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# Impact of Electronic Health Record Documentation and Clinical Documentation Specialists on Case Mix Index: A Retrospective Study for Quality Improvement

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## Abstract

**Background:** The implementation of hospital electronic health records software is considered a significant modernization in healthcare.

**Objective:** The objective of this study was to evaluate the impact of electronic health records and the addition of clinical documentation specialists as a clinical support group on hospitalist documentation using case mix index (CMI) as a measurement tool.

**Methods:** A two-group pre/postimplementation retrospective research design was used to evaluate the impact of electronic health records and clinical documentation specialists on CMI in a single 125-bed full-service community hospital in the greater Los Angeles area. All hospitalist medical records were reviewed in the pre/postphases. A total of 3,536 records were reviewed over the two phases. Phase one included a review of 1,712 hospitalist medical records before implementation of electronic health records. Phase two included a review of 1,824 hospitalist medical records after implementation of electronic health records and clinical documentation specialists. Change in CMI data were analyzed over the two phases. CMI data were treated as interval data and analyzed by parametric descriptive statistics in two phases by one-way ANOVA to compare the means between the two phases.

**Results:** The mean CMI value for phase one was 1.65 and 1.68 for phase two. One-way ANOVA yielded no difference between the mean CMI values for the two phases ($p$.53).

**Conclusion:** The implementation of electronic health records and clinical documentation specialists as a clinical support group did not make any significant difference in hospitalist documentation using CMI as a measurement tool.

**Keywords:** Case mix index; Clinical documentation specialist; Complications and comorbidities; Diagnosis related groups; Electronic health record; Medical severity-diagnosis related groups; Major complications and comorbidities

**Abbreviations:** CMI: Case Mix Index; CDS: Clinical Documentation Specialist; CCs: Complications and Comorbidities; DRGs: Diagnosis Related Groups; EHR: Electronic Health Record; MS-DRGs: Medical Severity-Diagnosis Related Groups; MCCs: Major Complications and Comorbidities; CMS: Center for Medicare and Medicaid Services.

## Introduction

In 2008, Medicare changed the Inpatient Prospective Payment System (IPPS) from Diagnosis Related Group (DRG) - to Medicare Severity-Diagnosis Related Group (MS-DRG)-based reimbursement, thereby escalating the importance of provider documentation. MS-DRG assignment now accounts for the severity of illness and the resources required caring for the patients in each assigned group. However, hospitals and providers have not accounted for the impact of provider documentation on MS-DRG reimbursement and quality of care representation. Medicare expects the documentation performed by providers to justify reimbursement and admission by accurately and comprehensively recording the severity of illness through the addition of major and minor comorbidities and complications. Provider documentation of accurate diagnoses and major comorbidities and complications (MCCs) constitute the sole driver of MS-DRG codes, reimbursement and quality of care representation. Unfortunately, hospitals are at a disadvantage in that they are dependent on providers who fail to learn up-to-date coding and documenting techniques. In

addition, most hospitals have difficulties with monitoring provider documentation as it relates to MS-DRGs because of a lack of understanding of Case Mix Index (CMI) as an invaluable measurement tool.

CMI is calculated by using MS-DRG as a single variable in any temporal sequence of interest that can be utilized as a measurement of provider documentation, severity of illness, mortality risk and revenue. Utilized as a monitoring tool, the information that can be derived from CMI is invaluable to administrators and medical officers who understand its use.

