# Association between health information technology and Case Mix Index

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A**bstract**

**Objective**
Health IT could facilitate the provider's medication ordering and adherence to the guidelines. It also could improve communication among providers and improve quality. However, the relationship between health IT and Case Mix Index (CMI) was not well understood.

**Methodology**
To examine the effect of health IT on CMI, generalized estimation equation (GEE) was employed using two years of California hospital data.

**Results**
We found that IT was positively associated with CMI. That means more IT adoption could lead to higher CMI or billing though DRG up-coding. It implies that hospitals could increase around $40,000 by increasing 10% of IT investment

**Conclusion**
The positive association between IT and CMI implies that IT adoption itself could lead to higher patients' billings. Generally, a higher CMI in hospitals represents that the hospital provides expensive services with higher coding and therefore get more money from patients. Thus, the way to prevent the up-coding by IT system should be accounted for.

**Key Words:** Case Mix index, Health Information Technology

## Introduction

Health information technology (IT) could facilitate the provider's medication ordering and adherence to appropriate guidelines in the treatment of disease [1]. It also could improve communication among providers within and between organizations [2]. In particular, health IT could be used for information gathering, information organization and display, facilitating follow-up, etc. [3, 4]. Moreover, health IT could improve quality by reducing errors [5-7] and improving patient safety by preventing adverse drug events [8-10].

Some studies reported that the health IT adoption was associated with reduced expense in the hospital setting by improving efficiently [11]. However, the effect of health IT on healthcare cost still was not clear because health IT could be used for providers to get higher billings (i.e. up-coding) than expected [12-13]. Some vendors argued that healthcare organizations are getting more money with IT adoption which could modify the patient diagnosis coding such as diagnosis-related group (DRG). This up-coding issue related to IT adoption could damage the national healthcare financial system. According to the Office of Inspector General (OIG), the federal government recovered nearly $5.7 billion and $3.35 billion in healthcare fraud cases in 2014 and 2015, respectively.

However, the effect of IT adoption on billing was not studied well. There are only a few studies to examine the relationship between IT adoption and billing [12-13]. Li [12] and Ganju et al., [13] used hospital-level Case Mix Index as the payment measure and found that health IT system including Electronic Medical Record (EMR) and Computerized Physician Order Entry (CPOE) inflated reimbursement through DRG up-coding. However, Adler-Milstein and Jha [14] did not find any significant relationship between IT adoption and billings. They used DRG coding ratio as the payment measure based on the patient-level and found payment per discharge were essentially the same between IT adopters and non-adopters. They concluded that hospitals are not systematically using EHRs to increase reimbursement.

These previous studies used specific function such as EMR and CPOE as the measure of IT even if there are more than 50 health IT systems in the hospitals [15]. Thus, it is a little hard to separate specific function from all others which may result in unobserved variable problems. Thus, in this study, health IT is measured as the continuous variable, not just as the dummy variable used in the previous study [12-14]. By using new variable different from previous studies, this study examine the effect of IT investment on CMI by utilizing California Office of Statewide Health Planning and Development (OSHPD) from 2006 to 207.

## Methods

*Data*

We used Hospital financial data from the California state government such as Office of Statewide Health Planning and Development (OSHPD) and the American Hospital Association (AHA) survey data. California hospital financial data include patient utilization, hospital characteristics and financial information. This data been used in some healthcare and economic studies [16-17]. On the other hand, AHA data provide detailed state-wide hospital information such as hospital staffing, profiles and utilization. There are 200 unique hospitals which present for two years from 2006 to 2007, making 400 hospital observations.

*Dependent Variable*

Dependent variable was measured as CMI which is relative value assigned to DRG of patients in a medical care environment. It is applied to determine the resource allocation to take care the patients in the group [18]. For the CMI, each patient treatment record is assigned to a Medicare Severity-DRG (MS-DRG) based on the patient characteristics. MS-DRG has a weight representing the national average hospital resource consumption by patient for that group, relative to that of all patients [18]. The CMI was used as payment measure to examine the relationship between IT adoption and billing [12-14].

*Independent Variable*

As the key explanatory variable, health IT expenditure is measured as a dollar amount and are extracted from each hospital's trial balance worksheets and supplemental information sheets. IT expenditure includes IT capital related cost (i.e. physical capital, purchased service, lease/rental and other direct expenditure) and IT labor related cost (i.e. salaries and Wages, employee benefits and professional fees) [19-20].

