Emergency Department-Treated Traumatic Brain Injury

Minnesota 1998-2003

Extent of the problem

Leading Causes

Future Directions

MINNESOTA MDH DEPARTMENT OF HEALTH

Injury and Violence PREVENTION

September 2005

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Injury and Violence
PREVENTION

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Emergency Department-Treated Traumatic Brain Injury in Minnesota, 1998-2003

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Emergency Department-Treated Traumatic Brain Injury In Minnesota, 1998-2003

Abstract

Background: In 2001, Minnesota was one of two states funded by the CDC to explore the feasibility of surveillance of emergency department (ED)-treated traumatic brain injury (TBI). This is the first report describing the burden of TBI-ED in Minnesota.

Methods: Electronic, centralized discharge data from the Minnesota Hospital Association (MHA) were analyzed using the CDC's TBI case definition. Cases with a diagnosis of "Head Injury, Unspecified" (HIU or 959.01) alone were analyzed separately since HIU is a new diagnostic code and preliminary analysis shows it does not predict the true occurrence of a TBI as well as other TBI diagnostic codes. Analysis for this report was limited to Minnesota residents. Deaths and hospital admissions / transfers were not included in this analysis as they are addressed in separate reports.

Results: A total of 102,293 individuals were treated in the ED setting during 1998-2003 and assigned at least one TBI diagnostic code. Of these, 63,750 (62 percent) individuals were given the diagnosis of HIU (959.01) alone and 38,543 (38 percent) were given other TBI diagnostic codes. Analysis of the data shows an upward trend over the surveillance period. The age-adjusted annualized rate was 129.3 per 100,000 population for other TBI diagnostic codes and 251.0 per 100,000 for HIU (959.01) alone cases. The ED-treated TBI rate was higher among residents of the Twin Cities seven county metropolitan area than the rate in Greater Minnesota; however, the rate difference decreased over the six-year period.

The data show a tri-modal curve, with peaks among the very young, adolescents / young adults, and the elderly. TBI-ED rate for males were consistently higher than those for females, with male rates among adolescents/young adults approximately twice that of the female rates. Unlike the nonfatal hospitalized TBI distribution, the TBI-ED peak occurs among adolescents / young adults, with the highest rates among 15-19 year olds followed by 10-14 year olds and 20-24 year olds (330.3, 221.1 and 206.5 per 100,000 population, respectively).

Leading causes were unintentional falls, sports and recreation, and motor vehicle traffic (MVT) - related injuries. Unintentional fall rates were distributed bi-modally with the highest rates among children less than five years old and those 85 years and older. Sports and recreation rates spiked among adolescents ages 10-19 years old, while MVT rates were highest for adolescents/young adults ages 15-24 years old.

The median ED treatment charges increased with increasing age; charges increased to $1,290 (72 percent increase) for all age groups combined over the six-year period. Total treatment charges for TBI-ED exceeded $44 million over the six-year period.

Discussion: It is unclear how well HIU (959.01) describes the true occurrence of TBI in the ED setting. Future reports using data from medical records abstraction will yield key insight on TBI-ED surveillance in Minnesota. Additionally, abstracted data will yield important information on demographic features (e.g., race / ethnicity), modifiable risk factors (e.g., alcohol use), and circumstances at time of injury (e.g., specific activity in which the individual was engaged at time of injury) that in turn can be used to guide intervention activities.

Emergency Department-Treated Traumatic Brain Injury In Minnesota, 1998-2003

Background

Traumatic brain injury (TBI) has been recognized as a health problem for over 3,000 years.[1] Numerous population-based studies have focused on TBI-related mortality and incidence of nonfatal hospitalized TBI.[2-9] However, a recent Centers for Disease Control (CDC) report estimated that 80 percent of TBI are treated in the emergency department (ED) setting.[10] Despite its proposed magnitude, population-based surveillance data for TBI-ED are relatively rare.

Possible reasons include (1) the perception that ED-treated TBI is far less severe than hospital-treated TBI, (2) a lack of availability of quality data sources and (3) a lack of funding for studies. The assumption that most TBI-ED is mild TBI (mTBI)[11] with short-term effects is contradicted by studies that suggest up to 50 percent of mTBI cases report post-concussive symptoms at one month and 15-25 percent at one year post-injury.[12-14]

Several TBI-ED studies have used National Hospital Ambulatory Medical Care Survey (NHAMCS) data to estimate national incidence rates.[10, 15-17] The NHAMCS utilizes data based upon physician interview from 398 participating hospitals nationwide and is not population-based.[18] Therefore, thus far, population-based TBI-ED surveillance data have not yet been published. In 2001, Minnesota and South Carolina were funded by the CDC Injury Prevention and Control Center (NCIPC) to evaluate the feasibility of state-level surveillance of TBI in the ED setting.

This is the first published report devoted solely to ED-treated TBI among Minnesota residents. It serves as a companion report to *Nonfatal Hospitalized Traumatic Brain Injury, Minnesota, 1998-2003*.[19*] Additionally, this report is a reference point for future publications summarizing clinical and demographic findings from abstraction of TBI-ED cases.

Methods

ED-treated TBI cases from the period January 1, 1998 to December 31, 2003, identified from the electronic universal bill 1992 (UB 92) revision from the Minnesota Hospital Association (MHA), were analyzed. Deaths and hospital admissions/transfers were excluded from the current analysis as they are addressed in separate reports published by the Minnesota Department of Health (MDH) Injury and Violence Prevention Unit (IVPU).[2, 7, 19-26]

Case Identification

The MDH IVPU has a long history of data collection for fatal and hospitalized nonfatal TBI. In 1991, the Minnesota Legislature passed Minnesota Statutes §144.661-144.665 mandating the creation of the traumatic brain injury (TBI)/spinal cord injury (SCI) registry. Data collection commenced in 1993. In 1998, the MDH IVPU began receiving centralized, statewide ED UB 92 data from the MHA.

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[*] *Nonfatal Hospitalized Traumatic Brain Injury, Minnesota, 1998-2003* can be found at http://www.health.state.mn.us/injury/pub/tbi9803.pdf

Case Definition

Operational Case Definition: The TBI administrative case definition, based upon ICD-9-CM diagnostic codes (see Table 1), was used for this study.[27, 28] The CDC's TBI operational case definition included "Head Injury, Unspecified" (HIU) or 959.01, an ICD-9-CM code that was first introduced in October 1, 1997. This code has vague language and it is not clear how well it captures the occurrence of TBI.

Individuals with brain injuries caused by anoxia due to trauma were excluded as were patients with brain dysfunction caused by congenital or degenerative disorders or birth trauma.[29] Patients with length of stay two days or greater were excluded from analysis because it was determined that these cases were likely miscoded hospitalized cases.

Table 1: CDC Operational Case Definition for TBI Surveillance or Research (ICD-9-CM)

Primary or Secondary Diagnosis Coded as One of the Following:

ICD-9-CM Description	ICD-9-CM Diagnostic Codes
Fracture Vault of Skull	800.00-800.99
Fracture Base of Skull	801.00- 801.99
Other and Unqualified Skull Fractures	803.00- 803.99
Multiple Fractures Involving Skull or Face with Other Bones	804.00- 804.99
Concussion	850.0-850.9
Cerebral Laceration and Contusion	851.00-851.99
Subarachnoid, Subdural, and Extradural Hemorrhage, Following Injury	852.00-859.59
Other and Unspecified Intracranial Hemorrhage Following Injury	853.00-853.19
Intracranial Injury of Other and Unspecified Nature	854.00-854.19
Injury to Optic Nerve and Pathways	950.1-950.3
Head Injury, Unspecified (HIU)	*959.01*
Shaken Infant Syndrome	995.55

Additional case definition criteria included:

- treated and released from ED setting;
- nonfatal case;
- Minnesota resident; and
- injury sustained between January 1, 1998 and December 31, 2003.

The six-year period was chosen since it parallels data from the nonfatal hospitalized report and includes the introduction of this new diagnostic code, allowing for separate analysis of HIU (959.01).

Data Collection and Processing

Collection of TBI-ED data was conducted in a manner consistent with the CDC's Central Nervous System Data Submission Guidelines.[27, 30] Data collection included demographic features, ICD-9-CM diagnostic codes, ICD-9-CM procedure codes, and ICD-9-CM external cause of injury codes (E-codes).

Quality Assurance, Data Unduplication and Linkage

Duplicate cases and redundant billing data were removed from the final dataset by including only cases where the ED was the individual's final acute care facility. Gender, ZIP code, dates of birth, admission, and discharge, discharge status, and source of admission were used to sequence unique injury events for all records received from the MHA.

Completeness of data was ascertained by assessing frequencies of essential variables such as gender and age.

Variables

The data set included most of the core CDC variables as defined by Central Nervous System Data Submission Standards[30] with the exception of race and ethnicity as these elements were not part of the UB 92 data form in Minnesota. Date of treatment was used as a proxy for date of injury. Classification of injury cause and intent was

primarily based upon guidelines from the CDC National Center for Injury Prevention and Control (NCIPC).[31] A new sports and recreation cause of injury category was created based upon sports and recreation-related E-codes (see Table 2).

