ORIGINAL ARTICLE

Performance of International Classification of Diseases, 9th Revision, Clinical Modification Codes as an Adverse Drug Event Surveillance System

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Background: Adverse drug events (ADEs) are one of the most frequent causes of iatrogenic injury. Because International Classification of Diseases, 9th Revision, Clinical Modification (ICD-9-CM) codes are routinely assigned to inpatient discharges, they could provide a method to detect ADEs within a hospital, a state, and the nation.

Objective: The objective of this study was to determine validity of selected ICD-9-CM codes in identifying inpatient ADEs.

Research Design: An expert panel identified 416 ICD-9-CM codes to represent ADEs (flagged ADE codes). Retrospective chart review using a structured tool was performed to ascertain code performance in detecting ADEs.

Subjects: Subjects included 3103 inpatients from all 41 acute care hospitals in Utah in 2001: 1961 inpatients sampled randomly (random sample) and 1142 inpatients sampled from the discharge records with at least one flagged ADE code (flagged sample).

Measures: Measures were ADEs identified by structured review.

Results: The flagged sample yields 1122 flagged ADE codes recorded in patient charts with 704 representing ADEs (63%). Two hundred eighty-six of the 704 verified ADE codes (41%) were determined to be inpatient ADEs. In the random sample, 32 of 58 ADEs (55%) causing hospital admission were detected by the ADE-flagged codes. Only 23 of 224 inpatient ADEs had been assigned a flagged ADE code (10%).

Conclusions: Flagged ADE codes have an overall positive predictive value of 63% and detect just over half of ADEs causing hospital admission. These codes have a positive predictive value of 25% for inpatient ADEs but detect only 10% of overall inpatient ADEs. Flagged ADE codes provide an imperfect but immediately available ADE surveillance system.

Key Words: adverse drug events, ICD-9-CM codes, patient safety, administrative data

(*Med Care* 2006;44: 000–000)

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This study was supported by grant number U18 HS11885 from the Agency for Healthcare Research and Quality.

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ISSN: 0025-7079/06/4407-0001

The burden that adverse drug events (ADEs) pose has been well documented both in terms of harm to patients and additional healthcare costs.[1–5] The availability of accessible methods that allow healthcare providers to systematically identify these events has been problematic. Voluntary reporting systems in the inpatient setting, although the most well-established and perhaps best known means of detecting adverse events (AEs), are the most poorly performing of available systems.[6]

Computerized surveillance systems, based on triggers such as administration of reversal agents and out-of-range laboratory values, have also been developed. One study found that computerized surveillance had a positive predictive value (PPV) of 10% and identified 10 times more ADEs than were detected by voluntary reports. Structured chart review identified 45% more ADEs than computerized surveillance but required 5 times more personnel time to complete.[7]

International Classification of Diseases, 9th Revision, Clinical Modification

Codes are assigned by hospitals to each inpatient chart after discharge for billing purposes.

The International Classification of Diseases, 9th Revision, Clinical Modification (ICD-9-CM) system includes diagnosis codes, procedure codes, and external cause of injury codes (E-codes). Diagnosis codes describe the nature of the patient's diagnosis, whereas E-codes describe the possible external cause of the injury, when appropriate. For example, if a drug were thought to have caused a rash, the diagnosis code would address the rash (eg, 782.1, rash and other nonspecific skin eruption), whereas the E-code would describe the drug class that was the external cause of the rash (eg, E930.0, penicillin causing adverse effect in therapeutic use). Although diagnosis codes play a critical role in determining how much a provider is paid for a service, E-codes are not directly related to reimbursement. Currently there is little financial incentive for E-code reporting. Therefore, AEs identified by E-codes probably are underreported.

Nonetheless, other studies have found ICD-9-CM codes to perform well in detecting AEs. For example, medical device ICD-9-CM codes were compared with other systems for detecting AEs related to medical devices.[8] The ICD-9-CM method detected more, as well as different kinds of, medical-device-related AEs than the 5 other detection methods exam-

ined (including computerized surveillance, online incident reporting, telemetry checklists, clinical engineering database, and a postdischarge patient survey). Review of a randomly selected sample of patient records with device codes revealed that 72% had a confirmed medical device AE.

