IT Adoption: HealthCare Metrics Tracking

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Abstract
Continuous improvement on core metrics is a goal of any organization. Progress toward these goals occurs over multiple time-periods and process changes and technology adoptions are intended to influence these metrics. Hospitals have been investing in technology for over two decades to improve on patient quality outcomes. This research examines how core patient safety and mortality metrics are impacted by investments in Electronic Medical Record (EMR) systems. The improvements in composite indicators are modeled as latent growth curves with adjustments based on the EMR stage for the individual hospitals. Differing results are identified based on whether the indicators are tracking medical conditions, surgical procedures or composites of all rates tracked. The latent growth model technique shows the EMR stage to be a significant predictor of reductions in hospital mortality rates.

1. Introduction
Immediate access to patient history is critical to reducing diagnostic errors and improving the likelihood of correctly diagnosing current patient conditions. The need for access has led to the adoption of IT systems designed to capture patient data at a particular care delivery organization. The capture of this data is referred to as an Electronic Medical Record (EMR) [18]. EMR adoption in the hospitals presents unique hurdles to the application of IT adoption and technology diffusion theory due to the sensitive nature of the patient-doctor relationship and the imperative that care continue regardless of the extent of EMR adoption. The implementation or diffusion of the EMR in hospitals takes such a long time that a stage based model has been developed to indicate the sophistication and extent of EMR implementation in hospitals.

The staged model of EMR adoption using an aggregate measure is applicable across all hospital settings. As an aggregate measure focused on medical records and not a specific technology, EMR adoption stages [13] represent decision making independence in hospitals over EMR implementation/diffusion/adoption. Higher EMR stages would indicate a greater integration of the EMR and therefore represent greater accuracy in capturing patient history that is available to physicians and health care personnel to aid in the accurate diagnosis of patient conditions. This increase in information should translate into decreases in aggregate mortality metrics experienced by individual hospitals.

This research uses Latent Growth Modeling (LGM) to explore the impact of EMR sophistication in hospitals on patient related outcome metrics. Using the extant literature as a backdrop, in Section 2, we focus on IT Adoption and contributions using a long-term perspective and include the use of LGM to account for potential endogeneity that could contribute to a hospital being an early or late adopter. Next, in Section 3, we address EMR related literature and associated quality outcomes. Section 4 details our approach and orientation to mortality metrics and how they are tracked in hospital settings. The section culminates by detailing the hypotheses of interest. In Section 5, the methodology for applying LGM to the EMR implementation is addressed. In Section 6 we present the results of our study and discuss implications. The paper concludes in Section 7 with a discussion of limitations and future research possibilities.
2. IT Diffusion/Technology Adoption

Technology adoption has a mature research history and future research has been cautioned to not just “tweak” prior studies [40]. Much of this prior research has been anchored in individual-level technology adoption as introduced by TAM [11, 12]. Many extensions to TAM have followed this pattern of investigating individual adoption through studies of intention [27], choice [36], personal innovativeness in IT [1] and even individual temporal dynamic effects [21, 28]. However, most significant investments in IT occur at the organizational level and performance improvements therefore need to be measured at the organizational level as well. Adoption of Enterprise systems also happen gradually (as in the case of EMR systems), and therefore measurement of investment impacts at the individual stages of adoption can provide managers better insights on how to plan staged implementation of Enterprise-wide systems.

For innovations in information technology to have a positive impact on quality and productivity, they must actually be deployed [14]. The conception of the EMR and purchase of EMR applications represents the acquisition of a technology that initially has organizational barriers to actual use. The assimilation gap referred to here has implications for actually recognizing the impact on patient care within healthcare organizations. Projecting patient care improvement cannot be dependent on only the acquisition of applications designed to support aspects of the EMR, but must be dependent on the actual deployment and use of the technology. HIMSS analytics has developed the EMR Adoption Model (EMRAD) as a seven stage implementation tracking process [22]. Application capabilities must be operational, fully deployed, before the next higher stage is achieved. The characteristics of completed stages are: Stage 1) began implementation of three core ancillary department information systems and a clinical data repository, Stage 2) stage 1 completion and beginning nursing document and implementation of nursing documentation and electronic medication administration records, and Stage 3) stage 2 completion and beginning implementation of clinical decision support and computerized physician order entry [16].

