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Frequency of Adverse Events Before, During, and After Hospital Admission

Lindsay D. Croft, MS, PhD, Michael E. Liquori, MD, James Ladd, MD, Hannah R. Day, MS, PhD, Lisa Pineles, MA, Elizabeth M. Lamos, MD, Preeti Mehrotra, MD, Eli N. Perencevich, MD, MS, Anthony D. Harris, MD, MPH, and Daniel J. Morgan, MD, MS

Department of Epidemiology and Public Health and the Division of Endocrinology, Diabetes and Metabolism, University of Maryland School of Medicine, Baltimore, the Department of Medicine, Thomas Jefferson University Hospital, Philadelphia, Pennsylvania, Sinai Hospital, Baltimore, Maryland, the Department of Medicine, Division of Infectious Diseases, Boston Children's Hospital, Boston, Massachusetts, and the Carver College of Medicine, University of Iowa, Iowa City.

Abstract

Objectives—Adverse events (AEs) are unintended physical injuries resulting from or contributed to by medical or surgical care. We determined the frequency and type of AEs before, during, and after hospital admission.

Methods—We conducted a cohort study of 296 adult hospital patients. We used the standardized Institute for Healthcare Improvement Global Trigger Tool for Measuring Adverse Events to review the medical records of the hospital patients for occurrence, timing relative to hospital admission, severity, and preventability of AEs. We also identified the primary physiologic system affected by the AE.

Results—Among 296 patients, we identified 338 AEs. AEs occurred with similar frequency before ($n = 148$; 43.8%) and during hospital admission ($n = 162$; 47.9%). Fewer AEs occurred after discharge ($n = 28$; 8.3%). Half of all AEs ($n = 169$; 50.0%) were severe, whereas 47.9% ($n = 162$) were preventable.

Conclusions—AEs occur with similar frequency before and during hospitalization and may contribute more to hospital admissions than previously recognized. These findings suggest that efforts to improve patient safety should include outpatient settings in addition to the more commonly targeted acute care settings.

Keywords

adverse events; patient harm; patient safety

Adverse events (AEs) are “unintended physical injuries resulting from or contributed to by medical or surgical care.”¹ AEs have been reported to occur during 3.7% to 16.6% of all

Correspondence to Dr Daniel J. Morgan, Department of Epidemiology and Public Health, University of Maryland School of Medicine, 685 W Baltimore St, MSTF 334, Baltimore, MD 21201. dmorgan@epi.umaryland.edu.

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hospital admissions.² Most studies of hospital AEs have focused on the frequency of AEs that occur during hospitalization.^{3–5} Data from >10 years ago suggest that 11% to 14% of AEs may occur outside acute care hospital settings,² whereas others report that 5.4% of all admissions are directly caused by AEs.⁶ In light of shifts in health care to the outpatient setting, we investigated the frequency of patient AEs in and outside the hospital in a prospective cohort of hospitalized patients.

Methods

We conducted a prospective cohort study of general medical and surgical patients at an academic tertiary care hospital between January 2010 and November 2010. Patients were required to have a minimum 3-day length of stay to be eligible for the study. The study was approved by the institutional review board at our institution. Further information on demographics of the cohort has been reported elsewhere.^{7,8}

AEs were defined as “unintended physical injury resulting from or contributed to by medical or surgical care that requires additional monitoring, treatment, or hospitalization or results in death,” as used by the Institute for Healthcare Improvement (IHI).¹ We identified AEs using the IHI Trigger Tool for Measuring Adverse Events, which is a standardized method for completion of structured medical record reviews within approximately 20 minutes.¹ Three initial reviewers used the trigger tool to review the patient charts of all of the members of the cohort for AEs. One initial reviewer (L.D.C.) reviewed all 296 cohort members and two physician reviewers (M.L. and J.L.) each reviewed half (n = 148) of the cohort. A third physician reviewer (D.J.M.) adjudicated any disagreements on AE occurrence among initial reviewers, per the IHI Global Trigger Tool method.¹ Reviewers determined whether each AE began before, during, or after the admission during which the patient was enrolled in the study. Prior AEs were those noted in the medical record for the index admission as having occurred during the patient encounter, before the index admission. A similar definition applied to the subsequent admission was used to determine occurrence of an AE after the index admission.

