Does the Adoption of EMR Systems Inflate Medicare Reimbursements?

Kartik K. Ganju
Department of Information Systems
Fox School of Business, Temple University, 1810 N. 13th Street, Philadelphia, PA 19122, USA
kartik.ganju@temple.edu

Hilal Atasoy
Department of Accounting
Fox School of Business, Temple University, 1810 N. 13th Street, Philadelphia, PA 19122, USA
hilal.atasoy@temple.edu

Paul A. Pavlou
Department of Information Systems
Fox School of Business, Temple University, 1810 N. 13th Street, Philadelphia, PA 19122, USA
pavlou@temple.edu

Abstract

The adoption of EMR systems has been argued to lead to physicians "upcoding" their patients to inflate insurance reimbursements. In this paper, we examine if the adoption of the Clinical Physician Order Entry (CPOE) system is associated with an increase in the complexity of the patients' case mix that hospitals report (termed "upcoding"). We make use of a staggered roll-out of the Recovery Audit Program to combat upcoding as a natural experiment to assess the impact of the adoption of the CPOE systems on the case mix that a hospital reports. We find that on average the adoption of CPOE systems is associated with an increase in the reported case mix of hospitals, and that the Audit program has had an effect on reducing the case mix that hospitals report to Medicare for reimbursement. Implications for preventing inflated reimbursements due to "upcoding" are discussed.

Keywords: Healthcare IT, Upcoding, Case Mix

Introduction

The adoption of EMR systems in hospitals in the US has been rapid in the last decade. While in 1996, 13% of hospitals had systems that would enable them to store clinical data in real time, by 2009, about 80% of hospitals had this capability (Dranove et al. 2012). The adoption of EMR systems has further been incentivized by the HITECH Act that provides $34 billion in incentives to hospitals to adopt EMR systems, while it penalizes hospitals that do not comply.

One of the main EMR systems is the Clinical Physician Order Entry (CPOE) system. This system enables physicians to electronically enter, store and share data. The CPOE system often allows physicians to electronically order medications – thus replacing the traditional methods. Additionally, the system allows physicians to store patient information electronically and it facilitates the correction of misspelt drug names. Besides, the CPOE system is often connected up with the Clinical Decision Support System (CDSS) to identify mistakes that may have occurred and checks for possible drug interactions that may be harmful. The electronic storage of information that can then be processed by the system and the associated communication of information has led to a greater adherence to guidelines-based care (Overhage et al. 1997), a reduction in the medication errors and adverse drug events (Bates et al. 1998), and a decrease in the physicians prescribing the inappropriate dose to patients (Chertow et al. 2001).

Despite the positive effects of CPOE systems, there has been anecdotal evidence of the effect that the adoption of these EMR systems has on allowing physicians to "upcode" the patients they treat (Abelson et al. 2012). "Upcoding" is the labeling of the patient diagnosis as more complex than what it actually is in order to unlawfully increase the reimbursements from the insurer. The adoption of CPOE systems has

enabled this practice by allowing physicians to cut and paste the same examination findings across patients to show more detailed examination histories than they actually exist, to generate detailed patient histories and to easily check a number of boxes simultaneously to indicate that the physician conducted a number of additional tests (Adler-Milstein et al. 2014; Bukata 2013; Li 2014) .

Recently, the Secretary of Health and Human Services, Kathleen Sebelius and the attorney general Eric Holder Jr., warned hospitals to refrain from the practice of upcoding. Although the practice is unethical and is openly discouraged, hospitals are reimbursed from Medicare using a trust or "honor" mechanism (although hospitals can subsequently be audited). However, the letter warned that the practice is illegal and warned hospitals to refrain from submitting false documentation to increase their reimbursements (Reed et al. 2012). Other insurers have already started dealing with this issue. A Medicare administrator, the National Government Services (NGS) warned doctors against the practice of "cloned documentation," warning them that it could lead to denial of service (Yale Medical Group 2012) and other penalties.

The adoption of CPOE systems by hospitals coincides with a staggered rollout of a National Audit program across the US. Initially implemented in California, Florida and New York, the program uses 'recovery auditors' to examine hospital data and identify overpayments and underpayments that have been made to service providers. The auditors were specifically tasked with identifying "[if the] submitted service was upcoded" (Centers for Medicare & Medicaid Services n.d.). After the demonstration resulted in $900 million in overpayments that were returned to Medicare, the program was expanded to all 50 states.

In this study, we examine if there is a change in the complexity of patients that hospitals report after they adopt CPOE systems. We argue that evidence of hospitals reporting a more complex set of patients after the adoption of CPOE systems is evidence that the hospitals may be "upcoding" their patients. Finally, we make use of the National Audit Program that was initiated by the Medicare trust during our analysis period to assess the impact that the audit program had on the reporting of case complexity.[1] Using a fixed effects estimation, a falsification test, a spillover effect and using the external shock of the audit program that was implemented, we first show that there is indeed a change in the complexity of the patients that hospitals report after the adoption of a CPOE, and we then extend our analysis to examine the effect of the audit program on the upcoding practices of hospitals. We hope that our research contributes to provide a better understanding of the role that the adoption of the CPOE system has had on upcoding in hospitals.