The OSHPD data did not provide the adoption status of specific IT system such as EMR, CPOE, etc. In order to examine the validity of our IT capital measure, we examine its relationship to the discrete measures of more than 50 health IT systems (i.e. EMR, CPOE, PACS, Patient Billing, Order Entry, Radiology information system, Clinical Documentation, etc.) which of information was provided by Healthcare Information and Management Systems Society (HIMSS) and found that the adoption of IT system is associated with IT capital investment. Thus, this measure of IT expenditure includes all of the IT systems mentioned above, not specific ones.

We controlled two groups of independent variables including hospital/market characteristics and volume of hospital service. Hospital/market characteristics include ownership (for-profit, not-for-profit and government), teaching status (being a Council of Teaching Hospital member), network hospital status (system member), number of beds (five specialized types of beds were included: general acute beds for adults, pediatrics, obstetrics, cardiac intensive and neonatal intensive) and competition which was measured as Herfindahl Index (HHI) for each hospital based on the admission given the geographical market of health service area [16, 17, 19-22]. The list of volume are total admissions, outpatient visits, percentage of Medicare and Medicaid admissions out of total admissions, emergency room (ER) visits and the number of inpatient and outpatient surgeries.

*Statistical Analyses*

To examine the effect of IT on CMI, this study utilized a generalized estimation equation (GEE) with log link and normal distribution. This estimation approach has been used in many studies focused on population-averaged [23]. For the covariance matrix, the independent variance model was adopted based on the smallest independence model criterion (QIC) [24]. Two groups of independent variables such as hospital/market characteristics and volume as well as IT expenditure were controlled. All analyses were conducted using Stata 11.2 software.

**Results**

Table 1 shows the descriptive statistics for the variables used. The first row shows the CMI and IT investment. Average CMI is 1.106 but standard deviation is little bit low (0.256). Average IT investment is over 11 million. The second row of Table 1 shows the hospital characteristics. Not-for-profit hospitals account for almost 55% while profit and government hospitals both accounted for 45%. Teaching and network hospitals accounted for 7.0% and 18.5%, respectively. Competition measured as HHI is 64.4% .The average number of specialized beds was 103 for adult general acute, 7 for pediatric general acute, 16 for obstetric, 5 for cardiac intensive care and 8 for neonatal intensive care beds. Network hospitals accounted for 18.8% of hospitals. Table 2 shows the variations of the key variables such as CMI and IT cost between 2006 and 2007. The CMI increased by 1.5 % from 1.098 to 1.114 and the IT cost increased by 14% from 10,241,705 to 11,812,718.

The last row of table 3 shows hospital volume. There were 10,370 total admissions and 147,375 outpatient visits. The percentage of Medicare admission out of total admissions was 44.1% and the percentage of Medicaid admission out of total admissions was 24.8%. The total number of emergency room visits was 31,902. The number of surgery inpatient and outpatient operations was 2,976 and 3,708, respectively.

Table 2 shows the GEE regression results. We found that IT was positively associated with CMI. For example, CMI increased by 0.86% when IT increases by 10%. Hospital characteristics were also important factors in CMI. Not-for-profit and government hospitals had lower CMI than for-profit hospitals. However, teaching hospitals had higher CMI than non-teaching hospitals. Only neonatal intensive beds were positively associated CMI, while obstetric beds were negatively associated with CMI. Moreover, higher competition was associated with higher CMI. In general, volume had a positive effect on CMI. The percentage of Medicare admission out of total admissions, ER visits and inpatient surgery were positively associated with CMI. However, the percentage of Medicaid admission out of total admissions was negatively associated with CMI.

## Discussion

This study examined the effect of health IT on CMI controlling hospital, market, and volume characteristics using California hospitals data for two years. Different from previous studies, we used continuous measure of IT investment and found that IT was positively associated with CMI. That means that more IT adoption could lead to higher CMI or billing though DRG up-coding. Generally, a higher CMI in hospitals represents that the hospital provides expensive services with higher coding and therefore get more money from patients. Our results implies that hospitals could increase around $40,000 by increasing 10% of IT investment, which is a significant amount of profit hospital receive [25]. Our study results consist with previous findings [12-13] which also found that IT adoption inflated reimbursement through DRG up-coding. This result confirmed that patient coding can be easily manipulated by using IT system.