Table 2: E-codes in Sports and Recreation Cause of Injury Category

E800-E807 with 4th digit 3 – railway train crash involving pedal cyclist
E810-E819 with 4th digit 6 – motor vehicle crash involving pedal cyclist
E820-E821 with 4th digit 0,1,8 – snowmobile rider (E820) or ATV rider (E821)
E826-E829 with 4th digit 1 – pedal cyclist involved in crash
E826-E829 with 4th digit 2 – rider of animal involved in crash
E830-E836 with 4th digit 0,1,3,4,5 – water transport crash involving occupant (.0,.1,.3), water-skier(.4) or swimmer (.5)
E842 with 4th digit 6 – injury to unpowered aircraft occupant
E849 with 4th digit 4 – injury at place for recreation and sport
E883 with 4th digit 0 – injury from diving or jumping into water (swimming pool)
E884 with 4th digit 0 – fall from playground equipment
E885 with 4th digit 0,1,2,3,4 – fall from non-motorized scooter (.0), roller skates (.1), skateboard (.2), skis (.3) or snowboard (.4)
E886 with 4th digit 0 – fall on same level from collision, pushing or shoving, by or with other person in sports
E910 with 4th digit 0,1,2 – unintentional drowning and submersion while water skiing (.0), engaged in other sport or recreational activity with diving equipment (.1), engaged in other sport or recreational activity without diving equipment (.2)
E917 with 4th digit 0 or 5 – striking against or struck accidentally by objects or persons in sports without subsequent fall (.0) or in sports with subsequent fall (.5)
E922 with 4th digit 4 – unintentional injury caused by air gun
E922 with 4th digit 5 – unintentional injury caused by paintball gun
E923 with 4th digit 0 – unintentional injury caused by explosive material, fireworks

Data Analysis

Analyses were conducted using PC SAS, Version 9 (SAS Institute, Cary, NC) and Microsoft Excel 2000 (Microsoft Corporation, Redmond, WA).

Annualized rates by year, age-adjusted to the U.S. 2000 Standard Population,[32] were calculated for HIU (959.01) alone and for other TBI diagnostic codes cases. Annualized rates were also calculated by age and gender, geographic location (age-adjusted), by leading cause and age group and leading cause and season (age-adjusted). Analysis by type of facility was conducted (i.e., trauma center vs. community hospital). The Twin Cities seven-county metropolitan area was defined as Anoka, Carver, Dakota, Hennepin, Ramsey, Scott and Washington counties. Leading cause categories included unintentional falls, sports and recreation, and motor vehicle traffic (MVT).

Median ED treatment charges (U.S. dollars) were calculated by age group and year of treatment. Charges were adjusted to 2003 U.S. dollars to adjust for inflation over the six-year period.[33] Total charges for other TBI-ED and HIU (959.01) alone cases were calculated.

Limitations

The major inherent limitation of the UB 92 dataset was its use for billing versus surveillance purposes. Thus, it did not contain information on race/ethnicity, clinical features such as Glasgow Coma Scale (GCS) score, and modifiable risk factors such as use of personal protective equipment. As such, it was not possible to analyze the contribution of modifiable risk factors until data from medical record abstraction is available.

Another limitation of the UB 92 data was incompleteness of facility reporting (case ascertainment bias). ED data from all reporting facilities were used (N=121) for this report, with data from 87 facilities available for the entire six-year period. MHA participation has continued to increase; as of 2003, 91 percent (n=117) of the 128 24-hour

EDs reported data. It was estimated that the reporting facilities represented approximately 94 percent of all ED treatments in Minnesota. Residents of several western counties were treated in trauma centers in the Dakotas; an estimated 480 cases annually (<3 percent) of TBI-ED were not reported due to "border leakage."

Several cases (<10) in the original UB 92 dataset were recorded as ED-treated, but had a length of stay of either 730 days or 365 days. These extremely long lengths of stay seemingly indicated a data entry error for year of discharge. Since there was no way to ascertain true length of stay without medical record abstraction, these cases were excluded from the analysis.

Results

From 1998-2003, a total of 102,293 Minnesota residents with diagnostic codes consistent with the CDC's operational case definition were treated and released from Minnesota EDs. Among these individuals, 63,750 (62 percent) were given a diagnosis of HIU (959.01) alone while 38,543 (38 percent) were given other TBI codes. The adjusted annualized rates were 129.3 per 100,000 population for cases with TBI codes and 251.0 per 100,000 population for HIU (959.01) cases. Both HIU alone and the other TBI codes show an increasing trend over the six-year period (Figure 1).

Gender and Age:
Age and / or gender were unknown for 13 individuals so these cases were not included in the gender and age rate calculations (See Table 5; Figure 3). The majority of TBI-ED cases were male (23,581, 61 percent), as compared with HIU (959.01) alone cases (56 percent male). Data show a tri-modal curve with peaks among very young, adolescents / young adults and elderly. The TBI-ED rate for males was consistently higher than for females; this was most notable among adolescents / young adults where male rates were approximately twice that of corresponding female rates. Unlike the nonfatal hospitalized TBI distribution with the highest rates among older adults, the ED peak occurs among adolescents / young adults, with the highest rates among 15-19 year olds (330.3 per 100,000 population) followed by 10-14 year olds (221.1 per 100,000 population) and 20-24 year olds (206.5 per 100,000 population).

Geographic Location:
County of residence and/or ZIP code were unknown for 1,745 (4.5 percent) individuals so they were not included in rate calculations. The percentage of cases with unknown county of residence and/or ZIP code was consistently between 4-5 percent over the surveillance period.

The overall annualized rate was 129.3 per 100,000 with higher rates in the Twins Cities seven-county metropolitan area than in greater Minnesota; 137.3 per 100,000 population and 108.4 per 100,000 population, respectively. However, it is important to note that the distribution by location changes over time with the percentage of cases from Greater Minnesota increasing from approximately 35 percent of cases in 1998 to approximately 50 percent in 2003

The highest rates were observed in Mille Lacs, Koochiching and Washington counties (301.6, 236.9 and 202.4 per 100,000 population, respectively). Conversely, the lowest rates were found in Martin, Freeborn and Clay counties (36.7, 27.5 and 8.6 per 100,000 population, respectively). Nine counties had less than 20 cases over the six-year period; rates for these counties were not

calculated due to instability due to small numbers. Detailed information on TBI-ED rates by county can be found in Figure 2, Table 3 and Table 4.

A total of 121 facilities (92 percent) reported data to the MHA in 2003; 87 facilities reported data during the entire six-year period. Eight facilities closed during the surveillance period and therefore did not submit data to the MHA the entire six years. In 2003, 25 new facilities began reporting data to the MHA. All of these newly reporting facilities were from outside the Twin Cities seven county metropolitan area and are smaller facilities (with the exception of one facility, all are licensed for 50 acute care beds or less). The increasing trend in the rate for Greater Minnesota residents persisted even when controlling for newly reporting facilities.

Ten trauma centers accounted for 14,607 cases (38 percent) over the report period, with the percentage from these trauma centers decreasing from 41 percent in 1998 to 33 percent in 2003.

Causes:
Cause of injury information was ascertained from E-codes (See Table 6; Figure 4 and 5). Although E-coding was voluntary in Minnesota, most hospitals E-code, ranging from 83 percent in 1998 to 97 percent in 2003. Leading causes of TBI-ED were unintentional falls, sports and recreation and MVT, with overall annualized rates of 38.5, 26.7 and 19.8 per 100,000 population, respectively.

The age-adjusted unintentional fall rate varied by year, but showed a 6 percent increase across the six-year surveillance period. Unintentional fall rates showed a bi-modal curve with the highest rates among children less than five years old and adults 85 years and older. Analysis of HIU (959.01) alone cases showed unintentional fall rates more than four times higher for children less than one year old, but very similar rates and distribution by age group for all other aspects of the leading causes discussed above.

Sports and recreation rates spiked among adolescents ages 10-19 years old. Overall sports and recreation-related age-adjusted rates had a consistently positive trend and increased more than 75 percent from 20.3 to 35.7 per 100,000 population during the six-year period. The largest increases in frequency were observed for the following categories: striking against or unintentionally struck in sports with or without subsequent fall (E917.0 and E917.5), all-terrain vehicles (E821.0, E821.1 and E821.8), falls while skiing/snowboarding (E885.3-E885.4), and injuries at a place for sports and recreation (E849.4).

MVT rates were highest for adolescents and young adults ages 15-24 years old. MVT rates also demonstrated a positive trend, with an approximately 19 percent increase in annual age-adjusted rates between 1998 and 2003.

Season:
There was some variation among leading causes by season of injury over the six-year period (See Figure 6). The unintentional fall rate was highest during the winter season (December 21 – March 20) while the rate of sports and recreation-related injuries increased over the summer season (June 21 – September 20).

