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Medication Errors Associated with Code Situations in U.S. Hospitals: Direct and Collateral Damage

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Medical errors are one of the leading causes of death and injury in the United States, responsible for more deaths each year than AIDS, breast cancer, or motor vehicle accidents.[1] Medication errors are the most common type of medical error.[2] A medication error is "any preventable event that may cause or lead to inappropriate medication use or patient harm while the medication is in the control of the health care professional, patient, or consumer."[3] Considerable evidence demonstrates that medication errors are frequent, costly, and occur in all health care settings.[4–6]

The analysis reported in this article focuses on one type of adverse event involving medications in acute care inpatient settings—errors associated with code situations. A *code situation* is defined as "an emergency situation in which a specialized team of health care professionals [is] summoned to the scene by an agreed upon signal (e.g., code blue), to deliver immediate life support measures to the patient."[7(p. 113)] This definition differs from the stricter definition of cardiac and/or respiratory arrest propounded by the American Heart Association in that it is more inclusive of severely harmful events such as profound hypotension, arrhythmias, and severe respiratory depression that may progress to an arrest.[8]

Code situations interrupt the normal work flow of a hospital, requiring staff from various areas of the hospital to leave their work areas to attend to a critically ill patient. Given the emergent nature of the situation, little time is available to providers for thought, discussion, and establishment of effective cross-coverage of duties. Many different types of error can occur during code situations, and these errors can affect a variety of patients. Such errors include not only errors to the patient coding but also errors to other patients whose health care providers are attending the code.

Literature on code-related errors is scarce, and information on code-related errors affecting patients other than the one involved in the code is largely unavailable. Improving the safety and efficacy of code situations requires a better understanding of the type and characteristics of errors that occur during these unique times. The specific aim of this study was to describe code-related errors using a national medication error report database (MEDMARX®) that captures information on these and other types of medication errors.

Methods

Data Source

MEDMARX is a national, voluntary, anonymous medication error reporting system maintained by the United States Pharmacopeia. Currently collecting more than 14,000 error reports per month from caregivers and staff of member facilities, the database now holds more than 1.2 million adverse drug event records from more than 880 subscribing hospitals, health systems, and other health care facilities. Subscribing facilities, representing every state in the United States, include academic centers, community facilities, government-affiliated hospitals, and

specialty hospitals of varying bed size. Nearly two-thirds of these facilities have fewer than 200 beds, 80% are general community hospitals, 7% are teaching institutions, and 30% are government operated, making MEDMARX comparable to the United States hospital population as characterized by the American Hospital Association.[9,10]

We included error reports submitted to MEDMARX between January 1, 2000, and December 31, 2005, with "code situation," as defined, selected from a structured list of contributing factors. Given the difference in code situations in-hospital as compared to out-of-hospital, only in-hospital errors were included. Non-code-related in-hospital errors were used for comparison.

Analysis

We performed both qualitative and quantitative analyses.

Qualitative Analysis. Our qualitative analysis of the reports used free-text descriptions of the error to create a new variable describing how the error was related to a code situation (the "relationship to code situation variable"). Values include error to the patient involved in the code, error to a patient other than the one coding (a "collateral damage error"), error that precipitated a code situation, and error that occurred after a code situation. We expected the majority of the error reports to describe errors to the patient involved in the code. Error reports were assigned values for the new variable only if the free-text description contained information confirming that the contributing factor "code situation" was chosen on the basis of the provided MEDMARX definition. Confirmation was based on the presence of one or more of the following key words in the free-text description: code, emergency, mask ventilation, intubation, advanced cardiac life support (ACLS), seizure, status epilepticus, cardiopulmonary resuscitation (CPR), defibrillation, arrhythmia, cardioversion, cardiac arrest, respiratory arrest, resuscitation, rescue efforts, STAT, trauma, ventilator, life-threatening, hypotension, critical situation, and airway established.

Two researchers [A.K.M.L., B.D.W.] independently reviewed the free-text descriptions and generated a value of the new variable for each report. Reports without any of these key words but describing grave clinical situations were assigned a value based on reviewer consensus. Error reports that did not meet these criteria were excluded from the analysis. The excluded reports described general medication errors and/or errors in which "code situation" was selected as a contributing factor on the basis of a definition of *code* that differs from the MEDMARX definition (for example, *code* defined as "a word, letter, number, or other symbol used in a code system to mark, represent, or identify something"[11]).

