Drug Errors and Related Interventions Reported by United States Clinical Pharmacists: The American College of Clinical Pharmacy Practice-Based Research Network Medication Error Detection, Amelioration and Prevention Study

Grace M. Kuo, Daniel R. Touchette, Jacqueline S. Marinac, for the American College of Clinical Pharmacy Practice-Based Research Network Collaborative

Objective. To describe and evaluate drug errors and related clinical pharmacist interventions.

Design. Cross-sectional observational study with an online data collection form.

Setting. American College of Clinical Pharmacy practice-based research network (ACCP PBRN).

Participants. A total of 62 clinical pharmacists from the ACCP PBRN who provided direct patient care in the inpatient and outpatient practice settings.

Intervention. Clinical pharmacist participants identified drug errors in their usual practices and submitted online error reports over a period of 14 consecutive days during 2010.

Measurements and Main Results. The 62 clinical pharmacists submitted 924 reports; of these, 779 reports from 53 clinical pharmacists had complete data. Drug errors occurred in both the inpatient (61%) and outpatient (39%) settings. Therapeutic categories most frequently associated with drug errors were systemic antiinfective (25%), hematologic (21%), and cardiovascular (19%) drugs. Approximately 95% of drug errors did not result in patient harm; however, 33 drug errors resulted in treatment or medical intervention, 6 resulted in hospitalization, 2 required treatment to sustain life, and 1 resulted in death. The types of drug errors were categorized as prescribing (53%), administering (13%), monitoring (13%), dispensing (10%), documenting (7%), and miscellaneous (4%). Clinical pharmacist interventions included communication (54%), drug changes (35%), and monitoring (9%). Approximately 89% of clinical pharmacist recommendations were accepted by the prescribers: 5% with drug therapy modifications, 28% due to clinical pharmacist prescriptive authority, and 56% without drug therapy modifications.

Conclusion. This study provides insight into the role clinical pharmacists play with regard to drug error interventions using a national practice-based research network. Most drug errors reported by clinical pharmacists in the United States did not result in patient harm; however, severe harm and death due to drug errors were reported. Drug error types,

therapeutic categories, and clinical pharmacist interventions varied between the inpatient and outpatient settings. Nearly half of reported errors were prevented by clinical pharmacists before the drugs reached the patients. The majority of clinical pharmacist recommendations were accepted by prescribers.

Key Words: medication error, error reporting, clinical pharmacy, medication safety, practice-based research, drug safety epidemiology, patient safety.
(**Pharmacotherapy 2013;33(3):253–265**)

The Institute of Medicine (IOM) has identified the mitigation of drug errors as a top national priority.[1] A drug error, as defined by the IOM report and the National Coordinating Council for Medication Error Reporting and Prevention, is any error occurring in the drug-use process or any preventable event that may cause or lead to inappropriate drug use or patient harm while the drug is in the control of the health care professional, patient, or consumer.[1, 2] Error reports may be related to professional practice, drug products, procedures, and systems. Drug errors originate at any stage of the drug-use process and include prescribing (wrong drug prescribed), dispensing (wrong drug dispensed), administering (wrong dosage administered), monitoring (lack of drug related laboratory monitoring), and documenting (drug discrepancy in medical records).

Two IOM reports published in 1999 and 2006 include recommendations for health systems to implement error reporting programs and collaborative practices between clinical pharmacists and physicians.[1, 3] In the inpatient setting, clinicians have used various drug event reporting programs to better understand and prevent drug errors.[1, 2, 4–7] In the outpatient setting, a few studies have reported errors from primary care physician offices.[8–10]

A number of studies have evaluated drug errors identified by pharmacists in a variety of settings. For example, recent publications have evaluated the impact of drug errors identified or intercepted by emergency department pharmacists[11–13] and inpatient medical and surgical wards;[14, 15] however, the findings of these studies were limited by focusing on specific types of drug errors such as prescribing errors only[15] or restriction to a specific setting such as the emergency department,[11–13] or they were conducted in a country outside of the United States, where health care practices may be considerably different.[14, 15]

The objectives of this study—the Medication Error Detection, Amelioration and Prevention (MEDAP) Study—were to assess the feasibility of conducting a project within a newly established national clinical pharmacist practice-based research network (PBRN) and to describe and evaluate drug errors and related clinical pharmacist interventions. This report focuses on the reported drug errors and clinical pharmacist interventions.

Methods

Eligibility of Study Participants

All American College of Clinical Pharmacy (ACCP) associate and full members were invited to join the PBRN and were eligible to participate in the MEDAP study provided they met the following criteria: were an ACCP PBRN member, were a clinical pharmacist providing direct patient care over a period of 14 consecutive days, and willing to voluntarily report interventions given to detect, ameliorate, and prevent drug errors. For the purposes of this study, we used the definition for drug error from the IOM report and the National Coordinating Council for Medication Error Reporting

From the Skaggs School of Pharmacy and Pharmaceutical Sciences, University of California, San Diego, California (G.M. Kuo), and the Family & Preventive Medicine, School of Medicine, University of California, San Diego, California (G.M. Kuo), the Department of Pharmacy Practice, University of Illinois at Chicago College of Pharmacy, Chicago, Illinois (D.R. Touchette), and the American College of Clinical Pharmacy, Lenexa, Kansas (J.S. Marinac).

This project was funded by the Frontiers Fund of the American College of Clinical Pharmacy (ACCP) Research Institute.

Preliminary results of this study were presented as a poster at the ACCP annual meeting, Pittsburgh, Pennsylvania, October 18, 2011.

For questions or comments, contact Grace M. Kuo, Skaggs School of Pharmacy and Pharmaceutical Sciences, University of California, 9500 Gilman Drive, MC 0719, La Jolla, CA 92093-0719; e-mail: gmkuo@ucsd.edu.

and Prevention.[1, 2] In addition, any omission of therapy for a drug considered standard of care in a patient without a contraindication would be considered an error. Direct patient care included patient rounding, "curbside" consultation, patient medical record review, formal consultation for clinical pharmacy services, and all related services. Acknowledging that clinical pharmacists may also be involved with dispensing drugs and other nonclinical administrative activities, time spent on dispensing and administrative duties was not counted as time spent on clinical activities because our membership registry[16] indicated that less than 10% of ACCP PBRN clinical pharmacist members reported having any dispensing duties; pharmacists were instructed to enter zero for both number of patients and hours of direct patient care while performing these duties. Several pharmacists from the same practice site could participate in the study. Participating clinical pharmacists were required to complete study-specific online training through the ACCP PBRN online portal called PBRNConnect. The online training program reviewed the study framework, data collection instruments, procedures, and error report coding methods. Institutional review board approval was obtained from the American Academy of Family Physicians first, then local institutions as needed. Study participation was voluntary and uncompensated.