The focus of IT research at the individual level and at the point of acquisition set the groundwork for questioning the value of IT [8]. Part of the answer is a focus on post adoption variables and incorporating organizationally relevant metrics. In e-business, IT impact on sales, internal operation and procurement determines the value [41]. However, in many industries such as healthcare, societal benefits can outweigh the monetary benefits to the organization itself. Thus long term value creation of IT through non-monetary metrics will have to be incorporated into research models.

The diffusion of IT within organizations has long used a staged approach which moved through Initiation, Adoption, Adaptation, Acceptance, Routinization and finally Infusion [10]. Early research of these stages covered the user, organization, task, technology and environment. A literature review called for future research to incorporate multiple implementation stages [10]. The EMRAD (Figure 1) is a result of a development to measure multiple IT implementations on a scale that represents coverage of a large portion of the organization. Different aspects of patient care associated with the EMR must be adopted prior to movement to the “next” stage. While the EMRAD does focus on adoption and implementation, the yearly assessment of hospitals at higher stages implies a temporal adjustment of prior adoption where subsequent implementation stages (adaptation, acceptance, routinization, or infusion) have been achieved. Especially with the higher stages of the EMRAD, the IT diffusion in the hospital will have had time to impact patient health. Mortality rates of patients are the organizational metric of interest for this study and therefore lead to our research objective to explore if Hospitals with higher EMR adoption will experience reduced mortality rates of patients.
3. EMR and Quality Outcomes

As a hospital moves up the EMR stages, the hypothesis is that quality of care should improve [7, 35]. More importantly, it is also expected that quality measures improve with more years of experience with EMR [19]. EMR enables better care through standardized care plans and guidelines as well as automated alerts for providers to cater to patients' needs [5, 35]. EMRs enable hospitals to prevent incidences of patient falls and pressure ulcers [23]. However, evidence of EMR benefits are mixed [9, 17]. A few studies have found that investments in IT are correlated with better process quality in terms of patient safety indicators and mortality [3, 24, 30]. Furukawa et al., [13] use a dataset from the same source as we do, and found that, surprisingly, EMR systems were adversely associated with patient quality outcomes. However, prior studies have not examined the correlations between EMR investments and pre-existing process quality levels nor have they examined the trend of process impacts over time. Thus, it is unclear whether conditions specific to hospitals (in terms of pre-existing patient quality indicators) have an impact on the extent to which EMR systems can yield benefits. The main objective of this study is to utilize the latent growth modeling approach to understand the impact of EMR systems on patient quality over time while controlling for the initial levels of patient quality outcomes prior to EMR implementation.

4. Mortality Metrics

The Agency for Healthcare Research and Quality (AHRQ) develops and maintains Quality Indicators (QIs) used to gauge performance in health care [32]. These indicators are reported by hospitals on a yearly basis. Three composite indexes have been selected for use in the analysis. Each composite index is a mortality metric where declining year over year rates indicate improving hospital conditions and service delivery. The three composite indexes come from two modules maintained by AHRQ.

### Table 1 - AHRQ IQC1 Composite Measures

<table>
<thead>
<tr>
<th>IQI</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>#15</td>
<td>Acute myocardial infarction (AMI)</td>
</tr>
<tr>
<td>#16</td>
<td>Congestive heart failure</td>
</tr>
<tr>
<td>#17</td>
<td>Stroke</td>
</tr>
<tr>
<td>#18</td>
<td>Gastrointestinal hemorrhage</td>
</tr>
<tr>
<td>#19</td>
<td>Hip fracture</td>
</tr>
<tr>
<td>#20</td>
<td>Pneumonia</td>
</tr>
<tr>
<td>#32</td>
<td>AMI, Without Transfer Cases</td>
</tr>
</tbody>
</table>

