Adequacy of Hospital Discharge Status as a Measure of Outcome Among Injured Patients

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Context.—Crude mortality rates at the time of hospital discharge are commonly used to assess the quality of care provided to patients hospitalized following trauma. 

Objectives.—To evaluate the adequacy of hospital death rates as an outcome measure following trauma and to determine the influence of noninjury illness as a cause of hospital death and the frequency of postdischarge death. 

Design.—Retrospective cohort analyses using hospital discharge data for injured patients cross-linked to death certificate data that provided 1 year of follow-up for all patients discharged alive.

Patients.—A total of 90 048 injured patients admitted to all acute care hospitals in the state of Washington from 1991 through 1993 and discharged with at least 1 diagnosis coded in the International Classification of Diseases, Ninth Revision, Clinical Modification to indicate trauma.

Main Outcome Measures.—Death in the hospital and death within 30 days of hospital discharge.

Results.—Among 1912 injured patients with in-hospital deaths, 825 death certificates (43%) listed a noninjury cause of death. The overall mortality rate at hospital discharge was 21.2 per 100 000 hospitalized injured patients, and was 12.1 per 100 000 for trauma deaths and 9.1 per 100 000 for those designated as nontrauma deaths. Patients with trauma-related death designations were younger (mean age, 51.5 years vs 77.9 years), had shorter lengths of stay (median stay, 2 days vs 5 days), and sustained more severe injuries (P<.001). Including the 1273 deaths that occurred within 30 days of hospital discharge increased rates for trauma-designated deaths to 14.1 per 100 000 and increased rates for nontrauma-designated deaths to 21.3 per 100 000.

Conclusions.—Hospital discharge death rates are incomplete measures of death frequency for injured patients. Designation of the cause of death, especially among older, hospitalized, injured patients often reflects preexisting medical conditions. Adequate assessment of mortality following trauma requires measurement of the frequency of death following hospital discharge.

DEATH DURING hospitalization is used as a principal indicator of outcome in injury research examining the effectiveness of trauma systems. Deaths among injured patients have been classified as preventable, possibly preventable, or nonpreventable for the purpose of quality assurance review. Logistic regression models developed from normative data have been used to predict the risk-adjusted odds of hospital death for injured patients to determine if trauma centers fail, meet, or exceed standards of care. Inherent in these analyses is the assumption that injured patients discharged alive following trauma demonstrate a risk of death similar to that of the general population. That is, these methods fail to account for deaths related to the injury that may occur after hospital discharge.

Using inpatient mortality as an outcome variable to assess effectiveness of medical care may produce different conclusions when compared with assessments of mortality that are expanded to include mortality after hospital discharge. Jenecks et al reported that for samples of Medicare patients, measuring mortality within 30 days of hospital admission was preferable to measuring hospital-associated death rates when comparing patient survival in 2 states that had different average lengths of hospital stay. In a large population-based study that examined the long-term outcome of injured patients, Gubler et al reported that the 5-year survival rate among a cohort of hospitalized, injured, elderly patients was less than that observed for an uninjured case-matched group of hospitalized patients. However, extrapolation of these observations in an older population to all hospitalized injured patients may be problematic. Deaths among elderly injured patients more commonly are due to associated medical conditions, whereas deaths among younger injured patients principally are due to their injuries. Age-related differences in risk factors may be further accentuated if trauma-related mortality is expanded to include deaths that occur after hospital discharge.