We rated AE severity using a five-point Likert scale (minimal, clinically significant, serious, life-threatening, fatal) with a severity index modified from the National Coordinating Council for Medication Error Reporting and Prevention.^{1,9} AEs were categorized as clinically significant if they represented symptomatic laboratory abnormalities, panic laboratory values, or common toxicity criteria. Serious AEs represented organ dysfunction (eg, delirium, pulmonary embolism, myocardial infarction, cerebrovascular accident), whereas life-threatening AEs occurred when death was possible without treatment (eg, intubation, pressor medications) within a few hours. Preventability was measured on a four-point Likert scale (definitely, probably, probably not, or definitely not preventable), as used previously.^{10–12} Preventable AEs were those considered preventable by existing knowledge, practice standards, or technology by the physician reviewers.¹¹ As a framework to help evaluate preventability, reviewers were asked to consider whether there was any way to prevent the AE from occurring (eg, with closer monitoring, patient or staff education, team training, information technology intervention). In addition to severity and preventability, AEs were categorized by the primary physiological system affected (Table 1). More than one

AE during an admission was allowed per patient, but only the first eligible admission was reviewed for AE occurrence (multiple admissions during the study period were not included). Additional details on study definitions and design have been described elsewhere.⁸

To better assess the clinical context of the AEs and aid future intervention efforts, we also examined the AEs identified to be both preventable and severe and then categorized the type of resulting harm as one of seven common patient harms: healthcare-associated infection, falls with injury, hospital-acquired pressure ulcers, medication-related harms, procedure-related harms, failure to prevent known complications, and iatrogenic AEs (eg, pneumothorax after central line placement).

Results

A little more than half of our study population was men (54.5%; Table 1), approximately half had at least some college education (47.6%), and slightly less than half (45.9%) of the population had the median Charlson comorbidity score of 2. Only 22 patients were admitted to the intensive care unit during their hospitalization; the majority were admitted to general medicine units (64.9%). The average age of patients in our study was 52.1 years (standard deviation 14.2).

Among 296 patients, we identified a total of 338 AEs (Table 2); 118 patients (39.9%) had an AE immediately before, 104 patients (35.1%) during, and 24 patients (8.1%) after the index admission. Of these AEs, 47.9% were severe and 50.0% were considered preventable. Six patients (2.0%) experienced an AE before, during, and after admission. The number of AEs observed during hospitalization (162 of 338 AEs, 47.9%) was similar to the frequency of AEs before hospitalization (43.8%); both were much more common than AEs after admission (8.3%).

There appeared to be fewer AEs affecting the cardiovascular, respiratory, renal or endocrine, and gastrointestinal systems for AEs occurring before the index admission as compared with during. Only healthcare-associated infections were more common before admission than during hospitalization. Severe AEs were 1.5 times more common among AEs before admission than during admission (Table 2).

Among the 338 AEs, 92 were both preventable and severe. Of the 92, 77 (83.7%) resulted in serious organ dysfunction, 14 (15.2%) were life threatening, and 1 (1.1%) was fatal. The majority of AEs that were preventable and severe occurred before admission (48 AEs, 52.1%) and 35.9% of AEs (n = 33) occurred during admission. Eleven (12.0%) of the preventable and severe AEs occurred after admission. More than one-third of these preventable, severe AEs were some type of healthcare-associated infection (n = 35, 38.0%; Table 3), which was primarily driven by surgical site infections. A similar frequency of AEs was harm caused by or contributed to by medications (n = 28; 30.4%), most often hypoglycemia related to insulin use, oversedation from pain medications, and administering medications at a too-high dose. AEs related to procedures were slightly less frequent (21.7%), whereas falls, failure to prevent known complications of medical interventions, and

iatrogenic AEs were much less common. No pressure ulcers were both preventable and severe.

Discussion

In this cohort study, we identified a high frequency of AEs in patients before hospital admission, with a similar proportion occurring before and during the index admission. Few were detected after discharge. AEs before admission tended to be healthcare-associated infections and severe.

