Characteristics and Causes of Penetrating Eye Injuries Reported to the National Eye Trauma System Registry, 1985–91

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Synopsis

Ocular trauma is one of the most important preventable causes of visual impairment. The National Eye Trauma System was developed to provide optimal clinical care for severe ocular injuries, to foster research on eye injury, and to increase awareness of ocular trauma as a public health problem. From 1985 through 1991, the National Eye Trauma System Registry collected data on 2,939 cases of penetrating eye injury reported by ophthalmologists at 48 collaborating eye trauma centers in 28 States and Washington, DC. Eighty-three percent of the cases involved men; the median age of the patients was 27 years, ranging from 1 to 92 years of age. Seventy-seven percent of the injuries were unintentional, 22 percent were the result of assault, and 1 percent were self-inflicted. In 62 percent of the cases studied, the injured person's initial best corrected visual acuity in the injured eye was the ability to perceive hand motion, or worse.

The settings in which the injuries occurred included the home (28 percent), the worksite (21 percent), at recreation (11 percent), and in transportation (8 percent). At the time of the injury, 1.5 percent of the injured persons were wearing safety glasses and 2.9 percent were wearing nonsafety glasses. There was evidence of definite or possible alcohol use by at least 24 percent of the injured persons and illicit drug use by 8 percent. The most frequent types of tissue damage included corneal or scleral laceration, traumatic cataract, intraocular foreign body, vitreous hemorrhage, and prolapse of intraocular tissue.

Analyses of the causes and characteristics of ocular injuries reported to the National Eye Trauma System Registry will help identify high risk settings for such injuries. Results will be used to develop and implement interventions that will reduce the incidence of eye trauma.

EYE INJURIES, 90 percent of which are thought to be preventable, are a leading cause of blindness and visual impairment (*1*).

Despite the role of ocular trauma as a cause of severe disability, and the dimensions of the potential societal and personal benefits to be gained from its prevention, only recently have the magnitude, causes, and severity of eye injury begun to be studied from an epidemiologic approach (*2–5*). The estimated number of eye injuries of all types occurring annually in the United States is 2.4 million. Of these, between 20,000 and 68,000 are serious, vision-threatening injuries (*6*).

In the early 1980s, the National Eye Trauma System (NETS) was formed both to provide optimal clinical management of severe eye injuries and to stimulate research in ocular trauma (*7*). NETS is a consortium of regional eye-trauma centers, each of which maintains a clinical staff as well as the diagnostic and surgical capabilities and resources needed to care for severe eye injuries (see accompanying box). The NETS trauma centers provide a

Table 1. Demographic characteristics of persons sustaining penetrating eye injury reported to the National Eye Trauma System Registry, 1985–91

Setting	Cases		Median age in years	Percent male
	Number	Percent		
Recreation	332	11.3	15	88.2
Home	831	28.3	23	73.8
Occupational	626	21.3	30	97.4
Transportation	245	8.3	27	70.5
Intentional	674	23.0	29	83.8
Other or unknown	231	7.9	27	83.0
Total	2,939	...	27	83.2

resource to the ophthalmic and emergency medical care communities, modeled after the burn, neonatal, and other subspecialty trauma facilities that support the medical community at large. In addition to providing optimal care for persons with severe eye injury, the goals of NETS are to foster research on all aspects of eye injury and to increase awareness of ocular injury as a public health problem.

The NETS Registry began in 1985 when participating eye trauma centers affiliated through NETS agreed to gather data in a uniform manner. The NETS Registry has focused on collection of data related to penetrating eye injuries because they are vision-threatening and are the most frequent trauma-related indication for hospital admission of ophthalmic patients (*7*). The criterion for identifying such cases is an injury that has perforated either the cornea (the transparent outer covering over the lens), or the sclera (the white, supporting surface that covers the other five-sixths of the eyeball), or both. Having such a clear case criterion is essential to establishing and operating the trauma registry (*8*).

Registry cases are not necessarily representative of all cases of penetrating eye trauma in the United States, because not all eye trauma is treated in eye trauma centers, and the NETS Registry is based on voluntary reporting by collaborating regional eye trauma centers. NETS data constitute a large case series, rather than a population-based sample of such injuries.

