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ORIGINAL RESEARCH

Bicycle Injuries—A Modern Perspective

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ABSTRACT

Introduction: Cycling-related injuries send half a million Americans to the emergency room yearly. Despite supporting evidence and laws, cyclist helmet wearing remains low. This study examines recent cycling-related injuries and assesses injury patterns between national and local databases.
Methods: The National Trauma Data Bank (NTDB) and a local Level I trauma center database were separately queried from January 2007 to December 2012. Cycling injuries were identified using ICD-9 E-codes. Patient and injury characteristics and short-term outcomes were analyzed using bivariate tests and multivariate models.
Results: The study identified 113,623 patients in NTDB and 240 patients in the local database with cycling injuries. In NTDB, only 32% of injured cyclists wore helmets. The non-helmet cyclists were younger, used more alcohol and illegal drugs, and were disproportionately male, Hispanic or non-Hispanic black, and suffered higher rates of traumatic brain injuries, head and neck injuries, and mortality. In the local trauma database, only 10% cyclists wore helmets, were more female, Hispanic, and had a lower average injury severity score.
Discussion: The results of the study indicate that helmets offer effective injury prevention for cyclists and show a low compliance with helmet wearing, especially among young minority cyclists.
Level of Evidence: III; Database study.
Keywords: Trauma; Injury database; Bicycle helmet wearing; Injury prevention.

INTRODUCTION

Bicycling is a popular recreational activity and means of transportation among people of all ages. A national survey by the Outdoor Foundation in 2013 identified bicycling as the most popular outdoor activity among U.S. children and the third most popular among U.S. adults [1]. Although various personal and structural safeguards have been studied and implemented, data from the Centers for Disease Control and Prevention (CDC) show that cycling-related injuries still send half a million people to the emergency room and cause 900 fatalities every year [2].

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Furthermore, reported numbers likely underestimate the true incidence of bicycle injuries, because not all injuries are documented in police or hospital records. Children are the most commonly injured age group, but the elderly sustain injuries with higher morbidity and mortality [3]. This suggests that bicycle injury patterns may vary with demographic and behavioral factors, and that prevention strategies can be differentially adjusted for each target population.

Current injury prevention methods include protected bicycle lanes, cyclist visibility, cyclist education, and protective equipment (eg, helmets) [3]. Of these, helmet use is by far the most extensively studied and commonly recommended. Many cities and states have enacted local helmet laws, most of which are limited to riders under the age of 18 [4]. These laws have been controversial—one side citing the number of studies indicating reduction of head injury and mortality with helmet use, and the other side pointing out the lack of high quality evidence that show helmet laws can effectively change injury patterns without also decreasing ridership [5-7]. Compliance with helmet-wearing is low, as low as one quarter of cyclists, which is especially true among young riders [8-9].

Many studies on bicycle ridership have previously identified risk factors for injury and mortality [3,10-15]. Additionally, other studies have focused on helmets, examining rates of, barriers to, and effectiveness of helmet use [3,8-9,16-18]. Yet, despite the published research and public reports, bicycle injuries have not seen a dramatic decline. Understanding factors associated with cycling-related injury severity and mortality may potentially help establish effective policy countermeasures. More importantly, further research can bring awareness to this ongoing issue that is both deadly and costly. The objectives of the current study were to examine cycling-related injuries from both local and national trauma databases and identify cyclist- and injury-related risk factors, and to compare the two sets of results to determine whether guidelines for bicycle safety can be adjusted for local communities.

PATIENTS & METHODS

Study Design

The National Trauma Data Bank (NTDB) and a local Level I trauma center database were separately queried for bicycle injury data from January 2007 to December 2012. NTDB is managed by the American College of Surgeons and contains prospectively collected, de-identified data from over 700 trauma centers across the USA. The local trauma database contains similar information and contributes data annually to the NTDB. Approval was obtained from the University of Texas Medical Branch's Institutional Review Board for this patient population.

