Physician Practice Variation in Electronic Health Record Documentation

by

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Dedicated to my father, Mark L. Cohen, whose experiences delivering healthcare inspired and continually enriched this dissertation. Thank you for always making my work your priority.

You're my big damn hero, sir.

"I'd trade the moon for the sun, but this feeling for no one."

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Go Blue.

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ABSTRACT

Adoption of electronic health records (EHRs) was motivated by the expectation that they would improve quality and decrease costs of care. EHRs' value, however, depends on how they are used, which likely explains the heterogeneous benefits observed in the literature. This dissertation uses mixed methods to explore a critical component of EHR use in primary care: variation in EHR documentation, defined as differences in how users record or remove information.

The first chapter delineates a conceptual framework of variation in EHR documentation that includes five different forms of variation and five levels where the forms may materialize. This chapter focuses on potentially harmful variation by detailing how non-patient factors foster variation that interferes with clinical decision support, care coordination, and population health management, jeopardizing the efficient delivery of high-quality healthcare.

The second chapter measures variation in one form of variation, completion of documentation, in a national sample of primary care practices. Using data from a major EHR vendor, this chapter finds differences in how variably providers complete fifteen different clinical documentation categories and identifies patient's problems, the provider's assessment and diagnosis, the social history, the review of systems, and communication about lab and test results as the most varied. The majority of variation exists across providers in the same practice,

suggesting providers are making different decisions about documentation for comparable patients.

The final chapter explores the context of this variation with semi-structured interviews, finding that variation in EHR documentation is perceived as a commonplace phenomenon resulting from a flexible EHR design that allows users to develop different documentation styles. Variation reportedly introduced inefficiencies into care delivery and created patient safety and care quality risks from missed or misinterpreted information. Respondents identified additional training, ongoing meetings, and improvements in EHR design as effective strategies to prevent harm.

Widespread variation in EHR documentation can interfere with care delivery by obscuring the location and meaning of patient information. In order to realize gains from adopting EHRs, practices, vendors, and policymakers must collaboratively develop better interfaces and clearer guidelines to support their effective use.

INTRODUCTION

Billions of public and private dollars are being invested to increase the adoption of electronic health records (EHRs) in the U.S. [1]. The investment is motivated by the expectation that moving to digital records will lead to higher-quality, lower-cost care [2, 3]. However, EHRs are only tools that support care delivery—they do not directly alter states of disease or health. As such, the potential gains from EHRs depend on how they are used. While federally-defined meaningful use criteria [1] and proposed Advancing Care Information measures under the Medicare Access and CHIP Reauthorization Act of 2015 (MACRA) [4] specify some key ways in which EHRs should be used, the criteria give providers substantial latitude to decide how to document and manage care in their EHR. These decisions undoubtedly impact the extent to which EHRs enable, or impede, improvements in care delivery.

Practice- and individual-level decisions about how to capture data within EHRs impacts the ability of EHR data to support key activities that will result in performance gains like care coordination and population health management. Although users need flexibility to adapt EHR use to different patient health needs, variation in EHR documentation could result in a disorganized record and encumber the delivery of efficient and high-quality care. Documentation is an essential building block of effective EHR use; if information is captured inaccurately or inconsistently, all future uses of the information (i.e., retrieval, review, and analysis) are

compromised [5]. Yet, there is limited prior research that examines this phenomenon to create a comprehensive picture of how documentation can vary in an EHR, what causes such variation, when and how such variation may be harmful, and what strategies may help mitigate these risks.

My dissertation uses mixed methods to help fill this gap in our understanding of variation in EHR documentation. I define variation in EHR documentation as differences in the content, structure, or location of comparable information in the EHR ("clinical documentation categories") that result from differences in how users record or remove that information. In order to focus on potentially harmful variation in EHR documentation, I further define variation in documentation as any differences in documentation that are not wholly driven by patient factors. Finally, the term "users" refers to any individual who completes documentation in the EHR, including independent health care providers such as doctors and nurse practitioners, clinical support staff such as nurses and medical assistants, and administrative staff such as office managers and clinic directors. However, much of my dissertation focuses on actions taken by providers because they complete the majority of documentation [6] and are ultimately responsible for documenting the care that was delivered to the patient.

Specifically, the first chapter of my dissertation introduces a conceptual model of variation in EHR documentation to frame this understudied phenomenon. It identifies the five forms of variation (e.g., variation in who completes documentation, variation in what information is documented in the EHR) as well as five levels of variation (e.g., variation across an individual's encounters, variation across practices that belong to the same overarching umbrella organization). This chapter also draws on a broad body of literature in health services research, information studies, organization studies, and implementation science to outline the types of drivers not wholly related to patient health that might cause variation in EHR

documentation, as well as how this variation in EHR documentation might interfere with three key activities that contribute to EHR value realization: the use of clinical decision support, care coordination, and population health management to improve healthcare delivery.

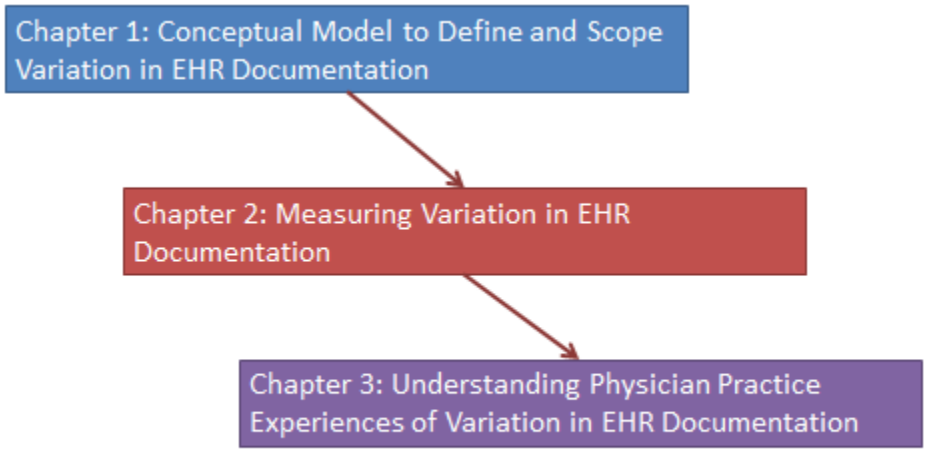
The second chapter of my dissertation focuses on measuring the prevalence of one form of variation identified in my conceptual framework: variation in *what* information is documented in an EHR. Using a dataset provided by a commercial EHR vendor, this chapter finds differences in how variably providers complete fifteen different clinical documentation categories and identifies that five clinical documentation categories in a national sample of primary care practices can be classified as "High Variation": (1) documentation of the patient's problems; (2) the social history; (3) the review of systems; (4) the provider's assessment and diagnosis; and (5) communication about lab and test results. Differences in the amount of variation observed across clinical documentation categories suggest that some of the identified variation may be driven by provider decisions about documentation, and not patient need. Furthermore, the critical nature of the High Variation clinical documentation categories suggests that some of the identified variation may be potentially harmful. Multilevel modeling demonstrates that the majority of variation in these clinical documentation categories exists across providers within a practice, and not across practices, umbrella provider organizations, or states. Because variation at this level is not likely driven by patient factors, it further suggests that the variation may be potentially harmful.

The third chapter of my dissertation builds on this work to explore the five High Variation clinical documentation categories in greater depth. Semi-structured interviews with 40 primary care providers and clinical and office staff in southern Michigan focused on variation not wholly driven by patient health needs, and revealed that variation in EHR documentation

across users within a practice was perceived as a commonplace phenomenon that resulted from different user preferences as well as EHR design. This study found that most forms of variation created inefficiencies in documentation, either due to users documenting some information in multiple places or due to users conducting prolonged searches for information. Respondents further believed that variation in documentation created patient safety and quality risks from missing or misinterpreting information, particularly regarding documentation of patient problems and provider's assessments and diagnoses. This chapter concludes that additional training, ongoing meetings, and improvements in EHR design may be useful strategies to prevent potentially harmful variation.

Taken together, this sequential, explanatory, mixed-methods dissertation creates a multi-faceted picture of the causes, manifestations, and effects of potentially harmful variation in EHR documentation to help primary care practices, EHR vendors, and policymakers better leverage EHRs in ways that improve care delivery (See Figure 1).

Figure 1: Three Studies of Variation in EHR Documentation



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CHAPTER ONE: A CONCEPTUAL FRAMEWORK TO GUIDE UNDERSTANDING OF VARIATION IN EHR DOCUMENTATION

Introduction

With widespread adoption of electronic health records (EHRs), scholars are beginning to understand differences in EHR use in clinical practice, and the implications of those differences [1, 2]. The documentation of care delivery, or providers', clinical support staff, and administrative staff's entry and removal of information in the EHR, is a critical component of use. Documentation can vary greatly because of the opportunities users have to differently record or remove information in the EHR, both within and across practice settings, even among those using the same EHR product [3-6]. This variation exists because EHRs offer many options for how to approach documentation; as a result, care for even an identical patient may be documented in different ways [1, 2]. Empirical evidence on such variation is beginning to emerge. A study of 18 sites within a New York Federally Qualified Health Center network found high variation in EHR documentation across 112 physicians, all using the Epic platform: the annual average proportion of encounters in which problem lists were updated ranged from 5% to 60% per physician [2]. At Intermountain Healthcare, a study of EHR use revealed high variation in the extent to which their 4,127 physicians completed seven categories of EHR documentation,

ranging from 75% of physicians documenting notes/medications to 11% documenting problems/allergies [1].

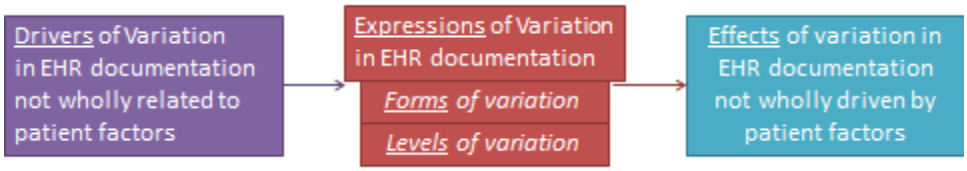
Better understanding variation in EHR documentation is critical because it can have dramatic consequences for EHRs' support of better individual and population-level outcomes. To illustrate, one choice providers face when completing documentation is whether to use structured fields, such as drop-down menus or radio boxes, or unstructured fields, such as comment boxes [7]. Numerous articles have identified tradeoffs between the analytic value of structured documentation and the expressivity of dictation [8-11], the former of which is a target of substantial financial incentives through the federal Meaningful Use program [12] and proposed Advancing Care Information measures under the Medicare Access and CHIP Reauthorization Act of 2015 (MACRA) [13]. If a provider typically uses drop-down menus to document patient problems but switches to free-text fields on a busy day because it is quicker in-the-moment, that variation produces a record that is more difficult to use effectively. When that provider or others in the practice attempt to find the patient's problems, they may fail to find the correct information or have to spend extra time locating it because it is not stored in a consistent and predictable format, encumbering the delivery of efficient and high-quality care [14, 15].

These examples reflect situations in which physician preferences drive variation. This raises the important distinction between variation in EHR documentation wholly driven by patient factors ("patient factors") and those driven, at least in part, by factors beyond the patient. In an ideal world, patient factors alone would drive the variation in documentation outlined above. For example, it is likely desirable for there to be variation in documentation of patient vitals based on patient conditions (e.g., documenting HbA1c for patients with diabetes but not for healthy patients). However, it is potentially problematic if other factors, such as users' daily

schedule or computer literacy, drive the decision about whether or not to document vitals because it could impede the quality and efficiency of care. As described above, if it takes providers or other practice staff extra time to search for information, this results in avoidable inefficiencies. If providers or other practice staff see a subset of correct information (i.e., they only see information in the structured fields and not in free-text fields), this could have implications for the quality and safety of clinical decisions.

While there is a small empirical literature base that documents instances of variation in EHR documentation [2, 16-18], there is no literature that systematically maps the different expressions of variation, and then identifies the drivers of variation that do not wholly stem from patient factors. It is also important to begin to understand the ways in which variation in EHR documentation not wholly driven by patient factors could impede the delivery of high-quality care. To address this gap, I develop a conceptual framework that identifies the different possible *expressions* of variation in EHR documentation, including both the *forms* that variation may take and the *levels* at which it may materialize. I then hypothesize about key upstream *drivers* of variation not wholly driven by patient factors and key downstream *effects*, focusing on the consequences for key care processes and associated outcomes. Figure 2 displays the temporal relationship between these three components:

Figure 2: General Framework of Variation in EHR Documentation



I focus on the primary care context because documentation of core clinical data in this setting creates an overall picture of patient health status that lays the foundation for encounters in other settings. This framework will help create a common understanding of this critically important but understudied dimension of EHR use. Defining key ideas related to variation in EHR documentation and mapping their relationships will also help identify high-impact areas of future research.

Approach

To develop this framework, I first sought to separate the expressions of variation in EHR documentation (forms and levels) into their mutually exclusive and collectively exhaustive components. I drew on the example of a primary care provider collecting and documenting a patient's smoking history. Because of the limited treatment of variation in prior research, it was not possible to conduct a systematic review to identify upstream drivers and downstream effects of variation in EHR documentation not wholly driven by patient factors. Instead, I drew on a related body of literature, geographic variation in the provision of care, to identify factors that might similarly cause providers to make different decisions when faced with the care, and in this case documentation of care, of a seemingly-identical patient [19]. In order to more accurately apply these factors to the topic of EHR documentation, I incorporated additional literature from health services research, organization studies, information studies, and implementation science when possible.

Definitions and Scope

I define variation in EHR documentation as differences in the content, structure, or location of comparable information in the EHR that result from differences in how users record or remove that information. The term "users" refers to any individual who completes documentation in the EHR, including health care providers such as doctors and nurse practitioners, clinical support staff such as nurses and medical assistants, and administrative staff such as office managers and clinic directors. In order to focus on potentially harmful variation in EHR documentation, I further define variation in documentation as any differences in documentation that are not wholly driven by patient factors.

I present examples of variation in EHR documentation that relate to delivering primary care to an individual patient. This paper does not examine variation in retrieving or reviewing information [4, 20-22] because of the foundational nature of documentation: if information is captured inaccurately or inconsistently, all future uses of the information are compromised [3-6]. Second, the examples assume that users are completing all documentation in the EHR, excluding scenarios when practices employ a combination of electronic and paper-based documentation. Third, the examples assume that all EHRs have the functionalities of a basic EHR, including computerized prescription order entry, laboratory and imaging results, and the ability to record clinical notes, structured patient demographics, medications, allergies, and problem lists [23], although these functionalities may not all be active in a given implementation [e.g., 24, 25].

Illustrative Example: Smoking History

A core component of primary care includes preventive care and health maintenance [26], such as smoking cessation interventions. Guidelines call for primary care providers to collect their

patients' smoking status at every visit and advise smokers on how to quit [27, 28]. In the context of a primary care visit, patients are likely to be asked about their smoking history as part of a broader conversation about their social history. This information, along with any resultant advice about smoking cessation, then needs to be documented in the EHR, creating the opportunity for variation in each form outlined below.

Expressions of Variation in EHR Documentation

Forms of Variation in EHR Documentation

When documenting an encounter with an individual patient in the primary care setting, there are five key forms in which EHR documentation might materialize. The forms are: (1) how users document information in the EHR; (2) what users document in the EHR; (3) where in the EHR users complete documentation; (4) who completes EHR documentation; and (5) when users complete EHR documentation.