Quantitative Analysis. We performed quantitative analysis on all reports that met inclusion criteria, as well as subgroup analysis by the variable describing relationship to the code situation. Comparisons were made among code-related errors as well as between code-related and non-code-related in-hospital errors reported during the same period. We hypothesized (1) that code-related errors would be more harmful and more likely to result in corrective action than non-code-related errors, and (2) that collateral damage errors would be more likely to report distractions and work load increases as contributing factors than noncollateral damage errors. Statistical significance was assessed using the chi-square test or Fisher's exact test (for cells with $n < 10$). Univariate odds ratios (ORs) were calculated.

We performed multiple logistic regression with generalized estimating equation and robust estimation of variance to examine the relationship between collateral damage errors and resulting corrective action, with adjustment for characteristics of the error and harm resulting from the error. Our primary outcome measure was whether the error resulted in any corrective action; we hypothesized that collateral damage errors would be less likely to result in corrective actions than other code-related errors. The type of action taken was a secondary outcome measure. We classified actions as policy-level or non-policy-level. Policy-level actions included acquisition or modification of computer software, environmental modification, change in formulary, initiation or alteration of a policy or procedure, and modification of staffing practice or policy. We assumed that errors with no reported corrective action resulted in no action. Our primary predictor variable was whether or not the code-related error was a collateral damage error; resulting harm was a secondary predictor variable. We adjusted for location of the error, node at which the error occurred, whether or not the error occurred on a weekend, contributing factors associated with the error, and cause of the error.

We checked for interaction between harm and all other covariates; no statistically significant interaction was found. The likelihood ratio test was used to exclude unnecessary covariates. Collinearity for logistic regression analyses was checked by performing multiple linear regression instead of the logistic regression analyses to calculate the variance inflation factors, which were all less than 2.0. We used the Hosmer-Lemeshow test to assess goodness of fit of the final model. Generalized linear models were used in the event of poor model fit.

We explored alternative models to test some of our assumptions. First, we imputed 452 missing values for the outcome of resulting corrective action and repeated the analysis. Imputation of the missing values did not change the results of the analysis. In addition, we repeated the analysis excluding a cluster of 100 collateral damage error reports from one facility that were identical in nature and therefore had questionable integrity. Exclusion of these reports did not affect our conclusions. Statistical analyses were performed using Stata statistical software release 9.0 (Stata Corporation, College Station, TX).

Results

Characteristics of Code-related Errors

From 2000 to 2005, a total of 1,043,939 errors were reported to the MEDMARX database from 834 health care facilities. Code situation was selected as a contributing factor in 2,288 (0.22%) errors from 384 facilities, 2,034 errors of which occurred in a hospital setting. In contrast, there were 897,194 non-code-related in-hospital errors. Among the 2,034 code-related errors,

- 29 were prescription coding errors (those who reported the error chose code situation on the basis of a definition of the term different from the one provided by MEDMARX).
- 1,163 were general medication errors with none of our key words in the free-text description; it was not possible to determine why code situation was chosen as a contributing factor in these cases nor to determine a value for the relationship to code variable. These 1,163 errors were excluded from the analysis.

Therefore, 842 error reports were available for this analysis.

Of these 842 errors, 94% occurred in general community hospitals. Errors most commonly occurred in a general patient care ward (70%), emergency department (ED; 8.2%), or intensive care unit (ICU; 7.5%). Eighty-six percent of these errors occurred during medication administration. The most common type of error was an omission error (72%); 9.0% were improper dose errors and 5.7% were unauthorized drug administration errors. Errors most frequently involved registered nurses (45%) and respiratory therapists (43%), and were also most frequently discovered by these two groups. The errors involved 137 unique drugs and 52 unique therapeutic classes. Anti-asthma/bronchodilators (69%), autonomic medications (5.2%), and sedative/hypnotics (4.5%) were the most common therapeutic classes implicated in the errors. Each report listed, on average, 1.5 causes of the error: 30% of errors were associated with performance (human) deficit, 16% with work flow disruption, and 12% with lack of adherence to a procedure or protocol. Although all reports listed "code situation" as a contributing factor, 37% selected at least one other contributing factor, and 7% had a total of four or more contributing factors. The most common additional contributing factors were emergency situation, work load increase, and insufficient staffing. Fifty five (6.5%) of the errors were associated with patient harm, and there were five deaths (0.59%), making code-related errors 39 times more likely to result in harm than non-code-related in-hospital errors (95% confidence interval [CI]: 28.9–51.4) and 51.5 times more likely to result in death (95% CI: 16.4–124.6).

