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Who Is Your Doctor? Analysis of Patient-Reported and EHR-Imputed Primary Care Physician

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Abstract

Significant efforts have been made to improve physician-to-physician communication and care coordination during transition of care in order to reduce adverse events and readmissions. As electronic health records (EHRs) become widely available, many hospitals have implemented physician collaboration and hand-off tools to automatically send admission notifications, discharge summaries, and pending laboratory results to a patient's primary care physician (PCP). However, the effectiveness of such tools depends on a fundamental question that remains unstudied: who is the patient's PCP? Missing or outdated PCP information may become the bottleneck to effective patient-centered care coordination regardless of existing efforts on promoting interoperability among healthcare providers. In this paper, we characterized patient-reported PCPs and experimented with an imputation algorithm that automatically infers a patient's primary provider based on patient-provider encounter data. We compared the imputation results with patient-reported PCPs and suggested practical uses of our findings.

Keywords:
Physicians, Primary Care; Patient-reported; Care Coordination

Introduction

Primary care physicians (PCPs, also known as general practitioners) play a critical role in providing continuing care of patients, especially those with complex health needs [1]. PCPs coordinate care among various care team members of a patient by communicating with hospitals, emergency departments, specialty care, home care and social service providers. Studies have reported that increased involvement of PCPs is associated with significant decreases in healthcare utilization [2]. In United States, diverse stakeholders, including Federal and State agencies, insurers and employers, are engaged in numerous efforts to promote the shift to new healthcare delivery models such as Patient-Centered Medical Homes (PCMH) [3] and Accountable Care Organizations (ACO) [4]. These models reward for value rather than volume and aim to improve clinical outcomes. Both the PCMH and ACO models rely on primary care physicians to coordinate care across the healthcare continuum. For example, patients discharged from the hospital are one major group being targeted for care coordination. Numerous studies have shown that timely outpatient follow-up is associated with lower readmission rates [5,6]. However, studies also reported that poor communication among physicians across care settings have posed practical challenges to coordinated care. In a study of primary care physicians across the industrialized world, only 31% of physicians surveyed said that they were always notified when a patient is discharged from the hospital and 32% for emergency department visits in United States [7]. Similarly, communication between PCPs and specialists regarding referrals and consultations is often inadequate. A study reported that 80% of specialists said they "always" or "most of the time" send consultation results to the referring PCP, but only 62% of PCPs said they received such information [8].

To promote effective communication among physicians during transition of care, most previous studies focused on designing hand-off tools or evaluating the availability and content of discharge summaries [9,10]. As the adoption of EHRs among hospitals and individual practices increases, many EHRs are configured to automatically fax or electronically send discharge summaries to PCPs upon patient's discharge. However, such automated services rely on accurate and complete PCP information captured in EHR or associated administrative systems. In other words, the practical value of the transition of care tools depends on the assumption that the hospital or specialist knows who the patient's PCP is and where to send discharge summaries or consultation notes. In reality, the PCP is not reliably captured. Hospitals are often faced with the challenge of missing or outdated PCP information in their system. Discharge summaries may be sent to an invalid fax number or the wrong physician if the patient has changed PCP for various reasons. The inaccurate PCP information causes communication lapses and poses significant privacy concerns considering the protected health information (PHI) contained in the documents.

Research into the clinical implications of accurate patient-PCP relationships has deferred to the focus of measurement for the operational payment imperative. In the health insurer industry, in order to measure a provider's performance, members (patients) are attributed to a provider through an analysis of healthcare claims [11]. Attribution rules vary across organizations, depending on the objectives and application. However, this patient attribution approach only focuses on insurance members and providers who participate in certain incentive programs such as the ACO delivery model or a specific health plan network. Our study examines the PCP relationship from a patient's perspective and is targeted at the complete patient population, including those uninsured and underinsured.

In this study, we focused on answering some fundamental questions regarding patient PCPs. How many patients have a PCP? Do all patients know who their PCP is? Do all patients

know what "PCP" refers to? Is patient-reported PCP information reliable? What should we do when the PCP information is missing? The specific objectives of this study were to a) understand patient-reported PCP information, b) demonstrate the feasibility of using EHR data to impute a patient's PCP, and c) compare the imputed PCP with patient-reported PCP.