What: A user must decide how much information to record in the EHR. If a patient reports smoking during a visit, a user could choose to record their status as a smoker, details of how often and how much they smoke, or could choose not to record this information.

Where: There are multiple areas in an EHR where information about smoking would be relevant, such as in the social history, in the problem list, or in a designated smoking tab. Depending on the structure of the EHR, the information in these different areas may be isolated, producing variation even if information is documented in the same way (e.g., structured vs. unstructured).

How: A user could vary in the method and format they use to complete documentation. In the case of a patient's smoking history, a user could use choose to enter structured information about smoking (e.g., units smoked per day) or could choose to enter information about smoking as narrative text (e.g., "patient smokes at lunch").

Who: Either a billing provider (e.g., physician, nurse practitioner) or clinical support staff (e.g., medical assistant) could collect and record information about the patient's smoking status in the EHR. This type of variation is common because patients typically interact with multiple clinical and administrative staff during their visit, creating the opportunity for variation in who completes EHR documentation. Variation in who completes documentation is particularly likely as care models begin to emphasize team-based care [29-31] and when scribes are used [32-35], changing the burden of documentation for different types of providers and staff.

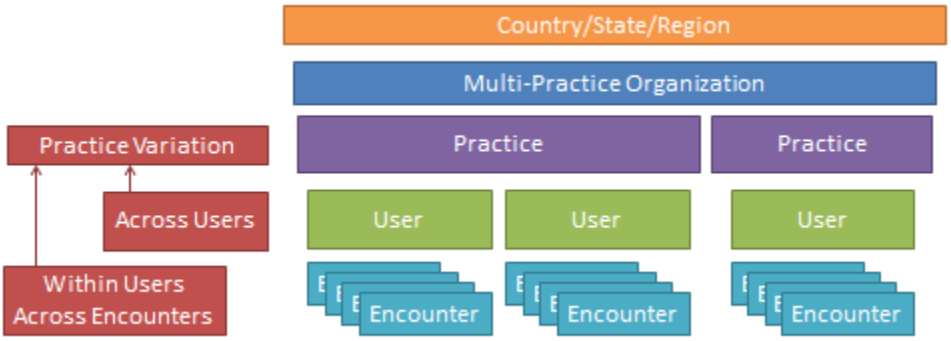
When: Information about a patient's smoking status could be documented before, during, or after the patient's visit. It could be collected during intake and recorded prior to the physician's exam, or could be collected by the physician during the exam and recorded immediately or sometime later in the day, as there is no standard workflow for information collection during primary care visits [36].

While some types of variation outlined above may be implausible for certain information (e.g., orders are typically entered by a provider, constraining variation in who completes documentation), it is clear EHR users have discretion along a number of dimensions when completing documentation.

Levels at Which EHR Documentation Might Vary

Each form of variation in EHR documentation can occur at multiple levels due to the nesting of patient encounters within providers within practices within multi-practice organizations within regions (see Figure 3).

Figure 3: Levels of Variation in EHR Documentation



First, a provider may vary in how s/he documents information across their encounters, producing variation within her- or himself: a provider could record smoking history for only a subset of their patients if they selectively chose to skip documentation for patients who were not active smokers. Second, providers may have little variation across their encounters but vary from each other, creating variation across individuals within practices: one provider could record all of his or her patient's smoking history while a colleague only records when a patient is an active smoker. Third, practices may have little variation within or across providers, but exhibit variation in documentation patterns compared to other practices: one practice could more strongly emphasize documenting smoking history than another practice, resulting in little variation within practices but significant variation across practices. Finally, a comparable pattern could exist when comparing documentation patterns across practices within counties, across counties within states, and across states within regions due to insurer requirements or local policies.

Drivers of Variation in EHR Documentation

Many potential factors beyond those related to the patient could drive documentation decisions along any of the five forms of variation. While providers and other EHR users must ultimately determine what falls under the definition of a "patient factor," I help frame this discussion by identifying categories of drivers that are either wholly or partially distinct from patient factors. These categories are experiential, user, practice, or environmental characteristics, and within each, I give an example as well as report the level on which the variation would be observed. (Table 1)

Table 1: Categories of Drivers of Variation in EHR Documentation

Category of Driver	Examples of Specific Drivers	Level on which Variation is Observed
Experiential Characteristics	Learning different ways to document information via experimentation	Across Encounters
	Time Pressures	
	Patient-Provider Interactions	
Individual Characteristics	Clinical Training and Role	Across Users
	Diagnostic Style	
	Perceived Malpractice Risk	
	Computer Savviness	
Practice Characteristics	EHR System and Implementation	Across Practices
	Ownership Status	
	Financial Arrangements	
	Social Influences	
	Resource Dependencies	
Environmental Characteristics	Service Availability	Across Practices
	Laws	

Drivers of Variation Across Encounters

Experiential characteristics could drive variation within users across encounters. This reflects the general finding that any intervention is likely to evolve over the implementation process [37]. Likewise, EHR use is likely to vary as users *learn* how to use the system. For example, a user may begin to use a template for the patient's review of systems rather than a free-text note after discovering the capability a week into using a new EHR. This would introduce variation within individuals across encounters over time in how or where information is documented, particularly during an initial implementation period.

Second, time pressures could affect documentation decisions, as the time-consuming nature of EHR documentation is a source of user-dissatisfaction [38, 39]. The amount of time available to complete documentation could produce variation within users in a practice in how or what they document, such that on a busier day users may document a lower volume of information or may make quick free-text notes rather than searching for the appropriate structured option. This driver could also lead to variation in who completes documentation, if a busier provider delegates documentation to another member of practice staff, or when documentation is completed, if there is a backlog of records to complete.

Third, the interaction between patients and EHR users could cause variation within users over time in when they complete documentation if certain patients are uncomfortable with computer use during the exam. Challenges communicating with certain patients could also take time during the visit, leaving less opportunity for documentation and creating variation in what is documented within individuals across encounters. While this category of driver includes patient factors, these factors are not wholly clinical.

Drivers of Variation across Users

At the next level of variation, user characteristics could drive differences in documentation across users in a practice. First, a robust literature demonstrates that medical school, internship, residency and fellowship affect provider treatment patterns, [19, 40] and these factors may similarly affect documentation patterns. Clinical training and role would likely suppress variation within users over time and could drive variation across individuals with different backgrounds and orientations. For example, providers may become accustomed to certain templates during their training and structure their documentation in accordance with this design throughout their career, leading to variation in how or where information is documented. In a cross-sectional study of outpatient physician visit notes at a single institution, providers exhibited different reliance on templates, free-text and dictation according to specialty [41]. This is also consistent with the literature on technological frames, which notes that individuals within organizations often view the nature and value of technology differently based on their role [42].

Second, differing abilities to diagnose may cause providers to recommend different treatment [19]. Likewise, providers differing abilities to diagnose could lead providers to document care differently, believing different details to be important and worth recording, leading to variation in what is documented. This would drive variation in what information is documented across individuals.

Third, a users' perceived malpractice risk affects service provision by encouraging providers to order additional tests and services (defensive medicine) [19]. There could be an analogous practice, defensive documentation, which causes variation in documentation volume and quality. This would likely suppress variation in documentation within users over time, and

could drive variation across users if they have different perceptions of malpractice risks or consequences. For example, users who perceive a lower risk of malpractice may delegate more documentation to clinical assistants rather than completing it themselves, leading to variation in who completes documentation.

Fourth, just as users' comfort with technology affects their satisfaction with EHRs post-implementation [43], computer savviness may also affect the way individuals use the EHR once it has been implemented. Quick typists could be prone to to select free-text documentation where other users who struggle with typing may prefer more point-and-click documentation, causing variation in how documentation is completed. Quick typists may also choose to document during the patient visit, where slower typists may need time at the end of the day to complete documentation, causing variation in when documentation is completed.

Drivers of Variation across Practices and Organizations

At the next level of variation, characteristics of the practice (i.e., office) could drive differences in documentation in a community. First, differences in practices' EHR systems and implementation could drive differences in documentation based on the unique capabilities and constraints of different EHR interfaces. There are a number of EHR vendors whose design features such as data entry forms and templates, information displays, prompts, and hard stops (i.e., when users cannot proceed with the desired action) guide documentation of different types of information [44, 45]. Furthermore, practices and their parent organizations often customize these features, increasing the differences between products. Designating certain fields as mandatory (e.g., a hard stop) would minimize variation across users in that practice, but could

lead to variation across practices. Analysis of an intervention at an academic medical center identified the dramatic influence information display can have clinical behavior [46], which would likely extend to documentation behavior and cause variation in how information is documented, what information is documented, and where information is documented.

Second, differing ownership status of primary care practices could also drive differences in documentation. Whether an organization is for-profit, not-for-profit, or government-operated status affects service provision when for-profit organizations focus more on profitability [19]. This practice characteristic would likely suppress variation in documentation within and across users by fostering shared expectations regarding the types of information that are important to record for billing purposes, and could lead to variation across practices in what information is documented.

Third, different financial incentives drive providers to deliver certain services over others [19], and may likewise drive documentation of services once provided. Because these relationships largely vary at the practice- and organization-level, they are only likely to produce variation across practices or at higher levels of aggregation (e.g., organization, county, state, or region). For example, a practice may be more likely to encourage documentation of the results of a patient's smoking history if their practice is participating in a pay-for-performance program that distributes rewards based on the percent of active smokers receiving smoking cessation counseling, leading to variation in what is documented across practices. Payment method may also affect documentation, although the relative effect is less clear. While physicians tend to provide more services when they are paid using fee-for-service, it could be that capitated providers document more because they have longer visits, or it could be that providers paid

under a fee-for-service system document more information because it allows them to bill for more services.

Fourth, social influences such as peer pressure and mimicry are two mechanisms that can create consistency within, and variation across, groups [47]. Organizational norms about the best way to document complex conditions or whether it is appropriate to bring a computer tablet into the exam room could suppress variation in documentation within and foster variation across physician practices in when documentation is completed. Culture may contribute to the significance of this effect; a group culture that emphasizes cohesiveness and participation or a hierarchical culture that privileges stability may minimize variation in EHR use across individuals within an organization. In contrast, a developmental or rational culture may foster variation across individuals within an organization by privileging innovation or competitive advantage [48]. Organizational climate has similarly proven to predict the effectiveness of newly implemented technology, including how much it is used [49].

Fifth, the presence of different relationships between practices might drive users to document information differently based on their referral network just as resource dependencies drive variation in healthcare service provision by introducing different incentives to different organizations [50]. For example, providers in a practice that use their EHR to access a hospital's records might document care differently than a provider in a practice without such ties based on different perceptions of what information would be valuable for subsequent EHR users, leading to variation in what information is documented in EHRs across organizations.

Drivers of Variation across Counties, States, and Regions

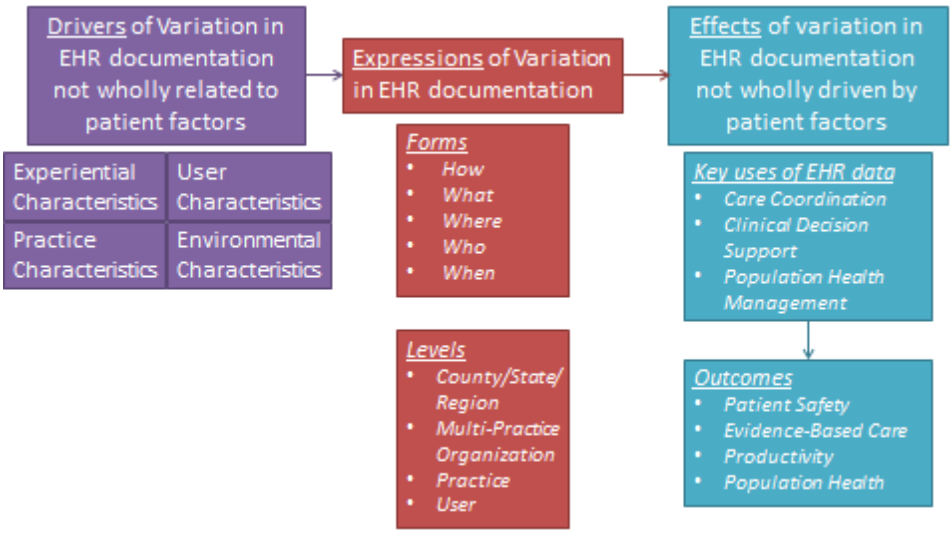
The factors that are likely to influence documentation patterns at higher levels of aggregation are rarer, and relate to environmental characteristics. First, service availability, such as the presence of different specialists, local emergency response, and other types of providers in the market would likely foster shared expectations regarding what different types of information would be valuable for referrals, which in turn could create variation in what is documented across counties. Second, laws could influence documentation practices by creating geographic pressures for certain types of documentation. For example, state regulations of nurse staffing ratios could affect which types of users are likely to complete documentation, creating variation in who completes documentation across different states. Disease reporting requirements, which could be created by state or county health departments, could also affect variation in documentation by creating different pressures to document information at those levels, leading to variation in what is documented. Third, disease-specific registries could foster documentation of particular information, creating variation in what information is documented across different states or regions.

Effects of Variation in EHR Documentation

As shown in Figure 4, variation in EHR documentation that is not wholly due to patient factors can have far-reaching implications because it compromises all future uses of EHR data. However, there are three key domains in which variation in EHR documentation that is not wholly due to patient factors is most likely to be detrimental: (1) care coordination; (2) clinical

decision support (CDS); and (3) population health management. In turn, this compromises the safety, quality, and efficiency of patient care.

Figure 4: Detailed Framework of Variation in EHR Documentation



Variation in documentation not wholly due to patient factors may impede care coordination by making it difficult for physicians and practice staff to find and interpret needed information. For example, if there is variation in how often users document the end-date for a medication in the medication list, future users seeking that information will not know how to interpret a medication that is typically prescribed for a limited course of treatment. Similarly, if users vary in the information they document on the problem list, subsequent users will not know how to evaluate available information. Participants in a recent qualitative study reported that care coordination was undermined in a pediatric practice when one physician documented both chronic and acute problems on the problem list, while her peer documented only chronic problems. When the former saw a child with an ear infection, she interpreted the lack of evidence of prior ear infections in the EHR as indicating no history when, in fact, the child had previously

been seen by the second physician who did not consider ear infections to be a chronic condition [51]. These issues are magnified in the increasing number of practices in which multiple physicians and other clinical staff care for the same patient [29, 30]. When physicians are not aware of the scope of their patients' conditions, medications, or other treatment plans, this leads to adverse events, failure to deliver evidence-based care, and avoidable visits and hospitalizations [52-54]. If providers document problems in varied locations in the record, subsequent users seeking this information must search all possible locations, hampering efficiency by increasing the time spent retrieving information in visits which are already time-pressured [e.g., 55, 56].

Second, variation in documentation may impede clinical decision support (CDS). CDS systems are designed to aid providers' decision-making during the patient visit through identification of errors, such as interactions between drugs and conditions, as well as through identification of opportunities to provide additional evidence-based care, such as overdue preventive services [57, 58]. CDS algorithms rely on complete information entered in a structured format [59]. Variation in what information is documented, when it is documented, and how it is documented, would create an insufficient and unreliable information base for these reminders or alerts. CDS would thus fail to identify harmful interactions or opportunities for evidence-based care during a patient visit [60]. For example, if one provider in a practice documents short-term medications but her or his partner does not, the *absence* of an alert may create a false sense of security when the former provider writes a prescription for the latter provider's patient.