Only 390 of the 842 reports answered the MEDMARX question regarding actions taken in response to the error. We assumed that lack of response to this question implied no action resulted from the error. Overall, 29% of errors resulted in some action. The most common reported actions were "informed staff who made the initial error" (17% of all errors) and provision of additional education or training (6.4% of all errors). Only 4.4% of errors resulted in report of a policy-level action. Harmful errors were 3.8 times more likely than non-harmful errors to result in action (95% CI: 2.17–6.64), and 3.7 times more likely to result in a policy-level action (95% CI: 1.54–8.80).

Characteristics of Errors by Relationship to the Code Situation

Not all the code-related error reports described errors occurring during a code situation and affecting the patient

Table 1. Excerpts of Free-Text Descriptions of Errors, by Relationship to Code Situation*

Error to patient coding during code	Patient on weight-based dopamine drip. Weight in pounds was entered as kilograms for drip calculation. Drip started during code/hypotensive crisis.
	Bretylium 500 mg (10mL) intravenous (IV) ordered for patient brought in by EMS in cardiac arrest with CPR. R.N. drew up Breviblock (Esmolol) 500 mg (50 mL). Vial and syringe shown to another R.N. and it was confirmed to be correct. Drug was pushed by second R.N. Code continued without success and patient expired.
	Epinephrine syringes defective during CPR. Unable to inject once screwed together. Patient finally resuscitated and transferred to MICU.
Error to patient other than the one coding (collateral damage)	Patient called for pain med. Patient's nurse was in a code in another room. Nurse at desk checked medication administration record (MAR) and administered 10 mg morphine IV. After code ended, nurses spoke and the patient's nurse had administered a dose prior to code but was unable to document it on the MAR due to the code situation.
	Lopressor, Vasotec, and Solucortef IV given to wrong patient. Nurse states another patient had just coded, was being transferred to CCU.
	Proventil dose was omitted on a 74-year-old female due to respiratory therapist busy at a code.
Error preceding a code	Demerol and Phenergan were ordered by the physician and given by the nurse. Both were listed in MAR with adverse reaction by patient. Patient felt "faint" with Phenergan given, she was laid flat and monitored. Within 5 minutes, respirations ceased—patient was bagged to 100% O_2 on bivalve mask. Several minutes later, the patient had no pulse and CPR was started. CPR was successful. Patient put on ventilator.
	After open heart surgery, the patient's blood pressure fell precipitously. Patient returned to operating room for exploratory surgery. The cause of the blood pressure drop was found to be the inadvertent restart of nitroglycerin, which was still hanging at the bedside but was not ordered.
Error occurring after a code	After surviving a code situation, the patient had systolic blood pressure in the 50s; a dopamine drip was started without improvement. Report from pulmonary step-down unit said the drip was infusing at 10 mcg/hr. It was actually infusing at 10 mcg/kg/hr or 0.4 cc/hr.
	Crash cart opened in ICU but not replaced until 5 days later. Policy is daily checks on the unit.

* Excerpts may have been edited for clarity, spelling, and grammar. EMS, emergency medical services; R.N., registered nurse; CPR, cardiopulmonary resuscitation; MICU, medical intensive care unit; CCU, critical care unit.

involved in the code. In fact, the error reports described four distinct ways in which the error could be associated with a code situation. Table 1 (above) provides excerpts from free-text error descriptions for error reports in each of these categories. Table 2 (page 50) summarizes the 842 error reports by their relationship to the code situation. Nearly three-quarters (74%) of the reported errors involved patients other than the patient involved in the code, that is, collateral damage errors. Twenty-one percent involved patients directly experiencing codes, 3% involved errors preceding—and possibly precipitating—codes, and 2% affected patients following a code.

