

Using ICD-9-CM Codes in Hospital Claims Data to Detect Adverse Events in Patient Safety Surveillance

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Abstract

Background: Adverse events (AEs) are significant and common sources of harm to inpatients. International Classification of Diseases, 9th Revision, Clinical Modification (ICD-9-CM) codes, assigned to virtually all inpatient discharges, could provide a readily available surveillance system capable of detecting a variety of AEs. **Objectives:** To determine the positive predictive value (PPV) of selected ICD-9-CM codes (flagged codes) in identifying inpatient AEs and AEs causing admission to the hospital. **Methods:** Samples were drawn from two distinct patient groups in calendar years 2001 and 2003: 7,070 inpatients from all acute care hospitals in Utah and 6,895 surgical inpatients from selected hospitals in Missouri. Structured chart review and abstraction identified all AEs and whether a flagged ICD-9-CM code represented an AE. AE codes were grouped into six categories to facilitate analysis: adverse drug events, surgical adverse events, misadventures, infections, device events, and other adverse events. **Results:** Among all inpatients, 4,416 of 11,619 flagged codes represented AEs (38 percent); 1,789 of the flagged codes were inpatient AEs (15 percent). Flagged code PPVs were higher for surgical inpatients, with 11,990 of 16,816 flagged codes representing AEs (74 percent), and 7,507 codes (46 percent) indicating inpatient AEs. There was wide variability among AE PPV categories, both for all inpatients (15 - 77 percent) and surgical inpatients (62 - 92 percent). **Conclusions:** Flagged AE codes were consistently more likely to indicate AEs in surgical inpatients than in all inpatient types. Given this, and the striking performance differences within and among AE code categories, ICD-9-CM codes are best suited to targeted AE surveillance.

Introduction

Adverse events (AEs) in the hospital setting carry with them significant patient morbidity and increased health care costs.^{1, 2, 3, 4} There is increasing interest in improved methods of AE surveillance as payers of medical care move towards systems that reward high quality and avoid paying for iatrogenic harm. The challenge that AEs, such as nosocomial infections^{5, 6} and adverse drug events,^{7, 8, 9} pose in the hospital setting has been well documented.

Currently available surveillance methods are not well suited to routine use in American health care organizations. Voluntary reporting detects only a small fraction of events.^{10, 11} Chart review can detect a large fraction of harm but is prohibitively expensive.¹⁰ Computerized alerts based on

clinical data have attracted attention but suffer from low accuracy and require sophisticated electronic health record systems available in a small minority of American hospitals.

Virtually all inpatient discharges are assigned International Classification of Diseases, 9th Revision, Clinical Modification (ICD-9-CM) codes.¹² Alerts based on ICD-9-CM codes show promise because all hospital admissions are assigned these codes. ICD-9-CM includes codes that explicitly target some types of iatrogenic harm. The most frequently assigned ICD-9-CM codes are diagnosis codes, external cause of injury codes (E-codes), and procedure codes. In the case of an adverse drug event (ADE), a diagnosis code would be used to indicate the patient's general diagnosis (e.g., 693.0, dermatitis due to drugs and medicines taken internally), while the E-code would indicate the drug class thought responsible for these symptoms (e.g., E933.1, antineoplastic and immunosuppressive drugs causing adverse effects in therapeutic use).

Previous studies have examined the use of ICD-9-CM codes as a means of detecting various inpatient complications,^{13, 14, 15, 16} but the results have been mixed. However, these studies were restricted to specific patient populations (i.e., Medicare patients,^{13, 14, 15} and VA patients with one of three specific diagnoses¹⁶), and records reviewed in these studies were between 10 and 20 years old. AHRQ Patient Safety Indicators appear promising for selected diagnoses, but many have not been fully validated, and only one targets selected ADEs.¹⁷ Nonetheless, a recent study focusing on AEs related to medical devices showed that ICD-9-CM detection compared favorably with other detection systems.¹⁸

Our goal was to develop a comprehensive system of AE codes and then examine the performance of these codes against the reference standard of chart review. We previously reported on performance of ICD-9-CM codes in ADE detection among all inpatients using the same methodology.¹⁹ This manuscript examines all AE types over a longer time period.

Methods

ICD-9-CM Adverse Event Classification

The report "Adverse Events related to Medical Care Utah: 1995-1999" featured 569 codes thought most likely to represent AEs due to medical care.²⁰ Three mutually exclusive main categories were developed: adverse drug events, misadventures, and complications of medical or surgical procedures. ADEs (395 codes) included both poisonings (medication errors) and adverse effects of medications. Misadventures consisted of 65 codes representing events most likely to be medical errors. The remaining events were grouped into complications of medical or surgical procedures (109 codes).

Although these codes were thought to be those most clearly associated with health care-associated injury, examination of the ICD-9-CM code set and existing literature revealed other codes that might be associated. Of the roughly 19,000 ICD-9-CM codes, roughly 1,200 codes were selected for examination. The question, "Realizing that every case is different, how likely is it that this code represents an adverse event?" was then posed to an expert panel of health information management professionals, nurses, pharmacists, and physicians.