Several studies have reflected the large amount of money lost and the decrease in quality of care representation due to poor provider documentation. Kumar and Thomas [1] performed a small pilot study of only five charts and, by re-coding the charts with accurate and comprehensive diagnoses that contained MCC and CC additions,

found an increase in hospital revenue of $50,000. In addition, they observed an increase in expected mortality rates without detecting an increase in observed mortality, thereby decreasing the mortality rate index. Barnes et al. [2] evaluated the impact of provider documentation education on a single trauma service, which increased revenues to the hospital by $1.45 million. Spellberg et al. [3] performed a similar study that noted substantial increases in hospital revenue and decreases in expected mortality rates as a result of educating residents and fellows in appropriate documentation. In 2007, J. A. Thomas & Associates analyzed 194,620 cases that adopted the new MS-DRG system at multiple hospital centers, to evaluate the revenue-generating power of MS-DRG as measured by CMI. The results yielded a powerful financial opportunity and improvement in quality. A CMI of 1.92, which has increased by 5% to 2.02, increased the monthly revenue to $406,212, annual revenue to $4,874,539 and 3-year revenue of $14,623,616.

The addition of electronic health record (EHR) systems has confounded the issue of inadequate provider documentation by mandating providers to adopt complex and time-consuming methods to perform documentation. The tedious manipulation of EHRs to perform tasks that take more time discourages providers and distracts them from undertaking accurate and comprehensive documentation [4]. Hospital organizations that have increased their quality ratings and have prospered financially through campaigns to educate providers in the principles of comprehensive documentation have found that they are struggling to keep providers focused on documentation after the adoption of EHRs.

The American Recovery and Reinvestment Act of 2009 (ARRA) was enacted to promote the adoption and use of EHRs through stages of meaningful use. The adoption of EHRs by providers and hospitals, as mandated by the Centers for Medicare and Medicaid Services (CMS), has resulted in concerns regarding the impacts on quality of care and provider documentation. Unfortunately, little research has been available to help guide the adoption of EHRs in hospital settings while preserving the quality of EHR provider documentation of MS-DRGs and quality of care. In fact, recent research establishing specific measurement variables that provide agencies with an evaluation mechanism to monitor provider documentation of MS-DRG diagnosis after adoption of EHRs has been unavailable. However, CMI is a well-known standard in hospital administration and operations that reflects the relative value assigned to MS-DRG diagnoses, which is used to determine the allocation of resources to care for, treat and determine the quality of provider documentation of MS-DRG diagnoses. Most importantly, accurate and comprehensive documentation of MS-DRG diagnoses with the appropriate and accurate addition of comorbidities improves the representation of the institution's delivery of quality of care by accurately estimating expected and observed mortality. With the addition of observed comorbidities to the MS-DRG diagnoses, the expected mortality rate appropriately increases without affecting the observed mortality rate [3]. This distinction is extremely imperative when institutions report mandatory mortality rates to regulatory agencies for assessment of quality. Those institutions that have poor documentation of MS-DRG diagnoses that do not reflect comorbid states can appear to have poor quality of care related to the comparisons of expected and observed mortality rates, which might or might not be accurate in relation to documentation alone. An added benefit of accurate and comprehensive documentation of MS-DRG diagnoses is the reimbursement associated with more highly weighted MS-DRGs.

The purposes of provider documentation are to establish diagnoses, evaluate progress and record evidence of care, which, in turn, is used to measure quality of care via mortality and morbidity statistics and finally to adjudicate for payment of the care delivered. The use of MS-DRGs is the standard for monitoring, evaluating and payment of care delivered. Measurement of CMI accounts for all of these variables and, therefore, can be utilized as a measurement tool for severity of illness, expected mortality rates and revenue.

The new MS-DRG standards for documenting and coding diagnoses have had profound documentation and coding implications for hospitals and providers. The new payment system is one of several new value-based care initiatives that CMS designed to influence patient care in acute care hospitals and provider reimbursement by rewarding the hospitals that yield best-practice outcomes and penalizing those that do not [5]. Utilizing the new MS-DRG system, CMS operates a substantial hospital- and provider-populated data system to analyze and measure clinical performance and best-practice care outcomes. These guidelines are applied to reward-and-penalty systems to guide reimbursement. Therefore, it has become increasingly imperative that providers document all diagnoses and comorbid conditions that are present on admission and that occur during hospitalization. The omission of any diagnosis that might be interpreted as a hospital-acquired condition will not be reimbursed and will be counted against the hospital in terms of quality and mortality statistics. An important characteristic of the new MS-DRG system is that any hospital-acquired complication is the financial responsibility of the hospital and is not reimbursed by payers that use MS-DRG as a payment system.