Previous Research

With the adoption of EMR systems in the last two decades by hospitals in the United States, researchers have attempted to understand the effect of the adoption of these systems on hospitals. Broadly, the literature has studied the effect of five EMR technologies that are typically grouped into a basic set of EMR technologies and an advanced set of EMR technologies. The set of basic systems that we analyze consists of Clinical Data Repository (CDR), Clinical Decision Support System (CDSS) and Order Entry (OE) system. The CDR is a data warehouse that stores patient data in real-time from a number of different clinical sources. The repository can be set up to store information about the history of patient conditions, diagnosis and treatments, demographics, as well as data on images and reports that have been generated during the various visits that a patient may have undertaken. The Clinical Decision Support System (CDSS) supports the physician in making decisions regarding the patient diagnosis and treatment. The system can alert physicians to possible drug interactions that may be harmful and to side-effects that may be present. The Order Entry (OE) system allows physicians to co-ordinate the delivery of drugs with the pharmacist.

Advanced EMR systems include the Physician Documentation (PD) system and the Clinical Practitioner Order Entry (CPOE) system. The physician documentation system is an automated interactive system to help physicians increase the accuracy and completeness of their documentation in their patient diagnosis, and the data that they require to complete the evaluation of the patient and to complete the claims that would be needed to be submitted for reimbursement (Nuance 2015). The system works by automating the workflow and enabling the input of structured data to enable communication among the various stakeholders, allow for easier reimbursements, enable the shift to different DRG coding standards, and

[1] The case complexity only captures data of the Medicare patients. We are unable to obtain any data on the reported case complexity for non-Medicare patients.

allow for quality reporting of data. On the other hand, the CPOE system allows physicians to enter patient data, share this data with other health care providers (such as with pharmacists and lab technicians) and record drug and treatment history for the patient. Although the adoption of CPOE is often problematic due to the need to coordinate the implementation across a number of departments, studies have shown that the adoption of the systems has several positive effects on patient treatment metrics (Chaudhry et al. 2006).

With the widespread adoption of EMR systems, there has been an interest in the effect that these systems have on performance metrics of hospitals as well as on metrics of the region that the hospitals is located in. Studies have found that the adoption of EMR systems leads to a reduction in the number of medical errors in hospitals (Bates et al. 1998), increases the productivity of hospitals (Lee et al. 2013), increases the operational cost of hospitals (Dranove et al. 2012). The adoption of EMR systems was shown to decrease infant mortality (Miller et al. 2011), decrease the number of tests that hospitals order (Tierney et al. 1990), increase the proportion of the population that gets vaccinations (Dexter et al. 2004), and decrease the operational cost of neighboring hospitals (Atasoy et al. 2014). Systematic reviews of the literature showed that the adoption of EMR systems leads to the a number of advantages for hospitals (Chaudhry et al. 2006).

Other studies have argued the adoption of EMR systems is associated with a disruption in the processes that have been adopted in these hospitals and workarounds that are needed both on the part of the software and a change in the processes that are in place in the hospital (Soh et al. 2004). Other studies have also found that the adoption of EMR systems is not associated with any change in the performance of hospitals. These studies report that the adoption of these systems has no effect on the mortality, adverse drug events, and readmission rates (Agha 2014).

On a geographical level, the adoption of these systems has also been shown to reduce the infant mortality rate of the county that the hospital is located in due to the better quality of records that the adoption of EMR systems provides (Miller et al. 2011). Other studies have found that the adoption of EMR systems leads to a reduction in the operational cost of neighboring hospitals due to access to a healthier patient pool without incurring any of the costs associated with the adoption of EMR systems (Atasoy et al. 2014).

On the whole, there has been extensive research on the effect of the adoption of EMR systems on a number of different performance metrics of hospitals. Although there has been extensive research on the effects of EMR adoption, there has been only a limited examination of the impact of EMR systems on the complexity of cases that these hospitals report. Hence, we discuss a mechanism that were proposed in the popular press that would lead hospitals to report patients with a higher complexity of cases than they may actually have (termed "upcoding"). Additionally, due to bills passed in the US Congress, we examine the impact of audits that are undertaken to examine what the role of these audits on how hospitals report patient complexity.

Upcoding

As patients are treated, hospitals place the patients in one of a number of Diagnosis Related Groups (DRGs). These DRGs represent diagnosis and procedures that hospitals use for patients. The proportion of patients in different DRGs creates a hospital level 'case mix' – that is an average level of complexity of patients in a hospital. As the code that the hospital places the patient in affects the amount of reimbursement that the hospital is able to obtain, there is an incentive for hospitals to optimize the assignment of patients to different DRGs. Small changes in the case mix between different years can result in dramatically different reimbursements, and hence the need to report these numbers in an optimum manner. For example, within the set respiratory set of DRGs in 2012, DRG 192 that indicated a diagnosis of "Chronic obstructive pulmonary disease without CC/MCC" provided for an average reimbursement rate of $4,865 whereas DRG 190, indicating a diagnosis of "Chronic obstructive pulmonary disease w MCC" was reimbursed at a rate of $ $7,899.98 – which is an increase of 62% more than the base case.[2] The case mix for the hospital is then calculated by summing the DRG weights for all Medicare discharges for a particular hospital and dividing it by the number of discharges. More complex DRGs are given higher weights in the calculation and hence a hospital with a more complex set of patients has a higher case mix index (CMI) and a higher proportion of patients that have been placed in a higher DRG due to upcoding will lead to a higher case mix index for