Selecting codes rated by reviewers to represent those events most likely to be harmful and due to medical care, 1,003 codes were initially chosen for review.²¹ These codes were grouped into a final classification scheme of six main categories that contains 75 total classes, with each class representing between 2 and 51 ICD-9-CM codes:

1. Adverse drug events.
2. Surgical events.
3. Misadventures.
4. Device events.
5. Infections.
6. Other adverse events.²²

Study Population and Sample Design

The review was conducted in two States, Utah and Missouri. Charts of inpatients admitted in calendar years 2001 and 2003 were selected for review. In Utah, all 41 acute care hospitals participated, while in Missouri, 36 of 123 hospitals were selected to participate. All inpatients were eligible for study inclusion in the Utah population. In Missouri, surgical inpatients served as the pool from which medical charts were selected. At each hospital in both States, randomly selected charts and charts with one or more ICD-9-CM AE flags were selected for review. As inpatient AEs represented the primary focus of this study, charts with AE flags in the secondary diagnosis field and/or E-code field were chosen. As charts could feasibly have both AEs causing admission and inpatient AEs, records selected on the above criteria that also had a flagged principal diagnosis code were not excluded from the sample.

A structured chart review tool based on previous large patient safety studies^{2, 23, 24, 25} was developed and tested on trial charts prior to initiation of formal chart review. Research nurses with ICD-9-CM coding experience used this tool to review the medical charts and to record pertinent information on AEs. The review tool was designed to accommodate multiple AEs, if necessary, for each medical chart.

After fully documenting information on any AEs present in the medical record, the reviewer then turned to the ICD-9-CM codes assigned by the hospital to that inpatient stay. If flagged AE codes were present, the reviewer recorded whether these flagged codes truly indicated AEs. If, in the reviewer's judgment, the flagged code did denote an AE, the reviewer also indicated whether the AE caused patient admission to the hospital or occurred in the inpatient setting subsequent to admission. AEs causing admission were thus AEs present on admission but clearly identified by reviewers as the cause for the hospitalization.

After accounting for any flagged ICD-9-CM codes, the reviewer noted whether any of the remaining unflagged codes assigned by the hospital pointed to an AE. Finally, for AEs that had no associated codes (flagged or unflagged) assigned by the hospital, the reviewer generated and recorded the appropriate code or codes.

The same reviewers were used throughout the chart review process. They underwent extensive training before chart review began in order to achieve consistency when evaluating AEs.²⁶ This

training consisted of both didactic training and review of prescreened medical records. Reviewers were required to demonstrate competency before the chart review began. While formal intra-rater reliability was not calculated, the review coordinators monitored quality throughout the project by reviewing the abstraction forms as they came in, focusing on AE harm/causality ratings and AE descriptions.

Statistical Analysis

Descriptive analysis focuses on positive predictive values (PPVs), which are calculated by the number of confirmed AE codes divided by the total number of corresponding flagged AE codes at each of the code, class, and category levels for both inpatient AEs and AEs causing admission. The overall PPVs equal the sum of PPV for AEs causing admission and AEs occurring in the hospital. All analyses were performed using SAS[®] (SAS Institute Inc., Release 8.2, 2001).

Results

A total of 13,965 charts containing 27,815 flagged codes were reviewed. The all-inpatient sample in Utah consisted of 7,070 charts containing 11,619 flagged codes, while the surgical inpatient sample in Missouri consisted of 6,895 charts with 16,186 flagged codes.

Results were reported both for code performance among all inpatients (Utah sample) and surgical inpatients (Missouri sample). For both patient samples, the initial analysis focused on the six primary AE categories, with overall AE PPVs broken out by inpatient AE PPV and PPV of AEs causing admission. For all six AE categories overall, AE PPV was higher among surgical inpatients than all inpatients (Table 1). ADEs and misadventures had overall PPV between 15 and 23 percent higher in the sample of surgical inpatients than in all inpatients. The difference was even more pronounced in infections, surgical AEs, and other, miscellaneous AEs, with overall PPV among infections and surgical AEs roughly 40 percent higher than that in all inpatients and roughly 60 percent higher in the category of other AEs.

Examining inpatient AE PPV, device events, and misadventures showed roughly equivalent PPV in both the inpatient and surgical patient samples (19 vs. 20 percent, respectively, for device events, and 76 vs. 73 percent, respectively, for misadventures). ADEs were half again more likely in inpatients in the surgical sample (29 percent) than in the sample of all inpatient types (20 percent). The gap in performance in inpatient AE PPV was largest in the three remaining categories of infections, surgical adverse events, and other adverse events. For each of these three categories, inpatient AE PPV was approximately 35 percentage points higher, with PPVs ranging from 7 to 14 percent in all inpatients compared to 42 to 51 percent in surgical inpatients.