The principal diagnosis is a predetermined diagnosis that is dictated by CMS, based on history and studies, which increases the cost of care by requiring increased hospital resources to treat patients. Documentation of the severity of illness is performed by the addition MCC and CC diagnoses. MCC and CC diagnoses are conditions or complications that complicate the treatment of the principal diagnosis by demanding greater resources to manage the patient. The addition of comorbidities also affects the representation of quality of care provided by appropriately adjusting observed and expected mortality rates, which accurately characterize the risk of morbidity and mortality of the patient. Additionally, comprehensive provider documentation provides for the justification of the medical necessity for hospital admission and the resources required caring for patients.

CMI can be utilized by hospital and administrative staff to measure and predict reimbursements, quality of care and quality of provider documentation of MS-DRG diagnoses. CMI is highly dependent on provider documentation and the coding of MS-DRGs, with the addition of MCC's and CCs. However, caution should be observed when using CMI to predict accurately the severity of illness of an institution without first evaluating the quality of provider documentation. Classifying institutions as poor-quality facilities have severe consequences for the physicians and staff. Determining the quality of documentation of the facility prior to classification could help to determine the accuracy of such classifications [6].

**Problem statement**

Comprehensive and accurate provider documentation represents the delivery of quality hospital patient care and financial status, as measured by CMI. However, recent research has shown that provider documentation compliance is difficult to achieve, despite quality methodologies and study designs using traditional paper populated charts [7]. Moreover, with the adoption of mandated EHRs, failure of providers to perform accurate and comprehensive documentation has the potential for negative quality and financial impacts for

providers and hospitals [8]. Recent mandates from CMS to adopt EHRs in hospitals and provider practices have complicated hospital initiatives for improving clinical provider documentation campaigns [5]. Furthermore, healthcare delivery organizations, specifically acute care hospitals, have a considerable interest in the success of their providers' compliance with documentation regulations for financial and quality success. Hospital Inpatient Quality Reporting mandates the reporting of quality measures to CMS as part of the Medicare Prescription Drug, Improvement and Modernization Act (MMA) of 2003, section 501 (b). Hospitals that fail to report quality measurements are penalized by up to 2% in annual payment rates. In addition, The Deficit Reduction Act of 2005 supports penalties, with the expectation that the reduction in payment could rise under the Affordable Care Act in or around 2014-2015. Public knowledge of provider and hospital quality mortality statistics and utilization is reported by CMS to the public for review on the Hospital Compare website, www. hospitalcompare.hhs.gov [9]. Currently, hospital organizations are struggling with provider compliance to comprehensively document diagnoses that reflect accurate MS-DRGs with accompanying MCCs/ CCs [5]. The adoption of mandated, complex EHR systems has resulted in considerable concern for hospitals that struggle with provider documentation compliance because providers tend to concentrate on maneuvering through the components of EHRs rather than on accurate and comprehensive documentation [10]. EHR adoption is a large endeavor for hospitals, both financially and logistically. Hospitals are at significant risk of losing revenue and quality ratings if providers are not committed to the success of the adoption because documentation quality will significantly decrease related to the EHR documentation time restraints placed on providers. Unlike hospitals, providers are compensated based on visit evaluations and management codes, which are set and do not change based on the quality of care provided. The incentive to perform documentation that requires more time, understandably, has not resulted in much provider enthusiasm or dedication. Most importantly, MS-DRG data are collected by CMS and other federal agencies for the analysis of disease states, predictions for future reimbursement schedules and epidemiological research. Inaccurate provider documentation of MS-DRG diagnoses ultimately places aspects of public health at risk by misrepresenting the data with which agencies make health policy decisions.