The purpose of this study is to assess the frequency and timing of death among hospitalized injured patients. Specific issues addressed include the proportion of injured patients that die during hospitalization vs after hospital discharge, the length of time after hospital discharge that deaths occur, the proportion of hospitalized injured patients whose deaths are designated on death certificates as having trauma as the principal cause, and whether demographic characteristics of patients who die after hospital discharge are different from the characteristics of those who die during hospitalization.
<table>
<thead>
<tr>
<th></th>
<th>Death in Hospital (Trauma)</th>
<th>Death in Hospital (Nontrauma)</th>
<th>Death Within 30 Days Postdischarge (Trauma)</th>
<th>Death Within 30 Days Postdischarge (Nontrauma)</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total sample</td>
<td>1087</td>
<td>825</td>
<td>182</td>
<td>1091</td>
<td>. . .</td>
</tr>
<tr>
<td>Male, %</td>
<td>65.9†</td>
<td>45.9</td>
<td>51.1</td>
<td>39.2</td>
<td>&lt;.001†</td>
</tr>
<tr>
<td>Age, mean (SD), y</td>
<td>51.5 (±27.9)*</td>
<td>77.9 (±12.8)</td>
<td>77.1 (±19.6)</td>
<td>81.2 (±11.4)†</td>
<td>&lt;.001‡</td>
</tr>
<tr>
<td>Preexisting conditions, %</td>
<td>11.7†</td>
<td>38.4</td>
<td>24.7</td>
<td>36.4</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Injury Severity Score, median (IQR)</td>
<td>25 (14-29)†</td>
<td>9 (4-9)</td>
<td>9 (4-9)</td>
<td>9 (4-9)</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Severe injury, %§</td>
<td>47.1†</td>
<td>2.6</td>
<td>5.5</td>
<td>0.2</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Multiple injuries, %§</td>
<td>21.2†</td>
<td>1.0</td>
<td>6.0†</td>
<td>1.0</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>LOS, median (IQR), d</td>
<td>2 (0-6)</td>
<td>5 (2-10)</td>
<td>6 (4-11)</td>
<td>7 (4-10)</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Transfer, %</td>
<td>1.6</td>
<td>2.4</td>
<td>3.3</td>
<td>2.4</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Injury, % (median AIS score)</td>
<td>傲 Head</td>
<td>62.4 (5)†</td>
<td>11.2 (4)</td>
<td>17.6 (4)</td>
<td>7.5 (3)</td>
</tr>
<tr>
<td></td>
<td>Chest</td>
<td>23.6 (3)†</td>
<td>12.7 (3)</td>
<td>11.5 (3)</td>
<td>10.3 (3)</td>
</tr>
<tr>
<td></td>
<td>Abdomen</td>
<td>18.4 (3)†</td>
<td>5.1 (3)</td>
<td>6.0 (3)</td>
<td>4.7 (3)</td>
</tr>
<tr>
<td></td>
<td>Extremity</td>
<td>30.9 (3)†</td>
<td>60.8 (3)</td>
<td>75.3 (3)</td>
<td>69.9 (3)</td>
</tr>
<tr>
<td></td>
<td>Face</td>
<td>8.5 (2)</td>
<td>2.7 (2)</td>
<td>3.3 (2)</td>
<td>1.3 (2)</td>
</tr>
<tr>
<td></td>
<td>External</td>
<td>17.8 (2)</td>
<td>16.4 (1)</td>
<td>8.8 (1)†</td>
<td>15.9 (1)</td>
</tr>
</tbody>
</table>

*IQR indicates interquartile range; LOS, length of stay; and AIS, Abbreviated Injury Scale. The IQR is defined as the lower quartile (25%) and the upper quartile (75%).†Data are significantly different from all other categories.‡Bonferroni adjusted P value is .003.§AIS score of at least 5 in any body region.

**METHODS**

**Definition of the Study Cohort**

The initial population selected for study included all hospitalized injured patients discharged from acute care hospitals (excluding federal government hospitals) in the state of Washington between January 1, 1991, and December 31, 1993, who had 1 or more International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM) discharge diagnosis codes within the 800 to 959 range, excluding 905 to 909 (late effects of injury), 930 to 939 (foreign bodies), and 958 (complications of injury). Injured patients who were admitted for rehabilitation to an acute care facility were identified by diagnosis code V57 and were excluded.