Methods

Setting

Intermountain Healthcare (hereafter referred to as "Intermountain") is a not-for-profit health system based in Salt Lake City, Utah that operates 22 hospitals, over 185 clinics, a broad range of laboratory and pharmacy services, and an affiliated health insurance company. Intermountain has about 1,400 employed physicians and 3,000 affiliated physicians. It is the largest integrated health system in the Intermountain West region of the United States.

Data Source

Data for this project included enterprise-wide inpatient, outpatient, and emergency department registration and encounter records at all Intermountain facilities.

Registration Dataset

To understand the characteristics of patient-reported PCP, we analyzed the registration data generated from two patient registration applications—one for hospital and emergency department encounters (R1) and one for outpatient clinic encounters (R2). R1 requires the registrar to collect encounter-based PCP information, which means that the patient needs to declare his/her PCP at each visit, regardless of whether the PCP information has been collected previously. R2 treats PCP as longitudinal data and allows the registrar to keep or update the PCP information if the patient has reported a PCP during previous visits. However, in R2, new PCP information simply overwrites the old information and current data do not support the analysis of a patient's PCP history. R2 also allows the registrar to enter the reason for missing PCP. We extracted registration data from both R1 and R2 during a two-year period between September 1, 2014 and September 1, 2016.

Encounter Dataset

To examine the feasibility of using EHR data to impute a patient's PCP, we analyzed patient encounter data to extract all patient-provider interactions during a five-year period between September 1, 2011 and September 1, 2016. The encounter dataset included all ambulatory visits at any Intermountain facility. Inpatient hospital visits and emergency department visits were excluded based on the assumption that hospitalists and emergency medical doctors focus on individual encounters and do not establish a longitudinal relationship with a patient. Each encounter record included in the analysis consisted of a unique patient identifier, the provider's identifier for that visit, and time and location of the visit.

We linked the registration dataset and encounter dataset with our internal provider directory that includes both Intermountain-employed providers and independent practitioners who are affiliated with Intermountain. Many of the independent practitioners have privileges to admit patients to an Intermountain hospital. However, they usually have separate patient registration and EHR systems for outpatient visits. Each record in the provider directory included a provider's full name, specialty, employment status, practice location, phone number, fax number, etc. However, many records in the provider directory were identified with incomplete information.

External Dataset

Considering the fact that patients frequently visit providers from multiple healthcare organizations, we extended the imputation analysis to statewide encounter data outside of our health system. We extracted all clinical messages received by the state Health Information Exchange (HIE) from major hospitals, clinics, labs and insurers in Utah between 2011 and 2016. The types of clinical messages included admit, discharge, and transfer (HL7 ADT), laboratory, radiology and transcription results, and prescriptions (HL7 Pharmacy/Treatment Encoded Order Message—RDE). Each clinical message extracted for this study consisted of a unique HIE patient identifier, provider information in the Patient Visit Information (PV1) segment, and date of service. The HIE patient identifier was linked to the Intermountain patient identifier through the community master patient index.

Analysis

The first part of the study was a descriptive analysis to characterize patient-reported PCPs. We analyzed the completeness of PCP information declared by patients or family members. We also analyzed the consistency of PCP declared across encounters for the same patient using the registration data from R1. Reasons for missing PCPs were summarized.

The second part of the study was to impute the primary provider for a subset of patients who had inpatient or emergency department encounters between September 1, 2014 and September 1, 2016. The imputation algorithm leveraged all records extracted into the encounter dataset and calculated a closeness score for each patient-provider pair using Eq.1 was an updated algorithm from our previous work [12]. The underlying design principle of our imputation algorithm is the more frequent and more recent a patient was seen by a provider, the higher the closeness score between the patient and the provider. Most existing attribution rules employed by health insurers are also based on this principle. However, these rules only use the date for the most recent visit when there is a tie between multiple providers. We further refined the algorithm by taking into account the date of each previous visit. Each patient-provider encounter record was assigned with a score that was inversely correlated to the lapsed time between the current date and the date of the encounter. The "current date" (denoted as "date of the target visit" in Formula (1) refers to the time when a provider is imputed based on all previous encounters. The sum of all visit scores for a unique patient-provider pair was the total score for that patient-provider relationship. A threshold (closeness score>=2) was defined to identify the providers who were considered as the primary provider. The parameters *k* and *e* in Eq.1 and the threshold were chosen based on iterative adjustments in order to make the algorithm clinically intuitive.

