ACCURACY OF CONDITION PRESENT ON ADMISSION, DO NOT RESUSCITATE, AND E-CODES IN CALIFORNIA PATIENT DISCHARGE DATA

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Executive Summary

The California Office of Statewide Health Planning and Development (OSHPD) contracted with the University of California, San Francisco to conduct an audit of the California Patient Discharge Data. All of the elements, except payer source, were audited and the design was structured to focus on three main data elements: 1) the Condition Present on Admission (CPOA), a data element used to distinguish comorbid conditions from hospital related complications, 2) Do Not Resuscitate (DNR), and 3) location of Injury E-Codes with missing location.

For this audit, UCSF sampled records of patients hospitalized in 2005 at an acute care hospital in California. Each record was reviewed by both a registered nurse and a health information technician. For the evaluation of CPOA, a complex sampling strategy focused on hospitalizations with a primary diagnosis of one of three medical conditions (acute myocardial infarction, congestive heart failure, or community-acquired pneumonia) or one principal procedure (percutaneous transluminal coronary angioplasty). For each of these records at least one of two pre-specified conditions known to be a highly predictive risk factor for mortality was also present. The registered nurses reviewed 1,649 records to assess the accuracy of CPOA and the health information technicians reviewed 1,569 records to assess reliability of coding. A gold standard based on multiple abstractions for each record was developed for the eight selected risk factors (two for each of the three selected diagnoses and the one principal procedure). Using the gold standard, sensitivity, specificity, positive predictive value, and negative predictive value were calculated.

To evaluate the accuracy and reliability of the DNR order within 24 hours of a hospital admission, health information technicians reviewed 1,981 records and registered nurses reviewed 2,136 records with the same four umbrella conditions. The registered nurses with their clinical expertise were considered the gold standard in this analysis.

A third group of 269 records were reviewed by a health information technician for the purpose of evaluating E-Codes indicating an injury without a known location. The health information technician determined the percent of records where a location of injury could be determined from the medical record, the location in the records where the information was founded, and the type of injury for which the location of injury was found.

Key Findings:

1. **The sensitivity of CPOA is relatively good but the specificity is lower and more variable across conditions.**

   Overall, the average sensitivity for the CPOA for the eight risk factors in the setting of the four umbrella conditions was 81.5% (range 72.2% to 88.9%), suggesting that if a condition was truly present on admission as defined by the gold standard, it was fairly likely that the hospitals would have coded it as "Present on Admission." However, the specificity across all eight conditions was lower and more variable across conditions (61.2%; range 30.2%- 81.4% across risk factors), indicating that if a condition was truly not present on admission, there is substantial variability across conditions as to whether it would be correctly coded as "Not Present on Admission."

2. **Overall, there is no evidence that the hospitals systematically coded CPOA as either present or not present on admission.**

   The agreement between the hospital coding and the gold standard assessment for CPOA was 74.1% (McNemar's $p = 0.149$). Some risk factors were over-coded as present on admission such as septicemia in the setting of community-acquired pneumonia (79.6% vs. 51.1%, $p = 0.0001$), while others such as, acute myocardial infarction in the setting of congestive heart failure (76.8% vs. 88.4%, $p = 0.012$) were under-coded.

3. **Chronic conditions tend to be coded more accurately and reliably than acute conditions, which may be more difficult to code.**

   The abstractors agreed with the hospital coding of CPOA for chronic conditions such as diabetes, hypertension, and chronic obstructive pulmonary disease more than 85% of the time.

4. **Hospitals are more likely to code DNR as present within 24 hours of admission.**

   Hospitals agreed with the health information technicians' coding of DNR in 81.1% of the records and the registered nurses' coding in 85.3%, but the hospitals were far more likely to code patients as having a DNR order within the first 24 hours than the health information technicians (30.9% vs. 24.6%; McNemar's, $p < 0.001$) or the registered nurses (32.5% vs. 24.7%; McNemar's, $p < 0.0001$). This difference in coding DNR was evident across all conditions.

5. **The accuracy of CPOA coding did not differ in patients who died or had a DNR order.**

   There were no substantive differences in hospital coding of CPOA when comparing patients who died in-hospital with those discharged alive. Similarly, no differences in CPOA coding were noted for patients with DNR coded versus those with DNR not coded.

6. **A high proportion of missing location of injury E-Codes are found in the physician notes and are most likely to be adverse effects of medical care, medical drugs, or falls.**

   The health information technicians found a known place of injury occurrence in 151 (56.1%) of the 269 records, and in the remaining 118 (43.9%) records, the health information technicians agreed with hospitals that the place of occurrence was unknown. Of records where health information technicians found a place of occurrence, the information was found in the physician note 73.5% of time and was most likely to be an adverse effect of medical care or medical drugs or a fall.

Policy recommendations

- There are no established standards of accuracy for determining whether a potential risk factor should be included in a publicly reported risk-adjusted outcomes model. The moderate positive predictive value and the low negative predictive value for CPOA coding for the acute conditions evaluated in this study raise concerns about the use of these conditions in risk-adjusted outcomes models. While there is little evidence suggesting systematic bias on the part of hospitals in coding acute conditions as present on admission, varied and sometimes low accuracy in coding CPOA for some acute conditions could undermine stakeholders' confidence in the results generated with these measures.

- CPOA coded by hospitals is not as good for the selected risk factors as for many of the other chronic conditions used in risk-adjusted outcome models. In general, the CPOA coding exceeds 85% percent agreement for most of the chronic conditions included in the models while it is in the 70% range for the acute risk factors. We recommend that further work be undertaken to model the impact of CPOA coding accuracy on the validity of risk-adjusted outcome assessments. Until more is understood about the impact of this measurement error, we would recommend that OSHPD be cautious in incorporating any acute risk factors that do not meet a minimum threshold of 85% agreement between hospital coding and a gold standard so as to be more in line with other chronic conditions used in the model.

- The potential for random error to influence risk-adjusted outcome assessments is greatest in circumstances in which there are small sample sizes. Future attention should be directed at determining the minimum number of cases needed to limit inaccurate assessments of hospital performance that result from CPOA measurement error.

- DNR as currently coded by hospitals is problematic for use in risk-adjusted outcome models. Hospitals tend to over-code DNR and therefore inclusion of this data element in risk-adjusted outcomes models may bias hospital assessments. Future studies should evaluate if there are hospital characteristics that drive over-coding of the DNR to help determine the most effective strategies to improve DNR coding. Potential areas of explorations include evaluating whether coding errors tend to occur around the timing of when DNR orders are written or in the setting of palliative care.

- Hospitals could improve their coding of the location where injuries occur by making better use of information that is already coded in physician notes.

Overview

The past two decades have seen an explosion of work on measuring and reporting healthcare quality as a means to ensure accountability and to stimulate quality improvement.[1] In the United States, hospital quality has been a central focus of this activity.

Currently the most readily available information for assessing hospital quality is administrative data.[2-6] One example of such data is the California Office of Statewide Health Planning and Development (OSHPD) patient-level hospital discharge data. Administrative data are a valuable resource for health services research and quality assessment because they are nearly universal in their coverage of hospitalizations in a state, available for a large number of patients, and uniform in their coding rules.[7] Mandatory collection of these data from all hospitals avoids the biases that typically arise with voluntary reporting systems.

Because patients are not randomly assigned to hospitals, differences in the health status of patients who are cared for in different hospitals can confound an assessment of healthcare quality based on patients' health outcomes. Outcome reporting usually relies upon risk-adjustment, a multivariate statistical technique that accounts for observed variation in the health of patients being cared for in different healthcare settings. Risk-adjustment is a powerful statistical method, but the quality of data in routine hospital discharge datasets could limit its application.

To understand the variability in coding quality in the California Patient Discharge Dataset (PDD), this study audits the validity and reliability of three key variables: CPOA, DNR, and the Place of Occurrence of Injury for External Cause of Injury Codes (E-Codes). As a secondary goal, the study also audits the reliability of other data elements in the PDD.

This report is organized into five sections: an Overview, CPOA, DNR, Place of Occurrence of E-Codes, and other data elements. The CPOA and DNR sections include reliability and validity analysis while the E-Code and other data elements sections focus on reliability only. The methodology used throughout the audit is similar. The sampling, data collection, vendor selection, abstractor selection and training, and pilot test will be described in the overview as it is relevant for all parts of the audit. Specific data analysis methodology and components unique to specific sections will be described in subsequent sections as appropriate.

Methods

We conducted an audit of the California PDD, which is composed of administrative data on inpatient hospitalizations reported by hospitals to OSHPD. OSHPD has been collecting inpatient hospitalization data since 1989. The dataset includes 18 data elements on patient demographics, diagnoses, procedures, and billing information. Data are self-reported by hospitals. For this audit, we reviewed medical records of patients discharged in 2005.

Each record was reviewed by a health information technician (HIT) and a registered nurse (RN) using a data collection tool designed by UCSF for this audit. HITs assessed coding reliability. They were instructed to blindly review the medical record following standard practice medical record coding rules. The HITs reviewed the medical record without any explicit information regarding the diagnostic codes or the CPOA coding previously completed by the hospitals. The HITs abstracted the record according to coding guidelines and referred to a 3M clinical software package, frequently used by hospitals, to help guide coding decisions. In contrast, the RNs assessed the validity of CPOA coding and DNR. As trained clinicians, the RNs assessed the

validity of the CPOA coding using signs and symptoms of conditions that might not be apparent to licensed HITs. The RNs were provided with the unblinded list of ICD-9-CM codes that the hospitals had coded in the original 2005 patient discharge data. They first determined whether the codes listed for the principal and all secondary diagnoses were actually reflected in the clinical records. For all diagnoses which the RNs determined to be accurately coded, the RNs determined whether each diagnosis was present on admission.

Sampling

Medical records were randomly selected for chart review using a complex sampling strategy. We focused on a limited number of medical conditions to permit adequate sample size for a robust assessment of CPOA in each condition. We selected three common and high mortality principal diagnoses and one principal procedure used by OSHPD in quality measurement reports, referred to as "umbrella conditions" in this report. OSHPD has developed risk-adjusted mortality models used in public reporting for two of the umbrella conditions: acute myocardial infarction[8] and community-acquired pneumonia.[9,10] The other two umbrella conditions, congestive heart failure and percutaneous transluminal coronary angioplasty, are of interest for future risk-adjusted outcomes reports.

For each umbrella condition, we selected two risk factors from which to sample charts for the CPOA analysis. We selected risk factors that were highly influential in risk-adjusted mortality models so that our results would have meaningful implications for mortality reports. We also focused on acute conditions that could either be comorbidities or complications of care, recognizing that these conditions would be some of the most difficult to abstract, and therefore increase the sensitivity of our study to find challenges in coding. We based our decision on a literature review (Appendix A) and on the number of cases per condition and per risk factor in the 2005 PDD. To assess whether there would be an adequate number of cases for sampling, we conducted cross-tabulations within each umbrella condition and risk factor for CPOA and death. The four criteria that each of the two risk factors had to fulfill were:

- An acute medical condition
- Strong association with in-hospital, thirty-day, or one-year mortality, based on available literature, for a specified umbrella condition
- Potential to be present on admission (co-morbidity) or not present on admission (arise as a complication of care)
- Have adequate numbers of cases in the 2005 PDD across risk factors

We randomly sampled hospitals proportionate to the number of patient records they had with any of the umbrella condition/risk factor combinations. To avoid too large an influence on the sample from any one hospital, we capped the number of records per combination of umbrella condition/risk factor at 10 cases per hospital, randomly selecting 10 if there were more than 10 available. On this basis, the maximum number of cases that could be chosen from any single hospital was 80 (4 umbrella conditions x 2 risk factors x 10 cases per combination). If there were less than 10 cases for an umbrella condition/risk factor combination at that facility, we selected all available.

Using this method, we targeted approximately 200 records per risk factor for the CPOA analysis, hence sampling approximately 1,600 records with one of the umbrella conditions as the principal diagnosis or procedure plus one of the specifically associated risk factors as a secondary diagnosis.

We estimated that to have adequate power to calculate sensitivity and specificity for the DNR data element in each of the four umbrella conditions, we would need to acquire, for each umbrella condition, approximately 100 records whose DNR status was recorded by the hospitals as having a DNR order (DNR "yes"). Our goal was to weight the sample towards DNR "yes" charts to ensure we had adequate power to evaluate the agreement in coding between the hospitals and our auditors, particularly for DNR "yes," which are less common than DNR "no" in the acute hospital setting. To achieve this, we evaluated the percent of records in our estimated CPOA sample which would be DNR "yes" and then determined that we would need an additional 400 records as the CPOA sampling strategies fell short of capturing the desired 100 DNR "yes" records per umbrella condition. We sampled these additional 400 DNR "yes" cases from the umbrella condition without regard to risk factors. By removing the risk factor requirement, there were an adequate number of cases to sample DNR cases for all umbrella conditions. This sample was taken only from hospitals which were selected for the umbrella condition plus risk factor sample.

A sample of 275 medical records with E-Codes with an unknown place of injury occurrence (E849.9) was also randomly selected from the hospitals selected for the umbrella condition plus risk factor sample.

We selected approximately 10% of all records to be abstracted twice by both RNs and HITs to assess inter-rater reliability.

The sample was drawn from 48 of 457 California hospitals (10.5% of California hospitals). The selected hospitals were located in 23 of 58 California counties (39.7% of California counties). Thirty-seven (77.1%) were non-profit hospitals, 8 (16.7%) were teaching hospitals, and 3 (6.3%) were rural hospitals (Table 1).

Table 1 Sampled Hospital Characteristics

Sampled Hospitals	48
Ownership	
Non-Profit	37 (77.1%)
Investor	9 (18.8%)
District	1 (2.1%)
City/county	1 (2.1%)
Teaching	8 (16.7%)
Small/Rural	3 (6.3%)

Data Collection Tool

HIT and RN abstractors entered data directly into (two different but related versions of) an electronic data collection tool, designed specifically for this project in Microsoft Access. The HIT version of this tool, designed to assess the reliability of data reported to the PDD, was used by HITs to reabstract all data elements in the California 2005 PDD excluding items related to payer/insurance, social security number, date of birth, date of admission, date of discharge, and hospital identifier. The RN version of this tool, designed to assess the validity of data reported to the PDD, was used by RNs to blindly reabstract CPOA and DNR in the PDD.

The HITs blindly abstracted whether there was a DNR order in the chart using the same methodology used by hospitals reporting to OSHPD for the PDD. In the HITs training session, we reviewed OSHPD's definition of a DNR order: a physician's order, dated and signed, within 24 hours of admission.

The RNs blindly abstracted the date and time of DNR orders signed by a physician. We then calculated whether this order was documented within 24 hours of the admission time recorded in the medical record.

The E-Code Tool was a modification of the HIT Tool and was used by HITs to blindly reabstract E-Codes, information regarding the place of occurrence of injury/trauma, and the type of note where the place of occurrence information was found. HITs determined whether the note was written by a physician, nurse, paramedic, and other provider.

Vendor Information

We contracted with an independent vendor to conduct the chart abstractions. Vendors were evaluated for qualifications, cost, staffing and logistical capabilities, proposed timeline, references, and timeliness of response.

Both RN and HIT abstractors' credentials were rigorously screened. RNs all had at least 5 years previous experience with adult inpatient medical care and had experience with quality review and chart abstraction. HITs were required to have up-to-date credentials with either a Registered Health Information Technician (RHIT) or Certified Coding Specialist license and at least 5 years of adult inpatient medical coding experience.

Training and Data Monitoring

All abstractors participated in a mandatory training session led by the UCSF auditing team. The training consisted of a 5 day in-person session (8 hours a day). The first 16 hours were devoted to training, with the remaining 3 days spent pilot testing with daily 2 hour feedback sessions. Physicians led the training sessions with input from an OSHPD coding expert and sub-specialist physician guidance. Abstractors were given an overview of the project, instruction in the data collection tool, standardized training examples, and abstraction of sample medical records. RNs and HITs were trained separately in the use of their respective data abstraction tools to address questions related to their specific tasks. Abstractors were provided with a coding manual for use during all abstractions, including the pilot and main study phase.

The training was evaluated by a post-training review of sample medical records to assess the abstractors' accuracy. Each abstractor had to meet a minimum standard of abstraction and coding knowledge. If that minimum standard was not met, further focused training was provided, followed by coding of additional sample medical records. Abstractors that did not meet the minimum standard subsequently were released.

Abstractors were provided with a coding manual for use throughout the audit. Particular focus was given to appropriate coding of CPOA, DNR, and the E-Code place of occurrence. HIT abstractors were also provided with the OSHPD PDD manual. RN abstractors were provided with guidance developed with input from physician specialists in the clinical areas of the umbrella conditions and risk factors to help them determine whether conditions were present during the hospitalization and at admission.

Data monitoring and feedback continued throughout the data collection process. Weekly mandatory conference calls between abstractors and UCSF were used to identify and address content issues and provide feedback to abstractors. UCSF physicians were available on-call with less than 24 hour response time to address content questions and circulated question and answer reports to the abstractor group to maintain consistency in approach to abstraction issues. Specific detailed information regarding records was not discussed in the group format in order to preserve blinding of charts reviewed by multiple coders.

Pilot Test

Following the training, a pilot test was performed on a convenience sample of randomly selected medical records from one hospital. Abstractions were entered directly into the Data Collection Tool. Cases were reviewed to ensure quality abstraction techniques. At the end of the pilot test an additional training session was held to address questions, issues, and feedback on the data collection tools.

The pilot test data was analyzed and reported to OSHPD. We evaluated intra- and inter-group agreement (e.g., RN-HIT, RN-RN, HIT-HIT) to assess for poor quality abstractors. All abstractors were of acceptable quality based on the agreement analysis. Kappa statistics were not calculated due to the small sample size and limited number of overlapping records.

Gold Standard

We developed a "gold standard" assessment of CPOA for the selected risk factors (pulmonary edema, shock, septicemia, respiratory failure, acute renal failure, and acute myocardial infarction) using multiple abstractions for each record. Any record that was not abstracted at least twice was excluded from the gold standard sample. For example, records that were reviewed by a HIT but not by an RN (who may have determined that a diagnosis was not present) were excluded. We applied an algorithm to records with multiple abstractions to categorize them in the gold standard sample. For records with two abstractions (usually one RN and one HIT), both needed to agree on the CPOA coding for a given diagnosis in order for the record to be included in the gold standard sample. For records abstracted by three abstractors, all three needed to agree on the CPOA coding for a given risk factor diagnosis in order for the record to be in the gold standard sample. For records in which four individuals abstracted a record, at least three needed to agree (on CPOA) for the record to be in the gold standard sample. For those records with two or more abstractions that did not meet our criteria for the gold standard sample, we had physicians trained in the specialty area of the diagnosis review the record to make a final determination of whether the condition was or was not present on admission and on this basis included the record in the gold standard sample. A cardiologist adjudicated the shock, pulmonary edema, and acute myocardial infarction records. An infectious disease physician adjudicated the septicemia cases. A pulmonary-critical care physician adjudicated the respiratory failure cases, and a nephrologist adjudicated the acute renal failure cases.