We describe the circumstances, types, and clinical presentations of 2,939 cases of penetrating eye injury reported to the NETS Registry in the period 1985–91. By extrapolating from data for the State of Maryland only, the annual number of penetrating eye injuries occurring in the United States may be estimated at about 3.81 per 100,000 population (*9*). The cases in the NETS Registry therefore constitute about 6 percent of all penetrating eye injuries that occurred nationally during the period covered by this report.

Methods

At each participating center, an attending or resident ophthalmologist records the registry data on two standardized, paper forms.

Preoperative form. The first 37 questions on the preoperative form focus on the patient's demographic characteristics; the setting in which the injury occurred; the object or objects that caused the injury; whether protective gear had been worn and the type, if any; associated factors, such as alcohol or drug use; a history of previous eye disease or eye surgery; and a history of treatment for the present injury, prior to evaluation at the regional eye trauma center. The physician's clinical impression of alcohol or drug use is used if formal alcohol or drug testing was not performed. The other 38 items on the preoperative form pertain to a detailed ocular evaluation, including questions about visual acuity, intraocular pressure, the size and type of the laceration, the presence of hyphema and traumatic cataract, the nature and location of foreign bodies, and the condition of the retina, the macula, and the optic nerve.

Operative form. The second data collection instrument, the operative form, includes 68 questions on the types of surgical procedures performed and on operative findings and complications. Analysis of that data will be published later. An updated version of the data collection forms may be obtained from the corresponding author.

Information was collected on the form on the setting of the injury, on the intent to injure, and on the physical shape of the object that caused the injury. The information was collected originally using terms that were not mutually exclusive, and consequently, an injury could be represented in more than one category. However, for the purposes of the analysis, those terms were redefined to avoid describing results in numerous combinations of settings of the injury and the shapes of the objects causing the injury.

The term *setting* was redefined using mutually exclusive categories. Every injury was assigned to one unique category of setting, with categories arranged in a descending hierarchy, with the assignment being made to the highest applicable category. The descending hierarchy was as follows: in-

tentional (including assault and self-inflicted), occupational, transportation, recreational, home, and other. Therefore, a work-related motor vehicle injury would be coded as an occupational injury, and an injury from an assault at work would be coded as an intentional injury.

Except where stated otherwise, the term *object shape* was redefined with mutually exclusive categories, using the following descending hierarchy: blast (such as from an explosion), animal (such as a bite or scratch caused by an animal), projectile (any flying object), sharp object, blunt object, and a category of "other cause." For example, an injury from a sharp projectile would be coded under projectile.

Participating centers send completed forms to the Maryland Institute for Emergency Medical Services Systems for editing and data entry. The Johns Hopkins University Injury Prevention Center has the primary responsibility for analyzing registry data. Frequency and cross-tabulation analyses for our report were performed using Statistical Analysis System (SAS) software (*A*). Because most missing data were excluded, denominator data may vary slightly among analyses.

Results

In the period 1985–91, preoperative forms for 2,939 patients with penetrating eye injury were submitted to the NETS Registry by 48 collaborating centers in 28 States and the District of Columbia (see box). The minimum and maximum number of preoperative forms received from individual centers ranged from 4 to 262; the median was 32. More than 100 preoperative forms were submitted by each of 8 centers. Fewer than 10 forms were submitted by each of 9 centers.

The most common settings in which injuries occurred were the home (28 percent), the workplace (21 percent), recreation settings (11 percent), and in transportation settings (8 percent) (table 1). Seventy-seven percent of the injuries were unintentional, 22 percent resulted from assault, and 1 percent were self-inflicted, intentional injuries.

Among all injured persons, 83 percent were male. In the category of the setting in which the injury occurred, the proportion of injured persons who were male ranged from 70 percent in transportation settings to 97 percent in occupational settings (table 1). The age distribution of injured persons reported to the registry is shown in figure 1. Their mean age was 29.2 years, their median age was 27 years, and the range was 1 to 92 years. By the

Figure 1. Penetrating eye injuries reported to the National Eye Trauma System Registry, by age and sex, among 2,624 cases, 1985–91