The MEDAP Error Reporting Form

The data fields of the electronic MEDAP error reporting form were adapted from the United States Food and Drug Administration MedWatch minimum dataset, the previous U.S. Pharmacopeia MedMarx database, the event reporting form developed by the Robert Graham Center and the American Academy of Family Physicians National Research Network, and the Medication Error and Adverse Drug Event Reporting System (MEADERS) study.[2, 8, 10, 17] Initial testing of the data collection form was performed by ACCP PBRN Community Advisory Panel members using sample cases. Based on feedback from the test group of 12 clinical pharmacists, the data collection form was modified and reevaluated. The form was finalized with input from investigators and ACCP Research Institute Board of Trustee members.

The MEDAP event reporting form (available on request) was composed of two parts: clinical pharmacist workplace information questions and drug error and clinical pharmacist intervention questions. The clinical pharmacist practice information included dates of study participation, times engaged in direct patient care activities, number of patients cared for, overall time worked, work setting, regional work location, and number of patients with drug errors. If no drug error–related interventions occurred during the study, that participant's entire data collection consisted only of the information related to the total hours engaged in patient care activities, hours worked, and the number of patients cared for. Participants answered additional questions for each drug error–related intervention including facility type and location where the drug error occurred, drug error type and reason (based on previously reported drug error categories identified by the MedMarx database, the event reporting form developed by the Robert Graham Center and the American Academy of Family Physicians National Research Network, and the MEADERS study), how the drug error was identified, level of drug error–related patient harm, and drug name and therapeutic category. The categories for drug error types and reasons were selected based on frequently reported error types and reasons from previous studies. The clinical pharmacist intervention questions included clinical pharmacist intervention or recommendation, estimated time to complete the initial intervention, health care provider's acceptance of the recommendation, estimated follow-up time, and primary outcome of the intervention (if known). Data presented in this report are from a subset of the questions; findings from other questions pertaining to project feasibility and cost estimates will be included in two other manuscripts under preparation.

The primary focus of this study was to assess project feasibility and to identify the step within the drug-use process, during the natural course of the pharmacist practice, where the error occurred, and to determine the type of intervention made by clinical pharmacist, without affixing blame or potential causative factors to any drug error. The investigators deliberately selected this study focus to better understand the role of clinical pharmacists in preventing, identifying, and resolving drug errors. The involvement of clinical pharmacists to reduce the risk and harm of drug errors is complementary to many recent automated or mechanical improvements related to dispensing and administering drugs, such as bar coding and automated dispensing systems, which have positively impacted drug errors within those phases of the drug process.

Data Collection

Eligible study pharmacists could participate in the study from August 5–December 31, 2010. Participants could choose any 14 consecutive days within this study recruitment period. The Cerner Discovere tool (Cerner Corp., Kansas City, MO) was used to support secure, online data entry by participating study pharmacists. Only deidentified data were used; no identifiable patient, clinical pharmacist, or pharmacist practice site information were collected in the study.

Statistical Analysis

Aggregate data were tabulated and summarized using common descriptive statistical methods, including frequency statistics such as count, range, mean and standard deviation. Drug errors were stratified by outcome into one of eight categories (designated as A–H) using the classification system developed by the National Coordinating Council for Medication Error Reporting and Prevention.[18, 19] Descriptive analyses of all drug error types and related interventions were tabulated. Clinical pharmacist intervention data were compared between different practice locations (e.g., inpatient vs outpatient) using the Chi-square test (or Fisher exact test, if appropriate) for dichotomous variables. Stata software, version 10.0 (StataCorp LP, College Station, TX) was used for all statistical analyses.

Results

Study Participants

There were 676 ACCP PBRN members at the time of the study recruitment period; 308 members engaged in any step(s) in completing the PBRNConnect portal. Of those, 87 clinical pharmacist members were eligible to participate in the MEDAP study and received passwords to start the online data collection process. A total of 53 clinical pharmacist participants (response rate of 82%) submitted complete information regarding 924 patient-level drug errors. Participants were from the Midwest (50%), Northeast (23%), West (16%), or South (9%); 2% did not indicate a geographic region.

Drug Error Reports

Of the 924 reports, 779 contained complete information (145 reports had missing information on drug names, practice locations, and related information). Drug errors occurred in both the inpatient (61%) and outpatient (39%) settings; the outpatient setting consisted of outpatient facilities (29%), home (7%), and other (3%) settings such as emergency departments. Participants discovered drug errors from review of patient medical records (70%) and from other health care professionals (11%), patients (8%), laboratory reports (4%), pharmacy computerized electronic alert systems (3%), caregivers or family members (1%), and other unspecified sources (3%). The total number of hours worked by clinical pharmacist participants in patient care duties was 2030 hours (range = 0–87 hrs/pharmacist; mean ± SD = 29.42 ± 24.66 hrs/pharmacist; median = 24 hrs/pharmacist). The total number of patients seen was 5028 patients (range = 0–553 patients/pharmacist; mean ± SD = 72.87 ± 110.64 patients/pharmacist; median = 42 patients/pharmacist). The rates of detecting and/or intervening on drug errors were 0.384 drug error/hour worked and 0.155 drug error/patient seen.

The five therapeutic drug categories most frequently associated with drug errors were systemic antiinfectives (25%), hematologics (21%), cardiovascular agents (19%), central nervous system agents (12%), and endocrine and metabolic agents (10%). The five most frequently reported classes of drugs associated with drug errors were antibiotics (172 reports), oral anticoagulants (75), injectable anticoagulants (67), beta-blockers (37), and insulin (29). Systematic antiinfective drug errors were reported more frequently in the inpatient than the outpatient setting (37% vs 5%, $p<0.001$). In contrast, drug errors associated with cardiovascular agents (10% vs 35%, $p<0.001$) and endocrine and metabolic agents (4% vs 19%, $p<0.001$) occurred more frequently in the outpatient setting. A breakdown of drug errors by therapeutic category is presented in Table 1. The most frequently reported drugs for inpatient and outpatient locations are listed in Table 2. For inpatients, vancomycin was most frequently cited, whereas warfarin was for outpatients.

