Identifying Potentially Preventable Complications Using a Present on Admission Indicator

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This article describes the development of Potentially Preventable Complications (PPCs), a new method that uses a present on admission (POA) indicator to identify in-hospital complications among secondary diagnoses that arise after admission. Analyses that used PPCs to obtain risk-adjusted complication rates for California hospitals showed that (1) the POA indicator is essential for identifying complications, (2) frequency of complications varies by reason for admission and severity of illness (SOI), (3) complications are associated with higher hospital charges, longer lengths of stay, and increased mortality, and (4) hospital complication rates tend to be stable over time.

INTRODUCTION

The Institute of Medicine’s 2000 report on the human and financial costs of medical errors, accelerated efforts to improve patient safety in the U.S. (Kohn, Corrigan, and Donaldson, 2000). Since then, an increasing number of policymakers have advocated not only public reporting of quality measures, but also linking payment to quality measures (Midwest Business Group on Health 2002; Medicare Payment Advisory Commission, 2005; National Committee for Quality Assurance, 2004). Performance-based payment proposals include rewards not only based on processes of care guidelines, but also on outcome measures such as mortality and complication rates. Performance measures are seen as a way to focus quality improvement efforts and to achieve a safer health care system.

In order to determine hospital complication rates, several investigators have created methods using computerized discharge abstract data as an alternative to the time and expense of detailed chart review (Braier et al., 1996; DesHarnais et al., 1990; Iezzoni et al., 1994; Iezzoni 1992; Romano et al., 2003). The ability to identify complications from discharge abstract diagnoses has been limited, however, because in most of the U.S. it is not possible to distinguish diagnoses that were present at the time of admission from those that arose after admission. As a result, the identification of complications has been limited to secondary diagnoses that are either unlikely to have been present on admission or are complications by definition (e.g., post-operative wound infection). Therefore, complications screening methods have tended to focus on patients that would be unlikely to have had a major complicating problem at the time of admission, such as those undergoing elective surgery. Even with these limits, however, complications screening methods still identify many cases where the condition was preexisting rather than hospital acquired (Lawthers et al., 2000, Naessens and Huschka, 2004).
The lack of a POA indicator also limits the use of risk-adjustment methods for complications screening. Risk of complications varies by the reason for admission, the severity of the underlying illness, and the presence of coexisting diagnoses at the time of admission (Thomas and Brennan, 2000). If present on admission, secondary diagnoses can be used to adjust for a patient’s risk of complications; if not present on admission, they could represent complications of care, and should not be used for risk adjustment.

The reason for admission is an important determinant of a patient’s risk of complications. Patients treated for medical conditions will be at risk for different complications, and at different rates, than patients admitted for surgery. Among surgical patients, the type of surgery will strongly influence the type and frequency of complications. For example, a patient admitted for coronary bypass grafting will be more likely to develop heart failure than one admitted for a hernia repair. Susceptibility to complications also varies widely among medical patients; a patient admitted with a stroke will be more likely to develop aspiration pneumonia than one admitted with acute urinary retention.

Risk of complications also depends on the severity of the illness that caused the admission, as well as the presence of coexisting illnesses. Patients hospitalized with a more severe form of the underlying illness or with multiple comorbid conditions have a higher risk of complications (Daley, Henderson, and Khuri, 2001; Rosen et al., 1995; Rothschild, Bates, and Leape, 2000). Fair comparisons of complication rates across hospitals require the use of risk-adjustment methods that account for each of these factors.

A POA indicator is currently required on all hospital discharge abstracts by New York and California. It has been proposed as an additional data element on the Uniform Billing form commonly referred to as the UB-04, and has been mandated by the Deficit Reduction Act of 2005 to be used on all bills submitted to Medicare beginning in October 2007. This article describes a new method of reporting risk-adjusted in-hospital complication rates using discharge abstract data and a present on admission indicator for secondary diagnoses. The POA indicator serves two purposes: (1) to create a method for identifying potentially preventable complications from among diagnoses not present on admission, and (2) to allow only those diagnoses designated as present on admission to be used for assessing the risk of incurring complications.

PPC SYSTEM METHODS

Overview

In developing the PPC System it was first necessary to identify the subset of diagnoses that, if not present on admission, would represent potentially preventable complications, and assemble them into groups containing similar diagnoses. The next step was to determine the types of patients for whom each group of complications was potentially preventable. The final step was to adjust for susceptibility to complications based on the reason for admission, SOI, and comorbid conditions. We could then calculate and compare actual and expected risk-adjusted complication rates for individual hospitals using norms derived from statewide average complication rates. This study in particular examines the effect of
the reason for admission and admission SOI on patients’ susceptibility to potentially preventable complications, and the effect of complications on costs and mortality.

**Identifying and Classifying Diagnosis Codes**

A core group of three physicians (two general internists and one pediatrician) supplemented by surgical, medical, obstetric, and pediatric specialists as needed, was responsible for creating a list of potentially preventable complications. The core panel first reviewed the existing literature and incorporated most of the diagnosis codes used in the Complications Screening Program (CSP) developed by Iezzoni and colleagues (1994; 1992) and the Patient Safety Indicators (PSI) from the Agency for Healthcare Research and Quality (2005). The physician panel then conducted its own review of all International Classification of Diseases Ninth Revision-Clinical Modification (ICD-9-CM) diagnosis codes to identify additional potentially preventable complications (Centers for Disease Control and Prevention, 2006).

We defined in-hospital complications as harmful events (e.g., accidental laceration during a procedure, improper administration of medication) or negative outcomes (e.g., hospital-acquired pneumonia, Clostridium Difficile Colitis) that may result from the processes of care and treatment rather than from natural progression of the underlying illness.

Complications do not necessarily represent medical errors, since they are not always preventable even with optimal care. In deciding which complications to classify as potentially preventable, the physician panel developed the following conceptual guide: If a hospital or other health care facility were to have a statistically significant, higher rate of a particular complication than comparable hospitals, reasonable clinicians would suggest further investigation for possible problems with quality of care.

The following specific criteria also provided guidance in choosing PPC diagnoses. In order to be considered a PPC diagnosis, the secondary diagnosis should:

- Not be redundant with the diagnosis that was the reason for hospital admission (e.g., a diagnosis of stroke in a patient admitted with intracranial hemorrhage).
- Not be an inevitable, natural, or expected consequence or manifestation of the reason for hospital admission (e.g., stroke in a patient admitted with a brain malignancy).
- Be expected to have a significant impact on short- or long-term debility, mortality, patient suffering, or resource use.
- Have a relatively narrow spectrum of manifestations, meaning that the impact of the diagnosis on the clinical course or on resource use must not be significant for some patients, but trivial for others (e.g., iron deficiency anemia, atelectasis).