Table 3 (page 51) and Table 4 (page 52) show the characteristics of the error reports by their relationship to the code situation. Errors affecting the patient involved in the code were statistically significantly more likely to be harmful than other code-related errors (OR for harm 6.7; 95% CI: 3.66–12.41), whereas collateral damage errors were less likely to be harmful (OR, 0.005; 95% CI: 0.0001–0.30). Not surprisingly, errors preceding codes were the most likely to result in harm. Two of the reported five deaths were associated with errors occurring during

Table 2: Code-Related Error Reports by Relationship to Code Situation

Relation of Error to Code Situation	*n*	%
Error to patient involved in code	177	21.0
Error to patient other than the one involved in the code	621	73.8
Error preceding a code	28	3.3
Error occurring after a code	16	1.9
Total	842	100

the code and affecting the patient involved in the code, and three were associated with errors preceding the code. No deaths were reported as a result of collateral damage errors. Errors among the four subgroups did not differ significantly by time of day or day of week.

Collateral Damage Errors. Collateral damage errors were statistically significantly more likely to report work flow disruption as a cause of the error than other code-related errors; more than 20% of collateral damage errors reported this type of disruption as a probable cause. In addition, insufficient staffing and work load increase were statistically significantly more likely to be reported as contributing factors for collateral damage errors than other code-related errors, reported in 17% and 15% of collateral damage reports, respectively. Collateral damage errors, overwhelmingly errors of omission (92%), were most commonly associated with the administration node. The errors occurred overwhelmingly on adult patient care units (86%).

As expected, the medications implicated in the error varied by subgroup as well. Nearly 90% of collateral damage errors involved anti-asthmatic drugs and bronchodilators, reflecting a high proportion of missed respiratory therapy treatments in this group. However, 52 unique drug classes were implicated in collateral damage errors; other drug classes commonly involved included central nervous system medications (13.1%) and autonomic medication (7.1%). (Percentage totals may exceed 100% because multiple therapeutic classes can be included in each report.)

Errors Affecting the Coded Patient. In comparison, errors occurring during the code and affecting the patient coding were more likely to be due to an improper dose or quantity of a drug, and contributing factors included emergency situation and distractions. Common causes included performance deficit and communication. These errors often occurred in the ED/admitting or adult ICU as well as the adult patient care unit and were more frequently due to problems at the dispensing (26%) and prescribing (11%) nodes. Autonomic medications and sedative hypnotics accounted for almost 40% of errors occurring during the code and affecting the patient coding. Errors preceding code situations involved a variety of therapeutic classes, including opioids (15%), antianginals (12%), and beta-lactams (8%).

Taking Corrective Action After Errors Occur

Table 5 (page 53) shows the percent of errors resulting in action by the relationship of the error to the code situation. As compared to other code-related errors and non-code-related in-hospital errors, collateral damage errors were statistically significantly less likely to result in any action taken. Only 18% of these errors resulted in an action; the most common action reported was "informed staff who made the initial error." In comparison, nearly 60% of other code-related errors resulted in action, and 40% of non-code-related in-hospital errors resulted in action. Furthermore, only 2.9% of collateral damage errors resulted in a policy-level action—statistically significantly less than other code-related errors (8.6%; $p = .0004$) but more than non-code-related errors (only 1.7% resulted in policy-level action, $p = .025$). Changes in staffing practice or policy accounted for more than 80% of policy-level actions reported after collateral damage errors.

Given evidence that action is more likely after harmful errors, we performed multiple logistic regression to assess the relationship between collateral damage errors and corrective action, controlling for harm and other potential confounders (Table 6, page 54). Collateral damage errors were 88% less likely than other code-related errors to result in corrective action of any kind (95% CI: 80%–92% less likely). Further, errors in which the reporter identified contributing factors in addition to code situation were statistically significantly more likely to result in action; of these, errors associated with distractions were the most likely to result in action ($p < .001$). Whether the error resulted in harm was not statistically significant in the multiple logistic regression model. The node of the

Table 3. Level of Harm, Contributing Factors, and Types of Error, by Relationship to Code Situation