Limitations

Our sample was weighted towards large urban hospitals to reflect the population of patients hospitalized in California. The generalizability of our findings to rural hospitals therefore is somewhat limited. We sampled from a subgroup of high-risk patients with selected principal and secondary conditions to ensure adequate sample sizes for our analysis and to enrich our

sample with difficult cases. Our analysis of coding quality may not be generalizable to all patients and clinical conditions. Our abstractor training mainly focused on CPOA, DNR, and E-Codes and relied on implicit rather than explicit review. Implicit review mimics real life abstraction in hospitals more closely than would explicit review. Previous studies have indicated that explicit reviews are more reliable but they are also more expensive to perform and tend to be narrower in their focus. We attempted to address the variability in inpatient coding by creating a gold standard that relied on the agreement among multiple reviewers.

CONDITION PRESENT ON ADMISSION (CPOA)

Background

Collection of data on whether a condition is present on admission, a strategy to distinguish between comorbidities and complications of care, is gaining widespread support on the federal level.[11] Conditions present on admission are by definition comorbidities, while those conditions that occur after admission may be complications of care. The National Committee on Vital and Health Statistics (NCVHS) has recommended inclusion of a CPOA indicator since 1992. In April 2006, the CPOA designation was added to the Implementation Guide for the Uniform Hospital Discharge Dataset.[12] The Centers for Medicare & Medicaid Services (CMS) has incorporated a CPOA-like indicator in the Deficit Reduction Act of 2005. In August 2007, CMS released an initial list of "reasonably preventable" hospital-acquired conditions for which hospitals would not receive additional payments when one of these selected conditions was acquired during the hospitalization. The CPOA indicator is utilized to distinguish comorbidities from complications of care as of October 1, 2008.

State agencies in New York and California have been collecting data on CPOA since 1994 and 1996, respectively. No large studies to date have assessed the accuracy of the CPOA data elements, despite the fact that administrative data is susceptible to inaccuracies and miscoding could bias quality comparisons.[13,14] Two prior audits of patient discharge data revealed substantial limitations in coding.[15,16] The 2000 OSHPD Community-Acquired Pneumonia Mortality Report noted that only 58.6% (605 of 1032 records) with a principal diagnosis of pneumonia actually were definitively diagnosed by chart review. An additional 31.9% had a possible diagnosis of pneumonia.[17] These same investigators evaluated the quality of CPOA coding on risk factors included in the community-acquired pneumonia model and found that CPOA coding was reasonably accurate for only three non-chronic risk factors (respiratory failure, coagulation deficit, and stroke) in the setting of community-acquired pneumonia. Subsequently, OSHPD has focused significant attention on improving CPOA coding. A goal of this study is to audit the California Patient Discharge Dataset (PDD) to evaluate CPOA coding accuracy.

Data Analysis

Reliability of Diagnosis and CPOA Coding (HIT Analysis)

<u>Reliability of diagnosis coding for umbrella condition and selected risk factor</u>

We calculated the percent of agreement between hospitals and HITs on the coding of the umbrella condition and risk factor diagnoses. In many cases an umbrella condition and/or risk factor could be identified with more than one ICD-9 code. These single/clusters of codes are derived from OSHPD risk-adjusted mortality models for acute myocardial infarction, community-

acquired pneumonia, and from Agency for Healthcare Research and Quality (AHRQ) models for congestive heart failure and percutaneous transluminal coronary angioplasty (Appendix B). To be considered a 'match', the HITs had to code a single/cluster of codes that corresponded to both the umbrella condition and the risk factor. We considered a record to have a 'match' if the ICD-9 codes of interest were either the principal or a secondary condition.

Reliability of CPOA coding for umbrella conditions and selected risk factors

We calculated a series of descriptive statistics in which we categorized the degree of agreement between the hospital and HITs on CPOA for umbrella and secondary diagnoses, including overall percent agreement, Cohen's Kappa statistic, and McNemar's test. The McNemar's test evaluates whether hospitals or HITs were more or less likely to code conditions as present on admission as this provides insight into either random error or systemic differences in the coding of CPOA by hospitals. A McNemar's test with a p-value less than 0.05 can be interpreted as showing that one of the two sides was more likely to code a given diagnoses as present on admission. We also stratified these analyses to assess whether CPOA coding agreement differed (between hospitals and HITs) on the basis of whether: (a) the patient died or not, and (b) the patient had a DNR order within 24 hours of admission or not. We performed these analyses pooling all 8 combinations of umbrella condition and risk factor, but limited the analyses to the subgroup of records in which the hospital and HIT(s) agreed on the umbrella condition and risk factor. To determine the frequency that the hospitals and the HITs would agree in coding the umbrella condition, the risk factor, and CPOA, we calculated the conditional probability of this occurrence for each of the umbrella condition-risk factor combinations.

Cohen's kappa is a commonly used measure of observed agreement against that which might be expected by chance. A kappa of 1 signifies perfect agreement, while 0 suggests agreement equivalent to chance. Chance is determined by the prevalence of the outcome; a very high or very low prevalence constrains the ability to do better than chance. The prevalence of CPOA in across the acute risk factors in our sample was 66.6%. Interpretation of kappa results between 0-1 is somewhat arbitrary. However, often 0-0.2 is considered poor, 0.2-0.4 is fair, 0.4-0.6 is moderate, and 0.6-0.8 is good, and 0.8-1.0 is excellent.

We used McNemar's chi-squared test for paired data to assess whether differences between the hospitals and HITs on CPOA coding were random, or skewed by one group being more likely to report CPOA "yes" or "no." A significant result for McNemar's test ($p < 0.05$) would suggest a non-random bias in coding differences between the hospitals and HITs.

Reliability of CPOA coding on all other secondary diagnoses

The reliability analysis of CPOA coding was performed on all secondary diagnoses (up to 24) that were not explicitly sampled in a given record. These secondary diagnoses consisted of a much broader set of conditions than the selected risk factors specifically chosen for sampling. However, the generalizability of the conditions from this analysis is limited because these are secondary diagnoses in the context of the selected umbrella condition and risk factor combination. In contrast to the selected risk factors on which we based our sampling, many secondary diagnoses are chronic conditions. Secondary diagnoses vary from record to record in both number and content.

To perform this analysis we first grouped secondary diagnosis ICD-9 codes into the 2008 Clinical Classification Software (CCS) Groups. CCS is a diagnosis and procedure categorization

scheme developed by AHRQ that groups codes into clinical and procedural categories and has been used to develop risk-adjustment models and for its morbidity classification system.[18-20]

For each secondary diagnosis, we determined the appropriate CCS group and then calculated the percentage of codes with a 'matching' CCS group documented by both the hospitals and the HITs for a particular chart. We compared CPOA coding only among diagnoses where the hospitals and the HIT coders matched on CCS group. We also calculated the percent agreement and kappa statistic of CPOA of matched CCS codes.

Validity of Diagnosis and CPOA Coding (RN Analysis)

Validity of diagnosis coding for umbrella condition and selected risk factor

To determine the validity of CPOA coding, we first calculated the frequency that the RNs confirmed existence of the umbrella condition and risk factor reported by the hospitals for a given record. We then calculated the percent agreement, Cohen's kappa, and McNemar's statistic of the CPOA first for the umbrella condition in cases where the RN confirmed the umbrella condition and then for the risk factor in the group of cases in which the RN confirmed both the umbrella condition and risk factor. Using McNemar's test, we evaluated whether hospitals or RNs were more likely to code conditions as present on admission as this would provide insight as to the likelihood that hospitals were coding differently from the RNs. We then compared whether percent agreement differed depending on whether the patient: (a) died or not, and (b) had a DNR order or not. These stratified analyses aimed to assess whether coding practices differed by illness severity, which could bias public reports. For each of these analyses, we made comparisons across all records and according to umbrella condition and specific risk factor. We then calculated the conditional probability of an RN confirming the presence of the umbrella condition, the selected risk factor, and then the coding of CPOA.

Validity of CPOA coding on all other secondary diagnoses using CCS groups

Similar to the HIT analysis, we performed validity testing of CPOA coding on all other secondary diagnoses (up to 24) that were not explicitly sampled in a given record. RNs were presented with the ICD-9 codes reported by hospitals. We included all ICD-9 codes that the RN confirmed were present in the analysis, and then determined the agreement between the hospitals and RNs on CPOA coding for confirmed diagnoses.

Gold Standard Sample

We used the gold standard sample to calculate sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV) for CPOA coding for the selected risk factors in the setting of the umbrella conditions.

Reliability of Reabstraction

To quantify the variability between HITs and RNs on CPOA coding, we calculated inter-rater reliability (IRR) statistics for records where there was a double abstraction by HITs and/or RNs. We calculated the overall agreement and the kappa statistic. The raw agreement measures show how often HIT and RN reviewers agreed on CPOA coding, while the kappa statistic measures agreement beyond that which one could expect to occur by chance.

To assess the influence of any given abstractor, we sequentially removed each abstractor's records from the analysis and re-calculated the agreement between the remaining abstractors and the hospitals and similarly the remaining RNs with the hospitals.

Results

Reliability of Diagnosis and CPOA Coding (HIT Analysis)

Reliability of diagnosis coding for umbrella conditions and selected risk factors

Table 2a describes the number of charts abstracted by a least one HIT abstractor. The HITs reviewed 1,569 records for the CPOA analysis. Of these, 1,469 matched the hospital on umbrella condition (93.6% of records reviewed), and 1,044 matched on umbrella condition and selected risk factor (66.5% of all reviewed records).

Table 2a Sampling for CPOA Analysis (HIT)

	Records	Umbrella Conditions	Risk factors
	Abstracted	Matched[a]	Matched[b]
	N	N (%)	N (%)
Acute myocardial infarction			
Shock	208	197 (94.7%)	167 (80.3%)
Pulmonary edema	198	172 (86.9%)	122 (61.6%)
Community-acquired pneumonia			
Respiratory failure	181	161 (89.0%)	117(64.6%)
Septicemia	172	153 (89.0%)	76 (44.2%)
Congestive heart failure			
Acute myocardial infarction	212	207 (97.6%)	137 (64.6)
Acute renal failure	210	207 (98.6%)	163 (77.6)
Percutaneous transluminal coronary angioplasty			
Acute myocardial infarction	204	199 (97.5%)	129 (63.2%)
Acute renal failure	184	173 (94.0%)	133 (72.3%)
Total	1,569	1,469 (93.6%)	1,044 (66.5%)

[a] Cases where both the hospitals and the HITs coded one of the ICD-9 codes used to sample the umbrella conditions (Appendix B)
[b] Cases where both the hospitals and the HITs coded one of the ICD-9 codes used to sample the umbrella conditions and one of the ICD-9 codes used to sample the selected risk factor

Reliability of CPOA coding for umbrella conditions and selected risk factors

Overall, there was a 90.8% agreement between the hospitals and the HITs on CPOA coding for the umbrella conditions in the setting of the confirmed umbrella condition, with a range of 79.7% to 98.4% (Table 2b). To interpret Table 2b, we will use the example of the acute myocardial infarction, the first umbrella condition listed. For cases coded by both the hospitals and the HITs as having an acute myocardial infarction as the umbrella condition, column 'a' represents cases (n = 357) where both the hospitals and the HITs agreed in the coding of CPOA for acute myocardial infarction. Column 'b' represents cases in which the hospitals coded the acute myocardial infarction as present on admission (n = 12), but the HITs did not determine it to be

present. Column ‘c’ represents cases where the HITs determined the acute myocardial infarction as present on admission and the hospitals did not (n = 0). Finally, column ‘d’ represents cases in which both the hospitals and the HITs agreed that the acute myocardial infarction was not present on admission (n = 0). The subsequent column demonstrates the percent of cases where both the hospitals and the HITs agreed in coding of CPOA. Percent agreement was calculated as the sum of the cases where the hospitals coded CPOA as present on admission (a + d) divided by the total number of cases where both the hospitals and the HITs agreed in the coding of the umbrella condition (a + b + c+ d). In the example of acute myocardial infarction the percent agreement was 96.7%. Overall, the percent agreement was 90.8% for the umbrella conditions, and overall, the hospitals were more likely to code CPOA as present on admission (99.9% versus 90.9%, McNemar’s, p-value < 0.0001), due predominately to the coding by hospitals of congestive heart failure as being present on admission.

Table 2b CPOA Reliability Analysis (HITs) for Umbrella Conditions Among Records with Agreement on Umbrella Condition

	a[a]	b	c	d	N[b]	% agrmt[c]	kappa	McNemar's p-value
Overall agreement	996	100	1	0	1097	90.8%	N/A[d]	< 0.0001
Acute myocardial infarction	357	12	0	0	369	96.7%	N/A	0.01
Community-acquired pneumonia	309	4	1	0	314	98.4%	-0.05	0.3711
Congestive heart failure	330	84	0	0	414	79.7%	N/A	< 0.0001
Percutaneous transluminal coronary angioplasty	N/A[d]	N/A	N/A	N/A	N/A	N/A	N/A	N/A

[a] Column ‘a’ represents cases where the hospitals and the abstractors coded CPOA as ‘yes’.
Column ‘b’ represents cases where the hospitals coded CPOA as ‘yes’ and abstractors coded ‘no’.
Column ‘c’ represents cases where the hospitals coded CPOA as ‘no’ and the abstractors coded as ‘yes’.
Column ‘d’ represents cases where the hospitals coded CPOA as ‘no’ and the abstractors coded as ‘no’.
[b] Records were dropped from the analysis if either the HITs or hospitals coded CPOA as uncertain.
[c] N/A = comparisons where kappa couldn’t t be calculated due to cells with more than one zero
[d] N/A = hospitals only code CPOA for diagnosis codes, not procedures.

For the selected risk factors (Table 2c), combined there was 71.2% agreement between the hospitals and HITs on CPOA coding, with a range of 58.6% - 79.1% across the eight combinations of umbrella conditions and risk factors. Neither hospitals nor HITs were more likely to code CPOA as “yes” (65.7% vs. 67.9%; McNemar’s, p = 0.185). However, when analyzing by specific risk factor, hospitals were less likely to code the acute myocardial infarction risk factors, both pulmonary edema (68.0% versus 77.0%, McNemar’s, p = 0.041) and shock (74.8% versus 83.8%. McNemar’s, p = 0.016), as present on admission. Analyzing by specific umbrella conditions demonstrated that there was little difference in CPOA percent agreement between conditions for which there are currently public mortality reports [acute myocardial infarction (76.5%) and community-acquired pneumonia (68.9%)] versus conditions for which there are not [congestive heart failure (72.3%) and percutaneous transluminal coronary angioplasty (65.6%)].

Table 2c CPOA Reliability Analysis (HITs) for Risk Factors Among Records with Agreement on both Umbrella Condition and Risk Factor

	a[a]	b	c	d	N[b]	% agrmt[c]	kappa	McNemar's p-value
Overall agreement	547	139	162	196	1044	71.2%	0.35	0.185
Acute myocardial infarction	187	21	47	34	289	76.5%	0.35	0.002
Shock	113	12	27	15	167	76.6%	0.30	0.016
Pulmonary edema	74	9	20	19	122	76.2%	0.41	0.041
Community-acquired pneumonia	98	30	30	35	193	68.9%	0.30	1
Respiratory failure	53	18	23	23	117	65.0%	0.25	0.435
Septicemia	45	12	7	12	76	75.0%	0.39	0.251
Congestive heart failure	191	43	40	26	300	72.3%	0.21	0.742
Acute myocardial infarction	77	26	23	11	137	64.2%	0.07	0.668
Acute renal failure	114	17	17	15	163	79.1%	0.34	1
Percutaneous transluminal coronary angioplasty	71	45	45	101	262	65.6%	0.30	1.00
Acute myocardial infarction	28	21	14	66	129	72.9%	0.41	0.237
Acute renal failure	43	24	31	35	133	58.6%	0.17	0.345

[a] Column ‘a’ represents cases where the hospitals and the abstractors coded CPOA as ‘yes’.
Column ‘b’ represents cases where the hospitals coded CPOA as ‘yes’ and abstractors coded ‘no’.
Column ‘c’ represents cases where the hospitals coded CPOA as ‘no’ and the abstractors coded as ‘yes’.
Column ‘d’ represents cases where the hospitals coded CPOA as ‘no’ and the abstractors coded as ‘no’.
[b] Records were dropped from the analysis if either the HITs or hospitals coded CPOA as uncertain.
[c] % agrmt = (a+d)/N

Table 2d CPOA Reliability (HITs) of Risk Factors Stratified by Death

		a[a]	b	c	d	N[b]	% agrmt[c]	kappa	McNemar's p-value
Acute myocardial infarction									
Shock	Died	44	6	13	7	70	72.9%	0.26	0.108
	Not died	68	6	14	8	96	79.2%	0.32	0.074
Pulmonary edema	Died	24	3	8	10	45	75.6%	0.47	0.132
	Not died	50	6	12	9	77	76.6%	0.35	0.157
Community-acquired pneumonia									
Respiratory failure	Died	19	7	7	14	47	70.2%	0.40	1
	Not died	33	11	16	9	69	60.9%	0.12	0.336
Septicemia	Died	12	4	3	4	23	69.6%	0.31	0.706
	Not died	31	8	4	8	51	76.5%	0.41	0.248
Congestive heart failure									
Acute myocardial infarction	Died	6	1	3	5	15	73.3%	0.47	0.317
	Not died	71	25	20	6	122	63.1%	-0.03	0.456
Acute renal failure	Died	12	4	3	6	25	72.0%	0.41	0.706
	Not died	101	13	13	9	136	80.9%	0.30	1
Percutaneous transluminal coronary angioplasty									
Acute myocardial infarction	Died	1	3	1	8	13	69.2%	0.16	0.317
	Not died	27	18	13	57	115	73.0%	0.42	0.369
Acute renal failure	Died	4	2	6	5	17	55.6%	0.11	0.157
	Not died	39	22	24	30	115	60.0%	0.19	0.662

[a] Column 'a' represents cases where the hospitals and the abstractors coded CPOA as 'yes'.
Column 'b' represents cases where the hospitals coded CPOA as 'yes' and abstractors coded 'no'.
Column 'c' represents cases where the hospitals coded CPOA as 'no' and the abstractors coded as 'yes'.
Column 'd' represents cases where the hospitals coded CPOA as 'no' and the abstractors coded as 'no'.
[b] Records were dropped from the analysis if either the HITs or hospitals coded CPOA as uncertain.
[c] % agrmt = (a+d)/N

Table 2d and 2e evaluate whether there were differences in coding CPOA by whether the patient died (Table 2d) or had a DNR order (Table 2e). Overall, we found little difference in the coding patterns of hospitals on the basis of whether the patient died in the hospital or had a DNR order. To the degree there are differences, they are not consistently in one direction or another in association with whether the patient died or had a DNR order in the hospital.

