Rate of Eye Injury in the United States

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Objective: To provide a comprehensive estimate of the rate of eye injury in the United States.

Methods: Data from the National Ambulatory Medical Care Survey, the National Hospital Ambulatory Medical Care Survey, and the National Hospital Discharge Survey for 2001 were combined and used to provide estimates of eye injuries treated in emergency departments, inpatient and outpatient facilities, and private physicians’ offices, as well as their causes and characteristics.

Results: In the United States in 2001, an estimated 1,990,872 (6.98 per 1000 population) individuals experienced an eye injury requiring treatment in an emergency department, inpatient or outpatient facility, or private physician’s office. Most eye injuries are treated in emergency departments (50.7%), followed by private physicians’ offices (38.7%), and outpatient (8.1%) and inpatient (2.5%) facilities. Eye injury rates were highest among individuals in their 20s, males, and whites. Injury rates were highest for superficial injuries, foreign bodies, contusions, and open wounds.

Conclusions: This study provides a comprehensive estimate of the rate of eye injury in the United States. Private physicians represent an important source of care for eye injury in the United States.

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A recent review of studies reporting the incidence of eye injury reported a wide range of estimates and suggested that the variability might be attributed to differences in study populations and definitions of eye injury.1 Studies limited to inpatient populations yield low rates, as eye injuries are rarely serious enough by themselves to require hospital admission. Serious eye injuries are more likely to result in visual impairment, and thus a focus on these types of injuries is important. However, to understand the true magnitude of eye injuries in the United States, other settings must be considered. Several studies have included both inpatient and outpatient (including emergency department) or outpatient-only data to provide a more comprehensive picture of eye injuries. However, even these studies fail to provide a comprehensive estimate of treated eye injuries, as they exclude injuries treated in private physicians’ offices.

To date, no study, to our knowledge, has estimated the rate of treated eye injury in the United States that includes data from inpatient and outpatient facilities and private physicians’ offices.

The objective of this study was to provide a comprehensive estimate of the rate of eye injury in the United States by using data from the National Ambulatory Medical Care Survey (NAMCS), National Hospital Ambulatory Medical Care Survey (NHAMCS), and the National Hospital Discharge Survey (NHDS) for 2001. We also analyzed this rate according to demographic characteristics as well as the distribution of the types and causes of eye injury.

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METHODS

DATA SOURCES

National Ambulatory Medical Care Survey

The NAMCS is a national survey of visits to office-based physicians conducted by the National Center for Health Statistics (NCHS).2 The NAMCS uses a multistage probability design involving probability samples of primary sampling units (PSUs), physician practices within
PSUs, and patient visits within practices. The PSUs consist of geographic areas such as counties and towns covering the 50 states and the District of Columbia. The second stage consists of a probability sample of practicing physicians selected from the American Medical Association and the American Osteopathic Association. To be considered, physicians had to meet the following criteria: office based, as defined by the American Medical Association and the American Osteopathic Association; principally engaged in patient care activities; non–federally employed; and not in specialties of anesthesiology, pathology, and radiology. The final stage was the selection of a sample of patient visits within the practices’ selected physicians.

Data collection for the NAMCS is carried out by physicians aided by their staff. Data are available on the patient’s smoking habits, reason for the visit, expected source of payment, the physician’s diagnosis, and the kinds of diagnostic and therapeutic services rendered. Other variables cover drugs and medications ordered, administered, or provided during office visits, with information on medication code, generic name and code, brand name, entry status, prescription status, federal controlled substance status, composition status, and related ingredient codes. Information is also included on the physician’s specialization and geographic location. Demographic information on patients, such as age, sex, race, and ethnicity, is also collected. Several data collection items require medical coding, which is done centrally by the NCHS staff; these items include diagnoses, screening and surgical procedures, and medications.

In 2001, of the 1910 eligible physicians, 1230 (64.4%) participated in the study and provided 24,281 patient records. Each NAMCS record contains a weighing factor that can be used to produce national estimates from the sampled data.