### Purpose statement

The purpose of this study is to evaluate the impact of implementation of EHRs and a clinical documentation specialist (CDS) as a clinical support team on provider documentation of MS-DRGs and MCCs/ CCs, as measured by CMI.

## Methods

Team members were chosen using a bottom-up approach, and staff members from all areas of the hospital organization were included. The members included those employees that participated in direct and indirect patient care. Prior to implementation of EHRs, a team of interested stakeholders was chosen that included physicians, nurse practitioners, pharmacists, staff nurses, administrative personnel, coders, information technology personnel (IT) and other multidisciplinary team members. During the development stage, the team used evidence from an extensive literature search that would help successfully promote the implementation of EHRs by engaging stakeholders and ensuring the continuation of excellent provider documentation.

Two physician champions were chosen by the medical staff to promote physician involvement and to achieve buy-in for the EHR and clinical documentation system. Singling out physician champions to promote buy-in was prompted mainly by the preliminary results of the MEMO study, performed in 2013. The study examined physicians' stress and burnout when asked to convert to electronic medical record documentation. Introducing physicians to complex and new electronic medical record systems significantly increased stress and burnout. Allowing physicians to be involved in the planning stages reduced this stress and burnout [4]. In addition to the chosen team of stakeholders and end users, a special question and answer panel with the medical staff was conducted to get the physicians on board with clinical documentation and EHR implementation. Leaders from the medical staff spoke about meaningful use and the government's purpose in establishing EHRs. In addition, 20 charts were pulled to demonstrate the impact of MS-DRG clinical documentation improvement on quality of care and financial improvement for the organization [8].

A retrospective study of CMI data one year before and one year after the implementation was performed in two phases. CMI data for all of the hospitalist patients were collected from the hospital financial software. Baseline CMI was calculated for this period. Phase two of the study, the implementation phase, was performed during the implementation phase. We noted 100% compliance with EHR documentation for all of the encounters from each hospitalist provider during the implementation phase. IRB approval was obtained from the hospital's ethical review board.

The project was undertaken in a Los Angeles, California, full-service 125 community hospital with a 24-hour emergency service. Medicare and private-sector insurance makeup the primary sources of payment. Several key employees were identified prior to the implementation phase. Hospitalists, clinical documentation specialists, coders and information technology technicians, were educated in the study design and purpose.

Hospitalist providers were contracted with the hospital to perform inpatient care services. The clinical documentation specialists (CDSs) were trained document specialists with advanced degrees in medicine. Specific to this project, we employed two physicians who had extensive training in documentation. Their specific training beyond a medical degree included DRGs and MS-DRG documentation expertise. The CDS knowledge base of major complications and comorbidities helped the hospitalist providers to document accurate and comprehensive medical records. Their roles in the project were to evaluate concurrent charts that were documented by the hospitalists and to suggest diagnoses for the chart that might have been missed by the hospitalists. The CDS personnel were not licensed in the United States as physicians, so their suggestions were limited to official coding queries, which were submitted for final review by the hospitalist provider.

Information technology was the largest group of employees utilized in our project, with many years of education and experience in hospital information systems. The IT team implemented the hardware and software for the EHR system used in our project.

The project intervention occurred in two phases: pre-implementation planning of the EHR system; and EHR implementation with CDS.