Treatment Charges:
Median ED treatment charges increased with increasing age (See Figure 7). For all ages combined, median charges increased 72 percent over the six-year period when adjusted for inflation[ψ] (See Figure 8). Total treatment charges for TBI-ED exceeded $44 million over the six-year period.

E-coding Changes:
There was a marked increase in E-coding (83 to 97 percent) over the surveillance period. Numerous E-code training sessions were provided to Health Information Management and Records Coding professionals throughout the state during the project period. It appears these trainings were helpful in increasing the frequency of E-coding by medical records staff. At this point, it remains unclear how increased E-coding affected the leading causes of injury – did sports and recreation injuries truly increase, is it a reflection of better E-coding, or is it a combination of both factors? For example, snowboarding is a relatively new recreational activity and zero injuries were reported in 1998 and 1999; however, in 2003, more than 140 snowboard-related injuries were reported.

Discussion

Analysis of UB data allowed for the identification of general risk factors such as age, gender, and cause/mechanism/intent (E-coding) that, in turn, can guide prevention and control activities and generate topics for further study. TBI-ED surveillance continues to evolve and findings have suggested the need to learn more about the reasons behind the variation by age, gender, cause and season.

Analysis of TBI-ED abstracted clinical data, selected from a random sample of medical records, is the second component of TBI-ED surveillance. Abstracted data reveal, for example, whether patients experienced amnesia. Results of these analyses will be published separately in 2006 and will include detailed clinical information on neurological and neuropsychological abnormalities as well as additional demographic data such as race / ethnicity, impact of socioeconomic status, prior disability, and payment source.

Abstraction allowed for evaluation of how well the CDC operational case definition (Table 1) accurately predicted the occurrence of a TBI or a true positive case. Predictive value positive (PVP), the statistical measure of choice, is expressed as a percentage, calculated by the number of true positive cases divided by the total number of cases abstracted.[34] Preliminary results showed that the PVP for HIU (959.01) was approximately 30 percent. However, because of the magnitude of cases with this diagnostic code in the ED setting (~13,000 cases per year), it continues to be a complex decision as to whether or not HIU (959.01) should be included in the TBI-ED operational case definition. Therefore, TBI-ED rates presented in this report may be adjusted based upon future findings from medical records abstraction.

[ψ] Adjusted to U.S. 2003 dollars.

In 2003, the CDC published a *Report to Congress on Mild Traumatic Brain Injury,* which outlined a charge to evaluate the magnitude and impact of mTBI.[11] One of the critical needs identified was to explore the association between mTBI and TBI-ED. Further analysis of TBI-ED abstracted clinical data (such as presence of amnesia, loss of consciousness, neurological abnormalities, etc.,) will allow for this comparison.

IVPU staff created the E-code based sports and recreation case definition (See Table 2) in order to analyze the TBI-ED data. Two previously published TBI papers proposed more limited sports and recreation case definitions, but it was felt that these definitions did not take advantage of all available sports and recreation-related E-codes.[35, 36] Additionally, there is a longstanding mandate from the National Institutes of Health Consensus Development Conference on the Rehabilitation of Persons with Traumatic Brain Injury to look at the contribution of sports and recreation-related injuries to TBI.[37] Preliminary analysis of abstracted data suggests that more than 35 percent of true positive TBI-ED cases were sports and recreation-related. Future analysis will provide additional information on specific activity, setting, mechanism of injury, injury intent, and use of personal protective equipment (e.g., a helmet for biking). Sports and recreation–related TBI is a complex and sensitive issue given the public health directives to increase physical activity (it is the leading health indicator in Healthy People 2010[38]).

The distribution of TBI-ED rates by age and gender differ from the nonfatal hospitalized TBI rates where we see a tri-modal curve with the highest peak among the elderly followed by young infants and adolescents/young adults, respectively.[19] Future analyses of hospital and ED data will ascertain whether this is due to physiological factors or to hospital admission biases for certain populations.

Rates by location were slightly underestimated because in 1,745 (4.5 percent) TBI-ED cases, county of residence and ZIP code were unknown. The population in Minnesota is fairly evenly distributed between the Twin Cities seven-county metropolitan area and Greater Minnesota. TBI-ED rates increased in Greater MN by year of treatment even when controlled for newly reporting facilities. Routine quality improvement efforts include plans for IVPU staff members to assess PVP and coding practices by location since it appears that a differential may exist between the application of the HIU (959.01) diagnostic code in metropolitan patients as compared to patients from Greater Minnesota.

There is no doubt that ED-treated TBI is a significant problem in Minnesota. Future reports using data from medical records abstraction will yield key insight on demographic features (e.g., race / ethnicity), modifiable risk factors (e.g., alcohol use), and circumstances at time of injury (e.g., specific activity in which the individual was engaged at time of injury) that in turn can be used to guide intervention activities.

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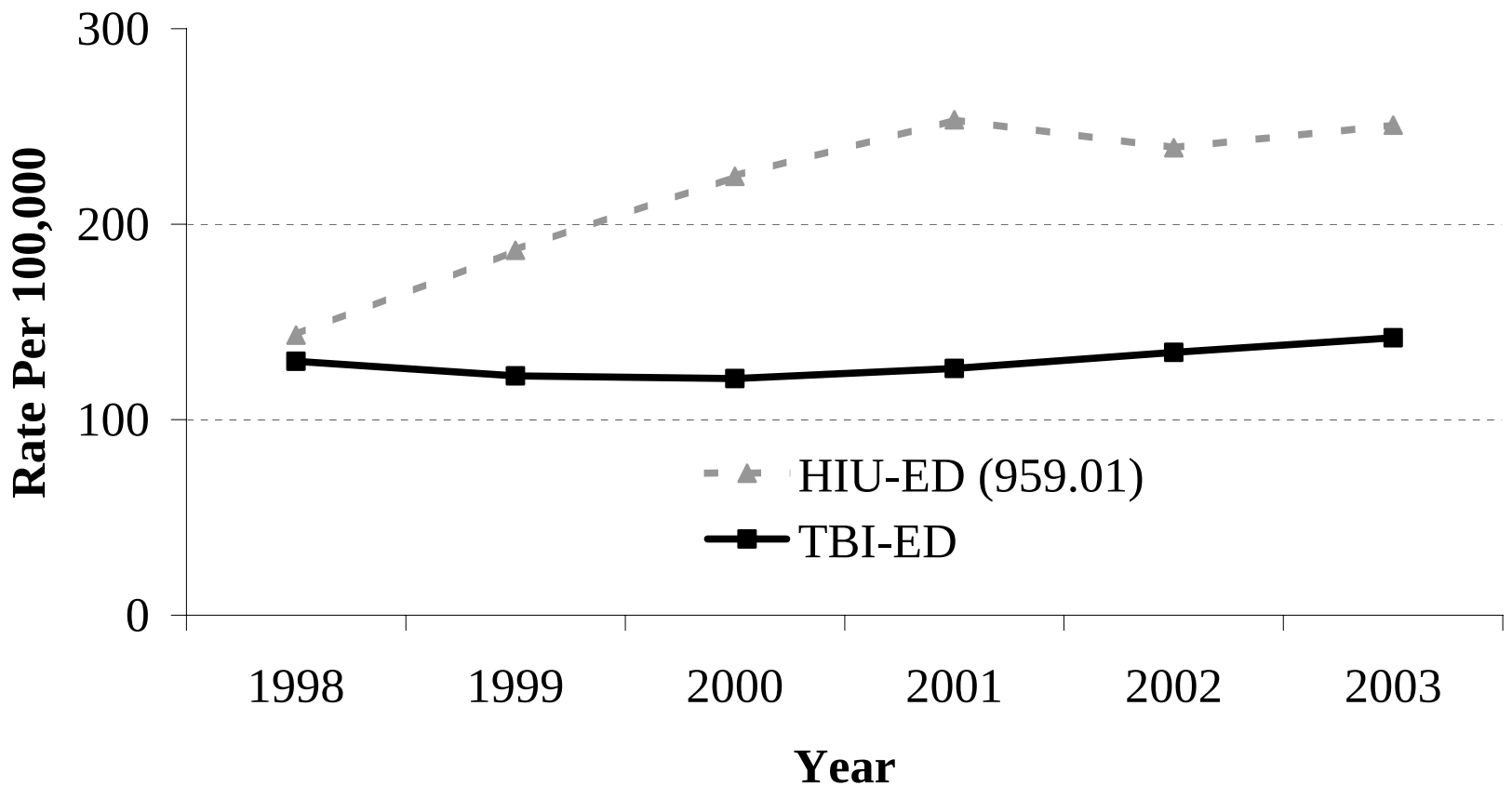
Figure 1

ED-Treated TBI Rate by Year

Minnesota, 1998-2003



Rates were age-adjusted to the U.S. 2000 population.