### Table 2 - AHRQ IQC2 Composite Measures

<table>
<thead>
<tr>
<th>IQI</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>#08</td>
<td>Esophageal resection</td>
</tr>
<tr>
<td>#09</td>
<td>Pancreatic resection</td>
</tr>
<tr>
<td>#11</td>
<td>Abdominal aortic aneurysm repair</td>
</tr>
<tr>
<td>#12</td>
<td>Coronary artery bypass graft</td>
</tr>
<tr>
<td>#13</td>
<td>Craniotomy</td>
</tr>
<tr>
<td>#14</td>
<td>Hip replacement</td>
</tr>
<tr>
<td>#30</td>
<td>Percutaneous transluminal coronary angioplasty</td>
</tr>
<tr>
<td>#31</td>
<td>Carotid endarterectomy</td>
</tr>
</tbody>
</table>

The first module contains QIs containing the Inpatient Quality Indicators (IQIs) [2]. These indicators reflect quality of care inside hospitals and include inpatient mortality. Two composite indicators are evaluated from this category. The first Inpatient Quality Composite indicator (IQC1) tracks the composite mortality rate for Medical Conditions per 1,000 patients. The IQI’s included in IQC1 are shown in Table 1 - AHRQ IQC1 Composite Measures. The second Inpatient Quality Composite indicator (IQC2) tracks the composite mortality rate for Surgical Procedures per 1,000 patients. The IQI’s included in IQC2 are shown in Table 2 - AHRQ IQC2 Composite Measures. Increased levels of EMR adoption lead to the following two hypothesis for these composite mortality measures.

**H1:** Hospitals with increased EMR adoption levels will have reduced IQC1 rates

**H2:** Hospitals with increased EMR adoption levels will have reduced IQC2 rates

The second module maintained by AHRQ contains QIs on Patient Safety Indicators (PSIs). These indicators focus on potentially preventable instances of complications and other iatrogenic events resulting from exposure to the health care system. These metrics are also collected as incidents per 1,000 patients. For the PSI module, a single composite indicator tracks individual PSIs. The PSIs included in the composite indicator are provided in Table 3 - AHRQ PSI Composite Measures. Increased levels of EMR adoption lead to the following hypothesis for the PSI composite mortality measure.
H3: Hospitals with increased EMR adoption levels will have reduced PSI rates

These three mortality metrics represent the main dependent construct that the technology adoption of the EMR is hypothesized to affect.

5. Research Methodology

Latent growth models (LGM), also referred to as latent curve modeling [6], is a structural equation modeling approach for studying changes over time or repeated measure designs [33]. The application and use of LGM on longitudinal data requires there be a variable of interest in which the causes for why change occurred are under investigation. The causes of change are referred to as covariates.

The variable of interest is collected at standard time intervals. The study of change over time using LGM has a rich research tradition across multiple disciplines. Alcohol use has been assessed on a six month timetable with a treatment program covariate [26]. Multiple Sclerosis progression has been investigated on a yearly basis with life style covariates [15]. Rates of autism identification have been investigated on a yearly basis with funding resource covariates [29]. Finally, antisocial behavior through middle school years has been investigated with respect to covariates of monitoring, discipline, wandering change and peer change [31].

IT diffusion and technology adoption research can advance with the collection of longitudinal data and LGM is a technique that can accurately assess the effect of differing levels of IT adoption. The use of the mortality metrics represents the variables of interest for constructing the LGM. The use of the EMR adoption level, as the covariate, can assess how these performance growth metrics have changed.