Table 3 presents the breakdown of drug error types and reasons. Participants were allowed to select more than one type or reason for each error. Reported drug errors were due to prescribing (53%), administering (13%), monitoring (13%), dispensing (10%), documenting (7%), and other miscellaneous types (4%). Common reasons underlying these drug error types included prescription of incorrect drugs or doses,

Table 1. Therapeutic Category Associated With the 779 Drug Error Reports

Category	Inpatient Reports (n=478) (%)	Outpatient Reports (n=301) (%)	p Value	Indication	No. of Reports
Systemic antiinfective agents (193 [25%])	178 (37)	15 (5)	< 0.001	Antibiotic	172
				Antiretroviral agent	10
				Antiviral agent	10
				Other	1
Hematologic agents (164 [21%])	113 (24)	51 (17)	0.026	Oral anticoagulant	75
				Injectable anticoagulant	67
				Antiplatelet agent	17
				Other	5
Cardiovascular agents (151 [19%])	46 (10)	105 (35)	< 0.001	Beta-blocker	37
				Renin-angiotensin system antagonist	25
				Diuretic	20
				Vasodilator	8
				Alpha-blocker	3
				Sympatholytic	1
				Combination antihypertensive	1
				Other	56
Central nervous system agents (94 [12%])	63 (13)	31 (10)	0.229	Opioid analgesic	25
				Antidepressant	18
				Sedative-hypnotic, barbiturate	15
				Anticonvulsant	12
				Antipsychotic agent	7
				Nonsteroidal antiinflammatory agent	6
				Opioid agonist-antagonist analgesic	1
				Other	10
Endocrine and metabolic agents (76 [10%])	19 (4)	57 (19)	< 0.001	Insulin	29
				Oral antidiabetic agent	20
				Noninsulin injectable antidiabetic agent	0
				Other	27
Gastrointestinal agents (2%)	15 (3)	3 (1)	0.083		18
Respiratory agents (2%)	7 (1.5)	7 (2)	0.414		14
Biologic and immunologic agents (1%)	9 (1.9)	2 (0.7)	0.218		11
Nutrients and nutritional products (1%)	1 (0.2)	5 (1.7)	0.034		6
Renal and genitourinary agents (1%)	4 (0.8)	2 (0.7)	> 0.999		6
Ophthalmic and optic agents (0%)	1 (0.2)	0 (0)	> 0.999		1
Dermatologic agents (0%)	0 (0)	0 (0)	Not applicable		0
Other (2%)	22 (5)	23 (8)	0.291		48
Total					779

failure to order the needed drug, patient failure to take the drug correctly, lack of laboratory drug monitoring, and documentation discrepancies. Significant differences between the inpatient and outpatient settings were found for prescribing (63% vs 39%, $p<0.001$), administering (4% vs 27%, $p<0.001$), dispensing (13% vs 5%, $p<0.001$), and documenting (3% vs 14%, $p<0.001$) drug errors. Drug error types according to drug category are summarized in Table 4.

Overall, 737 (95%) of 779 drug errors resulted in no patient harm. In total, 42% were prevented and did not reach the patient. A breakdown of the harm levels and the harm level frequency by the top five drugs in the inpatient and outpatient settings are summarized in Table 5. The frequency of harm levels by drug error types is presented in Figure 1.

The pharmacist participants made 1973 recommendations or interventions in response to

Table 2. Drugs Most Frequently Cited in the 779 Drug Error Reports

Drug	Inpatient Reports (n=478) (%)	Outpatient Reports (n=301) (%)	p Value
Warfarin (73 [9.4%])	39 (8.2)	34 (11.3)	0.144
Vancomycin (71 [9.1%])	68 (14.2)	3 (1.0)	< 0.001
Insulin (26 [3.3%])	7 (1.5)	19 (6.3)	< 0.001
Dalteparin (22 [2.8%])	21 (4.4)	1 (0.3)	< 0.001
Enoxaparin (21 [2.7%])	20 (4.2)	1 (0.3)	< 0.001
Metoprolol (20 [2.3%])	7 (1.5)	13 (4.3)	0.014
Piperacillin-tazobactam (18 [2.3%])	16 (3.4)	2 (0.7)	0.015
Lisinopril (17 [2.2%])	2 (0.4)	15 (5.0)	< 0.001
Ciprofloxacin (13 [1.7%)	12 (2.5)	1 (0.3)	0.021
Heparin (13 [1.7%])	13 (2.7)	0 (0)	0.004
Simvastatin (13 [1.7%])	5 (1.1)	8 (2.7)	0.148
Carvedilol (11 [1.4%])	7 (1.5)	4 (1.3)	0.876
Furosemide (10 [1.3%])	2 (0.4)	8 (2.7)	0.017
Metformin (10 [1.3%])	0 (0)	10 (3.3)	< 0.001
Famotidine (9 [1.2%])	9 (1.9)	0 (0)	0.017
Levofloxacin (9 [1.2%])	9 (1.9)	0 (0)	0.017
Trimethoprim (9 [1.2%])	8 (1.7)	1 (0.3)	0.165
Amiodarone (8 [1.0%])	5 (1.1)	3 (1.0)	0.947
Aspirin (8 [1.0%])	0 (0)	8 (2.7)	< 0.001
Clopidogrel (8 [1.0%])	2 (0.4)	6 (2.0)	0.061

drug errors (mean ± SD 1.8 ± 0.69, range 0–4, median 2 recommendations or interventions/drug error report). These recommendations or interventions commonly fell into the following categories as summarized in Table 6: communication (54%), drug regimen change (35%), and monitoring (9%). Communication-based recommendations or interventions were more common in the outpatient setting than in the inpatient setting (59% vs 49%, p<0.001) whereas drug regimen changes were more common in the inpatient setting than in the outpatient setting (39% vs 30%, p<0.001).

Drugs involving direct verbal contact of the clinical pharmacist with providers included vancomycin (32 reports), warfarin (29 reports), daltaparin (18 reports), enoxaparin (18 reports), and unfractionated heparin (13 reports) in the inpatient setting and warfarin (5 reports), insulin (4 reports), and simvastatin (4 reports) in the outpatient setting. Drugs involving dosage adjustment by clinical pharmacists included vancomycin (31 reports), warfarin (12 reports), enoxaparin (9 reports) in the inpatient setting and warfarin (18 reports), insulin (11 reports), and furosemide (6 reports) in the outpatient setting.