The project leaders adopted 11 factors for EHR implementation success, which were outlined in Keshavjee factors for EHR implementation success: governance; project leadership; involving stakeholders; selling benefits; technology usability; early planning; implementation assistance; training; feedback and dialogue; support;

and user groups [11]. Phase one started six months prior to the implementation of EHRs by forming a planning committee of key stakeholders from each patient care department. The committee included interested stakeholders from each hospital division that were considered end-users. End-users were defined as departments that were involved in direct and indirect patient care. The members of the team were specialists in particular areas who supported the project. The members of the team included a clinical documentation specialist, hospital administrators, internal medicine physicians, acute care nurse practitioners, information technology specialist, Meditech support staff, registered nurses and professional medical coders, who comprised the clinical support team. The team reviewed the latest research literature to implement the best evidence-supported practice. All of the studies were quantitative studies that were utilized to develop an understanding of the implementation of the EHR process based on evidence, as well as to understand the importance of provider documentation of MS-DRGs in yielding quality of care and positive financial impact. All of the studies were level 2 retrospective or retrospective cohorts. One study was a correlation study.

Chart evaluation for MS-DRGs, MCCs and CCs was performed based on recommendations from the literature review [1]. One of the key elements for success was the identification of positive elements for each group to achieve buy-in. The groups were allowed and encouraged to make important decisions regarding the implementation and construction of the components of EHRs, which proved to be essential to implementation success [11]. The process also identified leaders and champions who showed interest in the project. Several interested medical staff members were chosen to develop and build progress notes with the IT and Meditech teams [10]. The final progress note incorporated several timesaving features that were presented to the medical staff by the medical staff champions. Automatic and up-to-date data population of laboratory data, vital signs and parts of the histories of present illnesses were designed to pre-populate the data for subsequent notes [12]. The medical staff voted in favor of the progress note, thereby assisting buy-in. After six months of weekly meetings and strict adherence to the steps for successful implementation, a milieu of acceptance began to emerge, and engagement in training ensued. Providers, nurses, pharmacists and clerical staff were trained by IT support staff and Meditech support staff with "dummy patients." Several months of training and proficiency evaluations followed for each group of end-users. One of the most important decisions the committee made was to allow for the availability of the support staff to provided availability one-on-one training 24 hours per day, 7 days per week, for all of the participants who required it. All of the stakeholders were afforded the opportunity to choose the start date, which was followed by the administration. The implementation of the EHR system started on the agreed-upon date. Computerized provider order entry was delayed six months to allow time for the providers to familiarize themselves with the documentation modules of EHRs.

Phase one of the study consisted of preparation for EHR and CDS implementation and a retrospective analysis of CMI one year prior to phase two, which was the implementation phase. After successful buy-in by the stakeholders, the implementation phase successfully started. Directives from the administration required 100% compliance with the use of EHR progress notes and histories and physicals for patient documentation performed by all hospitalist providers. Hospitalist providers were prohibited by the medical director and administration from using paper chart progress notes in patient care areas, to ensure compliance by the hospitalist providers. IT and support staff were available in all of the patient care areas 24 hours per day and 7 days

per week. The IT and support staff prepared daily reports detailing compliance, complaints and interventions to help the providers achieve 100% compliance.

CDS personnel started performing real-time chart reviews and daily rounds one day after the start date. CDS staff assisted the hospitalist providers in identifying possible documentation deficits, by reviewing possible the MCC/CC diagnoses that were present. Formal queries were generated and presented to the hospitalists for review, and addenda were made on a daily basis. The appropriate addenda were performed by the hospitalists when appropriate.

**Data analysis**

Analysis was performed in two phases. The first phase of the analysis was performed prior to implementation of the EHR and clinical documentation specialists. The CMI data for all of the hospitalist patients were collected from the hospital financial software, and a baseline CMI was calculated for the period prior to the implementation of EHRs. The ongoing evaluation noted 100% compliance with EHR documentation for all of the encounters from each hospitalist provider during the implementation phase. Both phases of data collection were in the same data format. The second phase of the analysis was performed after the implementation of EHR and clinical documentation specialists. Data for each phase were extracted from the hospital financial software into separate Microsoft Excel spreadsheets. The data were cleaned up by deleting records with blank CMI values (n = 26). The spreadsheets were then combined into a single file, and a grouping variable was created to designate the phase from which the data originated. The final data file was then imported into Statistical Package for the Social Sciences (SPSS, version 21) for analysis.

All of the study data were extracted from the hospital financial software package, using the exact search criteria for each phase of the study. Search criteria were included for all of the patients in the hospitalist service during the time period specified, MS-DRGs, weights for each MS-DRG, the hospital blended rate (provided by CMS) and CMI. After analysis of the CMI data was performed, post-hoc and a priori power analysis were performed to facilitate future study preparation.

**Subgroup analysis methods**

CMI data were evaluated for five subgroups that have historically shown large differences in weights when MCC and CC have been appropriately applied. The detailed analysis evaluated CMI across phases, examining a more limited subgroup of MS-DRGs. Five MS-DRG codes were selected from the overall data, and mean CMI values were calculated for each study phase (Table 3). The five MS-DRG codes were 870 (Sepsis with mechanical ventilation 96 hours or greater); 871 (Sepsis without mechanical ventilation for 96 hours or greater with MCC); 872 (Sepsis without mechanical ventilation for 96 hours or greater without MCC); 682 (Acute Renal Failure with CC/MCC); and 684 (Acute Renal Failure without CC/MCC).

**Results**

This study's purpose was to evaluate the impact of the newly adopted EHR system and CDS on provider documentation of MS-DRGs, as measured by CMI. We noted no differences in race, sex, age, insurance status or provider or CDS participants between the pre-and post-implementation phases.

The final data file consisted of a total of 3,536 patient records. There were a total of 1,712 records for the phase one analysis. There were a

| DRG | Phase One CMI Mean | Phase Two CMI Mean |
|---|---|---|
| (682) Acute renal failure with MCC | 1.64 | 1.80 |
| (684) Acute renal failure without MCC | 0.65 | 0.64 |
| (870) Sepsis with mechanical ventilation greater than 96 hours | 5.83 | 5.70 |
| (871) Sepsis without mechanical ventilation for 96 hours or greater with MCC | 1.91 | 1.90 |
| (872) Sepsis without mechanical ventilation for 96 hours greater without MCC | 1.14 | 1.18 |

**Table 1:** Mean CMI Values for Each Phase by DRG Codes.

| CMI | Phase One | Phase Two |
|---|---|---|
| Mean | 1.64 | 1.68 |
| Median | 1.22 | 1.25 |
| Variance | 2.42 | 2.51 |
| Standard deviation | 1.56 | 1.58 |
| Minimum | 0.43 | 0.43 |
| Maximum | 18.12 | 17.99 |
| Range | 17.69 | 17.56 |

**Table 2:** Descriptive Statistics of CMI for Each Phase.

| CMI | Sum of Squares | df | Mean Square | F | Sig. |
|---|---|---|---|---|---|
| Between groups | .980 | 1 | .980 | .397 | .529 |
| Within groups | 8,716.764 | 3,534 | 2.467 | | |
| Total | 8,717.743 | 3,535 | | | |

**Table 3:** ANOVA of CMI by Phase.

| Source | Type III Sum of Squares | df | Mean Square | F | Sig. | Noncent. Parameter | Observed Power (a) |
|---|---|---|---|---|---|---|---|
| Corrected model | .980(b) | 1 | .980 | .397 | .529 | .397 | .097 |
| Intercept | 9,748.533 | 1 | 9,748.533 | 3,952.306 | .000 | 3,952.306 | 1.000 |
| Phase | .980 | 1 | .980 | .397 | .529 | .397 | .097 |
| Error | 8,716.764 | 3534 | 2.467 | | | | |
| Total | 18,482.265 | 3536 | | | | | |
| Corrected total | 8,717.743 | 3535 | | | | | |

a. Computed using alpha = .05
b. R squared = 0.000 (adjusted R squared = 0.000)

**Table 4:** Univariate, General Linear Model with Observed Power.

total of 1,824 records from phase two. Both phases of data collection used the same data format. Table 1 shows descriptive statistics for each phase. No difference was found in the mean between phase one, with a CMI of 1.64, and phase two, with a CMI of 1.68 (P=.529). The standard deviation range of the variants also remained the same between phase one and phase two. One-way ANOVA revealed that, between the two phases, there was no statistically significant difference in CMI ($F_{(1,3534)}$=.397, P=.529). Table 2 shows the results of ANOVA between the phases.

