Long-term Survival of Elderly Trauma Patients

K. Dean Gubler, DO, MPH; Robert Davis, MD, MPH; Thomas Koepsell, MD, MPH; Robert Soderberg; Ronald V. Maier, MD; Frederick P. Rivara, MD, MPH

Objective: To evaluate the long-term survival and factors that influence survival among a cohort of elderly trauma patients compared with an uninjured cohort.

Design: A retrospective cohort analysis.

Data Sources: Health Care Finance Administration, Baltimore, Md, Medicare data.

Subjects: A cohort of elderly patients (n=9424) hospitalized for injury in 1987 was identified using Medicare hospital discharge abstract data. An uninjured comparison group (n=37 787) was identified from Medicare eligibility files. For injured patients, an Injury Severity Score was generated from the *International Classification of Diseases, Ninth Revision, Clinical Modification* (*ICD-9CM*) codes. For both cohorts, preexisting illness was assessed by *ICD-9CM* codes from Health Care Finance Administration outpatient and inpatient data files for 1986 and 1987.

Main Outcome Measures: Relative risk for mortality within 5 years subsequent to injury, adjusted for age, sex, and preexisting illness, using Cox proportional hazard regression.

Results: The injured cohort had a significantly reduced 5-year survival when compared with the uninjured group (relative risk [RR]=1.71; 95% confidence interval, 1.66-1.77). The lower survival persisted even among patients who survived at least 3 years after injury. Coexisting disease, age, and Injury Severity Score were strong predictors of survival.

Conclusions: The adverse effect of trauma on survival in elderly patients is not isolated to the immediate postinjury period, but lasts years after the trauma episode. Further study is required to identify the reasons for this persistent effect of trauma on subsequent survival.

Arch Surg. 1997;132:1010-1014

GERIATRIC TRAUMA is a common problem in the United States. More than 800 000 elderly patients are hospitalized annually with injuries, and in 1991 more than 26 000 geriatric patients died as a direct result of trauma.[1,2] The economic impact of trauma care is enormous; geriatric patients account for almost one third of all trauma-related expenses.[3]

The magnitude of this problem is expected to increase. Representing 12.5% of the population, the 30 million Americans aged 65 years and older will increase to 52 million by the year 2020.[4] While the incidence of injury is lower in the elderly population than in any other age group, older patients are more likely to die or have prolonged hospitalization as a result of their injuries.[3] The elderly in-hospital case-fatality rate is 15% to 30% compared with a 4% to 8% case-fatality rate for younger trauma patients.[3] Elderly persons account for a disproportionate number of deaths due to injury.[5]

Most research of injury outcomes in elderly patients has addressed short-term measures only, including in-hospital mortality, days in the intensive care unit, and functional status at discharge and at 1 year.[6-12] Research into the long-term survival of injured elderly patients has been limited to small, uncontrolled, retrospective cohorts, mostly from selected patient populations admitted to trauma centers.[7,10] While some researchers have suggested there is little or no long-term decrease in the survival of elderly patients once they are discharged from the hospital, others suggest that the detrimental effects of injury lasts for years. To our knowledge, there have been no population-based studies of long-term survival among geriatric trauma patients compared with an uninjured cohort, and the research to date has not been of adequate size or scope to answer this controversy.[4]

From the Departments of Clinical Investigation and Surgery, Naval Medical Center San Diego, Calif (Dr Gubler); Harborview Injury Prevention and Research Center (Drs Davis, Koepsell, Maier, and Rivara and Mr Soderberg); Department of Epidemiology, School of Public Health and Community Medicine (Drs Davis, Koepsell, and Rivara); and Departments of Pediatrics (Drs Davis and Rivara) and Surgery (Dr Maier), School of Medicine, University of Washington, Seattle.