Finally, variation in EHR documentation may impede population health management, an essential component of new care delivery models like Patient-Centered Medical Homes and

Accountable Care Organizations [61, 62]. Like CDS, variation in what is documented or how it is documented may interfere with generating reports that capture accurate population-level snapshots of patients' health needs outside of the context of a patient visit [57, 58]. Reports are essential for identifying opportunities for performance improvement across panels of patients, such as generating lists of patients with overdue colonoscopies or identifying all diabetic patients to notify them about an upcoming group visit [63, 64]. Electronic reports can also provide important efficiency gains to practices, relative to paper tickler files.

Discussion

This paper identifies different expressions of variation in EHR documentation across multiple levels in the US healthcare system. Variation in EHR documentation can materialize in five different forms (what, where, how, when, and who) at multiple levels (across encounters, across users, across practices, and across regions). While documentation of patient information must vary to reflect patients' different clinical needs, there are additional factors that can drive variation in EHR documentation, spanning experiential, user, practice, and environmental factors. Variation in EHR documentation which is not wholly driven by patient factors has the potential to interfere with high-quality and efficient healthcare delivery through its effects on care coordination, CDS, and population health management.

Several studies have begun to address variation in EHR documentation, but have defined the phenomenon narrowly, looking most often at volume of documentation. Understanding the amount of documentation is valuable, but limited [44, 45]. For example, a qualitative study of six physician practices using the same EHR conceptualized standardized use of EHRs as uniformly

high use of at least two specific EHR functions across all users within a practice. In this framing of standardization as high use, there is no distinction between users who consistently perform a limited number of tasks and those who inconsistently perform a broader set of tasks [17]. These styles of practice may have different implications as users search for information in the EHR and try to make sense of what they find, creating predictability on the one hand and potential confusion on the other.

Future research should investigate both the prevalence of variation in EHR documentation and its relationship with care coordination, CDS, and population health management to better characterize expressions of variation as appropriate or inappropriate. For example, there may be areas of documentation where variation not wholly driven by patient factors is benign, either because it does not feed into automated reports or because it is rarely used for ongoing care management. Further exploring the relationship between different drivers of variation would also be valuable to identify influential factors that either magnify or suppress other drivers, both within and across levels. For example, it is unclear if a practice's ownership status would exert more influence in suppressing variation across users than differences in clinical training and role would exert in driving variation across users.

At present, there are limitations to studying these issues using existing national data sources that characterize EHR adoption. These surveys focus on the availability of specific functionality, overlooking the difference between software deployment and providers' effective use [e.g., 65, 66]. Furthermore, these surveys use individuals to represent their practice as a whole [e.g., 67, 68]. Conclusions about individual-level trends likewise draw from surveys of disaggregated physicians who are not linked to their practice in the data [e.g,. 66, 69]. These sampling methods fail to capture important variation within organizations [47]. There are a

number of different ways to address these limitations. First, chart auditing and other secondary analysis of recorded EHR data should take a more comprehensive view of variation to understand which forms are more or less common. Second, surveys should explicitly include questions about variation to better measure perceptions of prevalence and the potential drivers and effects. Surveys that have the ability to sample multiple individuals in an organization should further include measures of organizational affiliation to facilitate comparison of EHR documentation patterns within organizations and empirically assess variation. Future researchers can also employ qualitative interview and observation methodologies to better develop an understanding of the mechanisms by which practices manage variation in EHR documentation, either by suppressing its prevalence or working to ameliorate its potentially deleterious effects. A robust research program would incorporate each of these methods, which reach different audiences with different depth. Ultimately, this research can guide policymakers, EHR vendors and healthcare organizations to reduce variation in EHR documentation not wholly driven by patient factors through training, staffing, or design.

Limitations

This conceptual framework introduces healthcare providers, EHR vendors, policymakers, and scholars to a novel and understudied topic: variation in documentation not wholly driven by patient factors. While it seeks to comprehensively describe different potential expressions of variation, it was not possible to catalog the drivers and effects of variation systematically because so few studies focus on this topic directly and so many studies have the potential to reference it peripherally. As a result, some relevant elements were likely excluded, and this

should not be considered an exhaustive list of all potential factors relevant to the broader domain of variation in EHR documentation.

Conclusion

This article proposes a framework for understanding variation in EHR documentation in primary care practices, an understudied but important topic. This article maps the relationship between factors that drive variation in EHR documentation outside of clinical patient factors and the different forms and levels at which variation in EHR documentation may manifest. It also identifies how variation in EHR documentation may jeopardize care coordination, clinical decision support, and population health management, and therefore interfere with the quality, safety, and efficiency of healthcare delivery. In doing so, this article establishes an agenda for future research to improve EHR use in primary care.

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CHAPTER TWO: MEASURING VARIATION IN EHR DOCUMENTATION ACROSS PRIMARY CARE PROVIDERS

Introduction

Substantial public and private funding has been invested to increase the adoption of electronic health records (EHRs) in the U.S. healthcare delivery system [1], motivated by the expectation that use of EHRs will lead to higher-quality, lower-cost care [2, 3]. EHRs do not, however, directly alter states of disease or health [4]. Their value depends on how they are used, and EHRs typically offer substantial flexibility in how to use them. This means that little documentation is forced, and users often have multiple choices for how to document the same type of information. While federally-defined meaningful use criteria and proposed Advancing Care Information measures under the Medicare Access and CHIP Reauthorization Act of 2015 (MACRA) specify some key ways in which EHRs should be used [1, 5], the criteria give physicians, and the organizations in which they work, substantial latitude in how they document in their EHR. The subsequent decisions about documentation undoubtedly impact the extent to which EHRs enable (or impede) improvements in healthcare delivery.

One key dimension of the quality of documentation in the EHR is variation, defined as differences in the content, structure, or location of comparable information in the EHR ("clinical documentation categories") that result from differences in how users (providers, clinical support

staff, or administrative staff) record or remove that information [6]. Even for basic information, such as drug allergies and smoking status, studies from individual provider organizations reveal substantial variation in what documentation physicians complete in their EHR [7-9]. For example, an audit of EHR use at Intermountain Healthcare found significant variation in the extent to which their 4,127 physicians completed seven categories of EHR documentation in outpatient settings, ranging from 75% of physicians who documented notes and/or medications to 11% who documented problems and/or allergies [10]. A study of 18 sites within a New York federally-qualified health center network examined variation in EHR documentation across 112 physicians, all using the Epic EHR platform. Physician-level variation was high; for example, the annual average proportion of encounters in which the problem list field was updated ranged from 5% to 60% across physicians [11].

When there is little variation in how information is documented in the EHR, it is easier for users to find and act on relevant details of the patient's history. It also allows for tools that are designed to automatically extract information from the patient chart, such as clinical decision support functionality that alerts users to best practice management of medical conditions as well as reports to manage patient populations. Indeed, providers seem increasingly cognizant of the adverse consequences of variation in EHR documentation [12-14]. For example, in a qualitative study of how EHRs are used to support care coordination, respondents noted significant challenges in understanding patient history that arose from physicians using different documentation practices for short-term acute health issues, such as ear infections [15]. Furthermore, a survey of providers at three healthcare organizations in Oregon found that user inconsistencies in recording information was the most severe barrier to accessing information in the EHR [14]. These issues are magnified by the increasing number of practices in which

multiple physicians and other clinical staff provide and document care for the same patient [16, 17].

Some variation in EHR documentation is likely "appropriate" if it is driven by factors that relate to patients' clinical needs, but variation is likely to be harmful if it is driven by "inappropriate" factors that are not wholly related to the patients' conditions. For example, variation within physicians across encounters is most likely to be appropriate since it should be primarily driven by patient characteristics: it may not be necessary to document a "History of Present Illness" for a healthy patient seeking routine preventive care, in contrast to a patient who is seeking treatment for an acute illness. Variation is also likely to be mostly appropriate across practices within geographic regions, and across regions. For example, variation in EHR documentation across practices within regions could reflect differences in payer mix and associated documentation requirements, and variation across regions could reflect different regulatory requirements. The remaining variation, variation across providers within practices, is therefore the most likely to be inappropriate, reflecting a lack of consensus about how best to document within an EHR [18]. It is therefore critical to home in on variation at this level, and examine the extent to which observed variation is likely driven by provider choice about how to document information, instead of patient factors. I utilize data from a national, commercial EHR vendor to answer the following research questions:

(1) Are there clinical documentation categories for which providers variably complete documentation?

(2) Does a substantial proportion of variation among providers exist within practices?

a. If a substantial portion of variation exists among providers within practices, is this provider-level variation an equally big contributor across clinical documentation categories, suggesting that factors other than provider choice drive variation?

My results help inform ongoing efforts to optimize EHR use, and leverage these tools to support improvements in the quality, safety, and efficiency of healthcare delivery.

Methods

Setting and Data

I obtained de-identified EHR log data from a commercial, web-based EHR vendor. The EHR architecture automatically captures and stores granular clickstream data, recording the different actions that users take when interacting with the EHR, such as documenting the patient's height, the patient's weight, and their blood pressure. These different actions can be grouped into one of 15 overarching clinical documentation categories, such as collecting the patient's vital signs (see Appendix Table 5). Every element of EHR documentation is also tied to a patient visit ("encounter") ID as well as a user ID, which is tied to user credentials in order to determine the user's role (e.g., provider, staff) and additional information like provider specialty. Importantly, the architecture also captures nested relationships, such that users can be linked to their particular practice, and the particular practice can be linked to a parent provider organization and geographic location.

The EHR dataset was limited to encounters that occurred during a single month (June 2012) within ambulatory primary care practices. The dataset included user-completed clinical documentation activities in the EHR for each encounter. Encounters were nested within providers, who were nested within practices, which were nested within provider organizations,

which were nested within states. The dataset did not include any information captured in the fields within the EHR (e.g., the data show that vitals were documented but not the specific values for those vitals). I therefore do not have any data on patient characteristics or clinical conditions. However, providers working in the same practice should have the same distribution of patient documentation needs across the month [19], such that a large degree of observed variation at this level likely reflects at least some "inappropriate" differences driven by factors such as provider preferences.

I restricted the sample to encounters assigned to providers in one of seven primary care specialties: family practice, pediatrics, internal medicine, obstetrics/gynecology, general practitioners, nurse practitioners and physician assistants [20]. There were four potential ways to identify a provider in the data: (1) presence of an EHR-generated provider ID; (2) a field where users indicate their clinical degree (e.g., MD, DO, NP); (3) a field where users indicate a provider role, in contrast to an administrative role; and (4) a field where users indicate a primary care specialty (e.g., family practice, pediatrics), in contrast to other specialties. To ensure any observed variation reflected differences between similar providers, I only classified users as primary care providers if they met all four of the above criteria (provider ID, clinical degree, provider role, and primary care specialty). To further ensure any observed variation reflected the behavior of active providers, and not sporadic users, I also restricted the sample to providers who were regularly using the system, defined as averaging at least 2 days per week with documentation of at least one patient encounter. Together, these restrictions resulted in eliminating 891 individuals who only met a subset of the criteria, such as an individual who had a primary care specialty but no provider ID. To help ensure any observed variation reflected the behavior of established providers, and not new users, I additionally restricted the sample to

physicians who had been using the EHR for at least 6 months, which resulted in eliminating 53 providers. I also eliminated 40 providers from practices with only one provider to capture variation across multiple providers in a practice. My final analytic sample included 170,332 encounters led by 809 providers nested in 237 practices, which were nested in 76 provider organizations in 27 U.S. states.

Measures and Analysis

Dependent Variables: Completion of Clinical Documentation

For each encounter, I created 15 binary indicators of whether or not each clinical documentation category was completed by anyone in the practice, including clinical support staff and administrative staff. That is, I did not require that the provider him or herself complete the documentation, but attributed the activities of anyone who may have completed documentation in the encounter to the provider. The majority of encounters had only one provider, and the encounters were therefore assigned to that provider; when there was more than one provider contributing to documentation of a given encounter, I assigned the encounter to the provider who completed documentation for the most clinical documentation categories. Finally, for each provider, I calculated the proportion of their encounters with completed documentation for each of the fifteen clinical documentation categories over the course of the month (i.e. fifteen outcome measures per provider). For example, if a provider recorded a patient's vital signs in 5 out of 20 encounters in the month, his or her proportion would be 0.25 for that measure. I chose to create these measures at a high level of aggregation (e.g., a provider is seen as documenting vitals if any vitals field is modified by anyone in the practice) because variation at a more granular level

(e.g., whether or not the patient's height is documented) is more likely to be driven by patient characteristics, which were not available to incorporate in my analyses.

Explanatory Variables: User Specialty and Organizational Affiliation

I utilized the EHR data to create a categorical variable for provider primary care specialty type (e.g., family practice, pediatrics, internal medicine, and obstetrics/gynecology). I also assigned provider, practice, provider organization and state identifiers to capture the nesting of providers within practices, practices within provider organizations, and provider organizations within states.

Analytic Approach

To answer my first research question about variation across providers, I sought to identify which clinical documentation categories exhibited the largest range in providers' frequency of completing documentation. I first calculated, for each provider, the proportion of encounters in which they completed documentation for each clinical documentation category (e.g., if a provider documented vitals in 9 of their 10 encounters, the proportion would be 90%). Then, for each clinical documentation category, I calculated the median and interquartile range of those proportions across all providers. This approach follows prior studies of variation in EHR documentation [10, 11]. To facilitate interpretation, I used a threshold of 50% to classify clinical documentation categories as low- or high-variation and low- or high-completion.

To answer my second research question about the proportion of variation occurring across providers in the same practices, in comparison to other levels of healthcare organization, I estimated a multilevel linear regression model for each of the clinical documentation categories I

classified as "high variation" in Stata [21]. The outcome variable in these models is the proportion of encounters for which a given clinical documentation category is completed for provider *i* nested in practice *j* nested in provider organization *k* nested in state *l*. The model includes a single fixed effect parameter that captures the provider's specialty (i.e., family practice, pediatrics, internal medicine, and obstetrics/gynecology) because I expect differences in the distribution of patients treated by each type of provider and therefore their EHR documentation. I also include state-, provider organization-, and practice- specific effects (random intercepts) to capture variation in documentation that is occurring at each of those levels. In other words, random intercepts respectively capture variation that is occurring across states, variation that is occurring across provider organizations, and variation that is occurring across practices. Finally, the variation across providers in the same practice that is not explained by specialty, practice, provider organization, or state is captured by the unexplained error term in the model.

To interpret the proportion of variation explained by the different levels of healthcare organization, I calculate the ratio of explained variation to total variation for each level of healthcare organization (state, provider organization, practice, and provider). I tested whether these ratios were statistically different from zero using bootstrapped standard errors (2000 iterations) because the theoretical distribution of the test statistic for this ratio is unknown. Furthermore, to counteract the problem of multiple comparisons, I applied the Bonferroni correction and set the threshold for statistical significance at 0.0125.

To answer my last research question about the extent to which provider-level variation contributes to variation across clinical documentation categories, I ran identical multi-level models for two representative Low-Variation clinical documentation categories (Interpreting

Incoming Clinical Data and Updating the Patient's Medication List) and compared the proportion of provider-level variation. If the proportion of provider-level variation was similar across all clinical documentation categories, it would suggest that the variation exists for reasons other than provider discretion. However, if the proportion of provider-level variation is larger in the subset of tasks that are High Variation, it would suggest that such variation is the result of different choices providers make, and is thus a stronger signal of harmful variation.

Results

The most common specialty in my sample of primary care providers was family medicine (69.1%), followed by internal medicine (18.1%). Providers had an average of 16.7 encounters per day and worked with one additional user, on average, to complete documentation for each encounter. The average practice had 12.6 providers and 13.9 additional users, including administrative and clinical support staff. Practices had been using the EHR for 51.4 months (4.3 years) on average (see Table 2).

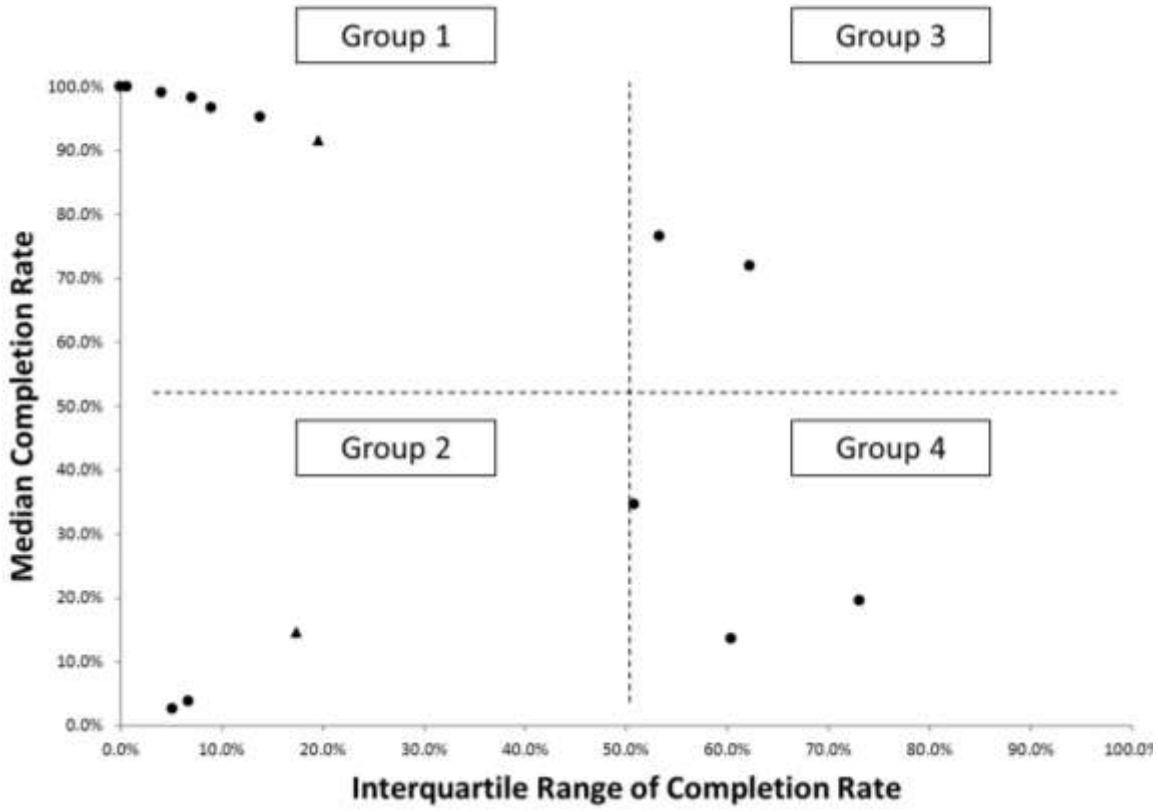
Table 2: Descriptive Characteristics of the Sample

Provider-Level Variables	Mean	Std.	Min	Max
Provider Age (years)	46.3	11.5	25	81
Provider Daily Encounter Volume	16.7	8.4	5	41
Number of Users Per Encounter*	2.2	0.5	1	4
Provider Specialty	Freq.	Percent	Cum.	
Family Medicine	559	69.1	69.1	
Internal Medicine	146	18.05	87.14	
OB/GYN	50	6.18	93.33	
Pediatric Medicine	54	6.67	100	
Practice-Level Variables	**Mean**	**Std.**	**Min**	**Max**
Number of Providers per Practice	12.6	15.9	2	65
Number of Other Users per Practice	13.9	10.1	0	45
Number of Total Users per Practice	26.3	22.7	2	89
Months on the EHR	51.4	44.4	6	213

* Number of users completing any documentation during each encounter, including the lead provider

When I calculated the IQR and median completion rate for each clinical documentation category, I found that seven categories were Low Variation and High Completion (Group 1); three categories were Low Variation and Low Completion (Group 2); two categories were High Variation and High Completion (Group 3); and three categories were High Variation and Low Completion (Group 4) (see Figure 5).

Figure 5: Groups of Clinical Documentation Categories



The IQR for the seven clinical documentation categories in Group 1 was between 0% and 19.5%; the median was between 91.5% and 100%. These clinical documentation categories were: Signing off and Closing the Encounter; Creating/Sending Orders; Collecting Vitals; Collecting the Clinical Encounter Reason; Conducting a Physical Exam; Collecting the History of Present Illness; and Updating the Patient's Medication List. The IQR for the three clinical documentation categories in Group 2 was between 5.2% and 17.3%; the median was between 2.6% and 14.6%. These clinical documentation categories were: Interpreting Incoming Clinical Data; Conducting a Procedure; and Updating Confidential Information (see Table 3)

The two clinical documentation categories in Group 3 were Updating the Patient's Social History (IQR 53.3%, median 76.1%) and Conducting a Review of Systems (IQR 62.3%, median 73.5%). The IQR for the three clinical documentation categories in Group 4 between 50.8% and

73.1%; the median was between 13.4% and 33.7%. The clinical documentation categories were: Reviewing and Discussing Documents; Updating the Patient's Problem List; and Assessing and Diagnosing the Patient (see Table 3)

Table 3: Provider Variation in Each Clinical Documentation Category

Clinical Documentation Category	Completion (Median Across Providers)	Interquartile Range (25%'ile-75%'ile)	Group
Sign-off/Close Encounter	100.0%	0.0% (100%-100%)	Low Variation, High Completion
Creating/Sending Out Orders	100.0%	0.7% (99.3%-100%)	Low Variation, High Completion
Collect Vitals	99.1%	4.1% (95.9%-100%)	Low Variation, High Completion
Collect Clinical Encounter Reason	98.2%	7.1% (92.9%-100%)	Low Variation, High Completion
Conduct Physical Exam	96.6%	9.0 (90.1%-99.1%)	Low Variation, High Completion
History of Present Illness	95.2%	13.8 (85.5%-99.3%)	Low Variation, High Completion
Medication List	91.5%	19.5% (77.9%-97.5%)	Low Variation, High Completion
Social History	76.1%	53.3% (39.5%-92.8%)	High Variation, High Completion
Conduct Review of Systems	73.5%	62.3% (32.9%-95.2%)	High Variation, High Completion
Problem List	33.7%	73.1% (3.5%-76.6%)	High Variation, Low Completion
Review/Discuss Documents	18.7%	50.8% (10.3%-61.2%)	High Variation, Low Completion
Assessment & Diagnosis	13.4%	60.4% (2.6%-62.9%)	High Variation, Low Completion
Interpret Incoming Clinical Data	14.6%	17.3% (8.1%-25.4%)	Low Variation, Low Completion
Conduct Procedure	3.7%	6.7% (1.8%-8.5%)	Low Variation, Low Completion
Confidential Information	2.6%	5.2% (1.1%-6.3%)	Low Variation, Low Completion

When I estimated multilevel models for the five High Variation clinical documentation categories (Groups 3 and 4) I did not find statistically significant variation at the state level (i.e., across states). I found statistically significant variation at the provider organization level (i.e., across provider organizations) for one clinical documentation category: Conducting a Review of Systems (15.6% of variation explained, p<.0125). I found statistically significant variation at the practice level (i.e., across practices) for all but one clinical documentation category (13.5%-19.0% of variation explained, p<.0125); the exception was Reviewing and Discussing Documents during the Visit (9.9% of variation explained, p=.08). Finally, I found that the majority of variation for every High Variation clinical documentation category was the variation across providers (which was the remaining variation not accounted for by variation across states, provider organizations, or practices). Documentation of Social History had the least variation at this level (62.2%, p<.001). Documentation of Reviewing and Discussing Documents during the patient's visit had the most variation at this level (78.1%, p<.001) (see Table 4).

Table 4: Variation Explained at Different Levels

Clinical Documentation Category	% Explained by State	% Explained by Provider Organization	% Explained by Practice	% Unexplained
Review/Discuss Documents	7.1%	5%	9.9%	78.1%**
	[0.03]	[0.04]	[0.06]	[0.04]
Assessment & Diagnosis	0%	8.3%	15.8%*	76%**
	[0.01]	[0.04]	[0.06]	[0.05]
Problem List	1.3%	9.7%	19%*	70.1%**
	[0.01]	[0.04]	[0.06]	[0.04]
Conduct Review of Systems	3.2%	15.6%*	13.5%*	67.7%**
	[0.03]	[0.05]	[0.05]	[0.04]
Social History	4%	17.8%**	16%*	62.2%**
	[0.02]	[0.04]	[0.05]	[0.03]
Interpret Incoming Clinical Documents[+]	2%	15.3%*	37.7%**	45%**
	[0.01]	[0.05]	[0.06]	[0.04]
Medication List[++]	7.7%	20.7%	27.8%	43.7%

	[0.15]	[0.15]	[0.15]	[0.46]

Bootstrapped standard errors appear in brackets. *p<.0125 **p<.001
+ Group 2 (Low Variation, Low Completion)
++ Group 1 (Low Variation, High Completion)

To answer my third research question, I compared the proportion of provider-level variation for the five High Variation clinical documentation categories to the proportion for one clinical documentation category in Group 1 (Updating the Patient's Medication List, represented as a triangle in Figure 5) and one clinical documentation category in Group 2 (Interpreting Incoming Clinical Data, represented as a triangle in Figure 5). I found that, unlike the High Variation clinical documentation categories, Updating the Patient's Medication List had no statistically significant explained variation across providers. While Interpreting Incoming Clinical Data had some statistically significant variation across providers, the proportion of explained variation at this level was at least 17 percentage points less than for the High Variation clinical documentation categories (45.0%, p<.001, see Table 4).

Discussion

Optimal EHR documentation requires balancing between the need for flexibility to accommodate differences across patients and a recognition that too much flexibility allows for inappropriate variation that compromises downstream uses of EHR data [22]. To date, there has been little exploration of the extent to which inappropriate variation may exist. While precisely identifying clinically inappropriate variation is exceedingly difficult and requires knowing detailed clinical information about each patient, I home in on inappropriate variation by focusing on the level on which it is most likely to be observed – across providers within practices. By using task-log data for 170,332 encounters led by 809 providers and accounting for variation at other levels (i.e., state, provider organization, and practice), I find that while there is consistency in how often

providers complete many clinical documentation categories across encounters, there is substantial variation in how often providers complete documentation in five categories: Updating the Patient's Social History; Conducting a Review of Systems; Reviewing and Discussing Documents; Updating the Patient's Problem List; and Assessing and Diagnosing the Patient.

Some of the variation I observe for High Variation clinical documentation categories exists across practices. This variation in documentation for Assessing and Diagnosing the Patient, Updating the Patient's Problem List, Conducting a Review of Systems, and Updating the Patient's Social History could reflect differences in the types of patients frequenting these practices, perhaps due to their geographic location and associated patient population demographics. For example, variation across practices could reflect different proportions of patients with a chronic, acute, or no conditions and the associated visit type mix at the practice. This is bolstered by prior work by Ancker et al who found that providers were more likely to update problem lists for a new patient than for a returning patient [11]. Variation at the practice level could also reflect formal organizational protocols regarding completion of documentation categories, particularly if some practices placed particular emphasis on maintaining a problem list or social history as part of a pay-for-performance or Patient-Centered Medical Home program. Alternatively, informal norms regarding communication could explain differences in practices' overall propensity to complete documentation in the EHR, as evidenced by a qualitative study of six physician practices operating within the same Provider Organization [23].

For all of the High Variation clinical documentation categories, the majority of variation in documentation exists within practices, which is likely a signal of inappropriate variation across providers. This interpretation is supported by the specific categories of clinical documentation in the High Variation group as well as the unique pattern of variation, as

compared to the categories in the Low Variation groups. Clinical documentation categories in the High Variation group are types of information for which there is a decision to make about where best to document it in the EHR, and therefore opportunity for provider preferences to result in variation. For example, a Review of Systems is often structured as a component of an admission note covering the patient's organ systems, with a focus upon the subjective symptoms perceived by the patient [24]. If the elicited information leads to the identification of a problem or diagnosis, that information could reasonably documented in the Problem List, as part of the Assessment & Diagnosis, or in all three categories. The observed, unexplained variation in completing these three clinical documentation categories may therefore be the result of different provider preferences about the relative benefits of documenting in different sections of the EHR [18]. These preferences may be shaped by the mix of free-text and structured data entry that the provider prefers, styles of documentation which differently privilege the in-the-moment expressivity of documentation and the perceived downstream value of structured documentation [8, 25-27]. In other words, a provider who prefers to document using more unstructured text may choose to document information in the Assessment and Diagnosis section that a provider who prefers more structured text would choose to document in the Problem List section. A provider who prefers to use templates to manage a mix of unstructured and structured text may choose to use the Review of Systems.

While the data do not allow for a definitive explanation of why certain clinical documentation categories are completed more variably than others, it provides direction for future research in this area. Specifically, additional analysis should explore variables at the provider- and practice- level that may explain additional variation, such as the number and type of users participating in a given encounter by role (physician, nurse, etc). These types of

variables would not necessarily reflect differences in patient needs, and would provide additional insight into the physician and staff work patterns that may contribute to variation. Identifying the mechanisms through which variation in EHR documentation impacts ongoing EHR use and care delivery likely requires qualitative interviews to better understand which types of variation providers and staff perceive as harmful, in addition to longitudinal quantitative analyses of these outcomes. These results would help target technical or operational interventions to minimize the deleterious effects of variation in EHR documentation. In the interim, EHR vendors and physician practices may want to consider developing clear guidelines and norms regarding High Variation clinical documentation categories to ensure that information which is entered in the EHR may be easily retrieved and used for high-value purposes.

Limitations

This study uses a novel dataset to quantify variation in EHR documentation in practices across the country. While the findings provide an important window into variation in documentation beyond single institution studies, there are several limitations that must be taken into account. First, the data reflect variation among users of the EHR from a single vendor. As evidenced by a recent study of physician order sets, EHR design features influence users' behavior [28], including where variation can and cannot occur. However, the EHR vendor limits the extent to which users can customize the interface, which helps ensure consistency in the task-log data that would be difficult to achieve in other study settings.

Second, generalizability is also limited because the data only captures a single month and only includes a relatively homogenous group of primary care providers. However, these limitations likely serve to minimize the variation observed in the data by eliminating seasonal

changes in patient care, such as the flu, as well as additional variation resulting from different patient populations seeking specialist care.

Third, the data exist within aggregate categories of clinical documentation, obscuring additional variation within clinical documentation categories (e.g., variation in whether specific vital signs are documented instead of whether any vital signs are documented). As a result, there may be additional variation that was not observed, including variation in how information is documented. Data limitations also prevented analysis of additional forms of variation such as how information was documented, where in the EHR particular information was documented, who completed documentation, and when information was documented [6].

Finally, the de-identified data lack patient characteristics and conditions, which prevents definitive classification of observed variation as appropriate or inappropriate. Even if such data were available, it would be difficult to precisely identify inappropriate variation without detailed chart review. Instead, I sought to assess whether there was a substantial amount of variation across the same types of providers – providers – in the same month across all their encounters at a level of aggregation in which I would not expect to see substantial variation. Given that I do observe substantial variation after accounting for differences in specialty, practice, physician organization and state, this is compelling evidence of the need for further investigation into inappropriate variation, and strategies to reduce it.

Conclusion

Providers' abilities to leverage EHRs for healthcare delivery improvements depend on how the EHRs are used to document care. This study is the first to measure one specific dimension of EHR use at a national scale: how providers choose to complete clinical documentation across

their encounters. For a set of important clinical documentation domains, I find substantial variation in completion of documentation that is not explained by variation across states, physician organizations, or physician practices. Because this variation has the potential to undermine potential gains from EHR adoption, it is an important area for provider organizations and policymakers to consider in their plans for ongoing EHR use.

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Appendix

Table 5: Description of Clinical Documentation Categories

Clinical Documentation Category	Definition
Assessment & Diagnosis	Synthesis of the thought processes of the provider caring for the patient.
Collect Clinical Encounter Reason	The purpose of the patient's visit.
Collect Vitals	Measurement of the body functions, such as body temperature, blood pressure, pulse (heart rate), and breathing rate (respiratory rate); includes documentation of adding, removing, or reviewing information.
Conduct Physical Exam	The medical professional examines the body of a patient for signs of disease, pertinent normal findings, and relevant negative findings.
Conduct Procedure	A course of action intended to achieve a result in the care of persons with health problems (e.g., insertion of an intrauterine device or removal of a wart).
Conduct Review of Systems	The status of the patient's organ systems, with a focus upon the subjective symptoms perceived by the patient. This category is a survey of the patient to complement the specific findings from the History of Present Illness.
Confidential Information	Information which the patient has requested to keep private; includes documentation of adding, removing, or reviewing information.
Creating/Sending Out Orders	Instructions by the medical practitioner for the treatment of the patient.
History of Present Illness	The interview prompted by the chief complaint or presenting symptom (e.g., a cough); includes documentation of adding, removing, or reviewing information.
Interpret Incoming Clinical Data	Interpretation of the results of tests, other notes, etc.
Medication List	The prescription and non-prescription medications the patient is taking or has taken; includes documentation of adding, removing, or reviewing information.
Problem List	The list of diagnoses the patient has or has had; includes documentation of adding, removing, or reviewing information.
Review/Discuss Documents	Documentation of discussion of external documents with the patient.
Sign-off/Close Encounter	Documentation of closing the encounter.
Social History	The patient's lifestyle practices (e.g., diet, exercise) and habits (e.g., smoking, alcohol consumption); includes documentation of adding, removing, or reviewing information.

CHAPTER THREE: PRIMARY CARE PRACTICES' EXPERIENCES OF VARIATION IN DOCUMENTATION

Introduction

The majority of office-based healthcare providers work in practices that have adopted an electronic health record (EHR) system [1, 2]. Although completing documentation in an EHR has become a fundamental component of healthcare delivery, there are ongoing challenges optimizing use of these tools [3]. One element of EHR use gaining increasing attention is variation in documentation, or differences in how users record information in an EHR. EHR systems have intentionally flexible user interfaces to allow users to customize documentation to a wide range of clinical scenarios and personal preferences. However, this flexibility creates the opportunity for variation driven by factors beyond the patient. Such variation may be harmful if it makes it difficult to find and use information in the EHR, interfering with EHRs' potential to facilitate the delivery of healthcare, as well as improvements in healthcare delivery [4-6].

Prior studies of variation in EHR documentation have focused almost exclusively on its prevalence. A national study of primary care practices using the same commercial EHR system, as well as a study of clinics in the same New York healthcare system, reveal differences in providers' rates of documenting common types of information, such as patient problems and social history [7, 8]. Observational studies of users in a Texas healthcare system further

demonstrate users' variable approaches to documentation [9, 10]. Finally, a recent experiment asked providers to generate patient problem lists based on clinical vignettes and quantified differences across participants [11]. Together, these studies reveal variation in EHR documentation, and suggest that it may be driven, at least in part, by factors beyond the patient. Missing from these studies is an assessment of impact: does such variation matter?

An important first step in understanding the effects of variation in EHR documentation is assessing users' perspectives on the phenomenon. Indeed, a basic signal of impact is whether users are even aware of variation in EHR documentation within their own practices and how such variation affects their work. Furthermore, to the extent that some forms of variation are seen as harmful, it is likely that practices would have taken action to either prevent variation or mitigate its potential for harm. Such strategies may be useful to identify and disseminate.

These issues are particularly relevant among primary care practices. Primary care is the broadest medical discipline, covering diagnosis and treatment of acute and chronic illnesses as well as health promotion, disease prevention, health maintenance, counseling, and patient education; documentation topics range from medications and problems to clinical assessment of social factors contributing to disease or health. Because of recent emphasis on primary care providers' roles in care coordination, and their reliance on EHRs to do so [12-14], the information that they document serves as the backbone of referrals, orders, and population health management. Therefore, I sought to explore dynamics related to variation in EHR documentation in primary care practices. I define variation as differences in the content, structure, or location of comparable information ("clinical documentation categories") in the EHR that result from differences in the processes used to record or remove that information in how users record or remove that information. In order to focus on potentially harmful variation in EHR

documentation, I further define variation in documentation as any differences in documentation that are not wholly driven by patient factors. I answer the following three questions:

1. Do primary care providers and staff perceive variation in EHR documentation within their practice? If so, which clinical documentation categories (e.g., problem lists, social history) do they perceive to be most variable? What factors do they perceive to cause such variation?
2. How, if at all, do primary care providers and staff believe variation in EHR documentation within their practice affects, or would affect, their ability to use their EHR to deliver high-quality care?
3. What strategies do primary care providers and staff think have been, or would be, useful to prevent or mitigate the impact of variation in EHR documentation on the delivery of high-quality care?

Methods

Sample and Sample Selection

Guided by prior work in this area [7, 9, 10], I used primary care practices as the sampling unit for this study. I partnered with Michigan's Regional Extension Center, the Michigan Center for Effective IT Adoption, to identify internal medicine or family practices using an electronic health record in southern- and mid-Michigan. I further restricted the sample to practices with at least two providers, including physicians and nurse practitioners, in order to ensure that there was the opportunity for variation across providers within the same practice.

My final sampling frame included 30 practices, of which I successfully recruited 10 to participate. Five practices were independent and the remaining 5 practices were part of a larger

health system (with three from the same integrated delivery network and two from the same ambulatory practice network). Practices used EHRs from five different commercial vendors: athenahealth, Cerner, eClinicalWorks, Epic, and NextGen. The majority of practices had been using their EHR for over three years. Most practices were medium sized, with 5-9 providers. Seven practices were federally qualified health centers (Table 6).

Table 6: Practice Characteristics

Organization	Practice	Size	FQHC	EHR Vendor	Year EHR Adopted
A	1	L (10+)	Yes	NextGen	2008
B	2	M (5-9)	Yes	athenahealth	2012
C	3	M (5-9)	Yes	Epic	2012
	4	S (2-4)	Yes	Epic	2006
	5	M (5-9)	Yes	Epic	Unknown
D	6	S (2-4)	No	eClinicalWorks	2015
E	7	M (5-9)	No	eClinicalWorks	2013
F	8	M (5-9)	Yes	athenahealth	2014
	9	S (2-4)	Yes	athenahealth	2014
G	10	L (10+)	No	Cerner	2013

I interviewed a total of 40 individuals across the 10 practices; this included 16 physicians and nurse practitioners; 13 medical assistants (MAs), nurses, and other clinical support staff; and 11 clinical directors, quality managers, or office administrators. I interviewed four individuals per practice, on average, ranging from two to six (Table 7).

Table 7: Respondent Characteristics

		Respondent Role*			
Organization	Practice	Providers	Clinical Staff	Other Staff	*Total*
A	1	2	1	1	*4*
B	2	2	4		*6*
C	3	1	2	1	*4*
	4	1	1		*2*
	5	4	1	1	*6*
D	6	1	1	3	*5*
E	7	2	1	2	*5*
F	8	1		1	*2*
	9	1	1		*2*
G	10	1	1	2	*4*
Total	*10*	*16*	*13*	*11*	*40*

*Providers includes physicians as well as nurse practitioners; Clinical Staff includes medical assistants and nurses; Other Staff includes medical directors, quality managers, and front office and other administrative staff

Data and Data Collection

I developed a semi-structured interview guide that asked respondents about their preferences for EHR documentation, perceived variation in EHR documentation, factors that caused variation, the effects of such variation on the delivery of high-quality care, and strategies to manage variation either by preventing its occurrence or mitigating its negative effects (see Appendix 1). The protocol focused on five clinical documentation categories previously identified as most variable in a national sample of primary care practices [8]:

(1) **Problem List:** Documentation of patient's problems, sometimes including notes.

(2) **Social History:** Documentation of familial, occupational, and recreational details that have the potential to be clinically significant, such as tobacco use and sexual activity.

(3) **Review of Systems:** Documentation of an inventory of patient's specific body systems, such as lung function.

(4) **Assessing and Diagnosing the Patient:** Documentation of patient's diagnoses and providers' overall impressions of the patient.

(5) **Reviewing and Discussing Documents with Patients:** Documentation of users' awareness of lab and test results, such as marking a particular report as reviewed, as well as documentation of communications with patients about results, such as a phone call or email message.

Respondents were first asked how, if at all, they completed each category of documentation in order to capture their preferences. Respondents were asked to elaborate on the scope of activities included in this clinical documentation category as well as their use of templates, free-text, or other methods to complete documentation. Respondents were then asked to describe differences (variation) in the content, structure, or location of comparable information other users in their practice documented in the EHR, as well as the likely causes of such variation. Next, respondents were asked about the perceived effects of variation in each category of documentation on the delivery of high-quality care. They were asked specifically about use of patient records for care of an individual patient at the time of the visit, clinical decision support, care coordination, and population health management because a prior study identified such activities as the likely mechanisms through which variation in EHR documentation would affect the quality and safety of healthcare delivery [15]. Finally, respondents were asked about strategies the practice used or thought might be useful to address variation in each category.

The protocol provided the opportunity for respondents to address categories of variation beyond the five focal categories. Respondents were asked about the general utility of vendor training, practice-level meetings, designated EHR scribes, or changes in EHR design to help

manage variation. Finally, respondents were asked about the effect that patient characteristics, such as age, gender, or health, had on the prevalence or impact of variation. Two members of the research team independently reviewed the interview protocol for clarity and comprehensiveness. The interview protocol was also piloted with two primary care providers and refined based on their feedback before being fielded.

I conducted face-to-face interviews with at least one provider and one other respondent who entered or searched for information in the EHR in every practice and transcribed a recording of the conversations. Interviews lasted 30-90 minutes and were a mix of one-on-one and group interviews, based on respondents' preferences. Each respondent received a $75 gift card. Data collection occurred between February and May 2015. The Michigan Institutional Review Board approved the study (OHRP IRB Registration Number IRB00000246).

Analytic Approach

I developed an a priori code list based on the research questions [16-18] and independently applied these codes to three transcripts to capture the clinical documentation categories being discussed, as well as the presence of upstream drivers, downstream consequences, or practice strategies to address variation. As I coded the three transcripts, I created supplementary codes to identify emergent topics not captured by initial codes, such as additional clinical documentation categories. I recoded the three transcripts as necessary, in line with the principles of the constant comparative method [19]. Two members of the research team independently reviewed the final code list and three coded transcripts to ensure comprehensiveness and consistency. I used this list to code the remaining 37 interviews.

I uploaded all coded interviews to Atlas.ti [20] and used the query function to group the different sections of the interviews by code. I synthesized this information in analytic matrices [21]. Specifically, I developed a matrix for each clinical documentation category that allowed me to capture respondents' reported documentation processes (e.g., use of templates to document patient's review of systems), their perceptions of variation (e.g., that some people in their practice used free-text instead of templates to document the patient's review of systems), and the perceived causes of variation (e.g., that people who used EHRs during medical school and residency tended to favor templates over free-text when documenting the patient's review of systems). I developed additional matrices to track other types of variation respondents perceived, the reported and perceived effects of variation in EHR documentation, and their practice's strategies to manage variation. I summarized the findings for each practice by comparing respondents' descriptions of how they completed documentation as well as their perceptions of variation. This allowed me to identify areas of agreement and disagreement across respondents within a practice [22, 23] to develop practice-level responses. Two members of the research team independently reviewed a completed analytic matrix for one practice to help ensure the approach would capture accurate and appropriate information [24].

I analyzed practice-level responses for each clinical documentation category to identify trends in variation and drivers of variation. Specifically, for each clinical documentation category, I assessed what differences respondents in each practice perceived in the content, structure, or location of comparable information that result from differences in the processes used to record or remove that information. I also compared respondents' reported processes for completing documentation to determine if there was variation respondents did not perceive. Combining these two measures, I counted the number of practices with variable documentation

for each clinical documentation category as well as the number of clinical documentation categories in which each practice experienced or perceived variation. I also compared practice-level responses regarding the cause of variation for each clinical documentation category to identify drivers. Finally, to identify the effects of variation and the potential strategies to address variation, I analyzed practice-level responses across clinical documentation categories for recurring challenges or approaches (e.g., instances of duplicate documentation or references to practice-wide meetings).

Results

Perceived Variation and Drivers of Variation

Interviews revealed that primary care providers and staff perceive there to be variation in EHR documentation within their practice. Practices most commonly identified variation pertaining to Reviewing and Discussing Documents with Patients, activities which were alternatingly performed by providers, clinical support staff, and administrative staff. At least one respondent from every practice observed variation in how users documented this information in the EHR. Most respondents attributed variation to user preference, which is facilitated by the multiple options available to document this category of information. For example, at one practice, providers and staff could generate a new communication note, generate a new result note, annotate reports in the EHR, include information in the after visit summary, or reach out to patients via portal and allow that record to serve as documentation of follow-up. Providers in the practice utilized each of these options at different times, with no articulated standard for how each would be used. Although these specific options are not part of every EHR interface, a common tension across practices was between some providers' preferences for writing a detailed

note and other providers' preferences to let other actions in the record (such as scheduling a follow up visit or prescribing a medication) serve as evidence of communication with patients. As a provider explained, "*we all have different ways of trying to remind ourselves that we're still working on this problem.*"

The second most commonly identified variation across practices was documentation of the patient's Review of Systems, an activity which was the exclusive responsibility of providers. Respondents from seven practices observed variation in the format providers used to document the Review of Systems, with some using a template and others using free-text to either describe the status of each body system or simply report that notes were elsewhere in the record. As one provider explained, "*it really depends on the provider whether they check more boxes or if they type more."* Respondents further identified providers' comfort using templates and their tenure caring for patients as the cause for such variation, suggesting that older providers with a history of using paper records were more likely to free-text the Review of Systems. Providers' response to patient complexity was also as a factor driving variation: in one practice, providers were split in using either template or free-text for more complex patients. Respondents from three practices did not identify any variation in how providers' documented the patient's Review of Systems in their EHR.

The third most commonly identified variation was documentation of the patient's Social History, an activity typically initiated by nurses, medical assistants, and other clinical staff during intake, and frequently supplemented by providers later in the visit. Respondents from four of the seven practices experiencing variation observed differences in the depth of information recorded in the social history, and believed this was primarily attributable to staff discomfort in discussing sensitive issues. As one provider related, "*It depends on the [person completing*

documentation]… some of the MAs don't feel comfortable asking about the sexuality. You see those variations." Respondents from three practices did not identify any variation in how providers' documented the patient's Social History.

The fourth most commonly identified variation was documentation of patient problems and use of the problem list, activities which were the exclusive responsibility of providers. At most practices, providers described the problem list as a repository of chronic problems for which the patient would require ongoing monitoring or medical care, such as hypertension or asthma. In the words of one provider, "*the problem list should be those chronic, always going to be there problems*." Respondents at two practices observed some exceptions to this rule, including temporarily persistent problems like heartburn during pregnancy and unusual diagnoses that would influence future medical care like a rare blood type. Among the six practices experiencing variation in documentation of patient problems, the variation typically emerged as differences in the extent to which providers acted as a "*steward of the problem list*" by regularly adding new problems and removing those which had been resolved. However, one provider identified variation among others at her practice who regularly maintained the problem list. She explained that while some providers chose to remove problems and add new ones in response to changes in the patient condition, as when an obese patient gained weight and developed morbid obesity, others would modify entries to ensure they were up-to-date. While both actions would result in a seemingly-identical problem list containing morbid obesity, only the latter strategy of modifying entries in the problem list would preserve provider notes that were associated with that particular condition because of the structure of the EHR. Few providers in her practice were aware of this distinction because they did not associate notes with specific entries in the problem list, instead keeping such information in the overview to the problem list.

Those providers reported deleting entries in the problem list which needed revision and adding new ones, citing a workflow that they found to be more intuitive. Among respondents identifying variation, there was no consensus about likely causes. Respondents from two practices suggested providers' varied documentation patterns were due to competing priorities, one provider thought it was because people had different philosophies about what belonged on the problem list, and one thought variation was the result of users' experiences with the EHR system. As she explained, "*If you're not in the habit of doing it, you're less likely to do it*."

Finally, respondents from six practices observed variation in how providers documented patients' assessment and diagnoses, activities which were the exclusive responsibility of providers. Consistent with prior literature, documenting diagnoses was one of the first actions providers at most practices would take during an encounter [25], as doing so would pull up a template for the relevant condition in providers' progress notes and also was a precursor to sending out orders. Diagnoses typically reflected issues that were discussed during the visit, and providers identified variation across their colleagues in the use of templates and free-text documentation. As one provider explained, "*I do brief instructions under each of my diagnoses...some providers just leave the diagnoses and have no comments, which can be a pretty big difference.*" These differences were not always as apparent to medical assistants or other office staff, although at one practice a medical assistant noted that providers "*for the most part have the same expectations [but]when we work with an individual provider, they kind of like their things a little differently*." Many respondents felt these preferences were shaped by experiences using different EHRs, as well as time pressures that might lead providers to habitually document less information in the assessment if they typically had busier schedules.

In every practice at least one respondent reported variation in at least one of the five focal categories (Updating the Patient's Problem List; Updating the Social History; Conducting a Review of Systems; Assessing and Diagnosing the Patient; and Reviewing and Discussing Documents with Patients). Three practices had at least one respondent report variation in every focal category, and the modal practice had at least one respondent report variation in four of the five focal categories. Respondents felt that EHR design fostered much of this variation by providing too many options for documentation. As a practice manager explained, "*part of the problem comes [from there being] three different ways of entering the information.*"

Outside the five focal categories, the only type of variation in documentation that was reported by more than one respondent was variation in when providers completed documentation. Respondents explained that some providers "*don't finish their note by the end of the day or even the end of the next day*" in contrast to others who complete documentation during the encounter.

Perceived Effects of Variation

Many respondents perceived variation as having minor negative effects on the delivery of high-quality care. As one provider explained, pertaining to documentation of reviewing and discussing documents with patients, such variation was "*cumbersome but doesn't hinder care.*" In some practices, this inconvenience took the form of extra steps to complete documentation, such as undertaking redundant documentation when there were multiple places to record comparable information. A nurse observed:

> *…documenting the patient's last period is in the template, the vitals, and the GYN history. There are 3 spots to put it, and one of the nurses only puts it in one spot, so you can look for it and think she didn't do it. I, on the other hand, do triple charting, so that's confusing too.*

In other practices, the inconvenience materialized as extra effort to search for information during the patient encounter to compensate for variation in documentation. As one provider stated about variation in documentation of patient problems, "*you have the potential to miss stuff if there's too much other information, but the problem list is a key part of the medical record so I review it pretty carefully*." Respondents from four total practices noted that it took extra time to review patient problems because Problem Lists were variably maintained. Respondents from 6 practices identified similar challenges parsing the relevant information from the EHR due to variation in documentation of other clinical documentation categories, including the assessment and diagnoses, problem list, social history, as well as documentation of reviewing and discussing documents with patients. These challenges were characterized as trivial inefficiencies or unavoidable delays.

However, some respondents relayed greater concern with the long-term repercussions of this tradeoff; as one provider lamented, although these recurring inefficiencies were "*only a few seconds, that adds up*." Several respondents felt that the challenges using automated and manual means to retrieve information were substantial. As a quality manager explained about variable documentation practices across categories, "*it does cause a lot of issues with reports and a lot of questioning as to whether or not it is accurate when we do get a report. Definitely frustrating*." The quality manager at another practice shared that "*there's some confusion finding [information about communication with patients]. There's also confusion in pulling it out when we pull out the data, so we always have to search all possible places.*" The health information manager from that same practice added that variation lead to challenges inputting information "*because you have to hit a certain box to make [the documentation] work a certain way. If you forget that box, it doesn't work.*"

Furthermore, a subset of respondents believed the effects of variation in EHR documentation extended beyond efficiency and were concerned it would interfere with healthcare safety and quality. These issues typically arose due to variation in documentation of patient problems; as one provider noted:

> *If there's a bunch of junk on [the problem list then] you don't trust it, you don't read it carefully, so I think it can impact clinical care in that way – you may not know of something that's important or see it…if there's a lot of irrelevant information you're more likely to gloss over the whole thing. It makes it harder to know what's a real problem versus what's transient.*

Respondents at three practices agreed that a variably maintained problem list had the potential to compromise quality of care. One respondent noted a similar risk of "*error via misinformation*" because variation in documentation of the assessment and diagnoses could lead to inaccuracies in the problem list. As one provider noted, "*everything is driven by the diagnosis nowadays…when you have misinformation in the chart it affects the way you approach the patient...It can affect everything.*" The medical director of another practice explained that variation in documentation of the social history could lead to another quality problem if providers misinterpreted missing information. She explained "*it's a big area of contention*" that providers don't always indicate in the social history tab when information was reviewed and instead made notes in an alternate section of the EHR.

Finally, respondents from two practices observed that variation in documentation jeopardized patient satisfaction. Specifically, the quality improvement director from one practice explained that patients were beginning to review their problem list because it was included in the summary of care record and any outdated or inaccurate information diminished their trust in the practice. A nurse practitioner from another practice further noted that follow-up calls slipped through the cracks because of variation in documentation of reviewing and discussing documents with patients, leading to patient frustration. She explained:

> *…the way that we notify patients of lab results is all over the place…You kind of have to dig for it, essentially. When things comes back you are constantly digging into individual results to get if it was done, was this person contacted, what happened.*

Respondents reported that variation in some clinical documentation categories had greater potential for harm than variation in other categories. Specifically, respondents reported that variation in documentation of the Review of Systems had no negative effects on the delivery of high-quality care, and were much more concerned about variation in documentation of assessments, diagnoses, and problems.

Strategies to Manage Variation

Regularly scheduled staff meetings were by far the most commonly identified strategy to prevent variation in EHR documentation. Although a quality manager and medical director from two different practices observed that variation in documentation resisted intervention, multiple respondents from the majority of practices said that having frequent opportunities to discuss EHR documentation was useful to "*get everyone on the same page*" and share optimal EHR documentation strategies. Meetings typically occurred monthly or quarterly, and were frequently reinforced by emails about best practices. Several respondents felt these follow up communications were essential, especially if people worked at other practices using other EHRs.

The second most commonly identified strategy to prevent variation was thorough training at the outset of implementation. One practice where respondents perceived very little variation in EHR documentation attributed their consistency to clearly articulated documentation procedures learned during implementation. Respondents from five additional practices with more perceived variation in EHR documentation lamented the lack of training during EHR implementation. One provider suggested that "*an initial, more organized, training process would be beneficial.*" A different provider from that same practice relayed that their video-based training was "*lousy*,"

and hypothesized that "*a lot of the variation*" in their practice was a result of people drawing different conclusions from the videos. She believed this variation would have been avoided if there had been more explicit training during the EHR implementation. Managers from another practice had a similar suggestion for more training, adding that it would be helpful to bring managers up to speed before the rest of the practice so they could provide ongoing coaching.

Respondents were less enthusiastic when asked about scribes. While one provider "wo*uld love one*," several were suspicious. As one manager explained, "*It makes me a little nervous that they're not actually gathering what the provider's doing and what the provider's saying*." Another provider felt that it would be more important to expand MAs' roles to ensure more thorough pre-visit documentation than to focus on documentation during the visit.

Select providers identified potential improvements to their EHR design that would help minimize variation, most of which focused on the problem list. One respondent suggested a feature that would prompt users to add diagnoses to the problem list, but did not do so automatically, would make it easier to consistently complete documentation. This suggestion would likely be welcomed by primary care providers; several respondents noted that when their EHR automatically updated the problem list with visit diagnoses, it created work to remove short-term issues they would never have intentionally added. Other strategies identified by a smaller number of respondents included the use of financial incentives to motivate providers to consistently document conversations with patients about lab and test results as well as the development of standard workflows before transitioning to an EHR.

Discussion

Semi-structured interviews with providers and staff in 10 Michigan primary care practices reveal habitual variation in EHR documentation across users, particularly in users' documentation of communication with patients about lab and test results. Respondents primarily attributed this and other variation to differences in user preferences as well as EHR designs which foster variation by creating multiple places to record comparable information. Respondents identified efficiency losses as a result of variation, as well potential interference with safety, quality, and patient satisfaction, primarily attributable to variation in the frequency and format of entries about patient problems, diagnoses, and clinical assessments. Thorough vendor training during implementation, ongoing meetings to reinforce best practices, and improved EHR design may minimize variation and thus mitigate these risks.

Implications for Primary Care Practices

Primary care practices should be aware that although the consequences of variation in EHR documentation may seem mundane to users in-the-moment, in reality it reflects a forced tradeoff between efficient or intuitive documentation practices and easy retrieval of information at subsequent visits. Primary care providers face incredible time pressures [26-28], and any opportunity to minimize the burden of documentation will free up valuable time for additional patient management and care delivery. Furthermore, when different providers in a practice use the same fields inconsistently (i.e., including both acute and chronic conditions in a problem list) it can lead to challenges interpreting information [29] which could lead to patient harm. Respondents suggested that the most essential variation to address relates to documentation of

patient problems, diagnoses, and provider assessments, consistent with the overall priorities of family and general medicine physicians [25].

Respondents in diverse primary care practices identified managerial interventions as valuable tools to address variation in EHR documentation. Although some variation in documentation may persist, respondents believed vendor training could prevent the development of idiosyncratic documentation styles and regular meetings for the practice could reinforce standard documentation procedures across users. Regular meetings are a hallmark of high-performing practices [30], and can provide critical opportunities to reflect and learn throughout an organization [31]. They may also help practices identify and refine their preferred balance between flexibility and standardization in documentation processes. Flexible office policies may relieve some of the strain of EHR adoption by minimizing the changes people need to make to their habitual methods of documentation [32, 33], but they also create subsequent challenges in utilizing EHR data for care delivery, care coordination, and population health management. Practices may want to revisit their initial EHR training after becoming more familiar with their system and regularly update guidelines for how to document in the EHR as this inflection point changes with additional experience. Indeed, respondents at one practice reported being long aware that there were different ways to update the patient problem list, but were only just beginning to recognize the implications of those differences at the time of this study.

Implications for Design

EHR vendors are in a unique position to reduce variation in EHR documentation as well as mitigate its potential for harm. This paper demonstrates that documentation patterns are likely to emerge in a practice when their EHR includes multiple areas to record comparable information,

especially in the absence of extended dialogue about this issue during training or after major system changes. This issue is particularly relevant for documentation of patient problems, diagnoses, and provider assessments, categories where providers felt there was the greatest potential for harm due to missed or misinterpreted information.

Vendors may therefore want to develop training that specifically addresses the intention behind different interfaces to explain any downstream consequences of variation in documentation, such as recording the patient's last period in the vitals instead of their medical history. Vendors may further benefit from enhancing linkages between structured elements of the record such that entering information in one field prompts users to select additional fields that should also be updated. However, vendors should be careful when creating linkages that automatically update related fields, a feature which prior research has shown can clutter information displays [34]. Finally, EHR templates for documentation of patient problems, diagnoses, and provider assessments may also benefit from additional user interface testing to create more intuitive ways to manage this critical information which is the foundation for provider behavior as well as automated clinical decision support.

Implications for Policy

The prevalence of variation in EHR documentation in small primary care practices and its potential for harm underscore the ongoing effort that will be required to translate EHR adoption into meaningful improvements in healthcare delivery. Many healthcare initiatives, such as precision medicine, assume EHRs can provide relevant, real-time information to providers applying the latest evidence to their patients' care plans [35]. Similarly, the potential power of analyzing data stored in EHRs across the country undergirds the promise of the learning health

system to provide ongoing feedback to both providers and healthcare standards [36]. Variation in EHR documentation has the potential to undermine these and other health reform priorities that rely on leveraging EHR data from different institutions and settings. A common example of variation in multiple clinical documentation categories included storing patient information outside designated areas, particularly the use of free-text notes in a general field instead of structured documentation in a more specific field. Because this behavior was not universal within practices, efforts to extract data would yield some returns, giving the impression that information was flowing freely while losing a subset of the data

Furthermore, the presence of variation *within* practices is likely mirrored by variation *across* practices, complicating health information exchange. Although analysis of a national sample of primary care practices using the same EHR revealed substantially more variation within- than across- practices [8], respondents using different EHR vendors in this study held different beliefs about the information that belonged in particular fields. This variation in documentation across practices has the same potential to introduce inefficiencies and errors as variation in documentation within practices. Future studies should investigate where these challenges are likely to arise and potential strategies to prevent patient harm.

Practices and vendors will continue to face complex challenges which they may not be able or motivated to address on their own. Continued investment in Regional Extension Centers [37], or other third party organizations that can work across institutional boundaries, may be a valuable national strategy to guide these processes and foster the sharing of best practices. These organizations can help practices map workflows for different types of documentation to identify variation. They can also evaluate behaviors across organizations to recommend optimal documentation protocols as well as strategies to minimize variation.

Limitations

There are two main limitations to this study. First, I was not able to exhaustively identify all expressions of variation or all of the ways that it affects healthcare quality. Data collection relied on respondents' perceptions, which were not compared to data from their EHR data to more conclusively determine the prevalence of certain forms of variation. Although multiple perspectives were triangulated within and across practices to gain a more comprehensive account, the small number of respondents at three practices introduced additional limitations to this process. There may thus be variable clinical documentation categories or effects which were not captured in interviews. Second, the practices included in this analysis were primarily small primary care practices. The prevalence of certain forms of variation, the impacts they have on care delivery, and the utility of different strategies may be different in larger practices or specialty practices, and should be explored in future research [6].

Conclusion

This is the first study to explore EHR users' perceptions of variation in EHR documentation within primary care practices. Respondents observed numerous differences in the content, structure, or location of comparable information in the EHR, as well as differences in the processes used to record or remove that information. These differences were particularly problematic when documenting patient problems, diagnoses, and providers' overall assessment, regularly resulting in inefficient documentation and creating situations that could cause patient harm due to missed- or misinterpreted information. Improving EHR design, user-training during

implementation, and regular practice meetings focused on documentation may minimize variation in documentation.

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Appendix 1: Semi-Structured Interview Guide

Introduction

Thank you for taking the time to speak with me today. The goal of the study is to understand variation in electronic health record (EHR) documentation, including its causes and its effects. I'm very interested in your experiences using an EHR -- there are no right- or wrong-answers to any of my questions, and you do not have to answer every question in order to participate.

I am conducting this study as part of my doctorate from the University of Michigan School of Public Health. The study has been reviewed by the Institutional Review Board[1].

Participation in this study is confidential. I will not release the names of interviewees or the practices in which they work, and will not share a transcript of this interview outside of my advising team. When disseminating the work, I may use direct quotes in publications, but will not attribute quotes to specific individuals or practices.

At this point, I would like your permission to record our conversation today.

Thank you. I'm now going to repeat this statement for the recording: I would like your permission to record our conversation today. The recording will not be made public and will only be used to create a transcript of the interview that I will then analyze. I am happy to turn off the recording at any time if you'd like to share information off-the-record. Do I have your consent?

One final note: I have a number of topics I'd like to address today, and may have to interrupt you at some point to make sure we cover them. I will make sure to leave time at the end of the interview for additional topics, and would be happy to leave my contact information with you if you'd like to schedule additional time to speak. Do you have any questions about the study that you'd like to discuss before we begin?

A. Interviewee and Practice Demographics

1. Please describe your role(s) in the practice and how long you have been with the practice.

2. [ADMIN ONLY] Can you tell me a bit about your practice in general?
    a. How many and what types of providers and staff work at the practice?
        i. How many billing providers? What are their degrees? What are their specialties?
        ii. How many clinical support staff? What are their degrees?
        iii. How many administrative staff? What are their roles?
    b. What is the average tenure of providers and practice staff?

[1] OHRP IRB Registration Number(s): IRB00000246

3. [ADMIN ONLY] Is your practice affiliated with a Physician Organization (PO)? If so, which one? How long have you been a member?

4. [ADMIN ONLY] Is your organization formally affiliated with any other organizations - hospital system, clinical networks, etc.? How long have you been a member?

5. [ADMIN ONLY] Does your organization participate in any quality improvement or pay-for-performance programs, like Blue Cross Blue Shield's Physician Group Incentive Program (PGIP)? Which are most notable?

B. <u>EHR Background</u>: Now, I have some questions for you about your electronic health record use

6. [ADMIN ONLY] I understand your practice uses *<u>[fill in EHR details from MCEITA data]</u>* EHR. Is that correct?
    a. How long have you had this EHR?
    b. What prompted your practice to adopt this EHR?
    c. Did any external organization (e.g., PO or hospital) help you acquire or implement your EHR?
    d. Have you met Stage 1 or Stage 2 meaningful use criteria?
        i. If so, when?
        ii. Were you assisted by M-CEITA or another entity?
    e. Is your EHR integrated with any other health information technology (e.g., patient or hospital portal)?

7. Are you completing any documentation on paper? (Probe if necessary on patient demographics, physician or nursing notes; problem lists; medication lists; discharge summaries; laboratory reports; radiology reports and images; and diagnostic test results and images)

8. Approximately how many different EHR systems have you used?
Thank you. I'd like to focus on your current EHR, but if at any point there's a particularly noteworthy difference or example, please let me know.

9. I'd like to walk through how you use the EHR – can you please tell me how you would interact with the EHR when seeing a patient for a routine health maintenance exam?
    a. Do you do any documentation yourself before the visit?
    b. Do you do any documentation yourself during the visit?
    c. Do you do any documentation yourself after the visit?
    d. Is anyone else involved in pulling or entering information?

C. <u>Experience with EHR Variation</u>:

As I mentioned at the outset of the interview, I am particularly interested in variation in EHR documentation – i.e., differences in how or when you and others in your practice might complete documentation in the EHR.

For much of this interview, I'm going to focus on certain places in the EHR where there is high potential for variation:

- *Assessing and Diagnosing the Patient*
- *Conducting a Review of Systems*
- *Updating the Patient's Problem List*
- *Updating the Social History; and*
- *Reviewing and Discussing Documents*

10. Before we dive into the specifics, does this list of areas seem intuitive to you? Is anything surprising? Is anything missing?

I'm now going to ask you a series of questions about each of the five areas I identified [as well as (respondent-identified variation)].

11. The first type of EHR documentation I want to talk to you about is the assessment and diagnosis.
    a. Can you walk me through how you document the patient's assessment and diagnosis in the EHR?
        i. Does your EHR have a designated section for a patient's assessment and diagnosis?
        ii. How do you complete this type of documentation (e.g., dictation, template, or structured data entry)?
        iii. For what proportion of your patients does someone complete this type of documentation?

    b. Do you perceive any differences in how others in your practice document information about the patient's assessment and diagnosis in the EHR?
        i. Please elaborate. [*Probe as necessary regarding <u>how often</u> tasks are documented, <u>who</u> completes documentation, <u>how</u> tasks are documented, and <u>when</u> tasks are documented*]
        ii. Why do you think this type of variation occurs? What causes it?
        iii. How, if at all, does this type of variation affect your ability to effectively use the EHR to care for your patients? [*Probe as necessary regarding clinical decision support; care coordination; population health management*]

    c. Is this something that's risen to the attention of your practice?
    d. Has your practice tried any strategies to address this type of variation?

i. Strategies to minimize the occurrence?
ii. Strategies to minimize the impact?

e. Are there other strategies that you think would be useful to address this type of variation?

f. Is there anything else you think I should know about variation in how the assessment and diagnosis is used in your practice?

12. The second type of EHR documentation I want to talk to you about is conducting a review of systems.
    a. Can you walk me through how you document the patient's review of systems in the EHR?
        i. Does your EHR have a designated section for a patient's review of systems?
        ii. How do you complete this type of documentation (e.g., dictation, template, or structured data entry)?
        iii. For what proportion of your patients does someone complete this type of documentation?

    b. Do you perceive any differences in how others in your practice document information about the patient's review of systems in the EHR?
        i. Please elaborate. [*Probe as necessary regarding how often tasks are documented, who completes documentation, how tasks are documented, and when tasks are documented*]
        ii. Why do you think this type of variation occurs? What causes it?
        iii. How, if at all, does this type of variation affect your ability to effectively use the EHR to care for your patients? [*Probe as necessary regarding clinical decision support; care coordination; population health management*]

    c. Is this something that's risen to the attention of your practice?
    d. Has your practice tried any strategies to address this type of variation?
        i. Strategies to minimize the occurrence?
        ii. Strategies to minimize the impact?
    e. Are there other strategies that you think would be useful to address this type of variation?

    f. Is there anything else you think I should know about variation in how the review of systems is used in your practice?

13. The third type of EHR documentation I want to talk to you about is updating and reviewing the patient's problem list.
    a. Can you walk me through how you document the patient's problems in the EHR?
        i. Does your EHR have a designated section for a patient's problem list?
            1. How do you distinguish between chronic and acute problems?

ii. How do you complete this type of documentation (e.g., dictation, template, or structured data entry)?
iii. For what proportion of your patients does someone complete this type of documentation?

b. Do you perceive any differences in how others in your practice document information about the patient's problems in the EHR?
   i. Please elaborate. [*Probe as necessary regarding <u>how often</u> tasks are documented, <u>who</u> completes documentation, <u>how</u> tasks are documented, and <u>when</u> tasks are documented*]
   ii. Why do you think this type of variation occurs? What causes it?
   iii. How, if at all, does this type of variation affect your ability to effectively use the EHR to care for your patients? [*Probe as necessary regarding clinical decision support; care coordination; population health management*]

c. Is this something that's risen to the attention of your practice?
d. Has your practice tried any strategies to address this type of variation?
   i. Strategies to minimize the <u>occurrence?</u>
   ii. Strategies to minimize the <u>impact?</u>
e. Are there other strategies that you think would be useful to address this type of variation?

f. Is there anything else you think I should know about variation in how the problem list is used in your practice?

14. The fourth type of EHR documentation I want to talk to you about is the social history.
   a. Can you walk me through how you document the patient's social history in the EHR?
      i. Does your EHR have a designated section for a patient's social history?
      ii. How do you complete this type of documentation (e.g., dictation, template, or structured data entry)?
      iii. For what proportion of your patients does someone complete this type of documentation?

   b. Do you perceive any differences in how others in your practice document information about the patient's review of systems in the EHR?
      i. Please elaborate. [*Probe as necessary regarding <u>how often</u> tasks are documented, <u>who</u> completes documentation, <u>how</u> tasks are documented, and <u>when</u> tasks are documented*]
      ii. Why do you think this type of variation occurs? What causes it?
      iii. How, if at all, does this type of variation affect your ability to effectively use the EHR to care for your patients? [*Probe as necessary regarding clinical decision support; care coordination; population health management*]

c. Is this something that's risen to the attention of your practice?
d. Has your practice tried any strategies to address this type of variation?
    i. Strategies to minimize the occurrence?
    ii. Strategies to minimize the impact?
e. Are there other strategies that you think would be useful to address this type of variation?

f. Is there anything else you think I should know about variation in how the social history is used in your practice?

15. The fifth type of EHR documentation I want to talk to you about is review of documents.
    a. Can you walk me through how you document the review of documents in the EHR?
        i. Does your EHR have a designated section for review of documents?
        ii. How do you complete this type of documentation (e.g., dictation, template, or structured data entry)?
        iii. For what proportion of your patients does someone complete this type of documentation?

    b. Do you perceive any differences in how others in your practice document information about review of documents in the EHR?
        i. Please elaborate. [*Probe as necessary regarding how often tasks are documented, who completes documentation, how tasks are documented, and when tasks are documented*]
        ii. Why do you think this type of variation occurs? What causes it?
        iii. How, if at all, does this type of variation affect your ability to effectively use the EHR to care for your patients? [*Probe as necessary regarding clinical decision support; care coordination; population health management*]

    c. Is this something that's risen to the attention of your practice?
    d. Has your practice tried any strategies to address this type of variation?
        i. Strategies to minimize the occurrence?
        ii. Strategies to minimize the impact?
    e. Are there other strategies that you think would be useful to address this type of variation?

    f. Is there anything else you think I should know about how review of documents is documented in your practice?

16. Have you encountered other types of variation…
    a. …in how often tasks are documented in the EHR?
    b. …in who documents tasks in the EHR?
    c. …in how tasks are documented in the EHR (e.g., free-text vs. structured data entry)?
    d. …in when tasks are documented in the EHR?

17. Regarding [*respondent-identified variation*]
    a. Can you walk me through how you document [*respondent-identified variation*] in the EHR?
        i. Does your EHR have a designated section for [*respondent-identified variation*]?
        ii. How do you complete this type of documentation (e.g., dictation, template, or structured data entry)?
        iii. For what proportion of your patients does someone complete this type of documentation?

    b. Do you perceive any differences in how others in your practice document information about [*respondent-identified variation*] in the EHR?
        i. Please elaborate. [*Probe as necessary regarding how often tasks are documented, who completes documentation, how tasks are documented, and when tasks are documented*]
        ii. Why do you think this type of variation occurs? What causes it?
        iii. How, if at all, does this type of variation affect your ability to effectively use the EHR to care for your patients? [*Probe as necessary regarding clinical decision support; care coordination; population health management*]

    c. Has your practice tried any strategies to address this type of variation?
        i. Strategies to minimize the occurrence?
        ii. Strategies to minimize the impact?
    d. Are there other strategies that you think would be useful to address this type of variation?

    e. Is there anything else you think I should know about [*respondent-identified variation*] in your practice?

Summarize interview this far: So, it sounds like _____ and _____ are common types of variation in your practice, which has _____ and _____ implications for your ability to use the EHR to deliver care. Is that accurate?

It also sounds like you've done _____ and _____ to address variation in EHR documentation, is that accurate? Now, I'd like to ask you about some other types of activities at the organization-level that might address variation,

18. Would it help prevent variation in EHR documentation if your practice:
    a. Had more training from your vendor about how to use the EHR?
    b. Made variation in EHR documentation a topic of regular discussion (i.e., at meetings)?
    c. Used scribes to complete documentation in a standard format?
    d. Used standard after-visit reports to summarize key details?

19. Assuming you're stuck with your current EHR, is there anything [else] you can think of that might help minimize the problems resulting from variation in documentation?

20. How could EHR design be improved in manage variation in documentation?
    a. By minimizing its occurrence?
    b. By minimizing negative impacts?

D. **Special populations**

21. Now, I'd like to talk to you about some specific types of patients for whom variation in EHR documentation may be different. Is there anything about documentation of healthcare for women; children; racial and ethnic minorities; populations with special healthcare needs (chronic illness, disabilities, and end of life care needs); elderly patients; low-income patients; inner-city patients; or rural patients that would make variation
    a. More or less likely?
    b. More or less problematic?
    c. Otherwise different?

Thank you for taking the time to speak with me today. Is there any additional information you think I should know about variation in EHR use?