The data set obtained included AHRQ indicators from 1998 through 2006 based on data collected from the California Office of Statewide Health Planning and Development (OSHPD). The level of technological implementation in a hospital is assessed by the EMR stage as reported by the Healthcare Information and Management Systems Society (HIMSS). The EMR stage includes four categories that indicate the level of technology implemented in a particular hospital. These stages are considered either at stage 0, 1, 2 or 3 and are also reported by each hospital. The base LGM model requires that data be available for each year of the model evaluation. The goals of the research were to be able to compare the EMR stage effect on each composite indicator for the same study periods. While the initial dataset was very large (over 5,000 individual records), each record related to a particular hospital in a particular year. Several steps were required to procure data for a particular hospital that was consistent across at least a portion of the study period. These steps reduced the number of records such that a single record represented the inclusion of the: Hospital ID, EMR stage for each year, and the IQC1, IQC2 and PSI for each year.

Missing data became a severe problem when a review of the data set eliminated virtually all hospitals if the study period was to include the years from 1998 to 2006. This shortcoming of the data set was due primarily to the lack of EMR stage data from 1998 through 2001. This difficulty has been noted in prior research where hospitals were not significantly beyond stage 1 until 2002 [16, 17]. Taking a five-year period of the data from 2002 through 2006 allowed the analysis of 226 hospitals for each of the three composite indicators. This sample size was determined adequate for the initial study. The descriptive statistics for this sample are provided in Table 4. With the study period selected, the base LGM model assumptions were established and plans for assessing the EMR covariate’s effect on the linearity of the model could continue.

<p>| Table 4 - Descriptive Statistics n=226 |
|-----------------|---------|---------|-------|---------|</p>
<table>
<thead>
<tr>
<th>Variable</th>
<th>Mean</th>
<th>S.D.</th>
<th>High</th>
<th>Low</th>
</tr>
</thead>
<tbody>
<tr>
<td>IQC1</td>
<td>0.98025</td>
<td>0.11565</td>
<td>1.81357</td>
<td>0.63742</td>
</tr>
<tr>
<td>IQC2</td>
<td>0.96678</td>
<td>0.12219</td>
<td>1.53166</td>
<td>0.44112</td>
</tr>
<tr>
<td>PSI</td>
<td>0.99861</td>
<td>0.12125</td>
<td>1.62703</td>
<td>0.70078</td>
</tr>
</tbody>
</table>
5.1. Base LGM Model

Improved health care quality in hospitals is represented by a reduction in mortality and incident rates. In line with the health care goals of continuing to improve quality, the modeled composite indicators are hypothesized as a declining scale over the five-year study period. Figure 2 - Base LGM Model – shows this assumption through the path coefficient of four on the 2002 composite rates declining to zero on the 2006 composite rates for the Slope. It is assumed that the Intercept will be the same for all hospital rates.

The base LGM models all provided very good model fit (Table 6 - LGM Fit) for each of the composite indexes. This would indicate that, over the course of the five-year study, the assumption of linearity in the model is sound and non-linear models were eliminated from further consideration.

An additional benefit of using LGM models is the ability to assess starting points for individual hospitals and determine the benefits of EMR adoption based on the slope to intercept covariance. An indication of the endogenous effects of EMR adoption can then be anticipated for new hospitals considering EMR implementations. Table 5 provides the results for assessing potential individual differences with respect to the three metrics. Note that all statistics for this analysis is significant at p<.001.

Additionally, the assessment at this point did not take into account any EMR implementation, but indicates the individual trends associated with the starting points of each hospital based on the covariance. For PSI, the mean slope is negative and indicates that, all influences taken into account, the hospitals have a downward trend (reduced incidents) with respect to patient safety. The negative covariance between slope and intercept indicates that those hospitals with higher intercepts (more patient safety incidents) progress more rapidly (steeper slope) over time with their improvement of the PSI. Conversely, those hospitals with lower intercepts (better patient safety indicators) will have a higher slope (slower progress) than other hospitals with a higher intercept.

Both IQC1 and IQC2 have positive slopes, however, both have negative correlations between the intercept and slope. Those hospitals
with a higher intercept will experience a greater downward trend (reduced incidents) than those hospitals with a lower intercept.

