Incidence and Outcome of Hospital-treated Head Injury in Rhode Island

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Abstract: Hospital discharge summary data were used to identify and study all 2,870 Rhode Island residents hospitalized in-state with head injuries during 1979 and 1980. The overall hospitalized incidence rate was 152 per 100,000 of population per year with age and sex variations similar to those found in other studies. This is consistent with the observation that fatal injury rates in Rhode Island are only 75 per cent of the United States average. Hospitalized incidence rates of head injury for the census tracts in the lowest decile of median income were twice those for census tracts in the highest decile. Smaller increases were also observed with increasing population density. Length of hospital stay increased with age. Discharge to chronic care facilities plus in-hospital deaths increased 20-fold with increasing age. In each age group, in-hospital deaths and discharge to chronic care facilities were associated with long hospital stays. (*Am J Public Health* 1986; 76:773–778.)

Introduction

Head injury is a major public health problem with an annual incidence of approximately 200 new cases per 100,000 population,[1–4] a case fatality rate variously estimated between 7 and 16 per cent,[3,4] and considerable morbidity among survivors.[1,4–6] Most population-based incidence data for head injury in the United States come from four studies: one concerned with the United States overall,[1] one with Olmsted County, Minnesota,[2] and two with San Diego County, California.[3,4] There have been no population-based incidence studies in the eastern United States.

These studies[1–4] are in substantial agreement on the way head injury incidence rates vary with age and sex, on the major causes of head injury (motor vehicle crashes, falls, and assaults), and on the approximate contribution of each major cause to the total in each age and sex group. The national study suggests that incidence rates show little regional variation,[1] a surprising finding in view of the considerable regional variation of mortality from injuries.[7]

Population-based studies in the United States have not addressed the variation of head injury incidence with income or with population density, and they have not extensively examined the relationship of the patient's age, gender, and cause of injury to the duration and outcome of the patient's acute medical care. The present study examines these issues in the Rhode Island population. Like the national study by Anderson, *et al,*[1] it tabulates only head injured people who were hospitalized.

Methods

The present study is based on all admissions to Rhode Island hospitals (January 1, 1979 to December 31, 1980) of head-injured people who were Rhode Island residents at the time of injury. Except for a review of selected hospital records, the present study is based on Professional Activities Study (PAS) data recorded from the medical records of all patients discharged from all 15 Rhode Island community hospitals. Fatally injured persons and emergency room patients who were never hospitalized were excluded. Thus, this study derives case fatality rates for hospitalized head injured patients rather than mortality rates for all head injury.

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The PAS data include age, sex, residence, date of admission, date of discharge, disposition at discharge, and up to 21 diagnoses. Diagnostic coding is based on the *International Classification of Diseases, Ninth Revision, Clinical Modification.*[8] Head injury was defined by the presence among the discharge diagnoses of any of the following International Classification of Diseases (ICD) codes: 800–801.9, 803–804.9, and 850–854.9. These codes include all head injuries likely to involve brain injuries.[1–4,8–10] The causes of the head injuries were divided on the basis of the external cause of injury codes (E-codes) into motor vehicle crashes, including crashes injuring motor vehicle occupants, pedestrians, bicyclists, and motorcyclists (E810–E823.9); falls (E880–E887.9); intentionally self-inflicted injury, including suicide (E950–958.9); assault, including homicide (E960–978.9); and other or unspecified causes.

According to the coding convention of the PAS system, the external cause of injury is to be coded only for incident cases (cases not previously treated for this injury). To determine the actual frequency of incident cases among those with external causes of injury coded and (separately) among those without, the hospital records of 316 patients, approximately half with E-codes and half without, were reviewed. These cases were drawn from three hospitals in the Providence area. Of 152 cases with E-codes, 99 per cent (all but one case) were incident cases. Of 164 head injury patients with no listed E-code, 92 per cent (all but 13 cases) were incident. From these percentages and the fact that 73 per cent of all head injury cases had a recorded E-code, 97 per cent of all cases regardless of E-code status were incident cases. Therefore, all head injury cases were included in the present study regardless of the presence or absence of a recorded E-code. The ages and outcomes of the cases without E-codes were similar to those of the entire group (Table 1). When data were analyzed by the cause of injury, analysis was restricted to the cases with a recorded cause of injury. No adjustment was made for the cases without E-codes.