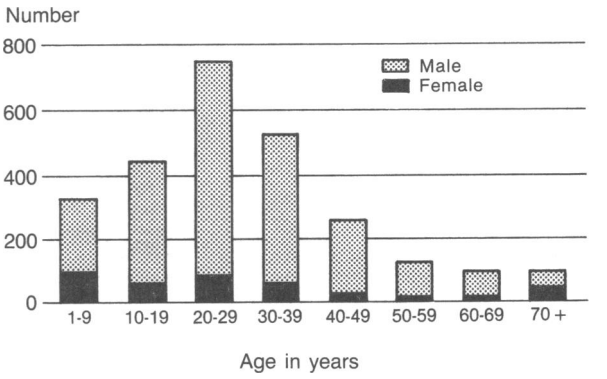
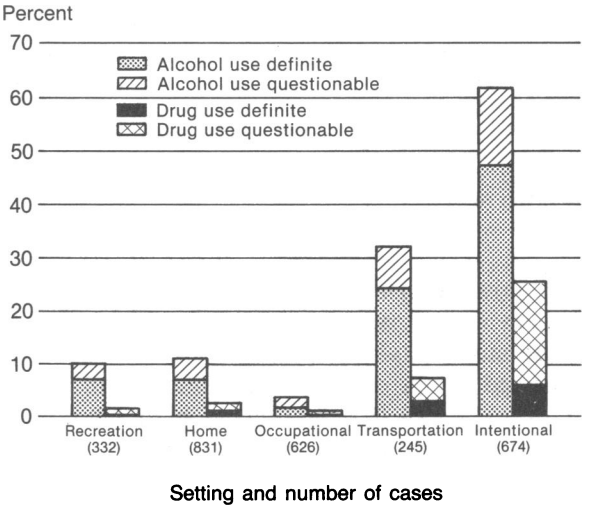


Figure 2. Alcohol and drug use involvement of 2,708 cases of penetrating eye injury reported to the National Eye Trauma System Registry, 1985-91



category of the setting, the median age ranged from 15 years in the recreational setting to 30 years in the occupational setting (table 1). Seventy-eight percent of injuries occurred among persons younger than 40 years, and 29 percent occurred among those younger than 20 years.

Using the mutually exclusive terms described, projectiles accounted for more than 40 percent of all penetrating injuries in the recreational, home, occupational, and transportation settings (table 2). Blunt objects accounted for nearly 40 percent of intentional penetrating injuries. Overall, the most common types of injury-causing projectiles were small metal objects or fragments, accounting for

Table 2. Penetrating eye injuries, by the category of the object [1] that caused the injury and by setting where injury occurred, reported to the National Eye Trauma System Registry, 1985–91

Setting	Number	Percent					
		Projectile	Sharp object	Blunt object	Blast	Animal	Other or unknown
Recreation	332	60	18	13	6	0	3
Home	831	42	33	17	3	<1	6
Occupational	626	71	16	7	4	<1	3
Transportation	245	40	18	21	1	0	20
Intentional	674	31	25	38	2	<1	4
Other or unknown	231	42	24	18	3	0	13
Total	2,939	47	24	19	3	<1	6

[1] Categories of object shapes are mutually exclusive.

Table 3. Best level of initial corrected visual acuity of the injured eye, in order of decreasing severity of impairment, for 2,816 cases of penetrating eye injury reported to the National Eye Trauma System Registry, 1985–91

Acuity level	Percent of cases
No light perception	21.4
Light perception	18.1
Light projection	7.8
Hand motion	15.0
Ranging from ability to count fingers to 20/200 visual acuity measurement	14.9
Ranging from 20/180 to 20/50	8.7
Ranging from 20/40 to 20/15	14.2

368 injuries. The most common types of sharp objects were those made of metal (175 injuries) and those made of glass or plastic (170 injuries). Other reported causes of injury were the human fist (237 injuries), a ball (104 injuries), a blast (90 injuries), a blunt wooden object (68 injuries), and an animal kick, bite, or scratch (5 injuries).

There was evidence of definite or possible alcohol use by at least 24 percent of the injured persons and of definite or possible illicit drug use by at least 8 percent of the injured (figure 2). Evidence of alcohol or illicit drug use was most common among persons with a transportation-related or assault-related injury and least common among those with an occupation-related injury.

For 62 percent of the injured persons, their initial best level of corrected visual acuity in the injured eye was being able to perceive hand motion, or a worse level of acuity. A best level of hand motion or worse was seen for 54 percent of those with a projectile injury, 63 percent of those with a sharp object injury, and 76 percent of those with a blunt object injury.