Adverse Drug Events

Clinical side effects of drugs. These first four classes describe potential ADEs in terms of specific symptoms rather than the drug or drug class causing the ADE. Among all inpatients, rash performed rather poorly, with an overall PPV of only 20 percent (Table 2). The other three classes showed better performance, with overall PPV between 46 and 68 percent. Of note is the predilection of these three classes for inpatient ADEs in the all-inpatient sample. Drug psychosis

Table 1. Adverse event-positive predictive value for ICD-9-CM codes

Adverse event category		N (%)	
		All patients	Surgical patients
1. ADEs	Inpatient	646/3252 (19.7)	123/417 (29.4)
	Causing admission	1454/3252 (45.1)	243/417 (58.3)
	Total %	64.9	87.8
2. Surgical AEs	Inpatient	411/2982 (13.8)	3847/7576 (50.8)
	Causing admission	343/2982 (11.5)	1161/7576 (15.3)
	Total %	25.3	66.1
3. Misadventures	Inpatient	40/53 (75.5)	313/432 (72.5)
	Causing admission	1/53 (1.9)	33/432 (19.9)
	Total %	77.4	92.4
4. Infections	Inpatient	110/1446 (7.6)	812/1850 (43.9)
	Causing admission	102/1446 (7.1)	371/1850 (20.1)
	Total %	14.7	63.9
5. Device events	Inpatient	19/102 (18.6)	240/1187 (20.2)
	Causing admission	39/102 (38.2)	490/1187 (41.3)
	Total %	56.8	61.5
6. Other AEs	Inpatient	610/4646 (13.1)	2420/5721 (42.3)
	Causing admission	740/4646 (15.9)	2619/5721 (45.8)
	Total %	29.0	88.1

Table 2. Adverse drug event ICD-9-CM class positive predictive values

Class		N (%)	
		All patients	Surgical patients ^a
1. Drug psychosis	Inpatient	73/262 (27.9)	12/37 (32.4)
	Causing admission	77/262 (29.4)	22/37 (59.5)
	Total %	57.3	91.9
2. Dermatitis	Inpatient	37/74 (50.0)	4/31 (12.9)
	Causing admission	17/74 (17.6)	25/31 (80.6)
	Total %	67.6	93.5
3. Maternal causes of perinatal morbidity & mortality, drug reactions & intoxications specific to newborn	Inpatient	17/41 (41.5)	–
	Causing admission	2/41 (4.9)	–
	Total %	46.3	–

Table 2. Adverse drug event ICD-9-CM class positive predictive values (continued)

Class		N (%)	
		All patients	Surgical patients ^a
4. Rash	Inpatient	7/83 (8.4)	9/21 (42.9)
	Causing admission	10/83 (12.0)	9/21 (42.9)
	Total %	20.5	85.7
5. Poisoning by antibiotics and other anti-infectives	Inpatient	4/18 (22.2)	–
	Causing admission	9/18 (47.4)	–
	Total %	72.2	–
6. Poisoning by hormones and synthetic substitutes	Inpatient	3/84 (3.6)	–
	Causing admission	60/84 (71.4)	–
	Total %	75.0	–
7. Poisoning by primary systematic agents	Inpatient	2/51 (3.9)	–
	Causing admission	19/51 (37.3)	–
	Total %	41.2	–
8. Poisoning by agents primarily affecting blood constituents	Inpatient	14/44 (31.8)	–
	Causing admission	17/44 (38.6)	–
	Total %	70.5	–
9. Poisoning by analgesics, antipyretics, antirheumatics	Inpatient	20/295 (6.8)	–
	Causing admission	163/295 (55.3)	–
	Total %	62.0	–
10. Poisoning by anticonvulsants and anti-Parkinsonism drugs	Inpatient	3/73 (4.1)	–
	Causing admission	58/73 (79.5)	–
	Total %	83.6	–
11. Poisoning by sedatives & hypnotics	Inpatient	7/102 (6.9)	–
	Causing admission	72/102 (70.6)	–
	Total %	77.5	–
12. Poisoning by other CNS depressants, stimulants, anesthetics	Inpatient	9/72 (12.5)	–
	Causing admission	35/72 (48.6)	–
	Total %	61.1	–
13. Poisoning by psychotropic agents	Inpatient	6/317 (1.9)	–
	Causing admission	221/317 (69.7)	–
	Total %	71.6	–
14. Poisoning by agents primarily affecting the cardiovascular system	Inpatient	4/40 (10.0)	–
	Causing admission	32/40 (80.0)	–
	Total %	90.0	–
15. Poisoning by other agents	Inpatient	13/153 (8.5)	–
	Causing admission	68/153 (44.4)	–
	Total %	52.5	–

Table 2. Adverse drug event ICD-9-CM class positive predictive values (continued)