It was not possible to track individual patients who were transferred from one acute care hospital to another, nor was it possible to identify such patients when they were admitted at the receiving hospital. Because transfers to another acute care hospital accounted for only 3 per cent of all head injury hospital discharges and were distributed among all age groups and causes of injury, inclusion of these patients is likely to have had little effect on the findings.

According to the 1980 census, the population of Rhode Island was 947,000 with a median age of 31.8 years, and 95 per cent of the residents were White.[11] In comparison, the United

TABLE 1—Discharge Outcome of Patients Hospitalized for Head Injury by Injury Cause and Age Group,* Rhode Island 1979, 1980

	Falls			MVC**			Assault			Self-Inflicted			Other***			No E-code			Total		
Age Group (years)	Home	CC	Death	Home	CC	Death	Home	CC	Death	Home	CC	Death	Home	CC	Death	Home	CC	Death	Home	CC	Death
0–14	297	4	3	117	1	4	9	1	2	0	0	0	186	0	1	218	1	0	827	7	10
	(98)	(1)	(1)	(96)	(1)	(3)	(75)	(8)	(17)				(99)	(0)	(1)	(100)	(0)	(0)	(98)	(1)	(1)
15–34	118	2	0	496	7	33	120	3	3	2	0	2	115	0	2	285	2	4	1136	14	44
	(98)	(2)	(0)	(93)	(1)	(6)	(95)	(2)	(2)				(98)	(0)	(2)	(98)	(1)	(1)	(95)	(1)	(4)
35–54	63	3	7	79	2	5	31	1	0	2	1	1	18	1	1	73	5	5	266	13	19
	(86)	(4)	(10)	(92)	(2)	(6)	(97)	(3)	(0)				(90)	(5)	(5)	(88)	(6)	(6)	(89)	(4)	(6)
55–64	48	5	4	29	2	1	5	0	1	0	0	1	8	1	0	40	0	4	130	8	11
	(84)	(9)	(7)	(91)	(6)	(3)	(83)	(0)	(17)				(89)	(11)	(0)	(91)	(0)	(9)	(87)	(5)	(7)
65–74	48	8	8	19	1	1	4	0	0	1	0	0	4	0	5	40	6	7	116	15	21
	(75)	(13)	(13)	(90)	(5)	(5)							(44)	(0)	(56)	(75)	(11)	(13)	(76)	(10)	(14)
75+	60	39	18	18	3	3	1	0	0	0	0	0	4	1	2	49	22	13	132	65	36
	(51)	(33)	(15)	(75)	(13)	(13)							(57)	(14)	(29)	(58)	(26)	(15)	(57)	(28)	(15)
All Ages	634	61	40	758	16	47	170	5	6	5	1	4	335	3	11	705	36	33	2607	122	141
	(86)	(8)	(5)	(92)	(2)	(6)	(94)	(3)	(3)	(50)	(10)	(40)	(96)	(1)	(3)	(91)	(5)	(4)	(91)	(4)	(5)

*Outcomes are "Home" which include all patients discharged home or transferred to an acute care hospital, "CC" which includes all patients discharged to a chronic care institution, and "Death" meaning death by the time of discharge. The numbers in parentheses are the per cent of the age and sex group with each outcome.
**Motor vehicle crash.
***All others with E-codes.

States population was 226,505,000 with a median age of 30.0 years, and 83 per cent of residents were White.