Table 3: Number and Rate of Emergency Department-Treated TBI by County and Year, Minnesota 1998-2003

	1998-2003		1998		1999		2000		2001		2002		2003	
County	**N**	**Rate**	**N**	**Rate**	**N**	**Rate**	**N**	**Rate**	**N**	**Rate**	**N**	**Rate**	**N**	**Rate**
Minnesota	38543	129.3	6230	129.9	5948	122.4	6028	121.0	6345	126.4	6800	134.5	7196	141.9
7 County Metro*	21803	137.3	3902	153.4	3574	138.3	3518	132.0	3517	130.7	3607	133.7	3685	136.0
Greater Minnesota	14999	108.4	2040	91.1	2122	93.5	2243	97.0	2537	109.6	2892	123.9	3165	135.5
Aitkin	96	122.0	6	.	14	.	15	.	20	144.4	17	.	24	182.2
Anoka	1876	101.5	435	147.5	296	97.1	257	83.5	273	87.8	287	90.1	328	102.8
Becker	114	64.3	11	.	10	.	19	.	20	69.3	22	73.5	32	105.1
Beltrami	144	54.6	19	.	19	.	29	68.8	23	51.6	31	68.1	23	51.6
Benton	205	91.7	9	.	14	.	57	154.1	40	111.4	36	93.8	49	129.5
Big Stone	22	74.5	3	.	3	.	4	.	8	.	3	.	1	.
Blue Earth	542	154.5	50	85.5	81	139.6	82	134.3	94	157.4	108	180.6	127	229.3
Brown	198	124.3	10	.	20	72.7	42	161.7	48	182.2	43	160.7	35	133.9
Carlton	360	191.1	39	132.7	23	69.5	49	162.0	92	296.3	69	215.1	88	271.0
Carver	584	130.9	79	116.3	88	127.5	98	137.4	88	118.2	107	134.8	124	151.3
Cass	152	100.5	10	.	20	80.1	28	122.6	18	.	37	140.3	39	144.1
Chippewa	68	88.6	10	.	8	.	15	.	6	.	11	.	18	.
Chisago	402	146.3	21	48.3	21	48.7	22	54.2	49	109.0	145	314.3	144	303.5
Clay	31	8.6	6	.	7	.	2	.	5	.	6	.	5	.
Clearwater	14	.	6	.	3	.	0	.	2	.	0	.	3	.
Cook	23	110.5	16	.	3	.	1	.	2	.	0	.	1	.
Cottonwood	10	.	1	.	0	.	3	.	0	.	0	.	6	.
Crow Wing	520	160.3	20	39.1	39	77.9	77	148.6	83	157.2	144	260.7	157	278.5
Dakota	3433	157.9	690	198.6	585	161.8	518	143.4	501	138.2	558	150.7	581	154.9
Dodge	166	148.5	48	267.0	30	157.3	22	118.9	24	130.1	18	.	24	122.9
Douglas	111	58.5	23	74.6	25	80.4	18	.	18	.	14	.	13	.
Faribault	88	100.3	15	.	14	.	16	.	10	.	13	.	20	146.4
Fillmore	170	142.6	44	229.0	32	165.4	27	136.5	24	116.2	20	101.7	23	106.8
Freeborn	47	27.5	14	.	5	.	7	.	5	.	9	.	7	.
Goodhue	444	172.6	73	175.0	61	142.7	56	133.2	70	163.2	91	205.7	93	215.8
Grant	33	97.6	2	.	9	.	4	.	8	.	7	.	3	.
Hennepin	7993	122.2	1484	140.3	1393	131.4	1338	120.0	1316	117.9	1297	117.5	1165	106.3
Houston	15	.	2	.	3	.	1	.	5	.	3	.	1	.
Hubbard	108	107.9	17	.	16	.	24	137.5	14	.	13	.	24	132.9
Isanti	384	194.0	71	218.8	62	197.7	48	151.8	63	192.9	70	207.7	70	195.0
Itasca	214	84.5	30	75.4	36	84.4	28	63.5	35	79.2	35	85.6	50	119.0
Jackson	54	86.6	8	.	8	.	6	.	10	.	13	.	9	.
Kanabec	143	162.3	15	.	16	.	23	151.9	31	214.6	30	207.9	28	193.3
Kandiyohi	238	95.1	40	96.3	44	106.7	44	102.5	32	77.1	44	103.1	34	84.8
Kittson	6	.	1	.	1	.	3	.	0	.	0	.	1	.
Koochiching	181	236.9	5	.	16	.	9	.	41	320.1	41	327.0	69	558.8
Lac Qui Parle	16	.	1	.	0	.	4	.	3	.	2	.	6	.
Lake	71	116.0	17	.	7	.	12	.	8	.	7	.	20	204.9
Lake Of The Woods	48	187.1	3	.	8	.	8	.	8	.	14	.	7	.
Le Sueur	222	141.8	15	.	37	143.5	24	96.2	41	157.5	43	165.4	62	231.4
Lincoln	32	85.2	6	.	2	.	1	.	3	.	11	.	9	.
Lyon	154	98.4	20	79.4	25	100.4	32	121.8	26	97.7	27	101.4	24	90.0
Mahnomen	112	52.5	16	.	25	70.5	21	57.5	17	.	14	.	19	.
Marshall	8	.	1	.	1	.	2	.	1	.	2	.	1	.
Martin	22	36.7	2	.	2	.	2	.	5	.	7	.	4	.
Mcleod	144	120.5	22	105.0	16	.	5	.	23	113.2	37	184.7	41	210.3
Meeker	224	168.5	31	136.8	34	162.4	20	85.0	39	178.9	40	177.2	60	270.4
Mille Lacs	405	301.6	40	185.6	56	283.3	52	246.6	60	253.4	105	453.0	92	387.5
Morrison	160	83.7	24	80.9	24	86.2	27	79.2	29	88.4	22	68.4	34	99.2
Mower	137	63.7	20	57.0	27	77.2	20	53.9	24	66.3	23	63.2	23	64.4
Murray	42	78.7	2	.	3	.	7	.	7	.	13	.	10	.
Nicollet	171	89.0	21	58.4	27	86.6	22	68.3	34	104.5	35	114.5	32	101.5
Nobles	127	108.8	24	130.1	23	131.4	17	.	30	149.1	24	120.3	9	.
Norman	23	58.7	6	.	2	.	7	.	3	.	2	.	3	.
Olmsted	1126	151.3	337	281.2	218	179.0	149	119.0	117	92.3	151	117.3	154	119.1
Otter Tail	304	91.7	31	59.2	40	72.5	38	68.7	65	122.0	68	121.6	62	106.5
Pennington	81	103.1	11	.	17	.	11	.	12	.	17	.	13	.
Pine	267	171.2	24	105.3	33	131.9	28	107.9	59	223.4	75	277.4	48	181.4
Pipestone	26	43.3	1	.	7	.	2	.	6	.	4	.	6	.
Polk	113	61.4	9	.	13	.	16	.	11	.	31	99.9	33	110.9
Pope	63	99.0	12	.	10	.	11	.	7	.	8	.	15	.
Ramsey	4629	151.4	688	140.5	681	137.7	786	150.0	821	158.8	819	158.1	834	163.2
Red Lake	26	97.7	1	.	3	.	8	.	2	.	7	.	5	.
Redwood	95	96.2	18	.	15	.	8	.	19	.	18	.	17	.
Renville	99	101.5	12	.	17	.	14	.	17	.	18	.	21	139.0
Rice	405	111.3	48	80.5	59	101.6	61	101.1	93	153.7	65	99.0	79	132.0
Rock	12	.	0	.	2	.	0	.	4	.	5	.	1	.
Roseau	110	110.0	24	138.4	18	.	9	.	10	.	25	157.5	24	147.4
St. Louis	1602	139.2	255	137.6	228	120.2	214	108.4	258	132.9	294	152.6	353	183.7
Scott	833	142.1	133	159.0	131	143.2	126	136.1	138	138.0	126	117.3	179	158.8
Sherburne	588	133.2	50	78.8	79	108.9	99	140.4	97	132.2	128	167.7	135	171.3
Sibley	58	63.1	4	.	6	.	6	.	13	.	11	.	18	.
Stearns	508	59.0	44	33.1	36	24.6	122	84.2	114	80.6	92	62.3	100	69.0
Steele	195	95.9	35	107.0	33	99.6	36	107.2	29	86.0	20	56.7	42	119.2
Stevens	10	.	4	.	1	.	0	.	1	.	2	.	2	.
Swift	49	78.3	7	.	11	.	7	.	6	.	7	.	11	.
Todd	166	113.9	25	103.5	30	131.5	29	118.7	26	102.9	25	101.4	31	125.4
Traverse	15	.	1	.	3	.	4	.	2	.	0	.	5	.
Wabasha	130	104.2	37	178.0	22	101.1	18	.	17	.	20	96.7	16	.
Wadena	61	79.5	9	.	11	.	13	.	9	.	9	.	10	.
Waseca	155	134.7	23	126.0	32	169.1	18	.	26	132.7	24	126.9	32	161.6
Washington	2455	202.4	393	205.0	400	198.4	395	206.1	380	186.0	413	198.3	474	220.6
Watonwan	37	52.6	2	.	3	.	6	.	8	.	8	.	10	.
Wilkin	24	61.4	4	.	5	.	3	.	3	.	4	.	5	.
Winona	455	143.4	21	43.1	74	146.6	87	155.1	101	188.4	82	154.0	90	173.1
Wright	758	127.7	70	76.1	110	115.4	157	166.0	140	142.3	143	138.0	138	128.5
Yellow Medicine	36	54.8	5	.	4	.	4	.	3	.	8	.	12	.
County Unknown	1745	.	288	.	252	.	268	.	292	.	299	.	346	.

