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Adverse events among medical patients after discharge from hospital

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Abstract

Background: Adverse events (AEs) are adverse outcomes caused by medical care. Several studies have indicated that a substantial number of patients experience AEs before or during hospitalization. However, few data describe AEs after hospital discharge. We determined the incidence, severity, preventability and ameliorability of AEs in patients discharged from the general internal medicine service of a Canadian hospital.

Methods: At a multisite Canadian teaching hospital, we prospectively studied patients who were consecutively discharged home or to a seniors' residence from the general internal medicine service during a 14-week interval in 2002. We used telephone interview and chart review to identify outcomes after discharge. Two physicians independently reviewed each outcome to determine if the patient experienced an AE. The severity, preventability and ameliorability of all AEs were classified.

Results: During the study period, outcomes were determined for 328 of the 361 eligible patients, who averaged 71 years of age (interquartile range 54–81 years). After discharge, 76 of the 328 patients experienced at least 1 AE (overall incidence 23%, 95% confidence interval [CI] 19%–28%). The AE severity ranged from symptoms only (68% of the AEs) or symptoms associated with a nonpermanent disability (25%) to permanent disability (3%) or death (3%). The most common AEs were adverse drug events (72%), therapeutic errors (16%) and nosocomial infections (11%). Of the 76 patients, 38 had an AE that was either preventable or ameliorable (overall incidence 12%, 95% CI 9%–16%).

Interpretation: Approximately one-quarter of patients in our study had an AE after hospital discharge, and half of the AEs were preventable or ameliorable.

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The Institute of Medicine report *Crossing the quality chasm* identifies patient safety as a prerequisite to high-quality care.[1] The need to improve safety is highlighted by research showing that hospitalized patients have a high risk of adverse outcomes resulting from treatment. For example, the Harvard Medical Practice Study found that adverse events (AEs) occurred in 3.7% of hospitalized patients.[2,3] Similar studies have found equivalent or greater rates.[4–6] Other research has found that AE risk increases with design flaws in the health care system.[7–10]

Such flaws may particularly affect patient care immediately after hospital discharge, a period associated with discontinuities in providers and in location of care. Some authors suggest that such "gaps" are important causes of error.[11] It is also a time when patients frequently experience extensive changes in health[12] and therapy.[13] Finally, communication between hospital and community physicians can be inadequate.[14] For these reasons, AEs may be common after discharge.

A recent study, by a group that included 1 of us, found that 19% of medical patients discharged from a single teaching hospital in the United States experienced an AE within a month.[15] One-third of these AEs were preventable because they were due to an error. Another third were judged "ameliorable" because their severity could have been reduced with better monitoring or earlier response to the problem.[15]

That study was important, but it had limitations. It was carried out in a single, very specialized institution, it relied on data available in an electronic medical record, and it had a high rate of loss to follow-up. To address these concerns, we carried out a new study to determine the risk, severity and type of AEs after discharge from 2 campuses of a Canadian teaching hospital.

Methods

This was a prospective study conducted at the Ottawa Hospital, a multisite tertiary-care teaching hospital. The protocol was approved by the Ottawa Hospital Research Ethics Board.

Consecutive patients discharged to independent or residential living from the general internal medicine service at the Ottawa Hospital over a 14-week interval in 2002 were eligible for the study. The general internal medicine service is staffed by an attending physician and several house staff. Patients are admitted from the emergency department (ED), and most are previously unknown to the attending physician. If necessary, discharge to the community is facilitated by home-care coordinators and social workers. At discharge, patients receive a handwritten interim report, which they take to follow-up physician visits. In addition, an official discharge summary is mailed to these physicians. Follow-up care is performed by the general internist if this is thought to be necessary.

We reviewed each patient's medical chart to record demographic data and information on chronic illnesses and the hospitalization. We telephoned the patient approximately 30 days after discharge. If the patient consented, a registered nurse or physician administered a structured telephone interview to determine the posthospital course.

We first determined, by means of a complete review of systems, whether the patient had any new or worsening symptoms. To assess the severity of any such symptom, we asked how the symptom affected physical functioning and what the patient had done to help resolve the symptom, including whether the cause had been determined. Timing of the symptom in relation to the hospitalization was documented. Finally, we recorded the date, location and reason for all physician visits, ED visits and hospital readmissions.

If the patient was unable to complete the telephone interview because of cognitive or language difficulty, we interviewed the caregiver or someone else living in the home.