National Hospital Ambulatory Medical Care Survey

The NHAMCS is a national survey of visits to hospital outpatient and emergency departments located in the 50 states and the District of Columbia, also conducted by the NCHS. The NHAMCS uses a 4-stage probability design with samples of PSUs, hospitals within PSUs, clinics and emergency service areas within outpatient or emergency departments, and patient visits within clinics and emergency service areas. As with the NAMCS, PSUs consist of geographic areas such as counties and towns covering the 50 states and the District of Columbia. Hospitals are sampled from the hospitals listed on the SMG Hospital Market Data Base. Hospitals with an average length of stay for all patients of less than 30 days and who are not in specialties of anesthesiology, pathology, and radiology. The final stage was the selection of a sample of patient visits within the practices’ selected physicians.

Data collection for the NHAMCS is primarily the responsibility of hospital staff and includes age, race, sex, reason for the visit, physician’s diagnosis, cause of injury, surgical procedures, medication therapy, and expected source of payment. As with the NAMCS, diagnoses, surgical procedures, and medications were coding centrally by trained NCHS staff.

The 2001 NHAMCS consisted of a sample of 409 eligible hospitals, of which 391 (95.6%) participated in the survey. The participating hospitals provided 34,546 emergency department records and 33,567 outpatient department records. Each NHAMCS record contains a weighting factor that can be used to produce national estimates from the sampled data.

National Hospital Discharge Survey

The NHDS is a national survey of discharges from noninstitutional hospitals located in the 50 states and the District of Columbia. Only hospitals with an average length of stay for all patients of less than 30 days or those whose specialty is general (medical or surgical) or children’s general are included in the survey. Like the NAMCS, the NHDS hospitals are sampled from the SMG Hospital Market Data File. The NHDS uses a 3-stage design involving probability samples of PSUs, hospitals within PSUs, and, finally, discharges within selected hospitals. Discharges are selected by systematic random sampling.

The NHDS uses 2 data collection procedures. The first is a manual system of data abstraction, used for approximately 59% of the responding hospitals. The second is an automated method, used for approximately 41% of the responding hospitals, which involves the purchase of computerized data files. In the manual system, the collection of information from the hospital records is performed at the hospitals by their own medical records staff or by the US Bureau of the Census for the NCHS. The completed forms are forwarded to NCHS for coding and editing. In the automated system, NCHS purchases files containing machine-readable medical record data from which records were systematically sampled by NCHS. Abstracted data, regardless of procedure, include age, sex, race, marital status, diagnoses, and surgical and nonsurgical procedures.

In 2001, the NHDS sample consisted of 477 eligible hospitals, of which 448 (93.9%) responded to the survey and provided 330,210 patient records. Each NHDS record contains a weighting factor that can be used to produce national estimates from the sampled data.

STUDY POPULATION

Within each data source, patient visits associated with eye injuries were identified with the use of the International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM) codes. The specific ICD-9-CM codes used include 802.6 and 802.7 (orbital floor fractures); 870.0 to 870.9 (open wounds of the ocular adnexa); 871.0 to 871.9 (open wounds of the eyeball); 918.0 to 918.9 (superficial wound of the eye and adnexa); 921.0 to 921.9 (contusion of the eye and adenexa); 930.0 to 930.9 (foreign body on the external eye); 940.0 to 940.9 (burn confined to the eye and adenexa); 941.02 to 941.52 (burn involving the eye with other parts of the face, head, and neck); 950.0 to 950.9 (injury to the optic nerve and pathways); and 951.0, 951.1, and 951.3 (injury to the oculomotor, trochlear, and abducens nerves). The NAMCS and NHAMCS provide up to 3 diagnosis codes while the NHDS provides up to 7; all were used to identify injury-related patient visits.

VARIABLE SELECTION AND DEFINITION

Most of the variables in the NAMCS, NHAMCS, and NHDS overlap and use the same coding systems, thus facilitating the pooling of records from each source. For the purposes of this study, demographic (age, sex, and race) and injury-specific (type and cause) variables were selected. Injury type (diagnosis) was classified as described above. The cause of injury was coded by means of the ICD-9-CM External Cause of Injury codes, or E-codes.
However, only the NAMCS and NHAMCS contain information on the cause of injury.