Given the difficulties associated with successful implementation of even computerized physician order entry,[9–11] computerized surveillance for ADEs remains out of reach of many healthcare institutions. Although useful for research, the resource burden associated with full chart review makes it untenable for routine ADE detection in healthcare facilities. Administrative data, which include ICD-9-CM codes, provide a readily accessible source using a standardized nomenclature that captures virtually all inpatients.[12] Our hypothesis was that using selected ICD-9-CM codes (flagged ADE codes) would provide an adequate ADE surveillance system without the accompanying burden of full chart reviews.

Scant Literature Exists Addressing This Hypothesis

A study examining ICD-9-CM codes and complication occurrence in inpatients was conducted at 1 Veterans Administration hospital on male veterans discharged from 1987–1989.[13] Six specific ADE types (such as dilantin toxicity or antibiotic-associated diarrhea) and one miscellaneous category were examined. However, only 86 occurrences of the 15 designated ADE codes were reviewed.

AE detection systems using administrative data have since been developed, including the Agency for Healthcare Research and Quality Patient Safety Indicators.[14] However, of the 20 indicators, none specifically targets ADEs. Three indicators do include a total of 31 ADE codes.

Our objective was to develop a comprehensive list of ICD-9-CM codes that could be reasonably expected to be associated with ADEs. Performance of these codes in identifying categories of frequent ADEs would then be measured by conducting retrospective chart review on medical records of inpatients. Positive predictive value would be evaluated by review of inpatient charts containing at least one of the flagged ADE codes, whereas sensitivity and specificity of the codes would be determined by review of a random sample of inpatient charts.

METHODS

International Classification of Diseases, 9th Revision, Clinical Modification Adverse Drug Event Flag Code Classification

The original ICD-9-CM classification in "Adverse Events related to Medical Care Utah: 1995–1999" had a total of 569 codes that represented AEs resulting from medical care with 395 codes representing ADEs.[15] These codes, along with over 800 additional potential AE codes, were reviewed by a national expert panel of health information management professionals, nurses, pharmacists, and physicians. Each code was rated on the likelihood that the coded condition would be the result of medical care and would result in patient harm. Based on the expert panel's ratings, the final AE classification included 1003 potential AE codes (2% of the 19,000 ICD-9-CM diagnosis, procedure, and E-codes), of which 416 codes represent potential ADEs (flagged ADE codes).[16] This article focuses on evaluating the effectiveness of the 416 flagged ADE codes in detecting true ADEs.

To facilitate sampling and analysis, we arranged the codes into 3 main groups: clinical side effects, poisoning by drug type, and adverse effects by drug type. These 3 groups were further subdivided into a total of 25 classes (Table 1). T1
The term "poisoning" in the ICD-9-CM nomenclature reflects occurrence of a medication error (eg, wrong medication, wrong patient, overdose), whereas "adverse effect" denotes an adverse drug reaction such as rash or nausea. Additional codes represented conditions like drug psychosis or dermatitis associated with a substance that, although likely constituting ADEs, is not associated with a specified drug type. Codes within each of these classes allow for further specificity, eg, within the antibiotics class, specific drug types such as macrolides or cephalosporins can be selected. In summary, this grouping of the ADE codes permits analysis at 4 levels: 1) overall ADEs, 2) ADEs by general type (poisonings, adverse effects, and clinical side effects), 3) ADEs by class (eg, poisoning by antibiotics, adverse effects of antibiotics, drug psychoses), and 4) ADEs by any of the individual ADE codes.

Study Population and Sample Design

Flagged Sample

Of 239,818 inpatient discharges from all 41 Utah acute care hospitals in calendar year 2001, 7670 had one or more flagged ADE codes as a secondary diagnosis or E-code. Inpatient medical records can be coded with one principal diagnosis and multiple secondary diagnoses and E-codes. The principal diagnosis code is defined as "that condition established after study to be chiefly responsible for occasioning the admission of the patient to the hospital for care."[17] Because our focus was on inpatient ADEs, records were sampled on the basis of having a flagged ADE secondary diagnosis or E-code rather than a principal diagnosis code. Charts with flagged ADE principal diagnosis codes were not excluded from the sample, however, so that subsequent inpatient ADEs occurring to the same patient would not be missed. Sampling of records (n = 1142) containing a flagged secondary or E-code was performed at the class level. The purpose for this sample was to determine the PPV of the code set. The number of records sampled per class was based on the total number of records in each class and including all cases for those codes with rare events. Records were sampled without replacement after the following random sample was selected.