The initial measurement of visual acuity in the injured eye following injury was better than 20/200 for 23 percent of all injured persons, 29 percent of those with a projectile injury, 22 percent of those with a sharp object injury, and 13 percent of those with a blunt object injury. (That measurement means that the person would be able to read with the injured eye at 20 feet a line on an eye chart that a person with normal vision could read at 200 feet.) Table 3 shows the proportions of 2,816 injured eyes with various levels of initial visual acuity following penetrating eye injury. Among them, 21.4 percent had no light perception in the injured eye.

Fewer than 10 percent of those injured in any setting were wearing any type of eyeglasses or goggles at the time of the injury; only 1.5 percent were wearing safety eye wear (figure 3). The highest proportion of injured persons wearing safety eye wear was reported among those with occupational injuries. For persons sustaining eye injuries despite wearing eyeglasses or safety eye wear, the causes of eye wear protection failure included broken frames, shattered lenses, and objects passing behind or beside the eye wear. Among 45 injured persons whose nonsafety glasses shattered at the time of injury, a glass or plastic object was recorded as a cause of injury in 16 cases, suggesting that a shattered lens may have contributed to the injury. It is not possible to estimate the number of eye injuries prevented among persons exposed to potential injury while wearing protective eye wear.

As an indicator of severity of injury, the types of tissue damage were examined (table 4). The posterior segment of the eyeball was damaged in 58 percent of all cases. The presence of intraocular foreign bodies was seen most frequently in occupational and recreational injuries; BB or pellet gun

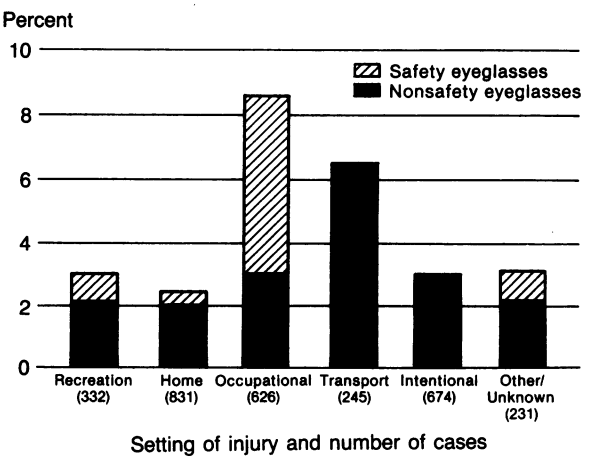
Table 4. Tissue damage among persons with penetrating eye injuries, with percents by type of damage and by setting where injury occurred, as reported to the National Eye Trauma System Registry, 1985–91

Type of tissue damage	Recreation (N = 332)	Home (N = 831)	Work (N = 626)	Transport (N = 245)	Intentional (N = 674)
Anterior segment involvement:					
Corneal laceration	58.1	71.5	72.5	58.8	52.1
Hyphema	55.7	41.8	35.3	49.8	54.5
Traumatic cataract	20.2	23.3	32.3	11.0	10.1
Lens capsule rupture	14.2	17.1	25.2	7.4	8.2
Total	94.0	93.5	93.0	92.2	90.5
Posterior segment involvement:					
Scleral laceration	40.1	30.1	33.2	49.8	56.2
Corneal and scleral laceration	16.6	14.6	15.2	27.4	27.9
Intraocular foreign body	18.4	13.5	35.0	4.5	6.5
Vitreous hemorrhage	43.7	26.6	41.7	31.4	39.2
Prolapse of intraocular tissue	41.9	49.8	32.6	49.0	47.5
Incarceration	44.6	52.0	37.1	43.3	42.3
Retinal detachment	9.9	6.1	9.6	7.8	10.5
Retinal tear	9.3	6.4	13.3	3.7	6.2
Double penetrating injury	13.0	3.0	5.3	4.5	7.4
Optic nerve injury	0.3	0.7	0.6	2.9	4.0
Total	60.8	44.8	62.6	60.4	69.4

injuries were one of the most common types of recreational ocular injury. Cases of double penetrating injury (two penetrations of the outer surface of the eye) were most frequent in the categories of recreational setting and intentional injury. Retinal detachment and optic nerve damage were most frequently seen in cases of intentional injury.