PARTICIPANTS AND METHODS

DATA SOURCE

The data for this study were obtained from public-use Medicare files acquired from the Health Care Financing Administration (HCFA), Baltimore, Md. Individuals in the Medicare tracking system are followed up by a unique file identifier. The cohort at risk of injury consisted of all Medicare-eligible residents in the state of Washington at least 66 years of age in 1986. Members of the cohort injured during the 1987 calendar year were identified from the expanded, modified Medicare Provider Analysis and Review (MEDPAR) hospital discharge data. These data contain records of all Medicare beneficiaries using hospital inpatient services and are uniformly collected for all Medicare beneficiaries discharged from acute-care hospitals. Data include patient demographics, type of admission, length of hospital stay, discharge status, and diagnoses and procedure codes using the *International Classification of Diseases, Ninth Revision, Clinical Modification* (*ICD-9CM*).

DETERMINATION OF EXPOSURE

The injured cohort of the study population was defined by a principal hospital discharge diagnosis for trauma (*ICD-9CM* codes 800-959) in 1987, excluding the following *ICD-9CM* diagnoses: late effects (*ICD-9CM* codes 905-909); foreign bodies (*ICD-9CM* codes 930-939); and complications (*ICD-9CM* code 958). To avoid double counting of interhospital transfers, only the first hospital admission for trauma in 1987 was included in the analysis.

Uninjured members of the cohort were identified from the population at risk and not hospitalized for a trauma-related injury during 1987 when cross-referenced to the MEDPAR data. Four uninjured persons were frequency matched for sex and age (within 5-year strata) for each injured member of the cohort.

DETERMINATION OF INJURY SEVERITY

The Injury Severity Score (ISS)[12] for each person in the exposed group was determined using a computer mapping program (ICD-MAP).[13] While the ICD-MAP conversion process does not provide an exact correspondence with the ISS calculated directly from the medical record, validation studies have shown that the ICD-MAP does provide good information on relative injury severity.[14] To improve reliability of the ISS as a determinant of injury severity, interval grouping (scores of 1-8, 9-16, 16-24, 25-40, 41-49, and 50-66) was used.[15]

COMORBIDITY

The presence of preexisting conditions was determined for both the exposed and nonexposed cohorts using inpatient and outpatient data sources. Inpatient data was obtained from the 1987 MEDPAR hospital data set. To more completely identify comorbid conditions, outpatient data were obtained from the Standard Analytical Outpatient File for the year 1986. A comorbidity index (developed by Charlson et al[16]) was used to account for the effects of multiple preexisting conditions on survival. As their results showed, this weighted index accounts for the seriousness and number of the preexisting conditions and has been previously validated in studies of mortality.[16-18] Thus the effect of comorbid illness on mortality can be accounted for in the analysis. The comorbid index used for this analysis is available from us on request. Statistically adjusting for the comorbid conditions in the Cox proportional hazards analysis is a way of controlling for the fact that the elderly patients with injuries had an increased prevalence of comorbid conditions at the time of injury.

MEASUREMENT OF OUTCOME

The long-term outcome measure of interest was the 5-year survival of the injured cohort compared with the uninjured cohort. Dead injured and uninjured patients were identified using the Medicare Mortality Information System, which identifies the death of a beneficiary through a uniform reporting system. The Medicare mortality data are cross-checked with Social Security system records to assure accuracy in reporting date of death. The system identifies all known deaths irrespective of location of death or residence of the beneficiary at time of death.

DATA MANAGEMENT AND ANALYSIS

Four separate data sets for the years 1986 through 1992 were linked for this study: MEDPAR hospital discharge data on injuries and comorbid conditions; Standard Analytical Outpatient File for comorbid conditions; Medicare eligibility file for selection of the cohort; and the Medicare Mortality Information System file for outcome. These files were linked using the patient's unique file identifier.

For the injured group, the distribution of injury severity, length of hospital stay, and date of discharge were determined. Cumulative incidence of hospitalization for trauma during 1987 was calculated using the Medicare enrollee data for the state of Washington.