If the patient visited the study hospital's ED or was readmitted to the study hospital, the medical record was reviewed to determine the reason for the encounter and its outcome. For an ED visit or admission to another hospital, we relied on the patient's description of the outcome, since the chart was unavailable. This occurred with 5 patients.

If we were unable to contact a patient after 3 months, we used a number of means to identify outcomes. First, we reviewed administrative databases to determine if ED visits or readmissions had occurred at the study hospital. Then, if we had not determined the patient's outcome, we checked with the registration departments of 2 local community hospitals to determine if the patient had visited their ED or had been admitted. Finally, we used the regional vital statistics registry to determine if the patient had died.

Patients were considered to have had an adverse outcome if, after discharge, they had new or worsening symptoms, a physician or health-facility visit that was unscheduled (i.e., not booked at the time of discharge), an ED visit or readmission to hospital, or if they had died. For such patients, 1 of us (A.J.F.) systematically summarized information from the chart review, telephone interview and records of any postdischarge ED visit or rehospitalization. The outcome summary included a detailed description of all outcomes, including time of onset, severity, health services used and resolution. When a patient had more than 1 adverse outcome, we prepared an outcome summary for each outcome.

All outcome summaries were independently reviewed by 2 certified general internists (H.D.C. and C.W.). Each summary was rated with standard techniques from previous research.[3–6,15] Briefly, the reviewers first determined whether the patient had experienced an adverse outcome. If so, they used a 6-point ordinal scale to cite their confidence that medical management had caused the adverse outcome (1, no evidence that the outcome was due to treatment; 2, little evidence that the outcome was due to treatment; 3, the outcome was possibly due to treatment [50/50 chance] but was more likely due to disease; 4, the outcome was possibly due to treatment [50/50 chance] and was more likely due to treatment than to disease; 5, the outcome was probably due to treatment; and 6, the outcome was definitely due to treatment). If both reviewers judged that the adverse outcome was probably or definitely due to medical management (rating 5 or 6), it was classified as an AE. If both reviewers judged that the adverse outcome was not caused by medical management (rating 4 or less), it was not classified as an AE. If there was disagreement, a third certified internist (A.J.F.) rated the event independently.

The 2 reviewers independently rated the type, severity, preventability and ameliorability of all the AEs. As in previous studies,[3–6,15] AE type was classified as adverse drug event, procedure-related injury, nosocomial infection, fall, therapeutic error, diagnostic error or other. AE severity was categorized as serious laboratory abnormality only, 1 day of symptoms, several days of symptoms, nonpermanent disability, permanent disability or death. Symptoms had to interfere with a patient's activities of daily living to be categorized as nonpermanent disability. AEs were considered preventable if the 2 reviewers agreed, using implicit judgement, on whether the outcome could have been prevented. AEs were considered ameliorable if the 2 reviewers agreed that the outcome severity could have been substantially reduced if alternative actions or procedures had occurred. If the 2 reviewers disagreed in their assessments of preventability or ameliorability, the third reviewer rated the outcome summary independently.

These reviews had moderate to high interrater reliability. For AE judgements the reviewers agreed 86% of the time on initial review ($\kappa = 0.61$). The third reviewer rated 22 of the 37 discrepant event summaries as indicating AEs. For preventability ratings there was 73% agreement ($\kappa = 0.44$), and for ameliorability ratings there was 90% agreement ($\kappa = 0.77$).

For the descriptive results, we described proportions and their 95% confidence intervals (CIs), as calculated by the Wilson score method. In addition, we used the Student's *t*, Wilcoxon rank-sum and χ^2 tests to determine the univariate association between outcomes of interest and continuous, ordinal and categorical vari-

Table 1: Characteristics of patients consecutively discharged from the general internal medicine service of a teaching hospital