Of the 12,988 ICD-9-CM diagnosis codes, we identified 1,357 codes as PPC diagnoses. We then assigned each PPC diagnosis to one of 66 mutually exclusive complication groups based on similarities in clinical presentation and clinical impact (Table 1). The number of diagnosis codes in a complication group ranged from 1 (Clostridium Difficile Colitis) to 215 (Poisoning Due to Drugs and Biological Substances). Table 2 contains examples of three complication groups.

**Use of Procedure Codes**

In addition to diagnosis codes, we used procedure codes to create some of the complication groups. In some cases, the procedure by itself could assign a patient to a complication group. For example, in
### Table 1

**List of Potentially Preventable Complications Groups (PPCs)**

| Group | Description |
|-------|-------------|
| 1*    | Stroke & Intracranial Hemorrhage |
| 2*    | Extreme CNS Complications |
| 3*    | Acute Lung Edema & Respiratory Failure |
| 4*    | Pneumonia, Lung Infection |
| 5*    | Aspiration Pneumonia |
| 6*    | Pulmonary Embolism |
| 7     | Complications of Thoracic Surgery & Other Pulmonary Complications |
| 8*    | Shock |
| 9*    | Congestive Heart Failure |
| 10*   | Acute Myocardial Infarct |
| 11    | Cardiac Arrhythmias & Conduction Disturbances |
| 12    | Other Cardiac Complications |
| 13*   | Ventricular Fibrillation/Cardiac Arrest |
| 14    | Hypotension |
| 15*   | Peripheral Vascular Complications Except Venous Thrombosis |
| 16    | Venous Thrombosis |
| 17    | Major GI Complications without Significant Bleeding |
| 18*   | Major GI Complications with Significant Bleeding |
| 19*   | Major Liver Complications |
| 20    | Other GI Complications without Report Of Significant Bleeding |
| 21*   | Other GI Complications with Report Of Significant Bleeding |
| 22    | Clostridium Difficile Colitis |
| 23    | Urinary Tract Infection |
| 24    | Complications of GU Surgery & Other GU Complications Except UTI |
| 25    | Renal Failure without Dialysis |
| 26*   | Renal Failure with Dialysis |
| 27    | Diabetic Ketoacidosis & Coma |
| 28    | Endocrine & Metabolic Complications except Diabetic Ketoacidosis/Coma |
| 29    | Post-Hemorrhagic & Other Acute Anemia without Transfusion |
| 30*   | Post-Hemorrhagic & Other Acute Anemia with Transfusion |
| 31    | Limb Fractures |
| 32    | Poisonings Of Drugs & Biological Substances |
| 33    | Anesthesia Poisonings & Adverse Effects |
| 34    | Abnormal Reactions |
| 35*   | Decubitus Ulcer |
| 36    | Transfusion Incompatibility Reaction |
| 37    | Moderate Infectious Complications |
| 38*   | Septicemia & Severe Infection |
| 39    | Adverse Effects Of Drugs, Transfusions & Biological Substances |
| 40    | Acute Mental State Changes |
| 41    | Post-Op Wound Infection & Deep Wound Disruption without Procedure |
| 42*   | Post-Op Wound Infection & Deep Wound Disruption with Procedure |
| 43*   | Reopening Or Revision Of Surgical Site |
| 44    | Post-Op Hemorrhage & Hematoma without Hemorrhage Control Or I&D Procedure |
| 45*   | Post-Op Hemorrhage & Hematoma with Hemorrhage Control Or I&D Procedure |
| 46    | Accidental Puncture/Laceration During O.R. Procedure |
| 47    | Non-O.R. Procedure Laceration |
| 48    | Other Surgical Complication - Mod |
| 49*   | Post-Op Foreign Body & Inappropriate Operation |
| 50    | Post-Op Substance Reaction & Non-O.R. Procedure for Foreign Body |
| 51*   | Other Major Complications Of Medical Care |
| 52    | Other Complications Of Medical Care |
| 53    | Iatrogenic Pneumothrax |
| 54*   | Malfunction Device, Prosthesis, Graft |
| 55    | GI Ostomy Complications |
| 56*   | Infection/Inflammation & Other Complication Of Device/Graft ex Vascular Infection |
| 57    | Complications Of Peripheral Intravenous Catheters |
| 58*   | Complications Of Central Venous & Other Vascular Catheters & Devices |
| 59    | Obstetrical Hemorrhage without Transfusion |
| 60*   | Obstetrical Hemorrhage with Transfusion |
| 61    | Obstetric 3rd&4th Degree Lacerations & Other Trauma |
| 62    | Medical & Anesthesia Obstetric Complications |
| 63*   | Major Obstetrical Complications |
| 64    | Other Complications Of Delivery |
| 65    | Delivery with Placental Complications |
| 66*   | Post-Operative Respiratory Failure with Tracheostomy |

*Major PPCs.

NOTE: The PPC System identifies in-hospital complications among secondary diagnoses not designated as present on admission (POA).

SOURCES: Hughes, J.S., Averill, R.F., Goldfield, N.I., Gay, J.C., Muldoon, J., McCullough, E., Xiang, J., 2005.
Table 2
Examples of the Diagnosis and Procedure Codes for Three Complication Groups in the Potentially Preventable Complications (PPCs) System

| ICD-9-CM Code | Description |
|---------------|-------------|
| PPC 01 Stroke and Intracranial Hemorrhage |
| Any one of the following diagnosis codes: |
| 430 Subarachnoid Hemorrhage |
| 431 Intracerebral Hemorrhage |
| 4320 Nontraumatic Extradural Hemorrhage |
| 4321 Subdural Hemorrhage |
| 4329 Intracranial Hemorrhage NOS |
| 43301 Occlusion of Basilar Artery with Infarction |
| 43311 Occlusion of Carotid Artery with Infarction |
| 43321 Occlusion of Vertebral Artery with Infarction |
| 43331 Occlusion of Multiple and Bilateral Arteries with Infarction |
| 43381 Occlusion of Other Specified Precerebral Artery with Infarction |
| 43391 Occlusion of Unspecified Precerebral Artery with Infarction |
| 43401 Cerebral Thrombosis with Infarction |
| 43411 Cerebral Embolism with Infarction |
| 43491 Cerebral Artery Occlusion, Unspecified, with Infarction |
| 436 Acute Cerebrovascular Disease |
| 99702 Iatrogenic Cerebrovascular Infarction or Hemorrhage |
| PPC 03 Acute Lung Edema and Respiratory Failure |
| Any one of the following diagnosis codes: |
| 5184 Acute Lung Edema NOS |
| 5185 Post Traumatic Pulmonary Insufficiency |
| 51881 Acute Respiratory Failure |
| 51884 Acute & Chronic Respiratory Failure |
| 7991 Respiratory Arrest |
| Or one of the Following Procedure Codes: |
| (Occurring > 2 Days after Admission or > 1 Day after a Significant Surgical Procedure) |
| 9604 Insertion Of Endotracheal Tube |
| 9670 Continuous Mechanical Ventilation for Unspecified Duration |
| 9671 Continuous Mechanical Ventilation for Less than 96 Hours |
| Or the Following Procedure Code: |
| (Occurring >2 Days after Admission (for Non-Surgical APR DRGs) or > 0 day post first significant surgery) |
| 9672 Continuous Mechanical Ventilation for at least 96 Hours |
| PPC 05 Aspiration Pneumonia |
| Any one of the following diagnosis codes: |
| 5070 Pneumonitis Due to Inhalation of Food or Vomitus |
| 5071 Pneumonitis Due to Inhalation of Oils or Essences |
| 5078 Pneumonitis Due to Other Solids or Liquids |

