



# Electronic health record implementation and hospitals' total factor productivity



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## ARTICLE INFO

Available online 6 October 2012

### Keywords:

EHR  
HIT implementation  
Data envelopment analysis  
Hospitals  
Meaningful use

## ABSTRACT

The adoption and implementation of electronic health record (EHR) systems have been widely promoted as a means for improving health care delivery and controlling costs in U.S. hospitals. To date, the results of efforts to adopt such systems have been mixed and often unsuccessful. This paper uses frontier analysis to measure hospitals' Total Factor Productivity (TFP) during 2006–2008 and compare it to nine different stages of EHR implementation. Overall, we find that hospitals implementing EHR systems have lower TFP gains relative to those facilities that have as yet to adopt. In particular, hospitals that attempt to fully implement an EHR in one year, the 'Big Bang' strategy, have relatively low TFP levels. Therefore, the anticipated savings from increased EHR use may not be realized in the near-term for EHR system adopters. Moreover, an evidence-based approach to developing the 'Meaningful Use' incentive and reward program for EHR implementation is warranted.

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## 1. Introduction

The U.S. healthcare system is far more costly to operate on a per capita basis than that of any other industrialized nation, many of which achieve comparable or superior clinical outcomes. One of the primary explanations offered for this excessive cost difference is the poor care coordination within U.S. hospitals. For example, both the duplication of diagnostic tests [32] and ordering unnecessary tests [37] could be avoided with better health information management. Further, as much as 20%, and perhaps more, of hospitals' lab orders are either unnecessary duplications or inappropriate requests that could be avoided [22,32]. In 2008, Peter Orszag, the Director of the Congressional Budget Office, estimated that five percent of the nation's GDP, about \$700 billion dollars per year, goes towards tests and procedures that do not improve health outcomes [30]. When one considers that the total cost of health care in the U.S. is estimated at 17%, this assessment implies that 30% of all healthcare expenses do not improve health outcomes. The difference in these numbers suggests an assessment on the costs associated with potential savings related to the 'Meaningful Use' of health information, such as avoiding medical errors, and the magnitude of the avoidable costs becomes much larger.

With the potential to create healthcare cost savings in the billions, electronic health records (EHRs) are considered a critical component of reform efforts [14]. Yet, despite the potential savings, EHR adoption is not widespread in U.S. hospitals [29]. Moreover, in most facilities where EHR systems have been adopted, the implementation is often incomplete. The slow uptake of EHRs has been attributed to the systems'

high costs, the significant change to a hospital's work processes that are required for the implementation and the major culture shift it represents for health professionals. Such factors can disrupt an EHR implementing facility's productivity in the short term. However, in the long run it is still assumed that EHRs will produce productivity gains for both individual hospitals and the health sector as a whole. To address these short-term costs, the Office of the National Coordinator for Health Information Technology introduced an EHR 'Meaningful Use' program in 2009 to reward and incentivize the systems' adoption and implementation in hospitals by 2014 [13]. As a result, EHR adoption strategies have been the subject of much discussion in the literature. One such taxonomy used by Jha, et al. [29] has sought to explore the state of the moment in terms of EHR adoption.

The purpose of this study is to measure EHR implementation's impacts on hospitals' efficiency change, technological process change and total factor productivity in the short term. The study uses a three-step process to assess hospitals' EHR implementation strategies in the early part of the Meaningful Use era. First, the taxonomy described by Jha et al. [29] is extended into a longitudinal form to classify hospitals' progress towards full EHR implementation over time. Next, frontier analysis is used to measure U.S. hospitals' productivity gains from 2006 through 2008 (3 years). In particular, the Malmquist Total Factor Productivity (TFP) index and its underlying indices, Technical Efficiency Change (EFFCH) and Technological Change (TC) are calculated. Finally, the longitudinal EHR implementation stages taxonomy is analyzed in relationship to the productivity change measures. The results and a discussion of their implications are presented last.

This research makes important contributions to the health policy, administration, and research literatures. With the large-scale investments made by the Federal Government to promote the Meaningful

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Use of health information technologies (HITs), there is a need to understand the implications of accelerating hospitals' EHR implementation on productivity [3,5], especially since meaningful use is a longitudinal reward system. While benefits may be gained from more extensive EHR use in the long term, the short-term EHR implementation impacts on facilities' EFFCH and TC can be significant relative to non-adopting facilities. For managers, healthcare executives and their boards of directors, empirically demonstrating the link between a sustained and incremental commitment to EHR use and its long-term positive relationship with productivity is an important aspect of promoting behavioral change in professional workforces who are often resistant to external pressures.

For researchers, the extension of the hospital EHR implementation taxonomy to a longitudinal measure increases its utility. In particular, the Meaningful Use reward and incentive program has multiple stages that are linked to varying levels of EHR use. Therefore, having an EHR implementation taxonomy that aligns with the Meaningful Use program's staged approach brings the outcomes experienced by hospitals into alignment with the rewards potentially garnered. A second important contribution is the use of frontier analysis to explicitly link a public policy initiative to the performance of the targeted organizations [26]. Assessing the impact of major programs, such as the Meaningful Use initiative, is difficult because there are varied outcomes – both intended and unintended. While this is not the first study employing productivity analysis in health care, it adds to the body of knowledge about how to assess various EHR implementation protocols, over time, in different organizational settings.