	Error to Patient Involved in Code *n* = 177		Error to Another Patient *n* = 621		Error Preceding Code *n* = 28		Error After Code *n* = 16		Total *n* = 842	
	n	%	*n*	%	*n*	%	*n*	%	*n*	%
Level of Harm										
No harm	144	81.4	620	99.8*	9	32.1	14	87.5	787	93.5
Harm	33	18.6*	1	0.2	19	67.9*	2	12.5	55	6.5
Common Contributing Factors†										
Emergency situation	43	24.3*	110	17.7	5	17.9	1	6.3	159	18.9
Insufficient staffing	3	1.7	106	17.1*	1	3.6	1	6.3	111	13.2
Work load increase	4	2.3	94	15.1*	2	7.1	1	6.3	100	11.9
Distractions	24	13.6*	25	4.0	4	14.3	1	6.3	54	6.4
Inexperienced staff	9	5.1*	4	0.6	3	10.7*	0	0	16	1.9
Cross-coverage	1	0.6	13	2.1	1	3.6	0	0	15	1.8
Shift change	2	1.1	5	0.8	1	3.6	0	0	8	1.0
Patient transfer	3	1.7	2	0.3	2	7.1	1	6.3	8	1.0
Common Types of Error†										
Omission error	23	13.0	574	92.4*	4	14.3	3	18.8	604	71.7
Improper dose/quantity	54	30.5*	9	1.4	9	32.1*	4	25.0*	76	9.0
Unauthorized/wrong drug	35	19.8*	3	0.5	8	28.6*	2	12.5	48	5.7
Wrong time	15	8.5*	15	2.4	2	7.1	1	6.3	33	3.9
Extra dose	8	4.5	12	1.9	1	3.6	0	0	21	2.5
Prescribing error	12	6.8*	3	0.5	0	0	2	12.5*	17	2.0
Drug prepared incorrectly	13	7.3*	1	0.2	1	3.6	0	0	15	1.8
Wrong administration technique	9	5.1*	0	0	1	3.6	3	18.8*	13	1.5
Wrong dosage form	4	2.3*	1	0.2	1	3.6	0	0	6	0.7

* Significantly greater at $p < 0.05$ (chi-square or Fisher's exact test compared to all other code-related errors)
† Multiple contributing factors and error types may be reported for each error; therefore column totals may exceed 100%

error and whether or not the error occurred on a weekend were not included in the final model on the basis of likelihood ratio testing. To evaluate policy-level corrective actions, we used underdispersed logistic regression to adjust for poor fit. Policy-level corrective actions were 73% less likely after collateral damage errors as compared with all other code-related errors, after adjusting for all covariates (95% CI: 54%–84% less likely).

Discussion

Several studies have assessed medication errors during resuscitations, and many other studies have looked at the larger issue of performance during code situations and code quality.[12–17] None of these studies, however, have effectively described the impact or nature of medication errors that occur during codes, nor have they attempted to assess the collateral damage associated with code situations. Our study describes the landscape of medication errors associated with code situations in hospitals in the United States and identifies potential opportunities to improve medication safety, on the basis of reports from a national, anonymous, voluntary error reporting system.

As reported, nearly three-quarters of code-related errors were collateral damage errors, in which the patient affected by the medication error was someone other than the patient involved in the code. Most of these errors were administration errors secondary to omission of a respiratory therapy treatment, but extra doses, improper quantities, prescribing errors, and wrong route/patient/time errors were also reported. Not surprisingly, collateral damage

Table 4: Error Node, Location and Common Causes, by Relationship to Code Situation