[2] CC/MCC indicates (Major) Complications and Comorbidity conditions and indicates issues such as diabetes. The analysis was conducted by the authors.

the hospital.[3] While we cannot objectively measure upcoding, we use abnormal changes in case mix due as indicative of upcoding practices that may be occurring. We attempt to rule out all confounding factors to be able to examine if any changes in reported complexity of patients is due to added complexity of patients or due to other confounding factors. Additionally, we make use of the staggered implementation of the audit program to assess if the adoption of CPOE systems under these different scenarios has any effect on the reported complexity of patients.

The practice of "upcoding" refers to placing a patient in a higher DRG than the one that they would actually qualify for. The practice has gained attention due to arguments that the adoption of CPOE systems has enabled hospitals to more easily upcode patients. Commentators have argued that it is easier for physicians to check off a number of boxes that would enable hospitals to place patients in different, often higher DRG (Abelson et al. 2012). The "cloning" of information to pad up one medical record by copying and pasting with information from another medical record has also been argued to be facilitated by the usage of CPOE systems by physicians (Bukata 2013). Additionally, some of these systems come with preloaded macros that generate certain types of reports automatically allowing the physician to indicate that a certain set of symptoms exist and a variety of checks have been performed that would then allow the physician to place the patient in a higher DRG (Li 2014).

However, upcoding may not always be motivated by unethical behavior. A better record keeping system may enable hospitals to file higher claims with Medicare – leading to a higher case mix of the hospital not due to unethical reasons but due to record keeping. Additionally, hospitals may upcode their patients to place them in different diagnosis groups to allow them to receive their medicines in an easier fashion. Hence, upcoding may not always indicate a malicious act on the part of the hospital but may be driven by other factors. This is because upcoding enables an increase in the amount of information in a particular chart to justify higher reimbursement rates (Bukata 2013). However, due to the anecdotal evidence of how CPOE systems can facilitate the "upcoding" of patients, we wish to posit that hospitals are now able to file for higher compensation after the adoption of CPOE systems. Hence, we posit:

H1: The adoption of CPOE leads to an increase in the case mix of a hospital.

Additionally, there has been research into the phenomenon of "upcoding". Research in this area has argued that for-profit hospitals are more likely to indulge in the practice due to higher alignment for the goals of the administration of the hospital (Silverman et al. 2004). It has been argued that a hospital ultimately is composed of two fundamentally different structures – one structure that consists of the clinical aspect, which is run by the physicians, and another one that is run by the hospital administrators (Harris 1997). The role of the clinical structure is to interact, diagnose and treat patients – however, the profitability and the solvency of the hospital is the responsibility of the administrative structure. Although upcoding may ultimately affect the administrative side of the hospital by allowing for higher revenues (and greater profits), it is ultimately the clinical side of the hospital that needs to allow the coding in an unethical manner to take place to facilitate upcoding.

However, there are a number of methods to get the incentives between the structures aligned (especially in the case of for-profit hospitals that have a higher incentive to align these incentives). Duggan (2002) found that in for-profit hospitals, 49% of the board members are likely to be physicians against 24% in the case of not-for-profit hospitals or public hospitals (12%) – allowing the physicians of for-profit hospitals to align the goals of the administration with the clinical side of the organization. Other for-profit hospitals have allowed physicians to purchase equity in the company (Barciela 1993), resulting in an increase in the billing of the highest DRG for patients that had respiratory infections. Gottlieb et al. (1997) documented that after an organization of for-profit hospitals took over a hospital in Miami in 1993, 76% of the patients were coded for the highest rate – as compared to 31% a year before. By 1995, the number had jumped to 90% (as opposed to 28% of cases for a neighboring hospital owned and operated by the local government).

With the theoretical justification for for-profit hospitals to have their incentives aligned to be more likely to indulge in upcoding their patients, we expect for-profit hospitals to be more likely to indulge in the practice

[3] Although the method to calculate the case mix index may change over time, the changes would need to be systematically correlated with the type of hospital to have an impact on our results.

of upcoding their patients. We argued that the adoption of CPOE systems by these hospitals would enable them to indulge in the practice of upcoding to a higher extent. Hence, we posit:

H2: The adoption of CPOE increases the case mix index to a greater extent in for-profit hospitals compared to other hospitals.

Effect of Audits

In 2005, Medicare implemented the Recovery Audit Program to determine if auditors could effectively identify and adjust improper payments. The program works by recovering any additional payments made to service providers (including hospitals) – but at the same time allowing for service providers to be reimbursed if they have been underpaid.[4] In 2013, the audit program identified and corrected $3.75 billion in improper payments (Centers for Medicare and Medicaid Services 2013). The audit program was authorized by the US Congress in the Tax Relief and Health Care Act of 2006. Initially the program was limited to states with the highest levels of payment – California, Florida and New York and later in 2007 expanded to Arizona, Massachusetts and South Carolina. After 2010, the program was expanded nationwide with the goal to reduce payments errors by $50 billion, cut the Medicare for-for-service error rate in half and recover $2 billion in improper payments by 2012 (Anderson et al. 2015).

