care Teams (N = 19 care teams)

Characteristic	Mean (SD)
Team size	17.6 (5.4)
EHR messages sent within team per 6 months	4099 (2462)
EHR messages to team PCP (%)	81.4 (13.6)
Team flow-betweenness <sup>a</sup> (%)	4.6 (2.8)
Face-to-face communication density <sup>b</sup> (%)	47.3 (13.4)

EHR indicates electronic health record; PCP, primary care provider.

<sup>a</sup>Flow-betweenness is the amount of information that travels between team members indirectly.

<sup>b</sup>Density is the percentage of the communication ties present in the team divided by all possible ties that could be present.

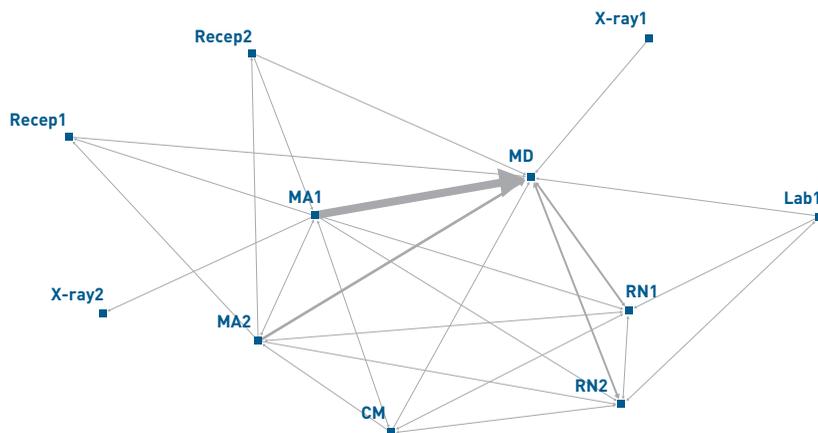
communication is probably the best if you need to talk to somebody about an issue or a question or anything like that. It is just easier to try to talk to somebody one-on-one rather than email back and forth or even call each other too."

Furthermore, teams may develop efficient ways to relate to one another in the EHR if they are communicating with fewer team members on a frequent basis. As the bold thick lines in the Figure illustrate, teams that developed frequent communication between the PCP and 1 other team member (ie, frequent communication between the PCP and 1 other team member in the EHR to the exclusion of others) had better patient diabetes outcomes and lower associated medical costs. Similarly, a study key informant emphasized the need for fewer EHR connections in the EHR communication network to guard against cognitive overload: "People get so overwhelmed with all the emails that they, they blow by them, don't read them and that communication, important information, is lost."

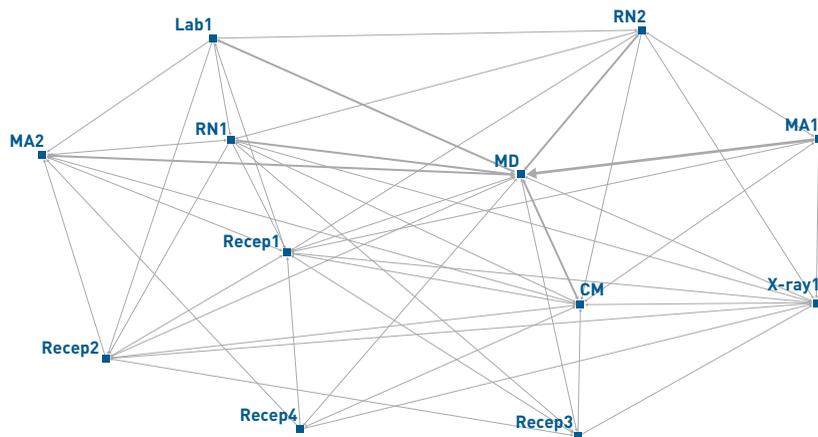
It is possible that high-performing teams with lower healthcare utilization have developed a better team cognitive ability to process

**FIGURE.** Primary Care Team EHR Communication Networks\*

**A.** Visual Representation of EHR Messaging Network Within a Primary Care Team With Lowest Quartile of Flow-Betweenness (2.3%) and Lowest Quartile of Patient Healthcare Utilization and Costs



**B.** Visual Representation of EHR Communication Within a Primary Care Team With Highest Quartile of Flow-Betweenness (10.6%) and Highest Quartile of Patient Healthcare Utilization and Costs



CM indicates clinic manager; EHR, electronic health record; Lab, laboratory technician; MA, medical assistant; MD, doctor of medicine; Recept, medical receptionist; RN, registered nurse; X-ray, radiology technician.  
\*Line size and arrow size are proportional to number of messages.

information and act upon it at the team level (ie, team cognition<sup>38</sup>), and, as such, these teams could be streamlining their EHR communication. It is also possible that PCPs working daily with a single MA benefit from the MA communication processes (eg, information seeking, information processing, individualizing information for the PCP<sup>39,40</sup>) that lead to high-quality care.

In contrast, teams that forwarded EHR messages more often than other teams had longer hospital stay outcomes for their patients with diabetes. It is possible that these teams may lack a full and timely understanding of unfolding situations if the team members rely on EHR forwarding to reach the right recipient. A study key informant points out that overreliance on EHR messaging is not beneficial for team functioning: “I think we communicate so much through the

electronic medical record that we forget to be human and interact that way.”