NOTES: Table shows three complication groups of the 66 groups in the PPC system. APR DRGs are All-Patient Refined Diagnosis-Related Groups. SOURCES: Hughes, J.S., Averill, R.F., Goldfield, N.I., Gay, J.C., Muldoon, J., McCullough, E., Xiang, J., 2005.

addition to the five diagnosis codes shown in the second example in Table 2, the procedure codes for endotracheal intubation or mechanical ventilation, if they met the appropriate timing criteria, could also generate the complication groups Acute Pulmonary Edema and Respiratory Failure. In other cases, the procedure code was combined with a diagnosis code to differentiate complication groups with greater clinical impact. For example, a patient with a secondary diagnosis of acute post-hemorrhagic anemia, not present on admission, would be assigned to a PPC named Hemorrhage or Anemia without Transfusion. The same diagnosis accompanied by a code for blood transfusion (at least 2 days after admission) would assign the patient to a different complication group, hemorrhage or anemia with transfusion.
### Table 3

**Examples of Exclusion Criteria for Three Complication Groups in the Potentially Preventable Complications (PPCs) System**

| Group   | Description                                                                                     |
|---------|-----------------------------------------------------------------------------------------------|
| PPC 01  | **Stroke and Intracranial Hemorrhage**                                                          |
|         | Will Not Count as a Complication for Patients Admitted with Any of the Following Conditions:   |
|         |   Intracranial Hemorrhage                                                                      |
|         |   CVA, Cerebral Infarction                                                                     |
|         |   Cerebral Artery Dissection                                                                   |
|         |   Severe Non-Traumatic Brain Injury                                                             |
|         |   Brain Contusion/Laceration and Complicated Skull Fracture                                    |
|         | And Will Not Apply to Patients with Ventilator Support Greater than 96 Hours                   |
| PPC 03  | **Acute Lung Edema and Respiratory Failure**                                                     |
|         | Will Not Count as a Complication for Patients Admitted with:                                   |
|         |   Pulmonary Edema and Respiratory Failure                                                       |
|         |   Septicemia and Disseminated Infections                                                       |
|         | And Will Not Apply to:                                                                           |
|         |   Patients with Ventilator Support Greater than 96 Hours                                         |
|         |   Patients with Tracheostomy and Prolonged Mechanical Ventilation                              |
|         | And Will Not Count as Complications for Surgical and Obstetric Patients Admitted with:         |
|         |   Intracranial Hemorrhage                                                                      |
|         |   Non-Traumatic Stupor and Coma                                                                  |
|         |   Pulmonary Embolism                                                                            |
|         |   Acute Myocardial Infarction                                                                   |
|         |   Acute Heart Failure                                                                           |
| PPC 05  | **Aspiration Pneumonia**                                                                        |
|         | Will Not Count as a Complication for Patients Admitted with:                                   |
|         |   Seizures                                                                                      |
|         |   Brain Contusions, Lacerations and Complicated Skull Fractures                                 |
|         |   Uncomplicated Closed Skull Fractures with Concussion                                           |
|         |   Hematologic Malignancies and Immunocompromised States                                         |
|         |   Septicemia and Disseminated Infections                                                       |
|         | And Will Not Apply to Patients with Ventilator Support Greater than 96 Hours                   |

**NOTE:** Table shows three complication groups of the 66 groups in the PPC system.

**SOURCES:** Hughes, J.S., Averill, R.F., Goldfield, N.I., Gay, J.C., Muldoon, J., McCullough, E., Xiang, J., 2005.

### Exclusions by Reason for Admission

A PPC diagnosis may be preventable for some types of patients, but not for others. Therefore the physician panel created clinical exclusions for each complication group. Some complication groups apply to only certain types of patients; for example post-operative complications occur only in surgical patients, and obstetric complications occur only in females who deliver after admission. The panel created a series of more specific clinical exclusions, most commonly dealing with possible complication diagnoses that were redundant codes or a natural consequence of one of the diagnoses present on admission, and therefore unpreventable. For example, the complication group aspiration pneumonia was not considered preventable for patients admitted with seizures, head trauma, respiratory failure requiring ventilator support, or septicemia. Table 3 contains exclusion criteria for each of the complication groups shown in Table 2.

The application of the POA logic and exclusion criteria makes a complication group potentially preventable, and the result is called a PPC Group. The PPC Groups are the final product of the PPC system logic. Hereafter the PPC Groups will be referred to as PPCs.
The panel also created global exclusions for patients with certain severe or catastrophic illnesses that were particularly susceptible to a range of complications, including those with trauma, HIV, and major or metastatic malignancies. These analyses also excluded newborns, which will be addressed by future versions of the PPC System. Details of these global exclusions are available on request from the authors.

Patients that were not globally excluded and had no specific clinical exclusions were considered at risk for the PPC, and therefore were included in the PPC rate calculation.

**Differences from Previous Methods**

The PPC System incorporates the great majority of the diagnosis codes used in both the CSP and PSI. PPCs use 502 of the 532 diagnosis codes (94 percent) and all 26 procedure codes used in CSP, and use 116 of 123 possible diagnosis codes (94 percent) and all 29 procedure codes used by the PSI. PPCs omit 1 complication of anesthesia code used by PSI, and 6 codes relating to obstetric lacerations (out of a total of 15) that our consultants thought would have only a minor impact on patient care. We added 524 diagnosis codes that were present in neither system. The most important difference with CSP and PSI was that the POA indicator allowed the PPCs to apply the complications to a larger group of patients—mainly to patients admitted with medical diagnoses. Most of the complications detected by both CSP and PSI occur in post-operative patients. Details of differences with CSP and PSI are available on request from the authors.