Table 2e CPOA Reliability (HITs) of Risk Factors Stratified by DNR

		a[a]	b	c	d	N[b]	% agrmt[c]	kappa	McNemar's p-value
Acute myocardial infarction									
Shock	DNR	16	0	8	2	26	69.2%	0.24	0.005
	Not DNR	97	12	19	13	141	78.0%	0.32	0.209
Pulmonary edema	DNR	5	0	5	4	14	64.3%	0.36	0.025
	Not DNR	69	9	15	15	108	77.8%	0.41	0.221
Community-acquired pneumonia									
Respiratory failure	DNR	11	5	9	2	27	48.1%	-0.14	0.285
	Not DNR	42	13	14	21	90	70.0%	0.37	0.847
Septicemia	DNR	10	4	1	0	15	66.7%	-0.12	0.180
	Not DNR	35	8	6	12	61	77.0%	0.47	0.593
Congestive heart failure									
Acute myocardial infarction	DNR	22	12	5	3	42	59.5%	0.017	0.090
	Not DNR	55	14	18	8	95	66.3%	0.11	0.480
Acute renal failure	DNR	25	2	3	3	33	84.8%	0.46	0.655
	Not DNR	89	15	14	12	130	77.7%	0.31	0.853
Percutaneous transluminal coronary angioplasty									
Acute myocardial infarction	DNR	1	1	1	3	6	66.7%	0.25	1
	Not DNR	27	20	13	63	123	73.2%	0.42	0.223
Acute renal failure	DNR	1	4	1	1	7	28.6%	-0.27	0.180
	Not DNR	42	20	30	34	125	62.4%	0.21	0.157

[a] Column 'a' represents cases where the hospitals and the abstractors coded CPOA as 'yes'.
Column 'b' represents cases where the hospitals coded CPOA as 'yes' and abstractors coded 'no'.
Column 'c' represents cases where the hospitals coded CPOA as 'no' and the abstractors coded as 'yes'.
Column 'd' represents cases where the hospitals coded CPOA as 'no' and the abstractors coded as 'no'.
[b] Records were dropped from the analysis if either the HITs or hospitals coded CPOA as uncertain.
[c] % agrmt = (a+d)/N

Reliability of CPOA coding for all other secondary diagnoses

Hospitals tended to code more secondary diagnoses than did HITs (mean 13.3 vs. 10.7 per chart), translating into a mean number of unique CCS groups of 11.8 and 9.3, respectively. More than 60% of the records had one or more CCS groups that were coded more than once.

Notably, there was substantial variability in percent agreement of CPOA coding across CCS groups (69.3% to 100%) (Table 2f). Chronic conditions (such as thyroid disorder, late effects of cerebrovascular disease, essential hypertension, and diabetes mellitus with complications) tended to have higher CPOA agreement than acute conditions (such as cardiac arrest and ventricular fibrillation, septicemia, and aspiration).

Table 2f CPOA Reliability Analysis (HITs) for All Secondary Diagnoses

	CCS #	a[a]	b	c	d	N[b]	% agrmt[c]	kappa	McNemar's p-value
All secondary diagnoses, in CCS groups[d]		9120	567	788	881	11356	88.1%	0.50	< 0.0001
Coronary atherosclerosis and other heart disease	101	1019	11	7	1	1038	98.3%	0.09	0.346
Fluid and electrolyte disorders	55	402	27	99	15	543	76.8%	0.09	<.0001
Cardiac dysrhythmias	106	431	26	55	33	545	85.1%	0.37	0.001
Congestive heart failure; nonhypertensive	108	408	10	37	6	461	89.8%	0.16	< 0.0001
Essential hypertension	98	433	1	1	0	435	99.5%	-0.002	1.000
Acute and unspecified renal failure	157	216	57	66	88	427	71.2%	0.37	0.659
Deficiency and other anemia	59	341	17	21	3	382	90.1%	0.08	0.516
Respiratory failure; insufficiency; arrest (adult)	131	173	37	66	82	358	71.2%	0.39	0.004
Diabetes mellitus without complication	49	270	2	4	0	276	97.8%	-0.01	0.414
Acute myocardial infarction	100	94	43	27	64	228	69.3%	0.38	0.056
Chronic obstructive pulmonary disease and bronchiectasis	127	253	1	4	1	259	98.1%	0.28	0.180
Pneumonia (except that caused by tuberculosis or sexually transmitted disease)	122	161	23	28	28	240	78.8%	0.39	0.484
Heart valve disorders	96	235	3	3	1	242	97.5%	0.24	1.000
Shock	249	143	17	34	38	232	78.0%	0.45	0.017
Diabetes mellitus with complications	50	225	2	1	0	228	98.7%	-0.01	0.564
Conduction disorders	105	195	4	7	0	206	94.7%	-0.03	0.366
Hypertension with complications and secondary hypertension	99	198	1	5	0	204	97.1%	-0.01	0.103
Substance-related mental disorders	67	198	1	2	1	202	98.5%	0.40	0.564
Other injuries and conditions due to external causes	244	120	22	12	34	188	81.9%	0.54	0.087
Disorders of lipid metabolism	53	178	0	1	0	179	99.4%	N/A [c]	N/A
Senility and organic mental disorders	68	167	2	5	2	176	96.0%	0.34	0.257
Urinary tract infections	159	108	24	17	18	167	75.4%	0.31	0.274
Other nutritional; endocrine; and metabolic disorders	58	133	5	10	2	150	90.0%	0.16	0.197
Other circulatory disease	117	112	12	20	5	149	78.5%	0.12	0.157
Complications of surgical procedures or medical care	238	7	22	9	110	148	79.1%	0.20	0.020
Chronic renal failure	158	125	4	1	0	130	96.2%	-0.01	0.180
Septicemia (except in labor)	2	56	20	15	36	127	72.4%	0.44	0.398
Other nervous system disorders	95	102	1	8	13	124	92.7%	0.70	0.020
Thyroid disorders	48	124	0	0	0	124	100.0%	N/A	N/A
Bacterial infection; unspecified site	3	79	13	10	20	122	81.1%	0.51	0.532
Cardiac arrest and ventricular fibrillation	107	54	14	18	35	121	73.6%	0.46	0.480
Other aftercare	257	97	1	4	1	103	95.1%	0.27	0.180

[a] Column 'a' represents cases where the hospitals and the abstractors coded CPOA as 'yes'.
Column 'b' represents cases where the hospitals coded CPOA as 'yes' and abstractors coded 'no'.
Column 'c' represents cases where the hospitals coded CPOA as 'no' and the abstractors coded as 'yes'.
Column 'd' represents cases where the hospitals coded CPOA as 'no' and the abstractors coded as 'no'.
[b] Records were dropped from the analysis if either the HITs or hospitals coded CPOA as uncertain.
[c] % agrmt = (a+d)/N
[d] N/A = comparisons where kappa couldn't be calculated due to cells with more than one zero

Table 2f (continued) CPOA Reliability Analysis (HITs) for All Secondary Diagnoses

		a[a]	b	c	d	N	% agrmt[b]	kappa	McNemar's p-value
Residual codes; unclassified	259	76	3	3	1	83	92.8%	0.21	1.000
Peri-; endo-; and myocarditis; cardiomyopathy (except that caused by tuberculosis or sexually transmitted disease)	97	108	0	3	2	113	97.3%	0.56	0.083
Pleurisy; pneumothorax; pulmonary collapse	130	62	9	8	13	92	81.5%	0.48	0.808
Coagulation and hemorrhagic disorders	62	50	12	14	14	90	71.1%	0.31	0.700
Other gastrointestinal disorders	155	63	8	7	5	83	81.9%	0.29	0.796
Peripheral and visceral atherosclerosis	114	79	0	2	1	82	97.6%	0.49	0.157
Chronic ulcer of skin	199	65	7	6	4	82	84.1%	0.29	0.782
Coma; stupor; and brain damage	85	45	6	8	16	75	81.3%	0.56	0.593
Late effects of cerebrovascular disease	113	73	0	0	0	73	100.0%	N/A[c]	N/A
Complication of device; implant or graft	237	32	5	4	27	68	86.8%	0.73	0.739
Other liver diseases	151	47	2	10	9	68	82.4%	0.50	0.021
Other diseases of kidney and ureters	161	58	6	1	1	66	89.4%	0.18	0.059
Pulmonary heart disease	103	56	6	2	2	66	87.9%	0.27	0.157
Nephritis; nephrosis; renal sclerosis	156	60	0	1	1	62	98.4%	0.66	0.317
Genitourinary symptoms and ill-defined conditions	163	29	9	7	16	61	73.8%	0.45	0.617
Asthma	128	58	1	2	0	61	95.1%	-0.02	0.564
Other connective tissue disease	211	54	1	1	1	57	96.5%	0.48	1.000
Esophageal disorders	138	54	0	2	0	56	96.4%	N/A	N/A
Other lower respiratory disease	133	42	2	3	6	53	90.6%	0.65	0.655
Gastrointestinal hemorrhage	153	24	6	7	15	52	75.0%	0.48	0.782
Aspiration pneumonitis; food/vomitus	129	15	7	7	21	50	72.0%	0.43	1.000
Secondary malignancies	42	49	0	1	0	50	98.0%	N/A	N/A

[a] Column 'a' represents cases where the hospitals and the abstractors coded CPOA as 'yes'.
Column 'b' represents cases where the hospitals coded CPOA as 'yes' and abstractors coded 'no'.
Column 'c' represents cases where the hospitals coded CPOA as 'no' and the abstractors coded as 'yes'.
Column 'd' represents cases where the hospitals coded CPOA as 'no' and the abstractors coded as 'no'.
[b] % agrmt = (a+d)/N
[c] N/A = comparisons where kappa couldn't be calculated due to cells with more than one zero
[d] CCS groups in order of frequency, beginning with most frequent, for CCS groups with ≥ 50 records, column totals including CCS groups with < than 50 records. Column totals include all CCS groups including those with < than 50 records.

Conditional probability of CPOA *agreement (HITs)*

The agreement in CPOA coding between the hospitals and abstractors calculated in Tables 2c-2f represent the agreement in CPOA coding at the level of the risk factor. The denominator in these analyses includes cases which the hospital and the abstractor agree in coding the umbrella condition and risk factor. To determine the chance that an independent reviewer will agree with the hospital in the labeling of whether the sampled acute conditions were present on admission in the context of the sampled umbrella condition the calculation must account for potential disagreement at each level of sampling. Disagreements in coding between the independent reviewer and the hospital can occur at three different points: 1) the coding of the umbrella condition, 2) the coding of the risk factor and 3) the assessment as to whether the risk factor is present at admission. Therefore, in Table 2g we demonstrate the chances that an independent review will agree with the hospital at all three points using the number of cases abstracted as our denominator. These conditional probabilities are substantially lower than the percent agreement for CPOA, ranging from a low of 33.1% to a high of 61.5%.

Table 2g Conditional Probability of CPOA Agreement (HIT) on the Probability of Agreement with Both Umbrella Condition and Risk Factor

	Records Abstracted N	Umbrella Conditions Confirmed N (%)[a]	Risk Factors Confirmed N (%)[b]	CPOA agrmt-Conditional Probability N (%)[c]
Acute myocardial infarction				
Shock	208	197 (94.7%)	167 (80.3%)	128 (61.5%)
Pulmonary edema	198	172 (86.9%)	122 (61.6%)	93 (47.0%)
Community-acquired pneumonia				
Respiratory failure	181	161 (89.0%)	117(64.6%)	76 (42.0%)
Septicemia	172	153 (89.0%)	76 (44.2%)	57 (33.1%)
Congestive heart failure				
Acute myocardial infarction	212	207 (97.6%)	137 (64.6)	88 (41.5%)
Acute renal failure	210	207 (98.6%)	163 (77.6)	129 (61.4%)
Percutaneous transluminal coronary angioplasty				
Acute myocardial infarction	204	199 (97.5%)	129 (63.2%)	94 (46.1%)
Acute renal failure	184	172 (93.5%)	131 (71.2%)	80 (43.5%)

[a] # cases where the HIT coded an ICD-9 code that 'matched' the umbrella condition coded by the hospital
[b] # cases where the HIT coded an ICD-9 code that 'matched' both umbrella condition and the risk factor
[c] # cases where the HIT and the hospital coded an ICD-9 code that 'matched' the umbrella condition, the risk factor and agreed on the coding of CPOA for the risk factor. The conditional probability is that number divided by the number of records abstracted (n).

Validity of Diagnosis and CPOA Coding (RN Analysis)

Validity of CPOA coding for umbrella conditions and selected risk factors

The RNs abstracted 1,649 charts, and confirmed the umbrella condition in 1,610 (97.6%) and the selected risk factor in 1,526 (92.5%) of the records reviewed (Table 3a). Because RNs were not blinded to the umbrella condition or the risk factor, it is to be expected that a higher percentage were confirmed than by the HITs abstractions.

Table 3a Sampling for CPOA Analysis (RN)

	Records Abstracted	Umbrella Conditions Confirmed[a]	Risk factors Confirmed[b]
	N	N (%)	N (%)
Acute myocardial infarction			
Shock	217	214 (98.6%)	209 (96.3%)
Pulmonary edema	207	201 (97.1%)	198 (95.7%)
Community-acquired pneumonia			
Respiratory failure	188	175 (93.1%)	165 (87.7%)
Septicemia	192	181 (94.3%)	155 (80.7%)
Congestive heart failure			
Acute myocardial infarction	222	220 (99.1%)	201 (91.0%)
Acute renal failure	216	212 (98.1%)	209 (96.8%)
Percutaneous transluminal coronary angioplasty			
Acute myocardial infarction	210	N/A[c]	199 (94.8%)
Acute renal failure	197	N/A[c]	190 (96.4%)
Total	1,649	1,610 (97.6%)	1,526 (92.5%)

[a] cases where the RN's confirmed the diagnosis of the umbrella conditions (Appendix B)
[b] cases where the RN confirmed the diagnosis of both the umbrella condition and the acute risk factor
[c] N/A = RNs only confirmed diagnosis codes, not procedures.

Overall, there was a 97.7% agreement between the hospitals and RNs on CPOA coding for the umbrella conditions in the setting of a confirmed umbrella condition (range 96.3% to 97.7%, Table 3b). The hospitals were statistically more likely to code the umbrella conditions as present on admission, however the difference was very small (99.8% versus 97.8%; McNemar's, p = 0.020).

Table 3b CPOA Validity Analysis (RNs) for Umbrella Conditions Among Records with Agreement for Umbrella Conditions

	a[a]	b	c	d	N[b]	% agrmt[c]	kappa	McNemar's p-value
Overall agreement for umbrella conditions	1,165	26	2	0	1,193	97.7%	0.98	0.020
Acute myocardial infarction	404	11	0	0	415	97.3%	N/A	0.0026
Community acquired pneumonia	343	11	2	0	356	96.3%	-0.01	0.0265
Congestive heart failure	418	4	0	0	432	96.8%	N/A	0.1336
Percutaneous transluminal coronary angioplasty[c]	N/A[d]	N/A	N/A	N/A				N/A

[a] Column 'a' represents cases where the hospitals and the abstractors coded CPOA as 'yes'.
Column 'b' represents cases where the hospitals coded CPOA as 'yes' and abstractors coded 'no'.
Column 'c' represents cases where the hospitals coded CPOA as 'no' and the abstractors coded as 'yes'.
Column 'd' represents cases where the hospitals coded CPOA as 'no' and the abstractors coded as 'no'.
[b] Records were dropped from the analysis if either the HITs or hospitals coded CPOA as uncertain.
[c] % agrmt = (a+d)/N
[d] N/A = hospitals only code CPOA for diagnosis codes, not procedures

Similarly, for the selected risk factors, there was 75.9% agreement overall between the hospitals and RNs on CPOA coding (range 66.3%-78.4%, Table 3c). In contrast to the umbrella conditions, the hospitals were less likely than the RNs to code the risk factors as present on admission (66.6% vs. 74.0%; McNemar's, p <0.0001). Analyzing within specific umbrella conditions, RNs were more likely than the hospitals to code acute myocardial infarction (90.0% versus 75.1%, McNemar's p < 0.0001) and acute renal failure (90.4% versus 78.5%,

McNemar's p = 0.0002) in the context of congestive heart failure and acute myocardial infarction (54.3% versus 44.2%, McNemar's p < 0.003) in the context of percutaneous transluminal coronary angioplasty as present on admission. Analyzing by specific umbrella condition showed little difference in CPOA percent agreement coding between conditions for which there are currently public mortality reports [acute myocardial infarction (76.9%) and community-acquired pneumonia (76.9%)] versus conditions for which there are not [community-acquired pneumonia (78.0%) and percutaneous transluminal coronary angioplasty (71.7%)]. Despite public reporting, hospitals were still under-coding acute risk factors when compared to the assessments made by RNs.

Table 3c CPOA Validity Analysis (RNs) for Risk Factors Among Records with Agreement for Both Umbrella Condition and Risk Factor

	a[a]	b	c	d	N[b]	% agrmt[c]	kappa	McNemar's p-value
Overall agreement for risk factors	889	128	240	269	1526	75.9%	0.42	< 0.0001
Acute myocardial infarction	240	41	53	73	407	76.9%	0.45	0.216
Shock	129	22	27	31	209	76.6%	0.40	0.475
Pulmonary edema	111	19	26	42	198	77.3%	0.48	0.297
Community-acquired pneumonia	205	29	45	41	320	76.9%	0.37	0.063
Respiratory failure	96	14	24	31	165	77.0%	0.46	0.105
Septicemia	109	15	21	10	155	76.8%	0.22	0.317
Congestive heart failure	297	18	72	23	410	78.0%	0.23	< 0.0001
Acute myocardial infarction	143	8	37	13	201	77.6%	0.26	< 0.0001
Acute renal failure	154	10	35	10	209	78.5%	0.20	0.0002
Percutaneous transluminal coronary angioplasty	147	40	70	132	389	71.7%	0.44	0.004
Acute myocardial infarction	75	13	33	78	199	76.9%	0.54	0.003
Acute renal failure	72	27	37	54	190	66.3%	0.32	0.211

[a] Column 'a' represents cases where the hospitals and the abstractors coded CPOA as 'yes'.
Column 'b' represents cases where the hospitals coded CPOA as 'yes' and abstractors coded 'no'.
Column 'c' represents cases where the hospitals coded CPOA as 'no' and the abstractors coded as 'yes'.
Column 'd' represents cases where the hospitals coded CPOA as 'no' and the abstractors coded as 'no'.
[b] Records were dropped from the analysis if either the HITs or hospitals coded CPOA as uncertain.
[c] % agrmt = (a+d)/N

Tables 3d and 3e show stratified analyses of the percent agreement and likelihood to code CPOA as "yes" by umbrella condition and risk factor for patients who died (and did not die) during the hospitalization (Table 3d), or had (or did not have) a DNR order (Table 3e). Overall, we found no substantive differences in hospital coding CPOA by either of these patient characteristics.