**Data Sources**

Hospital discharge data for injured patients in Washington were obtained from the Comprehensive Hospital Abstract Reporting System (CHARS) by application to the State of Washington Department of Social and Health Services. CHARS is a claims database with information collected primarily for billing purposes on all patients hospitalized in state-licensed acute care hospitals. Data available for each case included date of birth, sex, admission date, discharge date, ZIP code of residence, disposition at discharge, a hospital identifier, and up to 5 discharge diagnoses recorded using ICD-9-CM codes.

The Death and Illness History Database is constructed by linking information in the Washington CHARS database to death certificates. Data from CHARS are longitudinally linked to form individual patient hospitalization histories using a unique identifier code that identifies multiple hospital admissions. Longitudinal CHARS data are linked with death certificate records. On death certificate records, injury-related deaths are described using external-cause-of-injury codes (E-codes) (800-999), whereas noninjury-related deaths are recorded using ICD-9-CM codes. Death certificates are completed by medical examiners (forensic pathologists) in King, Pierce, Snohomish, and Clark counties and by coroners in the remainder of the state. Washington State statutes provide universal standards for determining location, mechanism, and cause of death for death certificate recording. For this study, longitudinal CHARS claims data for calendar years 1991 through 1993 were linked with death certificate records from calendar years 1991 through 1994. For every discharged patient, there was at least 1 year of death certificate records follow-up after hospital discharge.

**Data Linkage Protocols**

Computer algorithms linking death certificate records data and longitudinal CHARS data varied depending on whether death occurred in the hospital (CHARS data) or after hospital discharge (death certificate records data). Initially, CHARS and death certificate records were required to match regarding sex, discharge date, location of death (hospital), and any 1 of the following criteria: (1) PIC code (produced by combining the first 2 letters of the first name and the first 2 letters of the last name) and date of birth, (2) PIC code and identical discharge and death dates, or (3) date of birth and identical discharge and death dates. These algorithms ideally linked all CHARS-in-hospital deaths to death certificate records. The final set of 4 algorithms linked longitudinal CHARS data to death certificate records for deaths occurring after hospital discharge. These linking processes required matched responses for sex, date of birth, hospital disposition (alive), and date of death occurring on or after the date of hospital discharge. In addition, records had to match on 1 of the following criteria: (1) PIC code and ZIP code of residence, (2) PIC code alone, (3) ZIP code of residence and the first 2 letters of the first name, or (4) ZIP code of residence and the first 2 letters of the last name. These matching criteria move from a more stringent to less stringent linking definition, removing matched cases in each step. For a case to be considered linked, a 1-to-1 match must occur. That is, for any given death certificate record case, there must be only 1 linkage record in the longitudinal CHARS database.

**Outcome Measure**

The principal outcome of interest is death at hospital discharge or within 1 year after discharge. For the purposes of these death analyses, all hospitalizations except for the final one, whether patients lived or died, were eliminated from the Death and Illness History Database. Thus, in the 3-year period, 90 048 patients had 95 903 hospital admissions, and survival time was based only on the last hospital admission.
Definition of Computed Variables

Abbreviated Injury Scale Scores and Injury Severity Scores were calculated from ICD-9-CM discharge diagnoses using methods described by MacKenzie et al.10 Length of stay was calculated as the difference in number of days between hospital admission and hospital discharge. Preexisting conditions were abstracted from ICD-9-CM codes and categorized using the methods of Morris et al.10

Data Analysis

Decedent patients were divided into 2 groups, dead at time of hospital discharge and dead following hospital discharge. These 2 groups were further divided based on a death certificate designation of trauma death or nontrauma death. Demographic and clinical characteristics for these 4 classifications of patients were generated. Comparisons between groups were accomplished using χ2 in a multifactorial table or with 1-way analysis of variance modeling. A Scheffé test11 was used to assess differences between groups and a Bonferroni correction factor12 was used to adjust for multiple comparisons. Mortality trend lines evaluating death after patient discharge were constructed using a lowess smoothing technique (ie, a locally weighted regression technique using an iterative weighted least-squares algorithm).13 One-year death rates for stratified subgroups of patients discharged alive were compared with 1-year death rates of an age-matched and sex-matched general US population obtained from the National Center for Health Statistics.14 Data analyses were performed using SPSS for Windows Version 6.1.15 The study was considered exempt from patient consent requirements by the Oregon Health Sciences University Institutional Review Board.