Rates are age-adjusted to the U.S. 2000 standard population. Unstable rates (for less than 20 cases) are not displayed. The 1998-2003 rate is annualized.

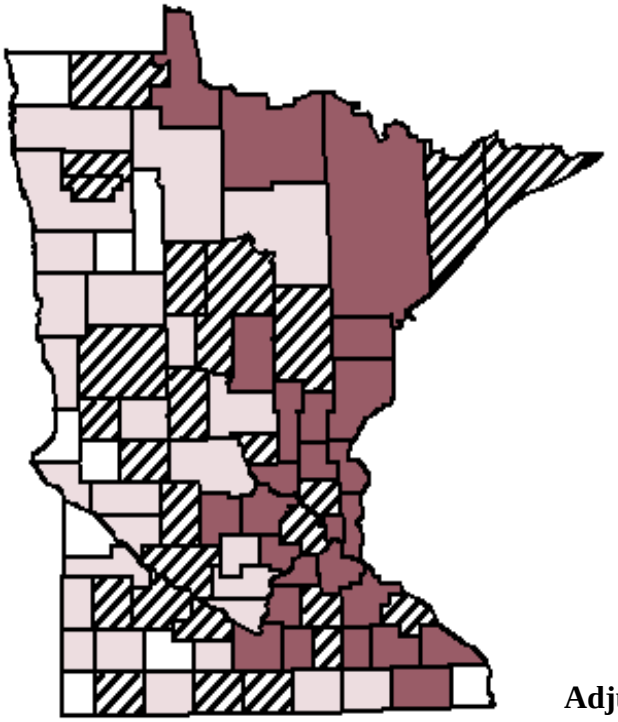
Seven County Metro defined as Anoka, Carver, Dakota, Hennepin, Ramsey, Scott and Washington counties.

HIU (959.01) alone cases were not included.

Figure 2

ED-Treated TBI* Rate by County

Minnesota, 1998-2003



Adjusted Rate per 100,000 (tertiles)

- **Unstable Rates (n<20)**
- **Low (8.6 - 91.6)**
- **Medium (91.7 – 127.6)**
- **High (127.7 – 301.6)**

*HIU (959.01) alone cases not included.

Table 4: Ranking of ED-Treated TBI County Rates, Minnesota 1998-2003

County	N	Annualized Rate	Rank
Mille Lacs	405	301.6	1
Koochiching	181	236.9	2
Washington	2,455	202.4	3
Isanti	384	194.0	4
Carlton	360	191.1	5
Lake Of The Woods	48	187.1	6
Goodhue	444	172.6	7
Pine	267	171.2	8
Meeker	224	168.5	9
Kanabec	143	162.3	10
Crow Wing	520	160.3	11
Dakota	3,433	157.9	12
Blue Earth	542	154.5	13
Ramsey	4,629	151.4	14
Olmsted	1,126	151.3	15
Dodge	166	148.5	16
Chisago	402	146.3	17
Winona	455	143.4	18
Fillmore	170	142.6	19
Scott	833	142.1	20
Le Sueur	222	141.8	21
St. Louis	1,602	139.2	22
7 County Metro*	**21,803**	**137.3**	
Waseca	155	134.7	23
Sherburne	588	133.2	24
Carver	584	130.9	25
Minnesota	**38,453**	**129.3**	
Wright	758	127.7	26
Brown	198	124.3	27
Hennepin	7,993	122.2	28
Aitkin	96	122.0	29
Mcleod	144	120.5	30
Lake	71	116.0	31
Todd	166	113.9	32
Rice	405	111.3	33
Cook	23	110.5	34
Roseau	110	110.0	35
Nobles	127	108.8	36
Greater Minnesota	**14,995**	**108.4**	
Hubbard	108	107.9	37
Wabasha	130	104.2	38
Pennington	81	103.1	39
Anoka	1,876	101.5	40
Renville	99	101.5	40
Cass	152	100.5	41
Faribault	88	100.3	42
Pope	63	99.0	43
Lyon	154	98.4	44
Red Lake	26	97.7	45
Grant	33	97.6	46
Redwood	95	96.2	47
Steele	195	95.9	48
Kandiyohi	238	95.1	49
Otter Tail	304	91.7	50
Benton	205	91.7	50
Nicollet	171	89.0	52
Chippewa	68	88.6	53
Jackson	54	86.6	54
Lincoln	32	85.2	55
Itasca	214	84.5	56
Morrison	160	83.7	57
Wadena	61	79.5	58
Murray	42	78.7	59
Swift	49	78.3	60
Big Stone	22	74.5	61
Becker	114	64.3	62
Mower	137	63.7	63
Sibley	58	63.1	64
Wilkin	24	61.4	65
Polk	113	61.4	65
Stearns	508	59.0	67
Norman	23	58.7	68
Douglas	111	58.5	69
Yellow Medicine	36	54.8	70
Beltrami	144	54.6	71
Watonwan	37	52.6	72
Mahnomen	112	52.5	73
Pipestone	26	43.3	74
Martin	22	36.7	75
Freeborn	47	27.5	76
Clay	31	8.6	77

Rates were age-adjusted to the U.S. 2000 population.
*Seven County Metro was defined as Anoka, Carver, Dakota, Hennepin, Ramsey, Scott and Washington counties.
Exclusions: Cases with unknown county and counties with unstable rates (N<20 cases): Clearwater, Cottonwood, Houston, Kittson, Lac Qui Parle, Marshall, Rock, Stevens and Traverse.
HIU (959.01) alone cases were not included.

Table 5: Number and Rate of ED-Treated TBI by Age Group and Gender, Minnesota, 1998-2003

	Total		Male		Female	
Age Group	**N**	**Rate**	**N**	**Rate**	**N**	**Rate**
All Ages	38,543	129.0	23,581	156.8	14,950	100.2
<1	757	187.1	405	195.6	351	177.6
1-4	2803	178.2	1561	193.7	1242	161.9
5-9	3135	146.8	2076	189.2	1057	101.8
10-14	4974	221.1	3517	305.1	1455	132.6
15-19	7419	330.3	4993	434.5	2422	220.8
20-24	3996	206.5	2486	252.6	1508	158.6
25-29	2534	132.1	1498	154.0	1036	109.5
30-34	2221	104.8	1288	120.3	933	89.0
35-39	2167	87.6	1241	99.5	926	75.5
40-44	2040	82.6	1187	95.4	852	69.5
45-49	1528	69.9	878	79.6	649	59.9
50-54	1118	61.8	651	72.0	467	51.6
55-59	809	59.4	451	67.0	358	52.0
60-64	614	57.5	345	66.4	269	49.1
65-69	476	51.8	242	55.5	234	48.5
70-74	443	51.8	209	53.9	234	50.0
75-79	461	62.6	201	64.8	260	61.1
80-84	433	80.0	168	83.6	265	77.9
85+	616	119.9	184	126.2	432	117.5

Total rates were annualized and adjusted to the U.S. 2000 standard population.

Thirteen cases with unknown age were included in total counts only.

HIU (959.01) alone cases were not included.