We observed a similar frequency of inpatient AEs compared with other studies^{3,5} and found that half of inpatient AEs are preventable, similar to previous findings.¹¹ Unlike these previous studies, however, we also examined AEs occurrence before and after hospital admission. Our results suggest that AEs may be contributing more to hospital admissions than previously recognized.² Reasons for a greater proportion of AEs occurring outside the acute care hospital setting may relate to the shift toward more aggressive outpatient care, including the expansion of ambulatory surgery and hemodialysis.^A We also observed that the most severe but preventable AEs often were healthcare-associated infections (primarily surgical site infections), medication-related harm, and bleeding AEs related to procedures. The frequency with which healthcare-associated infections occurred highlights the continuing importance of infection control programs and of extending the focus of these prevention efforts to the outpatient setting (where surgical site infection prevention efforts are minimal). The frequency of central-line associated bloodstream infection likely relates to home use of intravenous treatments. Prevention of such infections has been a focus within the hospital setting, but efforts may not translate to the outpatient setting. A wide range of medication-related harms occurred but insulin-related hypoglycemia in both the inpatient and outpatient settings was the most common. Harm-reduction efforts may focus on increased patient education regarding insulin use as well as among healthcare workers, given that a number of the AEs occurred during the hospital admission. In addition, because a number of preventable, severe AEs were related to the use of pain medications and the administration of a too-high dose of several different medication types, more general patient safety interventions could be targeted at increasing healthcare worker awareness of medication risk profiles and creating built-in measures designed to decrease the likelihood of medications being ordered at an excessive dosage. The overall preventability of AEs often relates to overly long or aggressive care. There is a growing awareness that overly aggressive use of medical devices can lead to infections and should be avoided,¹³ and likewise that overly aggressive use of insulin and other medications can result in more harm than benefit.¹⁴

Our population also included patients admitted from long-term care facilities (AEs that were classified as before admission). Our study was limited to a single-center cohort with a moderate sample size, yet was strengthened by the inclusion of AE assessment by two reviewers using a standardized tool. Because our definition of prior AEs may have selected for AEs severe enough to be noted in subsequent records, it is possible we underestimated

^AReference citation needed for sentence beginning "Reasons for a greater proportion."

the number of prior AEs. Furthermore, most AE and error-reporting systems (hospital based or Agency for Healthcare Research and Quality Patient Safety Indicators), as well as interventions, are focused on inpatient AEs. Considering the frequency with which AEs were found to occur in advance of the index admission, an expanded scope of AE monitoring and intervention should be strongly considered.

Conclusions

Patients were more likely to experience an AE before hospital admission than during hospitalization. This change in the epidemiology of AEs may reflect trends toward outpatient care. Quality improvement programs should focus on the outpatient setting as well as acute care hospitals to reduce AEs and medical overuse, with a focus on improving overall patient safety.

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Key Points

- Adverse events (AEs) occur with similar frequency before and during hospitalization.
- AEs often are severe and preventable, especially AEs that occur before or during hospitalization.
- AEs may contribute to hospitalization more than previously recognized.

Table 1

Demographic characteristics of patient cohort

Characteristic	n (%)
Age, y, mean $\pm$ SD	52.1 $\pm$ 14.2
Male sex	161 (54.4)
Education (some college)	141 (47.6)
Married or living with partner	131 (44.3)
Minority (nonwhite and/or Hispanic)	144 (48.6)
Charlson comorbidity score ≥ 2	136 (45.9)
Admission to intensive care unit during hospitalization	22 (7.4)
Study enrollment location	
General medicine	192 (64.9)
Surgery/transplant	68 (23.0)
Oncology	36 (12.1)
Length of hospital stay, d, median (IQR)	4.9 (3.5–7.9)

IQR, interquartile range; SD, standard deviation.