Patients with bicycle-related injuries were retrospectively identified using ICD-9 E-codes (800-807[.3], 810-825[.6], 826.1). All external causes in which the patient was a bicyclist, such as collisions with motor vehicles, were included. Each bicycle trauma event was considered independently, even if a patient was involved in more than one accident during the study period. Patient characteristics (demographics, drug use), injury factors (mechanism, location, body region, helmet use), and short-term outcomes (severity, complications, number of procedures, length of stay, death) of interest were extracted. Patients under the age of 3 were excluded due to low likelihood of independent riding.

Statistical Methodology

Data sets from the 2 databases were separately analyzed and then compared. Univariate analyses were carried out to describe each variable, using means (standard deviations) or proportions, as appropriate. Bivariate categorical comparisons were performed using the Pearson Chi-square test or Fisher's exact test. Groups were compared using the Student's t-test or analysis of variance (ANOVA). Multivariate models (logistic regressions) were built based on the bivariate analyses in order to relate predictor variables to outcome variables and control for confounding variables. In general, the variables with a bivariate analysis *P*-value <0.2 were included in the multivariate models. Odds ratios were determined for each predictor variable in the multivariate analyses. All tests were two-sided, and a *P*-value <0.05 considered significant. All analyses were completed using the R statistical package version 3.2.5 (R Developmental Core Team; R: A Language and Environment for Statistical Computing, 2009; available from: http://www.R-project.org).

Table 1. Patient Characteristics of National and Local Samples.

	National[a]	Local[a]	*P*-value
n	113623	240	
Sex			0.0094*
Male	80%	74%	
Female	20%	26%	
Age, years (mean±SD)	32.8±20.3	34.7±19.2	0.107
Race/Ethnicity			<0.001*
White	70%	59%	
Black	10%	15%	
Hispanic	13%	24%	
Alcohol (Above Legal Limit)	9.7%	0.97%	<0.001*
Drugs (Illegal Use)	9.2%	0%	<0.001*
Helmet (Yes)	32%	10%	<0.001*
Mechanism			<0.001*
Motor Vehicle Accident	34%	63%	
Bike Only	64%	35%	
Location			<0.001*
Street	72%	92%	
Recreation	10%	3.2%	
Injury Severity Score (mean±SD)	9.8±8.3	6.9 ± 7.7	<0.001*
AIS Head			<0.001*
GCS (mean±SD)	14.2±2.5	14.5±2.2	0.0168*
Death	1.9%	1.3%	0.486
Length of Stay, days (mean±SD)	3.9 ± 7.1	0.92±4.6	<0.001*
ICU Length of Stay, days (mean±SD)	0.99±3.9	0.92±4.6	0.224

[a]Denominator is the number of patients where the variable was recorded and excluded those that were unknown; *Statistically significant difference between groups at α=0.05.

RESULTS

National Database Summary

The NTDB query identified 113,623 bicycle trauma event evaluations in the years 2007-2012. Males made up 80% of injury evaluations (Table 1). The average patient age was 32.8 years (range 3-89). There was a 7:1:1 White:Black:Hispanic ratio. Of those patients whose alcohol and drug usage status were recorded (92,561 and 86,649, respectively), 9.7% were found to be using alcohol above the legal limit, and 9.2% were found to be using either illegal drugs or using prescription drugs illegally. Among the injured cyclists whose helmet status was recorded (92,209 incidents), 32% reported wearing helmets.

Motor vehicle accident was the mechanism behind 34% of injury evaluations, while bicycle-only accident was behind 64% of injuries identified. The most common location for injury was on the street (72%), and the second most common was recreation areas (10%). The average Injury Severity Score (ISS) was 9.8 (SD=8.3, range 1-75), and the mortality (at arrival and/or post-admission) was 1.9%. Average length of hospital stay was 3.9 days (SD=7.1, range 0-314).

Table 2. Body Region of Injury.