Random Sample

A stratified random sample of 1961 hospitalizations was selected from the statewide Utah inpatient discharges. Records were sampled based on frequency of discharges from each hospital. Hospital discharges from small rural hospitals and with a length of stay of 4 or more days were oversampled; at least 30 records were sampled from each hospital. This random sample was selected to try to determine sensitivity and specificity for the flagged ADE codes.

TABLE 1. International Classification of Diseases, 9th Revision, Clinical Modification Adverse Drug Events Flag Code Classification

Type	Class	No. Codes	Flag Codes
Clinical side effects	Drug psychoses	10	292.0–292.9
	Dermatitis	5	692.3, 692.9, 693.0, 693.8, 693.9
	Maternal causes of perinatal morbidity/mortality, drug reactions and intoxications specific to newborn	4	760.72, 760.74, 763.5, 779.4
	Rash, spontaneous ecchymoses	2	782.1, 782.7
Poisonings	By antibiotics and other antiinfectives	22	960–961, E856–857
	By hormones and synthetic substitutes	11	962, E858.0
	By primarily systemic agents	9	963, E858.1
	By agents primarily affecting blood constituents	11	964, E858.2
	By analgesics, antipyretics, antirheumatics	20	965, E850
	By anticonvulsant and anti-Parkinsonian drugs	7	966, E855.0
	By sedatives and hypnotics	18	967, E851–852
	By other central nervous system depressants, stimulants, anesthetics, nervous system agents	16	968, E855.1–855.9
	By psychotropic agents	20	969, E853–854
	By other agents	90	909.0, 970–979, E858.3 858.9, E929.2
Adverse effects	Of antibiotics and other antiinfectives	20	E930–931
	Of hormones and synthetic substitutes	10	E932
	Of primarily systemic agents	8	E933
	Of agents primarily affecting blood constituents	10	E934
	Of analgesics, antipyretics, antirheumatics	10	E935
	Of anticonvulsant and anti-Parkinsonian drugs	5	E936
	Of sedatives and hypnotics	9	E937
	Of other central nervous system depressants, stimulants, anesthetics, nervous system agents	18	E938, E940–941
	Of psychotropic agents	10	E939
	Of agents primarily affecting the cardiovascular system	10	E942
	Of other drugs, biological, medicinal substances in therapeutic use	61	E943–E949
Total		416	

Study Site

Sampled medical charts from all of the 41 acute care hospitals in Utah were reviewed. Twenty-one hospitals had less than 50 licensed inpatient beds, 12 hospitals had 50 to 200 beds, and 8 hospitals had more than 200 beds in 2001. Nineteen hospitals are categorized as urban facilities, whereas 22 hospitals are in considered rural or frontier areas.

Both randomly selected charts and charts with flagged ADE codes were reviewed from each hospital. The number of charts reviewed at each hospital ranged from 22 to 257. The Utah Department of Health Institutional Review Board approved this study.

Retrospective Chart Review

Using a structured chart review tool adapted from previous large studies,[18–20] trained nurses reviewed charts before knowing which flagged ADE codes, if any, were present. Full chart review was completed and the presence of any ADEs was documented. After each review was completed, the reviewers examined the hospital-assigned ICD-9-CM codes for each chart. The reviewer indicated whether each flagged ADE code indicated a true ADE and, if so, whether the ADE caused the admission or occurred afterward in the inpatient setting. If the discharge record had an ICD-9-CM code related to the ADE that was not among the 416 flagged ADE codes, the reviewer linked this code to the ADE. In the event a reviewer detected an ADE that had no associated code, the reviewer determined and recorded the appropriate ICD-9-CM code, which they were able to do in all of these cases.

Statistical Analysis

To focus on code performance, PPV of the ICD-9-CM flags was calculated by dividing the number of true-positive ADE flags in the flagged sample by the total number of flags. These true-positive ADE flags were then divided into ADEs causing hospital admission and those that occurred in the hospital. PPV was calculated for 1) all ADEs (including those causing admission) and 2) inpatient ADEs for the 3 main ADE types (poisonings, adverse effects, and clinical side effects) as well as the 25 classes.

