International Journal of Medical Informatics 109 (2018) 87–95

Contents lists available at ScienceDirect

International Journal of Medical Informatics

journal homepage: www.elsevier.com/locate/ijmedinf

Health IT and inappropriate utilization of outpatient imaging: A cross-sectional study of U.S. hospitals

Ajit Appari[a,*], M. Eric Johnson[b], Denise L. Anthony[c]

[a] Department of Management, Policy, and Community Health, UTHealth School of Public Health, 1200 Pressler Street, Suite RAS W-310, Houston, TX 77030, United States
[b] Ralph Owen Dean and Bruce D. Henderson Professor of Strategy, Owen Graduate School of Management, Vanderbilt University, United States
[c] Department of Sociology, Dartmouth College, United States

ARTICLE INFO

Keywords:
Stage-1 meaningful use capability
Imaging services
Hospital outpatient facilities
Cross–sectional Analysis
Generalized linear model

ABSTRACT

Objective: To determine whether the use of information technology (IT), measured by Meaningful Use capability, is associated with lower rates of inappropriate utilization of imaging services in hospital outpatient settings.
Research design: A retrospective cross-sectional analysis of 3332 nonfederal U.S. hospitals using data from: Hospital Compare (2011 outpatient imaging efficiency measures), HIMSS Analytics (2009 health IT), and Health Indicator Warehouse (market characteristics). Hospitals were categorized for their health IT infrastructure including EHR Stage-1 capability, and three advanced imaging functionalities/systems including integrated picture archiving and communication system, Web-based image distribution, and clinical decision support (CDS) with physician pathways. Three imaging efficiency measures suggesting inappropriate utilization during 2011 included: percentage of "combined" (with and without contrast) computed tomography (CT) studies out of all CT studies for abdomen and chest respectively, and percentage of magnetic resonance imaging (MRI) studies of lumbar spine without antecedent conservative therapy within 60 days. For each measure, three separate regression models (GLM with gamma-log link function, and denominator of imaging measure as exposure) were estimated adjusting for hospital characteristics, market characteristics, and state fixed effects. Additionally, Heckman's Inverse Mills Ratio and propensity for Stage-1 EHR capability were used to account for selection bias.
Principal findings: We find support for association of each of the four health IT capabilities with inappropriate utilization rates of one or more imaging modality. Stage-1 EHR capability is associated with lower inappropriate utilization rates for chest CT (incidence rate ratio IRR = 0.72, p-value < 0.01) and lumbar MRI (IRR = 0.87, p-value < 0.05). Integrated PACS is associated with lower inappropriate utilization rate of abdomen CT (IRR = 0.84, p-value < 0.05). Imaging distribution over Web capability is associated with lower inappropriate utilization rates for chest CT (IRR = 0.66, p-value < 0.05) and lumbar MRI (IRR = 0.86, p-value < 0.05). CDS with physician pathways is associated with lower inappropriate utilization rates for abdomen CT (IRR = 0.87, p-value < 0.01) and lumbar MRI (IRR = 0.90, p-value < 0.05). All other cases showed no association.
Conclusions: The study offers mixed results. Taken together, the results suggest that the use of Stage-1 Meaningful Use capable EHR systems along with advanced imaging related functionalities could have a beneficial impact on reducing some of the inappropriate utilization of outpatient imaging.

1. Introduction

Inefficient utilization of healthcare services, especially inappropriate utilization, contributes significantly to the rising cost burden of the U.S. healthcare system [1–3] while exposing patients to higher health risks [4,5]. Inappropriate utilization refers to use of health services without benefits or when potential for harm exceeds the potential for benefit [6–10]. Throughout much of the 2000s, medical imaging services utilization grew at a higher rate than most other types of services for Medicare patients [11,12] with for-profit hospitals having higher utilization rates than nonprofit hospitals [13]. However, this growth rate has recently reduced likely due to the adoption of the fee-capping structure under the Deficit Reduction Act of 2005 and other payer initiatives like prior authorization and increased cost sharing [14–16]. Researchers at the American College of Radiology argued that this slow-down in imaging may also be the result of a confluence of factors such as the maturation of imaging technology and market saturation, diffusion of best practice guidelines and increased physician

* Corresponding author.
E-mail address: Ajit.Appari@uth.tmc.edu (A. Appari).

https://doi.org/10.1016/j.ijmedinf.2017.10.020
Received 4 October 2016; Received in revised form 24 October 2017; Accepted 29 October 2017

and patient awareness of radiation exposure, as well as the increasing use and availability of clinical decision support tools and information technology for sharing imaging reports [15]. However, the large variation in imaging services across regions and providers suggests some possibility of inappropriate utilization of imaging services [17–20]. Notwithstanding this slow-down in the imaging utilization growth, the Center for Medicare and Medicaid Services (CMS) continues to be concerned with the high volume of imaging services and their potential adverse impact to Americans [21]. In June 2010, the CMS introduced public reporting of inappropriate outpatient imaging rates as quality measures to incentivize hospitals in reducing unnecessary exposure to contrast materials or radiation [22].