Class		N (%)	
		All patients	Surgical patients ^a
16. Adverse effects of antibiotics and other anti-infectives	Inpatient	72/172 (41.9)	11/44 (25.0)
	Causing admission	53/172 (30.8)	32/44 (72.7)
	Total %	72.7	97.7
17. Adverse effects of hormones and synthetic substitutes	Inpatient	29/156 (18.6)	15/26 (57.7)
	Causing admission	63/156 (40.4)	6/26 (23.1)
	Total %	59.0	80.8
18. Adverse effects of primarily systematic agents	Inpatient	29/95 (30.5)	5/11 (45.5)
	Causing admission	36/95 (37.9)	4/11 (36.4)
	Total %	68.4	81.8
19. Adverse effects of agents primarily affecting blood constituents	Inpatient	16/84 (19.0)	12/46 (26.1)
	Causing admission	39/84 (46.4)	25/46 (54.3)
	Total %	65.5	80.4
20. Adverse effects of analgesics, antipyretics, antirheumatics	Inpatient	77/241 (32.0)	16/72 (22.2)
	Causing admission	89/241 (36.9)	45/72 (62.5)
	Total %	68.9	84.7
21. Adverse effects of anticonvulsants and anti-Parkinsonism drugs	Inpatient	9/76 (11.8)	1/6 (16.7)
	Causing admission	44/76 (57.9)	2/6 (33.3)
	Total %	69.7	50.0
22. Adverse effects of sedatives and hypnotics	Inpatient	20/57 (35.1)	7/13 (53.8)
	Causing admission	19/57 (33.3)	6/13 (46.2)
	Total %	68.4	100.0
23. Adverse effects of other CNS depressants, stimulants, anesthetics	Inpatient	62/133 (46.6)	2/23 (8.7)
	Causing admission	38/133 (28.6)	21/23 (91.3)
	Total %	75.2	100.0
24. Adverse effects of psychotropic agents	Inpatient	29/158 (18.4)	3/6 (50.0)
	Causing admission	76/158 (48.1)	2/6 (33.3)
	Total %	66.5	83.3
25. Adverse effects of agents primarily affecting the cardiovascular system	Inpatient	35/175 (20.0)	10/27 (37.0)
	Causing admission	83/175 (47.4)	12/27 (44.4)
	Total %	67.4	81.5
26. Adverse effects of other drugs, biological, & medicinal substances in therapeutic use	Inpatient	53/236 (22.5)	15/47 (31.9)
	Causing admission	90/236 (38.1)	29/47 (61.7)
	Total %	60.6	93.6

a Classes with five or fewer reviewed cases are not reported.

codes had an inpatient PPV of 28 percent and PPV of ADEs causing admission of 29 percent. The class “maternal causes of perinatal morbidity and mortality/drug reactions and intoxications specific to newborn,” as well as the “dermatitis” class, actually were more likely to detect inpatient ADEs (42 percent inpatient PPV vs. 5 percent causing admission PPV for the maternal/newborn class; 50 percent inpatient PPV vs. 18 percent causing admission PPV for the dermatitis class).

Poisonings. These codes for medication errors are used relatively infrequently. None of the codes in these poisoning classes sampled greater than five times in the surgical sample, so that reported results are for the all-inpatient type sample only. On the whole, the poisoning classes had a high overall positive predictive value for ADEs. Overall PPV for these classes ranged from 40 percent to 90 percent, with overall PPV in 7 of the 11 poisoning classes above 70 percent.

However, the poisoning codes were much more likely to detect ADEs causing admission than those ADEs that occurred in the hospital. Only 4 of 11 poisoning classes had an inpatient PPV of 10 percent or greater: poisoning by agents primarily affecting blood constituents (32 percent); poisoning by antibiotics and antiinfectives (22 percent); poisoning by other CNS depressants, stimulants, and anesthetics (13 percent); and poisoning by agents primarily affecting the cardiovascular system (10 percent).

Of note, the two codes evaluated most frequently in the best-performing inpatient PPV class “Poisoning by agents primarily affecting blood constituents” were 964.2 “Poisoning by anticoagulants” and E858.2 “Accidental poisoning by agents primarily affecting blood constituents.” Although E858.2 is a catch-all code, 964.2, perhaps not surprisingly, includes the anticoagulants heparin and warfarin. Both of these codes had an inpatient PPV of 35 percent, and in addition, both codes pointed even more frequently to ADEs causing hospital admission.

Adverse effects. Used more commonly than the poisoning codes, the adverse effect codes (denoting adverse drug reactions) showed relatively uniform overall predictive value in all inpatients (59 percent to 75 percent, with 9 of 11 classes between 66 percent and 75 percent) and surgical inpatients (50 percent to 100 percent, with 10 of 11 classes between 80 percent and 100 percent) (Table 2). These codes were also more likely than poisoning codes to indicate inpatient ADEs, with the inpatient PPV for all adverse effects codes equal to 27 percent among all inpatient types and 30 percent among surgical inpatients. Seven of the 11 classes were more likely to indicate inpatient ADEs than ADEs causing admission in both all inpatients and surgical inpatients.

Surgical Events

This category shares the most codes with other AE categories, as some infection, misadventure, and device event codes are also represented in the category of surgical AEs. In addition, although these codes are targeted at surgical patients, some codes reflect procedures/conditions that can occur in patients who did not have surgery. For each surgical class, both overall AE PPV and inpatient AE PPV are higher in the surgical population than in the all-inpatient sample (Table 3). For the surgical patient sample, the overall AE PPV was 66 percent and the inpatient AE PPV was 51 percent, markedly higher than the all-inpatient sample (overall AE PPV of 25 percent and inpatient AE PPV of 14 percent).