**STATISTICAL ANALYSIS**

All analyses were conducted after the appropriate record weights were applied. The primary outcome of interest in this study was the incidence of eye injury. Eye injury incidence rates were calculated according to age, sex, and race by using denominators obtained from the US Bureau of the Census. This denominator is appropriate as, theoretically, everyone in the population is at risk of eye injury. Injury rates were also calculated for specific injury types and causes overall and according to age, sex, and race. All statistical analyses were conducted with SUDAAN, version 8.0 (Research Triangle Institute, Research Triangle Park, NC).

**RESULTS**

The combined NAMCS, NHAMCS, and NHDS data yielded a total of 422,604 actual patient visits for 2001. These visits represent an estimated 1 billion patient visits made to private physicians, emergency departments, outpatient clinics, and inpatient facilities in the United States in 2001. A total of 938 patient visits for eye injury were identified among the 3 data sources, representing an estimated 1,990,872 patient visits for eye injury in 2001 in the United States.

The overall estimated rate of eye injury in the United States for 2001 was 6.98 per 1000 population. The rate was highest in the emergency department setting (3.54 per 1000), followed by private physicians’ offices (2.70 per 1000), outpatient clinics (0.56 per 1000), and inpatient facilities (0.18 per 1000). Overall, males (9.5 per 1000) had more than twice the rate of eye injury compared with females (4.5 per 1000).

**Figure 1** presents the eye injury rate according to age and sex. The pattern of injury rates for males and females was similar across age groups, although males had consistently higher rates. The exception to this pattern was in the oldest age groups where the sex difference becomes less distinct. With respect to race, eye injury rates were calculated only for whites and blacks. There were insufficient numbers of eye injuries among other races for stable rates to be calculated. The rate of eye injury among whites and blacks was 7.6 and 5.2 per 1000, respectively.

**Figure 2A** presents the rate of eye injury according to age and race for males. For whites, the rate was elevated among those in their 20s and 50s and then declined, with a slight increase among those 80 years old and older. For blacks, the eye injury rate was elevated among those in their 30s, 40s, and 70s. The eye injury rate according to age and race for females is presented in **Figure 2B**. For whites there was a slight elevation in the 20s, followed by a larger elevation in the 50s; for blacks rates were elevated in the 30s, 50s, and 70s.

For males, the rate of emergency department-treated eye injuries was elevated among children younger than 10 years, declined slightly, and then, following a peak in the 20s, declined until the 60s, when a slight elevation was observed (**Figure 3A**). For males with eye injuries treated by private physicians, the rate rapidly increased into the 20s and then rapidly declined, only to reach another peak in the 50s and then decline again. In the outpatient setting, after a peak among those 10 to 19 years old, the rate declined only to increase among middle-aged adults and then remained elevated into the 60s, when it steadily declined. The rate of eye injuries treated in an inpatient setting was fairly stable until the oldest age groups, when it increased dramatically. For females, injury rates were elevated for the young age groups and then declined, whereas the private physician rate tended to increase with age (Figure 3B). The injury rate in the outpatient setting was fairly stable across age groups.
a slight elevation in the oldest age groups. For the inpatient setting, the rate was elevated for children and then declined, only to experience an increase beginning in the 50s.

Table 1 presents the rates for specific types of injuries. The highest rate was for superficial injury of the eye and adnexa, followed by foreign body on the external eye. Injury rates were also elevated for contusions and open wounds. Males had a higher rate of open wound and foreign body eye injuries than females, whereas females had a higher rate of contusion. Superficial injuries and adnexa had the highest rate across all age groups. Foreign bodies were more common among older age groups. Whites had higher rates of superficial and foreign body–related injuries than blacks.