Using the Cox proportional hazards regression, survivorship was compared for the injured and uninjured cohorts, adjusted for age, sex, race, and the comprehensive index of comorbidity. To investigate the long-term survival of the injured cohort, the survival analysis was repeated with various start times (1 month, 6 months, 1 year, and 3 years after injury). These secondary analyses of survival were performed to examine the long-term effects of injury among those who survived the more immediate effects of trauma.

This study was approved by the University of Washington Human Subjects Investigation Review Board, Seattle, and the Office of Data Release, Statistics, and Data Management of the Department of Health and Human Services, HCFA. All data used in this study were obtained from the public-use files provided by the Department of Health and Human Services, HCFA.

To address these questions, we performed a population-based retrospective cohort analysis comparing the survival of elderly persons who required hospitalization for injury during 1987 in the state of Washington with the survival of an uninjured cohort of comparable age. Using available data, we were able to statistically adjust for comorbid conditions within this population. Hence, we were able to isolate and study the long-term detrimental effects of injury among elderly persons.

Table 1. Characteristics of Injured and Uninjured Cohorts

Variable	No. (%) in Injured Cohort	No. (%) in Uninjured Cohort
Age group, y		
67-71	1620 (17.2)	6679 (17.7)
72-76	1925 (20.4)	7872 (20.9)
77-81	1967 (20.9)	7920 (20.9)
82-86	1865 (19.8)	7457 (19.7)
87-91	1307 (13.9)	5067 (13.4)
92-96	589 (6.3)	2222 (56.9)
97-100	151 (1.6)	566 (1.4)
Race		
White	9024 (95.8)	36 146 (95.7)
Black	68 (0.7)	414 (1.1)
Other	117 (1.2)	648 (1.7)
Unknown	215 (2.3)	597 (1.6)
Sex		
Male	6647 (70.5)	26 727 (70.7)
Female	2777 (29.5)	11 060 (29.3)
Comorbid diagnoses		
Any malignancy	352 (3.7)	1045 (2.7)
Metastatic tumor	128 (1.4)	356 (0.9)
Diabetes mellitus	267 (2.8)	658 (1.7)
Diabetes with complications	19 (0.2)	23 (0.1)
Dementia	206 (2.2)	364 (0.9)
Hemiplegia/paraplegia	147 (1.6)	277 (0.7)
Myocardial infarction	185 (2.0)	650 (1.7)
Congestive heart failure	567 (6.0)	1519 (3.9)
Cerebrovascular disease	580 (6.2)	1266 (3.2)
Peripheral vascular disease	123 (1.3)	291 (0.7)
Chronic pulmonary disease	653 (6.9)	1204 (3.1)
Peptic ulcer disease	111 (1.2)	306 (0.8)
Mild liver disease	22 (0.2)	41 (0.1)
Moderate/severe liver disease	15 (0.2)	29 (0.1)
Renal disease	89 (0.9)	196 (0.5)
Rheumatologic disease	87 (0.9)	109 (0.3)

RESULTS

CHARACTERISTICS OF THE STUDY POPULATION

There were 9424 persons aged 67 years or older admitted to hospitals for trauma in the state of Washington in 1987. The uninjured cohort comprised 37 787 persons, frequency matched 4:1 for sex and age to the injured cohort. The incidence of hospitalization for injury in Washington State in the elderly Medicare population was 27.1 per 1000 person-years.

The age and sex distribution of the injured and uninjured cohorts were similar (**Table 1**). While both groups were preponderantly white, there were notably more files with black and "other" races, and fewer files listing race "unknown" in the uninjured cohort compared with the injured cohort.

The injured cohort had more preexisting comorbid illness (Table 1). Myocardial infarction was the only preexisting illness not significantly more common in the injured cohort. The severity of injury for the injured cohort was skewed toward minor injury. Almost half (46.6%) of the injured cohort had an ISS of less than 9 (n=4582), and 97% had an ISS of less than 16 (n=9098). There were 321 patients (3.4%) with an ISS of between 16 and 40, and only 5 (0.1%) with an ISS of greater than 40.