**Use of APR DRGs for Risk Adjustment**

We used All-Patient Refined Diagnosis Related Groups (APR DRGs) version 20 to classify patients according to their reason for admission and SOI at admission. (Averill et al., 2002) APR DRGs use data from computerized discharge abstracts to assign patients to one of 314 base APR DRGs that are determined either by the principal diagnosis, or for surgical patients, the most important surgical procedure performed in an operating room. Each base APR DRG is then divided into four risk subclasses, determined primarily by secondary diagnoses that reflect both comorbid illnesses and severity of the principal diagnosis, creating the final set of 1,256 groups. The risk subclasses take two different forms: (1) risk of mortality, and (2) SOI. SOI was used to stratify the risk of complications in all of the analyses that follow, except that risk of mortality was used in examining the association of complications with increased mortality. The combination of the base APR DRG and the risk subclass is referred to as the APR DRG. In ordinary use, APR DRGs use all diagnoses from the hospitalization, whether present on admission or not. For risk adjustment of PPC rates in the analyses that follow, however, we used an admission APR DRG that is based on the principal diagnosis from the discharge abstract, but excludes all secondary diagnoses that are not present on admission. Thus, complications and other conditions that arise during the hospitalization are not used for risk adjustment.
ANALYSIS

Data Sources

We analyzed discharge abstract data for 5.15 million discharges from all California hospitals for 1999 and 2000. A total of 520,885 discharges from 99 hospitals that had not recorded the present on admission indicator accurately or consistently were eliminated (screening criteria available on request from the authors). These hospitals tended to be smaller, with an average of 5,304 discharges in the 2-year period compared to an average of 15,646 discharges for the included hospitals, but had similar distributions of age and sex. Another 16,501 discharges from 40 hospitals with fewer than 1,000 discharges and 5 hospitals with a death rate over 15 percent (compared to an average of 2.3 percent for included hospitals) were eliminated out of concern that they would not be representative of acute care hospitals. Thus, we were left with a total of 294 hospitals and 4.62 million discharges. From the eligible hospitals we then excluded 665,782 patients with charges less than $200 or greater than $2 million, or who had lengths of stay (LOS) recorded as zero. We excluded 314,881 patients with certain severe or catastrophic illnesses that were particularly susceptible to a range of complications, including those with trauma, HIV, and major or metastatic malignancies (global exclusions). We also excluded 602,114 newborns from these analyses.

Identifying Patients

This study focused on a subset of 29 major PPCs (Table 1). The major PPCs were selected by consensus of the physician panel as those most likely to have a consistent and significant impact on a patient’s clinical course. The ICD-9-CM (Centers for Disease Control and Prevention, 2006) diagnosis and procedure codes that comprise each of the major PPCs are available on request from the author.

We calculated the total number of California patients who had each one of the major PPCs, as well as all patients who had any one of the major PPCs. In order to gauge the impact of the POA indicator, we also identified the number of patients with a PPC secondary diagnosis code that was present on admission, and therefore not counted as a PPC.

Calculating Observed and Expected Rates

We calculated a statewide PPC norm—the average rate for each PPC for each admission APR DRG across all patients who were at risk for the PPC—using data only from those hospitals that passed the POA coding quality screens. Then, using indirect standardization, for each hospital we calculated the expected number of patients for each PPC by multiplying the statewide average rate for each PPC/APR DRG combination by the number of patients in the hospital in each admission APR DRG. The expected number of patients with a PPC in each admission APR DRG summed across all APR DRGs is the hospital’s overall expected number of patients with that PPC. In the same manner, we calculated expected rates for combinations of PPCs, and for all patients with any one of the major PPCs noted in Table 1. Any patient with more than one major PPC was only counted once when calculating rates for combinations of PPCs. We calculated differences in actual minus expected rates for individual PPCs and combinations of PPCs, for individual hospitals and for all hospitals in the State. We
determined statistical significance using the Cochrane-Mantel-Haenzel (CMH) test (Agresti, 1990).

Evaluating the Impact

In order to examine the impact of the occurrence of a PPC on hospital outcomes, we computed the statewide average charges, LOS, and death rates for each admission APR DRG. Then, using the statewide averages for each admission APR DRG, we computed the expected average charges, LOS and death rates by means of indirect rate standardization for patients with specific PPCs, and for all patients with any of the major PPCs. We then calculated the actual average charges, LOS, and death rates for the same sets of patients, and determined the ratio of actual values to expected values. We determined statistical significance using the CMH test for differences in actual and expected death rates, and Student’s t-test for average LOS and charge differences.

Evaluating Stability of Rates Over Time

We calculated actual minus expected rates of patients with any major PPC for the first 6 months of 1999 and the first 6 months of 2000 for all eligible California hospitals. We examined the stability of the actual minus expected rate differences for all hospitals that had a statically significant difference in 1999, 2000, or in both years. We calculated an $R^2$ value for the correlation of actual minus expected differences in the 2 years.

RESULTS

Table 4 contains, for each of the major PPCs, the number of California patients at risk, the total number of patients with a PPC diagnosis, whether present on admission or not, the number of patients excluded because the PPC diagnosis was POA, and the number of patients with a PPC diagnosis not POA, but excluded by a clinical exclusion rule. Table 4 also shows the number of patients with a true PPC and the positive predictive value, calculated as the proportion of true PPCs (not POA and without a clinical exclusion) among all patients with a PPC diagnosis.

As shown in Table 4, there is considerable variation in the occurrence of PPCs, ranging from a low of 0.15 per 1,000 for Post-Operative Respiratory Failure with Tracheostomy to a high of 7.26 per 1,000 for Acute Lung Edema and Respiratory Failure. The overall rate for patients with at least one major PPC is 27.6 per 1,000.

The POA indicator is more important for determining some PPCs than others. For most of the PPCs, the majority of the PPC diagnosis codes were present on admission, as reflected in the low positive predictive values. For those PPCs, screening for complications without the POA indicator would be impractical. For both of the Major Obstetrical PPCs and three of the Major Post-Operative PPCs, however, the number of false positives would have been much lower. The POA indicator is therefore of less value for these PPCs.

The effect of the POA indicator and the exclusion criteria on the number of patients with at least one major PPC is demonstrated in Table 4. Almost 580,000 of the California hospital discharges had at least one secondary diagnosis belonging to a major PPC, but 487,826 were not considered to have a PPC because the PPC diagnosis was present on admission. Another 7,831 were not considered to have a PPC because of clinical exclusions.