Body Region	National[a]	Local[a]	*P*-Value
Head/Neck	58%	55%	0.413
Spine/Back	14%	11%	0.220
Torso	28%	28%	0.74
Extremities	47%	4%	<0.001*

[a]Percentage of injured cyclists that sustained an injury to that body region; non-exclusive; *Statistically significant difference between groups at α=0.05.

Table 3. Nature of Injury.

Injury Type	National[a]
Fracture	66%
Dislocation	4.8%
Sprain/Strain	6.4%
Internal Organ	48%
Open Wound	34%
Amputation	0.18%
Blood Vessel	1.4%
Contusion/Superficial	0%
Crush	0.13%
Burn	0.13%
Nerve	0.71%

[a]Percentage of injured cyclists that sustained an injury of that nature; non-exclusive; *Statistically significant difference between groups at α=0.05.

Head and neck injuries occurred in 65,413 (57.6%) injury evaluations, and traumatic brain injuries occurred in 48,317 (42.5%; Table 2). Fractures, the most common injuries, were sustained by 66% of injured cyclists (Table 3).

Compared to helmeted cyclists, the non-helmeted cyclists were younger, used more alcohol and illegal drugs, and were disproportionately male, Hispanic or non-Hispanic black, and Medicaid-insured (p<0.001; Table 4). Non-helmeted cyclists also suffered higher rates of head and neck injuries, traumatic brain injuries, and mortality (p<0.001).

Local Database Summary

In the local trauma registry, 240 bicycle trauma event evaluations were identified in the

Table 4. Helmet versus No-Helmet Incidents.

	National			Local		
	Helmet	No-Helmet	*P*-value	Helmet	No-Helmet	*P*-value
Sex			<0.001*			0.578
Male	78%	82%		65%	72%	
Female	22%	18%		35%	28%	
Age, years (Mean)	40.5	29.7	<0.001*	45.2	34.0	0.010*
Race			<0.001*			0.014*
White	86%	63%		94%	53%	
Black	3%	13%		0%	18%	
Hispanic	4%	17%		6%	26%	
Alcohol (>Legal Limit)	2.4%	13%	<0.001*	1.6%	0%	---
Drugs (Illegal Use)	4.7%	11%	<0.001*	0%	0%	---
Mechanism			<0.001*			---
MVA	26%	38%		53%	66%	
Bike Only	72%	59%		47%	31%	
Location			<0.001*			0.112
Street	70%	75%		87%	94%	
Recreation	17%	6.7%		0%	3%	
ISS (Mean)	10.5	9.8	<0.001*	7.7	6.7	0.564
LOS, days (Mean)	3.7	4.0	<0.001*	2.4	2.1	0.821
Death	1.3%	2.1%	<0.001*	0%	1.4%	---

*Statistically significant difference between groups at α=0.05; --- Could not be calculated, too many missing values; MVA, motor vehicle accident; ISS, injury severity score; LOS, length of hospital stay.

years 2007-2012. Males made up 74% of injury evaluations. The average patient age was 34.7 years (range 3-88). There was an 8:2:3 White:Black:Hispanic ratio (Table 1). Of those patients whose alcohol and drug usage status were recorded (203 and 147, respectively), 0.97% were found to be using alcohol above the legal limit, and none were found to be using either illegal drugs or using prescription drugs illegally. Of those injured cyclists whose helmet status was recorded (163 incidents), only 10% reported wearing helmets. Compared to helmeted cyclists, the non-helmeted cyclists were younger (p=0.010) and Hispanic or non-Hispanic black (p<0.014).

Comparison of Databases

Only 10% of local database cyclists were reported to have been wearing a helmet, compared to 32% in the national database (p<0.001; Table 1). Compared to the national database, local trauma database cyclists were proportionally more female (p=0.00944) and black or Hispanic (p<0.001). Alcohol and drug use were significantly lower in the local database (p<0.001). