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Does the meaningful use of electronic health records improve patient outcomes?

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ABSTRACT

While Electronic Health Records (EHRs) hold the promise of improving patient outcomes, past research on their efficacy has yielded inconsistent results. In this study, we overcome several drawbacks of past research by examining not just partial versus full adoption, but the impact of meaningful assimilation of EHRs as mandated by the HITECH (Health Information Technology for Economic and Clinical Health) Act. Detailed patient-level data from acute-care hospitals in California, coupled with relevant data from several other sources, is used to conduct our analysis. After controlling for self-selection bias, our results show that overall length of stay (LOS) is reduced by 3%, on average, for all patients who undergo treatment at hospitals that are meaningful-use assimilated, relative to patients at hospitals that have fully adopted EHRs. The magnitude of this reduction is increased for patients with greater comorbidity complexity and greater coordination complexity. In addition, we find an overall decrease in readmission. We do not find such benefits among full adopters of EHRs. Thus, our study provides empirical evidence that instead of merely adoption, assimilation of EHRs at a hospital-wide level can improve the efficiency with which patients are treated, with benefits from such an assimilation being far more pronounced for patients with a greater degree of health complexities. These are important findings, because hospitals are struggling to deliver quality care to their sickest patients without severe cost overruns. Recommendations from our study point to a path forward in meeting this challenge.

1. Motivation

The importance and benefits of information technology (IT) in improving the efficiency and quality of customer-facing operations has been highlighted in previous literature (Froehle and Roth, 2004). Firms in industries such as telecommunications, retail, etc. have seen some benefits as a result of widespread use of IT throughout their organizations (Bower, 2005). Despite this enhancement, there is increasing pressure to justify how such investments create value for businesses (Zhu et al., 2006). As noted by Fichman and Kemerer (1999) (p. 256), "A new technology may be introduced amid great enthusiasm and enjoy widespread initial acquisition, but nevertheless still fails to be thoroughly deployed among many acquiring firms." As a result, scholars have started investigating the "innovation diffusion" aspect of IT, which goes beyond just adoption and focuses on topics related to factors affecting the usage and value of IT (Armstrong and Sambamurthy, 1999; Fichman, 2000; Purvis et al., 2001; Chatterjee et al., 2002; Zhu and Kraemer, 2005; Liang et al., 2007; Sodero et al., 2013). This debate on the efficacy of IT is even more acute in healthcare, which comprises nearly 20% of the United States' gross domestic product (GDP) (Berwick and Hackbarth, 2012). While healthcare has adopted various information technologies, none have received the kind of scrutiny that electronic health records (EHRs) have received. Researchers generally agree that EHRs, if used correctly, have the potential to transform healthcare delivery through the use of evidence-based medical guidelines and efficient coordination of patient treatment and care (Jha et al., 2009a,b; Blumenthal and Tavenner, 2010). Despite EHRs' potential to improve the efficiency and effectiveness of care, its adoption had been notoriously slow among US hospitals, with less than 10% of US hospitals reporting a comprehensive EHR system across all clinical units in 2009 (Jha et al., 2009a,b). In order to overcome barriers and accelerate the adoption of EHRs, the Health Information Technology for Economic and Clinical Health (HITECH) Act was introduced in 2009 (US Department of Health and Human Services, 2009). Under this Act, the government committed $27 billion to incentivize hospitals and clinicians to not only adopt, but also meaningfully use, EHRs. Through this HITECH Act, the government also set a high bar for healthcare providers to improve quality through the use of scientifically supported

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decision support systems and sharing of data to reduce costs. The adoption rates for basic EHRs climbed to 80% by 2015 (Office of the National Coordinator for Health Information Technology, 2016) due to the enactment of HITECH. It can be viewed as a mandate on IT adoption and assimilation, i.e., "the extent to which the use of technology diffuses across the organizational projects or work processes and becomes routinized in the activities of those projects and processes" (Purvis et al., 2001, p. 121). Does such a mandate on the meaningful use of these systems really improve patient outcomes, given that past studies have not found overwhelming support from the adoption of EHRs on outcomes? This remains an open empirical question.

We use Information Processing Theory (IPT), along with relevant literature on IT assimilation, to investigate whether a hospital-wide IT assimilation, as measured by the meaningful use of EHRs arising from the passage of the HITECH Act, has improved the effectiveness with which hospitals treat patients. By creating and contrasting three groups of hospitals – partial-EHR adopters, full-EHR adopters, and meaningful-EHR assimilators, we fill a critical gap in past healthcare studies which have almost exclusively focused on the adoption of EHRs, but not its actual assimilation. See Appendix A for more details. In addition, while previous studies have looked at the factors that impact adoption of IT and subsequent performance in a voluntary environment, we investigate the benefits of IT assimilation in a mandated environment. Another major limitation of previous healthcare studies is that they use adoption as a metric for IT assimilation, but this measure is ambiguous on the extent of adoption and use of EHRs within a given hospital. Furthermore, IT adoption and assimilation studies, in general, have relied on survey data or case studies to capture this important metric (Armstrong and Sambamurthy, 1999; Fichman, 2000; Purvis et al., 2001; Chatterjee et al., 2002; Premkumar et al., 2005; Gattiker and Goodhue, 2005; Zhu and Kraemer, 2005; Liang et al., 2007; Sodero et al., 2013) In contrast, by using a government dataset that provides a list of IT assimilators using a well-defined set of measures, we overcome a major limitation of self-reporting bias in the data. Limitations in healthcare studies also arise from a narrow focus on specific medical conditions, aggregate hospital-level data, and use of clinical outcomes (e.g. mortality, readmissions) that may require a well-established health information technology that a majority of hospitals lack (Jha et al., 2009a,b). By considering a wider patient population, we seek to shed light on whether the meaningful use of EHRs is beneficial to patients.