The program seeks to identify improper payments that have been made under the Medicare fee for service program. Improper payments fall into three broad categories 1) Payments for items and service that do not meet Medicare coverage and medical necessity criteria; 2) Payments that are incorrectly coded; and 3) Payments for services where the supporting services does not support the ordered service (Centers for Medicare and Medicaid Services 2010). Although the scope of the program is to identify both underpayments and overpayments to service providers in the demonstrated period, 96% of the claims that were submitted were for overpayments and only 4% of the claims were for underpayment (Levinson 2013). In fiscal year 2011, the program recovered $715 million from providers and returned $120 million to providers indicating a higher probability of the program identifying wrongdoing on behalf of the hospital (Levinson 2013).

In order to recover payments, Medicare has identified four regions comprising of a set of states in the US. Each of the regions has one auditor who is responsible for identifying improper payments in that region. The program hopes to correct errors in the over 1 billion claims that are submitted annually in the fee-for-service program. Auditors are paid on a percentage of the amount that they identify as improper payment (and ranges between 9-12.5% of the improper payment amount). However, the provider is allowed to appeal the audit case with Medicare.

One of the methods that the program uses to identify overpayment is by examining the Diagnosis Related Group (DRGs) that patients are placed in versus the codes that they should correctly be placed in. The statement of work for the Recovery Audit Program states that the Recovery Auditor may issue a partial denial (of the payment amount) "when the Recovery Auditor determines that:

(i) the submitted service was not reasonable and necessary but a lower level service would have been reasonable and necessary, or,

(ii) The submitted service was upcoded (and a lower level service was actually performed) or an incorrect code was submitted that caused a higher payment to be made." (Centers for Medicare & Medicaid Services n.d.).

During the demonstration period a quarter of all recovered and returned improper payments were due to providers billing incorrect codes on Medicare claims (Levinson 2013). In 2010, reassigning the values of DRGs was notified among the top issues by two of the nation's four recover auditors (Centers for Medicare and Medicaid Services 2010).

Due to the possibility of audits, service providers may be more apprehensive to upcode their patients. Although the program only allows for reimbursing the difference of the amounts, the process of dealing

[4] In 2010, the amount of improper payments incurred from Medicare and Medicaid was estimated to be in the range of $70 billion (GAO 2011).

with an audit case has been argued to be time-consuming and expensive for the hospital (American Hospital Association 2015). Additionally, the possibility of getting caught with upcoding may have an effect on the reputation of the provider.

Due to this staggered implementation, we examine if the roll-out of the audit program across different states on the case mix that hospital in these states were reporting. We argue that the possibility of audit of the case that the hospital wishes to bill for would lead service providers to the apprehensive to use EMR systems to increase the severity of the patients that they are diagnosing. We examine if the hospital being audited would decrease the case mix of the hospital. We posit:

H3a: The possibility of the Medicare auditing the records of a hospital results in a decrease in the case mix of the hospital.

The presence of a deterrence mechanism for upcoding would also limit how hospitals are being able to use EMR systems to upcode the claims that they submit. The effect of the adoption of EMR systems in this case would be limited by the possibility of audit. We argue that the effect of EMR systems on case mix would be moderated by the possibility of audit.

H3b: Increased complexity of the cases due to the adoption of CPOE by a hospital would be moderated by the possibility of an audit of the hospital.

Data and Results

Data

We obtained data on the adoption of CPOE system from the Healthcare Information and Management Systems Society (HIMSS) database. The database tracks information about the adoption of EMR systems in the US. The database contains information on the adoption of CDR, CDSS, OE, CPOE and PD by hospitals across the US and Canada. We used a panel from 2004-2012 to be able to understand the effect that the adoption of a system has on the case mix index of a hospital.[5] A hospital is coded as having the system in that year a systems contains a code of "Live and Operational" or "To be replaced" in the database.[6]

We obtained case mix information about the hospital from Medicare. The data contains information on the complexity of cases that the hospital treats under Medicare cases, and it is based on the proportion of patients that belong to different DRGs that are inpatients in the hospital in a particular year. A higher case mix indicates a more complex set of patients that a hospital admits, and this case mix variable forms our dependent variable of interest. In line with previous studies, we included a number of hospital level controls such as the number of beds, bed admit days, discharges and employees in a hospital. This data is provided by hospitals to Medicare to allow Medicare information to reimburse the hospital. We also included demographic controls for the average age, education, income, population and the proportion of the county that belongs to different races to account for the differences in different counties across the US. The data was obtained from the US census. As the demographic data were available only for one year, we multiplied it by the year so that it could be included in the fixed effect analysis.

The dataset was constructed by selecting hospitals for which we had no missing EMR data or CMI data. Missing data for the hospital operational controls were filled in by using a linear interpolation for missing values in the middle of the panel and using the most current value at the end of the panel. Hospitals-year observations below 1% for CMI and above 99% for CMI were trimmed to prevent outliers from affecting the results. This resulted in an unbalanced panel with 20,548 observations based on 2,320 hospitals.