Table 2. Summary of Multivariate Analysis of 5-Year Survival After Injury

Variable	Relative Risk for Death	95% Confidence Interval
Age group, y		
67-71	1.0	Reference
72-76	1.5	1.4-1.6
77-81	2.3	2.2-2.4
82-86	3.4	3.2-3.6
87-91	5.4	5.1-5.7
92-96	7.7	7.2-8.2
97-100	9.5	8.6-10.4
Race		
White	1.0	Reference
Black	1.0	0.9-1.2
Other	0.8	0.7-0.9
Sex		
Female	1.0	Reference
Male	1.4	1.4-1.5
Injury Severity Score grouping		
1-8	1.6	1.5-1.7
9-15	1.8	1.7-1.9
16-24	1.8	1.5-2.1
25-66	5.8	4.3-7.7
Comorbid Diagnosis Index score*		
1-3	2.0	1.9-2.0
4-6	3.6	3.3-4.0
7-9	5.6	4.9-6.4
10-13	8.4	6.2-11.3

**Developed by Charlson et al.[16]*

SURVIVAL

There were 382 deaths during the index hospitalization for trauma, resulting in a hospital case-fatality rate of 4.1%. The hospital case-fatality rate varied markedly with injury severity. More than half (55.9%) of those with an ISS of 25 or greater died in the hospital, compared with 13.4% for those with an ISS between 16 and 24, 4.0% for those with an ISS between 9 and 15, and only 2.8% of those with an ISS less than 9.

The risk for death in the injured compared with the uninjured cohort increased with age, injury severity, and the presence of preexisting comorbid conditions (**Table 2**). Persons between 72 and 76 years old were almost 50% more likely to die compared with those between 65 and 71 years old, while persons older than 97 years were almost 10 times more likely to die. Preexisting illness was strongly related to survival as well. Persons with a Charlson index rating of 1 to 3 were almost twice as likely to die within 5 years, while those with the most preexisting illness (Charlson index 10-13) were more than 8-fold more likely to die than those without preexisting illness. Men were about 44% more likely to die compared with women in the same 5-year age strata.

The overall 5-year risk for death among the injured cohort relative to the uninjured cohort was 1.7 (95% confidence interval [CI], 1.7-1.8; adjusted for age, sex, race, and comorbid conditions). The difference in death rate

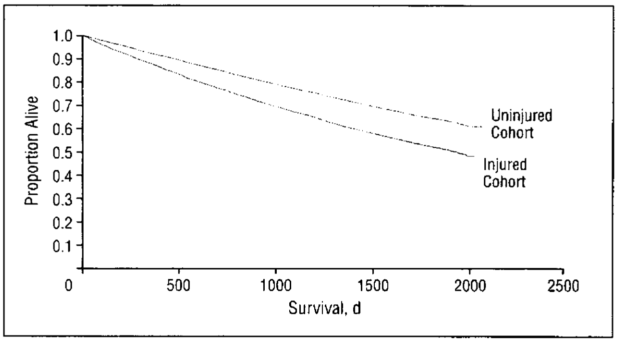

Figure 1. *Reduced 5-year survival experienced by the injured cohort compared with the survival of the uninjured cohort from date of admission for trauma.*