Table 3. Surgical event ICD-9-CM class positive predictive values

Class		N (%)	
		All patients ^a	Surgical patients
1. Reopening of surgical site	Inpatient	11/31 (35.5)	126/257 (49.0)
	Causing admission	1/31 (3.2)	34/257 (13.2)
	Total %	38.7	62.3
2. Control of post-procedure hemorrhage	Inpatient	–	43/67 (64.2)
	Causing admission	–	6/67 (9.0)
	Total %	–	73.1
3. Perforation or laceration	Inpatient	7/94 (7.4)	68/175 (38.9)
	Causing admission	13/94 (13.8)	43/175 (24.6)
	Total %	21.3	63.4
4. Bloodstream infections	Inpatient	19/245 (7.8)	176/442 (39.8)
	Causing admission	24/245 (9.8)	97/442 (21.9)
	Total %	17.6	61.8
5. Other infections	Inpatient	91/1201 (10.8)	636/1408 (36.8)
	Causing admission	78/1201 (8.6)	274/1408 (21.9)
	Total %	19.3	58.7
6. Acute myocardial infarction	Inpatient	5/128 (3.9)	91/214 (42.5)
	Causing admission	5/128 (3.9)	35/214 (16.4)
	Total %	7.8	58.9
7. Pulmonary embolism and infarction	Inpatient	6/89 (6.7)	2/9 (22.2)
	Causing admission	15/89 (16.9)	4/9 (44.4)
	Total %	23.6	66.7
8. Heart disease	Inpatient	5/38 (13.2)	43/91 (47.3)
	Causing admission	4/38 10.5	7/91 (7.7)
	Total %	23.7	54.9
9. Disease of respiratory system	Inpatient	122/647 (18.9)	729/1265 (57.6)
	Causing admission	81/647 (12.5)	132/1265 (10.4)
	Total %	31.4	68.1
10. Postoperative gastrointestinal disorders	Inpatient	–	15/57 (26.3)
	Causing admission	–	9/57 (15.8)
	Total %	–	42.1
11. Complications peculiar to specified procedures	Inpatient	15/96 (15.6)	222/577 (38.5)
	Causing admission	34/96 (35.4)	129/577 (22.4)
	Total %	51.0	60.8
12. Other complications of procedures	Inpatient	62/182 (34.1)	466/709 (65.7)
	Causing admission	29/182 (21.4)	73/709 (10.3)
	Total %	55.5	76.0

Table 3. Surgical event ICD-9-CM class positive predictive values (continued)

Class		N (%)	
		All patients ^a	Surgical patients
13. Accidental cut, puncture, perforation or hemorrhage during procedure	Inpatient	11/17 (64.7)	262/361 (72.6)
	Causing admission	0/17 (0.0)	28/361 (7.8)
	Total %	64.7	80.3
14. Other misadventures of surgical and medical care	Inpatient	–	51/71 (71.8)
	Causing admission	–	5/71 (7.0)
	Total %	–	78.9
15. Surgical operation/procedure as cause of abnormal reaction or later complications	Inpatient	32/139 (23.0)	641/1299 (49.3)
	Causing admission	36/139 (25.9)	191/1299 (11.5)
	Total %	48.9	60.8
16. Other procedures without mention of misadventure at time of procedure	Inpatient	20/66 (30.3)	276/574 (48.1)
	Causing admission	12/66 (18.2)	94/574 (16.4)
	Total %	48.5	64.5

a Classes with five or fewer reviewed cases are not reported.

Misadventures

The misadventure codes are used less frequently than all other AE codes discussed in this paper, with less than 1/100 inpatient discharges assigned one of these codes.²⁰ Because these codes are so rarely used, they are divided into only two classes: accidental cut, puncture, perforation, or hemorrhage during procedure; and other misadventures of medical or surgical care. These two classes have the highest overall PPV and inpatient PPV for both all-inpatients and surgical inpatients (Table 4). The inpatient PPV is remarkably consistent for both patient types for these two classes. For accidental cut, etc., the inpatient PPV was 74 percent for the all-inpatient sample and 73 percent for the surgical inpatient sample. For the other misadventures category, the surgical inpatient PPV was 73 percent (fewer than 20 codes reviewed in the all-inpatient sample).

Infections

These codes performed relatively poorly in the all-inpatient sample, with inpatient PPV for the three classes between 4 percent and 11 percent and overall PPV between 9 percent and 19 percent (Table 4). Performance was better in surgical patients, with inpatient PPV between 37 and 58 percent. In addition to the higher overall PPV in the surgical sample, for each of three classes codes were more likely to detect infections that had occurred during that hospital stay. For bloodstream infections, 40 percent of cases were inpatient AEs vs. 22 percent for cases causing admission, while for the miscellaneous class of other infections, we found 37 percent for inpatient AEs vs. 22 percent for AEs causing admission. Pneumonia showed the highest overall PPV and strongest predilection for inpatient AEs, with an overall AE PPV of 74 percent, which comprised 58 percent of inpatient AE PPV and 16 percent PPV for pneumonia cases causing admission.