Table 5 presents the number and rate of patients per 1,000 who incurred at least one major PPC for a selected group of 20
| Major PPC Group | (1) Patients at Risk | (2) All Patients with any PPC Diagnosis** | (3) PPC Diagnoses Excluded Because POA Exclusions | (4) PPC Diagnoses with Clinical Exclusions | (5) PPC Not POA, Excluded to Equals True PPC* | PPC Rate per 1,000*** | PPV |
|-----------------|----------------------|------------------------------------------|---------------------------------|---------------------------------|---------------------------------|-------------------|-----|
| **Major Cardiovascular and Pulmonary PPCs** | | | | | | | |
| 1 Stroke & Intracranial Hemorrhage | 2,969,740 | 15,743 | 9,797 | 414 | 5,532 | 1.86 | 0.35 |
| 2 Extreme CNS Complications | 2,855,451 | 17,414 | 14,657 | 949 | 1,808 | 0.63 | 0.10 |
| 3 Acute Lung Edema & Respiratory Failure | 2,919,995 | 135,341 | 110,404 | 3,745 | 21,192 | 7.26 | 0.16 |
| 4 Pneumonia, Lung Infection | 2,704,448 | 87,366 | 71,777 | 3,911 | 12,198 | 4.51 | 0.14 |
| 5 Aspiration Pneumonia | 2,865,642 | 20,344 | 12,033 | 1,536 | 6,775 | 2.36 | 0.33 |
| 6 Pulmonary Embolism | 3,022,644 | 4,443 | 2,957 | 1 | 1,485 | 0.49 | 0.33 |
| 7 Shock | 2,971,169 | 20,181 | 15,111 | 932 | 4,138 | 1.39 | 0.21 |
| 8 Congestive Heart Failure | 2,686,676 | 209,524 | 197,815 | 890 | 10,819 | 4.03 | 0.05 |
| 9 Acute Myocardial Infarct | 2,956,739 | 18,799 | 12,299 | 124 | 6,376 | 2.16 | 0.34 |
| 10 Ventricular Fibrillation/Cardiac Arrest | 3,031,554 | 27,167 | 16,103 | 0 | 11,064 | 3.65 | 0.41 |
| 11 Peripheral Vascular Complications Except Venous Thrombosis | 3,018,827 | 7,675 | 6,447 | 570 | 658 | 0.25 | 0.09 |
| 12 Major Gastrointestinal Complications with Transfusion | 2,614,013 | 19,552 | 18,065 | 190 | 1,297 | 0.5 | 0.07 |
| 13 Major Liver Complications | 2,994,021 | 11,594 | 10,414 | 456 | 724 | 0.24 | 0.06 |
| 14 Other GI Complications with Transfusion Or Post-Hemorrhagic Anemia | 2,622,763 | 7,675 | 6,447 | 570 | 658 | 0.25 | 0.09 |
| 15 Renal Failure with Dialysis | 2,956,451 | 8,180 | 6,222 | 480 | 1,478 | 0.5 | 0.18 |
| 16 Post-Hemorrhagic & Other Acute Anemia with Transfusion | 1,957,938 | 36,005 | 34,066 | 860 | 1,079 | 0.55 | 0.03 |
| 17 Decubitus Ulcer | 2,995,583 | 38,272 | 35,686 | 7 | 2,579 | 0.86 | 0.07 |
| 18 Septicemia & Severe Infection | 2,938,030 | 60,168 | 50,132 | 1,167 | 8,869 | 3.02 | 0.15 |
| 19 Major Complications Of Medical Care | 3,014,401 | 27,255 | 22,388 | 75 | 4,792 | 1.59 | 0.18 |
| **At Least One Major Cardiovascular or Pulmonary PPC** | 3,031,554 | | | | 59,850 | 19.74 | |
| **Major Peri-Operative PPCs** | | | | | | | |
| 21 Post-Op Wound Infection & Deep Wound Disruption with Procedure | 1,083,363 | 1,634 | 920 | 39 | 675 | 0.62 | 0.41 |
| 22 Reopening Or Revision Of Surgical Site | 1,098,260 | 14,163 | 12,917 | 0 | 1,246 | 1.13 | 0.09 |
| 23 Post-Op Hemorrhage with Hemorrhage Control or I&D Procedure | 1,098,260 | 4,381 | 2,004 | 23 | 2,354 | 2.14 | 0.54 |
| 24 Post-Op Foreign Body & Inappropriate Operation | 1,098,260 | 291 | 109 | 9 | 173 | 0.16 | 0.59 |
| 25 Post-Op Respiratory Failure with Tracheostomy | 2,332,281 | 1,558 | 1,215 | 0 | 343 | 0.15 | 0.22 |
| **At Least One Major Peri-Operative PPC** | 2,595,252 | | | | 4,732 | 1.82 | |
| **Major Complications of Devices, Grafts, Etc.** | | | | | | | |
| 26 Complications Of Devices, Grafts, Etc. | 2,967,872 | 8,425 | 6,002 | 175 | 2,248 | 0.76 | 0.27 |
| 27 Infection, Inflammation & Other Complications of Devices & Grafts | 2,967,872 | 9,365 | 6,529 | 106 | 2,730 | 0.92 | 0.29 |
| 28 Complications Of Central Venous & Other Vascular Catheters & Devices | 2,986,171 | 14,164 | 8,340 | 388 | 5,436 | 1.82 | 0.38 |
| **At Least One Major Complication Of Devices, Grafts, Etc.** | 2,986,171 | | | | 10,136 | 3.39 | |
| **Major Obstetrical Complications** | | | | | | | |
| 29 Obstetrical Hemorrhage with Transfusion | 618,708 | 1,187 | 159 | 121 | 907 | 1.47 | 0.76 |
| 30 Major Obstetrical Complications | 626,438 | 3,750 | 310 | 12 | 3,428 | 5.47 | 0.91 |
| **At Least One Major Obstetrical Complication** | 626,438 | | | | 4,275 | 6.82 | |

See footnotes at the end of the table.
### Table 4—Continued

| Major PPC Group | (1) Patients at Risk | (2) All Patients with any PPC Diagnosis** | (3) PPC Excluded Because POA | (4) PPC Excluded with Clinical Exclusions | (5) PPC Not Excluded - Equals True PPC* | PPC Rate per 1,000*** | PPV |
|-----------------|----------------------|----------------------------------------|----------------------------|------------------------------------------|----------------------------------------|-----------------------|-----|
| At Least One Major PPC of any kind | 3,031,554 | 579,424 | 487,826 | 7,831 | 83,767 | 27.63 | 0.14 |

*Includes only patients with PPC diagnosis codes not present on admission and without clinical exclusions.

**Includes all PPC diagnosis codes, both present on admission as well as not present on admission and with clinical exclusions (equals the sum of columns 3, 4, and 5).

***PPC Rate per 1,000 = (column 5 divided by column 1) x 1,000.

NOTES: Numbers in columns do not sum to numbers in subtotal and total rows due to patients with multiple PPCs. POA is present on admission. PPV is positive predictive value (equals column 5 divided by column 2).

SOURCE: Hospital data from California Office of Statewide Health Planning and Development.
Table 5
Percent of Patients with at Least One Major Potentially Preventable Complications Group (PPC) in Selected All-Patient Refined Diagnosis-Related Groups (APR DRGs)

| APR DRG Description                                                                 | Admission Severity of Illness (SOI) Level | SOI 1 | SOI 2 | SOI 3 | SOI 4 | Total |
|-------------------------------------------------------------------------------------|------------------------------------------|-------|-------|-------|-------|-------|
| Surgical APR DRGs                                                                    |                                          |       |       |       |       |       |
| Craniotomy except for Trauma                                                        | PPCs                                     | 264   | 553   | 663   | 150   | 1,630 |
|                                                                                     | At Risk                                  | 4,339 | 3,642 | 2,313 | 533   | 10,827|
|                                                                                     | Percent                                  | 6.1   | 15.2  | 28.7  | 28.1  | 15.1  |
| Extracranial Vascular Procedures                                                    | PPCs                                     | 238   | 297   | 161   | 6     | 702   |
|                                                                                     | At Risk                                  | 9,850 | 4,525 | 822   | 27    | 15,224|
|                                                                                     | Percent                                  | 2.4   | 6.6   | 19.6  | 22.2  | 4.6   |
| Coronary Artery Bypass Graft with Catheterization                                   | PPCs                                     | 336   | 1,998 | 1,433 | 99    | 3,866 |
|                                                                                     | At Risk                                  | 3,430 | 13,260| 4,946 | 348   | 21,984|
|                                                                                     | Percent                                  | 9.8   | 15.1  | 29.0  | 28.5  | 17.6  |
| Percutaneous Cardiovascular Procedures with Acute MI                                | PPCs                                     | 361   | 550   | 335   | 105   | 1,351 |
|                                                                                     | At Risk                                  | 27,295| 19,407| 4,366 | 517   | 51,585|
|                                                                                     | Percent                                  | 1.3   | 2.8   | 7.7   | 20.3  | 2.6   |
| Major Large & Small Bowel Procedures                                                | PPCs                                     | 320   | 1,156 | 1,416 | 353   | 3,245 |
|                                                                                     | At Risk                                  | 8,617 | 11,017| 5,187 | 894   | 25,715|
|                                                                                     | Percent                                  | 3.7   | 10.5  | 27.3  | 39.5  | 12.6  |
| Appendectomy                                                                       | PPCs                                     | 99    | 292   | 70    | 9     | 470   |
|                                                                                     | At Risk                                  | 24,599| 13,122| 700   | 47    | 38,468|
|                                                                                     | Percent                                  | 0.4   | 2.2   | 10.0  | 19.2  | 1.2   |
| Laparoscopic Cholecystectomy                                                        | PPCs                                     | 200   | 350   | 245   | 21    | 816   |
|                                                                                     | At Risk                                  | 20,928| 12,065| 3,057 | 138   | 36,188|
|                                                                                     | Percent                                  | 1.0   | 2.9   | 8.0   | 15.2  | 2.3   |
| Hip Joint Replacement                                                               | PPCs                                     | 184   | 775   | 654   | 32    | 1,645 |
|                                                                                     | At Risk                                  | 3,506 | 18,675| 10,357| 119   | 32,657|
|                                                                                     | Percent                                  | 5.3   | 4.2   | 6.3   | 26.9  | 5.0   |
| Intervertebral Disc Excision                                                        | PPCs                                     | 89    | 135   | 38    | 1     | 263   |
|                                                                                     | At Risk                                  | 22,454| 6,073 | 436   | 9     | 28,972|
|                                                                                     | Percent                                  | 0.4   | 2.2   | 8.7   | 11.1  | 0.9   |
| Uterine & Adnexal Procedures Except for Leiomyoma Excision                          | PPCs                                     | 263   | 138   | 53    | 4     | 458   |
|                                                                                     | At Risk                                  | 34,974| 6,828 | 482   | 20    | 42,304|
|                                                                                     | Percent                                  | 0.8   | 2.0   | 11.0  | 20.0  | 1.1   |

See footnotes at the end of the table.
### Table 5—Continued
Percent of Patients with at Least One Major Potentially Preventable Complications Group (PPC) in Selected All-Patient Refined Diagnosis-Related Groups (APR DRGs)

| APR DRG Description | Admission Severity of Illness (SOI) Level | SOI 1 | SOI 2 | SOI 3 | SOI 4 | Total |
|---------------------|------------------------------------------|-------|-------|-------|-------|-------|
| **Medical APR DRGs** |                                          |       |       |       |       |       |
| Cerebrovascular Accidents | PPCs | 34 | 590 | 813 | 245 | 1,682 |
|                      | At Risk | 4,056 | 21,231 | 8,307 | 1,192 | 34,786 |
|                      | Percent | 0.8 | 2.8 | 9.8 | 20.6 | 4.8 |
| Major Pneumonia | PPCs | 41 | 400 | 826 | 729 | 1,996 |
|                   | At Risk | 2,803 | 11,786 | 14,329 | 4,852 | 33,770 |
|                   | Percent | 1.5 | 3.4 | 5.8 | 15.0 | 5.9 |
| Other Pneumonia | PPCs | 101 | 891 | 1,027 | 807 | 2,826 |
|                  | At Risk | 24,694 | 57,313 | 28,300 | 3,892 | 114,199 |
|                  | Percent | 0.4 | 1.6 | 3.6 | 20.7 | 2.5 |
| COPD | PPCs | 144 | 432 | 400 | 400 | 1,376 |
|                   | At Risk | 20,224 | 27,677 | 10,845 | 2,211 | 60,957 |
|                   | Percent | 0.7 | 1.6 | 3.7 | 18.1 | 2.3 |
| Acute MI | PPCs | 155 | 976 | 873 | 420 | 2,424 |
|                  | At Risk | 6,925 | 20,510 | 8,959 | 2,530 | 38,924 |
|                  | Percent | 2.2 | 4.8 | 9.7 | 16.6 | 6.2 |
| Congestive Heart Failure | PPCs | 177 | 1,366 | 1,137 | 369 | 3,049 |
|                         | At Risk | 18,151 | 59,203 | 18,390 | 2,195 | 97,939 |
|                         | Percent | 1.0 | 2.3 | 6.2 | 16.8 | 3.1 |
| Peptic Disease & Gastritis | PPCs | 45 | 274 | 325 | 63 | 707 |
|                         | At Risk | 10,099 | 14,467 | 6,229 | 393 | 31,188 |
|                         | Percent | 0.5 | 1.9 | 5.2 | 16.0 | 2.3 |
| Cellulitis | PPCs | 24 | 152 | 123 | 23 | 322 |
|                         | At Risk | 15,395 | 16,089 | 4,275 | 187 | 35,946 |
|                         | Percent | 0.2 | 0.9 | 2.9 | 12.3 | 0.9 |
| Urinary Tract Infection | PPCs | 35 | 299 | 382 | 61 | 777 |
|                          | At Risk | 10,759 | 21,556 | 10,416 | 655 | 43,386 |
|                         | Percent | 0.3 | 1.4 | 3.7 | 9.3 | 1.8 |
| Septicemia | PPCs | 6 | 288 | 669 | 321 | 1,284 |
|                         | At Risk | 1,878 | 11,064 | 11,329 | 2,842 | 27,113 |
|                         | Percent | 0.3 | 2.6 | 5.9 | 11.3 | 4.7 |