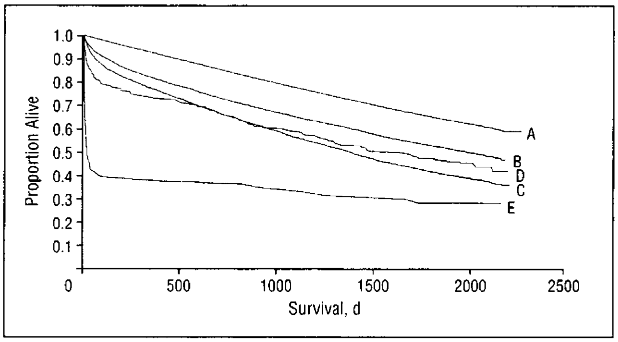

Figure 2. *Cox proportional hazard regression comparing the uninjured cohort with the injured cohort stratified by interval groupings of similar Injury Severity Scores (ISS) from date of admission for trauma. A indicates noninjured cohort (n=37 787); B, patients with ISS of 1 to 8 (n=4582); C, patients with ISS of 9 to 15 (n=4516); D, patients with ISS of 16 to 24 (n=262); and E, patients with ISS of greater than or equal to 25 (n=64).*

for the injured cohort compared with the uninjured cohort was greatest in the initial period after injury (**Figure 1**).

Survival was related to injury severity. The 5-year risk for death was greatest among those with more severe injury. Patients with an ISS greater than 25 were almost 6-fold more likely to die than the uninjured cohort. While risk for early death increased with the degree of injury severity, this effect was not constant during the entire 5-year period. Persons in the 3 less severe ISS categories continued to have a lower survival throughout the follow-up period. However, persons in the most severely injured groups had some plateauing of their survival curves after the immediate posttrauma period, a finding particularly seen in those patients with an ISS greater than 25 (**Figure 2**).

When the analysis was limited to patients who survived various amounts of time after injury, the injured cohort continued to demonstrate worse survival than the uninjured cohort. The relative risk for death (adjusted for age, sex, race, and comorbid conditions) among those who survived 30 days after injury was 1.6 (95% CI, 1.5-1.6), while among those who survived 6 months, 1 year, or 3 years, the relative risk (RR) for death was 1.4 (95% CI, 1.4-1.5), 1.4 (95% CI, 1.4-1.5), and 1.4 (95% CI, 1.3-1.4), respectively.

COMMENT

This is the largest study to date that examines the long-term outcome of an injured geriatric population. It demonstrates that elderly patients have a markedly increased risk for death following injury and that, even among those who survive for extended periods after injury, the risk for death remains high compared with the noninjured elderly population.

Our results differ from previous reports studying the outcomes of elderly victims of trauma, which have been restricted to the experience of a few trauma centers and limited by the duration of follow-up. The large sample size in our study enabled detection of effects that may have been too small to detect in previous studies. In one small study limited to elderly patients after burn injury, Manktelow and colleagues[19] found comparable life expectancy among patients who survived beyond 1 year relative to uninjured persons. In another study of 63 survivors of blunt trauma older than age 65 years followed up to 38 months after hospital discharge, DeMaria et al[9] found that 89% of patients returned home after injury, and thus concluded that aggressive support of the elderly trauma patient was justified. However, their study did not control for comorbid status, and was limited to selected patients within a single trauma center. A strong point for this study was our ability to control for the fact that elderly patients with injuries were more likely to have comorbid illness, such as liver or renal disease. The results demonstrate that, above and beyond the increased mortality associated with comorbid illness, injury is associated with decreased long-term survival among elderly patients.

Injured elderly patients not only had a higher hospital and short-term mortality compared with the uninjured cohort but, once discharged from the hospital, also had a persistently increased mortality rate. Unlike other studies that examined the outcomes of elderly trauma patients,[6,7] we found that the adverse effect of trauma on survival remained for an extended period after injury. The reason for this persistent negative effect on survival is unknown. It may be that, once injured, elderly patients never regain their level of preinjury health. Whether it is a direct loss of function secondary to injury, a complication of injury, or a depletion of body energy stores is unknown.

Our study differs from others because our data are derived from a wide population base, and thus represent the experience of community hospitals and trauma centers. Most other studies have been case series from trauma centers, where study subjects are likely to have a higher level of acute illness and associated mortality. As evidence of the difference between our study and those from trauma centers, the case-fatality rate of 4.1% shown in this study is strikingly lower than the 15% previously reported from our center and the case-fatality rates reported by others.