Table 1: Summary Statistics

[5] Although HIMSS provides information starting in 1996, we limit our analysis to systems adoption after 2004 as the CPOE information is only provided after 2004.

[6] Communications with HIMSS indicated that the code "To be replaced" indicated that the hospital uses the system and has not completely abandoned the use of the system.

Variable	Number of Observations	Mean	Std. Dev.	Min	Max
CDR	20548	0.783	0.411	0	1
CDSS	20548	0.738	0.439	0	1
CPOE	20548	0.283	0.450	0	1
OE	20548	0.839	0.366	0	1
PD	20548	0.297	0.457	0	1
CMI	20548	1.399	0.241	0.925	2.089
NFP	20548	0.166	0.372	0	1
Log(Bed Admit)	20548	10.233	1.032	4.718	13.332
Log(Discharge)	20548	8.936	0.946	3.332	11.816
Log(No of Employees)	20548	6.769	0.951	0	14.685
Log(Number of Beds)	20548	4.957	0.756	0.693	9.744
Population	20548	838431.7	1641446	3233	9818605
Percent; Age up to 25 years	20548	23.297	2.975	10.5	35.8
Percent; Age 65 years and above	20548	13.9187	3.438	6.6	35.1
Resident population: Black alone, percent, 2011	20548	13.465	13.951	0.2	77.8
Resident population: White alone, percent	20548	79.043	15.239	18.8	98.8
Income	20548	51542.78	13532.12	20206	108439
Educational attainment - - percent high school graduate	20548	84.827	6.108	56.1	98.6
Educational attainment - - percent bachelor's degree	20548	26.381	10.202	6.3	63.9
Change in CMI after CPOE adoption	1696	.016	.053	-.346	.303
Change in CMI without CPOE adoption	16480	.013	.055	-.686	.464

Difference in the change in CMI after CPOE adoption versus without CPOE adoption is significant at 5% level of significance.

Empirical Specification

The primary empirical specification that we used was a fixed effects estimate to control for hospital and time fixed effects. Mathematically, the speciation for the i^{th} hospital at the j^{th} year resembles:

$$CMI_{ij} = \beta_0 + \beta_1 CPOE_{ij} + \beta_2 Z_{ij} + \beta_3 \vartheta_{ij} + \beta_4 \delta_i + \beta_5 \gamma_j + \varepsilon_{ij}$$

Where Z_{ij} represents controls including adoption of other EMR systems by the hospital as well as other hospital level controls, δ_i represents hospital fixed effects and γ_j represents time fixed effects. ϑ_{ij} represents the county level control variables for the count that the i^{th} hospital exists in. For models where we examine the effect of possibility of audits (with $Audit_{ij}$ being set equal to 1 if hospital i can be audited in year j), we interact the adoption of EMR systems with a dummy to indicate the possibility of audit to give an empirical specification resembling:

$$CMI_{ij} = \beta_0 + \beta_1 CPOE_{ij} * Audit_{ij} + \beta_2 Audit_{ij} + \beta_3 Z_{ij} + \beta_4 \vartheta_{ij} + \beta_5 \delta_i + \beta_6 \gamma_j + \varepsilon_{ij}$$

Results

The first set of results presents the effect of the adoption of CPOE systems on the case mix index. We find that on average, there is an increase in the case mix after hospitals adopt CPOE. Additionally, this effect is more pronounced for for-profit hospitals where the objectives are more aligned to report a higher case mix. However, although there is a concurrent increase in the case mix that is reported, we see a positive although non-significant effect of the adoption of CPOE systems after a year on the case mix of the hospital.

Table 2: Controls included in the Empirical Model		
Demographic Controls for county hospital is located in	Hospital Controls	Fixed Effects included
population in 2010	Presence of Clinical Data Repository	Hospital
Median Income of the county	Presence of Clinical Decision Support System	Year
Percent of the population under 18	Presence of Order Entry	
Percent of the population above 65	Presence of Physician Documentation	
Percent of the population that is black	Number of Discharges	
Percent of the population that is white	Number of Bed Admit Days	
Percent Percent of the population that has at least a high school education	Number of Employees	
Proportion of the population that has at least a bachelor's degree.		

Table 3: Effect of CPOE on the case mix index			
	1	2	3
VARIABLES	CMI	CMI	CMI
CPOE	0.004***	0.002	0.004**
	(0.001)	(0.001)	(0.002)
CPOE (t-1)			0.001
			(0.002)
For Profit * CPOE		0.014***	
		(0.005)	
Controls	Yes	Yes	Yes
Time and Hospital FE	Yes	Yes	Yes
Constant	-27.452***	-27.456***	-25.397**
	(9.834)	(9.836)	(11.129)
Observations	20,548	20,548	18,176
R-squared	0.298	0.299	0.305

*Controls in Table 2 included. Errors clustered by hospital and year. *** p<0.01, ** p<0.05, * p<0.1*

Endogeneity

Endogeneity is a potential problem in the relationship between CPOE adoption and the case mix index, if the adoption of CPOE attracts patients with more complex cases. Thus, case mix would increase due to a change in the incoming patient profile and admission of more complicated patients, rather than upcoding.