Overall, 465 of the 2,939 penetrating eye injuries (16 percent) were associated with injuries of other areas of the body. Such multiple trauma occurred in 110 of 245 transportation-related eye injuries (45 percent), in 226 of 674 intentional eye injuries (34 percent), and in less than 7 percent of eye injuries in the recreational, occupational, and home settings. Cases of multiple trauma involving only the head occurred in 18 percent of the 245 transportation-related eye injuries, in 23 percent of the 674 intentional eye injuries, and in fewer than 4 percent of eye injuries in the recreational, occupational, and home settings.

Figure 3. Use of safety and nonsafety eye wear by persons with penetrating eye injuries reported to the National Eye Trauma System Registry, by the setting in which the injury occurred, 1985–91



Discussion

The data reported represent the largest case series of penetrating eye injuries described in the literature. Because penetrating injuries are among the most serious types of eye trauma, analyses of these data can help in identifying high-risk settings where engineering controls, prevention education, and the use of protective eye wear should be encouraged or required.

In particular, further investigation of the occupational and recreational settings of many eye injuries may lead to recommendations both on the use of protective eye wear and on methods to modify the agent (such as the tool or toy) leading to the eye injury. The high frequency of penetrating eye injuries among children and young adults (nearly 30 percent of injuries occurred in persons younger than age 20 years) underscores the economic and social costs of severe eye trauma. The large number of eye injuries related to assault in this and other reports (*9–12*) is of particular concern; the best preventive measures for such injuries involve reducing the level of violence in our society and are difficult to implement.

National Eye Trauma System

Centers contributing data analyzed for the report, May 1991

California: Estelle Doheny Eye Institute, Los Angeles; Mercy General Hospital, Sacramento
Colorado: University of Colorado Health Sciences Center, Denver
Connecticut: Yale University School of Medicine, New Haven
District of Columbia: Georgetown University Hospital
Florida: University of Florida College of Medicine, Gainesville
Georgia: Emory University Clinic, Atlanta
Illinois: University of Illinois Eye Center, Chicago
Indiana: Indiana University, Indianapolis
Iowa: University of Iowa Hospital and Clinic, Iowa City
Kentucky: Center for Advanced Eye Surgery (Humana Hospital), Lexington; University of Louisville, Louisville
Louisiana: Louisiana State University Eye Center, New Orleans; Louisiana State University Medical Center, Shreveport
Maryland: Wilmer Eye Institute, Baltimore; National Naval Medical Center Eye Clinic, Bethesda
Massachusetts: Massachusetts Eye and Ear Infirmary, Boston
Michigan: W.K. Kellogg Eye Center, Ann Arbor
Missouri: Truman Medical Center, Kansas City; St. Louis University School of Medicine, St. Louis
New Jersey: Newark Eye and Ear Infirmary, Newark
New Mexico: Presbyterian Hospital, Albuquerque
New York: Albany Medical College, Albany; State University of New York, Buffalo; New York Hospital/Cornell Medical Center, New York; New York Eye and Ear Infirmary, New York
North Carolina: University of North Carolina at Chapel Hill, School of Medicine; Bowman-Gray School of Medicine, Winston-Salem
Ohio: Retinal Associates of Cleveland, Cleveland; St. Vincent Medical Center, Toledo
Oklahoma: Dean A. McGee Eye Institute, Oklahoma City
Pennsylvania: Hershey Medical Center and Pennsylvania State University, College of Medicine, Hershey; Eye and Ear Hospital and Retinal Vitreous Consultants, Pittsburgh; Scheie Eye Institute, Philadelphia; Wills Eye Hospital, Philadelphia
South Carolina: University of South Carolina, School of Medicine, Columbia
Tennessee: University of Tennessee, Memphis
Texas: University of Texas, Southwestern Medical Center, Dallas; Texas Retina Associates, Dallas; University of Texas Medical Branch, Galveston; Baylor College of Medicine, Houston; Wilford Hall, U.S. Air Force Medical Center, Lackland AFB
Utah: University of Utah, School of Medicine, Salt Lake City
Virginia: Medical College of Virginia, Richmond; University of Virginia Medical Center, Charlottesville
Wisconsin: University of Wisconsin, Madison; Medical College of Wisconsin, Milwaukee
Wyoming: Cheyenne Ocular Trauma Center, Cheyenne