To assess this surveillance method for hospitalizations, flagged ADE code sensitivity was evaluated on the basis of whether or not a reviewer-confirmed ADE was present in the discharge record and, if so, whether a hospital-assigned flagged ADE code was in the record. Flagged ADE code specificity was evaluated by determining how many records

TABLE 2. Patient Scenario Where E-Code Causing Record to be Sampled has Similar Code Causing Admission

	ADE Flag?	Code	Code Description
DX1	Yes	962.3	Poisoning by insulins and antidiabetic agents
DX2	No	250.01	Type I (insulin dependent type) diabetes mellitus
DX3	No	790.92	Abnormal coagulation profile
DX4	No	404.01	Malignant hypertensive heart and renal disease with congestive heart failure
DX5			
DX6			
DX7			
DX8			
DX9			
E-code	Yes	E858.0	Accidental poisoning by hormones and synthetic substitutes

without reviewer-confirmed ADEs actually had a flagged ADE code. All analyses were performed using SAS.[21]

RESULTS

Of the 7670 records of inpatients discharged in 2001 that had one or more secondary diagnosis or E-code flagged ADE codes, 1142 inpatient charts (containing 1790 flagged ADE codes) were reviewed. A total of 1185 of the total 1790 flagged ADE codes (66%) were determined to be linked to ADEs after review. Eight hundred ninety-seven of the 1185 codes linked to ADEs by reviewers (76%) indicated ADEs that the reviewers deemed the cause for hospital admission. The remaining 288 ADE codes (24%) represented ADEs that occurred during the hospital stay. Because multiple ICD-9-CM codes can be assigned to a single ADE, these 288 flagged codes represented 240 discrete inpatient discharges.

Although the overall PPV for a flagged code representing an ADE was 66%, the PPV for inpatient ADEs was 16% (288 of 1790 flagged codes). Because assessing the validity of ICD-9-CM codes in detecting inpatient ADEs was the primary goal of this research, only charts with a flagged ADE code in the secondary code or E-code position were sampled. Although secondary codes and E-codes can represent conditions present on admission, the goal was to exclude charts in which the principal code was a flagged ADE code (which should mean that an ADE caused admission if coding rules were followed).

However, some charts had both a flagged ADE secondary diagnosis or E-code and a similar flagged ADE principal diagnosis code (Table 2). In this scenario, the chart would not have been sampled as a result of the principal diagnosis code 962.3, poisoning by insulins and antidiabetic agents. However, the chart could have been included in the sample as a result of the E-code E858.0, accidental poisoning by hormones and synthetic substitutes. Review of the data revealed that in almost all cases, the principal flagged ADE code indeed referred to the same event as the secondary or E-code that caused the chart to be sampled. T2

Because the focus of this article is the flag codes' ability to detect ADEs that occur during hospital stays, a second analysis was performed that excluded those charts that had both a principal code and a secondary or E-code in one of the same ADE types, poisoning, adverse effect, or clinical side effect. Excluding these records eliminated 232 of the original 1142 records (20%) and 668 of the original 1790 flagged ADE codes (37%), yielding 910 records with 1122 flagged ADE codes. The reviewers determined that 704 of these 1122 flagged codes were true ADEs, yielding a PPV of 63%, similar to the 66% PPV for the entire set of flagged ADE codes reviewed (Table 3). The PPV for an inpatient ADE, however, increased from 16% to 25%, because 286 of the 1122 flagged codes represented inpatient ADEs. Of the 288 flagged codes indicating inpatient ADEs in the original set of 1142 records, only 2 records were excluded when records with a principal ADE code and similar secondary or E-code were excluded. Of the 240 inpatient ADEs detected by the flagged codes in the original flagged sample, only 2 were excluded on the basis of this selection criterion. T3

Because excluding these records improved specificity for inpatient ADEs without an accompanying loss of sensitivity, we next examined ICD-9-CM code performance of the 3 main ADE types and their 25 ADE classes among this subset of records (Table 4). Two ADE types, poisoning codes and adverse effects codes, showed higher PPVs for all ADE (68% and 67%, respectively) than did clinical side effects (45%). However, for inpatient ADEs, clinical side effects codes (30% PPV) and adverse effects codes (29% PPV) outperformed poisoning codes (15% PPV). T4

The random sample of charts from the 41 acute care hospitals aimed at evaluating sensitivity and specificity of the flagged ADE codes yielded 1961 charts. For inpatient ADEs, the sensitivity of the flagged codes was 10% (23 of 224) and the specificity was 97% (1689 of 1737) (Table 5). The sensitivity for ADEs causing hospital admission was higher (55% [32 of 58]) than for inpatient ADEs, whereas the T5