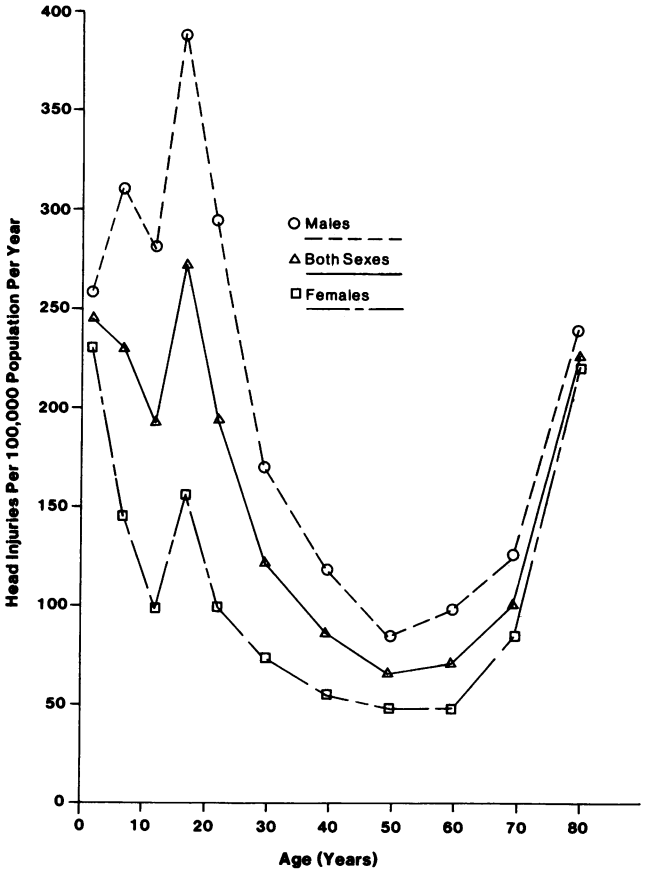
For the analyses of head injury incidence rates by income, each head injury patient was assigned to his census tract of residence (Rhode Island is divided entirely into census tracts). The census tracts were ranked according to median income as determined from the 1980 census, and head injury incidence rates were tabulated by the decile of income of the census tract of residency. These rates were tabulated for only those head injury cases whose injury was identified among the patient's first seven diagnoses (97 per cent of all cases tabulated in the present study met this condition). Age- and sex-adjusted rates were calculated using the indirect method with the state population as the reference population. For the analysis of head injury incidence rates by population density of the census tract of residency, a similar division was employed, this time into population density deciles.

Results

During the two years studied, there were 2,872 admissions of head-injured Rhode Island residents to Rhode Island hospitals. Two cases were excluded because of missing data on age or sex. The present study is based on the remaining 2,870 hospital admissions (1,860 males and 1,010 females). A cause of injury (E-code) was specified for 2,096 (73 per cent) of the cases.

The annual incidence of hospitalization for head injury was 152 per 100,000 of population (206 for males and 102 for females). Male incidence rates exceeded female incidence rates in every age group except the oldest. The age specific incidence rate for males and females (Figure 1) showed three peaks: the first in early childhood, the second at age 15 to 25 years, and the third in the elderly.

Hospitalized incidence rates of head injury from all causes increased markedly with decreasing income level of the census tract of residency (Figure 2) and with increasing population density of the census tract of residency (Figure 3). Very low income was associated with very high density, intermediate income with very low density, and very high income with intermediate density. As functions of median income (or population density) of census tract, head injury hospitalization rates for assaults varied five-fold; rates for falls varied two-fold to three-fold, yet rates for motor vehicle injuries varied little and showed no obvious pattern of variation by census tract of residence.



*Excludes people treated out-of-state and those dying before hospital admission.

FIGURE 1—Incidence* of Hospitalization due to Head Injury by Age and Sex, Rhode Island Residents, 1979 and 1980

The largest single cause of head injury—motor vehicle crashes—was responsible for 821 cases (539 males and 282