Among the ownership, the profit hospitals had higher CMI associated with IT rather than not-for-profit and government hospitals. It is also consistent with other studies. Generally, profit hospitals are keen to profit which may result from higher CMI [12]. Teaching hospitals had higher CMI because teaching hospitals may serve as referral centers for patients with severe diseases [26].

Among the beds, only neonatal intensive bed is positively associated with CMI. This unit provides mechanical ventilation, neonatal surgery, and special care for the sickest infants born in the hospital or transferred from another institution [27]. Thus, more neonatal intensive bed may result in higher CMI. Network hospitals had higher CMI. These hospitals may have had tougher cases or better medical records systems [28].

Among the volume variables, percent of Medicare, ER visit and Surgery inpatient are positively associated with CMI. Medicare patient are those who are older than 65 and may have more severe or chronic disease. Those with ER visit have emergent situation and may need more resource than regular visit. Surgery inpatient operation also needs more resource to treat patients.

We examined the effect of health IT on CMI using two years of California hospital data and found that health IT was positively associated with CMI. The study results implies that the third party payer or insurers could be cautious to interpret the effect of health IT on CMI and that they should remember that the IT adoption itself could lead to higher patients' billings. Thus, the way to prevent the up-coding by IT system should be accounted for.

## Conflict of Interest

No potential conflict of interest relevant to this article was reported.

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Table 1: Descriptive statistics for California hospitals from 2006 to 2007

| Variables | | Description | Mean | Std. Dev. |
|---|---|---|---|---|
| Case Mix Index | | | 1.106 | 0.256 |
| IT Cost | | | 11,027,212 | 18,955,172 |
| Characteristics | Ownership | Profit | 22.25% | 41.64% |
| | | NFP | 55.3% | 49.8% |
| | | Government | 22.5% | 41.8% |
| | Teaching Hospital | | 7.0% | 25.5% |
| | Beds | Adult General Acute | 103 | 100 |
| | | Pediatric General Acute | 7 | 13 |
| | | Obstetrics | 16 | 18 |
| | | Cardiac Intensive | 5 | 7 |
| | | Neonatal Intensive | 8 | 14 |
| | Network | | 18.5% | 38.9% |
| | Competition | | 64.4% | 42.9% |
| Volume | Total Admissions | | 10,370 | 8,223 |
| | Outpatient Visits | | 147,375 | 164,082 |
| | % Medicare | | 44.2% | 13.8% |
| | % Medicaid | | 24.8% | 15.8% |
| | ER Visits | | 31,902 | 21,897 |
| | Surgery Inpatient | | 2,976 | 2,853 |
| | Surgery Outpatient | | 3,708 | 3,060 |

Table 2: Case Mix Index and IT Cost Variation between 2006 and 2007

| Year | 2006 | | 2007 | |
|---|---|---|---|---|
| Variables | Mean | Std. Dev. | Mean | Std. Dev. |
| Case Mix Index | 1.098 | 0.254 | 1.114 | 0.257 |
| IT Cost | 10,241,705 | 17,980,839 | 11,812,718 | 19,896,024 |

Table 3: Generalized estimation equation (GEE) regression results with log link and normal distribution for California hospitals from 2006 to 2007

| | Description | Coeff | (S.D.) |
|---|---|---|---|
| IT Cost | | 0.086*** | (0.012) |
| Ownership | NFP | -0.089*** | (0.024) |
| | Government | -0.092*** | (0.032) |
| Teaching Hospital | | 0.106** | (0.047) |
| Beds | Adult General Acute | 0.000 | (0.000) |
| | Pediatric General Acute | -0.001 | (0.001) |
| | Obstetrics | -0.004*** | (0.001) |
| | Cardiac Intensive | 0.002 | (0.001) |
| | Neonatal Intensive | 0.002* | (0.001) |
| Network | | 0.071*** | (0.022) |
| Competition | | -0.054** | (0.022) |
| Total Admissions | | 0.000 | (0.000) |
| Outpatient Visits | | 0.000 | (0.000) |
| % Medicare | | 0.284*** | (0.098) |
| % Medicaid | | -0.160* | (0.086) |
| ER Visits | | 0.000* | (0.000) |
| Surgery Inpatient | | 0.000*** | (0.000) |
| Surgery Outpatient | | 0.000 | (0.000) |
| Const. | | -1.178*** | (0.179) |

*** p<0.01, ** p<0.05, * p<0.1