Drugs involving clinical pharmacist intervention for harm levels of E and higher (i.e., drug reached the patient and error resulted in hospitalization, permanent patient harm, necessary intervention to sustain life, or error contributed to death) included cephalexin, doxazosin, unfractionated heparin, piperacillin-tazobactam, and vancomycin in the inpatient setting, and amlodipine and prasugrel in the outpatient setting. Approximately 89% of clinical pharmacist recommendations were accepted by prescribers (90% inpatient setting vs 86% outpatient setting, p=0.078), with 5% with drug therapy modifications (6% inpatient vs 3% outpatient), 28% as a result of clinical pharmacist prescriptive authority (21% inpatient vs 38% outpatient), and 56% without drug therapy modifications (63% inpatient vs 45% outpatient).

Discussion

This study reports on drug errors detected and addressed by clinical pharmacists in numerous health systems. Seventy-one clinical pharmacist participants from inpatient and outpatient settings throughout the United States submitted 779 complete drug error reports over a period of 14 consecutive days. The study methodology using online reporting for drug errors was similar to voluntary reporting of errors conducted in previous studies using MEDMARX and MEADERS.[2, 8]

The categories of drugs most often associated with drug error reports were similar to those reported from previous studies and included systemic antiinfectives,[7, 10, 20] hematologics,[20, 21] cardiovascular agents,[7, 10, 21] central nervous system agents,[7, 10, 21] and endocrine and metabolic agents,[10, 21] suggesting that future strategies for reducing drug errors could target these agents. Furthermore, specific drugs reported

Table 3. Drug Error Types and Reasons

Type	Inpatient Reports (n=605) (%)[a]	Outpatient Reports (n=402) (%)[a]	p Value	Reason	No. of Reports
Ordering and prescribing (538 [53%])	381 (63)	157 (39)	< 0.001	Wrong drug prescribed	217
				Failure to order needed drug	101
				Other (not specified)	91
				Dose prescribed wrong	84
				Contraindicated drug prescribed	42
				ePrescribing tool generated errors	3
				Wrong patient name on prescription	0
				Prescription phoned, faxed, or transmitted to wrong pharmacy	0
Receiving or administering (133 [13%])	25 (4)	108 (27)	< 0.001	Patient failed to take drug correctly	71
				Other	36
				Patient continued drug after stop order	12
				Transition of care from inpatient to outpatient site resulted in error in drug reconciliation	8
				Different care providers mixed up drug	6
				Sample or over-the-counter drug supplied incorrectly	0
Monitoring or follow-up (130 [13%])	85 (14)	45 (11)	0.186	Inadequate monitoring	52
				Other	49
				Laboratory test omitted	29
Implementing or dispensing (98 [10%])	77 (13)	21 (5)	< 0.001	Other	31
				Failure to stop order	24
				Incorrect dose dispensed	15
				Failure to continue long-term drug	10
				Manual data entry error	5
				Drug label incorrect	4
				Scanned prescription misinterpreted	4
				Drug not dispensed	3
				Incorrect drug dispensed	1
				Handwritten prescription misinterpreted	1
				Pharmacy dispensing software failure	0
				Drug dispensed after stop order	0
Documentation (72 [7%])	15 (3)	57 (14)	< 0.001	Drug record not up to date	50
				Home drug list not up to date	13
				Other	9
Other (36 [4%])	22 (3)	14 (4)	0.898		36
Total					1007

[a]The total number of drug error types (1007) is greater than the total number of drug error reports (779) because participants were allowed to select more than one type or reason for each error

in our study are similar to drugs (e.g., warfarin, insulins, oral antiplatelet agents, and oral hypoglycemic agents) identified in one study that assessed emergency hospitalizations for adverse drug events in older adults.[22]

Studies assessing drug errors reported by physicians,[8, 10, 23, 24] nurses,[9, 25] clinical pharmacists,[6, 26] clinic staff,[8, 10] and hospital staff[2, 7] were previously conducted; however, those studies were conducted only in inpatient or outpatient settings. Our study included clinical pharmacists from both inpatient and outpatient settings. We found that prescribing and dispensing errors were more frequently reported from the inpatient setting, whereas administering and documentation errors were more frequently reported from the outpatient setting. Monitoring or follow-up errors were similar in both settings.

The most frequently reported drug errors found in our study originated from drug prescribing. This finding is consistent with findings from other studies conducted in the intensive[27] and ambulatory[10, 28] care settings. The most commonly reported prescribing drug error was prescribing a wrong drug (Table 3). Other studies found that dosage error was more frequently reported than wrong drug selection.[7, 10, 19, 29–31] The most frequently reported drugs associated with prescribing errors included systemic antiinfective agents in the inpatient setting and cardiovascular agents in the outpatient setting (Table 4). During dispensing, the most commonly

Table 4. Frequency of Drug Error Types in Each Drug Category[a]