TABLE 3. Overall Positive Predictive Value of International Classification of Diseases, 9th Revision, Clinical Modification Adverse Drug Event (ADE) Flags

	No. Charts	Flagged Codes	Codes Associated With Any ADE	Any ADE Positive Predictive Value (%)	Codes Associated With Inpatient ADE	Inpatient ADE Positive Predictive Value (%)
Flagged sample	1142	1790	1185	66	288	16
Flagged subsample*	910	1122	704	63	286	25

*Sample excluding charts that had a principal code in one of the same main categories (poisoning, adverse effect, or clinical side effect) as the accompanying secondary or E-code.

TABLE 4. Positive Predictive Value of International Classification of Diseases, 9th Revision, Clinical Modification Adverse Drug Event (ADE) Flags by ADE Class in Flagged Subsample of 910 Charts

ADE Class	Flagged Codes	Codes Associated With Any ADE	Any ADE Positive Predictive Value (%)	Codes Associated With Inpatient ADE	Inpatient ADE Positive Predictive Value (%)
Drug psychoses	118	71	60	42	36
Dermatitis	38	15	39	12	32
Maternal causes of perinatal morbidity/mortality, drug reactions, and intoxications specific to newborn	25	12	48	12	48
Rash, spontaneous ecchymoses	56	9	16	4	7
Clinical side effects subtotal	237	107	45	70	30
Poisoning by antibiotics and other antiinfectives	10	7	70	4	40
Poisoning by hormones and synthetic substitutes	18	13	72	2	11
Poisoning by primarily systemic agents	18	6	33	2	11
Poisoning by agents primarily affecting blood constituents	11	9	82	6	55
Poisoning by analgesics, antipyretics, antirheumatics	73	45	62	12	16
Poisoning by anticonvulsant and anti-Parkinsonian drugs	12	10	83	0	0
Poisoning by sedatives and hypnotics	25	19	76	4	16
Poisoning by other central nervous system depressants, stimulants, anesthetics, nervous system agents	18	11	61	6	33
Poisoning by psychotropic agents	47	38	81	1	2
Poisoning by other agents	36	24	67	2	6
Poisonings subtotal	268	182	68	39	15
Adverse effects of antibiotics and other antiinfectives	56	42	75	22	39
Adverse effects of hormones and synthetic substitutes	70	37	53	15	21
Adverse effects of primarily systemic agents	52	34	65	14	27
Adverse effects of agents primarily affecting blood constituents	45	28	62	7	16
Adverse effects of analgesics, antipyretics, antirheumatics	61	42	69	29	48
Adverse effects of anticonvulsant and anti-Parkinsonian drugs	42	34	81	6	14
Adverse effects of sedatives and hypnotics	47	31	66	17	36
Adverse effects of other central nervous system depressants, stimulants, anesthetics, nervous system agents	62	48	77	29	47
Adverse effects of psychotropic agents	46	33	72	10	22
Adverse effects of agents primarily affecting the cardiovascular system	53	36	68	10	19
Adverse effects of other agents	83	50	60	18	22
Adverse effects subtotal	617	415	67	177	29
Total	1122	704	63	286	25

T6

specificity was identical (97% [1855 of 1903]) (Table 6). Of the 270 total charts in this sample with any ADE (either inpatient or causing admission), 54 had one or more flagged codes assigned for an overall sensitivity of 20%.

DISCUSSION

For the 416 flagged ADE codes examined in this study, the majority of events linked to these codes (roughly two thirds) are indeed ADEs associated with patient harm. Our data indicate that the selected 416 ICD-9-CM codes provide PPV and sensitivity for surveillance of ADEs that compare favorably to other reported methods, including computerized ADE detection systems.

After charts with similar flagged ADE codes for principal and secondary diagnoses are excluded, roughly 1 of every 7 events coded with one or more ICD-9-CM poisoning codes were in-hospital ADEs. For the ADE types, clinical side effects and adverse effects, roughly 1 of 3 events was an

TABLE 5. Sensitivity and Specificity of International Classification of Diseases, 9th Revision, Clinical Modification Adverse Drug Event (ADE) Flag Codes for Inpatient ADEs in a Random Sample of 1961 Charts

	Confirmed ADE	No ADE	Total
Flagged	23	48	71
Not flagged	201	1689	1890
Total	224	1737	1961

Sensitivity = 10% (23 of 201).
Specificity = 97% (1689 of 1737).