According to IPT, a key challenge for organizations is managing uncertainty, one important form of which can be task complexity (Galbraith, 1973, 1977; Tushman and Nadler, 1978). As task complexity increases, decision makers face greater cognitive loads and may possibly seek tradeoffs between decision accuracy and decision-making time (Johnson and Payne, 1985; Speier et al., 2003). Unlike other industries, such as telecommunications, manufacturing, retail, and e-commerce, where products and services can be standardized to a great extent, every patient is unique, which puts greater challenges of providing personalized care on healthcare providers. But previous healthcare studies have also not taken into account various types of patient complexities in their analysis. This is important to investigate, because, in a knowledge-intensive industry like healthcare, diagnosing a patient's condition and treating it effectively is a complex task due to the fact there are currently about 13,600 diagnoses with 6000 drugs and 4000 procedures to treat these diagnoses (The New Yorker, 2011). In addition, the US has adopted the International Classification of Diseases (ICD) 10 codes since 2015, which permits tracking of up to 14,400 different codes associated with various diseases, causes, and symptoms (Centers for Medicare and Medicaid Services, 2015). Comorbidities such as hypertension, diabetes, obesity, etc. are increasing in the United States, and clinicians have to take these factors into consideration while designing effective treatment plans. Given the heterogeneity and complexity that healthcare providers face, does the value of meaningful-EHR assimilation increase or decrease with increasing patient complexity? We conduct a thorough examination of the arguments that associate meaningful use of EHRs with improved operating efficiency.

To answer our research questions, we conducted a longitudinal study using patient-level data from 2010 to 2013 from all acute-care hospitals in California, and a new dataset from the Medicare EHR Incentive Program (with data on meaningful-use hospitals available from 2011 onwards). Our econometric model of patient length of stay and readmission is based on multiple datasets, including detailed patient data containing important patient-level controls and patient-specific conditions which help us account for a multitude of factors that may affect outcomes. One of the key challenges in measuring the effect of EHR assimilation on patient outcomes is the presence of self-selection bias, which requires us to model a hospital's decision to pursue meaningful-use attestation sooner, rather than later. It is possible that hospital factors associated with earlier adoption of such EHRs may play a role in earlier attestation of meaningful use of EHRs. Financial incentives also progressively diminish if hospitals delay attestation for meaningful use of EHRs. Without controlling for this endogenous selection process, the impact of EHR assimilation on outcomes may be biased. Our analysis explicitly deals with the endogeneity inherent in self-selecting to attest for meaningful use sooner. Our model and related analysis thus offer a new perspective on this issue that has captured the attention of healthcare providers, policymakers, and academicians over the last few years. More specifically, to the best of our knowledge, this is one of the first healthcare studies to empirically use objective secondary data to show that meaningful-EHR assimilation in a mandatory environment can transform healthcare delivery through the use of built-in, evidence-based medical guidelines, efficient coordination of patient treatment and care, and reduction of a health care provider's cognitive load when working on complex tasks.

The remainder of our paper is organized as follows: In Section 2, we discuss the problem background on the meaningful use of EHRs, followed by a review of the relevant literature in Section 3. Our hypotheses are described in Section 4. Data description and the econometric model used in this paper are in Sections 5 and 6, respectively. We present our results, robustness test, and post-hoc tests in Section 7, and conclude with a discussion of implications for research and practice in Section 8.

2. Background on the meaningful use of electronic health records

The HITECH Act was passed in October 2010 to encourage hospitals to not just adopt EHRs, but also use them meaningfully. Full details of the meaningful use program can be found at Healthit.gov (2013), but we provide a brief summary below.

The EHR initiative is rolled out in three stages. In the first stage, which is the focus of this paper, hospitals have to "successfully attest to demonstrating meaningful use of certified EHRs to qualify for an incentive payment scheme through the Medicare EHR program administered by the Centers for Medicare and Medicaid Services (CMS)" (Healthit.gov, 2013). Hospitals must demonstrate *use of EHRs* at the hospital-wide level to receive financial incentives. This use includes capturing patient information electronically in a standardized format, using patient information to track key clinical conditions, integrating test and imaging results and using decision support tools, communicating the information to all providers for the purposes of care coordination, initiating reporting of key clinical quality measures, and, finally, using the information to engage families and patients in their care. For the successful attestation of first stage of EHRs, which measures how well EHRs have been assimilated, hospitals are also required to maintain a current list of diagnoses, maintain active medication and allergy lists, implement drug-drug and drug-allergy checks, record vital statistics and demographics, enter medication orders electronically for at least 80% of their patients, and provide electronic copies of health records and discharge instructions for at least 50% of patients. Based on the certification requirements, EHR depends not only on demonstrating

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