Subgroup analysis of the five chosen MS-DRGs yielded no difference in the mean between phase one and phase two, with the exception of MS-DRG (682) Acute Renal Failure with MCC; phase one yielded a CMI of 1.64 and phase two yielded a CMI of 1.80.

Power analysis and effect size were not performed at the beginning of the study because no previous studies were performed; thus, we were unable to acquire working data that would facilitate power analysis. However, for future research, a post-hoc power analysis and a priori power analysis will be performed. We calculated an observed power of .097 in the current study, using a univariate, general linear model analysis, which was undertaken using the observed group means, standard deviation, sample size and an alpha of .05 (Table 4). Figure 1 illustrates the distribution of the post-hoc power analysis with an effect size .02, and Figure 2 illustrates the distribution of the a priori power analysis (Table 5).

## Discussion

Our findings suggest that the implementation of EHR and clinical documentation specialists did not show a statistically significant impact on CMI. Rather, the diligence of providers that documented accurate and comprehensive MS-DRG diagnoses, with the appropriate addition of MCC and CC diagnoses, guided CMI.

This study was underpowered, with a limited sample size. Post-hoc power analysis revealed a sample size of 69,758. Given the size of our hospital, the time to acquire this sample size was unrealistic. The main questions were answered given the restraints of the study sample size. The objective of the study was to ascertain whether EHRs degraded our high-quality documentation of MS-DRG diagnoses. We discovered that the implementation of EHRs did not significantly impact our documentation techniques. On a practical basis, the addition of CDS, as a clinical support group, countered any untoward documentation effects of the new EHR system.

Furthermore, the effect size of the study was an important variable that should not be overlooked. Small changes in CMI reflect large reimbursement swings. The study revealed that the implementation of EHRs and CDSs did not significantly impact CMI. An increase in CMI from 1.64 to 1.68, although not statistically significant, actually translated into financial gain for the study period of $414,923. Additionally, based on the study findings, it is difficult to comment on the small increase in CMI specific to our study because our starting
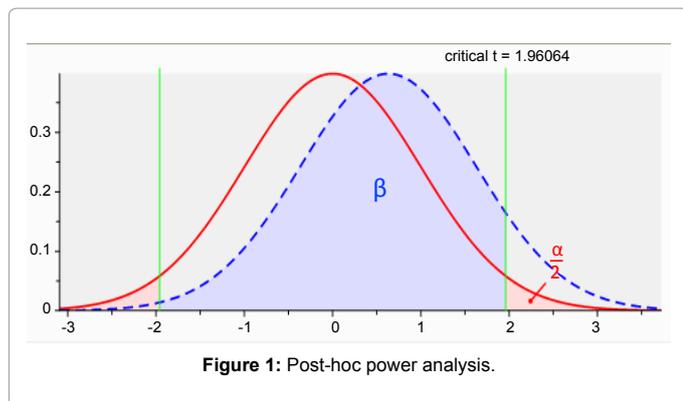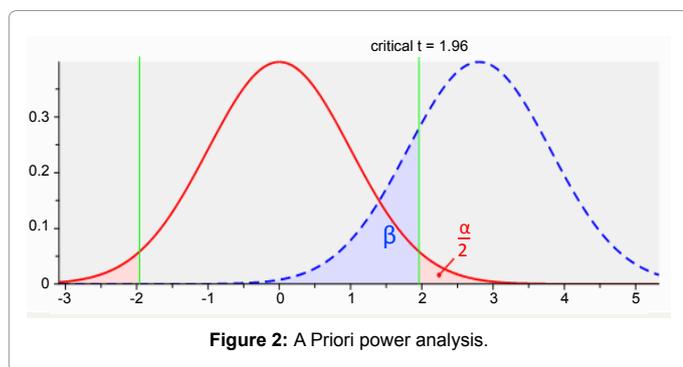
**Figure 1:** Post-hoc power analysis.