TABLE 6. Sensitivity and Specificity of International Classification of Diseases, 9th Revision, Clinical Modification Adverse Drug Event (ADE) Flag Codes for ADEs Causing Admission in a Random Sample of 1961 Charts

	Confirmed ADE	No ADE	Total
Flagged	32	48	80
Not flagged	26	1855	1881
Total	58	1903	1961

Sensitivity = 55% (32 of 58).
Specificity = 97% (1855 of 1903).

inpatient ADE. Within each of these groups, there is wide variation in PPV performance of various classes. Three of the 4 clinical side effects classes have PPVs ranging from 32% to 48%, whereas the fourth class (rash and spontaneous ecchymoses) has a PPV of only 7%. For poisonings, 7 of the 10 drug classes have PPVs between 0% and 16%; the remaining 3 class PPVs are 33%, 40%, and 55%. Adverse effects classes also can be grouped into 2 sets in terms of performance—7 classes have PPVs from 14% to 27% and 4 classes have PPVs from 36% to 48%. The variation among ADE classes may not be reliable because the sample size for 8 of 25 classes was smaller than 30 cases. Also, some ICD-9-CM classes of ADE codes (such as "poisoning by anticonvulsant and anti-Parkinsonian drugs") are used relatively infrequently for inpatients. Therefore, this article has focused on the type-level analysis.

Although specificity of the flagged ADE codes was high (over 95%), sensitivity of the flagged ADE codes was low, detecting only 20% of all ADEs. Like computerized surveillance systems, our research found that these selected codes detected a minority of inpatient ADEs. Flagged ADE codes were more sensitive to ADEs causing admission than those that occurred in the hospital. Whereas the majority of ADE research has focused on the inpatient setting, ADEs are certainly not localized solely to the inpatient domain. Rather, an ADE can occur in any setting where medical care is administered: nursing homes, ambulatory surgical centers, and even the patient's home. In addition, these outpatient ADEs can be events caused by a previous inpatient admission (for example, an outpatient ADE resulting from a medication prescribed to the patient on previous discharge from the hospital).

It is interesting to note the variability in PPV for the poisoning category of ADEs compared with the other 2 categories of clinical side effects and adverse effects. Although the term "poisoning" applies to a broad array of medication errors within the ICD-9 nomenclature, its common definition may influence hospital coders against its selection for wrong medication, wrong patient, or even unintentional overdose inpatient ADEs. This bias would be reinforced by concerns of hospital liability related to documenting a "poisoning" event. This bias could explain the much higher PPV for outpatient poisonings because the common definition is more consistent with intentional and unintentional outpatient overdoses that are relatively common causes of inpatient admission and also do not usually carry the same liability for the hospital. This bias against self-reporting would also help explain the higher sensitivity for outpatient ADEs (55%) than inpatient ADEs (10%).

Documentation of the physical symptoms required for coding of clinical side effects would likely be better for inpatients than outpatients, whereas the documentation of specific drug classes related to an ADE required for the adverse effects codes would probably be equally well documented for both.

One study, examining medication errors in acute care hospitals accredited by the Joint Commission on Accreditation of Healthcare Organizations, as well as nonaccredited hospitals and skilled nursing facilities, found that medication errors are "common" and actually occur at the same frequency—nearly 1 of every 5 doses—in all 3 facility types.[22] The number of ADEs, of which medication errors comprise only a portion, would be even higher. In addition, a study involving both patient survey and chart review found that 25% of outpatients had ADEs.[23] Our data reveal that a large number of the most serious of these outpatient ADEs—those causing hospital admission—can be identified by ICD-9-CM codes. Specifically, ICD-9-CM ADE poisoning flags show a predilection for medication errors causing admission to the hospital. Sixty-six percent of all poisoning codes examined by reviewers were determined to be ADEs causing admission. Even after excluding charts in which the code causing admission was similar to a code elsewhere in the record, the majority of poisoning codes (53%) were ADEs causing admission to the hospital. In this case, hospital discharge data provides an accessible and intriguing surveillance tool for healthcare events that occur outside the hospital setting.