$$\text{closeness\_score} = \sum_{i=1}^{n} e^{-k(T-ti)} \quad (1)$$

where
n= total number of encounters;
k=0.001;
T= date of the target visit;
t_i*= date of the* i^{th} *encounter*

We compared the imputed primary providers with patient-reported PCPs for two subsets of patients: 1) patients who had more than one inpatient or emergency department encounters during the study period and declared the same PCP across

multiple encounters, and 2) patients who had inpatient or emergency department encounters during the study period and did not declare a PCP at the encounter. Step 1) was to understand the strength and weakness of the imputation algorithm. Step 2) was to demonstrate the potential value of the imputation algorithm in identifying primary providers to be notified for inpatient and emergency encounters when the PCP information is missing.

Results

There were 2.5 million registration records for about 830,000 patients generated from R1 between September 1, 2014 and September 1, 2016. R2 had about 1 million registration updates during the two-year period.

Completeness of Patient-reported PCP

Table 1 shows the completeness of patient-reported PCP information by encounter type. About 58% of all inpatient encounters had some PCP documented during registration and 52% for emergency visits. Inpatient Behavioral health encounters had the lowest PCP declaration rate (24%). Outpatient registrations had the highest PCP declaration rate in general (74-89%). For patients who reported PCPs, the PCP information was not consistent across encounters. Among all inpatient and emergency encounters generated in R1, 31% of the patients had more than one encounter during the two-year period, only 27% of whom reported the same PCP across multiple encounters. Over 5,000 patients had more than five PCPs reported and the maximum number of PCPs reported by a patient (or family member) was 15 during the two-year period.

Table 1 – Patient-reported PCP by Encounter Type

Encounter Type	Proportion of Paitent who Reported a PCP
Inpatient	58%
Maternity/newborn	*42%*
Behavioral Health	*24%*
Inpatient Transplant	*75%*
Inpatient Other	*65%*
Outpatient	N/A*
Laboratory	*83%*
Imaging	*75%*
Same-day Surgery	*74%*
Clinic	*89%*
Emergency	52%

**The outpatient registration records were extracted from a combination of R1 and R2. The overall proportion of outpatient PCPs does not apply here.*

For patients with missing PCP during registration, only 0.2% had a reason documented. About a third of these patients reported that they did not have a doctor they see regularly, and 5% of the patients did not remember or only remember partial information about their PCP (Figure 1). Very few patients did not want to disclose their PCP information and did not want the hospital to forward the discharge summaries to their PCP.

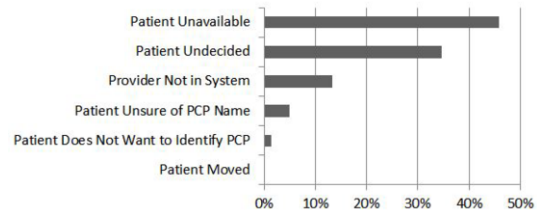

Figure 1 – Reason for Missing PCP at Registration

Provider Profiles

The top ten primary specialties of patient-reported PCPs are illustrated by the dark grey bars in Figure 2. Eleven percent of patient-declared PCPs were Family Medicine doctors, followed by Physician Assistants (6%). Surprisingly, Emergency Medicine doctors and Dentists were at the top ten most popular PCP specialties reported by patients. Due to the data quality issue of the provider database, not all providers have a primary specialty recorded. One percent of patient-reported PCPs were non-person accounts (e.g. facilities or clinics). Forty percent had an inactive status at the time of query. Eighty-one percent had either a phone number or fax number recorded in the provider directory. However, our analysis did not validate the phone number and fax numbers.

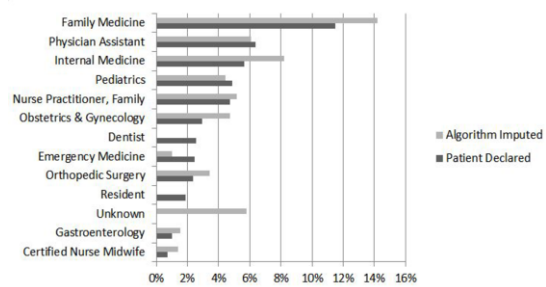

Figure 2 – Patient-reported vs. Imputed PCP by Specialty

As shown by the dark grey bars in Figure 3, about half of the patient-reported providers were independent practitioners, most of whom have their own practices and EHR systems. Some of the independent practitioners were affiliated with Intermountain hospitals and had access to the EHR while others do not.