Table 3d CPOA Validity (RNs) of Risk Factors Stratified by Death

		a[a]	b	c	d	N[b]	% agrmt[c]	kappa	McNemar's p-value
Acute myocardial infarction									
Shock	Died	46	11	13	11	81	70.4%	0.27	0.683
	Not died	83	11	14	20	128	80.5%	0.49	0.549
Pulmonary edema	Died	39	6	12	17	74	75.7%	0.47	0.157
	Not died	72	13	14	25	124	78.2%	0.49	0.847
Community-acquired pneumonia									
Respiratory failure	Died	29	7	12	14	62	69.4%	0.354	0.251
	Not died	67	7	12	17	103	81.6%	0.52	0.251
Septicemia	Died	31	8	10	5	54	66.7%	0.13	0.637
	Not died	78	7	11	5	101	82.2%	0.26	0.346
Congestive heart failure									
Acute myocardial infarction	Died	17	2	7	5	31	71.0%	0.34	0.096
	Not died	126	6	30	8	170	78.8%	0.21	<0.0001
Acute renal failure	Died	14	2	8	2	26	61.5%	0.08	0.058
	Not died	140	8	27	8	183	80.9%	0.22	0.001
Percutaneous transluminal coronary angioplasty									
Acute myocardial infarction	Died	6	1	3	11	21	81.0%	0.60	0.317
	Not died	69	12	30	67	178	76.4%	0.01	0.533
Acute renal failure	Died	5	5	6	10	26	57.7%	0.12	0.763
	Not died	67	22	31	44	164	67.7%	0.34	0.216

[a] Column 'a' represents cases where the hospitals and the abstractors coded CPOA as 'yes'.
Column 'b' represents cases where the hospitals coded CPOA as 'yes' and abstractors coded 'no'.
Column 'c' represents cases where the hospitals coded CPOA as 'no' and the abstractors coded as 'yes'.
Column 'd' represents cases where the hospitals coded CPOA as 'no' and the abstractors coded as 'no'.
[b] Records were dropped from the analysis if either the RNs or hospitals coded CPOA as uncertain.
[c] % agrmt = (a+d)/N

Table 3e CPOA Validity (RNs) of Risk Factors Stratified by DNR

		a[a]	b	c	d	N[b]	% agrmt[c]	kappa	McNemar's p-value
Acute myocardial infarction									
Shock	DNR	24	3	5	5	37	78.4%	0.42	0.480
	Not DNR	105	19	22	26	172	76.2%	0.40	0.640
Pulmonary edema	DNR	14	3	3	6	26	76.9%	0.49	1
	Not DNR	97	16	23	36	172	77.3%	0.48	0.262
Community-acquired pneumonia									
Respiratory failure	DNR	14	1	4	0	19	73.7%	-0.09	0.180
	Not DNR	82	13	20	31	146	77.4%	0.49	0.223
Septicemia	DNR	19	1	3	1	24	83.3%	0.25	0.317
	Not DNR	90	14	18	9	131	75.6%	0.21	0.480
Congestive heart failure									
Acute myocardial infarction	DNR	28	3	8	1	40	72.5%	0.02	0.132
	Not DNR	115	5	29	12	161	78.9%	0.31	<0.0001
Acute renal failure	DNR	19	7	2	0	28	67.9%	-0.13	0.096
	Not DNR	135	3	33	10	181	80.1%	0.28	<0.0001
Percutaneous transluminal coronary angioplasty									
Acute myocardial infarction	DNR	1	0	0	0	1	100.0%	N/A[d]	N/A[d]
	Not DNR	74	13	33	78	198	76.8%	0.54	0.003
Acute renal failure	DNR	1	1	0	0	2	50.0%	N/A[d]	N/A[d]
	Not DNR	71	26	37	54	188	66.5%	0.33	0.166

[a] Column 'a' represents cases where the hospitals and the abstractors coded CPOA as 'yes'.
Column 'b' represents cases where the hospitals coded CPOA as 'yes' and abstractors coded 'no'.
Column 'c' represents cases where the hospitals coded CPOA as 'no' and the abstractors coded as 'yes'.
Column 'd' represents cases where the hospitals coded CPOA as 'no' and the abstractors coded as 'no'.
[b] Records were dropped from the analysis if either the RNs or hospitals coded CPOA as uncertain.
[c] % agrmt = (a+d)/N
[d] N/A = comparisons where kappa couldn't be calculated due to cells with more than one zero

Validity of CPOA coding for all other secondary conditions (Table 3f)

The RNs confirmed on average 13.3 of 13.9 secondary conditions (95.7%) reported by hospitals (mean number of unique CCS groups for hospitals 11.8 vs. RNs 11.6). Overall, similar to the HIT analysis of secondary diagnoses, hospitals and RNs agreed on the CPOA coding of the CCS group 87.9% of the time. Hospitals were minimally more likely to code CPOA as "yes" than RNs (85.8% vs. 84.5%; McNemar's, $p < 0.0001$), again statistically significant, but the size of the difference is small and probably not clinically meaningful (Table 3f). Across different CCS groups, however, there was substantial variability in percent agreement (64-100%). Chronic conditions such as osteoarthritis, thyroid disorders, and hyperplasia of the prostate tended to have higher agreement in CPOA coding than acute conditions such as bacterial infections, gastrointestinal hemorrhage, and acute post-hemorrhagic anemia.

Table 3f CPOA Validity Analysis (RNs) for All Secondary Diagnoses

	CCS #	a[a]	b	c	d	N[b]	% agrmt[c]	kappa	McNemar's p-value
All secondary diagnoses, in CCS groups [d]		22,515	1,899	1,531	2,500	28,445	87.9%	0.51	< 0.0001
Coronary atherosclerosis and other heart disease	101	1,326	9	10	2	1,347	98.6%	0.17	0.819
Cardiac dysrhythmias	106	717	170	73	160	1,120	78.3%	0.42	<.0001
Fluid and electrolyte disorders	55	657	155	109	142	1,063	75.2%	0.35	0.005
Essential hypertension	98	1,028	9	5	0	1,042	98.7%	-0.006	0.285
Acute and unspecified renal failure	157	561	76	166	160	963	74.9%	0.40	<.0001
Disorders of lipid metabolism	53	907	2	5	0	914	99.2%	-0.003	0.257
Deficiency and other anemia	59	737	94	41	33	905	85.1%	0.25	<.0001
Congestive heart failure; nonhypertensive	108	740	59	54	42	895	87.4%	0.36	0.221
Respiratory failure; insufficiency; arrest (adult)	131	436	77	127	207	847	75.9%	0.48	0.001
Substance-related mental disorders	67	734	19	4	5	762	97.0%	0.29	0.002
Diabetes mellitus without complication	49	599	10	6	0	615	97.4%	-0.01	0.317
Chronic obstructive pulmonary disease and bronchiectasis	127	584	16	6	2	608	96.4%	0.14	0.033
Shock	249	319	69	68	111	567	75.8%	0.44	0.932
Acute myocardial infarction	100	307	41	100	117	565	75.0%	0.44	<.0001
Other injuries and conditions due to external causes	244	372	52	58	69	551	80.0%	0.43	0.567
Pneumonia (except that caused by tuberculosis or sexually transmitted disease)	122	371	41	54	67	533	82.2%	0.47	0.182
Other circulatory disease	117	383	53	40	36	512	81.8%	0.33	0.178
Hypertension with complications and secondary hypertension	99	489	3	9	1	502	97.6%	0.13	0.083
Heart valve disorders	96	486	3	5	0	494	98.4%	-0.01	0.480
Residual codes; unclassified	259	424	22	20	14	480	91.3%	0.35	0.758
Other aftercare	257	373	27	22	47	469	89.6%	0.60	0.475
Conduction disorders	105	386	22	14	9	431	91.6%	0.30	0.182
Other nutritional; endocrine; and metabolic disorders	58	362	22	17	24	425	90.8%	0.64	0.423
Diabetes mellitus with complications	50	401	1	7	0	409	98.0%	-0.004	0.034
Urinary tract infections	159	228	48	39	60	375	76.8%	0.42	0.335
Septicemia (except in labor)	2	192	35	58	79	364	74.5%	0.44	0.017
Thyroid disorders	48	361	0	0	1	362	100.0%	N/A[e]	N/A[e]

Table 3f (continued) CPOA Validity Analysis (RNs) for All Secondary Diagnoses

		a[a]	b	c	d	N[b]	% agrmt[c]	kappa	McNemar's p-value
Other diseases of kidney and ureters	161	292	25	7	4	328	90.2%	0.16	0.002
Peri-; endo-; and myocarditis; cardiomyopathy (except that caused by tuberculosis or sexually transmitted disease)	97	288	8	6	8	310	95.5%	0.51	0.593
Other nervous system disorders	95	238	14	18	29	299	89.3%	0.58	0.480
Senility and organic mental disorders	68	272	5	5	13	295	96.6%	0.70	1.000
Other gastrointestinal disorders	155	182	47	19	42	290	77.2%	0.41	0.001
Complications of surgical procedures or medical care	238	31	37	50	168	286	69.6%	0.21	0.163
Esophageal disorders	138	261	10	3	4	278	95.3%	0.36	0.052
Chronic renal failure	158	240	10	7	1	258	93.4%	0.07	0.467
Bacterial infection; unspecified site	3	135	54	21	48	258	70.9%	0.36	0.0001
Cardiac arrest and ventricular fibrillation	107	98	38	19	98	253	77.5%	0.55	0.012
Peripheral and visceral atherosclerosis	114	238	5	2	7	252	97.2%	0.65	0.257
Pleurisy; pneumothorax; pulmonary collapse	130	122	38	35	51	246	70.3%	0.35	0.726
Coagulation and hemorrhagic disorders	62	120	31	34	30	215	69.8%	0.27	0.710
Other liver diseases	151	146	15	14	35	210	86.2%	0.62	0.853
Complication of device; implant or graft	237	116	20	17	56	209	82.3%	0.61	0.622
Other connective tissue disease	211	188	4	4	0	196	95.9%	-0.02	1.000
Osteoarthritis	203	192	0	0	0	192	100.0%	N/A[e]	N/A[e]
Other mental conditions	74	173	11	1	1	186	93.5%	0.13	0.004
Other lower respiratory disease	133	135	14	16	17	182	83.5%	0.43	0.715
Chronic ulcer of skin	199	127	15	7	20	169	87.0%	0.57	0.088
Coma; stupor; and brain damage	85	118	8	12	30	168	88.1%	0.67	0.371
Nephritis; nephrosis; renal sclerosis	156	156	6	5	1	168	93.5%	0.12	0.763
Asthma	128	162	0	3	0	165	98.2%	N/A[e]	N/A[e]
Pulmonary heart disease	103	152	4	4	4	164	95.1%	0.47	1.000
Genitourinary symptoms and ill-defined conditions	163	88	23	9	40	160	80.0%	0.56	0.013
Nutritional deficiencies	52	95	17	18	19	149	76.5%	0.37	0.866
Hyperplasia of prostate	164	140	0	0	0	140	100.0%	N/A[e]	N/A[e]
Gastrointestinal hemorrhage	153	66	22	18	30	136	70.6%	0.37	0.527
Osteoporosis	206	132	0	0	0	132	100.0%	N/A[e]	N/A[e]
Meningitis (except that caused by tuberculosis or sexually transmitted disease)	66	111	3	3	3	120	95.0%	0.47	1.000

Table 3f (continued) CPOA Validity Analysis (RNs) for All Secondary Diagnoses

		a[a]	b	c	d	N[b]	% agrmt[c]	kappa	McNemar's p-value
Gout and other crystal arthropathies	54	111	0	2	0	113	98.2%	N/A[e]	N/A[e]
Phlebitis; thrombophlebitis and thromboembolism	118	75	13	7	16	111	82.0%	0.50	0.180
Late effects of cerebrovascular disease	113	108	0	1	0	109	99.1%	N/A[e]	N/A[e]
Aspiration pneumonitis; food/vomitus	129	43	14	12	37	106	75.5%	0.51	0.690
Allergic reactions	253	93	4	3	4	104	93.3%	0.50	0.706
Retinal detachments; defects; vascular occlusion; and retinopathy	87	99	0	0	0	99	100.0%	N/A[e]	N/A[e]
Spondylosis; intervertebral disc disorders; other back problems	205	96	1	1	1	99	98.0%	0.49	1.000
Mycoses	4	36	22	9	20	87	64.4%	0.28	0.020
Skin and subcutaneous tissue infections	197	72	4	3	4	83	91.6%	0.49	0.706
Cancer of prostate	29	80	0	0	0	80	100.0%	N/A[e]	N/A[e]
Diseases of white blood cells	63	56	8	7	9	80	81.3%	0.43	0.796
Epilepsy; convulsions	83	54	9	4	11	78	83.3%	0.52	0.166
Anxiety; somatoform; dissociative; and personality disorders	72	52	5	6	6	69	84.1%	0.43	0.091
Gastroduodenal ulcer (except hemorrhage)	139	66	0	2	0	68	97.1%	N/A[e]	N/A[e]
Acute cerebrovascular disease	109	30	8	10	20	68	73.5%	0.46	0.637
Glaucoma	88	68	0	0	0	68	100.0%	N/A[e]	N/A[e]
Diverticulosis and diverticulitis	146	59	5	3	1	68	88.2%	0.13	0.480
Other upper respiratory disease	134	36	11	3	18	68	79.4%	0.56	0.033
Cancer of breast	24	64	0	2	0	66	97.0%	N/A[e]	N/A[e]
Secondary malignancies	42	64	0	1	0	65	98.5%	N/A[e]	N/A[e]
Biliary tract disease	149	46	6	6	7	65	81.5%	0.42	1.000
Acute posthemorrhagic anemia	60	15	19	2	28	64	67.2%	0.36	0.0002
Affective disorders	69	52	7	3	1	63	84.1%	0.09	0.206
Other and ill-defined heart disease	104	39	3	4	15	61	88.5%	0.73	0.706
Cancer of colon	14	54	1	0	1	56	98.2%	0.66	0.317
Cancer of bronchus; lung	19	56	0	0	0	56	100.0%	N/A[e]	N/A[e]
Abdominal hernia	143	53	0	1	0	54	98.1%	N/A[e]	N/A[e]
Aortic; peripheral; and visceral artery aneurysms	115	45	2	1	5	53	94.3%	0.74	0.564
Other endocrine disorders	51	36	6	6	3	51	76.5%	0.19	1.000

[a] Column 'a' represents cases where the hospitals and the abstractors coded CPOA as 'yes'.
Column 'b' represents cases where the hospitals coded CPOA as 'yes' and abstractors coded 'no'.
Column 'c' represents cases where the hospitals coded CPOA as 'no' and the abstractors coded as 'yes'.
Column 'd' represents cases where the hospitals coded CPOA as 'no' and the abstractors coded as 'no'.

[b] Records were dropped from the analysis if either the RNs or hospitals coded CPOA as uncertain

[c] % agrmt = (a+d)/N; N/A = comparisons where kappa couldn't be calculated due to cells with zero

[d] CCS groups in order of frequency, beginning with most frequent, for CCS groups with ≥ 50 records. Column totals include all CCS groups including those with < than 50 records.

[e] N/A = comparisons where kappa couldn't be calculated due to cells with more than one

Conditional probability of CPOA agreement (RN)

Similar to the sampling strategy used in the HIT analyses, for each of the selected risk factors, the agreement in coding CPOA was conditional on whether the RN abstractor had confirmed the diagnosis for both the umbrella condition and the selected risk factor. The RNs and the hospitals had to agree in coding at three places: at the level of 1) umbrella condition, 2) the risk factor, and 3) the coding of CPOA for the selected acute condition. Table 3g presents the percent of cases in which the RNs agreed with the hospitals on the coding at all three levels, the conditional probability that the RNs and the hospitals agreed, again using the number of records abstracted as the denominator. Accounting for the agreement at each level decreases the apparent agreement between the hospitals and the RNs. Conditional probabilities of CPOA for the acute risk factor ranged from a low of 62% to a high of 75.9%.

Table 3g Conditional Probability of CPOA Agreement (RN)

	Records Abstracted N	Umbrella Conditions Confirmed N (%)[a]	Risk Factors Confirmed N (%)[b]	CPOA agrmt N (Conditional Probability %)[c]
Acute myocardial infarction				
Shock	217	214 (98.6%)	209 (96.3%)	160 (73.7%)
Pulmonary edema	207	201 (97.1%)	198 (95.7%)	153 (73.9%)
Community-acquired pneumonia				
Respiratory failure	188	175 (93.1%)	165 (87.8%)	127 (67.6%)
Septicemia	192	181 (94.3%)	155 (80.7%)	119 (62.0%)
Congestive heart failure				
Acute myocardial infarction	222	220 (99.1%)	201 (90.5%)	156 (70.3%)
Acute renal failure	216	212 (98.1%)	209 (96.8%)	164 (75.9%)
Percutaneous transluminal coronary angioplasty				
Acute myocardial infarction	210	N/A[d]	199 (94.8%)	153 (72.9%)
Acute renal failure	197	N/A[d]	190 (96.4%)	126 (64.0%)

[a] # cases where the RN confirmed the umbrella condition coded by the hospital
[b] # cases where the RN confirmed both umbrella condition and the risk factor
[c] # cases where the RN confirmed the umbrella condition, the risk factor, and agreed on the coding of CPOA for the risk factor
[d] N/A RNs only confirmed diagnoses, not procedures; the percutaneous transluminal coronary angioplasty was not confirmed.

Gold Standard (Table 4)

The gold standard sample consisted of 749 records for which multiple abstractors agreed on the coding of CPOA in accordance with our algorithm and an additional 331 records with multiple reviews that could not be convincingly classified by the initial reviews but were resolved using physician adjudication. Nine of the 331 cases selected for adjudication could not be recovered from the hospitals and therefore were excluded. This resulted in 1,071 total records in the gold standard sample.