**SOURCE:** Hospital data from California Office of Statewide Health Planning and Development.
### Table 6
Actual and Expected Death Rate, Length of Stay (LOS), and Charges for Patients With Selected Potentially Preventable Complications Groups (PPCs)

| PPC Title                                      | PPC Rate | At Risk | PPC/ 1,000 | Actual/ 1,000 | Expected/ 1,000 | Actual/ Expect | Mean Length of Stay** | Mean Charges** |
|------------------------------------------------|----------|---------|------------|---------------|-----------------|----------------|-----------------------|----------------|
| Stroke & Intracranial Hemorrhage               | 2,969,740| 1.86    | 0.53       | 0.13          | 4.15            | 15.3           | 8.2                   | 114,337        |
| Acute Lung Edema & Resp. Failure               | 2,919,995| 7.26    | 2.74       | 0.52          | 5.24            | 18.1           | 9.2                   | 143,872        |
| Pneumonia, Lung Infection                      | 2,704,448| 4.51    | 0.75       | 0.23          | 3.22            | 19.7           | 7.7                   | 125,302        |
| Aspiration Pneumonia                           | 2,865,642| 2.36    | 0.64       | 0.20          | 3.27            | 18.8           | 8.1                   | 128,798        |
| Pulmonary Embolism                              | 3,022,644| 0.49    | 0.13       | 0.03          | 4.90            | 16.9           | 7.9                   | 113,503        |
| Congestive Heart Failure                       | 2,686,676| 4.03    | 0.69       | 0.25          | 2.71            | 14.1           | 7.8                   | 98,507         |
| Acute Myocardial Infarct                       | 2,956,739| 2.16    | 0.62       | 0.18          | 3.56            | 12.6           | 8.2                   | 97,917         |
| Major GI Complications with Transfusion        | 2,614,013| 0.50    | 0.14       | 0.05          | 2.69            | 20.3           | 10.0                  | 134,883        |
| Major Liver Complications                      | 2,994,021| 0.24    | 0.13       | 0.03          | 5.14            | 21.0           | 10.3                  | 179,045        |
| Renal Failure with Dialysis                    | 2,956,451| 0.50    | 0.28       | 0.05          | 5.11            | 28.5           | 11.5                  | 257,594        |
| Decubitus Ulcer                                | 2,995,583| 0.86    | 0.17       | 0.09          | 1.76            | 27.9           | 10.7                  | 191,603        |
| Septicemia & Severe Infection                  | 2,938,030| 3.02    | 1.12       | 0.29          | 3.89            | 25.3           | 10.6                  | 189,563        |
| Reopening Surgical Site                        | 1,098,260| 1.13    | 0.18       | 0.08          | 2.37            | 18.5           | 10.3                  | 149,176        |
| Post-Op Hemorrhage with procedure              | 1,098,260| 2.14    | 0.23       | 0.08          | 2.75            | 13.9           | 8.5                   | 139,739        |
| All patients with At Least One Major PPCG*     | 3,031,554| 27.63   | 6.64       | 2.59          | 2.56            | 14.2           | 8.3                   | 98,515         |

*Includes all 29 major PPCs.

*All differences statistically significant by Cochrane-Mantel-Haenzel (CMH) test at $p<0.01$.

**All differences statistically significant by t-test at $p<0.01$.

NOTES: Expected deaths: calculated based on All-Patient Refined Diagnosis Related Group (APR DRG) risk of mortality at admission, using statewide California data for all patients at risk for each PPC. Expected mean LOS and mean charges: calculated based on APR DRG severity of illness at admission, using statewide California data for all patients at risk for each PPC.

SOURCE: Hospital data from California Office of Statewide Health Planning and Development.
admission base APR DRGs, sorted by SOI subclass (the APR DRGs severity subclasses were assigned using only secondary diagnoses present on admission). It shows that the rate of major complications varies not only by the reason for admission (categorized by base APR DRG), but also by the admission SOI. The monotonic increases in major PPC rates with increasing admission SOI are representative of all but a few combinations of base APR DRGs and individual PPCs or groups of PPCs. Across all reasons for admission, patients with greater SOI on admission were more susceptible to complications.

Table 6 shows the impact of several individual PPCs on death rates, LOS, and charges. In this table, the actual average charges, LOS, and death rates for patients with each PPC are compared to their expected values, which were derived by indirect standardization from the statewide APR DRG averages. The presence of a major PPC is associated with large increases in charges, LOS, and deaths over what would have been expected based on SOI at admission. For example, patients with a PPC of Acute Lung Edema and Respiratory Failure had death rates that were five times higher than expected, and mean LOS and charges twice as high as expected. Although they showed a very strong association with complications, these data cannot be assumed to represent the impact of medical errors on costs, deaths, and LOS. This analysis could not identify the number of true medical errors because, although it identified the number of complications that
were potentially preventable, it could not determine how many of those complications were actually preventable.

Calculation of the difference in the actual minus expected rate of major PPCs for each of the California hospitals yielded a range from -2.48 per 1,000 (better than expected) to 2.79 per 1,000 (worse than expected). Sixty hospitals were classified as having PPC rates significantly lower than expected at a \( p \) value of <0.05, and 45 hospitals were classified as having significantly higher PPC rates than expected for the 2-year period.