The finding in this study that preexisting illness adversely affects the long-term survival is in contrast to other studies, including one from our own institution.[4] However, those studies included relatively few patients, were limited to trauma centers, and did not have set criteria for the identification of preexisting comorbid illness. As in other studies[3,4] our study found older age to be the best single predictor of an adverse outcome, and that sex also predicts survival.

This study has limitations. We accounted for the effects of concurrent and preexisting disease on mortality by using HCFA administrative databases to identify and statistically adjust for these conditions. A weighted index, developed by Charlson et al[16] and validated for use with administrative databases, was used to account for the number and seriousness of preexisting illnesses. The utility of this index can be seen by the marked association with risk for death as the comorbidity index increases (Table 2).

We also performed an additional analysis adjusting for age, sex, race, and preexisting illness in an unweighted form. This regression model, to adjust for the presence of preexisting illness in the injured and uninjured cohort, showed no appreciable difference from the analysis that solely used the weighted index. It is possible that neither model completely captured all differences in preexisting illness among the cohorts and that the poorer survival after injury is in part caused by these differences.

Although the results of this study are provocative, the findings must be qualified. The study of trauma depends on the reliability of the ISS as a useful and accurate method for quantifying injury severity. Copes and others[15] have demonstrated that the placement of ISS values into cohort interval groupings improves the validity of the ISS as a predictor of mortality. The data used in the analysis were not collected specifically for this study. Health care providers are required to report the information used in our analysis to Medicare to receive reimbursement. Medicare data files have been used to determine incidence and risk factors for disease, mortality rates, quality of care, and treatment outcomes. The limitations of Medicare data for epidemiologic research have been described by others.[20-24] Data from HCFA do not include patient identifiers and cannot be validated against medical records or other data sources such as trauma registries. Additionally, the data may be biased by the method of coding. Hospital discharge abstracts, the basis of HCFA data, are not uniformly collected by hospitals and may differ in the number, ordering, or criteria for coding of comorbid conditions. Nevertheless, many of these limitations have been minimized in this study by the careful linking of data from multiple files, cross-checking of results, and using the same data sources for the injured and uninjured cohorts.[24]

This study demonstrates that the effect of trauma is not isolated to the immediate postinjury period but adversely affects the long-term survival of injured elderly persons. Apart from the particular medical and surgical problems associated with care of elderly patients, the adverse effects of injury on the long-term survival of the elderly trauma patient are striking. Efforts to improve outcomes of trauma in elderly patients may need to focus on their long-term care and rehabilitation in addition to care in the immediate postinjury period.

This research was supported by grant R01-AA-07116 from the National Institutes of Health, Bethesda, Md, and grant R40-CCR-00-2750 from the Centers for Disease Control and Prevention, Atlanta, Ga.

The views expressed in this article are those of the authors and do not reflect the official policy or position of the Department of the Navy, Department of Defense, or the United States Government.

Reprints: K. Dean Gubler, DO, MPH, Department of Surgery, Naval Medical Center San Diego, San Diego, CA 92134.

