The Relationship of Family Income to the Incidence, External Causes, and Outcomes of Serious Brain Injury, San Diego County, California

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Abstract: Among residents of San Diego County, California the incidence and external causes of serious brain injury were related to the median family income of the census tract of residency. Low income tracts had high incidence rates— a finding not changed by adjustment for age and race/ethnicity. For those injured, the type of emergency transport, time from injury to treatment, and outcome of treatment were not related to the median income of the census tract of residency. (*Am J Public Health* 1986; 76:1345–1347.)

Introduction

Injury rates vary inversely with socioeconomic status.[1–5] This paper examines the relationship of socioeconomic status to the incidence, external causes, and outcome of serious brain injury in a defined United States population. This information is relevant to public health policy issues, such as the location of emergency medical transportation and the designation of trauma centers.

Methods

The study population, sources and methods of data collection, and definitions are described in detail elsewhere.[6] New occurrences of serious brain injury in 1981 were identified among all usual residents of San Diego County, California, excluding transients, migrants, and illegal aliens but including personnel residing on military bases in the county. Brain injury was defined as physical damage to, or functional impairment of, the cranial contents from acute mechanical energy exchange exclusive of birth trauma.

Identification was made by examining the records of the county's acute-care general hospitals; all coroner's records for San Diego and the adjoining counties; all death certificates for residents of San Diego County; nursing home and extended-care facility records in San Diego County; and the medical records of major hospitals in the adjoining counties. Twenty-five of the 28 acute-care hospitals in San Diego County (accounting for 95.3 per cent of the total number of beds) participated in the study. The three nonparticipating hospitals were small community hospitals which accounted for an estimated 30 to 40 cases (< 1 per cent) none of which were serious cases since those are usually transported to larger hospitals having neurosurgical capabilities.

Tabulation was limited to fatalities, cases with a Glasgow Coma Scale (GCS)[7] of 8 or lower (severe brain injury), and cases with a moderate brain injury (i.e., with a hospital stay of at least 48 hours together with a GCS of 9–12, an abnormal computerized axial tomography (CAT) scan, or brain surgery). Neurologic status upon discharge from the primary treatment facility was classified using the Glasgow Outcome Scale (GOS)[7] as good recovery, moderate disability, severe disability, persistent vegetative state (PVS), or death. Race/ethnicity was determined from the hospital or autopsy record for each case; therefore, the definition of "Hispanic"* may differ from that used by the census. In this study "Hispanics" presumably are "Mexican Americans."

US census data for 1980 were used to estimate the population size of San Diego County, enumerate race/ethnic subgroups of the population, and identify census tracts by median family income, a proxy measure of socioeconomic status. The 280 census tracts in San Diego County had median annual family incomes ranging from $4,927 to

TABLE 1—Number and Rates of Serious Brain Injuries per 100,000 Persons by Median Family Income and Race/Ethnicity, San Diego County, 1981

	Median Family Income ($)							
	<15,000		15,000–19,999		20,000+		Total	
Race/Ethnicity	No.	Rate	No.	Rate	No.	Rate	No.	Rate
White	294	65	173	41	246	37	713	47
Black	23	41	12	42	4	27	39	39
American Indian/Asian	10	34	6	19	4	11	20	21
"Hispanic"	22	31	13	39	16	56	51	38
All Race/* Ethnic Groups	349	58	204	40	270	37	823	44
Race/Ethnicity Adjusted Rate		60		40		40		

*Excludes 13 with unknown race/ethnicity.

TABLE 2—External Cause and Median Family Income, Specific Serious Brain Injury Rates per 100,000, San Diego County, California, 1981

	Median Family Income ($) and Rate*			
External cause	<15,000	15,000–19,999	20,000+	Total
Firearms/assaults	19	11	9	13
Falls	7	5	8	6
Motor-vehicle (Total)	29	22	20	24
(Motor-vehicle occupant)	(13)	(13)	(12)	(13)
(Pedestrian)	(5)	(3)	(2)	(4)
(Motorcyclist)	(9)	(4)	(5)	(6)
(Bicyclist)	(1)	(1)	(1)	(1)
All Others	3	2	**	2
All Causes	58	40	37	44

*Rates may not add to total because of rounding errors.
**Less than one.

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*Term used by 1980 US Census.

TABLE 3—Prehospital and Inhospital Case Fatality Rates by Median Family Income, San Diego County, 1981

Median Family Income ($)	Prehospital Deaths			Inhospital Deaths		
	Number at Risk	Number of Deaths	Rate per 100 Persons	Number at Risk	Number of Deaths	Rate per 100 Persons
<15,000	355	163	50	192	78	41
15,000–19,999	208	105	50	103	38	37
20,000+	277	118	43	159	57	36
All MFI	840	386	46	454	173	38

$45,723. The tracts were grouped into three median annual family income categories: low (< $15,000), middle ($15,000 to $19,000), and high (≥ $20,000). Each category contained approximately one-third of the county's population. Median family income was not adjusted for family size.