Table 4. Positive predictive values for misadventure, infection, and device event ICD-9-CM classes

Class		N (%)	
		All patients	Surgical patients ^a
Misadventure codes			
1. Accidental cut, puncture, perforation or hemorrhage during procedure	Inpatient	37/50 (74.0)	262/361 (72.6)
	Causing admission	1/50 (2.0)	28/361 (19.7)
	Total %	76.0	92.2
2. Other misadventures of medical or surgical care	Inpatient	3/3 (100.0)	313/432 (72.5)
	Causing admission	0/3 (0.0)	33/432 (19.9)
	Total %	100.0	92.4
Infection codes			
1. Bloodstream	Inpatient	19/245 (7.8)	176/442 (39.8)
	Causing admission	24/245 (9.8)	97/442 (15.7)
	Total %	17.6	61.8
2. Pneumonia	Inpatient	28/617 (4.5)	322/555 (58.0)
	Causing admission	28/617 (4.5)	87/555 (21.9)
	Total %	9.1	73.7
3. Other	Inpatient	63/584 (10.8)	314/853 (36.8)
	Causing admission	50/584 (8.6)	188/853 (21.9)
	Total %	19.3	58.7
Device codes			
1. Cardiac and vascular	Inpatient	5/22 (22.7)	130/296 (43.9)
	Causing admission	7/22 (31.9)	53/296 (17.9)
	Total %	54.5	61.8
2. Orthopedic	Inpatient	3/30 (10.0)	24/111 (21.6)
	Causing admission	16/30 (53.3)	36/111 (32.4)
	Total %	63.3	53.0
3. Renal and genitourinary	Inpatient	2/6 (33.3)	41/104 (39.4)
	Causing admission	1/6 (16.7)	30/104 (28.9)
	Total %	71.4	68.3
4. Nervous system	Inpatient	1/7 (14.3)	–
	Causing admission	4/7 (57.1)	–
	Total %	50.0	–
5. Miscellaneous	Inpatient	8/37 (21.6)	295/675 (43.7)
	Causing admission	11/37 (29.7)	121/675 (17.9)
	Total %	51.3	61.6

a Classes with five or fewer reviewed cases are not reported.

Device Events

Among the five device classes, the four classes reviewed had consistent overall AE PPV of 50 to 70 percent for both all inpatient types and surgical inpatients (Table 4). The class of codes describing complications of nervous system devices was reviewed fewer than five times in the surgical inpatient sample and so is reported only for the all inpatient sample. Because AEs related to permanent implantable devices can manifest long after hospital discharge from the initial surgery in which the device was implanted—and indeed, may cause hospital readmission—and because device event codes are by nature relatively specific, it is not surprising that both inpatient AE PPV and AE PPV of device events causing hospital admission are relatively high for device AE codes.

Miscellaneous Adverse Events

This category of codes represents codes that did not seem to naturally group with the previous five categories. Like other categories, surgical inpatient AE PPV (88 percent) was far higher than that of all inpatients (29 percent). Events were split roughly evenly between inpatient AEs and AEs causing admission. As these classes showed wide variability in terms of event type, there was a correspondingly wide range of overall AE PPVs, from 9 to 75 percent among all inpatients and 61 to 100 percent among surgical inpatients (Table 5).

Decubitus ulcers—a problem in both long-term care facilities and hospitals and a frequent target of quality improvement efforts—were AEs in over 70 percent of surgical inpatients; 37 percent of these were inpatient events, and 33 percent were events causing admission. Accidental falls in the hospital represent another iatrogenic event that hospital patient safety programs have attempted to prevent via mechanisms, such as identifying patients at high risk for falls and implementing appropriate precautions. Among all inpatients, this is a poor AE indicator with an overall PPV of 9 percent. However, among surgical inpatients, the overall AE PPV was 61 percent, with inpatient AE PPV at 54 percent.

Discussion

This report enumerates the PPV of selected ICD-9-CM codes across a wide variety of targeted iatrogenic AEs. A panel of clinicians and patient safety experts selected the codes prior to any data collection. They were evaluated against chart review in nearly 14,000 patients in two States. The results show that with a few exceptions (e.g., infections), the selected ICD-9-CM codes have good PPV for iatrogenic AEs that occurred during or prior to a hospital admission. In decisions to use these codes as part of a surveillance system, several factors should be considered.

The PPV of ICD-9-CM codes varied widely among the classes of AEs and the patient populations. Because PPV is a function of specificity, it is not surprising that codes more specific for iatrogenic AEs performed better than nonspecific codes. For example, arguably the most specific iatrogenic adverse event codes—the “misadventure” codes—reflected inpatient AEs with patient harm in over 70 percent of cases in both the Utah and Missouri samples. Similarly, specific ICD-9-CM codes such as 292.12, “Drug induced hallucinosis” and 693.0, “Dermatitis

Table 5. Adverse event positive predictive value for ICD-9-CM miscellaneous codes