The 2009 HITECH Act committed $27 billion dollars on an incentive-based program for organizations to achieve "Meaningful Use" of certified EHR technology [23]. This program requires incentive recipients to attest and demonstrate compliance with the use of an increasing set of functionalities in multiple phases. Stage-1 Meaningful Use (MU) criteria, in effect since 2011, required electronic recording of patients' health information and demographics, application of basic clinical decision support tools, electronic ordering, providing health information to patients, and reporting of quality measures to public agencies [24]. Subsequently, the Stage-2 requirements, effective from 2014, include several additional requirements such as electronic radiology orders, transmission of electronic prescriptions, structured lab results, and making imaging results and reports available through certified EHR technology [25]. Though attestation to Stage-1 MU requirements in the initial year has been moderate among hospitals [26,27] and physician organizations [28], the widespread diffusion of advanced health IT functionalities that facilitates timely access to images and imaging reports are expected to reduce repeat and other inappropriate uses of imaging tests [15]. For example, recent studies reported that the adoption of order entry systems with decision support leads to a substantial reduction in imaging growth [29], including reduction in undesired imaging tests [30]. However, such evidence is limited to single institution–based studies. Further, although major strides have been made in the development of measures for (systematic) inappropriate utilization of different healthcare services [7,31], research on the determinants of inappropriate utilization including structural characteristics of providers continues to be a critical gap. Researchers have called for more research to inform ongoing U.S. healthcare reform to better target lowering of inappropriate utilization in the US healthcare system [32].

In this retrospective observational study, our primary focus is to examine the relationship between hospitals' health IT infrastructure capable of meeting EHR Stage-1 Meaningful Use criteria and the use of additional imaging related functionalities, applicable for future stages of MU criteria, with their performance on the inappropriate utilization of outpatient imaging services. We analyzed data on 3332 nonfederal U.S. hospitals providing outpatient care that reported imaging efficiency measures for the period January-December 2011, capturing potentially inappropriate utilization. The measures include abdomen CT scan, chest CT scan, and lumbar MRI scan. The CT scan measures refer to the percentage of patients administered double scans, i.e. with and without contrasting agents, within a year when either one would have been adequate. The MRI scan refers to patients receiving MRI scan without documentary evidence of conservative therapy within 60 days. Hospitals were categorized by their health IT infrastructure based on the 2009 operational status of several clinical applications for EHR Stage-1 capability, and three advanced imaging functionalities/systems including integrated picture archiving and communication system (PACS), Web-based image distribution, and clinical decision support (CDS) with physician pathways. We analyzed the data using a generalized linear model with gamma–log link in STATA 14.2 for each imaging measure separately. In each regression, we adjusted for hospital characteristics, market factors, and state fixed effects to account for unobserved factors that vary by state. Additionally, we used Heckman's approach (inverse Mills Ratio as covariate) [33] to account for selection bias arising from certain hospitals not reporting imaging measures (i.e., our dependent variables) or reported measures that did not satisfy the minimum threshold of denominator size. Finally, we included a propensity score adjustment (as inverse probability treatment weight) accounting for endogeneity bias arising from certain hospitals that were early adopters of Stage–1 EHR capable systems (i.e., our 'treatment' variable) [34].

The study contributes to the literature in several ways. First, unlike prior research, our study is one of the first to employ a national sample of nonfederal hospitals to examine the influence of structural characteristics, specifically health IT capability satisfying the Stage–1 Meaningful Use requirements and advanced imaging functionalities, on hospital performance on select outpatient imaging measures that indicate potentially inappropriate utilization. Second, from a policy perspective, especially in the context of the ongoing EHR incentive program and recent reforms in payment policies, our study finds an association between the adoption of advanced EHR systems and lower rates of inappropriate imaging utilization.

2. Methods

2.1. Data sources

Our sample includes 3332 nonfederal acute care hospitals based on data drawn from multiple sources. Data on the operational status of health IT applications came from the 2009 release of Health Information Management Systems and Society (HIMSS) Analytics. HIMSS data on hospital IT has been extensively used in health IT research [35–39]. Data on hospital outpatient imaging utilization rates and corresponding denominator over the calendar period January-December 2011 came from the September 2012 release of Hospital Compare. We did not include data from later periods because Hospital Compare does not report denominator volumes (number of beneficiaries associated with imaging measures) for facilities in the post 2011 period that are essential to adjust for facility-level heterogeneity. We matched the 2009 health IT data from HIMSS to 2011 hospital imaging data from Hospital Compare. Employing this time lag between technology data and imaging performance is a strategy used in prior health IT research [36–41] to avoid an overlap of the performance measurement period with the initial adoption and deployment of new technology. Finally, the Provider of Service file was used for hospital factors and data on market-level imaging utilization rates were obtained from the Health Indicator Warehouse (http://healthindicators.gov) with markets being defined as 306 hospital referral regions (HRR) [42].

2.2. Measurement of imaging

We focused on three types of hospital outpatient imaging services identified by the Centers for Medicare and Medicaid Services (CMS) to capture the quality of outpatient imaging services for the purpose of promoting "high quality efficient care": abdomen computed tomography (CT) scan, chest CT scan, and the magnetic resonance imaging (MRI) of the lumbar spine [22]. CT scanning technology uses multiple x-rays to produce detailed pictures of the body site under investigation. For some patients, contrast agents may be administered either orally or through injection into the veins to highlight areas under investigation. These contrast agents could potentially harm kidneys or cause allergic reactions. Many times, patients are given "combination" CT scans, i.e., one without the contrast agent followed by a second with the contrast agent. The radiation exposure from a single CT scan of the abdomen is about 11 times higher than ordinary x-ray whereas for chest it can be as much as 350 times higher [22]. Clearly, combination scans would double the radiation exposure. Standards of care for CT scans suggest that although combination scans are useful for some medical