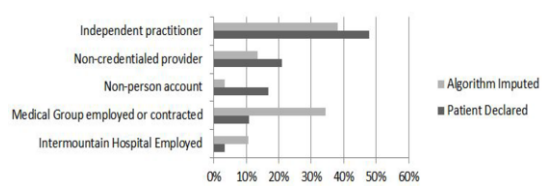

Figure 3 – Patient-reported vs. Imputed PCP by Employment Status

Algorithm-imputed PCPs

Firstly, we conducted the imputation algorithm on patients who reported the same PCP across multiple encounters during the

two-year period. The results showed that the algorithm identified one or more primary providers (closeness score>=2) for 62% of the patients and 38% of the imputed providers were consistent with patient-reported PCPs. Table 2 shows some example closeness scores calculated by the imputation algorithm using the "Target Visit Date" as the reference point of time. Any visit occurred before the target visit date was counted in the closeness score. As shown by the highlighted rows for pt001, even though the number of visits with pv102 exceeded the number of visits with pv101, the closeness score for pv101 was higher since the visits were more recent.

For those patients who did not get an imputed provider, we manually reviewed some randomly selected patients' chart. As expected, the primary factor was that these patients only had emergency visits at Intermountain. Reported PCPs from these patients were independent practitioners who were not employed by Intermountain. As a result, the visit history was captured by the doctor's own EHR that was not part of the analysis dataset.

Table 2 – Example Closeness Scores Calculated from Previous Visits

Patient ID	Imputed Provider ID	Target Visit Date	Total No.of Visits	Last Seen	Score
pt000	pv100	10/09/2015	5	08/26/2013	1.4
pt001	pv101	11/29/2015	7	08/03/2015	5.4
pt001	pv102	11/29/2015	17	11/14/2010	2.2
pt002	pv100	07/30/2016	38	07/08/2016	13.8
pt002	pv103	07/30/2016	10	01/22/2015	4.4
pt002	pv105	07/30/2016	3	04/28/2016	2.6

Note: all identifiers and dates were de-identified without affecting the trend of the algorithm.

Secondly, we applied the algorithm to patients who did not have a PCP declared at the inpatient or emergency encounter during the study period. The purpose of the second part of the imputation analysis was to demonstrate the feasibility of identifying the appropriate provider who should be notified about a hospital stay or emergency visit when the PCP was not collected from the patient. Results showed that the algorithm could identify one or more primary provider for 38% of the encounters.

We further compared the primary specialty and employment status of the algorithm-imputed providers with the patient-reported PCPs. As shown in Figure 2, the top 5 specialties for imputed providers aligned with patient-reported PCPs. Dentist, resident and emergency medicine did not have or had very low representation in imputed providers. Figure 3 shows that the imputed providers were more likely to be Intermountain employed. This can attributed to the input dataset used by the algorithm.

Imputation Results from External Data

Considering the limitations of Intermountain-only encounter data, we conducted a preliminary analysis on a subset of patients (2,600) who had an inpatient stay at one of the Intermountain facilities between June 2015 and February 2016 and did not specify a PCP at registration. We queried the state HIE database to extract all clinical messages that indicated a patient-provider encounter. Results showed that 71% of the patients can be matched in the HIE dataset. A total number of 26,888 messages were received from 37 healthcare organizations on 693 (27%) patients. The distribution of message types is illustrated by Figure 4.

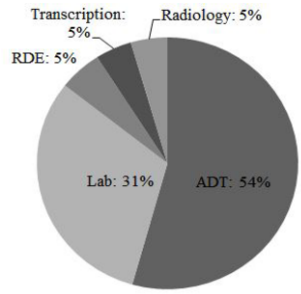

Figure 4 – Clinical messages received by the state HIE on sample patients

By applying the same imputation algorithm from Formula 1, we identified the primary provider for an additional 15% of the patients. As shown in Table 3, the completeness of the provider information contained in the PV1 segment of the HL7 messages was between 1% and 17%.