REFERENCES

1. Champion HR, Copes WS, Flanagan ME, Bain LB, Sacco WJ. Major trauma in geriatric patients. *Am J Public Health.* 1989;79:1278-1282.
2. *Statistical Abstract of the United States.* 114th ed. Washington, DC: US Dept of Commerce; September 1994.
3. Schwab CW, Kauder DR. Trauma in the geriatric patient. *Arch Surg.* 1992;127:701-706.
4. Spencer G. *Projections of the Population of the United States, by Age, Sex, and Race: 1988-2080.* Washington, DC; US Bureau of the Census: 1989.
5. Kauder DR, Schwab CW. Comorbidity in geriatric patients. In: Maull K, Cleveland H, Strauch G, eds. *Advances in Trauma.* St Louis, Mo: Mosby-Year Book Inc; 1990:215-230.
6. Oreskovich MR, Howard JD, Copass MK, Carrico CJ. Geriatric trauma: injury patterns and outcome. *J Trauma.* 1984;24:565-572.
7. DeMaria EJ, Kenney PR, Merriam MA, Casanova LA, Gann DS. Survival after trauma in geriatric patients. *Ann Surg.* 1987;206:738-743.
8. Broos PL, Stappaerts KH, Rommens PM, Louette LK, Gruwez JA. Polytrauma in patients of 65 and over: injury patterns and outcome. *Int Surg.* 1988;73:119-122.
9. DeMaria EJ, Kenney PR, Merriam MA, Casanova LA, Gann DS. Aggressive trauma care benefits the elderly. *J Trauma.* 1987;27:1200-1206.
10. Horst HM, Obeid FN, Sorensen VJ, Biving BA. Factors influencing survival of elderly trauma patients. *Crit Care Med.* 1986;14:681-684.
11. *The Abbreviated Injury Scale: 1985 Revision.* Des Plaines, Ill: Association for the Advancement of Automotive Medicine: 1985.
12. Baker SP, O'Neill B, Haddon WJ, Long W. The Injury Severity Score: a method of describing patients with multiple injuries and evaluating emergency care. *J Trauma.* 1974;14:187-196.
13. MacKenzie EJ, Steinwaches DM, Shankar B. An ICD-9CM to AIS conversion table: development and application. In: *The 30th Proceedings of the American Association for Automotive Medicine.* Des Plaines, Ill: American Association for Automotive Medicine; 1986:135-151.
14. MacKenzie EJ, Steinwachs DM, Shankar B. Classifying trauma severity based on hospital discharge diagnosis: validation of an *ICD-9CM* to AIS-85 conversion table. *Med Care.* 1989;27:412-422.
15. Copes WS, Champion HR, Sacco WJ, Lawnick MM, Keast SL, Bain LW. The Injury Severity Score revisited. *J Trauma.* 1988;28:69-77.
16. Charlson ME, Pompei P, Ales KL, MacKenzie CR. A new method of classifying prognostic comorbidity in longitudinal studies: development and validation. *J Chronic Dis.* 1987;40:373-383.
17. Greenfield S, Blanco DM, Elashoff RM, Aronow HU. Development and testing of a new index of comorbidity. *Clin Res.* 1987;35:346A.
18. Deyo RA, Cherkin DC, Ciol MA. Adapting a clinical comorbidity index for use with ICD-9-CM administrative databases. *J Clin Epidemiol.* 1992;45:613-619.
19. Manktelow A, Meyer AA, Herzog SR, Peterson HD. Analysis of life expectancy and living status of elderly patients surviving a burn injury. *J Trauma.* 1989;29:203-207.
20. Wennberg JE, Freeman JL, Shelton RM, Bubolz TA. Hospital use and mortality among Medicare beneficiaries in Boston and New Haven. *N Engl J Med.* 1989;321:1168-1173.
21. *Health Care Financing Administration: Medicare Hospital Mortality Information, 1987.* Washington, DC; US Dept of Health and Human Services: 1988.
22. Roos NP, Roos LL, Mossey J, Havens B. Using administrative data to predict important health outcomes: entry to hospital, nursing home, and death. *Med Care.* 1988;26:221-239.
23. Iezzoni LI, Foley SM, Daley J, Hughes J, Fisher ES, Heeren T. Comorbidities, complications, and coding bias? Does the number of diagnosis codes matter in predicting in-hospital mortality? *JAMA.* 1992;267:2197-2203. Comment in: *JAMA.* 1992;267:2238-2239.
24. Fisher ES, Baron JA, Malenka DJ, Barrett J, Bubloz TA. Overcoming potential pitfalls in the use of Medicare data for epidemiologic research. *Am J Public Health.* 1990;80:1487-1490.