Several possible explanations exist for why teams that have less information forwarding through the EHR have better patient outcomes. One possible explanation is causal, whereby information forwarding leads to a slower response to necessary diabetes-related care tasks. Another possible explanation is that the degree to which message forwarding occurs is simply a marker for overall team function. High-performing teams may, in general, have a more thorough understanding of how best to use the EHR to communicate among each other and have a working understanding of which situations require face-to-face communication and which can be addressed through the EHR. We define high-performing teams as groups of healthcare professionals who are capable of responding to each other’s changing needs and patient care circumstances while skillfully engaging in their specialized tasks under the conditions of reciprocal interdependency, task and input uncertainty, and time constraints.<sup>41</sup> Teams that are more capable of establishing effective workflows, defining task delegation, and improving communication pathways may be better equipped to deal with uncertainty in the rapidly changing context of primary care practice.<sup>42-44</sup> A third possible explanation could be related to reverse causality. Patients who are sicker may generate more information flow within the team.

The findings suggest that exploring the ways in which teams use the EHR may be useful in efforts to raise quality of care for patients with diabetes. One benefit of implementing effective EHR communication patterns to improve diabetes care delivery is that it does not require significant amounts of additional investment, as EHR adoption and implementation is under way in primary care clinics nationwide.

The study results have important implications for team-based care delivery for patients with diabetes. Team EHR communication that is not supported by optimal face-to-face interactions among team members is associated with worse patient outcomes for the team’s diabetes patient panels. Our results indicate that overreliance on EHRs alone could not produce desired improvements in quality of diabetes care. A key informant underscored the need for the team’s capacity to problem solve in real time: “I think just talking it out, being able to go to those team members and talk to them about a certain problem [is sometimes necessary]...You can’t do it over email so [you need] to have the capability to talk to somebody

with regards to it.” To share in team-based care delivery and raise the quality of diabetes care, teams need, in addition to EHR technical solutions, to make concerted efforts to develop team cognition and create a shared vision of the team’s objectives and expectations.

**Limitations**

The study’s findings should be viewed in light of its limitations. First, this study cannot support a causal mechanism between team EHR interaction networks and diabetes-related patient outcomes due to endogeneity concerns with the data. Experimental study designs are needed to uncover the causal pathways between team EHR communication patterns and diabetes-related patient care. Second, the study data come from 4 practices in the Midwest, so the results may not be generalizable to a broad national context. Third, the study looked only at frequency of EHR interactions and did not attempt to measure communication content or timeliness of communication. Future research is needed to directly address the link between team EHR interaction patterns and quality of diabetes care services. Fourth, the care teams in this study did not include any certified diabetes educators. The results are applicable to care teams whose diabetes-related tasks are shared among the care team members with no access to certified diabetes educators. Future researchers may wish to explore how EHR communication differs on teams with certified diabetes educators. Finally, the study did not explore why team members chose a particular mode of communication (ie, face-to-face vs EHR) to coordinate patient care.

**CONCLUSIONS**

Patients with diabetes may fare better if they are cared for by teams with a focused EHR team communication network defined by well-established, frequent EHR communication with fewer teammates. ■

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**TABLE 3.** Hierarchical Model of Changes in EHR Communication and Patient Outcomes, Adjusted for Patient Characteristics\* (N = 19 teams; N = 2242 patients)

	ED Visits		Hospital Days		Healthcare Costs (\$)	
	β (SE)	P	β (SE)	P	β (SE)	P
Team EHR messaging network						
Team flow-betweenness <sup>b</sup>	0.03 (0.02)	.222	0.13 (0.06)	.027*	226 (104)	.031*
Team size	0.02 (0.01)	.220	0.06 (0.04)	.099	111 (71)	.121
Face-to-face communication						
Face-to-face communication density <sup>c</sup>	0.02 (0.01)	.728	0.01 (0.02)	.700	12 (29)	.682
Patient panel						
Male	0.07 (0.06)	.200	0.28 (0.15)	.061	473 (273)	.083
Age	-0.01 (0.003)	.020*	-0.02 (0.01)	.009*	-39 (14)	.006*
White	0.08 (0.06)	.395	-0.05 (0.31)	.873	-55 (564)	.922
Medicare	0.36 (0.22)	.093	0.82 (0.57)	.146	1564 (1025)	.127
Medicaid	0.12 (0.25)	.650	0.19 (0.67)	.777	393 (1208)	.745
Private insurance	0.21 (0.21)	.319	0.54 (0.55)	.329	1004 (997)	.314
Charlson Comorbidity Index	0.04 (0.02)	.024*	0.16 (0.04)	<.001*	282 (88)	.001*

ED indicates emergency department; EHR, electronic health record; SE, standard error.

\*P < .05.

<sup>a</sup>Patient-level covariates entered in the model: gender, age, race/ethnicity, insurance, acute myocardial infarction, asthma, atrial fibrillation, cancer, cerebrovascular disease, chronic kidney disease stage, chronic obstructive pulmonary disease severity, congestive heart failure, dementia, depression, hyperlipidemia, hypertension, ischemic heart disease, osteoarthritis, osteoporosis, peptic ulcer disease, rheumatoid arthritis, and Charlson Comorbidity Index score.

<sup>b</sup>Flow-betweenness is the amount of information that travels between team members indirectly.

<sup>c</sup>Density is the percentage of the communication ties present in the team divided by all possible ties that could be present.

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