Table 2Frequency of specific AE types by time of event occurrence^a

Type of AE	Total events, n = 338	Events before, n = 148	Events during, n = 162	Events after, n = 28
Infectious	83 ^A	55 ^B	16	12
Catheter-related bloodstream infection	14	10	3	1
Nosocomial pneumonia, not ventilator related	9	5	1	3
Urinary tract infection	12	6	3	3
Surgical site infection	24	19	2	3
<i>Clostridium difficile</i> colitis	9	3	5	1
Other healthcare-associated infection ^b	14	11	2	1
Cardiovascular system	13 ^C	4 ^D	9	0
Hypotension	9	3	6	0
Arrhythmias or conduction abnormality	3	0	3	0
Respiratory system	9	0	8	1
Acute respiratory failure	4	0	4	0
Pneumothorax or atelectasis	3	0	3	0
Other respiratory event ^C	2	0	1	1
Renal or endocrine system	37	13	22	2
Fluid overload	4	1	3	0
Acute renal failure	11	5	5	1
Hyperglycemia	10	5	5	0
Hypoglycemia	10	1	8	1
Other renal or endocrine event ^d	2	1	1	0
Hematologic system	31	17	10	4
Hemorrhage	4	1	2	1
Thromboembolic venous event	11	7	2	2
Hematoma	4	2	2	0
Other hematologic event ^e	12	7	4	1
Gastrointestinal system	63	14	46	3
Nausea or vomiting	47	8	39	0
Diarrhea	7	3	3	1
Constipation	5	2	3	0
Other gastrointestinal event ^f	4	1	1	2
Neurologic system	14	6	8	0
Oversedation	7	1	6	0
Delirium or encephalopathy	6	4	2	0
Other neurologic event ^g	1	1	0	0
Surgical event	34	13	19	2
Postoperative hemorrhage/hematoma	18	3	14	1
Laceration or other organ injury	2	1	1	0

Type of AE	Total events, n = 338	Events before, n = 148	Events during, n = 162	Events after, n = 28
Other surgical event ^h	14	9	4	1
Other types of harm	54	26	24	4
Allergic reaction	13	1	11	1
Pyrexia	2	1	1	0
Fall	2	1	1	0
Pressure ulcer	10	7	2	1
Rash	3	1	1	1
Catheter complication	3	1	2	0
Other ⁱ	21	14	6	1
Severe events ^{j,k}	162	86	57	19
Preventable events ^{j,l}	169	69	85	15

^A Col only equals 82.

^B Col only equals 54.

^C Col only equals 12.

^D Col only equals 3.

AE, adverse event.

^a AEs occurring in one physiologic system are mutually exclusive and do not appear elsewhere within other types of AEs/harms unless otherwise indicated.

^b Other hospital-acquired infection events include bronchitis; infected implantable cardioverter-defibrillator; abscess, bacteremia, and/or infections of liver, lung, perianal area, or lower extremities caused by immunosuppressants; oral *Candida albicans*; hemodialysis catheter endocarditis; infected aortic/mitral valve replacement with recurrent bacteremia; and *Klebsiella* bacteremia.

^c Other respiratory events include aspiration and medication-induced pulmonary toxicity.

^d Other renal or endocrine events include hyponatremia and hypovolemia secondary to diuresis.

^e Other hematologic events include chemotherapy-induced need for transfusion and/or neutropenia or thrombocytopenia, medication-induced thrombocytopenia, medication-induced leukopenia, medication-induced anemia, chemotherapy-related anemia, postoperative thrombophlebitis, thrombophlebitis from an intravenous therapy requiring vein excision, and medication-induced methemoglobinemia.

^f Other gastrointestinal events include medication-related Crohn disease flare or gastrointestinal upset, pancreatic fistula, esophagogastroduodenoscopy-related transfusion, and epigastric pain.

^g Other neurologic events include chemotherapy-induced paresthesia and neuropathy.

^h Other surgical events include wound dehiscence; failed procedure; unplanned return to surgery; perfusion-related swelling, numbness, and lower extremity wounds; periorbital cellulitis and fluid collection; itching and insomnia; ureteral stricture; small bowel obstruction posttransplant; collapsed arterial stent; anesthetic-induced transaminases and bilirubin elevation; acute rejection; and endoscopic retrograde cholangiopancreatography-related acute on chronic pancreatitis.