That being said, the most glaring correctable limitation in using ICD-9-CM for inpatient AE detection is the inability of the codes themselves to differentiate events that happen before hospital admission from those that occur in the hospital. Our correspondence to the Institute of Medicine Committee on Data Standards for Patient Safety regarding the forthcoming ICD-10-CM addressed this limitation.[24] California and New York already collect "onset of diagnosis" or "present on admission" information as a sixth digit appended to each ICD-9-CM code. With broad support from public health agencies, the National Uniform Billing Committee will formally accept the recommendation of including the present on admission indicator as an independent field in the Uniform Bill 04 (UB04) Form in February 2006. The implementation guideline of the UB04 data standards will be effective in 2007.

New place of occurrence codes in the forthcoming ICD-10-CM will allow for more precise identification of place of injury. The current ICD-9-CM code for place of occurrence used to designate the location of injury is E849.7 for "residential institution." This code includes 7 locations, including hospital, nursing home, orphanage, and prison. The ICD-10-CM system will have a specific code for hospital, Y92.23x (with the x modifier indicating specific locations within the hospital). Although an important step, it would be impossible to know which of the other codes with which Y92.23x should be linked. It would be regrettable if the more precise place of occurrence codes in ICD-10-CM could not be linked to their intended codes. Currently, there are proposed bills before Congress that would mandate implementation of the ICD-10-CM in the United States in 2009.

An obvious question arises—how would these selected ICD-9-CM codes perform in ADE detection compared with an ADE computer-based surveillance system currently in use? At a healthcare facility that pioneered and routinely uses computerized ADE surveillance, investigators compared detection of potential ADEs using computerized ADE surveillance and the 416 ADE codes assessed in this article. Chart review was conducted on the cases in which a flagged ADE code was assigned to a chart in which no computerized surveillance trigger was generated and cases with a flagged ADE code for which computerized surveillance generated an ADE trigger that later could not be verified. The flagged ADE codes detected more verified ADEs (n = 431) than computerized surveillance (n = 258) with higher PPV (27% for the flagged ADE codes vs 10% for the computerized surveillance system).[25]

ADE detection has 3 major applications each with different requirements for precision. Community public health surveillance requires sufficient sensitivity to identify general trends and target interventions but can often be productive with relatively low detection levels as evidenced by effective public health responses to many infectious diseases. This application could use the combined inpatient and outpatient detection capacity of the ICD-9-CM data to identify and target ADEs that occurred across multiple healthcare settings. Given the absence of currently affordable alternatives, this method of community surveillance is clearly worth testing.

Hospital quality improvement requires more precision but might use the ICD-9-CM data to identify general trends within their facility and then design more robust detection systems such as flagged ADE codes combined with clinical trigger systems and focused chart reviews to evaluate the success of interventions. For many hospitals, use of flagged ADE codes could begin immediately, whereas more robust methods are in development. Finally, flagged ADE codes might be useful in ADE research for research case selection and subsequent in-depth chart review.

Our data indicate that selected ICD-9-CM codes provide an acceptable predictive value in detecting ADEs and that these codes compare favorably with existing computerized ADE detection systems. However, like the computerized systems, our research found that these selected codes detected a minority of inpatient ADEs. Future improvements to this code set will involve removing codes with poor predictive value while adding codes not in the original set determined by reviewers to detect ADEs.

There is clearly much ground to be covered in making things safer for patients. One key question that often seems overlooked when actually talking about practical ADE detection at the facility level is, where to start? Effective patient safety surveillance systems of the future will rely on a variety of information sources.[26] ICD-9-CM data are readily available and use a universally accepted nomenclature that is applied to virtually all inpatient discharges. Any institution, whether large or small, urban or rural, can make use of this system. Leveraging this already existing system provides an attractive starting point for institutions developing new ADE detection systems and improving existing systems.

ACKNOWLEDGMENTS

The authors thank Robert Rolfs, MD, for his contributions in developing the initial ICD-9-CM adverse event classification and for chairing the Expert Panel for Classification of Adverse Event ICD-9-CM Codes. The work of the Expert Panel was invaluable, with particular thanks going to those members who evaluated the potential ADE codes: Dave Bestenlehner, PharmD, Jeffrey Geppert, JD, Steven Meisel, PharmD, Jonathan Nebeker, MD, and Rosalyn Steck, RHIA CCS. Finally, the authors thank the Utah/Missouri Patient Safety Consortium for their support.

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AUTHOR QUERIES

AUTHOR PLEASE ANSWER ALL QUERIES **1**