Characteristic	Study participants *n = 328*	Patients lost to follow-up *n = 33*	*p* value*
Female, no. (and %)	147 (55)	18 (45)	0.28
Median age (and IQR), yr	71 (54–81)	67 (52–81)	0.58
No. (and %) with baseline disabilities†			0.81
0	255 (78)	27 (82)	
1–4	53 (16)	4 (12)	
5	17 (5)	2 (6)	
Median Charlson index‡ (and IQR)	2 (1–3)	1 (0–2)	0.14
No. (and %) with chronic illnesses			
Obstructive lung disease	92 (28)	7 (21)	0.40
Coronary artery disease	83 (25)	5 (15)	0.20
Type 2 diabetes mellitus	75 (23)	7 (21)	0.83
Psychiatric disorders	58 (18)	1 (3)	0.05
Congestive heart failure	53 (16)	3 (9)	0.29
No. (and %) with acute conditions			
Pneumonia	74 (23)	11 (33)	0.16
Acute renal failure	45 (14)	5 (15)	0.82
Exacerbation of congestive heart failure	47 (14)	1 (3)	0.07
Exacerbation of obstructive lung disease	41 (13)	5 (15)	0.66
Electrolyte disturbance	39 (12)	5 (15)	0.59
Hospital stay, no. of days	5 (3–8)	3 (2–5)	0.041

Note: IQR = interquartile range.
*We assessed differences between the study participants and nonparticipants for statistical significance using the Student's *t* test for age, the Wilcoxon test for the Charlson index[16] and hospital stay, and the χ^2 test for the remainder of the variables.
†Defined according to a scale developed by Walter and colleagues[17] that identifies whether there is a need for personal assistance with dressing, toileting, eating, transferring and bathing within the 2 weeks before admission. A score of 5 means a patient requires assistance with all these activities of daily living.
‡This index is a method of determining prognosis that is based on a patient's comorbidities. Points are assigned according to the presence and seriousness of specific medical conditions. Higher scores indicate a worse prognosis.

ables, respectively. We used multiple logistic regression to measure the independent association of patient characteristics with the likelihood of an AE, including variables that were significantly associated according to the univariate analysis ($p < 0.10$).

Results

During the study period, 620 patients were discharged from the general internal medicine service of the participating hospital; 259 were excluded because they were transferred to other services or hospitals, were discharged to a nursing home, were homeless or had died in hospital. Of the 361 eligible patients, 291 completed the interview. For the other 70 we relied on chart reviews to determine outcomes; 37 had visited an ED or been readmitted, and the other 33 were considered lost to follow-up. Thus, the study included 328 patients (91% of those eligible).

The study participants are described in Table 1. They averaged 71 years of age (interquartile range [IQR] 54–81 years), and 55% were female. They tended to have several coexisting medical conditions, as measured by the Charlson index.[16] This index is a method of determining prognosis that is based on a patient's comorbidities. Points are assigned according to the presence and seriousness of specific medical conditions. Higher scores indicate a worse prognosis. In the original validation study,[16] the predicted 1-year mortality rates based on scores of 0, 1, 2 and 3 or more points were 8%, 25%, 48% and 59%, respectively. The median Charlson index in our cohort was 2 (IQR 1–3). For 21%, assistance was required with at least 1 activity of daily living. The most common chronic illnesses were obstructive lung disease, coronary artery disease, type 2 diabetes mellitus, psychiatric disorders (including substance abuse) and congestive heart failure. The most common acute conditions were pneumonia, fluid and electrolyte problems, and exacerbations of chronic health problems.

The 33 patients for whom we were unable to determine outcomes may have been slightly "healthier" since their stay in hospital was significantly shorter (3 v. 5 days; $p = 0.041$), they were younger (67 v. 71 years; $p = 0.58$), and they had a lower median Charlson index (1 v. 2; $p = 0.14$).

Prevalence of adverse events after discharge from hospital

After discharge, 204 patients (62%, 95% CI 57%–67%) had an adverse outcome (Table 2). In 76 patients the adverse outcome was classified as an AE (incidence 23%, 95% CI 19%–28%); 21 patients had a preventable AE (incidence 6%, 95% CI 4%–10%) and 17 an ameliorable AE (incidence 5%, 95% CI 3%–8%).

One-quarter of the ED visits, readmissions and deaths were classified as an AE (Table 2). Of the 56 readmissions, 8 (14%) were classified as a preventable AE, as was 1 of the 7 deaths (14%). Most preventable or ameliorable AEs resulted in laboratory abnormalities, symptoms or visits to physicians' offices.

Table 2: Adverse outcomes, adverse events (AEs), preventable AEs and ameliorable AEs among the 328 study patients

Outcome severity	No. of patients with 1 or more adverse outcomes	No. (and %*) of patients with 1 or more AEs		
		Preventable	Ameliorable	All
All severities	204	21 (28)	17 (22)	76
Laboratory abnormality, symptom or MD visit	107	10 (19)	14 (26)	52
Emergency department visit	34	2 (22)	2 (22)	9
Readmission to hospital	56	8 (62)	1 (8)	13
Death	7	1 (50)	0 (0)	2

*The denominator is the number of patients with 1 or more AEs. AEs were considered preventable if the 2 reviewers agreed, using implicit judgement, on whether the outcome could have been prevented. AEs were considered ameliorable if the 2 reviewers agreed that the outcome severity could have been substantially reduced if alternative actions or procedures had occurred.