RESULTS

Performance of Linkage Criteria

Of the 2012 patients designated as dead at hospital discharge, 1912 were linked to individuals in the death certificate database. Thus, 100 patients (5%) designated as dead at discharge in CHARS could not be linked to death certificate records data. Unlinked cases did not differ significantly from linked cases on demographic characteristics or clinical variables, except that unlinked patients had a tendency to be older. Unlinked patients were excluded from further analyses.

Mortality Rates

The unadjusted mortality rate at hospital discharge for the entire population of hospitalized injured patients (n = 1912) was 21.2 per 100 000. Based on death certificate data, the hospital discharge death rate was divided into deaths (n = 1087, 57%) designated as trauma deaths (rate, 12.1 per 100 000) and deaths (n = 825, 43%) designated as nontrauma deaths (rate, 9.1 per 100 000) (Table 1). The cumulative unadjusted death rate for patients who died in the hospital or within 30 days of hospital discharge was 35.4 per 100 000, with rates of 14.1 per 100 000 designated as trauma deaths (n = 182, 11%) and 21.3 per 100 000 designated as nontrauma deaths (n = 1091, 89%). The number of patients who died per day following hospital discharge declined rapidly through the first 60 days (Figure). A higher proportion of postdischarge decedents were designated by death certificate records as having a non–trauma-related cause of death than a trauma-related cause of death.

Characteristics by Date and Cause of Death

Decedents were categorized based on the death certificate death designation (ie, trauma vs nontrauma) and by date of death (ie, dichotomized as death in hospital vs death within 30 days of hospital discharge) (Table 1). Patients who died in the hospital as a result of injury were younger, had more severe injuries, and had fewer preexisting medical conditions. Patients who died from injuries within 30 days of hospital discharge had fewer external injuries, and those with a designated noninjury cause of death constituted the oldest group.

The proportion of in-hospital patient deaths designated as trauma related was slightly higher (61%) in counties served by medical examiners compared with counties with coroners (50%). This higher proportion may be explained by the fact that the state’s only level I trauma center is in a county served by a medical examiner.

The dominant mechanisms of injury for in-hospital trauma deaths were motor vehicle collision (35%), “accidental fall” (29%), homicide (9%), and suicide (9%). The mechanism of “accidental fall” was the predominant mechanism of injury listed in CHARS for hospitalized injured patients who died in the hospital from nontraumatic causes (Table 2). Several medical conditions common among elderly patients were listed as the cause...
COMMENT

Understanding the cause of death for hospitalized injured patients is essential to determine if trauma systems improve care. Our study supports the conclusion that evaluation of traumatic-related deaths would be biased if analyses were limited to patients who die during hospitalization. Patients in the Washington State claims databases who died in the hospital were younger and frequently died of severe injuries. In contrast, patients who died after discharge, as identified by expanding the data with linked death certificate records, were more commonly older patients and died soon after being hospitalized for less severe injuries. Patients who died after hospital discharge had a high rate of preexisting medical conditions, as did patients who died of nontrauma causes during hospitalization. Patients in the Washington State claims databases who died in the hospital were younger and frequently died of severe injuries. In contrast, patients who died after discharge, as identified by expanding the data with linked death certificate records, were more commonly older patients and died soon after being hospitalized for less severe injuries. Patients who died after hospital discharge had a high rate of preexisting medical conditions, as did patients who died of nontrauma causes during hospitalization. Patients in the Washington State claims databases who died in the hospital were younger and frequently died of severe injuries. In contrast, patients who died after discharge, as identified by expanding the data with linked death certificate records, were more commonly older patients and died soon after being hospitalized for less severe injuries. Patients who died after hospital discharge had a high rate of preexisting medical conditions, as did patients who died of nontrauma causes during hospitalization. Patients in the Washington State claims databases who died in the hospital were younger and frequently died of severe injuries. In contrast, patients who died after discharge, as identified by expanding the data with linked death certificate records, were more commonly older patients and died soon after being hospitalized for less severe injuries. Patients who died after hospital discharge had a high rate of preexisting medical conditions, as did patients who died of nontrauma causes during hospitalization.