ⁱ Other types of AEs include chemotherapy-related mucositis; medication-related nausea, vomiting, and diarrhea; posttransplant graft-versus-host disease, nausea, and vomiting; medication-induced hepatic impairment; medication-induced restless leg; chemotherapy-induced muscositis, nausea, vomiting, acute renal failure, and elevated transaminases; radiation-induced swelling; hyperkalemia and prerenal azotemia from percutaneous endoscopic gastrostomy tube clog; severe gout flare related to rapamune-induced arthritis; hypotension, edema and ostomy site protrusion caused by retained fluid from high ostomy output; pain and urine leakage from ureteral stent irritation; skin breakdown caused by ostomy site leakage; posttransplant lymphoproliferative disorder; narcotic-induced itching; peristomal skin excoriation; medication-induced gallstones requiring surgery

and transfusion; narcotic-related constipation, bloody stool, nausea, and vomiting with duodenal abscess; striae secondary to long-term prednisone use; syncope, low glucose, and hypoglycemia; and patch site itching.

^jNot included in total AEs count for the rest of the table because these AEs are not mutually exclusive of physiological system affected.

^kSevere events include AEs that are serious (eg, organ dysfunction), life threatening (death possible without therapy within a few hours), and death.

^lPreventable events are AEs that are considered probably or definitely preventable by current practice standards, knowledge, and/or technology.

Table 3

Description of AEs that were serious and preventable (N = 92)

Description	n
Healthcare-associated infection	35
Catheter-related bloodstream infection	8
Nosocomial pneumonia, not ventilator related	1
Urinary tract infection	1
Surgical site infection	17
<i>Clostridium difficile</i> colitis	2
Sepsis or bacteremia unrelated to catheter	1
Other healthcare-associated infection	5
Fall with injury	1
Humerus fracture, requiring open reduction and internal fixation surgery	1
Medication-related harm ¹	28
Acute renal failure (contrast-induced nephropathy and vancomycin toxicity; cisplatin induced, requiring dialysis; cefepime induced)	3
Constipation, bloody stool, nausea, vomiting, and duodenal abscess related to narcotic use	1
Hypoglycemia, altered mental status (9 caused by insulin, 1 caused by immunosuppressants)	10
Orthostatic hypotension caused by furosemide and lisinopril	1
Overdose	5
Tacrolimus-related acute renal failure	1
Supratherapeutic deep vein thrombosis treatment, requiring transfusion	3
Voriconazole-induced fluid overload	1
Oversedation (morphine, narcotics, or combination of morphine and diphenhydramine)	5
Posttransplant lymphoproliferative disorder related to mycophenolic acid use	1
Steroid-induced hyperglycemia ^a	2
Procedure-related harm	20
Endoscopic retrograde cholangiopancreatography-induced acute on chronic pancreatitis	1
Esophageal perforation resulting from esophageal dilation	1
Hemorrhage, anemia, hematoma, hypotension, and/or altered mental status postoperatively, requiring transfusion ^b	11
Hypotension resulting from too much fluid removal during hemodialysis	1
Pain and hematuria due to ureteral stent, requiring stent removal	1
Pancreatic fistula after Whipple procedure	1
Postoperative afibrillation	1
Postoperative hemoperitoneum	1
Postoperative pain and diarrhea requiring hospital readmission	1
Postoperative thrombophlebitis	1
Failure to prevent known complication	4
Aspiration pneumonia	1
Postoperative bilateral deep vein thrombosis	2
Skin breakdown from leaking ostomy site	1

Description	n
Iatrogenic event	4
Thrombophlebitis leading to vein excision due to IV therapy	1
Deep vein thrombosis resulting from catheter (peripherally inserted central catheter, dialysis catheter)	2
Medication and blood leak from central catheter leading to readmission with pulmonary hypertension	1

AE, adverse event; IV, intravenous.

^aOne case was overcorrected, resulting in symptomatic hypoglycemia.

^bOne case also had hematuria and bleeding from endotracheal tube, which was fatal.

^lThis col equals 33, not 28.