Figure 3

ED-Treated TBI Rate by Age Group and Gender

Minnesota, 1998-2003

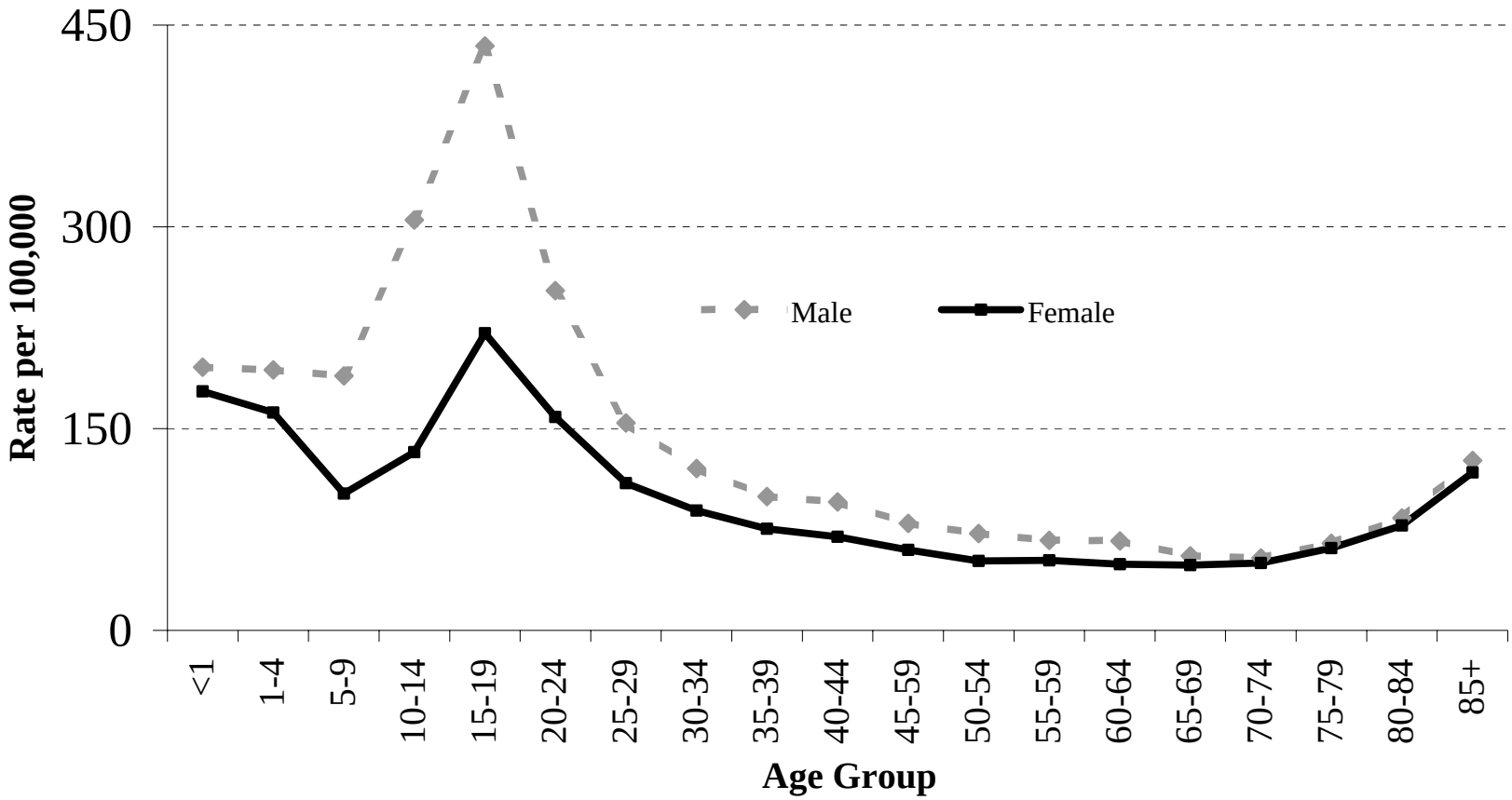


Table 6: Number and Rate of TBI-ED by Gender, Age Group, and Cause, Minnesota, 1998-2003

	Fall, Unintentional		Sports and Recreation		MV-Traffic	
Total	**N**	**Rate**	**N**	**Rate**	**N**	**Rate**
All Ages	11,369	38.5	8,095	26.7	5,925	19.8
<1	548	135.4	5	.	6	.
1-4	1,694	107.7	236	15.0	93	5.9
5-9	1,104	51.7	874	40.9	149	7.0
10-14	1,093	48.6	2,350	104.5	259	11.5
15-19	942	41.9	2,683	119.5	1,593	70.9
20-24	639	33.0	591	30.5	1,035	53.5
25-29	487	25.4	273	14.2	603	31.4
30-34	465	21.9	265	12.5	488	23.0
35-39	532	21.5	245	9.9	407	16.4
40-44	578	23.4	201	8.1	363	14.7
45-49	502	23.0	150	6.9	275	12.6
50-54	463	25.6	88	4.9	214	11.8
55-59	388	28.5	47	3.5	122	9.0
60-64	320	30.0	36	3.4	96	9.0
65-69	274	29.8	17	.	64	7.0
70-74	265	31.0	22	2.6	49	5.7
75-79	299	40.6	6	.	54	7.3
80-84	308	56.9	4	.	35	6.5
85+	468	91.1	2	.	20	3.9
Male	**N**	**Rate**	**N**	**Rate**	**N**	**Rate**
All Ages	6,098	41.9	5,947	38.3	3,227	21.4
<1	296	143.0	2	.	1	.
1-4	922	114.4	143	17.7	56	7.0
5-9	713	65.0	609	55.5	80	7.3
10-14	719	62.4	1,770	153.6	141	12.2
15-19	550	47.9	2,090	181.9	842	73.3
20-24	339	34.4	448	45.5	595	60.5
25-29	243	25.0	190	19.5	373	38.3
30-34	240	22.4	180	16.8	265	24.7
35-39	265	21.2	165	13.2	202	16.2
40-44	306	24.6	123	9.9	190	15.3
45-49	279	25.3	83	7.5	136	12.3
50-54	259	28.6	50	5.5	123	13.6
55-59	197	29.3	33	4.9	56	8.3
60-64	156	30.0	26	5.0	51	9.8
65-69	134	30.7	10	.	37	8.5
70-74	115	29.7	16	.	21	5.4
75-79	122	39.3	4	.	31	10.0
80-84	111	55.3	4	.	17	.
85+	132	90.5	1	.	10	.
Female						
All Ages	5,269	35.0	2,146	14.5	2,697	18.2
<1	252	127.5	3	.	5	.
1-4	772	100.7	93	12.1	37	4.8
5-9	390	37.6	265	25.5	69	6.7
10-14	374	34.1	579	52.8	118	10.8
15-19	391	35.6	592	54.0	751	68.5
20-24	300	31.6	143	15.0	440	46.3
25-29	244	25.8	83	8.8	230	24.3
30-34	225	21.5	85	8.1	223	21.3
35-39	267	21.8	80	6.5	205	16.7
40-44	272	22.2	78	6.4	173	14.1
45-49	223	20.6	67	6.2	138	12.8
50-54	204	22.6	38	4.2	91	10.1
55-59	191	27.8	14	.	66	9.6
60-64	164	29.9	10	.	45	8.2
65-69	140	29.0	7	.	27	5.6
70-74	150	32.1	6	.	28	6.0
75-79	177	41.6	2	.	23	5.4
80-84	197	57.9	0	.	18	.
85+	336	91.4	1	.	10	.

Rates were annualized and per 100,000 population.
Total rates were adjusted to the U.S. 2000 standard population
Five individuals with unknown gender were not included in the table.
HIU (959.01) alone cases were not included.