	Error to Patient Involved in Code *n* = 177		Error to Another Patient *n* = 621		Error Preceding Code *n* = 28		Error After Code *n* = 16		Total *n* = 842	
	n	%	*n*	%	*n*	%	*n*	%	*n*	%
Node										
Prescribing	19	10.7*	1	0.2	4	14.3*	1	6.3	25	3.0
Transcribing/documenting	10	5.7*	6	1.0	3	10.7*	3	18.8*	22	2.6
Dispensing	46	26.0*	18	2.9	2	7.1	3	18.8	69	8.2
Administering	102	57.6	595	95.8*	19	67.9	8	50.0	724	86.0
Monitoring	0	0.0	1	0.2	0	0	1	6.3*	2	0.2
Location										
Adult ward	52	29.4	535	86.2*	9	32.1	7	43.8	603	71.6
Adult ICU	31	17.5*	22	3.5	10	35.7*	6	37.5*	69	8.2
ED/admitting	45	25.4*	18	2.9	3	10.7	3	18.8	69	8.2
Pediatrics	4	2.3	11	1.8	0	0	0	0	15	1.8
Pediatric ICU	3	1.7	2	0.3	0	0	0	0	5	0.6
Peri-op/procedure labs	13	7.3*	0	0	0	0	0	0	13	1.5
Obstetrics	2	1.1	5	0.8	1	3.6	0	0	8	1.0
Psychiatry	1	0.6	5	0.8	0	0	0	0	6	0.7
Ancillary services	26	14.7*	23	3.7	5	17.9*	0	0	54	6.4
Common Causes†										
Performance (human) deficit	69	39*	138	22.2	12	42.9	8	50.0*	227	27.0
Workflow disruption	2	1.1	128	20.6*	0	0	0	0	130	15.4
Procedure/protocol not followed	35	19.8*	54	8.7	6	21.4	3	18.8	98	11.6
Communication	45	25.4*	31	5.0	4	14.3	1	6.3	81	9.6
Knowledge deficit	32	18.1*	6	1.0	5	17.9*	1	6.3	44	5.2
Verbal order	37	20.9*	0	0	2	7.1	0	0	39	4.6
System safeguard(s)	19	10.7*	10	1.6	2	7.1	1	6.3	32	3.8
Dispensing device involved	22	12.4*	4	0.6	1	3.6	0	0	27	3.2
Calculation error	13	7.3*	1	0.2	5	17.9*	2	12.5	21	2.5
Drug distribution system	18	10.2*	3	0.5	0	0	0	0	21	2.5
Documentation	8	4.5*	7	1.1	2	7.1	1	6.3	18	2.1
Monitoring inadequate/lacking	4	2.3	10	1.6	1	3.6	1	6.3	16	1.9

* Significantly greater at $p < 0.05$ (chi-square or Fisher's exact test compared to all other code-related errors)
† Multiple causes of errors may be reported for each error; therefore column totals may exceed 100%

errors were often attributed to work load increases, insufficient staffing, work flow disruption, and performance deficit. Fortunately, these errors were likely to result in near misses rather than patient harm.

Even after controlling for harm level, however, collateral damage errors were far less likely to result in any action to reduce the risk of recurrence and, when actions were taken, they were often not policy-level actions. This lack of corrective action is troubling given that all errors harbor the potential for harm and even death. Often, little is known about harmless errors and near misses, making it difficult to make system-level changes to prevent a similar error from leading to a sentinel event; with this large number of collateral damage errors, we have uncovered system-level problems in ready need of corrective action.

Table 5. Actions Taken as Result of the Error, by Relationship to Code Situation

	Error to Patient Involved in Code *n* = 177		Error to Another Patient = 621		Error Preceding Code *n* = 28		Error After Code *n* = 16		Total *n* = 842	
	n	%	*n*	%	*n*	%	*n*	%	*n*	%
No action taken	70	39.5	509	82.0	10	35.7	10	62.5	599	71.1
Action taken	107	60.5	112	18.0*	18	64.3	6	37.5	243	28.9
No policy-level action taken	161	91.0	603	97.1	25	89.3	16	100	805	95.6
Policy-level action taken	16	9.0	18	2.9*	3	10.7	0	0	37	4.4

* Significantly less at $p < .001$ (chi-square or Fisher's exact test compared with all other code-related errors).

Strategies for Reducing Errors: Prevention of Code Situations

The ideal solution to the problem of code-related medication errors is prevention of code situations. Although complete elimination is not a realistic goal, reducing the frequency of code situations is potentially feasible. Implementation of rapid response systems (RRS) is one strategy that may decrease the frequency of codes. In one study, introduction of an RRS was associated with a 50% reduction in the incidence of unexpected cardiac arrest.[18] Although a recent systematic review of RRSs found only weak to moderate evidence that such systems are associated with a decrease in cardiac arrest rates,[19] these systems do show promise in reducing the number of code situations. However, RRSs still require planning for the adequate coverage of all patients when caregivers on the rapid response team respond to a deteriorating patient.