We attempt to address this endogeneity issue with two sets of analysis. First, we use the introduction of the audit program as a quasi-natural experiment to examine what the impact of having a CPOE system in a hospital is both before and after the introduction of the audit program. If the adoption of CPOE systems was in fact the hospital attracting sicker patients, we would see a similar increase in the effect of the adoption of CPOE systems on CMI – both during and after the audit program. On the other hand, if increases in CPOE are bringing sicker patients to the hospital, then there will be a similar increase in the case mix even after the adoption of CPOE systems.

Second, we test whether the case mix index of the other hospitals in the area are affected. If the increase in the case mix index in a hospital was due to that hospital attracting more complex patients after CPOE adoption, we would expect the case mix index to decrease for the neighboring hospitals.

Effect of Audits

In the following section, we examine of the audit program on the reported case mix of hospitals. We see that audits decreased the reported case mix of hospitals. There is a negative and significant effect on the case mix of a hospital after the possibility of audit in the hospital.

Table 4: Effect of Audit on case mix index

	1	2	3
VARIABLES	CMI	CMI	CMI
Audit	-0.005**	-0.005	-0.004
	(0.002)	(0.003)	(0.003)
CPOE	0.004***	0.004**	0.003
	(0.001)	(0.002)	(0.002)
For Profit * CPOE			0.004
			(0.007)
Audit * CPOE		0.000	-0.002
		(0.002)	(0.003)
Audit * CPOE * For Profit			0.016*
			(0.009)
Audit * For Profit			-0.007
			(0.008)
Controls	Yes	Yes	Yes
Hospital and Time FE	Yes	Yes	Yes
Constant	-29.035***	-29.219***	-28.829***
	(9.870)	(9.877)	(9.890)
Observations	20,548	20,548	20,548
R-squared	0.298	0.299	0.300

*Controls in Table 2 included. Errors clustered by hospital and year. *** p<0.01, ** p<0.05, * p<0.1*

On average, the adoption of CPOE systems does not have an impact on the case mix of the hospital when an audit is possible (Model 2). This is in contrast to the findings in Table 3 which show that on average, there is an increase in the reported case mix of a hospital after the adoption of the CPOE system. However, when we examine the effect of the use of CPOE systems by for profit hospitals, we actually observe that there is still a positive (and significant at $p<.10$) effect of this treatment. This shows that although on average there is a reduction in the case mix of hospitals after the adoption of EMR systems, for-profit hospitals actually show an increase in the case mix after the adoption of CPOE systems even when audits are possible.

Effect on Neighboring Hospitals

Additionally, studies have argued that the adoption of EMR systems is associated with the changes in the outcomes for more complicated cases. McCullough et al. (2013) found that the adoption of EMR systems is associated with better care for complicated cases – especially those involving the co-ordination between different departments. The study finds that patients with severe conditions that require cross-specialty care, that require co-ordination between different departments are likely to see changes in their outcomes after a hospital adopts EMR systems. They also find that there is no evidence that the median patient's outcomes are any different after the adoption of EMR systems by hospitals.

Additionally, previous research has shown that collocated hospitals share a common pool of patients (Huang et al. 2010; Lee et al. 2011). Wennberg et al. (2004) find that between 17-58% of all patients across 77 cohorts saw more than 10 physicians during the last 6 months of their life. Hence, as patients are mobile between hospitals and hospitals that have adopted EMR systems have better outcomes for patients with more complex medical cases, there may be a shift in patients with complicated cases to hospitals that have EMR systems. Additionally the effects of adopting IT systems and EMR systems in particular are not constrained to the adopting firm. Atasoy et al. (2014) finds that while the adoption of EMR systems increases the operational cost of hospitals, it decreases the operational cost of neighboring hospitals possibly due to better care that is provided to a cohort of patients or due to information sharing between hospitals. Other studies have also found the spillover effects of the adoption of Information Systems to firms of the same supply chain, network, industries and regional clusters (Cheng et al. 2007; Cheng et al. 2012; Tambe et al. 2014).

Under the assumption that the complexity of patients does not change in a geographical location over time, there may be shift of patients with more complicated cases to hospitals that have adopted EMR systems in order to avail of the better care thy would receive at these facilities. This would result in an increase in the complexity of cases at the hospital adopting EMR systems – but would reduce the complexity of cases that are seen at neighboring hospitals. On the other hand, if there is no transfer of complex cases to hospitals that adopt EMR systems, this may be evidence that upcoding is at work.

In this section, we group hospitals based on the Hospital Referral Region (HRR) or the Hospital Service Area that have been published by the Dartmouth atlas of healthcare (Wennberg et al. 1999). These regions are defined using Medicare data on patient movement between different physicians and hospitals in national, regional and local markets. The atlas defines two geographical areas – the Health Service Area (HSA) is a geographical area where residents usually receive most of their health services. The Hospital Referral Region (HRR) is an area where people travel which has a major referral center. Each HRR has at least once city where both major cardiovascular and neurosurgery procedures are performed. We use these HSA and HRR definitions to examine if there is evidence of a shift away from other hospitals in the HSA/HRR after the adoption of EMR systems by a hospital.

Model specification 1 below presents the results of an empirical model when the dependent variable is the CMI of other hospitals in the HSA. In model 2, the CMI of other hospitals in the HSA is weighted by the size of the hospital proxied by the number of employees in the hospital. We include the weighted average of EMR systems in other hospitals in the HSA/HRR in the empirical specification.

We find that the adoption of CPOE systems by a hospital does *not* reduce the complexity of cases in neighboring hospitals. Instead, what we see is that the adoption of CPOE by the neighboring hospitals increase the case mix (indicating that there is no shift away from complex cases at neighboring hospitals).

Table 5: Effect of CPOE on CMI of Neighboring Hospitals				
	1	2	3	4
VARIABLES	CMI other Hospitals HSA	Weighted CMI other Hospitals HSA	CMI other Hospitals HRR	Weighted CMI other Hospitals HRR
CPOE	0.002	0.002	-0.000	-0.001
	(0.002)	(0.002)	(0.001)	(0.001)
Adoption of CPOE by other hospitals in the HSA	0.009***	0.006**		
	(0.003)	(0.003)		
Adoption of CPOE by other hospitals in the HRR			0.010***	0.007***
			(0.002)	(0.003)
Controls	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes
Constant	22.419*	11.390	4.589	-10.943*
	(12.432)	(13.246)	(4.849)	(6.610)
Observations	8,919	8,919	20,384	20,384
R-squared	0.363	0.287	0.610	0.443

*Controls in Table 2 included. Additional controls include the adoption of CDR, CDSS, OE and PD, the average of discharges, number of bed admit days and number of employees for other hospitals in the HSA/HRR as the case may be. Errors clustered by hospital and year. *** p<0.01, ** p<0.05, * p<0.1*

Robustness Tests

In this section, we test for the robustness of our results. Rather than using fixed effects model, we used an OLS model where the dependent variable is *changes in the case mix index (Table 6)*. This is used to conduct a diff-in-diff model. We examine the effect of adoption of CPOE on the case mix and find that the adoption of CPOE has a positive and significant effect on the change in the case mix of the hospital – although when the CPOE systems is adopted under the possibility of audit – there is no change in the reported case mix index – even for for-profit hospitals. We argue that this is further evidence that our main results hold with a different identifying assumption and this is further evidence that there is an increase in the case mix after the adoption of CMI only when audits are not possible.

Falsification Test

Additionally, we conducted a test to examine the effect of other EMR systems on the changes in the case mix index of hospitals. Although the problem with upcoming has been widely acknowledged to be a problem that has been associated with the adoption of CPOE system (due to the system allowing users to tick off characteristics of patients that would allow them to file for higher DRG codes), we test to examine what the effect of the adoption of the adoption of Clinical Data Repository (CDR) system would be. The repository is a data base for storing current and historical patient data about medications, test results and procedures that were conducted. Some systems also allow the hospital to store information on patient demographics. Due to the additional information that the hospital can store and the easy retrieval and analysis of this data, the system has been found to lead to better hospital infection control.

Previous research has argued that the adoption of CPOE systems is problematic due to upcoding. However, as the Clinical Data Repository is only associated with storing patient data, it does not allow the user to upcode patient characteristics. Hence, we argue that the adoption of the CDR system should not be associated with an increase in the case mix of the hospital which is supported by results shown in Table 7.

Table 6: OLS specification results (DV: Change in case mix index)			
	(1)	(2)	(3)
VARIABLES	Change in CMI	Change in CMI	Change in CMI
Adopt CPOE	0.002**	0.003*	0.003*
	(0.001)	(0.002)	(0.002)
Adopt CPOE * Audit		-0.000	-0.001
		(0.002)	(0.002)
Adopt CPOE * Audit * FP			-0.002
			(0.006)
Controls	Yes	Yes	Yes
Hospital and Time	No	No	No
Constant	-5.272***	-5.045***	0.385
	(0.349)	(0.354)	(0.520)
Observations	18,176	18,176	18,176
R-squared	0.019	0.024	0.031

*Controls in Table 2 included. However, the level of EMR systems has been replaced by the adoption of systems. Errors clustered by hospital and year. *** p<0.01, ** p<0.05, * p<0.1*

Table 7: Effect of the adoption of CDR on Hospital Case Mix			
	1	2	3
VARIABLES	CMI	CMI	CMI
CDR	0.001	0.001	-0.001
	(0.002)	(0.002)	(0.002)
CDR (t-1)			0.001
			(0.002)
For Profit * CDR		-0.001	
		(0.004)	
Controls	Yes	Yes	Yes
Hospital and Time FE	Yes	Yes	Yes
Constant	-27.452***	-27.456***	-25.397**
	(9.834)	(9.836)	(11.129)
Observations	20,548	20,548	18,176
R-squared	0.298	0.299	0.305

*Controls in Table 2 included. However, adoption of CPOE is now a control and adoption of CDR has been presented. Errors clustered by hospital and year. *** p<0.01, ** p<0.05, * p<0.1*

Discussion

Key Findings

The adoption of EMR systems has been found to have significant benefits for hospitals and societies. Studies have shown that the adoption of these systems leads to changes in a number of metrics such as the infant mortality, the operational cost of neighboring hospitals as well as lowering of error rates. However, anecdotal evidence has often suggested that the adoption of the CPOE system may be changing the manner in which hospitals are coding their patients in order to obtain higher reimbursements from insurers. The adoption of CPOE systems may be allowing physicians to code for services that in an unethical manner – something that has attracted the interest of the administration.