Type	Drug Category	Inpatient Reports n, (%) in Each Drug Error Type	Outpatient Reports n, (%) in Each Drug Error Type
Ordering and prescribing (538 [53%])	Systemic antiinfective agents	130 (24)	11 (2)
	Hematologic agents	83 (15.4)	15 (2.8)
	Cardiovascular agents	45 (8.4)	62 (11.5)
	Central nervous system agents	55 (10.2)	11 (2)
	Endocrine and metabolic agents	17 (3.2)	32 (6)
	Gastrointestinal agents	16 (3)	2 (0.4)
	Respiratory agents	4 (0.7)	3 (0.6)
	Biologic and immunologic agents	3 (0.6)	2 (0.4)
	Nutrients and nutritional products	1 (0.2)	1 (0.2)
	Renal and genitourinary agents	2 (0.4)	1 (0.2)
	Ophthalmic and optic agents	1 (0.2)	0 (0)
	Other	24 (4.5)	17 (3.1)
Receiving or administering (133 [13%])	Systemic antiinfective agents	3 (2.3)	0 (0)
	Hematologic agents	6 (4.5)	36 (27)
	Cardiovascular agents	10 (7.5)	25 (18.8)
	Central nervous system agents	2 (1.5)	17 (12.8)
	Endocrine and metabolic agents	0 (0)	17 (12.8)
	Gastrointestinal agents	0 (0)	2 (1.5)
	Respiratory agents	1 (0.75)	5 (3.8)
	Biologic and immunologic agents	1 (0.75)	0 (0)
	Nutrients and nutritional products	0 (0)	2 (1.5)
	Renal and genitourinary agents	0 (0%)	0 (0)
	Ophthalmic and optic agents	0 (0)	0 (0)
	Other	2 (1.5)	4 (3)
Monitoring or follow-up (130 [13%])	Systemic antiinfective agents	47 (36.2)	1 (0.8)
	Hematologil agents	23 (17.7)	9 (6.9)
	Cardiovascular agents	3 (2.3)	16 (12.3)
	Central nervous system agents	6 (4.6)	2 (1.5)
	Endocrine and metabolic agents	0 (0)	10 (7.7)
	Gastrointestinal agents	1 (0.8)	0 (0)
	Respiratory agents	0 (0)	0 (0)
	Biologic and immunologic agents	5 (3.9)	0 (0)
	Nutrients and nutritional products	0 (0)	1 (0.8)
	Renal and genitourinary agents	0 (0)	2 (1.5)
	Ophthalmic and optic agents	0 (0)	0 (0)
	Other	0 (0)	4 (3)
Implementing or dispensing (98 [10%])	Systemic antiinfective agents	30 (30.6)	0 (0)
	Hematologic agents	12 (12.3)	5 (5.1)
	Cardiovascular agents	10 (10.2)	12 (12.3)
	Central nervous system agents	10 (10.2)	0 (0)
	Endocrine and metabolic agents	1 (1)	0 (0)
	Gastrointestinal agents	4 (4.1)	0 (0)
	Respiratory agents	5 (5.1)	0 (0)
	Biologic and immunologic agents	0 (0)	0 (0)
	Nutrients and nutritional products	0 (0)	1 (1)
	Renal and genitourinary agents	3 (3.1)	0 (0)
	Ophthalmic and optic agents	0 (0)	0 (0)
	Other	2 (2)	3 (3.1)
Documentation (72 [7%])	Systemic antiinfective agents	2 (2.8)	4 (5.6)
	Hematologic agents	1 (1.4)	12 (16.7)
	Cardiovascular agents	4 (5.6)	18 (25)
	Central nervous system agents	5 (7)	10 (13.9)
	Endocrine and metabolic agents	2 (2.8)	7 (9.7)
	Gastrointestinal agents	0 (0)	0 (0)
	Respiratory agents	1 (1.4)	2 (2.8)
	Biologic and immunologic agents	0 (0)	0 (0)
	Nutrients and nutritional products	0 (0)	0 (0)
	Renal and genitourinary agents	0 (0)	1 (1.4)
	Ophthalmic and optic agents	0 (0)	0 (0)
	Other	0 (0)	3 (4.2)

(continued)

Table 4. (continued)

Type	Drug Category	Inpatient Reports n, (%) in Each Drug Error Type	Outpatient Reports n, (%) in Each Drug Error Type
Other (36 [4%])	Systemic antiinfective agents	9 (25)	0 (0)
	Hematologic agents	5 (13.9)	3 (8.3)
	Cardiovascular agents	2 (5.5)	7 (19.4)
	Central nervous system agents	3 (8.3)	1 (2.8)
	Endocrine and metabolic agents	1 (2.8)	0 (0)
	Gastrointestinal agents	0 (0)	0 (0)
	Respiratory agents	0 (0)	1 (2.8)
	Biologic and immunologic agents	1 (2.8)	0 (0)
	Nutrients and nutritional products	0 (0)	1 (2.8)
	Renal and genitourinary agents	0 (0)	0 (0)
	Ophthalmic and optic agents	0 (0)	0 (0)
	Other	1 (2.8)	1 (2.8)
Total			1007

[a]The total number of drug error types (1007) is greater than the total number of drug error reports (779) because participants were allowed to select more than one type or reason for each error

reported drug error was failure to stop a drug order, followed by dispensing an incorrect dose (Table 3). In previous studies, dispensing wrong drugs or doses, or dispensing to wrong patients was reported more frequently than failure to stop a drug order.[26] Most frequently reported drugs associated with dispensing errors included systemic antiinfective agents in the inpatient setting and cardiovascular agents in the outpatient setting (Table 4).

During administration, the most commonly reported drug error was the patient's failure to take drugs correctly (Table 3). Previous studies reported administering errors related to the high occurrence in the pediatric setting[5, 10, 32] or specifically related to incorrect timing or technique of drug administration.[27, 33] No previously published drug error report studies mentioned a patient's failure to take drugs. The most frequently reported drugs associated with administering errors in our study included cardiovascular agents in the inpatient setting and hematologic agents in the outpatient setting (Table 4). The most commonly reported documentation drug error was not updating drug records (Table 3). Documentation errors have been previously reported from ambulatory care and pediatric settings.[8, 10, 32] The most frequently reported drugs associated with documentation errors included central nervous system agents in the inpatient setting and cardiovascular agents in the outpatient setting (Table 4). Monitoring errors had been previously reported in two ambulatory care studies;[8, 10] however, the frequency of these errors was much lower (3–4%) compared with our study (11–14%). This might be due to the MEDAP study allowing participants to select more than one type or reason for each error.

Most reported errors (95%) resulted in no patient harm; however, 5% of drug errors resulted in harm and could have been prevented. Reported errors resulting in no harm in previous studies were either similar, at 90% in primary care offices,[9] or lower, at 84% in hospitals and 69% in other primary care clinics.[8]

In our study, nearly half (42%) of the drugs with reported errors were prevented from reaching patients by clinical pharmacists. Of note, clinical pharmacists discovered 70% of drug errors from review of patient medical records; therefore, it is imperative that clinical pharmacists have access to full patient data in order to optimize their ability to detect drug errors. Previous studies reported that clinical pharmacists in an inpatient collaborative medical team helped reduce adverse drug events by 30–78%;[34–36] in the outpatient setting, clinical pharmacists prevented 40% of the drugs with drug errors from reaching the patient in primary care clinics.[10] Interventions that clinical pharmacists used to detect, ameliorate, and prevent drug errors included communicating with providers (more frequent in the outpatient setting) and changing drug regimens (more frequent in the inpatient setting). The most frequent intervention methods identified in our study were direct verbal contact with the primary care provider or other health care provider, dosage adjustment, and providing written recommendations in the patient's chart (Table 6).