Overall, the sensitivity of CPOA coding was relatively high but varied somewhat across risk factors. A high sensitivity of CPOA coding indicates that a condition is more likely to be correctly coded as positive when the condition truly was present on admission. Sensitivity ranged from 72.2% for acute renal failure in the setting of percutaneous transluminal coronary angioplasty to 88.9% for septicemia in the setting of community-acquired pneumonia. In contrast, the specificity of CPOA coding was relatively low. A low specificity indicates that when a condition

was truly not present on admission, there is still a high probability that the condition was coded CPOA "yes" by the hospital. Specificity ranged from 30.2% in acute myocardial infarction (as a risk factor) in the setting of congestive heart failure to 81.4% in pulmonary edema in the setting of an acute myocardial infarction. Both the positive predictive value (PPV) and the negative predictive value (NPV) had wide ranges as well, varying by specific risk factor and umbrella condition. The PPV measures the proportion of conditions coded CPOA present that were truly present on admission, while the NPV is the proportion of conditions coded CPOA negative that were truly not present on admission.

The higher the value for PPV and NPV the more accurately CPOA coding predicts whether the condition truly is or is not present on admission, respectively. The PPV was above 80% for five of the acute risk factors. It was lower for septicemia in the context of community-acquired pneumonia (PPV= 57.1%) and for acute myocardial infarction (PPV = 50.9%) and acute renal failure (54.2%) in the context of percutaneous transluminal coronary angioplasty. In general, the NPV was lower than the PPV. The NPV was the lowest for congestive heart failure (acute myocardial infarction, NPV = 18.8% and acute renal failure, NPV = 35.7%). There was no major delineation in the PPV by whether conditions are publicly reported, (acute myocardial infarction, PPV = 88.2% and community-acquired pneumonia, PPV = 70.8% versus congestive heart failure, PPV = 89.2% and percutaneous transluminal coronary angioplasty, PPV = 52.8%). The same was true for NPV (acute myocardial infarction, NPV = 59.8% and community-acquired pneumonia, NPV = 69.4% versus congestive heart failure, NPV = 26.7% and percutaneous transluminal coronary angioplasty, NPV = 83.4%).

While there was wide variability, there was no overall tendency for hospitals to code conditions either as present or not present on admission (McNemar's, $p = 0.149$). However, in septicemia in the setting of community-acquired pneumonia and acute myocardial infarction and acute renal failure in the setting of percutaneous transluminal coronary angioplasty, the hospitals were more likely than the gold standard to code these risk factors as present on admission (septicemia, McNemar's, $p = 0.0001$, acute myocardial infarction in percutaneous transluminal coronary angioplasty, McNemar's, $p = 0.005$, and acute renal failure, McNemar's, $p = 0.014$). In contrast, the hospitals were less likely to code acute myocardial infarction in the setting of congestive heart failure (McNemar, $p = 0.012$) as present on admission.

Table 4 Gold Standard

	a[a]	b	c	d	N[b]	% agrmt[c]	McNemar's p-value	sens[d]	spec[d]	PPV[d]	NPV[d]
Overall umbrella condition + risk factor	556	151	126	238	1071	74.1%	0.149	81.5%	61.2%	78.6%	65.4%
Acute myocardial infarction	180	24	39	58	301	79.1%	0.078	82.2%	70.7%	88.2%	59.8%
Shock	97	16	21	23	157	76.4%	0.432	82.2%	59.0%	85.8%	52.3%
Pulmonary edema	83	8	18	35	144	81.9%	0.078	82.2%	81.4%	91.2%	66.0%
Community-acquired pneumonia	102	42	19	43	206	70.4%	0.005	84.3%	50.6%	70.8%	69.4%
Respiratory failure	62	12	14	30	118	78.0%	0.845	81.6%	71.4%	83.8%	68.2%
Septicemia	40	30	5	13	88	60.2%	0.0001	88.9%	30.2%	57.1%	72.2%
Congestive heart failure	207	25	44	16	292	76.4%	0.030	82.5%	39.0%	89.2%	26.7%
Acute myocardial infarction	96	10	26	6	138	73.9%	0.012	78.7%	37.5%	90.6%	18.8%
Acute renal failure	111	15	18	10	154	78.6%	0.833	86.0%	40.0%	88.1%	35.7%
Percutaneous transluminal coronary angioplasty	67	60	24	121	272	69.1%	0.0001	73.6%	66.9%	52.8%	83.4%
Acute myocardial infarction	28	27	9	72	136	73.5%	0.005	75.7%	72.7%	50.9%	88.9%
Acute renal failure	39	33	15	49	136	64.7%	0.014	72.2%	59.8%	54.2%	76.6%

[a] Column 'a' represents cases where the hospitals and the abstractors coded CPOA as 'yes'.
Column 'b' represents cases where the hospitals coded CPOA as 'yes' and abstractors coded 'no'.
Column 'c' represents cases where the hospitals coded CPOA as 'no' and the abstractors coded as 'yes'.
Column 'd' represents cases where the hospitals coded CPOA as 'no' and the abstractors coded as 'no'.
[b] Records were dropped from the analysis if either the RNs or hospitals coded CPOA as uncertain.
[c] % agrmt = (a+d)/N
[d] sens = sensitivity, spec = specificity, PPV = positive predictive value, NPV = negative predictive value

Reliability of CPOA Reabstraction (Table 5)

The HITs completed 281 double abstractions (17.9% of the total records the HITs abstracted) matching umbrella condition in 205 and the combination of umbrella condition and risk factor in 143 (50.9%). Of the matched records, there was 48.3% agreement on CPOA with a kappa of 0.56.

The RNs completed 343 double abstractions (20.8% of the total records the RNs abstracted) with confirmation of umbrella condition in 262 (as percutaneous transluminal coronary angioplasty was not confirmed because it is a procedure) and the combination of the risk factor and umbrella condition in 288 (84.0%). Of the records where RNs confirmed both the umbrella condition and the risk factor, the RNs agreed on CPOA in 81.3% of the cases, with a kappa of 0.54.

As a strategy to understand our low inter-rater reliability for the HIT abstractors, we investigated whether a single abstractor was driving our results by acting as an outlier. Therefore, we sequentially removed individual abstractors from the overall CPOA analysis and found that there was little change in the overall percent agreement among the remaining abstractors. Results ranged from 68.2% to 72.3% for HITs with the hospitals and 72.6% to 74.3% for RNs with the hospitals. The inter-rater reliability varied little across umbrella conditions and risk factors.

Table 5 CPOA Inter-Rater Reliability for Umbrella Conditions and Selected Risk Factors

Overall	a[a]	b	c	d	N	% agrmt[b]	kappa
HIT-HIT							
Umbrella Conditions	181	14	8	2	205	89.3%	-0.20
Risk Factors	48	11	63	21	143	48.3%	0.56
RN-RN							
Umbrella Conditions[c]	246	4	9	3	262	95.0%	0.29
Risk Factors	181	18	36	53	288	81.3%	0.54
IRR for Umbrella Conditions by Umbrella Condition							
HIT-HIT							
Acute myocardial infarction	45	3	2	2	52	90.4%	0.39
Community-acquired pneumonia	40	6	4	0	50	80.0%	-0.11
Congestive heart failure	50	3	1	0	54	92.6%	-0.03
Percutaneous transluminal coronary angioplasty	46	2	1	0	49	93.9%	-0.03
RN-RN							
Acute myocardial infarction	91	1	0	1	93	98.9%	0.66
Community-acquired pneumonia	65	2	7	2	76	88.2%	0.25
Congestive heart failure	90	1	2	0	93	96.8%	-0.01
Percutaneous transluminal coronary angioplasty[c]	N/A [c]	N/A [c]	N/A [c]	N/A [c]	N/A [c]	N/A [c]	N/A [c]
IRR for Risk factors by Umbrella Condition							
HIT-HIT							
Acute myocardial infarction	16	3	12	4	35	57.1%	0.10
Community-acquired pneumonia	7	1	16	4	28	39.3%	0.05
Congestive heart failure	20	4	21	6	51	51.0%	0.05
Percutaneous transluminal coronary angioplasty	5	3	14	7	29	41.4%	0.50
RN-RN							
Acute myocardial infarction	49	4	10	23	86	83.7%	0.64
Community-acquired pneumonia	34	4	9	12	59	78.0%	0.49
Congestive heart failure	65	3	7	1	76	86.8%	0.10
Percutaneous transluminal coronary angioplasty	33	7	10	17	67	74.6%	0.46

[a] Column 'a' represents cases where the hospitals and the abstractors coded CPOA as 'yes'.
Column 'b' represents cases where the hospitals coded CPOA as 'yes' and abstractors coded 'no'.
Column 'c' represents cases where the hospitals coded CPOA as 'no' and the abstractors coded as 'yes'.
Column 'd' represents cases where the hospitals coded CPOA as 'no' and the abstractors coded as 'no'.

[b] % agrmt = (a+d)/N

[c] RNs only confirmed diagnoses, not procedures. Percutaneous transluminal coronary angioplasty cases were not included in the RN-RN inter-rater reliability analysis for the umbrella conditions.

Conclusions

We found moderate agreement in CPOA coding between the hospitals and both the HITs and the RNs across our selected acute risk factors. Overall, the sensitivity of CPOA is high for the sampled risk factors, whereas its specificity, PPV, and NPV are relatively low and quite variable across specific risk factors and umbrella conditions. Coding CPOA in these acute risk factors was challenging, even for abstractors with clinical training. The hospitals' coding of whether a condition was present on admission was often different than that determined by multiple abstractors who contributed to a gold standard. In general, the hospitals were more reliable and accurate at coding chronic conditions than acute conditions.

The risk factors selected for this study were acute conditions that could potentially be either comorbidities or complications of care. The clinical circumstances in which they arise often make it challenging for an abstractor to determine whether they are a part of the natural history of the disease course (comorbidity) or occur as the result of a provider action to cause it by an action or inaction (complication). The errors made by hospitals in coding these conditions seem to reflect how difficult the determination of CPOA is to make for certain acute conditions. The errors appear to be random rather than systematic for many of the selected risk factors. Furthermore, the errors did not appear to be influenced by whether a condition's outcomes were publicly reported, by whether the patient died, or by whether the patient had a DNR order in the hospital. There was no evidence of systematic over-coding of conditions as present on admission by hospitals. If anything, we found a tendency for hospitals to under-code CPOA.

The substantial variability in the PPV and NPV across the selected risk factors raises concern regarding the use of CPOA coding of acute risk factors as a part of risk-adjusted outcomes models used for creating public reports of quality. Even if hospitals are not systematically biased in how they code acute risk factors, there is the very real possibility that when the unit of analysis to which these are applied is small, such as a hospital with relatively few patients, the random error in the assessment of whether a condition is present on admission can lead to inaccurate assessments of quality. The variability across different conditions suggests that it is not only difficult to code CPOA for acute risk factors, but that this difficulty is in part dependent on the clinical circumstance in which they arise. This variability also makes it hard to predict whether other acute risk factors that were not sampled for this study could be reliably incorporated into risk-adjusted outcomes models.

As anticipated, the acute risk factors were coded less reliably than chronic conditions such as diabetes, hypertension, and chronic obstructive pulmonary disease. Many of these more reliably coded chronic conditions are included in risk-adjustment models. The substantial variability in CPOA coding across diagnoses grouped as CCS conditions needs to be considered as conditions are added to risk-adjustment models. Our analysis of secondary diagnoses compared CPOA coding quality only after categorizing the secondary diagnoses into CCS groups. Comparing CPOA agreement for individual codes would presumably have even greater variability. There needs to be a way of anticipating and handling multiple ICD-9 codes within the same chart mapping to the same diagnostic cluster (CCS) but having inconsistent CPOA coding.

The inter-rater reliability kappa statistic for the UCSF HITs abstractors was low reflecting the real life challenges medical record abstractors face in reliably coding medical records

using implicit methods. This is particularly challenging and problematic for issues such as whether a condition is present on admission. While the low level of HIT inter-rater reliability makes it difficult to determine which assessment is correct when comparing the hospitals and the UCSF HIT abstractors, we conducted two additional steps to clarify this issue. First, we performed a sensitivity analysis in which we sequentially removed individual HIT abstractors and recalculated the agreement between the coding of the remaining HIT abstractors and the hospitals. We found that regardless of the subset of HIT abstractors who coded the charts, we found a fairly stable level of agreement between the HIT abstractors and the hospital. This suggests that the relatively low inter-rater reliability among HITs did not compromise the study findings. Second, we developed a gold standard methodology based on multiple reviews of the same chart that allowed for a more definitive determination of the reliability and validity of hospital coding. It is reassuring that, in general, the results from our gold standard analysis in comparison to hospital coding are relatively similar to what we found in the comparison of hospital coding with HITs abstractors. To the extent there are differences we would recommend that the gold standard analysis be considered more definitive.

The HIT blind review of medical records highlighted previously noted limitations in coding of administrative data. Our study confirmed these limitations and is consistent with the 1999-2001 Community-Acquired Pneumonia mortality report that suggested that a large number of cases with a principal diagnosis of community-acquired pneumonia were not reliably coded.[14] We found greater limitations in coding reliability for the selected risk factors than the umbrella conditions. Our finding that coding reliability was relatively poor for these risk factors may limit their incorporation into risk adjustment models and thereby decrease the discriminatory power of mortality models because our eight risk factors are highly associated with mortality.

The inter-rater reliability (IRR) was higher among RNs than HITs and found to be moderately reliable. This suggests that although clinical experience helps to clarify whether conditions are present on admission it is still insufficient to achieve highly reliable coding of CPOA for certain acute conditions. Further work should focus on understanding clinical situations and documentation characteristics that affect CPOA coding reliability and determine what, if any, additional information, training, or documentation would help clarify whether or not conditions are present on admission. CCS groups for chronic conditions consistently had higher CPOA agreement by both HIT and RN abstractors than acute conditions, suggesting that future efforts to improve coding CPOA should target coding CPOA for acute conditions.

The methodology used to determine whether a condition was present differed between the RNs and the HITs, making it difficult to directly compare their results. While both the RNs and the HITs determined CPOA blindly, the RNs were given the diagnostic codes documented by the hospitals. Their task, to confirm the diagnoses rather than determine which code to use, undoubtedly increased the RN-hospital agreement on the (umbrella condition and risk factor) diagnoses compared to the HITs. Since we encouraged the RNs to use their clinical expertise to determine CPOA, we hypothesized that the RNs would be more likely to document conditions as present on admission than hospitals and HITs because, for example, the RNs might interpret elements of the history, physical findings, and laboratory abnormalities at admission in a way that could enable them to conclude that a condition was present on admission when the less clinically trained HITs abstractors would not reach this conclusion. Our findings in part support this hypothesis that in clinical conditions such as acute renal failure and myocardial infarction, our RN

coders who were clinically trained, were more likely to code these conditions as present on admission compared to our HITs and in turn the hospitals who employ HITs to do their chart abstractions.

Finally, our HITs coded fewer secondary diagnoses on average than the hospitals. This finding could either represent over-coding by hospitals or under-coding by our HITs. Further investigation should evaluate whether there were any systematic differences in the types of coded conditions and whether more extensive coding by hospitals affects risk-adjustment models or payments.[21]

Policy Recommendations

1. There are no established standards of accuracy for determining whether a potential risk factor should be included in a publicly reported risk-adjusted outcomes model. The moderate positive predictive value and the low negative predictive value for CPOA coding for the acute conditions we evaluated in this study raise concerns about the use of these conditions in risk-adjusted outcomes models. While there is little evidence suggesting systematic bias on the part of hospitals in coding acute conditions as present on admission, the high degree of inaccuracy in coding CPOA for acute conditions could undermine stakeholders' confidence in the results generated with these measures.

2. The gold standard assessment of the acute risk factors evaluated in this study suggests that the CPOA coded by hospitals is not as good for the selected acute risk factors as for many of the other variables used in the model. In general, the CPOA coding exceeds 85% percent agreement for most of the chronic conditions included in the models while it is in the 70% range for the evaluated acute risk factors (Appendix C).

    a. We recommend that further work be undertaken to model the impact of varying levels of risk factor accuracy on the validity of risk-adjusted outcome reports.

    b. Until more is understood about the impact of this measurement error, we would recommend that OSHPD be cautious in incorporating any acute risk factors that do not meet a minimum threshold of 85% agreement between hospital coding and a gold standard so as to be in line with other measures used in the model.

    c. The use of the kappa statistic may be useful as an additional way of judging the suitability of a risk factor for use in a risk-adjustment model, however in those circumstances where the expected agreement is very high (close to 100%) it is quite difficult to have a higher than expected agreement and therefore kappas can proportionately be quite low.

3. The potential for random error to influence outcome models is greatest in circumstances in which there are small sample sizes. Future attention should be directed at determining the minimum number of cases needed to limit inaccurate assessments that result from CPOA measurement error.

4. The potential for coding errors to lead to inaccurate results would be even more problematic if it were demonstrated that the level of accuracy was not only suboptimal but that it varied substantially across hospitals. This study did not evaluate whether particular types of hospitals may be more at risk for coding inaccuracies. Further work should determine whether there are hospitals more at risk for coding errors to help direct resources to improve coding.

Do Not Resuscitate

Background

Physician's Do Not Resuscitate (DNR) orders document patients' preferences in the setting of a cardiac arrest. These DNR orders attempt to capture patient preferences regarding end-of-life care. However, the in-hospital practice of using DNR orders varies significantly across hospitals and patient characteristics, suggesting both a patient and provider influence.[22-24] The 1996 OSHPD Community-Acquired Pneumonia risk-adjusted mortality report found that DNR is highly predictive of 30-day mortality,[9] an association stronger than any other clinical risk factors used in the model. Incorporating DNR into the model substantially raised the discriminatory ability of the model and has been demonstrated to influence hospital performance reports.[25] Yet none of California's current public reports incorporate DNR due to the lack of validation of this variable and concern that it is susceptible to manipulation.

In 1999, OSHPD began collecting the presence of a DNR order within 24 hours of admission in its PDD.[9] The OSHPD manual outlines strict criteria to define a DNR order: a physician or physician extender must sign and date a DNR order within 24 hours of admission. DNR orders signed later than 24 hours do not qualify, nor does documentation of a discussion with a patient regarding their end-of-life preferences. While previous work suggested its predictive ability, there has been criticism of using DNR in mortality models because of both its construct validity as an indication of unmeasured variation in treatment and its coding reliability.

Our goal was to evaluate the reliability of DNR coding, to assess whether hospitals are more or less likely than auditors to code patients as having a DNR order, and to understand whether clinical knowledge of a medical record abstractor contributes to the reliability of the assessment of DNR coding.

Data Analysis

We conducted statistical comparisons between hospitals and HITs and between hospitals and RNs on the presence of a DNR order. Descriptive statistics included percent agreement, kappa, and McNemar's test. We also calculated sensitivity, specificity, positive predictive value, and negative predictive value using the RNs as the gold standard.