Box 1: Examples of adverse events after discharge from hospital

- Severe candidal esophagitis, presenting as food-bolus blockage, in a patient treated with corticosteroids. *Ameliorable.*
- Profound hypoglycemia necessitating readmission, which developed days after discharge in a patient treated orally with hypoglycemics. *Preventable.*
- Acute exacerbation of congestive heart failure in a patient with severe left ventricular dysfunction for whom diltiazem was prescribed. The patient's condition was inadequately monitored after discharge. *Preventable.*
- Transient ischemic attack with a normal international normalized ratio in a patient known to have atrial fibrillation whose anticoagulation therapy was inadequately monitored after discharge. *Preventable.*
- Antibiotic-associated diarrhea, leading to dehydration and syncope, in a patient treated for pneumonia. The patient was readmitted to hospital and given fluids intravenously; the antibiotic therapy was stopped. *Ameliorable.*
- Profound hyperkalemia (serum potassium level 7.7 mmol/L) and acute renal failure (serum creatinine level 1134 μmol/L) in a patient treated with an angiotensin-converting-enzyme inhibitor and diuretics. The electrolyte levels were not monitored after discharge. *Preventable.*
- Antibiotic-associated nausea, which was self-limiting. *Not preventable or ameliorable.*

Types and severity of AEs

Of all the AEs, 72% were due to medications. Other types of AE included therapeutic errors (16%), nosocomial infections (11%), procedure-related problems (7%), pressure ulcers (7%), diagnostic errors (6%) and falls (2%). The types of preventable and ameliorable AEs were similarly distributed.

The most common AE was antibiotic-associated diarrhea, which occurred in 27 patients. Six of these patients required either an ED visit or readmission to hospital for definitive treatment, and one eventually died. Preventable AEs were most often therapeutic errors, defined as the concomitant use of medications known to interact, the use of a treatment known to be contraindicated in a specific condition or failure to adequately monitor a treatment. Examples of such errors that we found were concomitant prescriptions for angiotensin converting enzyme inhibitors and nonsteroidal anti-inflammatory drugs, which led to renal failure; prescription of diltiazem for a patient with severe left ventricular dysfunction, which led to exacerbation of heart failure; and inadequate monitoring of warfarin therapy, which led to a stroke. Ameliorable AEs were most often classified as adverse drug events. The most common method of amelioration was improved monitoring for medication side effects (75%) and for symptoms (25%) after discharge. Box 1 lists selected examples of AEs.

The severity of the AEs was classified as laboratory abnormalities only (1%), several days of symptoms (68%), nonpermanent disability (25%), permanent disability (3%) or death (3%). More than half the AEs required no additional use of health services. However, 21% resulted in an additional physician visit, 12% an ED visit and 17% readmission to hospital.

Table 3: Characteristics of patients without or with an AE

Characteristic	No. (and %) of patients		Odds ratio (and 95% confidence interval)	
	Without an AE *n = 252*	With an AE *n = 76*	Unadjusted	Adjusted
Female, no. (and %)	128 (51)	53 (70)	2.2 (1.3–3.9)†	2.3 (1.3–4.1)
Median age (and IQR), yr	70 (51–80)	73 (58–83)	1.1 (1.0–1.3)*†	1.0 (1.0–1.0)
No. (and %) with baseline disabilities				
0	199 (79)	58 (76)	1.0	
1–4	40 (16)	14 (19)	1.2 (0.6–2.4)	
5	13 (5)	4 (5)	1.1 (0.3–3.7)	
Median Charlson index‡ (and IQR)	2 (1–3)	2 (2–3)	1.1 (0.9–1.4)*	
No. (and %) with chronic illnesses				
Obstructive lung disease	70 (28)	22 (29)	1.1 (0.6–1.9)	
Coronary artery disease	59 (25)	24 (32)	1.5 (0.8–2.7)	
Type 2 diabetes mellitus	50 (23)	25 (33)	2.0 (1.1–3.6)†	1.9 (1.0–3.6)
Psychiatric disorders	47 (18)	11 (15)	0.7 (0.3–1.6)	
Congestive heart failure	39 (16)	14 (18)	1.2 (0.6–2.5)	
Atrial fibrillation	19 (10)	13 (17)	2.5 (1.1–5.7)†	2.0 (0.9–3.6)
HIV infection	9 (3)	0 (0)	0.2 (0–2.9)	
No. (and %) with acute conditions				
Pneumonia	48 (19)	26 (34)	2.2 (1.2–4.0)†	1.9 (1.0–3.6)
Acute renal failure	30 (12)	15 (20)	1.8 (0.9–3.7)†	1.3 (0.6–2.9)
Exacerbation of congestive heart failure	30 (12)	17 (22)	2.1 (1.0–4.3)†	1.3 (0.6–2.8)
Exacerbation of obstructive lung disease	29 (12)	12 (16)	1.4 (0.6–3.1)	
Electrolyte disturbance	29 (12)	10 (13)	1.2 (0.5–2.6)	
No. (and %) in hospital campus 1	121 (48)	36 (47)	1.0 (0.6–1.6)	
Hospital stay, no. of days	5 (3–8)	6 (3.5–9.5)	1.0 (1.0–1.1)*†	1.0 (1.0–1.1)