### 5.2. EMR Implementation

The base models provided very good fit and this result provides an additional difficulty in assessing the EMR impact due to the ability to detect differences between the models. Assessing the significance of the EMR covariate is done by using the chi-squared difference test since these are nested models. The difficulty that arises is that the chi-squared difference test has a smaller range available to detect significant model differences for a single specific covariate.

The EMR implementation process occurs over multiple years. Even though the data period has the highest staged hospital at EMR stage 3, many of the hospitals went through two stages of implementation and some started in stage 1 and ended in stage 3. In each stage, hospitals may be at various stages of stability in approaching the next EMR stage. This “measurement error” has been discussed in prior research [16] and was evaluated for this research as to its impact as a covariate. Since a single EMR stage could not be used to represent a hospital over the course of the study period, several covariate models were investigated in which the EMR stage used was at the beginning, middle and end of the study period. While many of these models converged, the results were not satisfactory and the EMR stage was not adequately captured across the entirety of the study period.

To capture each hospital’s IT implementation represented by the EMR yearly stage across the study period more accurately, an EMR average was calculated for each hospital in the study group. This resulted in a covariate referred to as the EMR Average and represents a scale based on how the different hospitals’ technology implementation progressed across all five years. A set of calculations to show examples of possible hospital rankings across the study period is provided in Table 7 - EMR Average Calculation.

Using the EMR Average as the covariate (Figure 3 - EMR Average as a Covariate), convergence of all three models was achieved with good fit on all models (Table 6 - LGM Fit). However, a chi-squared difference test indicated that only two of the models showed significant improvement. The first model is the PSI composite indicator and was significant at the P<.001. The second model was the IQC2 composite indicators and was significant at P<.05 (Table 8 - Chi Square Difference Results). For these two indicators, the Chi Square difference test would indicate that the EMR implementation had a significant impact on the progression of these indicators over the course of the study period.

**Table 7 - EMR Average Calculation**

$$\frac{(E02 + E03 + E04 + E05 + E06)/5}{5} = EAvg$$

- E02 – Electronic Medical Record stage for year 2002
- E03 – Electronic Medical Record stage for year 2003
- E04 – Electronic Medical Record stage for year 2004
- E05 – Electronic Medical Record stage for year 2005
- E06 – Electronic Medical Record stage for year 2006

For the PSI, the negative change in the Slope, at the .10 level of significance, would indicate that the higher the EMR stage the hospital reaches, the more rapid the improvement of the patient safety indicators. The positive change in the Intercept, at the .001 level of significance, would indicate that the initial implementation of the EMR may show an increase in patient safety related incidents. This is consistent with prior research that only focuses on time static data techniques [16]. The significance of the chi-square test and the negative slope results in accepting H3.

For IQC2, a more immediate impact is seen by the significance of the negative intercept.

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1 E02 – Electronic Medical Record stage for year 2002
E03 – Electronic Medical Record stage for year 2003
EAvg – The average Electronic Medical Record stage for the years 2002 through 2006. Calculation is as follows – (EMR02 + EMR03 + EMR04 + EMR05 + EMR06)/5.
Those hospitals at higher EMR implementation levels have a lower IQC2 incident rate. However, the positive slope would indicate that the same hospitals at higher EMR levels experience a slower improvement rate when compared to hospitals at lower EMR levels. The significance of the chi-square test and the negative intercept result is sufficient to accept H2.

For IQC1, the slope and intercept results have been provided in Table 9. Since the chi-square difference test was not significant, it was expected that neither the slope nor the intercept change would be significant in this model. Therefore, H1 is not accepted.

6. Results and Discussion

Of the three EMR Average models, only the IQC1 linear model (H1:) was not significant. Even though the slope and intercept did not both adjust in the hypothesized direction for H2: and H3:, the significance of the model along with noted improvement of at least one of the slope and intercept factors is enough to accept the hypothesis that EMR implementation contributes to a reduced mortality rate overall. (Table 9 - EMR Covariate on LGM). Evaluating the meaning and events surrounding each composite indicator illuminate why H2: and H3: indicate a potential success for hospitals initiating an EMR implementation.

Starting with the IQC2 success indicators, recall that all of these indicators focus on the surgical procedures provided by the hospitals. These surgical procedures can be viewed as a major event in which the information provided by the EMR can have a critical impact on the results. Lack of information, inaccurate information or information from different sources can result in decision errors or conflicting decisions by hospital personnel involved with the surgery. Higher levels of EMR implementation indicates a more consistent accurate focus on the patient’s prior history such that the participating hospital personnel are more aligned to the requirements of that patient’s surgical needs. Hospitals would have stricter procedures in place to insure little variance in procedure that would endanger the patient. The negative intercept for the IQC2 model indicates that hospitals at higher levels of EMR implementation earlier in the study period are experiencing lower mortality rates.

When assessing the meaning of a negative slope change and positive intercept change for H3:, two factors may be associated that illuminate this result. First, the EMR implementation is a disruptive event. Existing policies and procedures in hospitals may be disrupted from their prior norms. This sort of disruption would explain the positive intercept adjusted for higher levels of the EMR implementation process. Since an EMR implementation involves a learning curve for hospitals and this occurs over multiple years, the PSI indicator negative slope is an indication that as the EMR implementation process progressed, additional improvement in the PSI metrics were observed. The EMR implementation provide a quicker improvement in the PSI metrics than would have otherwise occurred.

There are two possibilities with respect to the all of the indicators that should also be evaluated with respect to EMR implementations. First, prior research has documented the finding that EMR implementation does not improve PSI metrics. Since EMR implementation is designed to improve documentation, more complications may be captured and documented than in prior environments which may also bias longitudinal findings [37].

The final possibility resides in the short time period of this study. The implementation of the

Table 8 - Chi Square Difference Results

<table>
<thead>
<tr>
<th>Model</th>
<th>Base ChiSquare</th>
<th>Base df</th>
<th>EMR Avg ChiSquare</th>
<th>EMR Avg df</th>
<th>Difference ChiSquare</th>
<th>Difference df</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>IQC1</td>
<td>11.32</td>
<td>10</td>
<td>11.31</td>
<td>10</td>
<td>0.01</td>
<td>0</td>
<td>NS</td>
</tr>
<tr>
<td>IQC2</td>
<td>16.63</td>
<td>10</td>
<td>12.67</td>
<td>10</td>
<td>3.96</td>
<td>0</td>
<td>P&lt;.05</td>
</tr>
<tr>
<td>PSI</td>
<td>24.73</td>
<td>10</td>
<td>14.02</td>
<td>10</td>
<td>10.71</td>
<td>0</td>
<td>P&lt;.001</td>
</tr>
</tbody>
</table>

Table 9 - EMR Covariate on LGM

<table>
<thead>
<tr>
<th>Model</th>
<th>Linear Function</th>
<th>Slope Modification</th>
<th>Intercept Modification</th>
<th>Hypothesis</th>
<th>Reject/Fail to Reject</th>
</tr>
</thead>
<tbody>
<tr>
<td>IQC1</td>
<td>-0.00022</td>
<td>-0.00954</td>
<td></td>
<td>H1:</td>
<td>Reject</td>
</tr>
<tr>
<td>IQC2</td>
<td>0.00512**</td>
<td>-0.01981**</td>
<td></td>
<td>H2:</td>
<td>Fail to Reject</td>
</tr>
<tr>
<td>PSI</td>
<td>-0.00341*</td>
<td>0.01802***</td>
<td></td>
<td>H3:</td>
<td>Fail to Reject</td>
</tr>
</tbody>
</table>
EMR is a new phenomenon with no hospitals having a long history of use. None of the hospitals were in the final EMR stage for the entire study period. This would indicate a consistent disruptive event for those hospitals advancing in the EMR stages that was not experienced by those hospitals slower to adopt the EMR. Once the new processes and procedures implemented by progression through the EMR stages have stabilized, the PSI composite indicator should become insignificant with respect to the EMR stage.

Since the IQC1 model did not show a significant difference between the base model and the EMR model, it is more difficult to assess why there is no impact of the EMR stage on these indicators. Perhaps, there is a distinction in how EMRs contribute to improved procedures as opposed to patient conditions. The finding from this study indicates the need for a better understanding of the contexts in which EMR information can be helpful for an in-patient setting.

7. Limitations & Future Research

Since EMR systems adoption is a long term project, many additional factors may be involved with and have an impact on the metrics under study in this research. Our investigation included a few additional models in which the EMR average was replaced with other factors to discern other possible impacts on patient improvement. The primary variable of interest for this research was the EMR stage. However, these additional covariates were available in the dataset obtained and were used as convenience exploratory testing examples. Their selection had purpose even though all the results were non-significant.

EMR implementation can occur in both rural and urban hospitals. Based on the population density, it was hypothesized that the pace of EMR implementation and the ability to attract employees to the different location areas may differ between rural and urban hospitals. The urban hospitals, due to the size of the population served and the ability to attract more experienced personnel may experience a quicker integration of the EMR and therefore a quicker improvement of the patient metrics.

A second available covariate separated the sample data set into three segments: For Profit, Not for Profit, and Government. The distinctly different motivations that should be resident within each of these hospitals based on their intended structure may reflect a difference in the patient metrics while implementing the EMR.

The third covariate investigated was a size split amongst the hospitals in the study based on the number of beds. The separation was based on hospitals with less than 75 beds, between 75 and 150 beds and more than 150 beds. The hypothesis with this investigation was that the IT implementation should allow a more efficient handling of the greater complexity associated with more beds and therefore more patients.

The fourth model tested was conceptualized due to the nursing level mandate that took effect in California during the study years of 2004 and 2005 [34]. The model tested hypothesized a staged shift in which the linear slope was anticipated to be a downward shift compared to the years prior to the mandated regulations. A significant model would have indicated that the regulation had an improvement on the patient metrics. Several confounding issues may have kept this model from being significant. One issue may be the anticipation of hospital administration as to the timing of the regulation. The anticipation could have taken the form of additional hiring of nurses in prior years to ensure compliance once the regulations took effect. This could have confounded the resulting model to where a difference could not be detected [16].

Extant research has begun to document some EMR issues that relate to changes in the patient’s length of stay, nurse staffing levels, costs associated with nurse experience levels, poor implementation, cultural resistance to change, lack of coordination between physicians and nurses, and workarounds [4, 16, 20, 25, 38]. These prior studies provide additional insights as to the limitations of the available EMRAD data and the long term nature of this IT implementation.

There are a few additional limitations that should be addressed with respect to the data collection and use for this study. First, the mortality metrics are aggregates and grouping are based on clinical categorization. Statistical evidence of their groupings has not been presented. The use of the metric has been justified by the importance in the healthcare community. Secondly, the EMR stage is an indication of a base level of attainment for each hospital. The adjustment of the EMR stage to an average across the study period is considered rigorous in its conception, but there may be other representations of this covariate that would improve the models. Finally, similar to problems
identified when developing data infrastructures for eHealth [39], the collection of data from multiple hospitals and individuals at those hospitals may introduce some variance that is unforeseen in this analysis.

With respect to future research, an investigation into the individual metrics, instead of the composite metrics, may provide additional insights based on the MRAD level. The ability to discern the impact such a large IT adoption program has on individual metrics may allow hospitals to take useful procedural steps to accelerate ERM integration or mitigate the initial disruption.

This extension would also have the ability to explore additional covariates that had indicated no significant differences between models. For instance, while a nursing level mandate in California did not detect a noticeable improvement at the aggregate level for the three models investigated, individual metrics may be impacted favorably by this mandate. This may be especially true for the PSI metrics since adherence to hospital policies and procedures may be significantly improved with a mandated minimum level of staffing.

8. References