**Figure 2:** A Priori power analysis.

|  | Effect Size | Alpha Error Probability | Degrees of Freedom | Power | Mean Group 1 | Mean Group 2 |
|---|---|---|---|---|---|---|
| Post-Hoc | 0.02 | 0.05 | 3534 | .097 | 1.65 | 1.68 |
| A Priori | 0.02 | 0.05 | 69,760 (each group with 34,880) | 0.80 | 1.65 | 1.68 |

**Table 5:** Power Analysis Results.

CMI was considerably higher compared to similar geographic hospitals in our region. As the documentation of MS-DRG diagnoses with the addition of MCCs and CCs reaches a maximal level, the potential for improvement or increases in CMI diminishes. The limited ability to improve documentation might also have contributed to the statistical significance.

A post-study review of CMI data in our geographic area, comparing hospitals within a 40-mile radius that were similar in patient population served, size, services rendered and blended rate, yielded an average CMI for these institutions of 1.34. Calculating the financial impact of the difference, we used the findings for our post-implementation data (N=1,824; blended rate=$5,600; CMI=1.68) and found that our institution's revenue was $3,472,896.00 during the study period.

The most important attribute of CMI is the representation of quality patient care. It has become increasingly clear that the reporting of hospital quality statistics to federal and public forums will be an important variable in the success of institutions, both financially and in their reputations. Documentation of MS-DRG, MCC and CC diagnoses accurately reflects the expected mortality of a hospital patient population. In contrast, inaccurate documentation will reduce the expected mortality statistics, thereby increasing the expected/observed mortality ratio and consequently placing the institution at risk for penalties and investigations.

In comparison to similar hospitals in our geographic area with similar patient populations and resources, our institution carries a CMI that is substantially higher. This difference can be explained by the general culture of the institution to educate providers using accurate and comprehensive documentation. Zalatimo et al. [13], Spellberg et al. [3] and Barnes et al. [2] found that educational methods to improve provider documentation of MS-DRG, MCC and CC diagnosis improved CMI, ultimately increasing institutional revenue and quality markers.

EHR systems will become more advanced and better engineered to enhance provider documentation when institutions move toward understanding the importance of comprehensive documentation and CMI as a measurement of provider documentation as tools for organizational success.

## Study Limitations

Several study limitations existed for this study. The study was performed at a single hospital. The sample was extremely small, with a post-hoc power analysis of .097. The allowable time for the study was restricted to one year post-implementation, which could not control for a post-implementation learning curve for the providers to learn the EHR system. We did not have the resources or our funding to control for the impact of CDSs and EHRs on CMI individually. Hence, we were unable to evaluate the effects on CMI of each independent variable separately. The initial CMI was extremely high at the start of the study, which could have limited the study results impact.

## Suggestions for Further Research

A priori power analysis was performed to facilitate future studies. Our main recommendations for further studies advise larger sample sizes and control of EHRs and CDSs independently. The impact result of MS-DRG documentation, with the appropriate addition of MCC and CC on CMI, must start with an educational documentation program for providers. EHRs should be used as a tool to enhance documentation accuracy. Without foundational knowledge of comprehensive documentation, the impact on CMI will be negligible.

Finally, our study CMI values were remarkably higher than the geographic area (CMI=1.37). Applying provider documentation education and CDS personnel, as detailed in this study, to hospitals that have considerably lower CMI will yield greater gains in representation of quality with large revenue increases.

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