Class		N (%)	
		All patients ^a	Surgical patients ^a
1. Endocrine disorders	Inpatient	2/64 (3.1)	–
	Causing admission	6/64 (9.4)	–
	Total %	12.5	–
2. Metabolic and immunity disorders	Inpatient	94/1408 (6.7)	588/1054 (55.8)
	Causing admission	233/1408 (16.5)	301/1054 (28.6)
	Total %	23.2	84.3
3. Anemias, coagulation defects, & hemorrhagic conditions	Inpatient	7/103 (6.8)	101/176 (57.4)
	Causing admission	38/103 (36.9)	53/176 (30.1)
	Total %	43.7	87.5
4. Disorders of the nervous system	Inpatient	17/113 (15.0)	30/76 (39.5)
	Causing admission	21/113 (18.6)	38/76 (50.0)
	Total %	33.6	89.5
5. Diseases of veins and lymphatics, other diseases of circulatory system	Inpatient	23/127 (18.1)	120/340 (35.3)
	Causing admission	9/127 (12.5)	185/340 (54.4)
	Total %	25.2	89.7
6. Diseases of respiratory system	Inpatient	122/647 (18.9)	414/1272 (32.5)
	Causing admission	81/647 (7.1)	729/1272 (57.3)
	Total %	31.4	89.8
7. Acute GI ulcer, GI bleed, & other GI disorders	Inpatient	7/248 (2.8)	107/196 (54.6)
	Causing admission	64/248 (25.8)	70/196 (35.7)
	Total %	28.6	90.3
8. Nausea, vomiting, diarrhea	Inpatient	87/373 (23.3)	144/298 (48.3)
	Causing admission	59/373 (15.8)	135/298 (45.3)
	Total %	39.1	93.6
9. Disorders of urinary system	Inpatient	7/206 (3.4)	176/378 (46.6)
	Causing admission	45/206 (21.8)	145/378 (38.4)
	Total %	25.2	85.0
10. Complications occurring mainly in the course of labor and delivery	Inpatient	52/239 (21.8)	62/148 (41.9)
	Causing admission	1/239 (0.4)	84/148 (56.8)
	Total %	22.2	98.7
11. Complications of the puerperium	Inpatient	34/48 (70.8)	–
	Causing admission	2/48 (4.2)	–
	Total %	75.0	–
12. Decubitus ulcer	Inpatient	6/60 (10.0)	68/184 (37.0)
	Causing admission	6/60 (10.0)	62/184 (33.7)
	Total %	20.0	70.1

Table 5. Adverse event positive predictive value for ICD-9-CM miscellaneous codes (continued)

Class		N (%)	
		All patients ^a	Surgical patients ^a
13. Urticaria	Inpatient	12/37 (32.4)	–
	Causing admission	9/37 (24.3)	–
	Total %	56.7	–
14. Alterations in mental status	Inpatient	11/412 (2.7)	127/192 (66.1)
	Causing admission	80/412 (19.4)	34/192 (17.7)
	Total %	22.1	83.8
15. Epistaxis, hemorrhage from throat	Inpatient	7/26 (26.9)	8/15 (53.3)
	Causing admission	7/26 (26.9)	7/15 (46.7)
	Total %	53.8	100.0
16. Shock	Inpatient	9/63 (14.3)	75/189 (39.7)
	Causing admission	9/63 (14.3)	78/189 (41.3)
	Total %	28.6	81.0
17. Hemoptysis	Inpatient	2/29 (6.9)	16/31 (51.6)
	Causing admission	3/29 (10.3)	10/31 (32.3)
	Total %	17.2	83.9
18. Sudden death	Inpatient	–	–
	Causing admission	–	–
	Total %	–	–
19. Respiratory arrest	Inpatient	14/43 (32.6)	4/10 (40.0)
	Causing admission	2/43 (4.7)	5/10 (50.0)
	Total %	37.3	90.0
20. Certain adverse effects not elsewhere classified	Inpatient	10/68 (14.7)	2/8 (25.0)
	Causing admission	33/68 (48.5)	6/8 (75.0)
	Total %	63.2	100.0
21. Complications affecting specified body systems	Inpatient	77/251 (30.7)	290/936 (31.0)
	Causing admission	26/251 (10.4)	600/936 (64.1)
	Total %	41.1	95.1
22. Complications of medical care, not elsewhere classified	Inpatient	9/22 (40.9)	17/86 (19.8)
	Causing admission	2/22 (9.1)	64/86 (74.4)
	Total %	50.0	94.2
23. Accidental falls	Inpatient	1/58 (1.7)	66/122 (54.1)
	Causing admission	4/58 (6.9)	8/122 (6.6)
	Total %	8.6	60.7

a Classes with five or fewer reviewed cases are not reported.

due to drugs and medicines taken internally,” were reviewed over 40 times each and had high overall AE PPVs (88 and 77 percent, respectively).

On the other hand, ICD-9-CM codes selected to identify hospital-acquired infections performed poorly. Despite a few exceptions, ICD-9-CM appears to lack codes specific to iatrogenic infections. The differences in PPV between the Utah general and the Missouri surgical population are interesting. Generally, PPV was much higher in the Missouri surgical population. It is not clear whether this finding is driven by the difference in coding practices or patient care in the two States or differences in the care of surgical patients compared with other patients. Examining infections, where the discrepancy between surgical inpatients (44 percent inpatient AE PPV) and all inpatients (8 percent inpatient PPV) was high, one reasonable supposition is that clearly elective surgery patients suffering from an active infectious process would have their surgery delayed. This would eliminate many of these “false-positives” from the surgical inpatient sample and help explain the much higher specificity.