Appendix 2: Code List

1a-1b. types of perceived variation: codes will flag the sections of the EHR that were previously identified, as well as other respondent-identified types of variation:

- [ASSESS]: Assessment (subjective/evaluative notes)
- [DIAG]: Diagnosis (codes for conditions)
- [PL]: Problem List
- [ROS]: Review of Systems
- [SH]: Social History
- [RESULTS]: Documenting Communication with patients about results
- [OTHERVAR]: respondent-identified type of variation

I will also code the level at which variation occurs:

- [INDIV]: variation occurs within people (across patients)
- [OFFICE]: variation occurs within offices (across people)
- [ORG]: variation occurs within organizations (across offices)
- [TIME]: variation occurred over time
- [NOVAR]: respondent doesn't perceive any variation
- [PROCESS]: description of documentation styles, to help compare different methods

1c: causes of variation: codes will flag factors respondents identified as related to variation

- [CAUSE]: Causes of variation

2a-c: Perceived effects of variation on efficiency, quality, and safety: codes will flag the effects that identified variation might have on care delivery outcomes, as well as the mechanisms through which these effects are likely to accrue:

- [EFFICIENCY]: speed of data entry/retrieval
- [QUALITY/SAFETY]: delivering needed care and avoiding errors, including trust of the data
- [CDS]: relationship between variation and algorithms/decision support
- [POPHEALTH]: relationship between variation and running reports or other panel management
- [REPORTING]: variation interferes with audits and reports
- [NOIMPACT]: respondent doesn't perceive an impact from variation

3a-b: Strategies to address variation: Codes will identify the effect of different organizational strategies had or are thought to have on preventing and/or managing variation

- [MEETING]: office has conversations and meetings about how to document
- [EHRTRAINING]: vendor training about how to use the EHR
- [SCRIBE]: use of designated EHR documenters
- [REDESIGN]: benefits of particular EHR design features or suggested improvements
- [QA]: designated person manages documentation outside the confines of patient encounters

- [P4P]: anything with financial incentives
- [OTHERSTRATEGY]

Other codes:

- [GOODQUOTE]: highlights succinct or salient examples and turns of phrase
- [T1_PERSON]: information about individual's background
- [T1_PRACTICE]: information about practice background
- [T1_IT]: information about EHR background
- [SPECIALPOP]: effect of patient characteristics on variation
- [MISCEHR] : other comments about EHR design or use not directly related to variation

DISCUSSION

The three chapters in this dissertation explore different dimensions of variation in electronic health record (EHR) documentation, using mixed methods to identify drivers, expressions, effects, and strategies to minimize its potential for harm. The first chapter developed a conceptual model of variation in EHR documentation to understand the phenomenon holistically, delineating how factors not wholly related to patient needs can drive different expressions of variation. The five forms of variation which this chapter described (how, what, where, who, when) may each exist at multiple levels of healthcare delivery (across encounters within providers, across providers within practices, across practices within umbrella provider organizations, across organizations within different geographic areas, or across geographic areas). Each of these expressions of variation can interfere with the organization of information in the EHR, and thus the EHR's utility for optimal care delivery. This chapter lays the foundation for empirically examining the variables that are likely to cause different expressions of variation in EHR documentation, as well as the care processes (clinical decision support, care coordination, and population health management) that may be disrupted as a result of variation.

The second chapter drew on the conceptual model to understand the prevalence of one particular form of EHR documentation: variation in what information is documented in the EHR. By focusing on the completion of fifteen different clinical documentation categories (e.g.,

Documentation of Patient Vitals), the study was able to home in on the information that was most variably documented as well as the level of healthcare organization with the most variation. The five most variable clinical documentation categories (Updating the Patient's Problem List; Updating the Social History; Conducting a Review of Systems; Assessing and Diagnosing the Patient; and Reviewing and Discussing Documents with Patients) reflect types of information that could be documented in multiple potential places in the EHR. For example, a Review of Systems is often structured as a component of an admission note covering the patient's organ systems. If the elicited information leads to the identification of a problem or diagnosis, the Review of Systems could instead be documented in the Problem List, as part of the Assessment & Diagnosis, or in some combination of the three categories. Because the majority of the identified variation existed across providers in the same practice, it has the greatest potential to affect the healthcare activities which are based in practices: provision of care to individual patients, coordination with other providers, and management of patients as a panel. This is the first study to examine variation across multiple institutions [1-3] and empirically demonstrate that the majority of variation exists across providers in the same practice and not at other levels of healthcare organization. Furthermore, by revealing that not all clinical documentation categories exhibit the same amount of variation across providers, this study provided further evidence that the variation is likely a result of providers making different decisions about how to use the EHR and not a result of patient factors.

The third chapter expounds on the identification of the most variable clinical documentation categories, using qualitative data to understand providers' perceptions of this phenomenon and how they believe it affects their work. This chapter revealed habitual variation in EHR documentation across users in primary care practices, particularly in documentation of

communication with patients about lab and test results due to differences in user preferences as well as EHR designs which foster variation. While there were recurring efficiency losses from completing redundant documentation or time lost searching for information as a result of all variation, it was the less commonly experienced variation in the frequency and format of entries about patient problems, diagnoses, and clinical assessments that was revealed to have the greatest potential to interfere with healthcare safety and quality. Comprehensive vendor training during implementation, ongoing meetings to reinforce best practices, and improved EHR design to minimize variation may mitigate these risks, but will require ongoing investment by multiple parties to successfully execute. This study was the first to directly elicit providers' perspectives on variation in EHR documentation, as well as the first to explore the effects of variation in EHR documentation can have on healthcare delivery, revealing the widespread nature of this previously hidden the phenomenon. This study was also the first to identify specific strategies to prevent variation, namely in-depth and ongoing training for users paired with EHR redesign to better differentiate similar fields in the EHR.

Taken together, this dissertation documents the relationship between the drivers, expressions, and effects of variation in EHR documentation. The drivers of variations that respondents identified in the third chapter map to factors in the conceptual framework, supporting, for example, the idea that providers' medical training and initial experiences using EHRs continue to influence their styles of documentation in other settings. Similarly, respondents did not identify additional clinical documentation categories, such as documentation of the patient's medication list or vital signs, as being particularly variable in qualitative interviews, bolstering the evidence from analysis of task-log data. Interviews did provide additional nuance to the exploration of effects in the conceptual framework, highlighting

variation's tangible interference with efficiency as more salient to users than the potential for a patient safety event. However, even the low probability of a high-impact event deserves recognition, especially in healthcare and other high-reliability organizations that must operate with small margins for error [4, 5].

Focusing on EHRs' ability to support the provision of status-quo care to individual-patients in the short-term has endangered the provision of evidence-based care to populations of patients in the long-term. EHR use should unmistakably abide by the principle to first, do no harm ("primum non nocere"), but healthcare delivery has advanced beyond privileging the isolated needs of a single physician [6]. Indeed, current policy priorities upset this traditional model, promoting a vision of healthcare delivery in which multiple individuals across institutions share information to fulfill the triple aim of improving the patient's experience of care, the health of populations, and per capita healthcare costs [7]. This vision relies on meaningful use of information technology, particularly EHRs [8, 9]. It is manifest in the patient-centered medical home, a model in which integrated healthcare teams use the same record to find patient information [10]. It is manifest in health information exchanges, a model in which practices share information to ensure complete records inform future care decisions [11, 12]. It is manifest in the accountable care organization, a model in which multiple organizations share responsibility for coordinating and improving patient care [13]. It is manifest in precision medicine initiatives, which promise to deliver tailored recommendations based on the patient genome as well as life experiences [14]. And, finally, it is manifest in the learning health system, a model in which EHR data feeds back to providers to improve patient care and medical science [15]. Variation in EHR documentation inhibits each of these initiatives by obscuring the location and meaning of patient data. The resulting record of patient care is disorganized, making it

difficult to use for manual review of relevant information, automated queries and reports, and integration into larger databases. It is perhaps unsurprising then that practices around the country have long struggled to leverage EHRs in ways that improve healthcare delivery [16-20].

Recommendations for Practitioners

As my work demonstrates, variation in EHR documentation has the potential to increase the overall burden of documentation when users enter information in duplicate or must spend time removing unnecessary information from the EHR. Variation in EHR documentation also has the potential to interfere with care delivery by concealing important information if such actions are not taken. It is therefore important that physician practices develop policies to prevent its emergence or manage its negative effects. Specifically, physician practices must first identify how, if at all, their users are variably recording or removing information in the EHR. Given that I find variation in documentation of patient problems, diagnoses, and provider assessments is most likely to be harmful, practices may want to first focus on these particular clinical documentation categories because of their potential to affect care delivery.

My dissertation also reveals that while some variation in EHR documentation is likely to be innocuous, such as documentation of the Review of Systems, other variation is likely to be insidious, and affect care delivery in ways that are not immediately obvious to providers, clinical staff, and other staff. As a result, practices should examine the effects of variation on processes to deliver care during an encounter, such as providers' efficient review of information for individual patients, as well as processes to manage care delivery across encounters, such as identifying particular patient populations. If practices find variation interferes with the efficiency or quality of these processes, or seems likely to in the future, then better understanding the

reasons for these different documentation styles can help determine which strategies are most likely to be successful. For example, I found that some variation in documentation of patient problems was the result of different philosophies about the value of the problem list, so it may be necessary to discuss the issue at an organizational level to arrive at a consensus about best practices. Providers may also want to appeal to their particular specialty societies, such as the American Academy of Family Physicians or the American College of Physicians, to arbitrate disputes.

I also found that some variation in documentation of patient problems was the result of different processes to update the problem list. It may thus be necessary to consult with EHR vendors about the dependencies in their systems that would be affected by selecting a particular process over another. Regardless of the solution, as I found in my qualitative interviews, explicitly communicating these preferred processes to new staff and reinforcing these decisions at ongoing meetings will be necessary to ensure the stability of new routines [21].

Managing variation will become increasingly necessary due to a shift from episodic, fee-for-service compensation towards population- and value-based payment that leave providers responsible for the downstream consequences of care delivery [22]. Physician practices may run into challenges implementing these recommendations due to physicians' resistance to change, which can even create a sense of loss accompanying adoption of an EHR [23]. Fortunately, the shift in healthcare policy towards population- and value-based payment may serve to call attention to the importance of variation, raising its relevance in the minds of healthcare providers and other EHR users, and thus increasing their receptivity to these managerial solutions.

Recommendations for EHR Vendors

To date, EHR vendors have designed products that maximize fee-for-service billing opportunities [24, 25] and visit-based documentation, rather than longitudinal or population-based documentation [26]. Variation in EHR documentation is one manifestation of this approach, and represents a lens through which vendors may be able to improve their products. Specifically, vendors have an opportunity to create products that support "getting the right care to the right patient at the right time – every time" by collecting and storing the information needed to measure healthcare quality and coordinate care across settings [27].

Vendors may therefore want to collect data from their users to observe how use of their products evolves over time, how it varies across individuals, and how it varies in different settings. While each variant of use may be individually acceptable for fee-for-service billing, the compatibility of these different documentation patterns (or lack thereof) may reveal ways to improve EHR products as well as training during implementation. For example, I found that there was variation in whether or not providers used a comments field affiliated with specific patient problems as well as variation in the processes providers used to update the problem list. In one practice where both of those forms of variation existed, there was the potential for providers to inadvertently remove relevant information. Vendors have the ability to minimize this particular risk through redesign. For example, they could alert providers if they are about to remove free-text comments when they remove a structured problem. They could also minimize variation by creating a specific training-module that describes the different ways to record and remove information in the problem list and highlights the resulting dependencies in the system.

While providers have previously sought flexible EHR designs that would allow them to continue employing documentation techniques that worked for paper records, my results show that some providers were beginning to recognize the downside of an EHR design that

accommodates every potential variant of use. Although payment is currently focused on individual service provision, the increasing number of health reform and pay-for-value programs suggests the market may soon demand vendors create EHR products and training programs focused on the EHR as a team-based tool for evidence-based care delivery, care coordination, and population health management.

Recommendations for Policymakers

Addressing variation in EHR documentation has the potential to improve the utility of information in the EHR and support multiple policy priorities. Although doing so is compatible with federal meaningful use [28] and Medicare Access and CHIP Reauthorization Act priorities [29], practices and vendors may struggle to address such a complex issue on their own. However, the appropriate policy action is questionable in light of providers' sensitivity to additional regulation of their documentation patterns [30] and vendors' fatigue from meaningful use certification [31]. Compounding this challenge facing policymakers is the exploratory nature of the information surrounding the optimal strategies for preventing or managing variation in EHR documentation. Specifically, it is unclear which strategies will be most effective, or the conditions necessary to ensure success.

In the absence of an evidence-based solution to prevent or manage variation in EHR documentation, policymakers can support the infrastructure that will facilitate the identification and implementation of successful strategies. Because my data demonstrate that the majority of variation exists across users within a practice, practice-oriented solutions focused on observing and altering within behavior are likely to be necessary. For example, the Medicare Access and CHIP Reauthorization Act allocates $20 million per year for Regional Extension Centers and

Quality Improvement Organizations to support practices' efforts to participate in Alternative Payment Models such as shared savings programs, Accountable Care Organizations, and Patient-Centered Medical Homes [32]. Specifically directing these entities to incorporate variation in EHR documentation into their technical assistance by measuring its prevalence, organizing training and meetings, and monitoring the effect of such interventions could facilitate the goals of Accountable Care Organizations and Patient-Centered Medical Homes while also creating the data needed to more thoroughly study variation.

Alternatively, because my data demonstrate that some variation in EHR documentation is the result of different philosophies about how to complete documentation, policymakers can spur conversations among providers to create consensus about best documentation processes. For example, federal agencies could request or Congress could mandate that the Health and Medicine Division of the National Academies of Sciences, Engineering, and Medicine (formerly the Institute of Medicine) convene committees, forums, or roundtables focused on variation in EHR documentation. These conversations could better distinguish appropriate from inappropriate variation in EHR documentation, develop recommendations for best practices in documentation, and also develop recommendations for interventions to ensure best practices are followed.

With this additional evidence, policymakers will be able to address variation in documentation more directly. For example, policymakers could incorporate measures of variation in EHR documentation into pay-for-performance and pay-for-value programs to reward practices that take certain actions known to minimize variation. Alternatively, policymakers could reimburse time spent on EHR implementation or ongoing EHR training if such activities are demonstrated to be beneficial at minimizing variation. Policymakers could also use

certification requirements for vendors to standardize the format of certain fields, such as the Problem List, to lessen users' uncertainty.

Directions for Future Research

This dissertation establishes the importance of understanding documentation processes at an organization level, and sets the foundation for future research in several different domains. First, future work should explore the expressions and levels of variation that were not as thoroughly addressed in the empirical chapters of this work. Specifically, scholars should examine variation in who completes documentation and variation in when documentation is completed to better understand its causes, prevalence, and effects. Furthermore, future studies should examine the extent to which there is variation across encounters within individual providers, as well as providers' experiences of variation across organizations. This last issue is likely to be particularly relevant as different specialists' mental models for patient care come in conflict with increased information sharing.

Secondly, scholars should leverage alternate methods to test and extend the findings of this study. Specifically, more detailed task-log data or chart review could illuminate where users store information about certain patient problems, such as diabetes. User surveys could extend the generalizability of the qualitative study, providing additional information about providers' perceptions of variation. Researchers could also build on the experimental model advanced in a recent study of problem list creation [33] to provide alternate measures of variation in documentation patterns. It would also enhance our understanding of variation in EHR documentation to collect longitudinal measures of variation to empirically test the causal relationship between variables such as schedule fluctuations and changes in documentation.

Third, the concept of variation in documentation may prove to be an illuminating variable in other research on EHR implementation and healthcare transformation. For example, longitudinally measuring when variation in EHR documentation tapers may provide important insight into a critical period of EHR implementation when patterns have not yet solidified. This knowledge may then inform the optimal timing of training or other interventions targeting documentation. Moreover, scholars evaluating the efficacy of Accountable Care Organizations and Patient-Centered Medical Homes should be sensitive to the role that variation in EHR documentation may play in undermining the success of these and other innovations in healthcare organization.

Conclusion

EHR documentation is an essential building block of effective EHR use. Understanding the ways in which variation in EHR documentation may interfere with key uses of EHR data (and therefore harm patient safety, evidence-based care delivery, productivity, and population health) is critically important to ensure that EHR adoption translates into better care. Equally important is the identification of effective strategies to mitigate potentially harmful variation in EHR documentation. My use of mixed-methods yields a multi-faceted understanding of this foundational component of EHR use. By combining creation of a conceptual framework, multi-level modeling of a national sample of primary-care practices, and qualitative interviews with a diverse sample of primary care practices, my dissertation demonstrates the inefficiencies and risks to overall safety and quality from variation in documenting patient problems, diagnoses, and clinical assessments across providers in the same primary care practice.

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