Another strategy involves do-not-resuscitate (DNR) orders. The frequency of errors due to code situations highlights the importance of having early conversations with patients regarding code status and DNR orders. Knowledge of a patient's preference not to be resuscitated can save the patient from the trauma of being coded, save the family from the anguish that such a situation can bring about, and prevent collateral damage errors from affecting other patients. Still, only 52% of patients who do not wish to be resuscitated have DNR orders on their charts.[20]

Strategies for Reducing Collateral Damage Errors

Although reduction in the frequency of code situations may decrease the incidence of all code-related errors, other system-level solutions must also be considered to reduce the risk of future harm (Table 7, page 55). Given the frequency with which work load increases, insufficient staffing, and workflow disruption were associated with collateral damage errors (Sidebar 1, page 55), staffing level and structure and cross-coverage protocols and strategies should be scrutinized. Increased nurse staffing levels have been shown to reduce adverse patient outcomes, decrease rates of cardiac arrest, and shorten lengths of stay in both medical and surgical patients.[21] Undoubtedly, increased nurse staffing levels would decrease the incidence of collateral damage errors associated with code situations. However, such a solution has significant financial costs. Other, less expensive solutions could include staffing redesign, such that every patient has a backup care provider in the event his or her primary care provider is away at a code, and cross-coverage protocols for code situations.

Because omissions of respiratory therapy as a result of another patient's code situation were found at such high frequency, consideration of these treatments is warranted. First, we should ask whether they are necessary in all cases. Although evidence substantiates the usefulness of nebulizer treatments in asthma,[22] chronic obstructive pulmonary disease,[23] and mechanically ventilated patients,[24] widespread use in hospitalized patients is not supported in the literature. Indeed, respiratory therapy is only one example of drugs that are commonly used, perhaps without a valid clinical indication. Research into the proportion of patients receiving drug therapy without a valid indication

Table 6. Results of Logistic Regression Analysis with Any Corrective Action as Outcome Variable (n = 842)

	Odds Ratio	Robust 95% CI		p Value
		LL	UL	
Collateral damage error*	0.12	0.08	0.20	< .001
Harm	0.73	0.37	1.43	0.36
Contributing factor reported†				
Distractions	9.76	2.86	33.29	< .001
Emergency situation	2.08	1.19	3.65	0.01
Workload increase	2.62	1.26	5.47	0.01
Staffing issues	5.21	3.27	8.31	< .001
Location of error				
Intensive care unit	1.78	0.94	3.35	0.08
Pediatrics	1.44	0.40	5.16	0.57
Error caused by human deficit	1.54	1.06	2.24	0.02
Hosmer-Lemeshow Chi-Square	6.38			0.38

*Compared with other code-related errors. CI, confidence interval; LL, lower limit; UL, upper limit.

† Compared with reports with no contributing factor other than "code situation."

must be undertaken, and the unnecessary use of such treatment should be stopped. Second, the human resources associated with the administration of these medications should be addressed. The free-text descriptions of collateral damage errors in our study implied that in many institutions, nurses are not permitted to administer respiratory treatments even when a respiratory therapist is busy in a code situation. Although division of labor is obviously beneficial, rigid policies and procedures regarding delineation of responsibilities regarding respiratory therapy, as well as other duties, may need to be modified to ensure appropriate provision of care when human resources are limited.

Study Limitations

First, although the sample was drawn from one of the largest medication error reporting systems in the United States, the sample size in our study is relatively small and may not accurately reflect the universe of code-related errors. It is also possible that the proportion of collateral damage errors in our study overestimates the actual proportion of collateral damage errors among all code-related errors. This may be true for several reasons. Errors involving the coding patient may be underreported. Because the expected success rate of resuscitation is low, "an unsuccessful outcome does not invoke looking for errors in treatment."[13(p. 404)] In addition, patients involved in a failed resuscitation do not show signs of unexpected deterioration as other patients do, making errors harder to identify. Further, collateral damage errors may have been overreported in our database by nurses and respiratory therapists eager for change in policies and/or practices. More than 100 of the collateral damage errors came from one facility; however, the reports were submitted during a period of three and a half years, and results of the primary analysis did not differ significantly when these reports were excluded (analysis not shown), suggesting this cluster did not significantly affect our conclusions.

A second consideration is that MEDMARX error reports may underestimate the level of resulting harm because of omitted or unknown data. Providers who complete the error reports may not know or evaluate the full impact of the collateral damage error, especially if that impact is delayed. Providers may also be hesitant to report the actual severity of a harmful error because of fear of reprisal or lack of a culture of safety. Indeed, in our analysis, we observed that reporters of code-related errors tended to underestimate the level of severity of the error; for example, errors preceding code situations often were not reported as errors "that required intervention necessary to sustain life"—the definition of a code situation. In addition, many omission errors were reported as errors that "did not reach the patient." Of course, omission errors by definition involve medication failing to reach the patient; but it does not necessarily follow that the error (and its deleterious effects) does not reach the patient.