Centers joining NETS since May 1991
Illinois: Springfield Clinic and St. John's Hospital, Springfield
Louisana: Tulane Medical Center, New Orleans
Minnesota Hennepin County Medical Center and Phillip Eye Institute, Minneapolis
New York: Eye Research Institute, Syracuse; Manhattan Eye, Ear and Throat Hospital, New York
Texas: Brooke Army Medical Center, Ft. Sam Houston
Vermont: University of Vermont, Burlington

The recent use of alcohol by persons sustaining penetrating eye injuries of the home, transportation, recreational, and intentional types is consistent with other studies suggesting alcohol use as a risk factor for injury (*13–15*). Public health interventions to reduce the overall use of alcohol may lower the incidence of many types of injuries, including those involving the eye.

One would expect that eyeglasses of the nonsafety type would provide some protection against flying metal fragments (such as those related to hammering), but minimal protection against a blow from a fist. Our data suggest that glass or plastic fragments from shattered nonsafety glasses contributed to some injuries. Widespread use of polycarbonate lenses in nonsafety glasses could reduce the incidence of eye injury among regular users of nonsafety glasses (*16*).

Nationally, the prevalence of eyeglasses use in the period 1979–80 was 14 percent for persons ages 3 to 16 years, 28 percent for those ages 17 to 24 years, 38 percent for those ages 25–44 years, and 88 percent for those ages 45 years and older (*17*). The high proportion of eye injuries occurring among children and young adults may relate both to a greater frequency of involvement in high-risk activities and to a lower prevalence of eyeglasses use.

Most published reports on characteristics of eye injuries are based on case series collected at one or several emergency rooms or hospitals (*4, 11, 12, 18–22*). A few studies have presented population-based data (*2, 3, 9, 23, 24*). Such reports vary in the definition of eye injury, methods of case ascertainment, and size of the study population. The proportion of injuries occurring in various settings differed among reports. For example, assault was the most common cause of eye injury in an urban population in Los Angeles (*11*). In Scotland, eye injuries treated at an emergency department were most frequently work related, while those requiring hospital admission were most commonly related to sports (*18*).

In interpreting data from the NETS Registry, several limitations should be considered. The cases in the registry represent a large case series rather than a random sample of all cases of penetrating eye injuries. The characteristics of eye injuries treated at trauma centers may differ from injuries treated at general hospitals, especially with regard to severity (*25, 26*). Currently it is not possible to use registry data to estimate population-based rates for penetrating eye injury, owing to a lack of completeness of the registry for any fixed population. If all major hospitals that treat severe ocular trauma became NETS participants, we would be able to estimate a conservative national incidence rate for penetrating eye injuries.

'Among all injured persons, 83 percent were male. In the category of the setting in which the injury occurred, the proportion of injured persons who were male ranged from 70 percent in transportation settings to 97 percent in occupational settings.'

All data collected reflect information available in physician and hospital records; no attempt was made to interview independent observers of the injuries or to seek police records on assaults or motor vehicle crashes. Analyses were based on information gathered from data collection instruments used by registry collaborators in 1985–91. Registry instruments are being revised to optimize the quality and usefulness of the data being collected.

Further development of the NETS Registry is in progress. One priority is to ascertain clinical outcomes for a higher proportion of registry cases than is currently available; outcome data can be used to assess the benefits of specific medical and surgical clinical treatments. A computer-assisted data entry system with built-in editing capabilities is being considered to improve both the accuracy and timeliness of the data collection process (*27*). Reports are being developed to provide feedback to the individual eye trauma centers, so that collaborators can review patient care at their own centers in addition to the cumulated data from the full registry.

Trauma registries are an important component of national surveillance of injury (*8*). NETS Registry data are useful to document the causes and characteristics of eye trauma. For example, recent analyses of registry data include detailed examinations of occupational and assault-related eye injury (*28, 29*). Data from the registry will be used to identify high-risk settings to develop and implement interventions that can reduce the incidence of eye trauma. Occupational and recreational activities appear to be the settings in which technologic changes, education, and mandating the use of protective eye wear can be implemented most readily to prevent eye injury.

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Equipment

A. SAS Institute Inc., Box 8000, Cary, NC 27512.