*Represents change in AE risk associated with an increase in the independent variable by 1 unit.
†Univariate predictors of AE at a p value < 0.1. After adjustment for these characteristics in a multiple logistic regression model, being female, having type 2 diabetes mellitus or having pneumonia remained significantly associated with AE occurrence.
‡See Table 1 for a definition of this index.

We assessed the data for predictors of AEs (Table 3). According to the univariate analysis, patients were significantly more likely to experience an AE if they were female, were older, had type 2 diabetes mellitus, atrial fibrillation, pneumonia, acute renal failure or an acute exacerbation of congestive heart failure or stayed longer in hospital. Independent predictors of an AE included being female (odds ratio [OR] 2.3, 95% CI 1.3–4.1), having type 2 diabetes mellitus (OR 1.9, 95% CI 1.0–3.6) or having pneumonia (OR 1.9, 95% CI 1.0–3.6).

Interpretation

Of the 328 study patients, 23% experienced an AE after discharge from hospital; 6% had a preventable AE and 5% an ameliorable one. Two-thirds of the AEs caused only symptoms, but 12% led to an ED visit, 17% led to a hospital readmission, and 3% resulted in death. Nearly three-quarters of the AEs were medication-related, but more than one-fifth were a result of diagnostic or therapeutic error. Being female, having type 2 diabetes mellitus or having pneumonia independently predicted AE occurrence.

The findings in this study were similar to those in a previous one despite differences in study population. The AE rates were almost the same, adverse drug events were the most common AE type, and physician judgements in AE determination had similar reliability. One striking difference in patient

population was age: in our cohort the average age was 71 years, whereas it was 57 in the previous study.

One of our study's strengths was the small proportion of patients lost to follow-up. We were able to determine outcomes for 91% of eligible patients. In this type of study, a large proportion of nonresponders could lead to an underestimate of the number of severe AEs because of nonselective dropout. Another strength of this study was the use of guided, implicit judgements for AE determination. Other researchers have used this methodology,[4] and, although it has limitations and has been criticized,[18–21] it is generally accepted. Furthermore, it has high face validity, and the physician judgements in our study had moderate to high reliability.

Our study has important findings that have direct implications for quality improvement at the time of discharge. First, it is necessary to follow patients more closely after discharge. Monitoring was judged to have been inadequate for each patient with an ameliorable AE and a substantial proportion of those with preventable ones. Interventions to improve monitoring could include enhanced communication with community care providers, better integration of home-care services with hospital care, hospital-based follow-up clinics and early telephone contact. Second, an important impediment to caring for patients after discharge is their frailty. A quarter of the patients were over 81 years of age, most had several diagnoses, and 21% required assistance with at least 1 activity of daily living. These characteristics are associated with a high likelihood of adverse outcomes.[22] They also suggest that it may be difficult for these patients to attend follow-up clinics. Strategies to improve monitoring must take these difficulties into account.

In conclusion, more than 1 in 5 patients discharged from a Canadian teaching hospital's general internal medicine service experienced an adverse outcome related to their medical care. We need to identify if other patient populations, such as those discharged from surgical services or from community hospitals, are at similar risk. We also need to evaluate methods of improving safety after discharge.

This article has been peer reviewed.

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