This study is also limited by our assumption that errors

Table 7. Strategies for Reducing Code-Related Medication Errors

1. Reduce the frequency of code situations.
   - Implement Rapid Response Systems (RRS).
   - Review institutional policies and procedures regarding do-not-resuscitate (DNR) orders.
   - Ensure adequate patient-to-staff ratios.
2. Reduce collateral damage medication errors.
   - Consider "redundant staffing" so that all patients have "backup" providers in the event their primary providers are responding to a code. (This may include creating "groups" of patient responsibility so that more than one person is familiar with each patient.)
   - Develop cross-coverage protocols to care for patients whose providers are responding to a code.
   - Avoid cross-coverage of patients by providers who do not know them.
   - Examine institutional policies and procedures regarding indications for the necessity of respiratory therapy.
   - Consider whether trained nurses can deliver respiratory drugs when respiratory therapists are responding to a code or other emergency.
   - Develop protocols and systems that require a double-check for all medication administration for all patients when a cardiopulmonary arrest or RRS event occurs on the ward.
3. Review postcode procedures.
   - Establish clear roles and responsibilities for postcode procedures, including restocking the "crash cart."

with no reported corrective action resulted in no action. In fact, some of the errors with no reported corrective action might have resulted in corrective action that was either not reported or took place after the error report was filed. Finally, other limitations of this study relate to the use of data from an anonymous reporting system. These include inability to assess the validity of the data as well as the inability to identify over- and underreporting. Although we excluded code situation errors that clearly used a different definition of *code situation* than the one employed by MEDMARX, it is possible that not all code-related errors included in this analysis were truly related to code situations in accordance with the MEDMARX definition. It is also possible that some errors related to MEDMARX-defined code situations were mistakenly omitted because of our relatively conservative inclusion criteria.

Sidebar 1. Case Study

A complex patient with a medical history that included hypertension, coronary artery disease (CAD), and severe chronic obstructive pulmonary disease (COPD) was recuperating on an intermediate-care medical ward after a COPD exacerbation associated with a pulmonary infection. The patient's medications included a course of levofloxacin for the infection, intravenous (IV) metoprolol and enalapril for the hypertension and CAD, and IV hydrocortisone taper for the COPD exacerbation.

One evening, the patient's registered nurse (R.N.) became involved in the cardiac arrest of another patient on the ward. The resuscitation was long but successful, and the nurse became very busy arranging for the transfer of the postcode patient to the intensive care unit. The R.N. asked a licensed practical nurse (L.P.N.) to administer the COPD patient's IV medications, which were due during the time he was occupied with the coding patient. The L.P.N., who had not previously cared for the COPD patient, accessed the medication administration record but mistakenly administered the metoprolol, hydrocortisone, and enalapril to a third, unrelated patient, who did not have a history of hypertension or COPD.

After the code patient's transfer was completed, the R.N. noted that the medications had been administered to the wrong patient. Physical examination and vital signs demonstrated that, despite the error, the patient who mistakenly received the three medications was able to maintain his blood pressure and heart rate within acceptable limits, although these vital signs were depressed from baseline. This patient required an increased level of monitoring. The patient with the COPD exacerbation received the appropriate medication several hours late.

The MEDMARX report of this incident identified the following factors as contributing to the error:

- Communication
- Performance (human) deficit
- Procedure/protocol not followed
- Work flow disruption
- Code situation
- Distractions

Conclusion

Medication errors associated with code situations not only affect only the patient involved in the code but have implications for other patients as well. Code-related errors involving the coding patient carry significant risk for harm, whereas collateral damage errors seem to have a

lower risk. However, because collateral damage errors are often secondary to system problems such as understaffing and limited cross-coverage, they are likely harbingers of future harmful errors. Unfortunately, collateral damage errors are unlikely to result in corrective action. The system problems exposed by collateral damage errors deserve attention. Further research into the causes and consequences of these errors is in order. Action must be taken at the policy level to mitigate the weaknesses in the system that allow these errors to occur. J

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