Figure 4

Leading Causes of ED-Treated TBI by Age Group

Minnesota, 1998-2003

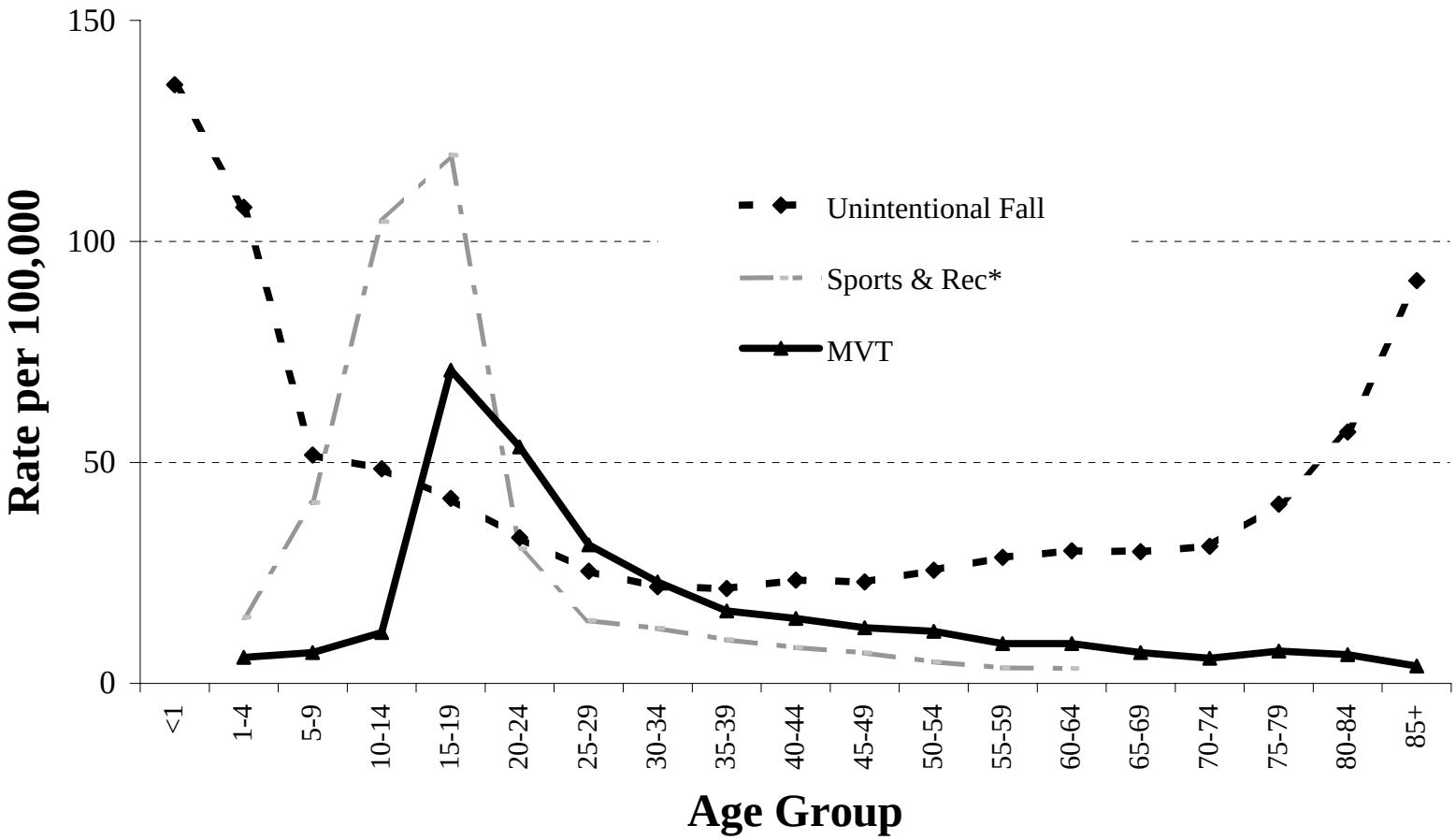
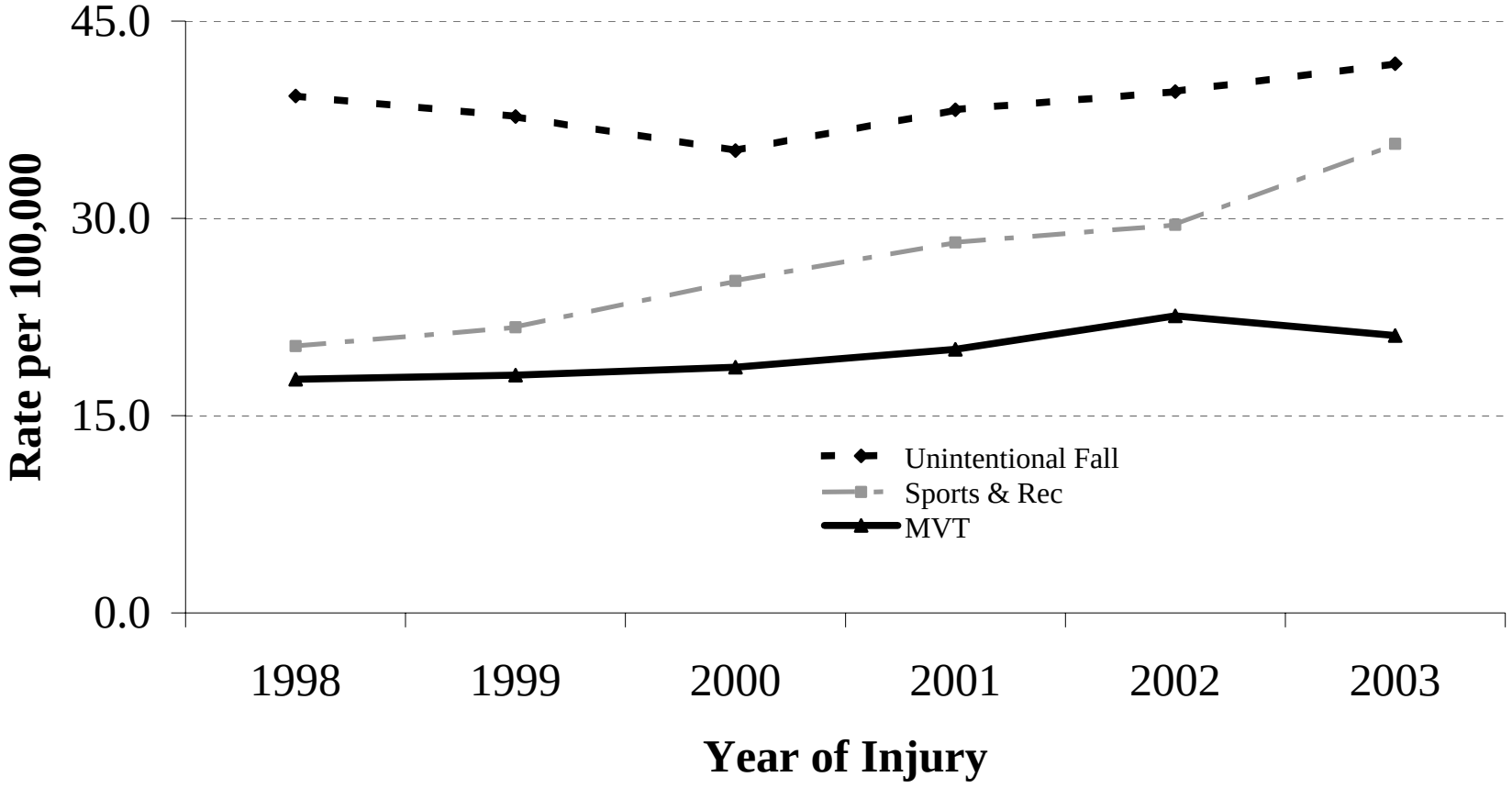


Figure 5

Leading Causes of ED-Treated TBI by Year of Treatment

Minnesota, 1998-2003

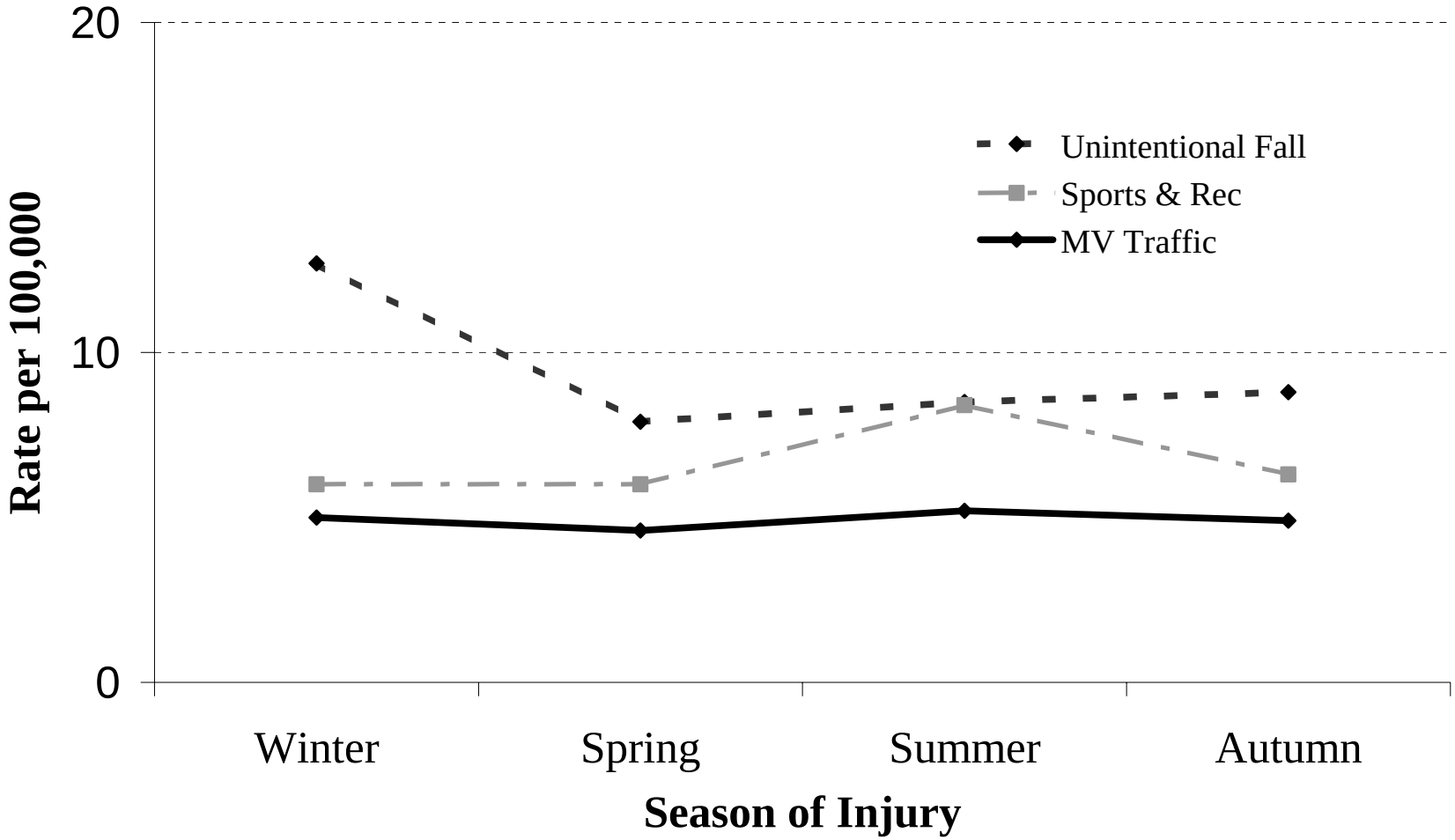


Rates were age-adjusted to the U.S. 2000 population.