Table 3 – Completeness of Provider Information in Clinical Messages(HL7) Sent to State HIE

Provider Segment	Proportion of Patients with Provider Information
PCP	9%
Referring Provider	10%
Ordering Provider	17%
Prescribing Provider	1%

Discussion

Our study suggest that PCP information is not well-documented in EHRs. Only about half of the inpatient and emergency encounters have PCPs reported by the patient or family members. For certain types of encounters such as behavioral health inpatient stays, the completeness of PCP information can be as low as 24%. Missing, incomplete or outdated PCP information can become the bottleneck to effective physician communication and care coordination, especially during transition of care. Based on our analysis, the reasons for missing PCPs were multifaceted. There may not be sufficient time to collect the PCP information during registration. Some patients may only remember their PCP's last name or practice clinic.

For patients who reported a PCP during registration, it is not clear how reliable the PCP information is. As shown by our provider profile analysis on patient-reported PCPs, some patients declared an emergency doctor or dentist as their PCP. This may indicate that patients or family memebers do not understand what a PCP refers to. As part of the care coordination and outreach effort, Intermountain has been instructing designated staff to collect PCP information by visiting patient rooms at an inpatient facility if the PCP information was not documented during registration. We found that sometimes the hospital staff needs to ask the question in several different ways to explain what a PCP is. For example:

Which doctor do you usually see for your annual visit?

Who ordered your medications?

Who do you want us to send your discharge information and lab results to after you go home?

Our imputation analysis demonstrates a promising approach to infer a patient's primary provider based on encounter history. This will greatly benefit patients discharged from hospitals or emergency departments whose PCP was not captured during registration. The imputation results only showed 38% consistency with patient-declared PCP. There are several reasons for this: 1) Patient-reported PCPs are not the gold standard. It only reflects patients' perceptions, which may not be reliable as indicated by various findings in ths study. In other words, the algorithm-derived primary providers may be more accurate since they are based on the actual patient-provider interactions; 2) The performance of the imputation algorithm depends on the comprehensiveness of the patient-provider encounter dataset as input. We only used enterprise wide encounter data for the first part of the analysis to infer the primary providers for 62% of the patients. As we extended the input to include state wide data, it increased the proportion by 15%.

Our study also suggests that the lack of a statewide or national provider directory is a limitation preventing both PCP information collection from patients and PCP imputation by the algorithm. A complete and up-to-date provider directory will facilitate provider lookup when the patient could not remember his/her PCP's full name, especially when the provider is outside of the health system. Most healthcare orgnizations maintain their own provider directory, which normally has up-to-date information for internally employed providers. However, as the adoption of interoperable health information technology such as Direct messaging [13] increases, the need to maintain providers from external organizations and their communication preferences grows. Currently, many hospital units maintain a separate list of commonly interacted providers (e.g. referral doctors) with phone number, address and fax number in a spreadsheet file. Some healthcare organizations exchange provider list that contains Direct email addresses with their partner organizations on a regular base. A formal provider directory management infrastructure could help to overcome the duplicate and uncoordinated efforts required from individual organizations.

Limitations and Future Work

The major limitation of our study is the lack of external encounter data as input to the imputation algorithm to infer PCPs outside of Intermountain. Although we conducted a preliminary analysis using the state HIE clinical messages received from other healthcare providers, the missing values in the provider information segment of the HL7 messages limited the performance of the algorithm. In addition, for those HL7 messages with provider information, there is no unique provider identifier across organizations. Each organization used its own provider identifier and some HL7 messages only had provider's name without an identifier.

Nevertheless, our analysis demonstrated feasibility of using EHR data to infer a patient's PCP. It is important to note that algorithmic imputation should not overwrite patient's preferences. The purpose of the imputation algorithm is not to replace patient-reported PCPs but to serve as a complementary mechinism to support accurate PCP information collection. As future work, we plan to display the imputed primary provider(s) in the registration systems and patient portals to allow patients to confirm or modify the list and specify their information disclosure preferences. PCP is longitudinal information and should be maintained across encounters regardless of the care setting. We plan to test the algorithm with other healthcare organizations and design a community care team framework to allow organizations to share the imputed provider information through an ongoing statewide care coordination effort [14].

Conclusion

Effective and seamless communication with primary care physicians during the discharge period is pivotal to boosting patient safety and reducing the likelihood of avoidable readmissions. Our findings suggest that complete and reliable PCP information may not be available in EHRs and associated administrative systems. Lack of PCP information may hinder collaboration among physicians and delay timely follow-up. We demonstrated the feasibility of using historical encounter data that is easily accessible in any EHR to infer complementary provider information when a self-reported PCP is missing or invalid. Our methods can be generalized to any healthcare organization to improve the availability and accuracy of PCP information for care coordination purpose.

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