**Stability of Hospital Performance Over Time**

Figure 1 plots the actual minus expected major PPCs rate for the first 6 months of 1999 and the first 6 months of 2000 for each of the 179 hospitals that had a statistically significant difference in either of those years (97 of the 179 hospitals had a statistically significant difference in both years). It shows that hospitals that performed worse than expected in one year tended to perform worse than expected in both years, and conversely, those that performed better than expected in one year tended to do so in both years. The \( R^2 \) value was 0.55 for the correlation between the 2 years.

**DISCUSSION**

This article describes the development of a new method for evaluating in-hospital complication rates, the first to use the POA indicator applied to statewide data. The PPC method builds on existing complication screening methods, substantially expanding the number of diagnoses that can be considered complications, as well as expanding the number of patients for whom the occurrence of complications can be assessed. These analyses confirm the value of the POA indicator for identifying complications, particularly for those that are neither obstetric nor specific postoperative complications.

These analyses also demonstrate that the reason for admission, comorbid conditions, and admission SOI—measured here by APR DRGs—have a dramatic effect on the risk of complications. The findings emphasize that any comparisons of hospital complication rates, if they are to be fair, require not only the POA indicator to identify complications, but also the availability of adequate risk-adjustment methods. The PPC System provides a built-in risk-adjustment method with APR DRGs assigned using only diagnoses present on admission. PSIs use age, sex, and an updated version of AHRQ comorbidity software for risk adjustment. In contrast, the CSP provided no mechanism for risk adjustment.

These findings also demonstrate the association of complications with increased costs, LOS, and mortality, an association that has been shown previously (Naessens and Huschka, 2004).

**Limitations and Next Steps**

The PPC System has the limitations inherent in any system that uses discharge abstract codes, since the accuracy and completeness of coding can vary across hospitals, and may vary from one diagnosis to another within a hospital (Iezzoni, 1997). Furthermore, any system that relies on diagnosis coding can be subject to systematic coding bias in response to the inherent incentives in the system. Hospitals would have two strong incentives to code actual complications as present on admission: first to minimize their complication rates, and second to increase their patients’ SOI at admission. Furthermore, the fact that almost 20 percent of California hospitals had to be eliminated from these
analyses because of poor coding of the POA indicator emphasizes that attention would have to be directed to coding compliance. Compliance can be a particular problem for smaller hospitals that may lack the resources to upgrade their coding accuracy. The identification of statistically significant differences in individual PPC rates may also be problematic for smaller hospitals, and it may be necessary to examine only aggregate PPC rates for these hospitals. The applicability of screening algorithms to small hospitals will require more examination.

The PPC method will need to be validated in a variety of ways to ensure that the identification of hospital complications is accurate, and also useful in improving quality of care and patient safety. Validation can take the form of chart review studies to examine the association of various complications with quality problems, and review by expert panels and quality review organizations to examine face validity and content validity.

**Acceptability of Complications Methods**

If complications screening methods such as PPCs are to be used for performance assessment, they must first address whether ICD-9-CM (Centers for Disease Control and Prevention, 2006) discharge abstract codes can identify in-hospital complications with reasonable accuracy. Several authors have reported low sensitivity, meaning large numbers of unrecorded complications (Best et al., 2002; Geraci et al., 2002, 1997; Romano et al., 2002; Romano, Schembri, and Rainwater, 2002). False-positive rates, on the other hand, have been shown to be lower in several studies, and further reducible if complications were distinguished from comorbidities using chart review (Hannan et al., 1997; Lawthers et al., 2000; Naessens and Huschka, 2004).

Another issue is whether presence of complications correlates with problems in quality of care. Several studies have linked poorer quality of care with in-hospital complications (Geraci et al., 1999; Weingart et al., 2000) but others have identified problems with reproducibility of reviewer judgments (Caplan, Posner, and Cheney, 1991; Goldman, 1992; Hayward, McMahon, and Bernard, 1993; Iezzoni et al., 1999; Rubin et al., 1992), discordance between implicit and explicit assessments of quality, and judgments about whether complications resulted from error and/or negligence (Thomas et al., 2002; Weingart et al., 2002). Despite the uncertain state of current literature, it makes intuitive sense that complications are often related to substandard care. In hospitals where potentially preventable complication rates are significantly higher than average, the expectation of quality problems is higher, and the processes of care at those institutions should be scrutinized more closely.

Complications screening can prompt hospitals to focus in-depth reviews either on individual patient records or on processes of care that are potentially deficient. For example, a hospital with a higher than expected rate of aspiration pneumonia or decubitus ulcer among stroke patients might need to review the nursing care on its neurology service. Alternatively, complications screening could be used to create public reports for hospital comparisons, which many quality advocates have endorsed in addition to reports on process measures, mortality rates, LOS, and costs (Berwick, 2002; Steinberg, 2003). Others, perceiving a perverse incentive in paying hospitals more for patients who have complications, have suggested tying
reimbursement to complication rates as well as other performance measures (Midwest Business Group on Health, 2002; National Committee for Quality Assurance, 2004).

Although some commentators have raised concerns about the effectiveness and possible negative consequences of such proposals (Mello, Studdert, and Brennan, 2003; Werner and Asch, 2005), and others have been more cautiously optimistic (Marshall, Romano, and Davies, 2004), it is clear that momentum for public performance reporting and pay-for-performance initiatives is increasing. Federal efforts, in addition to the Patient Safety Indicators (Agency for Healthcare Research and Quality, 2005), include a CMS requirement that participating hospitals report selected performance data or face a reduction in payments. CMS has also started several pay-for-performance demonstration projects, and the Medicare Payment Advisory Commission (2005) has recommended a range of pay for performance measures and also endorsed the use of POA indicators. In the Deficit Reduction Act of 2005, Congress required that the POA indicator be reported on all Medicare claims beginning in fiscal year 2008, and further instructed CMS, beginning in fiscal year 2009, to select at least two types of post admission infectious complications that would to no longer be allowed to affect DRG assignment.

Given the level of public and governmental scrutiny, and the considerable resources and effort expended to date on these issues, it is likely that public reporting and financial incentives related to patient safety performance measures in general, and hospital complication rates in particular, will only increase. The effectiveness of these efforts will depend on the integrity of the data and the validity of the methods used in any public reports and performance-based payment systems. Our study suggests that the ability to identify diagnoses present at the time of admission is necessary not only for the proper identification of complications, but also for adequate risk stratification based on patient type and SOI. This ability is critical to the fairness and usefulness of any evaluations of hospital complication rates.

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