Results

In addition to the cases sampled for CPOA, an additional 412 cases were abstracted by the HITs and 478 cases were abstracted by the RN for the DNR analysis (Table 6a).

Table 6a Additional Sampling by Umbrella Condition for DNR Analysis

	HITs	RN
Acute myocardial infarction	138	162
Community-acquired pneumonia	113	123
Congestive heart failure	125	135
Percutaneous transluminal coronary angioplasty	36	55
Total	412	478

Reliability (HIT) DNR Coding (Table 6b)

HITs agreed with hospital coding of DNR in 81.1% of 1,981 records. Hospitals coded patients as DNR "yes" more often than HITs did (30.9% vs. 24.6%; McNemar's, $p < 0.0001$).

Validity (RN) of DNR Coding

RNs agreed with hospital coding of DNR in 85.3% of 2,136 records. Hospitals coded patients as DNR "yes" more often than RNs did (32.5% vs. 24.7%; McNemar's, $p < 0.0001$). Using the clinically trained RNs as the gold standard, the sensitivity of the DNR was 86.0%. Specificity was 85.0%. PPV and NPV were 65.2% and 5.7%, respectively.

Table 6b DNR Reliability and Validity

	a[a]	b	c	d	N	% agrmt[b]	kappa	McNemar's p-value
HIT	363	249	125	1244	1981	81.1%	0.53	< 0.0001
RN	453	241	74	1368	2136	85.3%	0.64	< 0.0001
By Umbrella Condition								
HIT								
Acute myocardial infarction	114	89	31	310	544	77.9%	0.50	<0.0001
Community-acquired pneumonia	103	67	32	264	466	78.8%	0.52	0.0004
Congestive heart failure	133	66	45	303	547	79.7%	0.55	0.05
Percutaneous transluminal coronary angioplasty	13	27	17	367	424	89.6%	0.32	0.13
RN								
Acute myocardial infarction	146	85	31	325	587	80.2%	0.57	<0.0001
Community-acquired pneumonia	136	50	14	310	510	87.5%	0.72	<0.0001
Congestive heart failure	159	56	26	335	576	85.8%	0.69	0.0009
Percutaneous transluminal coronary angioplasty	12	50	3	398	463	88.6%	0.27	<0.0001

[a] Column 'a' represents cases where the hospitals and the abstractors coded DNR as 'yes'.
Column 'b' represents cases where the hospitals coded DNR as 'yes' and abstractors coded 'no'.
Column 'c' represents cases where the hospitals coded DNR as 'no' and the abstractors coded as 'yes'.
Column 'd' represents cases where the hospitals coded DNR as 'no' and the abstractors coded as 'no'.
[b] % agrmt = (a+d)/N

Inter-rater Reliability of DNR (Table 6c)

To quantify the variability between HITs and RNs on DNR coding, we calculated inter-rater reliability statistics for records where either the HITs and/or RNs double abstracted. The percent agreement in DNR coding between the HITs was 84.0% of 213 records and for RNs was 95.9% of 343 records.

Table 6c DNR Inter-Rater Reliability

	a[a]	b	c	d	N	% agrmt[b]	kappa
HIT-HIT	22	20	14	157	213	84.0%	0.47
RN-RN	45	5	8	284	343	95.9%	0.85
By Umbrella Condition							
HIT-HIT							
Acute myocardial infarction	7	5	6	39	57	80.7%	0.44
Community-acquired pneumonia	5	7	3	35	50	80.0%	0.38
Congestive heart failure	9	5	3	40	57	86.0%	0.60
Percutaneous transluminal coronary angioplasty	1	3	2	43	49	89.8%	0.23
RN-RN							
Acute myocardial infarction	15	1	2	75	93	96.8%	0.89
Community-acquired pneumonia	12	0	2	62	76	97.4%	0.91
Congestive heart failure	16	4	4	69	93	91.4%	0.75
Percutaneous transluminal coronary angioplasty	2	0	1	78	81	98.8%	0.79

[a] Column 'a' represents cases where the hospitals and the abstractors coded DNR as 'yes'.
Column 'b' represents cases where the hospitals coded DNR as 'yes' and abstractors coded 'no'.
Column 'c' represents cases where the hospitals coded DNR as 'no' and the abstractors coded as 'yes'.
Column 'd' represents cases where the hospitals coded DNR as 'no' and the abstractors coded as 'no'.
[b] % agrmt = (a+d)/N

Conclusions

The reliability and validity of DNR coding by hospitals was somewhat higher than their CPOA coding, however hospitals coded records as having a DNR order within 24 hours more often than the auditors (HITs and RNs), on average.

Recent recognition of and increased attention to palliative care and advanced directives has reshaped the discussion between patients and providers regarding end-of-life preferences for severely ill hospitalized patients. The intention to capture patient preferences towards end-of-life care through DNR orders and use of DNR to risk-adjust for unmeasured differences associated with choosing to be DNR may need to be reconsidered in light of the growing number of care preferences that exist. Incorporating DNR into risk-adjustment as a proxy for pre-hospital patient preferences for less aggressive care and to adjust for risk of death prior to hospital care is important as a potential means to improve the discriminatory capabilities of risk-models. However, our finding that hospitals tend to over-code patients' DNR status as "yes" suggests that this variable may not be valid for inclusion in risk adjustment models.

RN abstractors achieved a particularly high DNR inter-rater reliability. The RNs documented the date and time that the DNR order was signed, permitting us to calculate whether the order was written within 24 hours of admission. This methodology strictly interprets the guidelines OSHPD generated for defining a DNR order. The high inter-rater reliability for the RNs suggests that either their clinical expertise or their following explicit instructions (documenting the exact date and time of the order) could improve DNR coding reliability. The HITs abstracted DNR in the same manner as the hospitals and had good but lower inter-rater reliability that the RNs.

Understanding the underlying reasons that hospitals over-code DNR may help elucidate strategies to improve its coding. A potential explanation is that hospitals may code a patient as DNR even if the order does not adhere to OSHPD's definition, such as an order that is not dated or signed by a physician, is written more than 24 hours into the hospitalization, or is documented in physician notes without an accompanying order. Alternatively, a physician may write 'palliative care' orders with an implicit DNR. All of these potential explanations would be conducive to hospital education.

Policy Recommendations

1. DNR as currently coded by hospitals is problematic for use in risk-adjusted outcome models. Hospitals tend to over-code DNR and therefore incorporation of this data element may risk biasing hospital reports. However, based on our RN assessments, there seems to be clear and feasible strategies to improve DNR coding that could make it more appropriate for use in risk-adjustment models.

2. Recommended steps would include a more complete assessment of the underlying reasons that hospitals may be over-coding DNR to assess whether certain hospital characteristics are associated with DNR coding inaccuracy, for instance, recent development of a palliative care service or presence of a high proportion of skilled nursing home patients or misinterpretation of the DNR finding provided by OSHPD.

3. Future studies should evaluate the current DNR definition and potentially expand the definition to palliative care.

4. Specific communication with hospitals should be encouraged to emphasize the current OSHPD definition of a DNR order. Future work should evaluate its quality and variability.

External Cause of Injury Codes

Background

Treatment of injuries represents a substantial cost to the healthcare system, representing billions of dollars per year in hospital costs alone.[26] State agencies and public health departments use External Cause of Injury Codes (E-Codes) in hospital discharge data to collect data needed for injury prevention efforts. E-Codes are ICD-9 codes that describe the mechanism and intent of injuries. Variation in rules and practices for collecting E-Codes is well documented.[27]

A specific class of E-Codes, called place of occurrence codes (E849.0-E849.9), report the location of an injury. These places of occurrence codes can assist public health agencies in injury prevention efforts. Yet the place of occurrence is reported as unknown in up to 30% of cases.[28]

The goal of the E-Code audit is to evaluate records where a place of occurrence was reported by hospitals as unknown to determine whether place can be found in the medical record, and if so, where that information is recorded.

Data Analysis

HITs abstracted 269 records in which the place of occurrence codes was documented as unknown. We calculated descriptive statistics of the percentage of records in which a place of occurrence was noted and the type of note in which the information was found.

Results

The HITs found a known place of injury occurrence in 151 (56.1%) of the 269 records, and in the remaining 118 (43.9%) records, the HITs agreed with hospitals that the place of occurrence was unknown (Table 7a). Of records where HITs found a place of occurrence, the information was found in the physician note 73.5% of time (Table 7b). Of the cases where the HITs found a place of occurrence, the type of injury was most likely to be an adverse effect of medical care or medical drugs or a fall (Table 7c).

Table 7a E-Codes by Location of Injury Among Unknown Location

E-Code	Description	N (% column total)[a]
E849.0	Home	83 (30.9%)
E849.3	Industrial place/premises	3 (1.1%)
E849.5	Street/highway	9 (3.3 %)
E849.6	Public building	7 (2.6%)
E849.7	Residential institution	39 (14.5%)
E849.8	Other specified place	10 (3.7%)
E849.9	Unspecified place	118 (43.9%)
	Total	269 (100%)

[a] % = N/ total

Table 7b HIT Source of Place of Occurrence Information

Note	N (% column total)
Physician	111 (73.5%)
Nurse	3 (2.0%)
Paramedic	2 (1.3%)
Other health professional	17 (11.3%)
Other note	6 (4.0%)
No source [a]	12 (7.9%)
Total[b]	151 (100%)

[a] Source not documented by HITs in 12 cases
[b] Cases included in total if E849.x not E849.9

Table 7c Unknown Location of Injury E-Codes by Whether Location of Injury Was Found

CCS group for E-Codes	Description	E849.9 N Location unknown	E849.0-E849.8 N Found
2601	Cut/pierced	3	2
2603	Fall	30	26
2605	Firearm	4	2
2607	Motor vehicle traffic (MVT)	0	1
2608	Pedal cyclist/not MVT	1	3
2610	Transport/not MVT	1	4
2611	Natural/environment	3	5
2612	Overexertion	0	3
2613	Poisoning	0	2
2614	Struck by/against	2	2
2615	Suffocation	0	2
2616	Adverse effects of medical care	21	24
2617	Adverse effects of medical drugs	12	61
2618	Other specified and classifiable	8	7
2619	Other specified / NEC	9	0
2620	Unspecified	21	2
2621	Place of occurrence	1	0
	Total N = 262[a]	116	146

[a] Eight cases not categorized by Clinical Classification Software for E-Codes

Conclusions

We were able to find a place of occurrence over 50% of the time and mostly found the information in the physicians' notes. Overall, this suggests that administrative data can be improved with better abstraction of the medical record. Notably, many of the injuries, for which the location of injury was not specified by the hospitals, were found to be adverse effects of medical care, medical drugs, or a fall. In summary, the recording of the location of injury in medical records remains incomplete and therefore may limit the utility of patient discharge data as a surveillance tool for the locations of injuries. We could not determine whether physicians do not document the place of occurrence

consistently as a result of being unaware of the place of occurrence or because of facility charting practices.

Policy Recommendations

1. Using E-Codes as surveillance tool is limited in that the location of injury is still missing from the medical record in a large percent of the cases.

2. We recommend training coders to review physician notes carefully for place of occurrence.

3. If public health researchers and policymakers wish to use administrative data as a surveillance tool for injuries, we recommend developing a more systematic approach to documenting location of injury and communicating this approach to the hospitals and their providers.

Other Variables - Procedures, Source and Type of Admission, Disposition, and Sex

Background

Other variables in the discharge data are important for quality assessment. Procedure codes are used to study the quality of procedures as well as in epidemiologic studies. Source and type of admission and disposition are used as part of exclusion and inclusion criteria for several risk-adjusted mortality models. Disposition is also used to determine hospital survival/mortality. Sex is a key variable for modeling as well. Overall, understanding the reliability of discharge data coding is important to ensure reliable modeling, quality measurement, and accurate billing.

The purpose of this part of the study is to assess the reliability of procedure, source and type of admission, disposition, and sex in the patient discharge data.

Methods

Reliability of Procedure Coding

The reliability analysis was performed on all principal and secondary procedures (up to 20) in a given record. We used a similar methodology to the methodology we used to group the secondary diagnoses where we first grouped the principal procedure ICD-9 codes into CCS Groups. Then, for each of the principal procedures, we determined which of the CCS groups each principal procedure belonged to and calculated the percentage of codes with a ‘matching’ CCS group documented by both the hospitals and the HIT coders for a particular chart. We then calculated the percent of times that both the HITs and the hospitals agreed on a CCS procedure group. We then repeated the process for the secondary procedures using the same methodology.

Other Variables

We calculated percent agreement between the hospitals and HITs on other variables in the patient discharge data including source of admission (site, licensure of site, route of admission), type of admission, disposition of patient, and sex.

Results

Reliability of Procedure Coding

Overall, the hospitals coded 1,644 principal procedures across all charts and in general were more likely than the HITs to code both principal and secondary procedures (Table 8a and 8b).

Table 8a Primary Procedure Analysis (HITs)

	CCS#	a[a]	b	c	d	N[b]	% agrmt[c]	kappa	McNemar's p-value
Diagnostic cardiac catheterization; coronary arteriography	47	66	3	0	1508	1577	99.8%	0.98	0.0833
Blood transfusion	222	37	41	6	1493	1577	97.0%	0.85	<0.0001
Respiratory intubation and mechanical ventilation	216	235	51	15	1276	1577	95.8%	0.85	<0.0001
Other vascular catheterization; not heart	54	24	23	6	1524	1577	98.2%	0.61	0.0016
Percutaneous transluminal coronary angioplasty (Percutaneous transluminal coronary angioplasty)	45	361	50	1	1165	1577	96.8%	0.91	<0.0001
Other OR heart procedures	49	81	9	0	1487	1577	99.4%	0.94	0.0027
Diagnostic ultrasound of heart (echocardiogram)	193	7	57	11	1502	1577	95.7%	0.16	<0.0001
Coronary artery bypass graft (CABG)	44	52	4	0	1521	1577	99.7%	0.96	0.0455

[a] Column 'a' represents cases when the hospital and the HIT coded a procedure in the same CCS group.
Column 'b' represents cases where the hospital coded a procedure belonging to a particular CCS group and the HIT abstractor did not.
Column 'c' represents cases where the HIT abstractor coded a procedure in a given CCS group and the hospital did not.
Column 'd' represents cases where the hospital and the HIT abstractor agreed that a given procedure was not in the record.
[b] CCS groups in order of frequency, beginning with most frequent, for CCS groups with ≥ 50 records
[c] % agrmt = (a+d)/N

There was moderate variability in percent agreement across CCS groups for secondary procedures, ranging from 84.3% to 99.3%. Procedures with the highest coding agreement tended to be major procedures, such as cardiac catheterization (98.2%), percutaneous transluminal coronary angioplasty (98.8%), and hemodialysis (98.3%).

Table 8b Secondary Procedure Analysis (HITs)

	CCS#	a[a]	b	C	d	N[b]	% agrmt[c]	kappa	McNemar's p-value
Diagnostic cardiac catheterization; coronary arteriography	47	619	25	3	930	1,577	98.2%	0.96	< 0.0001
Other therapeutic procedures	231	134	233	15	1,195	1,577	84.3%	0.45	<0.0001
Other non-OR therapeutic cardiovascular procedures	63	527	68	4	978	1,577	95.4%	0.90	<0.0001
Other OR procedures on vessels other than head and neck	61	142	29	203	1,203	1,577	85.3%	0.47	<0.0001
Blood transfusion	222	126	231	15	1,205	1,577	84.4%	0.43	<0.0001
Respiratory intubation and mechanical ventilation	216	284	68	11	1,214	1,577	95.0%	0.85	<0.0001
Other vascular catheterization; not heart	54	142	163	21	1,251	1,577	88.3%	0.55	<0.0001
Diagnostic ultrasound of heart (echocardiogram)	193	33	208	10	1,326	1,577	86.2%	0.20	<0.001
Conversion of cardiac rhythm	225	114	60	8	1,395	1,577	95.7%	0.75	<0.0001
Percutaneous transluminal coronary angioplasty (Percutaneous transluminal coronary angioplasty)	45	153	19	0	1,405	1,577	98.8%	0.94	<0.0001
Hemodialysis	58	138	25	2	1,412	1,577	98.3%	0.90	<0.0001
Diagnostic bronchoscopy and biopsy of bronchus	37	84	17	2	1,474	1,577	98.8%	0.89	0.0006
Swan-Ganz catheterization for monitoring	204	35	49	6	1,487	1,577	96.5%	0.98	<0.0001
Incision of pleura; thoracentesis; chest drainage	39	70	16	3	1,488	1,577	98.8%	0.87	0.003
Other respiratory therapy	217	9	0	102	1,466	1,577	93.5%	0.14	<0.0001
Other OR heart procedures	49	62	12	9	1,494	1,577	98.7%	0.85	0.513
Extracorporeal circulation auxiliary to open heart procedures	50	60	16	6	1,495	1,577	98.6%	0.84	0.033
Upper gastrointestinal endoscopy; biopsy	70	54	11	6	1,506	1,577	98.9%	0.86	0.225
Contrast aortogram	189	35	40	2	1,500	1,577	97.3%	0.61	<0.0001
Contrast arteriogram of femoral and lower extremity arteries	190	33	28	11	1,505	1,577	97.5%	0.62	0.007
Other diagnostic procedures (interview; evaluation; consultation)	227	13	57	1	1,506	1,577	96.3%	0.30	<0.0001
Arterio- or venogram (not heart and head)	191	20	42	10	1,505	1,577	96.7%	0.42	<0.0001
Enteral and parenteral nutrition	223	6	64	3	1,504	1,577	95.8%	0.14	<0.0001
Computerized axial tomography (CT) scan head	177	4	51	2	1,520	1,577	96.6%	0.13	<0.0001
Computerized axial tomography (CT) scan chest	178	2	55	0	1,520	1,577	96.5%	0.07	<0.0001
Radioisotope scan and function studies	209	5	0	48	1,524	1,577	97.0%	0.17	<0.0001
Insertion; revision; replacement; removal of cardiac pacemaker or cardioverter/defibrillator	48	41	8	3	1,525	1,577	99.3%	0.88	0.132
Other diagnostic ultrasound	197	3	45	3	1,526	1,577	97.0%	0.11	<0.0001

[a] Column 'a' represents cases when the hospital and the HIT coded a procedure in the same CCS group.
Column 'b' represents cases where the hospitals coded a procedure belonging to a particular CCS group and the HIT abstractor did not.
Column 'c' represents cases where the HIT abstractor coded a procedure in a given CCS group and the hospital did not
Column 'd' is not applicable in this analysis
[b] CCS groups in order of frequency, beginning with most frequency, for CCS groups with ≥ 50 record. Column totals include all CCS groups including those with < than 50 records.
[c] % agrmt = (a+d)/N

Other Variables (Table 9)

The percent agreement between hospitals and HITs on coding of other variables was highest for sex (98.4%), followed by type of admission (94.9%), route of admission (92.5%), site of admission (90.3%), disposition of patient (85.1%), and licensure of site (61.8%). Death as the discharge disposition had 99% agreement. There was no significant variability in these additional variables across umbrella conditions.