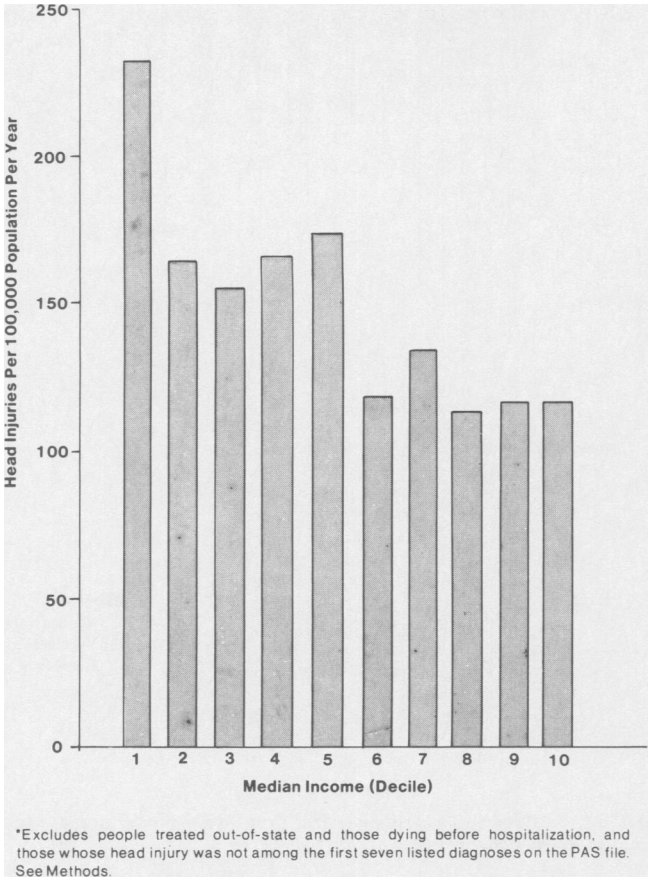


FIGURE 2—Age- and Sex-adjusted Incidence of Hospitalization due to Head Injury* by Median Income of Census Tract of Residency, Rhode Island Residents, 1979 and 1980

females), 39 per cent of all cases with a specified cause of injury. The annual incidence of head injury from motor vehicle crash was 43 per 100,000 of population (60 for males and 28 for females). Incidence rates increased sharply in the teenage years and remained elevated into middle age for both sexes (Figure 4). At the peak incidence, age 15–19, motor vehicle injury accounted for 60 per cent of all head injuries of specified cause for males and 69 per cent for females.

Falls were the cause of injury for 735 cases (419 males and 316 females), 35 per cent of all those with a specified cause of injury. The annual incidence of head injury from falls was 39 per 100,000 of population (46 for males and 32 for females). At all ages, incidence rates for males were higher than those for females. Head injury rates due to falls were highest in earliest childhood and among the elderly. For those aged 65 and older, and for those aged four or younger, falls accounted for 73 per cent of all head injuries with specified cause.

Assault was the cause of head injury for 181 cases (144 males and 37 females), 9 per cent of the total. The annual incidence of head injury from assault was 10 per 100,000 of population (16 for males and 4 for females). Rates for males were higher than those for females at all ages except 0–4 years; in this age group, rates for females were higher. Among males, head injury due to assault had a single peak beginning in the teenage years and extending into late middle age. Among females, rates peaked at ages 0–4 and again beginning in the teenage years and extending into late middle