Overall, injury rates were highest for foreign bodies, followed by being struck against or by an object; rates for fights and assaults and for falls were also elevated (Table 2). For females and males, foreign bodies and being struck against or by an object had the highest injury rates. Rates for the fight- or assault-related eye injuries were also elevated among both sexes. The rate for fall-related eye injury was higher among females, whereas rates for injuries related to machinery and cutting or piercing objects were higher among males. Injury rates for fights or assaults were higher among those aged 0 to 29 years.
The rate of eye injury in the United States has been presented previously.6-11 These studies have generally focused on specific patient populations and provided rates for eye injuries treated in emergency departments or for eye injuries requiring hospitalization. However, even different studies using the same study base have produced differing results. For example, 2 studies focused on the emergency department setting estimated the annual incidence of eye injury to be 3.2 and 4.5 per 1000 population, respectively,1,11 representing an absolute difference of more than 300,000 injuries each year. Although studies providing estimates for the rate of eye injury based on inpatient- and emergency department–treated eye injuries provide a more complete picture than those focusing on one or the other of these settings, the picture remains incomplete. To date no study has provided an estimate for the rate of eye injury that includes those injuries treated by private physicians.

The current study estimated that, in 2001, approximately 2 million persons in the United States sustained eye injuries that required medical treatment, a rate of 6.98 per 1000 population. To obtain this estimate, data from 3 sources were combined. The NAMCS provided data on eye injuries treated in private physician offices, the NHAMCS provided data on eye injuries treated in emergency departments and outpatient clinics, and the NHDS provided data in eye injuries treated on an inpatient basis. It is likely that additional eye injuries occur each year that are not captured by these settings. Among the settings not considered in the present study are optometrists’ offices and facilities that provide specialty eye care. Injuries seen in those settings may be more severe than the ones seen in other settings; however, these more severe injuries are also less common. Thus, the incidence rates in the current study are likely to be conservative, but perhaps only minimally so based on a potentially skewed distribution of injuries with respect to severity.

It is difficult to compare the eye injury rate reported in this study with the existing literature given that private physicians and outpatient clinics have not been used before as a source of information on eye injury. Three studies6,9,10 have reported eye injury rates in the United States requiring treatment in an inpatient or emergency department setting. The rates reported in those studies (423, 490, and 980 per 100,000 population [injury rates have been converted to common units, per 100,000, to facilitate comparisons between studies]) are higher than the rate reported in this study when limited to these same settings (372 per 100,000 population). The data from out patient clinics are included, the rate (428 per 100,000 population) is more consistent with at least 2 of these previous studies. Each of these previous studies is also limited in that information on eye injuries was obtained via self-report or other nonstandardized mechanisms. Two studies have estimated eye injury rates requiring hospitalization and produced similar results (27.3 and 29.1 per 100,000 population).7,8 The inpatient eye injury rate in the current study was approximately 18 per 100,000 population. The difference between these findings could be chronological, as the 2 previous studies use data from approximately 20 years ago, or attributed to random variation given the relatively infrequent nature of eye injuries requiring hospitalization. Two studies have presented rates for emergency department–treated eye injuries. One of these studies also used the 1993 NHAMCS data and reported a rate of 447.1 per 100,000 population. This is compared with the rate of 354 per 100,000 for emergency department–treated eye injuries in the current study. However, another study using data from 2001 reported a rate of 315 per 100,000 for emergency department–treated eye injuries.

Contrary to our prior expectations, the inclusion of data from private physicians showed a high rate of eye injury. Although this rate was lower than the rate of emergency department–treated injuries, it was still substantial. This suggests that research involving the nature, circumstances, and outcomes associated with eye injuries should consider this setting. Moreover, private physicians’ offices should be considered as an important setting for eye injury prevention initiatives.

### Table 2. Rate of Eye Injury Causes According to Sex, Age, and Race, United States, 2001*

<table>
<thead>
<tr>
<th>Cause</th>
<th>Rate per 1000 Population</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>All</td>
</tr>
<tr>
<td>Foreign body</td>
<td>2.62</td>
</tr>
<tr>
<td>Struck against or by an object</td>
<td>1.14</td>
</tr>
<tr>
<td>Fight/assault</td>
<td>0.47</td>
</tr>
<tr>
<td>Fall</td>
<td>0.28</td>
</tr>
<tr>
<td>Cutting/piercing objects</td>
<td>0.23</td>
</tr>
<tr>
<td>Vehicle related</td>
<td>0.22</td>
</tr>
<tr>
<td>Machinery</td>
<td>0.20</td>
</tr>
<tr>
<td>Burn</td>
<td>0.12</td>
</tr>
<tr>
<td>Other</td>
<td>0.47</td>
</tr>
</tbody>
</table>

*Only data from the National Hospital Ambulatory Medical Care Survey and the National Ambulatory Medical Care Survey are presented.