The AE codes for surgical inpatients perform better than those for all inpatients, not just for surgical events, but also for the overwhelming majority of events. Misadventure codes had the highest overall PPV among all six AE categories, both for all inpatients and for surgical inpatients. Infections codes had the lowest overall PPV among all inpatients, whereas device codes’ PPV was the lowest among surgical patients. Poisoning ADE codes indicating medication errors were more likely to detect AEs that caused admission, while adverse drug reaction codes were more likely to record inpatient adverse events. Second to the misadventure codes, the surgical codes detected slightly higher than half of confirmed AEs among inpatients whose discharge records were flagged by one of the surgical AE codes.

It should be noted that while PPV is linked to both sensitivity and specificity, given the number of AE categories and classes examined in this study, sensitivity and specificity were not addressed. In our previous work solely examining ADE flagged codes,¹⁹ specificity was high (97 percent) for both inpatient ADEs and ADEs causing admission. Sensitivity was much higher for ADEs causing admission (55 percent) than inpatient ADEs (10 percent), paralleling the PPV results reported in this paper.

One interesting finding is that the selected ICD-9-CM codes have high PPV for both inpatient and outpatient ADEs. Four distinct adverse effects of antibiotics codes (including adverse effects caused by penicillins and cephalosporins) were reviewed and had overall AE PPVs over 70 percent. For each of these codes, both the inpatient AE PPV and outpatient AE PPV were over 30 percent. At the time of the study, there was no mechanism to distinguish whether a code represented an event that the patient suffered during or prior to hospitalization in Utah or Missouri. However, the National Uniform Billing Committee (NUBC) adopted the present on-admission indicator to be used as a modifier for ICD-9-CM diagnosis codes in 2005, with hospital implementation beginning in 2007.²⁷ A recent study found that adding the present on-admission field to existing administrative data improved the value of the administrative data.²⁸ If this field is widely adopted by medical coders and all other factors remain equal, the PPV of nearly all ICD-9-CM codes will greatly increase for both the inpatient and outpatient sites of origin. A quick review of the tables shows that being able distinguish these AEs present on

admission will result in inpatient AEs roughly doubling for categories, such as adverse drug events and device events.

While making this present-on-admission designator a standard element in ICD-9-CM could be considered an incremental step forward, the next iteration—ICD-10-CM—has greater capability to describe AEs. In addition to more refined codes for AEs, specific locations, such as hospital or nursing home as place of occurrence, can be identified. The National Center for Health Statistics (NCHS), under authorization by the World Health Organization, released the International Classification of Diseases, 10th Revision, Clinical Modification (ICD-10-CM) in July 2007. The American Health Information Management Association has strongly recommended that Congress pass legislation enabling adoption and implementation of the ICD-10-CM and ICD-10-PCS classification by no later than October 1, 2011.²⁹

How can ICD-9-CM codes currently be incorporated into surveillance systems? Obviously, these codes can only be used for retrospective chart review. They will rarely be useful for identifying and treating patients who recently suffered an AE. They could, however, be very useful for facilitating retrospective reviews of AEs. The PPVs in this report provide information regarding the resources that can be saved by using these codes, as opposed to reviewing all charts. PPV can be translated into a number needed to review by dividing 100 by the PPV. Given that the prevalence of many of the individual targeted AEs is less than 1 percent,³⁰ chart reviews may be reduced by a corresponding factor. These codes may greatly facilitate evaluation of the need for, and efficacy of, a targeted quality improvement initiative designed to reduce AEs.

Another application of these codes could be to serve as the basis of new patient safety indicators. For some events, exposure information is reflected in procedure or diagnostic codes. For example, currently there are no specific codes for surgical site infections. A reasonable approach to target these nosocomial infections would be to screen for patients with both an infection code and a procedure code for selected surgical procedures. However, for other AEs, discharge ICD-9-CM codes do not provide adequate exposure information. ADEs are one notable category of event without specific exposure codes. Nonetheless, it is possible to derive exposure information for some types of therapy—such as exposure to anticoagulants—and construct useful surveillance rules.³⁰

Despite the benefits listed above, the characterization of the ICD-9-CM codes has limitations. First, this report does not provide enough information about sensitivity to allow these codes to be used for rate estimation. It may be tempting to multiply the number of positive codes per admission by the PPV and declare a proportion of admissions with the event. This would be a mistake because it is unknown how many events would be missed by the codes. For some types of events, such as ADEs, more information on the test characteristics of the codes is available.¹⁹ However, the sensitivity and specificity of most codes are too low to reliably estimate rates for an institution. Moreover, their validity and reliability for estimating changes in rates over time and among institutions are unknown. It is premature to use these codes for benchmarking.

With the exception of infections, ICD-9-CM codes have PPVs that are high enough to be useful in a variety of surveillance activities. The application of present on-admission codes may greatly increase the utility of ICD-9-CM codes in the surveillance of iatrogenic harm in both the

outpatient and inpatient settings. More characterization of these codes is needed before they can be used for rate estimation or benchmarking.

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