Eighty-three of the total of 923 persons with serious brain injuries (9 per cent) were excluded from all analyses because their census tracts of residence (and, therefore, median family income) could not be identified. These 83 cases differed from those included by sex (60 per cent vs 76 per cent males), percentage with GCS 9 or higher[6] (77 per cent vs 36 per cent), percentage aged 15 years or less (23 per cent vs 10 per cent), percentage injured in falls (30 per cent vs 12 per cent), and percentage injured in motor vehicle crashes (25 per cent vs 45 per cent).

Results

The incidence of serious brain injury among San Diego County residents in 1981 was 44 per 100,000 persons. Rates for persons in census tracts with low, middle, and high median family income were 58, 40, and 37 serious brain injuries per 100,000 persons, respectively (Table 1). Fatal and non-fatal serious brain injury rates when tabulated separately were each elevated in the lowest income category.

The above incidence rates are not adjusted for sex, age, or race/ethnic group. Sex was uniformly distributed across the three groups of census tracts so no adjustment was required. Adjustment for age produced only a minimal change in the overall rates per 100,000 persons to 56 for low, 40 for middle, and 40 for high income census tracts. The observed race/ethnicity specific brain injury rates by median family income differed from those expected based on the percentage of the population in each cell (Table 1). Overall, and for all race/ethnicity groups except "Hispanic", rates declined with increasing median family income. Among "Hispanics", rates increased with increasing median family income. Race/ethnicity adjusted rates were similar to the unadjusted rates (Table 1).

Brain injury rates from firearms and assaults were higher in the lowest median family income group than in other income groups (Table 2). There were many fewer differences in the incidence rates of serious brain injury from motor vehicles, and still smaller differences in rates from falls among the median family income groups. There were no differences in brain injury rates to motor vehicle occupants in the middle or highest median family income census tracts compared to the lowest median family income census tracts but higher rates to pedestrians and motorcyclists in the lowest income tracts compared to the higher income tracts.

For those who had sustained a serious brain injury, median family income was not related to type of emergency transport, time from injury to first medical contact, probability of pre-hospital death, or probability of death once hospitalized alive (Table 3). For those who survived to hospital discharge, the outcome of serious brain injury as defined by the Glasgow Outcome Scale was not related to median family income (Table 4).

TABLE 4—Per Cent Serious Brain Injuries by Median Family Income and Glasgow Outcome Scale, San Diego County, 1981

Glasgow Outcome Scale	Median Family Income ($)			
	<15,000	15,000–19,000	20,000+	Total
Good Recovery	38	41	41	40
Moderate Disability	11	15	16	14
Severe Disability	7	7	5	6
Persistent Vegetative State/Death	44	38	38	41
Total (%)	100	101	100	101
Number	(192)	(103)	(159)	(454)

Discussion

Consistent with previous reports,[1–4] the present study documents an inverse relationship between socioeconomic status (median family income) and the incidence of serious brain injury, with the excess incidence among low income groups attributable primarily to excess injuries from interpersonal violence. Median family income was not related to the incidence of injury from motor vehicle crashes overall but was related to the risks of injury for motorcyclists or pedestrians. This finding illustrates the need to examine motor vehicle injury data for each road-use group separately rather than as a single large external cause category.

After median family income is taken into account, consideration of race/ethnicity does not change the rates appreciably. Unlike the findings reported by Cooper and colleagues[8] in the Bronx, New York, no excess for Blacks or "Hispanics" was found. In fact, there were fewer injuries than expected among "Hispanics". The different findings of the two studies may reflect different exposures among residents of the Bronx and those of San Diego County. The lower rates for Blacks and "Hispanics" and higher rates for Whites suggest that the use of race/ethnicity as a proxy for socioeconomic status may be inappropriate.

Once injured, high median family income is associated with a slight improvement in outcome for each category of injury examined. It should be noted, however, that because associations found for grouped data may not be present at the individual level, inferences from the present study could be examples of the "ecologic fallacy".[9]

ACKNOWLEDGMENTS

This work was supported by a grant from the Insurance Institute for Highway Safety, Washington, DC. The opinions, findings, and conclusions

expressed are those of the authors and do not necessarily reflect the views of the IIHS. The authors appreciate comments by Brian O'Neill, President, and Alan Williams, Vice President, of the Insurance Institute for Highway Safety.

REFERENCES

1. Mierley MC, Baker SP: Fatal house fires in an urban population. JAMA 1983; 249:1466–1468.
2. Whitman S, Coonley-Hoganson R, Desai B: Comparative head trauma experiences in two socioeconomically different Chicago area communities: A population study. Am J Epidemiol 1984; 119:570–580.
3. Wise PH: Mills M, Wilson M, *et al*: The influence of race and socioeconomic status on childhood mortality in Boston. Am J Dis Child 1983; 137:538.
4. Baker SP, O'Neill B, Karpf RS: The Injury Fact Book. Lexington, MA: Lexington Books, 1984; 49–53, 131.
5. Collins JG: Persons injured and disability days due to injuries, United States, 1980–81 Vital and Health Statistics. Series 10, No. 149. DHHS Pub. No. (PHS) 85-1577. Washington, DC: Govt Printing Office, March 1985.
6. Kraus JF, Black MA, Hessol N, *et al*: The incidence of acute brain injury and serious impairment in a defined population. Am J Epidemiol 1984; 119:186–201.
7. Jennett B, Teasdale G: Management of Head Injuries. Philadelphia: F.A. Davis, 1981; 77–84, 304–306.
8. Cooper KD, Tabaddor K, Hauser WA, *et al*: The epidemiology of head injury in the Bronx. Neuroepidemiology 1983; 2:70–88.
9. Kleinbaum D, Kupper L, Morgenstern H: Epidemiologic Research: Principles and Quantitative Methods. Belmont, CA: Lifetime Learning Publications, 1982; 79–80.

Johns Hopkins Begins AIDS Drug Testing

Scientists at Johns Hopkins Medical Institutions will begin testing the value of anti-AIDS drugs on dozens of patients within the next six months. The treatment studies are part of a 14-center, $100 million contract awarded June 30, 1986 by the National Institute of Allergy and Infectious Diseases (NIAID). Hopkins' contract is for $6 million over five years. An estimated 1,000 AIDS patients will be enrolled in the program nationwide, with 50 to 150 in the first six months at each center for initial phases of the study. At least six experimental drugs are expected to be evaluated for safety and effectiveness against the AIDS virus. Other drugs will be tested for their value in treating the cancers and opportunistic infections that kill AIDS patients.

The NIAID project marks the latest increase in national support of research directed at the AIDS epidemic. The US Public Health Service (PHS) estimates that some 270,000 Americans will develop the fatal disorder by 1991. PHS predicts 35,000 people will have AIDS by the beginning of 1987, with 16,000 new cases diagnosed in 1986, and that medical care for AIDS patients will cost between $8 billion and $16 billion in 1991.

The 14-center cooperative project differs from traditional drug studies of infectious diseases in several ways. First, scientists design the studies, rather than the drug suppliers. Second, the federal government is sponsoring the project rather than pharmaceutical companies, traditional supporters of experimental drug studies. Finally, the project is a multi-centered study, which will allow sharing of information, generated in a common protocol, so as to obtain answers faster.

The 14-center project will concentrate initially on drugs that stop replication of the AIDS virus, although drugs that stimulate immune defenses also will be studied. The drugs likely to be tested in the first year of the NIAID project include azidothymidine (AZT), dideoxycytidine, foscarnet, HPA-23, interferon alpha, and ribavirin. With the exception of dideoxycytidine, which is still under study in animals, all of these have been examined in humans.

AZT was developed by the Burroughs-Wellcome Company, which currently is conducting a multi-center study of the drug in patients with AIDS and AIDS-Related Complex. The drug inhibits the enzyme reverse transcriptase essential for viral replication.

Dideoxycytidine is a newer antiviral drug that has not been examined as a treatment for other diseases, according to Paul S. Lietman, M.D., Ph.D., professor of medicine and of pharmacology and experimental therapeutics and a co-investigator in the Hopkins treatment evaluation unit.

Foscarnet, developed by Astro in Sweden, is still under investigation as a treatment for herpes infection. Also an antiviral drug, it inhibits reverse transcriptase.

HPA-23, the only inorganic drug, is made from two heavy metals, antimony and tungsten. Developed in France by Rhone-Poulenc, it also interfers with reverse transcriptase. Hopkins has conducted studies of this drug.

Interferon alpha blocks the replication of the virus in new cells, thus preventing spread of the virus in the body, unlike the other candidate drugs, which scientists believe have the potential to stop the actual replication of the virus in infected cells. Interferon alpha is a normally-occurring, immunity-boosting body substance. When a virus infects a cell, the cell makes interferon, sending the small, proteinlike substance to other cells to warn and fortify them against a viral attack. The Food and Drug Administration has just approved the marketing of genetically engineered interferon as a treatment for a few rare cancers, most notably, hairy cell leukemia. "In people who have AIDS, the interferon system may be malfunctioning," Lietman says.

Ribavirin, developed in the United States, currently is used for uncommon infections, such as Lassa fever and Ebola virus infection in Africa. The drug also is used to treat infants with respiratory syncytial virus infection, which frequently causes pneumonia. Ribavarin is an antiviral drug that prevents messenger RNA from carrying out its function during viral replication. A trial with this drug as treatment for ARC is currently underway at Hopkins.