Relative to other age groups, the rate for foreign bodies was higher among whites than blacks.

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Despite the inclusion of settings not used in previous studies, the rates of eye injury according to age, sex, and race were generally consistent with previous studies, with a few exceptions. First, most of the studies reported a peak in the rate of eye injury among those in their 20s and, although less consistently, a slight increase among older adults. The current study also reported a peak among individuals in their 50s. On close inspection, it became apparent why this elevation had not been previously documented. It was determined that it was limited to 2 settings (ie, private physicians and outpatient clinics), both of which have not been considered in previous studies. It was also determined that this elevation was, for the most part, limited to white rather than black individuals. Second, we also reported that the eye injury rate was higher among whites than blacks, a finding contrary to most other studies on this topic. However, when injury rates are calculated according to setting, blacks have higher rates than whites in magnitude consistent with previous studies in every setting except for private physicians’ offices. In this setting, injury rates are substantially higher for whites. The racial disparity in injury rates between private physicians and other settings perhaps reflects differences in the use of eye care. Research has demonstrated that in general blacks are less likely than whites to use eye care services. Thus, it is not unexpected that the rate of eye injuries among private physicians was lower for blacks than whites but higher in other settings that provide acute care. Because previous studies have not included data from private physicians, research to date has generally considered blacks to have higher rates of eye injury. In fact, when a broader spectrum of medical care settings is considered, the results of the current study suggest that blacks may have lower rates. Given the observed racial differences in the eye injury rate between the private physician and other settings, the conclusions represented by the aggregated data should be applied with caution when a single treatment setting is considered.

The results of this study should be interpreted in light of several strengths and limitations. By including data from a variety of settings, we have been able to construct what is likely the most comprehensive assessment of treated eye injuries in the United States to date. This was facilitated by the similarity of the sampling and data collection used by the NAMCS, NHAMCS, and NHDS. What this study was not able to include were eye injuries treated in certain specific settings, which include optometrists’ offices, Veterans Affairs hospitals, and specialty eye hospitals, as these facilities are not included in the NAMCS sample. It is difficult to estimate how many eye injuries these sources treat each year, and thus the impact of their omission from this study is similarly difficult to assess. We can say with certainty that the injury rate reported herein is conservative, but how conservative is not clear.

The extent to which those seeking care for eye injury at these locations differs from those seeking care in other settings is also unknown. Thus, the potential for bias in the current study resulting from this omission is hard to evaluate. Eye injuries were identified by means of ICD-9-CM codes that were similar to those used by other studies on this topic. This prevents potential biases that may arise when other sources such as self-report are used but also facilitates comparisons between this and previous studies. Although we were able to present data with respect to the cause of eye injury, this information was only available in 2, but fortunately the largest, sources, the NAMCS and NHAMCS. However, the broad categories reflective of the ICD-9-CM E-code system do not provide a satisfying, in-depth picture of the causes of eye injuries. For example, the 2 most common injury mechanisms, foreign bodies and struck against or by objects, do not provide adequate information to identify where injury prevention resources should be directed. Population-based studies that provide a detailed understanding of the specific causes of eye injuries are necessary so that appropriate injury prevention initiatives can be developed and appropriately targeted.

The primary outcome in this study was the incidence of eye injury. With respect to the numerator, the data sources used in this study provide information on patient visits and not patients. Thus, it is possible that a single patient seeking care on multiple occasions would be counted more than once, thereby inflating the rate reported in this study. However, given the sampling used by the 3 data sources, it is unlikely that our estimate contains a substantial number of repeated visits for the same individual. It is also important that the NAMCS, NHAMCS, and NHDS are samples of visits to private physicians, emergency departments, and outpatient inpatient facilities. Thus, the actual number of eye injuries in some of these sources is small relative to the weighted estimates meant to represent the national experience. The NCHS provides ample documentation regarding the proper techniques for extrapolating the sampled data to obtain national estimates; these techniques were closely adhered to in the present study. Given this, one can expect that the data reported herein reflect an unbiased picture on eye injury experience in the United States.