## 2. Literature and policy reviews

EHR systems were first introduced in 1969 and have been evolving ever since [21]. In 2007 and 2008, The American Hospital Association (AHA) measured four major classes of EHR sub-systems that were anticipated to be part of the Meaningful Use program. The most frequently discussed of these classes is Computerized Provider Order Entry (CPOE), which includes electronic prescribing (ePrescribing or eRx) because of the significant role medication errors play in compromising care quality [49]. The second major EHR application is 'Decision Support', which is designed to facilitate adherence to clinical guidelines and the avoidance of errors, such as drug–drug interactions, by providing real-time feedback to EHR users. The use of those systems has been slow to take hold because it is difficult to get large groups of physicians to agree on standardized regimens of care [45].

The third major class of EHR application is 'Results Management'. Such systems are the most widely adopted EHR application because physicians and nurses value the timeliness of electronic results management compared to paper-based systems [7]. Further, results management systems require very little organizational change to implement because most of the work is confined to a few specialized units that already rely on other HITs to conduct their work. Front-line employees are, by-and-large, passive information consumers as it relates to results management.

The last major class of EHR applications is related to 'Patient Health Information'. Electronic patient health information involves collecting demographic measures, important health history events (e.g., prior surgeries), immunizations records, drug allergies and other data in a structured format. Having patient health information in a structured database is critical to the function of an effective decision support application. For example, knowing a patient's allergies provides critical information about potential adverse reactions to many classes of drugs. In order for patient health information to be effectively managed, HIT systems from physicians' offices, health insurance companies, hospitals and other healthcare organizations must all share data. A complete, patient-centered record therefore requires robust interoperability in an EHR system, beyond individual clinical applications.

Ensuring effective EHR interoperability with other HIT applications is a significant challenge [34]. With a growing number of reports of costly EHR implementation failures [23], there is a reticence to adopt and implement EHR systems that may engender yet another failure or negatively impact productivity in either the short or long term. The ability to integrate EHR data into existing HITs, such as legacy billing systems that were not originally built to handle laboratory data, can slow adoption. The inherently networked nature of HIT systems makes their coordinated adoption more complicated than stand alone technologies and thus slowed their widespread adoption [15]. As a result, the full implementation of a high performing EHR system therefore requires extensive workflow redesigns across the entire organization. The high start-up costs for HIT adoption and resistance to change that accompanies their implementation lead many administrators to take a wait-and-see approach rather than joining the 'bleeding edge' of the earlier adopters. The potential negative impacts that implementing EHR solutions can have on their organizations' productivity was seen as such a significant issue that the AHA successfully petitioned the Office of the National Coordinator for Health Information Technology to delay pressing for early 'Meaningful Use' of some EHR applications requirements being promulgated as part of the Patient Protection and Affordable Care Act [44].

This is not to say that the challenge of change is insurmountable. There are several factors helping to accelerate EHR adoption and implementation. First, as younger physicians are brought into the clinical community, they bring with them an increased familiarity with EHRs. Many medical residents have never used a paper-based health record system. As a result, the medical field is experiencing an evolutionary shift in their expectations for clinical systems in the hospital environment, creating new internal influences on technology innovation [19]. As this new generation of end-users systematically replaces the retiring cohort of physicians, it is likely that their generation of physician-users will accelerate EHR adoption through their expectations and experiences.

A second factor supporting increased adoption is the labor savings that hospitals may realize by eliminating unnecessary duplication of services such as laboratory orders. Consider the labor costs associated with a laboratory order. Sometimes the nursing staff must prepare the patient for an initial procedure (e.g., X-rays, blood draws, and other screening). Laboratory procedures may then require the patient be moved to another part of the facility (e.g., radiology) to be examined. Such movements require the coordination of resources, and constitute a patient hand-off, which is a source of potential medical errors that can prove costly [8]. Even when laboratory orders do not require the patient to be moved, the nursing staff is often redirected from care of other patients as they become involved in completing the order. In either case, unnecessary laboratory orders represent both direct and indirect costs to the nursing staff and a reduction of duplicative orders is a potential source of significant savings. The more readily measured cost of unnecessary or duplicate laboratory orders is within the lab itself. While the materials needed to conduct laboratory tests can be expensive, it is typically the technician's compensation that constitutes the major cost. Unnecessary testing creates avoidable expenses. In an environment where hospitals are remunerated through the use of capitated payments, such additional costs cannot be passed through to the purchaser. These costs must therefore be absorbed by the hospital and result in a concomitant reduction of the operating profit of the facility.

Coordinated EHR implementation also increases the availability of information that can be used to demonstrate service delivery and support billing claims. As greater documentation of clinical activities is required for reimbursement, it becomes increasingly impractical to have manual, post hoc entry of orders and other diagnostic information. Medicare has begun the process of requiring providers to track patient outcomes as part of its reimbursement program [4,47]. Patients that are re-admitted to a hospital within thirty days of

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