The MEDAP study showed that communication-based recommendations or interventions were more common in the outpatient setting,

Table 5. Frequency of Harm Severity Levels by Drug Category[a]

Harm Severity Level	Drug Category	No. of Reports	Inpatient Reports n, (%) in Each Harm Level	Outpatient Reports n, (%) in Each Harm Level
Harm level A (n=327)	Systemic antiinfective agents	89	78 (24)	11 (3)
	Cardiovascular agent	70	19 (6)	51 (16)
	Hematologic agents	54	46 (14)	8 (2)
	Central nervous system agents	33	22 (7)	11 (3)
	Endocrine and metabolic agents	32	6 (2)	26 (8)
Harm level B (n=269)	Systemic antiinfective agents	62	60 (22)	2 (0.7)
	Hematologic agents	55	39 (15)	16 (6)
	Cardiovascular agent	43	12 (4)	31 (12)
	Central nervous system agents	40	24 (9)	16 (6)
	Endocrine and metabolic agents	27	10 (4)	17 (6)
Harm level C (n=141)	Hematologic agents	49	24 (17)	25 (18)
	Cardiovascular agent	30	14 (10)	16 (11)
	Systemic antiinfective agents	27	26 (18)	1 (0.7)
	Central nervous system agents	14	11 (8)	3 (2)
	Endocrine and metabolic agents	14	11 (8)	3 (2)
Harm level D (n=33)	Systemic antiinfective agents	12	11 (33)	1 (3)
	Central nervous system agents	7	1 (3)	6 (18)
	Cardiovascular agent	6	0 (0)	6 (18)
	Hematologic agents	3	3 (9)	0 (0)
	Endocrine and metabolic agents	3	0 (0)	3 (9)
Harm level E (n=6)	Systemic antiinfective agents	3	3 (50)	0 (0)
	Cardiovascular agent	2	1 (17)	1 (17)
	Hematologic agents	1	1 (17)	0 (0)
Harm level G (n=2)	Hematologic agents	1	0 (0)	1 (50)
	Nutrients and nutritional	1	0 (0)	1 (50)
Harm level H (n=1)	Hematologic agents	1	0 (0)	1 (100)

Harm level A = error occurred but was prevented, and drug did not reach the patient; harm level B = error occurred, and drug reached the patient but did not require monitoring; harm level C = error occurred, and drug reached the patient and required monitoring; harm level D = error occurred, drug reached the patient, and intervention was required; harm level E = error occurred, drug reached the patient, and patient required hospitalization; harm level F = error occurred that may have contributed to or resulted in permanent patient harm; harm level G = error occurred that required necessary intervention to sustain life; harm level H = error occurred that may have contributed to or resulted in death. Error + no harm = harm levels A, B, and C; error + harm = harm levels D, E, F, and G; error + death = harm level H.
[a]Only the top five drugs are listed for each category.

whereas drug regimen changes were more common in the inpatient setting. This suggests there might be differences related to the scope of drug error safety practices within the two settings. Identifying those differences requires further investigation and is outside the scope of this work; however, it should not be surprising that clinical pharmacists practicing within closed inpatient systems were more likely to detect dosing errors than outpatient pharmacists. Specifically, inpatient clinical pharmacists' roles may include order review and/or drug review, or be dictated by policies mandating the review of certain drugs, such as vancomycin, within their institutions.

In the outpatient setting, clinical pharmacists are frequently embedded within the outpatient practice site and are in close proximity with health care providers; this affords direct communication with prescribers, thus preempting potential prescribing errors. Although other studies identified miscommunication or lack of communication as major factors in contributing to drug errors,[8, 10, 37] none reported interventions used to detect, ameliorate, or prevent drug errors. The investigators can only speculate as to the reason for the differences and unique findings of our study.

Our study found that the majority of clinical pharmacist recommendations (nearly 90%) were accepted by prescribers; however, we did not assess any longitudinal pattern of such acceptance. In comparison, a previous study found increasing pharmacist activities (e.g., implementing computerized order entry, increasing access to patient-specific data) over a 3-year period in the hospital setting.[38]

Our results should be interpreted in the context of some limitations. First, voluntary reports could be underreported and did not provide the actual frequency of the total denominator of errors that were detected, ameliorated, or

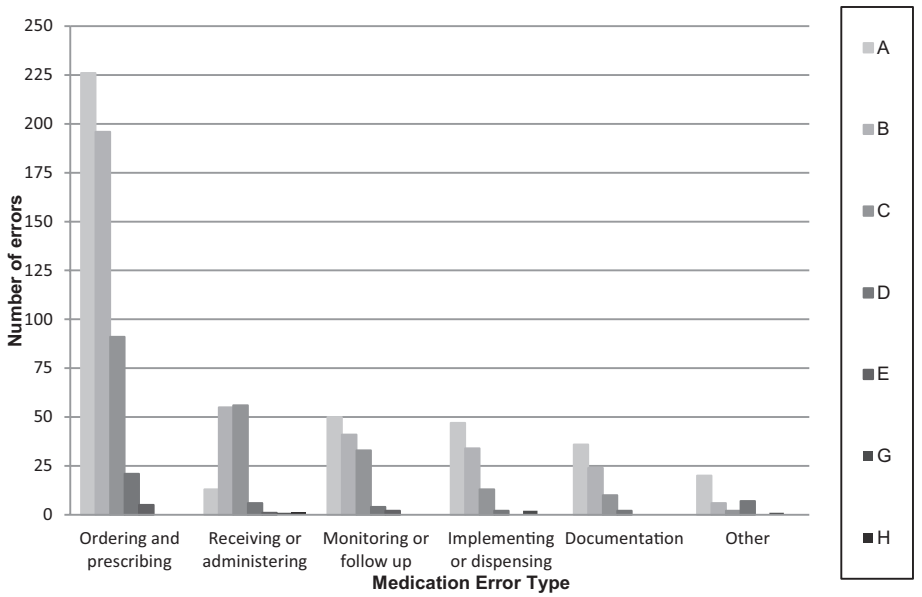

Figure 1. Frequency of drug errors by drug error type and harm level for the 779 drug error reports. Harm level A = error occurred but was prevented, and drug did not reach the patient; harm level B = error occurred, and drug reached the patient but did not require monitoring; harm level C = error occurred, and drug reached the patient and required monitoring; harm level D = error occurred, drug reached the patient, and intervention was required; harm level E = error occurred, drug reached the patient, and patient required hospitalization; harm level F = error occurred that may have contributed to or resulted in permanent patient harm; harm level G = error occurred that required necessary intervention to sustain life; harm level H = error occurred that may have contributed to or resulted in death. Error + no harm = harm levels A, B, and C; error + harm = harm levels D, E, F, and G; error + death = harm level H.