With respect to the denominator, ie, the population at risk of eye injury, we used the entire population of the United States. This is reasonable given that an eye injury can occur to most, if not all, persons and in nearly any setting. For the purposes of this study, we have assumed the US population is fixed. However, in fact the US population is dynamic, but we do not have information to account for mortality, migration (legal and undocumented), and other population changes needed to accurately enumerate person-time. Given population dynamics, our denominator is likely to be an underestimate, thereby inflating our estimates; however, given the focus on data from a single year, we would expect the failure to account for these population dynamics to be minimal.

Missing from the data sources used in this study is information on visual outcomes. Visual impairment resulting from eye injury is infrequent, although the frequency increases with the severity of the injury. Thus, it may be expected that most of the injuries described in this study will result in no long-term visual impairment, although acute, short-term impairment might be expected for a larger proportion. Finally, the depiction of eye injury presented in this article represents a single year.
Despite the fact that nearly 2 million eye injuries occur each year, they are still a relatively uncommon injury, and thus random variation from year to year may produce spurious characteristics that, when viewed longitudinally, appear less dramatic.

This is the first study, to our knowledge, to provide a population-based depiction of eye injuries using data representing a broad spectrum of health care settings wherein most, if not all, individuals with eye injuries would be expected to seek care. While the epidemiologic pattern of eye injury presented in this article is consistent with previous research from other settings, some important differences emerged. Private physicians represent an important source of care for eye injury in the United States, particularly for middle-aged adults. Future research should focus on a more detailed documentation of the causes of eye injuries as well as long-term functional outcomes as, despite the relatively frequent nature of eye injury documented in this study, injuries with potential visual significance more accurately reflect the public health impact of eye injury in the United States.

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REFERENCES

nation through month 48. Nevertheless, to our knowledge, this report represents the only information on follow-up with standardized refractions and visual acuity measurements obtained in a prospective manner on individuals judged to have a predominantly classic lesion by an experienced photograph-reading center at the onset of verteporfin therapy. Physicians involved in the management of patients with the neovascular stage of age-related macular degeneration can relate these conclusions to patients who have received verteporfin therapy and in whom additional therapy might be considered at some point from 24 months after initiating therapy through 48 months of follow-up after starting treatment.

**Treatment of Age-Related Macular Degeneration With Photodynamic Therapy (TAP) Study Group**

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**Financial Disclosure:** Johns Hopkins University, Dr Bressler's employer, but not Dr Bressler, is paid for Dr Bressler to provide research and consultation to Novartis AG (Basel, Switzerland) and QLT Inc (Vancouver, BC). The terms of these consultant agreements are managed by Johns Hopkins University in accordance with its conflict-of-interest policies. The following authors have indicated that they are or have been paid as consultants to Novartis AG or QLT Inc or both (which may also include travel expenses at meetings or participation in a speakers' bureau): Michael J. Potter, MD, FRCSC; Philip J. Rosenfeld, MD, PhD; Jason S. Slakter, MD. The following authors have indicated support for travel expenses at meetings or participation in a speakers' bureau: Susan B. Bressler, MD; Peter K. Kaiser, MD; Joan W. Miller, MD; Ursula Schmidt-Erfurth, MD, PhD. Joan W. Miller, MD, and Ursula Schmidt-Erfurth, MD, PhD, have a patent interest in verteporfin under the guidelines of the Massachusetts General Hospital/Harvard Medical School (Boston, Mass).

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**Correction**

In the Epidemiology article by McGwin et al titled “Rate of Eye Injury in the United States,” published in the July issue of the ARCHIVES (2005;123:970-976), an error appeared in the abstract on page 970. The “Methods” section of the abstract should have read as follows: “Data from the National Ambulatory Medical Care Survey, the National Hospital Ambulatory Medical Care Survey, and the National Hospital Discharge Survey for 2001 were combined and used to provide estimates of eye injuries treated in emergency departments, inpatient and outpatient facilities, and private physicians’ offices, as well as their causes and characteristics.” The journal regrets the error. This correction was made previously to online versions of this article.