Table 9a Other Variables - Summary[a]

	N	% agrmt	kappa
Source of Admission - Site	1999	90.3%	N/A [b]
Source of Admission - Licensure of site	1999	61.8%	0.08
Source of Admission - Route of admission	1985	92.5%	0.75
Type of Admission	1985	94.9%	N/A [b]
Disposition of Patient	1999	85.1%	0.71
Sex	1999	98.4%	0.97

[a] Summary lines for each variable include additional charts in the total sampled only for DNR. Refer to Table 2a.
[b] N/A = non-square table or table with zeros in cells

Table 9b Site of Admission[a]

		HITs								
Hospitals		Home[a]	RCF[b]	Amb Surgery	SNF	AHC	Other Inpatient	Prison	Newborn	Other
	Home	1722	51	7	42	11	4	0	0	6
	RCF[b]	13	22	1	4	0	0	0	0	0
	Amb Surgery	13	0	7	0	0	0	0	0	0
	SNF/IC	9	4	0	24	0	0	0	0	0
	AHC	18	0	0	1	28	2	0	0	1
	Other Inpatient	2	0	0	0	3	2	0	0	0
	Prison	0	0	0	0	0	0	0	0	0
	Newborn	0	0	0	0	0	0	0	0	0
	Other	1	0	0	0	0	0	0	1	0

[a] Unable to calculate kappa
[b] RCF = Residential Care Facility, Amb Surgery = Ambulatory Surgery, SNF/IC = Skilled Nursing/Intermediate Care, AHC = Acute (Inpatient) Hospital Care, Other Inpatient= Other Inpatient Hospital Care, Prison = Prison/Jail, Newborn = Newborn, 9 = Other

Table 9c Licensure of Site[a]

	HITS			
Hospitals		This hospital	Another hospital	Not a hospital
	This hospital	23	9	644
	Another hospital	1	26	84
	Not a hospital	6	19	1187

[a] kappa = 0.08

Table 9d Route of Admission[a]

	HITS		
Hospitals		Your emergency room	Not your emergency room
	Your emergency room	1545	34
	Not your emergency room	114	292

[a] kappa = 0.75

Table 9e Type of Admission[a]

	HITS				
Hospitals		Scheduled admission	Unscheduled admission	Infant, < 24 hours	Unknown
	Scheduled admission	77	42	0	0
	Unscheduled admission	59	1806	0	1
	Infant, < 24 hours	0	0	0	0
	Unknown	0	0	0	0
[a] Unable to calculate kappa					

Table 9f Disposition of Patient[a]

	HITs													
Hospitals		1[b]	2	3	4	5	6	7	8	9	10	11	12	13
	1[b]	682	0	1	2	1	0	8	5	0	1	0	15	0
	2	1	0	0	0	2	0	0	0	0	0	1	0	0
	3	2	0	15	3	0	0	1	0	0	0	1	1	0
	4	1	2	2	44	0	0	25	0	0	0	0	2	0
	5	4	6	1	0	53	3	2	0	0	0	0	0	1
	6	2	0	1	01	2	2	13	3	0	0	0	1	0
	7	13	0	1	7	3	5	195	7	0	0	0	2	2
	8	5	0	0	0	0	0	0	13	0	0	0	1	0
	9	0	0	0	0	0	0	0	0	0	0	0	0	0
	10	3	0	0	0	0	1	0	0	0	12	1	0	0
	11	3	0	0	0	0	1	0	0	0	1	489	0	1
	12	101	0	0	2	0	0	4	8	0	0	0	181	0
	13	2	1	0	0	2	0	0	0	0	0	0	1	0

[a] kappa = 0.71
[b] 1 = Routine Discharge, 2 = Acute care within this hospital, 3 = Other type of hospital care within this hospital, 4 = Skilled nursing/intermediate care within this hospital, 05 = Acute care at another hospital, 06 = Other type of hospital care at another hospital, 07 = Skilled nursing/intermediate care elsewhere, 08 = Residential care facility, 09 = Prison/jail, 10 = Against Medical Advice, 11 = Died, 12 = Home health service, 13 = Other

Table 9g Sex[a]

	HITs		
Hospital		Male	Female
	Male	1039	20
	Female	11	929

[a] kappa = 0.97

Conclusions

The hospitals tended to code more procedures than the HITs. Moreover, major procedures appeared to have a higher percent agreement than minor procedures. We realize that hospital coders and auditors may have different incentives. Hospitals may be more likely to code both major and minor procedures because they could affect payment. Previous literature demonstrates coding practices vary by hospital characteristics, such as teaching and profit status.[21,29,30] Further studies may wish to investigate differences in coding procedures in more detail. Notably, the very high percent agreement for both primary and secondary procedures was driven mostly by the agreement between the HIT abstractors and the hospitals that a given procedure did not take place during the hospitalization.

Non-clinical variables in the hospital patient discharge data tended to be coded reliably, with sex being the most reliable and licensure of site the least.

Policy Recommendations

1. More detailed analysis should investigate if differences in coding of secondary procedures leads to differences in hospital payments.

2. Sex, source and type of admission, and disposition are fairly reliably coded, and it is unlikely that these codes would affect risk-adjustment models substantially. However, to be certain, we recommend conducting sensitivity analyses, particularly for site of licensure, to assess for bias.

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APPENDIX A: LITERATURE REVIEW

Appendix A: Literature Review

Overview

We conducted a thorough literature review to find four umbrella conditions each with two acute risk factors suitable for evaluating the Office of Statewide Health Planning and Development patient discharge data variables of interest, Condition Present on Admission (CPOA) and Do Not Resuscitate (DNR). Based on interest expressed by OSHPD, conditions considered were: acute myocardial infarction, community acquired pneumonia, cerebral vascular accident (stroke), congestive heart failure, abdominal aortic aneurysm and two procedural conditions, hip fracture, and percutaneous transluminal coronary angioplasty.

The extensive literature review consisted of separate PubMed searches inputting relevant MESH terms and key words (including mortality, risk-adjustment and the particular condition) and review of bibliographies for each of the seven potential umbrella conditions. The review focused on articles that pertained to adults aged 18 years or greater, and in-hospital, 30-day, or one-year mortality. First abstracts were screened for pertinence. Corresponding articles were reviewed and screened for clinically appropriate acute risk factors. We evaluated all potential risk factors for each of the umbrella conditions. The following three criteria needed to be fulfilled for the risk factor to be considered appropriate:

1. An acute medical condition
2. Strong association with in-hospital,30-day, or one-year mortality for one of the umbrella condition of interest, based on available literature
3. Potential to be present on admission or not present on admission (arise as a complication of care)

Results

<u>Acute myocardial infarction</u>

Shock[1,2] and pulmonary edema[1,2,3,4] are two acute conditions strongly associated with mortality in the setting of acute myocardial infarction. Both are part of the previous OSHPD acute myocardial infarction risk-adjusted mortality models. In addition, both can cause morbidity pre-hospitalization or may arise as a complication of care. For these reasons, we chose the umbrella condition of acute myocardial infarction and the associated risk factors of shock and pulmonary edema for the audit.

Community-Acquired Pneumonia

Among patients diagnosed with community-acquired pneumonia, respiratory failure[5] and septicemia[6,7] are both well-supported risk factors for mortality and both are used in the OSHPD community-acquired pneumonia report released in 2000. As a result, we selected community-acquired pneumonia as an umbrella condition and respiratory failure and septicemia as associated risk factors for the audit.

Congestive Heart Failure

Atrial fibrillation,[8] acute myocardial infarction,[9] and acute renal failure[10] are risk factors for congestive heart failure that can contribute to morbidity pre-hospitalization or may arise as a complication of care. We chose congestive heart failure as an umbrella condition and acute myocardial infarction and acute renal failure as risk factors for the audit. Atrial fibrillation was highly prevalent, but was not chosen because of its weaker association with mortality.

Percutaneous transluminal coronary angioplasty

Acute myocardial infarction[11] and acute renal failure[10,12,13,14] predict mortality in patients undergoing percutaneous transluminal coronary angioplasty. Both can be comorbidities or complications of care associated with percutaneous transluminal coronary angioplasty. A portion of patients undergoing percutaneous transluminal coronary angioplasty may do so electively and may be serviced outside the California acute care hospital setting. Regardless of this small percentage, percutaneous coronary angioplasty predominately occurs in the hospital setting, is widely performed, and therefore should substantially add to the evaluation of CPOA and DNR accuracy. As a result, we chose percutaneous transluminal coronary angioplasty as an umbrella condition and acute myocardial infarction and acute renal failure as risk factors for the audit.

Cerebral Vascular Accident

Most documented risk factors for cerebral vascular accident were either 1) chronic conditions that would not easily be considered complications of care, such hyperglycemia;[15,16,17] 2) conditions that were markers for good prognosis at admission but predictive of cerebral vascular accident chronically such as hypertension and[18,19] clinical signs,[20] or; 3) conditions that had extremely poor reliability in ICD-9 coding, such as coma. For these reasons we did not select cerebral vascular accident as an umbrella condition.

Hip Fracture

The literature supported pneumonia[21,22] and congestive heart failure[20,21] as promising risk factors for hip fracture. Both can contribute to morbidity pre-hospitalization or may arise as a complication of care. Both these potential risk factors may contribute to hospitalization. Reports had demonstrated that delirium was also associated with mortality and could be both a risk factor and

a complication of hip fracture. However, on further review, delirium did not appear to be an appropriate risk factor for this analysis for two main reasons. Coding of delirium has been shown to be problematic in other OSHPD mortality reports[5] and its association with mortality in the setting of a hip fracture was inconsistent.[23]

We decided against hip fracture as an umbrella condition for two reasons: 1) there was not a current risk-adjustment model used in performance reports, 2) overall mortality in the 2005 California PDD was rather low. Therefore, coding inaccuracies would be less likely to influence performance reports.

Abdominal Aortic Aneurysm

There are very few cases of abdominal aortic aneurysm in California, limiting our ability to sample effectively. For this reason we did not select it as an umbrella condition.

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APPENDIX B: ICD-9 CODES USED IN SAMPLING

Appendix B.1: Acute Myocardial Infarction Diagnoses Included in the Analysis [a]

ICD-9-CM Code	Principal Diagnoses	Principal Acute Myocardial Infarction Codes	Non-Acute Myocardial Infarction Principal Diagnosis Codes[b]
410.x0	Acute myocardial infarction	X	
410.x1	Acute myocardial infarction	X	
427.1	Paroxysmal ventricular tachycardia		X
427.41	Ventricular fibrillation		X
427.42	Ventricular flutter		X
427.5	Cardiac arrest		X
429.5	Rupture of chordae tendinae		X
429.6	Rupture of papillary muscle		X
429.71	Acquired cardiac septal defect		X
429.79	Other sequelae of myocardial infarction		X
429.81	Other disorders of papillary muscle		X
518.4	Acute edema of lung, unspecified		X
780.2	Syncope and collapse		X
785.51	Cardiogenic shock, without mention of trauma		X

[a] Source of codes: Office of Statewide Health Planning and Development Report on Heart Attack Outcomes in California 1996-1998

[b] To be used as an inclusion criterion, a non-acute myocardial infarction principal diagnosis must occur with a secondary diagnosis of acute myocardial infarction.

Appendix B.2: Community-Acquired Pneumonia Diagnoses Included in the Analysis [a]

ICD-9-CM Code	Principal Diagnoses	Principal Community-Acquired Pneumonia Codes	Non-Community-Acquired Pneumonia Principal Diagnosis Codes [b]
480.0	Pneumonia due to adenovirus	X	
480.1	Pneumonia due to respiratory syncytial virus	X	
480.2	Pneumonia due to parainfluenza virus	X	
480.8	Pneumonia due to other virus not elsewhere classified	X	
480.9	Viral pneumonia, unspecified	X	
481	Pneumococcal Pneumonia (Streptococcus pneumoniae)	X	
482.0	Pneumonia due to klebsiella pneumoniae	X	
482.1	Pneumonia due to pseudomonas	X	
482.2	Pneumonia due to hemophilus influenza	X	
482.30	Pneumonia due to streptococcus, unspecified	X	
482.31	Pneumonia due to streptococcus, Group A	X	
482.32	Pneumonia due to streptococcus, Group B	X	
482.39	Other streptococcus species	X	
482.4	Pneumonia due to staphylococcus species	X	
482.81	Pneumonia due to other specified bacteria - Anaerobes	X	
482.82	Pneumonia due to escherichia coli (E. Coli)	X	
482.83	Other gram negative bacteria	X	
482.84	Legionnaires' disease	X	
482.89	Other specified disease	X	
482.9	Bacterial pneumonia unspecified	X	
483.0	Pneumonia due to other specified organism-mycoplasma	X	
483.1	Pneumonia due to other specified organism - chlamydia	X	
483.8	Pneumonia due to other specified organism	X	
485	Bronchopneumonia, organism unspecified	X	
486	Pneumonia, organism unspecified	X	
487.0	Influenza with pneumonia	X	
510.0	Empyema with fistula		X
510.9	Empyema without fistula		X
511.0	Pleurisy without mention of effusion or current tuberculosis		X
511.1	Pleurisy with effusion, with bacterial cause other than tuberculosis		X
512.0	Spontaneous tension pneumothorax		X
512.1	Iatrogenic pneumothorax		X
512.8	Other spontaneous pneumothorax		X
513.0	Abscess of lung		X
518.0	Pulmonary Collapse		X
518.81	Acute respiratory failure		X
518.82	Other pulmonary insufficiency, not elsewhere classified		X
785.5x	Shock without mention of trauma - shock unspecified		X
786.00	Dyspnea and respiratory abnormalities-respiratory abnormality, unspecified		X

786.09	Other dyspnea and respiratory abnormalities		X
786.2	Cough		X
786.3	Hemoptysis		X
786.4	Abnormal sputum		X
038.xx	Septicemia		X

[a] Source of codes: Office of Statewide Health Planning and Development Community-Acquired Pneumonia: Hospital Outcomes in California, 1999-2001

[b] To be used as an inclusion criterion, a non-community-acquired pneumonia principal diagnosis must occur with a secondary diagnosis of community-acquired pneumonia.

Appendix B.3: Congestive Heart Failure Diagnoses Included in the Analysis [a]

ICD-9-CM Code	Principal Diagnoses	Principal CHF Codes
398.91	Rheumatic heart failure (congestive)	X
402.01	Malignant hypertensive heart disease with congestive heart failure	X
402.11	Benign hypertensive heart disease with congestive heart failure	X
402.91	Unspecified hypertensive heart disease with congestive heart failure	X
404.01	Malignant hypertensive heart and renal disease with congestive heart failure	X
404.03	Malignant heart and renal disease with congestive heart failure and renal failure	X
404.11	Benign hypertensive heart and renal disease with congestive heart failure	X
404.13	Benign heart and renal disease with congestive heart failure and renal failure	X
404.91	Unspecified hypertensive heart and renal disease with congestive heart failure	X
404.93	Unspecified heart and renal disease with congestive heart failure and renal failure	X
425.x	Cardiomyopathy	X
428.x	Heart Failure	X
780.2	Syncope and collapse	X
785.51	Cardiogenic shock, without mention of trauma	X

** Source of codes: Agency for Healthcare Research and Quality Inpatient Quality Indicators, Version 3.0

Appendix B.4: Percutaneous Transluminal Coronary Angioplasty Procedures Included in the Analysis

ICD-9-CM Code	Principal Procedures	Principal Percutaneous Transluminal Coronary Angioplasty Codes
00.66	Percutaneous transluminal coronary angioplasty or coronary atherectomy	X
36.01	Percutaneous transluminal coronary angioplasty-one vessel w/o agent*	X
36.02	Percutaneous transluminal coronary angioplasty-one vessel with agent*	X
36.05	Percutaneous transluminal coronary angioplasty-multiple vessel*	X
36.06	Insertion of coronary artery stent*	X
36.07	Insertion of drug eluting coronary artery stent*	X

* Percutaneous transluminal coronary angioplasty codes used before October 2005. Replaced in October 2005 by a single code, 00.66 Percutaneous transluminal coronary angioplasty or coronary atherectomy.
** Source of codes: Agency for Healthcare Research and Quality Inpatient Quality Indicators, Version 3.0

Appendix B.5: Selected Risk Factors Included in the Analysis

Umbrella Condition	Selected Risk Factor	ICD-9-CM Code	Secondary Diagnosis
Acute myocardial infarction [a]	Shock	785.5x	Shock without mention of trauma
Acute myocardial infarction [a]	Pulmonary Edema	514	Pulmonary congestion and hypostasis
		518.4	Acute edema of lung, unspecified
		518.5	Pulmonary insufficiency following trauma and surgery
		518.81	Acute respiratory failure
		518.82	Other pulmonary insufficiency, not elsewhere classified
Community-acquired pneumonia [b]	Respiratory Failure	518.81	Acute respiratory failure
		518.82	Other pulmonary insufficiency NEC
Community-acquired pneumonia [b]	Septicemia	038.xx	Septicemia
Congestive heart failure [c]	AMI	410.x0	Acute myocardial infarction
		410.x1	Acute myocardial infarction
Congestive heart failure [c]	Acute renal failure	584.x	Acute renal failure
		586	Renal failure, unspecified
		788.5	Oliguria and anuria
Percutaneous transluminal coronary angioplasty [c]	AMI	410.x0	Acute myocardial infarction
		410.x1	Acute myocardial infarction
Percutaneous transluminal coronary angioplasty [c]	Acute renal failure	584.x	Acute renal failure
		586	Renal failure, unspecified
		788.5	Oliguria and anuria

[a] Office of Statewide Health Planning and Development Report on Heart Attack Outcomes in California 1996-1998
[b] Office of Statewide Health Planning and Development Community-Acquired Pneumonia: Hospital Outcomes in California, 1999-2001
[c] Agency for Healthcare Research and Quality Inpatient Quality Indicators, Version 3.0

Appendix C: Accuracy of CCS Grouping Best Correlated to Risk factors in Publicly Reported Risk-Adjusted Mortality Models