prevented at participating sites. Several methods of drug event detection are needed to comprehensively identify drug errors and adverse drug events;[39–41] however, the MEDAP study was not designed to collect drug error reports using several error detection methods. First, the short duration of data collection period over 14 consecutive days might have biased the data. Second, drug error classifications (e.g., type and reason, harm levels, clinical pharmacist interventions) were reported by the participants and not determined by the investigators. Even though participants were required to complete study-specific online training and complete the data collection forms, we did not verify these reports. Because the study did not collect textual descriptions of the drug errors or interventions, we did not perform further analysis to determine the patient harm likely resulting from the drug errors. Because participants could report more than one drug error type and reason for each error, this approach prevented us from identifying the phase from which the drug error originated. Third, volunteer participants might have been more willing to report drug errors that they detected, ameliorated, or prevented, thus biasing error or harm level distribution.

Conclusion and Future Directions

Our findings showed that it is feasible to conduct a drug error reporting study in a national practice-based clinical pharmacist research network, regardless of clinical pharmacist practice settings. Most reported drug errors did not result in patient harm; however, drug error types, drugs categories, and clinical pharmacist interventions varied between the inpatient and outpatient settings. Communication-based recommendations or interventions were more common in the outpatient setting, whereas drug regimen changes were more common in the inpatient setting. Nearly half of reported errors were prevented by clinical pharmacists before the drugs reached patients, and the majority of clinical pharmacist interventions and recommendations to prevent or ameliorate drug errors were accepted by prescribers.

Several potential studies are warranted in the future, including methods for adjudication of drug error reports, textual descriptions of drug errors to help assess patient harms likely resulting from these errors, more information on the drug use system (e.g., workflow, use of informatics technology) to better understand drug

Table 6. Type of Clinical Pharmacist Recommendation or Intervention for the Drug Error (n=1973)[a]

Type	Inpatient Reports (n=1041) (%)	Outpatient Reports (n=932) (%)	p Value	Method	No. of Reports
Communication (1057 [54%])	508 (49)	549 (59)	< 0.001	Direct verbal contact with primary care provider or other health care provider	433
				Provided written recommendation in patient chart	208
				Communication with patient	158
				Verbal or written drug counseling	115
				Verbal or written education	39
				Provided evidence-based handwritten drug information	36
				Adverse effect reported to authorities	6
				Other	62
Drug regimen change (688 [35%])	410 (39)	278 (30)	< 0.001	Adjust dosage	258
				Stop drug	168
				Add new drug	106
				Performed drug reconciliation	47
				Add new drug for an omission	36
				Add new drug to ameliorate error	7
				Antidote administered	1
				Other	65
Monitoring (180 [9%])	94 (9)	86 (9)	0.879	Ordered or recommended laboratory test	93
				Add new monitoring parameters	54
				Ordered or recommended pharmacogenetic laboratory test	6
				Ordered or recommended x-ray or other radiographic test	0
				Other	27
None (23 [1%])	18 (2)	5 (0.5)	0.019	No intervention was needed	23
Treatment referral (8 [1%])	0 (0.0)	8 (0.9)	0.002	Patient instructed to call health care provider	6
				Patient referred to clinic or emergency department within 24 hours	0
				Other	2
Other (not specified) (17 [1%])	11 (1)	6 (0.6)	0.343		17
Total					1973

[a]The total number of pharmacist recommendation or intervention types (1973) is greater than the total number of drug error reports (779) because participants were allowed to select more than one type for each error.

errors identified in the reporting study, tracking pharmacist recommendations and interventions on a longitudinal basis, and conducting cost analysis of drug errors or cost-savings from clinical pharmacist interventions. The implications for drug errors detected, ameliorated, and prevented (e.g., harm avoided) are worthy of further exploration. Future studies can also focus on high risk drugs (e.g., systemic antiinfective, hematologic, and cardiovascular drugs) and assess the role of clinical pharmacists in preventing errors associated with them.

Acknowledgments

We sincerely thank the clinical pharmacists of the ACCP PBRN. A full list of participating ACCP PBRN members can be found at http://www.accpri.org/pbrn/researchProjects.aspx. The ACCP PBRN would like to acknowledge Tim Burkhart for creating the PBRN-Connect system; Matthew Moore, B.S., for his assistance in Discovere tool design, implementation, and data management; Andrea Schiff for her assistance in data analysis and table formatting; Erin W. Moore, M.A., for her assistance in table formatting; the ACCP PBRN Community Advisory Panel for beta-testing the data collection form; the ACCP Research Institute Board of Trustees for its oversight of this project; and the Frontiers Fund donors whose generosity funded this research.

References

1. **Aspden P, Wolcott J, Bootman JL, Cronenwett LR, eds.** Committee on identifying and preventing medication errors: preventing medication errors. Washington DC: The National Academies Press, 2006.
2. **Santell JP, Hicks RW, McMeekin J, Cousins DD.** Medication errors: experience of the United States Pharmacopeia (USP) MEDMARX reporting system. J Clin Pharmacol 2003;43: 760–7.