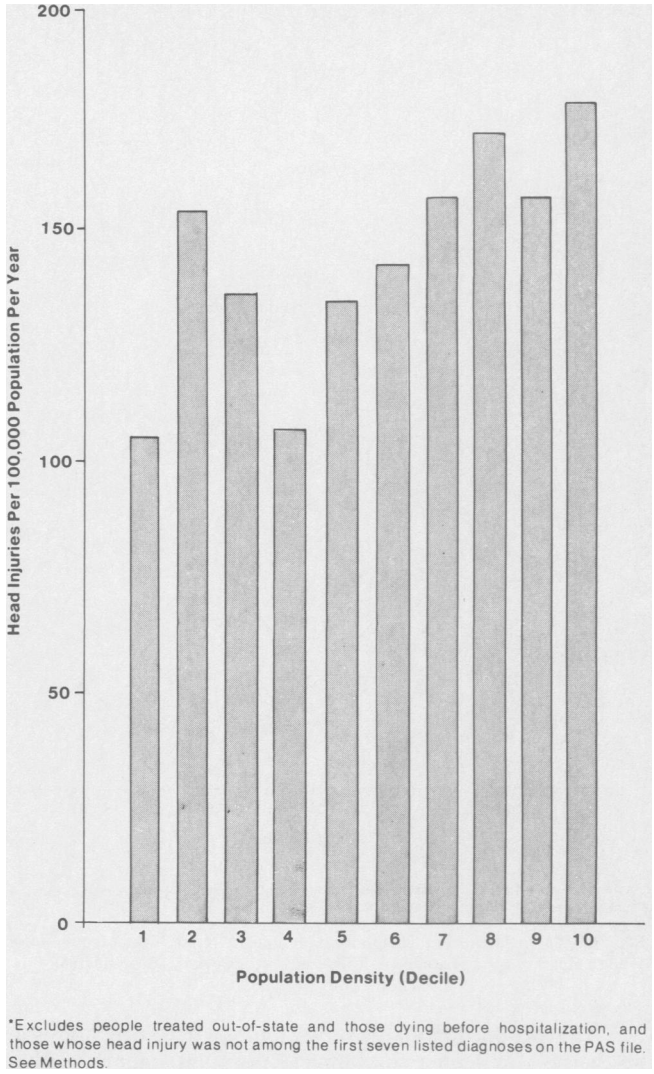
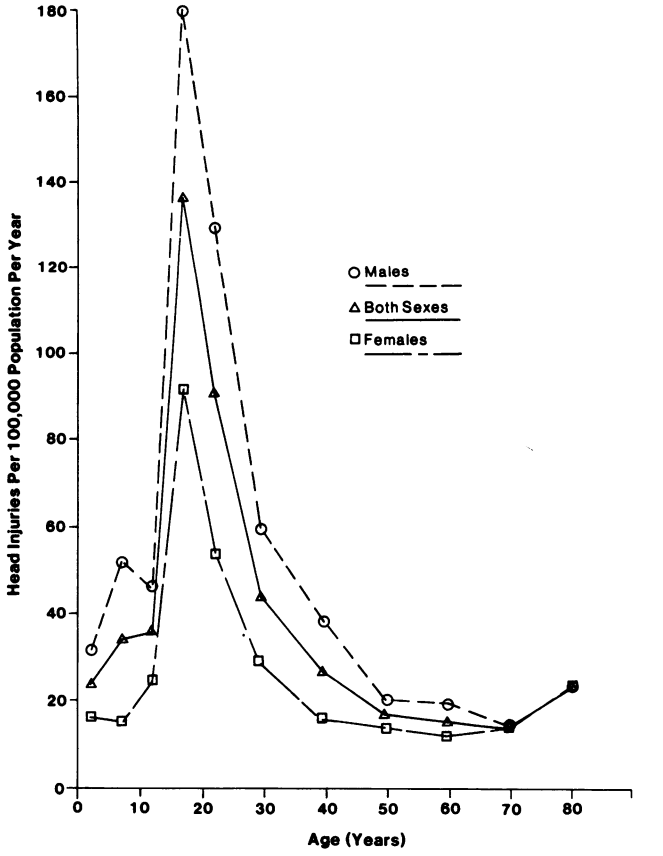


FIGURE 3—Age- and Sex-adjusted Incidence of Hospitalization due to Head Injury* by Population Density of Census Tract of Residency, Rhode Island Residents, 1979 and 1980

age. At the peak incidence, ages 15–19, injuries from assault accounted for 11 per cent of all head injuries.

At discharge from the hospital, the patient's outcome was classified into one of five categories: 2,465 (86 per cent) of the patients went home without home health care nursing services, 55 (2 per cent) went home with home health care nursing services, 87 (3 per cent) went to another acute care institution, 122 (4 per cent) went to a chronic care institution, and 141 (5 per cent) died in the hospital. For several tabulations, all patients returning home or transferred to acute care institutions were grouped together and compared to the patients who were discharged to chronic care institutions or died in the hospital.

The proportion of head-injured patients failing to return home rose markedly with advancing age (Figure 5). The age-specific discharge status for males and females was similar for those under age 55. For those age 55 or older who did not return home, it was more common for males to die in the hospital (38 deaths and 33 discharges to chronic care) and for females to be discharged to nursing homes (30 deaths and 55 discharges to chronic care).



*Excludes people treated out-of-state, people dying before hospital admission, and those for whom no cause of injury was specified in the PAS record.

FIGURE 4—Incidence* of Hospitalization due to Head Injury from Motor Vehicle Crashes by Age and Sex, Rhode Island Residents, 1979 and 1980

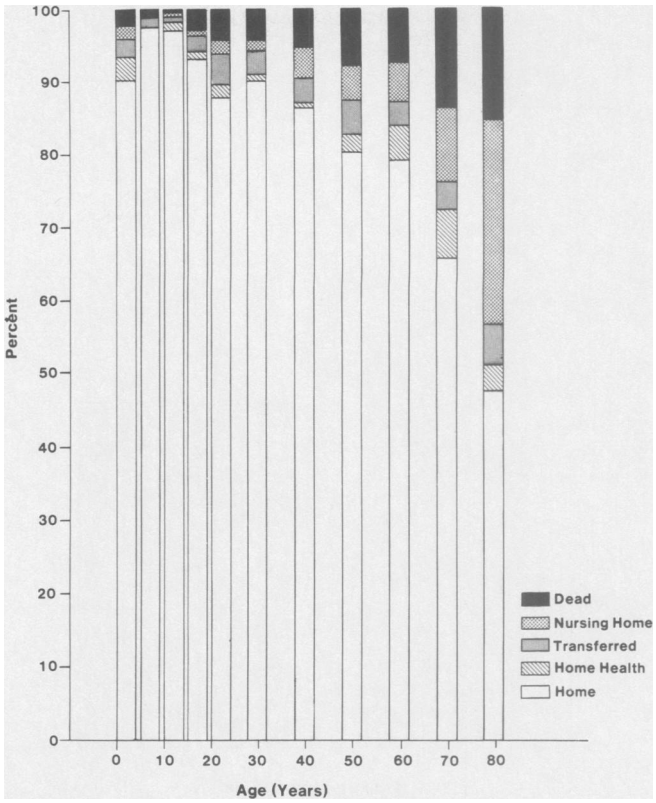


FIGURE 5—Hospital Discharge Status Per Cent Distribution by Age of Head-injured Rhode Island Residents, 1979 and 1980

The proportion of patients failing to return home at discharge was higher for falls (14 per cent) than for other causes of injury (9 per cent). However, those injured in falls tended to be older than those with head injury from other causes (Table 1): after age adjustment, the difference in discharge outcome was reduced.

The length of hospital stay increased with increasing age (Table 2). Hospital stays of a week or longer occurred in 20 per cent of those aged 34 or younger and 56 per cent of those aged 65 or older. After age stratification, the lengths of stay for males and females were similar. In-hospital deaths increased with increasing length of stay, but the two were not directly related after age was taken into account. Among the patients discharged alive, the likelihood of being discharged to a chronic care institution increased with increasing length of stay (Table 2).

People who died without being admitted to a hospital are not included in the hospital discharge data that are the basis of this study. Thus, calculation of a case fatality rate requires an estimate of the number of head-injured people who died prior to hospitalization. Therefore, the records of the medical examiner were reviewed for deaths of head-injured people. There were 248 such deaths during the study period. Of these, 88 were brought directly to the morgue and the remaining 160 came to the morgue via a hospital. Among the patients who were brought to the morgue via a hospital, it was not possible to distinguish the patients who were admitted to the hospital and included in the PAS tabulations from those who were not admitted and were excluded from the PAS tabulations.

Discussion

In the present study, as in other studies of head injury[1–4] motor vehicle crashes are the most common cause of head injury and falls are the second most common. Incidence rates for males are approximately double those for females and incidence rates are elevated among adolescents and the elderly; in this study and that of Kraus, *et al,*[4] a peak of incidence is also seen among the very young. The early and late peaks correspond to the high incidence of head injury from falls among the very young and the elderly. The middle peak corresponds to the high incidence of head injury from motor vehicle crashes and assault among adolescents and youths.

The annual incidence rate of 152 per 100,000 of population observed in this study is lower than the annual incidence rates found in other studies, which ranged from 182 to 295 per 100,000 of population based on data from San Diego,[3,4] the northeastern United States as described in a national study,[1] and Olmsted County, Minnesota.[2] Like the present study, the estimate from the national study excluded prehospital deaths. The large difference between the incidence rates found by the two San Diego studies suggests that methodological differences may be responsible; but geographic variation of head injury rates may also play a role because injury rates, as reflected by mortality rates from injury, vary by geographic region.[7] The mortality rate of fatal injuries in Rhode Island (52 per 100,000 of population per year) is 74 per cent of the US figure (70 per 100,000 of population per year), and the head injury incidence rate found in the present study (152 per

TABLE 2—Length of Stay of Patients Hospitalized for Head Injury by Age Group,* Rhode Island, 1979, 1980

	Less Than 3 Days			3–6 Days			7–29 Days			More Than 29 Days			Total		
Age Group (years)	Home	CC	Death	Home	CC	Death	Home	CC	Death	Home	CC	Death	Home	CC	Death
0–14	544	0	6	208	5	4	62	2	0	13	0	0	827	7	10
	(99)	(0)	(1)	(96)	(2)	(2)	(97)	(3)	(0)	(100)	(0)	(0)	(98)	(1)	(1)
15–34	430	3	8	400	3	19	261	0	15	45	8	2	1136	14	44
	(98)	(1)	(2)	(95)	(1)	(5)	(95)	(0)	(5)	(82)	(15)	(4)	(95)	(1)	(4)
35–54	83	0	2	96	3	7	74	2	8	13	8	2	266	13	19
	(98)	(0)	(2)	(91)	(3)	(7)	(88)	(2)	(10)	(57)	(35)	(9)	(89)	(4)	(6)
55–64	26	1	3	38	1	3	53	2	5	13	4	0	130	8	11
	(87)	(3)	(10)	(90)	(2)	(7)	(88)	(3)	(8)	(76)	(24)	(0)	(87)	(5)	(7)
65–74	16	1	7	34	2	3	59	8	8	7	4	3	116	15	21
	(67)	(4)	(29)	(87)	(5)	(8)	(79)	(11)	(11)	(50)	(29)	(21)	(76)	(10)	(14)
75+	21	3	11	44	20	8	55	33	13	12	9	4	132	65	36
	(60)	(9)	(31)	(61)	(28)	(11)	(54)	(33)	(13)	(48)	(36)	(16)	(57)	(28)	(15)
All Ages	1120	8	37	820	34	44	564	47	49	103	33	11	2607	122	141
	(96)	(1)	(3)	(91)	(4)	(5)	(85)	(7)	(7)	(70)	(22)	(7)	(91)	(4)	(5)

*Outcomes are "Home", which includes all patients discharged home or transferred to an acute care hospital; "CC", which includes all patients discharged to a chronic care institution; and "Death", meaning death by the time of discharge. The numbers in parentheses are the per cent of the age and sex group with each outcome.

100,000 of population per year) is proportionally lower than the national incidence (204 per 100,000 people per year).[1]

Three potential sources of error deserve mention: Rhode Island residents injured out of state, nonincident cases, and cases taken to a morgue without being admitted to a hospital. Rhode Island residents injured out of state would not be likely to be hospitalized in Rhode Island and, therefore, would not be identified in this study. Hospital utilization data collected by the Rhode Island Department of Health suggest that 90 per cent of all hospitalizations of Rhode Island residents occur in state.[13]

A small percentage of the cases tabulated were nonincident cases. Review of a sample of medical records, as described in the methods section, suggests that approximately 3 per cent of the cases in the study are nonincident cases and an additional 3 per cent are cases transferred between acute care hospitals and may have been counted twice.

The PAS files identified 2,870 cases including 141 deaths. The number of cases taken to a morgue without being admitted to any hospital can be estimated from the medical examiner's data. The maximum number of such cases is 248 (assuming that no deaths of hospitalized patients were included among the medical examiner's cases) and the minimum is 107 (assuming that all 141 of the deaths of hospitalized patients were included among the medical examiner's cases). These figures suggest that 4–8 per cent of head injury cases are unrecorded by the PAS files because they are transported to a morgue without ever being admitted to a hospital.