Appendix C.1: Accuracy of CPOA of Diagnoses in 1996-1998 Acute Myocardial Infarction Risk-Adjusted Mortality Model				
ICD-9-CM Code	**Risk factors [a]**	**CPOA Accuracy using Gold Standard PPV [b]**	**CCS Grouping Approximating Risk factor [c]**	**CPOA Accuracy using CCS groups % agrmt**
Aspiration pneumonia	507.0	N/A [d]	N/A	N/A
Catastrophic sequelae of AMI	429.5 Rupture of chordae tendineae 429.6 Rupture of papillary muscle 429.71 Acquired cardiac septal defect 745.4 Ventricular septal defect	N/A	N/A	N/A
Central nervous system disease	331.1-331.9 Other cerebral degenerations (except Alzheimer's disease) 332.x Parkinson's disease 333.0 Other degenerative diseases of the basal ganglia 333.2 Myoclonus 333.3 Tics of organic origin 333.4 Huntington's chorea 333.5 Other choreas 333.6 Idiopathic torsion dystonia 333.7 Symptomatic torsion dystonia 340 Multiple sclerosis 341.x Other demyelinating diseases of central nervous system 344.x Other paralytic syndromes	N/A	N/A	N/A
Cerebrovascular disease, other	430 Subarachnoid hemorrhage 431 Interacerebral hemorrhage 432.x Other and unspecified intracranial hemorrhage 434.x Occlusion of cerebral arteries 436 Acute but ill-defined cerebrovascular disease 437.1 Other generalized ischemic cerebrovascular disease	N/A	Acute cerebrovascular disease (109) 34660 34661 34662 34663 430 431 4320 4321 4329 43301 43311 43321 4333143381 43391 4340 43400 43401 4341 43410 43411 4349 43490 43491 436	73.5%

Coma	780.0x Alteration of consciousness 250.2x Diabetes with hyperosmolarity (hyperosmolar coma) 250.3x Diabetes with other coma 572.2 Hepatic coma	N/A	Coma; stupor; and brain damage (CCS 85) 3481 7800 78001 78003 78009	88.1%
Complete atrioventricular block	426.0 Complete atrioventricular block	N/A	Conduction disorders (105) 4260 42610 42611 42612 42613 4262 4263 4264 42650 42651 42652 42653 42654 4266 4267 42681 42682 42689 4269 V450 V4500 V4501 V4502 V4509 V533 V5331 V5332 V5339	91.6%
Congestive heart failure	425.x Cardiomyopathy 428.x Heart failure	N/A	Congestive heart failure; non-hypertensive (CCS 108) 39891 4280 4281 42820 42821 42822 42823 42830 42831 42832 42833 42840 42841 42842 42843 4289	87.4%

Diabetes, complicated	250.1x- 250.9x Diabetes with mention of complication 357.2 Polyneuropathy in diabetes 362.0x Diabetic retinopathy	N/A	Diabetes with complication (CCS 50) 24901 24910 24911 24920 24921 24930 24931 24940 24941 24950 24951 24960 24961 24970 24971 24980 24981 24990 24991 25002 25003 25010 25011 25012 25013 25020 25021 25022 25023 25030 25031 25032 25033 25040 25041 25042 25043 25050 25051 25052 25053 25060 25061 25062 25063 25070 25071 25072 25073 25080 25081 25082 25083 25090 25091 25092 25093	98.0%
High-risk or secondary malignant neoplasm	141.x-152.x Malignant neoplasm of oral cavity, pharynx, esophagus, stomach, small intestine 155.x-159.x Malignant neoplasm of liver, gall bladder, pancreas, peritoneum 162.x-171.x Malignant neoplasm of lung, pleura, heart, thorax, bone, connective tissue 196.x-199.x Second malignant neoplasm	N/A	Cancer of bronchus; lung (CCS 19) 1622 1623 1624 1625 1628 1629 20921 2312 V1011 Secondary malignancies (CCS 42) 1960 1961 1962 1963 1965 1966 1968 1969 1970 1971 1972 1973 1974 1975 1976 1977 1978 1980 1981 1982 1983 1984 1985 1986 1987 19881 19882 19889 51181 78951	100% 98.0%

Hypertension	401.x Essential hypertension 402.x0 Hypertensive heart disease 403.x0 Hypertensive renal disease 404.x0 Hypertensive heart and renal disease 405.xx Secondary hypertension	N/A	Hypertension with complications and secondary hypertension (CCS 99) 4010 40200 40201 40210 40211 40290 40291 4030 40300 40301 4031 40310 40311 4039 40390 40391 4040 40400 40401 40402 40403 4041 40410 40411 40412 40413 4049 40490 40491 40492 40493 40501 40509 40511 40519 40591 40599 4372	97.6%
Infarction site, anterior wall **Infarction site, inferior wall** **Infarction site, other** **Infarction site, subendocardial**	410.0x Anterior wall 410.1x Other anterior wall 410.2x Inferolateral 410.5x Other lateral 410.3x Inferoposterior wall 410.4x Other inferior wall 410.6x Posterior wall 410.8x Other unspecified sites 410.9x Unspecified sites 410.7x Subendocardial	90.3%[e]	Acute myocardial infarction (CCS 100) 4100 41000 41001 41002 4101 41010 41011 41012 4102 41020 41021 41022 4103 41030 41031 41032 4104 41040 41041 41042 4105 41050 41051 41052 4106 41060 41061 41062 4107 41070 41071 41072 4108 41080 41081 41082 4109 41090 41091 41092	75.0%
Ischemic bowel or liver	557.x Vascular insufficiency of intestine 570 Acute and subacute necrosis of liver	N/A	N/A	N/A
Paroxysmal ventricular tachycardia	427.1 Paroxysmal ventricular tachycardia	N/A	Cardiac arrest and ventricular fibrillation (CCS 107) 42741 42742 4275	77.5%

Prior coronary artery bypass graft	996.03 Mechanical complication due to coronary bypass graft Index or prior6 V45.81 Aortocoronary bypass status Index or prior7 36.1x Bypass anastomosis for heart revascularization	N/A	N/A	N/A
Pulmonary edema	514 Pulmonary congestion and hypostasis 518.4 Acute edema of lung, unspecified 518.5 Pulmonary insufficiency following trauma and surgery 518.81 Respiratory failure 518.82 Other pulmonary insufficiency, not elsewhere classified	92.1%	N/A	N/A
Renal Failure, acute or unspecified	584.x Acute renal failure 586 Renal failure, unspecified 788.5 Oliguria and anuria	89.0%[f] 68.4%[g]	Acute and unspecified renal failure (CCS 157) 5845 5846 5847 5848 5849 586	74.9%
Renal failure, chronic	585 Chronic renal failure Index or prior 403.x1 Hypertensive renal disease (malignant, benign, or unspecified), with renal failure Index or prior 404.x2 Hypertensive heart and renal disease (malignant, benign, or unspecified), with renal failure Index or prior 404.x3 Hypertensive heart and renal disease (malignant, benign, or unspecified), with congestive heart and renal failure Index or prior 996.73 Other complications due to renal dialysis device, implant, and graft Index or prior9 39.27 Arteriovenostomy for renal dialysis Prior only 39.42 Revision of arteriovenous shunt for renal dialysis Index or prior10 39.93 Insertion of vessel-to-vessel cannula Prior only 39.94 Replacement of vessel-to-vessel cannula Index or prior1 V45.1 Renal dialysis status	N/A	Chronic renal failure (158) 585 5853 5854 5855 5856 5859 7925 V420 V451 V4511 V4512 V560 V561 V562 V5631 V5632 V568	96.2%

Seizure disorder	345.xx Epilepsy 780.3 Convulsions	N/A	Epilepsy; convulsions (CCS 83) 3450 34500 34501 3451 34510 34511 3452 3453 3454 34540 34541 3455 34550 34551 3456 34560 34561 3457 34570 34571 3458 34580 34581 3459 34590 34591 7803 78031 78032 78039	86.1%
Sepsis	038.xx Sepsis 112.5 Disseminated candidiasis	61.5%	Septicemia (CCS 2) 0031 0202 0223 0362 0380 0381 03810 03811 03812 03819 0382 0383 03840 03841 03842 03843 03844 03849 0388 0389 0545 449 7907	74.6%
Shock	785.5x Shock without mention of trauma	86.9%	Shock (CCS 249) 78550 78551 78552 78559	75.8%
Skin ulcer	707.x Chronic skin ulcer	N/A	Chronic ulcer of skin (CCS 199) 7070 70700 70701 70702 70703 70704 70705 70706 70707 70709 7071 70710 70711 70712 70713 70714 70715 70719 70720 70721 70722 70723 70724 70725 7078 7079	84.1%

Thyroid disease	243.x-244.x Hypothyroidism	N/A	Thyroid disorders (CCS 48) 2400 2409 2410 2411 2419 24200 24201 24210 24211 24220 24221 24230 24231 24240 24241 24280 24281 24290 24291 243 2440 2441 2442 2443 2448 2449 2450 2451 2452 2453 2454 2458 2459 2460 2461 2462 2463 2468 2469 7945	100%

[a] Source of codes: Office of Statewide Health Planning and Development Report on Community-Acquired Pneumonia in California 1999-2001.
[b] Accuracy data taken from Table 4 Gold Standard. All other data from Table 3f CPOA Validity Analysis (RNs) for All Secondary Diagnoses. Data only pertinent to secondary diagnoses, though acute myocardial infarction model includes principal diagnoses for certain conditions.
[c] Source of codes: Clinical Classification Software 2008. ICD-9 codes in bold demonstrate codes overlapping the Office of Statewide Health Planning and Development Report on acute myocardial infarction and the Clinical Classification Software.
[d] N/A signifies a diagnosis without appropriate comparator in our study
[e] Positive Predictive Value for acute myocardial infarction in the context of congestive heart failure
[f] Positive Predictive Value for acute renal failure in the context of congestive heart failure
[g] Positive Predictive Value for acute renal failure in the context of percutaneous transluminal coronary angioplasty

Appendix C.2: Accuracy of CPOA of Diagnoses in 1999-2001 Community-Acquired Pneumonia Risk-Adjusted Mortality Model				
ICD-9-CM Code	**Risk factor [a]**	**CPOA Accuracy using Gold Standard PPV [b]**	**CCS Grouping Most Approximating Risk factor [c]**	**CPOA Accuracy using CCS groups % agreement**
Respiratory Failure	518.81 Respiratory failure 518.82 Other pulmonary insufficiency NEC	N/A [d]	Respiratory failure; insufficiency; arrest (CCS 131) 5173 5185 51881 51882 51883 51884 7991 V461 V4611 V4612 V4613 V4614 V462	71.2%
Solid Non-Lung Cancer	140.x, 150.x 160.x Malignant neoplasm of head, neck, digestive organs and peritoneum 170.x-172.x Malignant neoplasm of bone, connective tissue, malignant melanoma of skin 174.x Malignant neoplasm of female breast 179.x-189.x Malignant neoplasia of genitourinary organs 191.x-192.x Malignant neoplasm of brain and other CNS 193.x-195.x Malignant neoplasm of thyroid, endocrine glands 196.x-199.x Secondary malignant neoplasm V10.0x Personal history of malignant neoplasm	N/A	Cancer of breast (CCS 24) 1740 1741 1742 1743 1744 1745 1746 1748 1749 1750 1759 2330 V103 Cancer colon (CCS 14) 1530 1531 1532 1533 1534 1535 1536 1537 1538 1539 1590 20910 20911 20912 20913 20914 20915 20916 2303 V1005 Secondary malignancies (CCS 42) 1960 1961 1962 1963 1965 1966 1968 1969 1970 1971 1972 1973 1974 1975 1976 1977 1978 1980 1981 1982 1983 1984 1985 1986 1987 19881 19882 19889 51181 78951	97% 98.2% 98.0%

Septicemia	038.xx Septicemia 790.7 Bacteremia	61.5%	Septicemia (CCS 2) 0031 0202 0223 0362 0380 0381 03810 03811 03812 03819 0382 0383 03840 03841 03842 03843 03844 03849 0388 0389 0545 449 7907	74.6%
Lung Cancer	162.x Malignant neoplasm of trachea, bronchus, and lung 163.x Malignant neoplasm of pleura 165.x Malignant neoplasm of other respiratory site	N/A	Cancer of bronchus; lung (CCS 19) 1622 1623 1624 1625 1628 1629 20921 2312 V1011	100%
Chronic Liver Disease	571.x Chronic liver disease and cirrhosis 572.x-573.x Liver abscess and sequelae of chronic liver disease, other disorders of the liver 070.22, 070.32, 070.44, 070.54 Chronic hepatitis	N/A	N/A	N/A
Blood Cancer	200.x-203.x Lymphosarcoma and reticulosarcoma, Hodgkin's disease, other malignant neoplasms of lymphoid and histiocytic tissue, multiple myeloma and histiocytic tissue, multiple myeloma and immunoproliferative neoplasms 204.xx-208.xx Leukemia 284.x, 273.8 Aplastic anemia, other disorders of plasma protein metabolism	N/A	N/A	N/A

Chronic Renal Disease	585 Chronic renal failure 403.91 Unspecified hypertensive renal disease with renal failure 403.01, 403.11 Malignant, benign hypertensive renal disease with renal failure 404.02, 404.12, 404.92 Malignant, benign, unspecified hypertensive heart and renal disease with renal failure 996.73 Other complications of internal prosthetic device, implant, and graft due to renal dialysis device V45.1 Renal dialysis status	N/A	Chronic renal failure (CCS 158) 585 5853 5854 5855 5856 5859 7925 V420 V451 V4511 V4512 V560 V561 V562 V5631 V5632 V568	96.2%
Coagulopathy	287.4, 287.5, 287.9 Secondary thrombocytopenia, unspecified thrombocytopenia, unspecified hemorrhagic conditions 286.6, 286.7, 286.9 Defibrination syndrome, acquired coagulation factor deficiency, other and unspecified coagulation defects	N/A	Coagulation and hemorrhagic disorders (CCS 62) 2860 2861 2862 2863 2864 2865 2866 2867 2869 2870 2871 2872 2873 28730 28731 28732 28733 28739 2874 2875 2878 2879 28981 28982 28984 7827	69.8%
Staphylococcus Pneumonia	482.4 Pneumonia due to Staphylococcus species	N/A	N/A	N/A

Congestive Heart Failure	398.91 Rheumatic heart failure (congestive) 402.91 Unspecified hypertensive heart disease with CHF 404.01, 404.11, 404.91 Malignant, benign, and unspecified hypertensive heart and renal disease with CHF 404.03, 404.13, 404.93 Malignant, benign, and unspecified heart and renal disease with CHF and renal failure 425.x Cardiomyopathy 428.x Heart Failure	N/A	Congestive heart failure; non-hypertensive (CCS 108) 39891 4280 4281 42820 42821 42822 42823 42830 42831 42832 42833 42840 42841 42842 42843 4289 Hypertension with complications and secondary hypertension (CCS 99) 4010 40200 40201 40210 40211 40290 40291 4030 40300 40301 4031 40310 40311 4039 40390 40391 4040 40400 40401 40402 40403 4041 40410 40411 40412 40413 4049 40490 40491 40492 40493 40501 40509 40511 40519 40591 40599 4372	87.4% 97.6%
Gram Negative Pneumonia	482.0, 482.1, 482.82 Pneumonia due to Klebsiella pneumonia, pneumonia due to Pseudomonas, pneumonia due to Escherichia coli	N/A	N/A	N/A
Late Effects of Stroke/Hemiplegia	342xx Hemiplegia and hemiparesis Late effects of cerebrovascular disease	N/A	N/A	N/A
Asthma	493.xx Asthma	N/A	Asthma (CCS 128) 49300 49301 49302 49310 49311 49312 49320 49321 49322 49381 49382 49390 49391 49392	98.2%

Acute Cerebrovascular Accident	430;431;432.x-435.x; 437.1 Subarachnoid hemorrhage; intracerebral hemorrhage; other and unspecified intracranial hemorrhage, occlusion and stenosis of precerebral arteries, occlusion of cerebral arteries, transient cerebral ischemia; acute but ill-defined cerebrovascular disease; other generalized ischemic cerebrovascular disease	N/A	N/A	N/A
Parkinson's Disease	332.x Paralysis agitans, secondary parkinsonism	N/A	N/A	N/A

[a] Source of ICD-9 codes: Office of Statewide Health Planning and Development Report on Community-Acquired Pneumonia in California 1999-2001.
[b] Accuracy data taken from Table 4 Gold Standard. All other data from Table 3f CPOA Validity Analysis (RNs) for All Secondary Diagnoses. Data only pertinent to secondary diagnoses though Community-Acquired Pneumonia model includes principal diagnoses for certain conditions.
[c] Source of ICD-9 codes: Clinical Classification Software 2008. ICD-9 codes in bold demonstrate codes overlapping the Office of Statewide Health Planning and Development Report on Community-Acquired Pneumonia and the Clinical Classification Software.
[d] N/A signifies a diagnosis without appropriate comparator in our study

Appendix C.3: Accuracy of CPOA of Diagnoses in Congestive Heart Failure Risk-Adjusted Mortality Model			
Diagnoses in Congestive Heart Failure Model [a]	**Associated Clinical Classification Software Group**	**Accuracy of Acute Risk Factors [b] CPOA = Yes**	**Accuracy of Chronic Risk Factors [b] (CPOA flags not used)**
Shock	249	75.8	
Adult respiratory failure	131	75.9	
Acute renal failure	157	74.9	
Cardiac arrest	107	77.5	
Cerebral vascular disease	109	73.5	
	111	N/A	
	113	99.1	
Fluid and electrolyte disorders	55	75.2	
Pneumonia	129	75.5	
	122	82.2	
Hemorrhage	62	69.8	
	153	70.6	
Septicemia	2	72.4	
Coma / brain damage	85	88.1	
Nutritional deficiency	52	76.5	
Acute Myocardial infarction	100	75	
Intestinal obstruction	145	N/A	
Skin ulcer	199	87	
Anemia	59	85.1	
Urinary tract infections	159	76.8	
Cancer	12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42		
	14		98.2
	19		100
	24		97
	29		100
	42		98.5
Renal failure (chronic)	158		93.4

Dementia	68		96.6
Other circulatory diagnoses	117		81.8
Gangrene	248		N/A
Chronic Obstructive Pulmonary Disease	127		96.4
Diabetes	49		97.4
	40		98
Heart valve disorders	96		98.4
Other diseases of kidney and ureters	161		90.2
Peripheral and visceral atherosclerosis	114		97.2
Other lower respiratory disease	133		83.5
Pulmonary heart disease	103		95.1

[a] Diagnoses used in the Office of Statewide Health Planning and Development congestive heart failure risk-adjusted mortality model
[b] Accuracy data taken from Table 3f CPOA validity analysis (RNs)
[c] N/A signifies a Clinical Classification Software (CCS) group without comparator in our study
[d] No assessment of accuracy for liver disease which uses individual ICD-9 codes: 5712, 5715, 5714 as secondary diagnoses were analyzed by CCS groups.