3. **Kohn LT, Corrigan JM, Donaldson MS.** To err is human: building a safer health system. Washington, DC: National Academies Press, 1999.
4. **Bates DW, Leape LL, Cullen DJ, et al.** Effect of computerized physician order entry and a team intervention on prevention of serious medication errors. JAMA 1998;280:1311–6.
5. **Belela AS, Peterlini MA, Pedreira ML.** Medication errors reported in a pediatric intensive care unit for oncologic patients. Cancer Nurs 2011;34:393–400.
6. **LaPointe NM, Jollis JG.** Medication errors in hospitalized cardiovascular patients. Arch Intern Med 2003;163:1461–6.
7. **Lesar TS, Lomaestro BM, Pohl H.** Medication-prescribing errors in a teaching hospital. A 9-year experience. Arch Intern Med 1997;157:1569–76.
8. **Hickner J, Zafar A, Kuo GM, et al.** Field test results of a new ambulatory care Medication Error and Adverse Drug Event Reporting System–MEADERS. Ann Fam Med 2010;8:517–25.
9. **Kennedy AG, Littenberg B, Senders JW.** Using nurses and office staff to report prescribing errors in primary care. Int J Qual Health Care 2008;20:238–45.
10. **Kuo GM, Phillips RL, Graham D, Hickner JM.** Medication errors reported by US family physicians and their office staff. Qual Saf Health Care 2008;17:286–90.
11. **Patanwala AE, Sanders AB, Thomas MC, et al.** A prospective, multicenter study of pharmacist activities resulting in medication error interception in the emergency department. Ann Emerg Med 2012;59:369–73.
12. **Rothschild JM, Churchill W, Erickson A, et al.** Medication errors recovered by emergency department pharmacists. Ann Emerg Med 2009;55:513–21.
13. **Vasileff HM, Whitten LE, Pink JA, Goldsworthy SJ, Angley MT.** The effect on medication errors of pharmacists charting medication in an emergency department. Pharm World Sci 2009;31:373–9.
14. **Franklin BD, Reynolds M, Shebl NA, Burnett S, Jacklin A.** Prescribing errors in hospital inpatients: a three-centre study of their prevalence, types and causes. Postgrad Med J 2011;87:739–45.
15. **Tully MP, Buchan IE.** Prescribing errors during hospital inpatient care: factors influencing identification by pharmacists. Pharm World Sci 2009;31:682–8.
16. **Marinac JS, Kuo GM.** Characterizing the American college of clinical pharmacy practice-based research network. Pharmacotherapy 2010;30:865.
17. **FDA.** MedWatch Form. Available from http://www.fda.gov/downloads/Safety/MedWatch/HowToReport/DownloadForms/ucm082725.pdf. Accessed January 28, 2010.
18. **Hartwig SC, Denger SD, Schneider PJ.** Severity-indexed, incident report-based medication error-reporting program. Am J Hosp Pharm 1991;48:2611–6.
19. **Snyder RA, Abarca J, Meza JL, Rothschild JM, Rizos A, Bates DW.** Reliability evaluation of the adapted national coordinating council medication error reporting and prevention (NCC MERP) index. Pharmacoepidemiol Drug Saf 2007;16:1006–13.
20. **Young, M.**, ed. Hospitals tracking intervention data find huge cost avoidance, savings. Drug Form Rev 2009;25:109–12.
21. **Hansen RA, Greene SB, Williams CE, Richards BL.** Types of medication errors in North Carolina nursing homes: a target for quality improvement. Am J Geriatr Pharmacother 2006;4:52–61.
22. **Budnitz DS, Lovegrove MC, Shehab N, Richards BL.** Emergency hospitalizations for adverse drug events in older Americans. N Engl J Med 2011;365:2002–12.
23. **Bar-Oz B, Goldman M, Lahat E, et al.** Medication errors and response bias: the tip of the iceberg. Isr Med Assoc J 2008;10:771–4.
24. **Orser BA, Chen RJ, Yee DA.** Medication errors in anesthetic practice: a survey of 687 practitioners. Can J Anaesth 2001;48:139–46.
25. **Sheu SJ, Wei IL, Chen CH, Yu S, Tang FI.** Using snowball sampling method with nurses to understand medication administration errors. J Clin Nurs 2009;18:559–69.
26. **Rolland P.** Occurrence of dispensing errors and efforts to reduce medication errors at the Central Arkansas Veteran's Healthcare System. Drug Saf 2004;27:271–82.
27. **Benkirane RR, Abouqal R, Haimeur CC, et al.** Incidence of adverse drug events and medication errors in intensive care units: a prospective multicenter study. J Patient Saf 2009;5:16–22.
28. **Kuo GM.** Medication errors in community/ambulatory care: incidence and reduction strategies. J Pharmaceut Finance Econ Po 2006;15:43–136.
29. **Flynn EA, Barker KN, Pepper GA, Bates DW, Mikeal RL.** Comparison of methods for detecting medication errors in 36 hospitals and skilled-nursing facilities. Am J Health Syst Pharm 2002;59:436–46.
30. **Vilke GM, Tornabene SV, Stepanski B, et al.** Paramedic self-reported medication errors. Prehosp Emerg Care 2007;11:80–4.
31. **Zhan C, Hicks RW, Blanchette CM, Keyes MA, Cousins DD.** Potential benefits and problems with computerized prescriber order entry: analysis of a voluntary medication error-reporting database. Am J Health Syst Pharm 2006;63:353–8.
32. **Miller MR, Robinson KA, Lubomski LH, Rinke ML, Pronovost PJ.** Medication errors in paediatric care: a systematic review of epidemiology and an evaluation of evidence supporting reduction strategy recommendations. Qual Saf Health Care 2007;16:116–26.
33. **Fontan JE, Maneglier V, Nguyen VX, Loirat C, Brion F.** Medication errors in hospitals: computerized unit dose drug dispensing system versus ward stock distribution system. Pharm World Sci 2003;25:112–7.
34. **Anglim AM, Klym B, Byers KE, Scheld WM, Farr BM.** Effect of a vancomycin restriction policy on ordering practices during an outbreak of vancomycin-resistant Enterococcus faecium. Arch Intern Med 1997;157:1132–6.
35. **Kucukarslan SN, Peters M, Mlynarek M, Nafziger DA.** Pharmacists on rounding teams reduce preventable adverse drug events in hospital general medicine units. Arch Intern Med 2003;163:2014–8.
36. **Leape LL, Cullen DJ, Clapp MD, et al.** Pharmacist participation on physician rounds and adverse drug events in the intensive care unit. JAMA 1999;282:267–70.
37. **Rubin G, George A, Chinn DJ, Richardson C.** Errors in general practice: development of an error classification and pilot study of a method for detecting errors. Qual Saf Health Care 2003;12:443–7.
38. **Pedersen CA, Schneider PJ, Scheckelhoff DJ.** ASHP national survey of pharmacy practice in hospital settings: Monitoring and patient education–2009. Am J Health Syst Pharm 2010;67:542–58.
39. **Kaboli PJ, Glasgow JM, Jaipaul CK, et al.** Identifying medication misadventures: poor agreement among medical record, physician, nurse, and patient reports. Pharmacotherapy 2010;30:529–38.
40. **Meyer-Massetti C, Cheng CM, Schwappach DL, et al.** Systematic review of medication safety assessment methods. Am J Health Syst Pharm 2011;68:227–40.
41. **Morimoto T, Gandhi TK, Seger AC, Hsieh TC, Bates DW.** Adverse drug events and medication errors: detection and classification methods. Qual Saf Health Care 2004;13:306–14.