It is also possible to estimate the case fatality ratio for head injury from the PAS data on deaths of hospitalized cases and the medical examiner's data on fatal cases who may not have been hospitalized. The maximum case fatality estimate would be obtained by assuming all 248 medical examiner's cases and 141 hospital deaths were separate. In this situation, there would be 2,870 hospital cases and 248 medical examiner's cases, for a total of 3,118, with 389 deaths and a case fatality ratio of 12 per cent. The minimum estimate would be obtained by assuming all 141 hospital deaths were medical examiner's cases. In this situation, there would be 107 medical examiner's deaths not reported in the PAS files. Thus, there would be a total of 2,977 head-injured people with 248 deaths, and a case fatality ratio of 8 per cent. Case fatality ratios of 8 to 12 per cent are within the range reported by other authors.[3,4]

From the incidence rate for nonfatal head injury, it is possible to calculate a cumulative incidence of head injury as was done by Annengers, *et al.*[2] The cumulative incidence at any age, calculated by summing the incidence rates for all the years up to that age, represents the fraction of the population that would be expected to have sustained a head injury by that age. Such a calculation makes two major assumptions: first, that cross sectional data can be used to calculate a rate for a cohort, and second that repeated occurrences of head injury in the same person are sufficiently uncommon to be ignored.

The cumulative incidence of hospital-treated head injury by age 20 years is 6 per cent for males and 3 per cent for females. By age 50, the respective figures are 11 per cent and 5 per cent. Because many head injuries are not treated in hospitals,[2] the actual cumulative incidence of head injury is likely to be considerably higher than the figures given here. The high cumulative incidence of head injury is particularly ominous in light of recent work that suggests even "minor" head injury may have significant sequelae.[10]

As has been observed elsewhere,[14] the likelihood that a patient would require follow-up care after discharge increased with the length of hospital stay. Although it is not a cause-effect relationship, the association between length of stay and the need for follow-up care suggests that length of hospital stay may be a convenient measure of (head) injury severity in patients discharged alive from the hospital.

Among the elderly, head injury is a major problem with a high incidence and a grim prognosis. The large proportion of elderly who require nursing home care after head injury may reflect a limited ability of elderly patients to recover from head injury or from other injuries sustained at the time of head injury. However, several other possibilities deserve consideration. Elderly people may lack the home support available to younger people. It is also possible among the elderly, that injury may be a marker for underlying medical problems and that the poor prognosis after head injury may reflect the poor prognosis of these underlying problems. Further research is needed in this area.

The present study did not show any variation of consequence in the outcome of head injury by cause of injury once the age of the person injured was considered. It is possible, however, that the sample size was not large enough to detect such variation. In addition, an appreciable number of the

adverse outcomes are prehospital deaths,[4] and those who died without hospital admission were not included on the present study.

The relationship between low income (or high population density) and high incidence of head injury is consistent with the recent report of Whitman, *et al,* that in Evanston, Illinois head trauma incidence rates among Blacks are approximately double those among Whites.[15] The findings of this study and of Whitman, *et al,* are also consistent with the observation from mortality data that environmental conditions are an important predictor of injury incidence rates.[7] Head injury is not simply a random event; it is related to living circumstances and behavior, and therefore, reducing its incidence by appropriate alterations of the social and physical environment may be possible.

The current literature documents the high incidence of head injury, and its relationship to age and sex, but relatively little is known that would be of use in designing countermeasures against head injury from falls or from assault directed to adults. Attention has been given to the prevention of head injuries among young children in so far as they are related to child abuse, but effective measures are yet to be documented.[16] Head injury to automobile occupants is a major category for which occupant restraints are a countermeasure of proven efficacy. Active restraints, such as manual three-point seat belts, are used by only a small minority of motor vehicle occupants, and automatic restraints, such as airbags, are not currently available in most passenger cars. The implementation of such documented effective methods for head injury reduction represents a challenge as well as an opportunity for those concerned with public health in the United States.

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