Survival models may be an alternative to logistic regression when evaluating death as an outcome. Survival analyses depend on time interval to death and might have particular use when evaluating care delivered to older trauma patients. Gubler et al reported that Cox proportional hazard regression was useful in evaluating Medicare patients hospitalized in the state of Washington. Their findings indicated that injured elderly patients demonstrate an increased mortality risk for at least 3 years following injury when compared with noninjured hospitalized control subjects. Our study complements the findings of Gubler et al by also docu-
menting an increased risk of death among younger adults in the immediate postinjury period.

The optimal choice of a control group to compare with the hospitalized injured population depends on the hypothesis being tested. One approach is to compare the hospitalized injured population with hospitalized noninjured patients after adjustment for specific independent variables (eg, age, diagnoses, comorbidity, and sex). Using this approach, Gubler et al determined that hospitalization for injury adds to the risk of death for elderly hospitalized patients. In contrast, we compared mortality rates of injured patients discharged alive from the hospital with those of an age-stratified and sex-stratified general population to determine whether injured patients discharged alive from the hospital have an increased risk of death in the following year. We chose this approach because research relying on death at discharge to quantify risk of death assumes that injured patients discharged alive will immediately return to the same mortality risk demonstrated by the general population. Our analysis determined that this assumption was not valid, because, in almost every sex and age group, injured patients alive at the time of discharge from the hospital were at increased risk of death compared with the general population.

There are several limitations to the claims data used in our study. Only 5 diagnoses were recorded in the claims databases. When only 5 diagnoses are recorded, those selected by medical records personnel may be biased to favor maximum reimbursement. However, Iezzoni et al found that little difference exists in the classification of primary conditions when 5 vs 10 or more diagnostic categories are available. Validation studies of claims databases have reported inaccuracies or incomplete data recording.18-22

Linkage of databases is also problematic because the magnitude of errors in identifying the same individual in 2 databases depends on the matching criteria selected. Stringent or lax linkage algorithms between hospital claims data and the death certificate database may underestimate or overestimate the true number of deaths, respectively. In the current study, the magnitude of underreporting deaths was only 5% for patients who died in the hospital, although it is reasonable to suspect underreporting may have been higher for patients who died after discharge, in part because the only death certificate file examined was for the state of Washington. Overestimates of true mortality (or overmatching of records) are more difficult to identify. Information recorded in the death certificate may be erroneous or influenced by different conventions in different locations.22 Messite and Stellman reported that accuracy in death certificates was generally good, although mortality from circulatory diseases and diabetes was underreported. Pollock et al described the limitations of using a single cause of death rather than multiple causes. In our study, stratification of decedents by counties and cause of death for medical examiners vs coroners showed only a modest trend toward medical examiners more frequently assigning injury as the mechanism of death. Finally, the claims data used in our study do not incorporate the 2 largest fractions of death after trauma, death at the injury scene and immediate hospital death, usually occurring in the emergency department.1,14 Thus, the databases used in this study are not indicative of the entire scope of risk of death for injured patients.

In conclusion, these cross-linked population-based data indicate that mortality rates as a measure of outcome for hospitalized injured patients are complicated by death from nontraumatic causes and a substantial frequency of death after hospital discharge. If quality of care and efficacy of trauma systems are assessed by death rates, particularly risk-adjusted odds of death for hospitalized injured patients, sophisticated methods of hospital data linkage with post–hospital-discharge survival information may be required. A practical solution is the greater use of composite databases constructed by reliable and accurate cross-linkage of population-based data.

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