Overall, we find that there are practices that are consistent with the inappropriate practice of "upcoding" after the adoption of CPOE systems. We find evidence that on average the adoption of CPOE systems leads to an increase in the case mix index of hospital and that this effect is stronger for for-profit hospitals. Additionally, in the presence of audits, hospitals report a lower case mix of hospital. However, we find that the complexity of cases that for-profit hospitals report after the adoption of CPOE even in the possibility of audit does not differ.

We find that the adoption of CPOE systems is associated with a .004 increase in the case mix of a hospital. As the average CMI of our sample is 1.3993, this implies a .2% increase in the reported case mix of a hospital after the adoption of CMI systems. Additionally, for profit hospitals seem to be more likely to upcode their patients (in line with theoretical arguments and previous research) and we find that the adoption of CPOE systems by for-profit hospitals increases their case mix by .013. With an average case-mix index of 1.34, the change in the case mix that this represents is .009%.

Additionally, we find that the implementation of the audit program leads to a reduction in the reported case mix for the hospital. We find that on average the implementation of the audit program leads to a reduction in the reported case mix for a hospital and that if the hospital adopts a CPOE system while they can be audited, it is unlikely to increase the case mix of the hospital. However, if the hospital is for-profit, there is indication that it is more likely to report an increase in the case mix after the adoption of CPOE even when audits can take place. For profit hospitals are also more likely to report higher patient complexity even in the presence of audits.

Implications for Practice and Public Policy

Back of the envelop calculates suggest that by using a hospital specific rate of $8676 with the number of Medicare discharges, the increase in reimbursement per discharge would be $34 after the adoption of CPOE systems.[7] The total number of 'bills' of Medicare in 10936114 across all hospitals in the US in 2010, this would represent an additional payment of $379.5 million to hospitals. Although this figure may be limited to $136.1 billion that was paid out by Medicare for hospital stays in 2010 (representing a .2% of the hospital stay budget of Medicare), it is nevertheless a significant amount in the fight to reduce healthcare costs.

Additionally, the paper sets itself apart from other analysis that has attempted to examine the effect of the adoption of CPOE on case mix of the hospital. Surprisingly, although Adler-Milstein et al. (2014) examines the effect of the CPOE system on a limited set of hospitals, and Li (2014) fails to find an effect of for-profit hospitals greater than other hospitals. In addition, we set our paper apart by examining the effect of the systematic implementation of the audit program on the effect of CMI.

[7] The hospital specific rate is determined by the multiplying the average payment amounts for all DRGs with the number of patients in these DRGs. These values are then added to give the total Medicare payment for the hospital and divided by the number of cases in the hospital to give the hospital specific rate for the hospital. An average of these values for 2010 gives $8,676. If number of cases had been suppressed, then we replaced the value with 0.

Limitations and Suggestions for Future Research

There are inevitable alternative explanations that we cannot rule out. For example, we cannot know whether these are fraudulent claims or they are due to ability of these systems to be able to capture the details of the doctor-patient interaction in a richer manner than traditional paper based mechanisms. The adoption of these systems could be allowing physicians the ability to capture a larger set of procedures that are being provided to the patient hence increasing the reported complexity of the patients. Although, it will be nearly impossible to be able disentangle these effects from the researcher's perspective unless a physician level analysis is undertaken, what is being observed is that the adoption of the CPOE system increases the reported case mix of the hospital – with evidence in line with theoretical expectations of upcoding. Additionally, although we have tried to rule out endogenous causes for our results, there may still be other factors that could be having an effect.

Additionally, our research has been limited to patients that belong to the Medicare pool. However, Medicare insures 48 million Americans with a payment of $182.7 billion in aggregate hospital stays in 2011 for 15.3 million hospital stays. This accounted for 47.2 percent of the aggregate costs (Torio et al. 2013). This astronomical funds have raised concern with the Medicare Part A (funds that are used to pay for services including inpatient hospital) expected to go bankrupt by 2019 – although more recent estimates have said that the date for bankruptcy may be nearer (Centers for Medicare & Medicaid Services n.d.). As the trust is funded by the taxpayer, it is important to determine if the money is being used to pay for unethical practices.

However, the effect of the adoption of CPOE may not be limited to changes in the case mix of hospitals. Instead, the adoption of CPOE may increase the complexity of cases that are reported to private payers as well. However, we opt to limit our analysis to the case mix that is reported by Medicare as they are the single largest provider of insurance and due to the fact that they the payments that are made by them are paid by the taxpayer.

However, there are a number of implications for our findings. Although Information Systems have often argued to facilitate better record keeping, increased automation in the storage of records could enable hospitals to manipulate these records in an easier manner to meet their objectives. Additionally, although the adoption of EMR systems is being pushed by the administration as a mechanism to reduce costs, hospitals may be using these systems to have exactly the opposite effect.

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