Figure 6

ED-Treated TBI by Leading Cause and Season*,

Minnesota, 1998-2003



* Winter (December 21-March 20); Spring (March 21 - June 20); Summer (June 21-September 20); Autumn (September 21-December 20)

Rates were age-adjusted to the U.S. 2000 population.

Figure 7

Median Charges for ED-Treated TBI by Age Group

Minnesota, 1998-2003

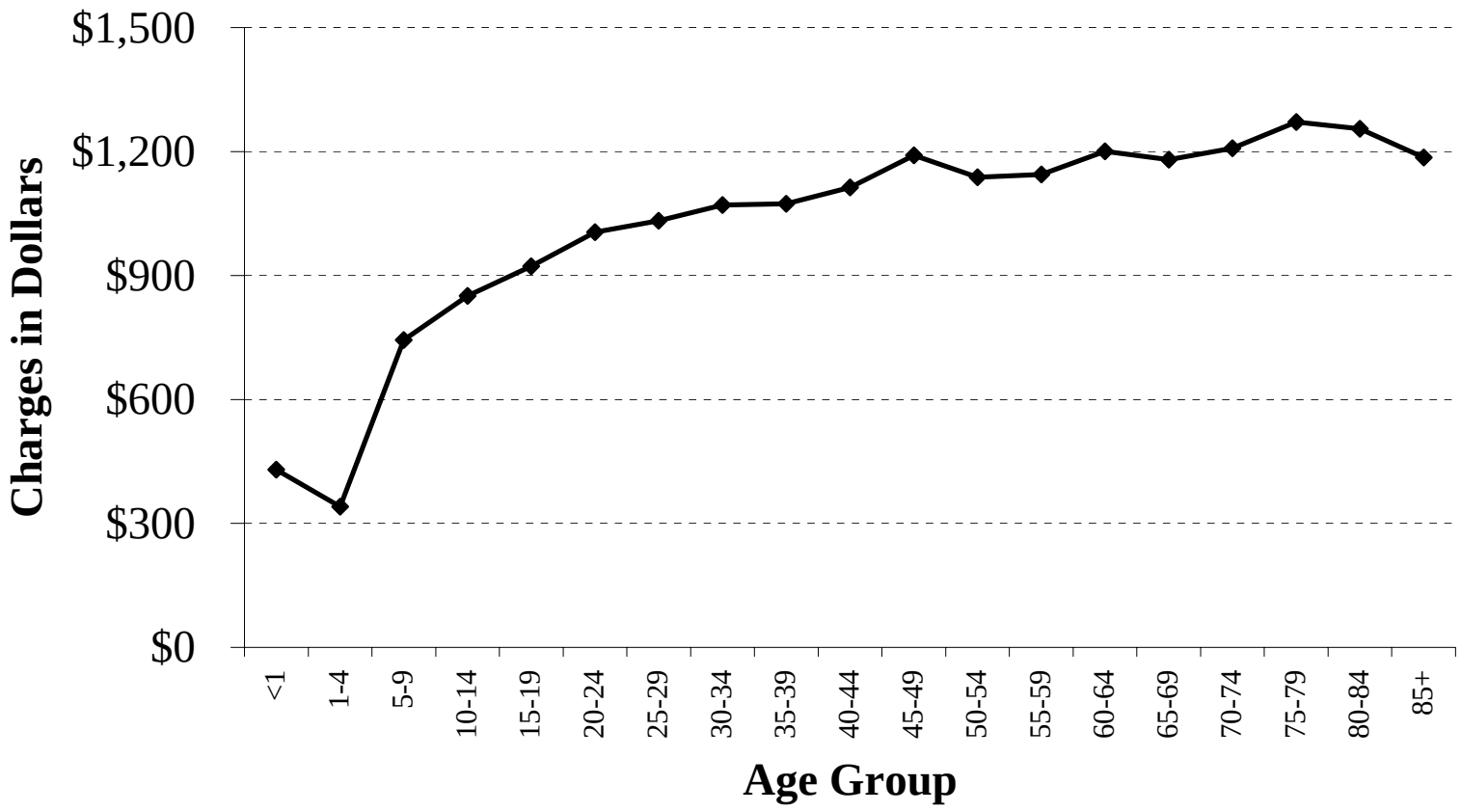
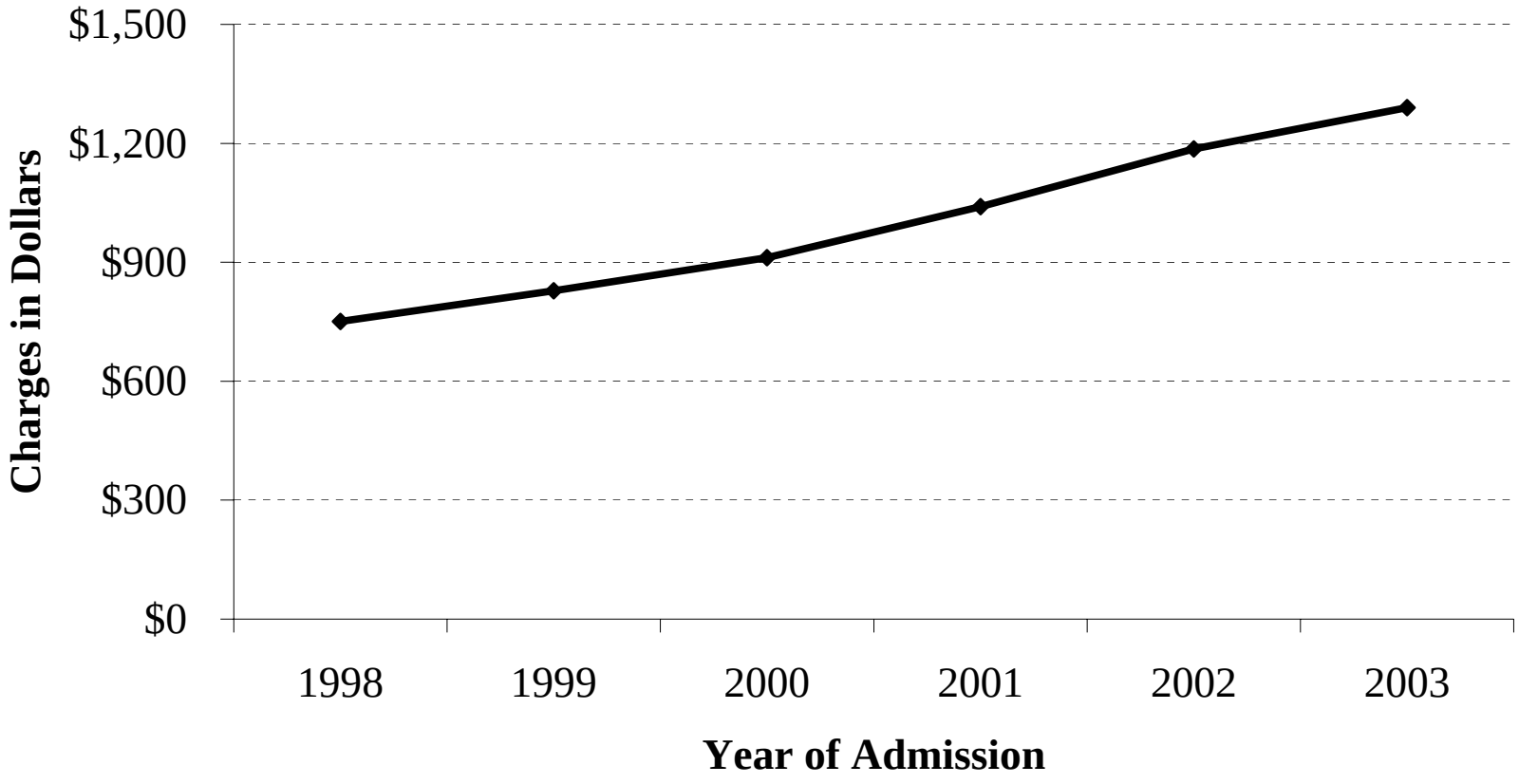


Figure 8

Median Charges* for ED-Treated TBI by Year of Treatment

Minnesota, 1998-2003



*Median charges were adjusted for inflation to 2003 U.S. dollars.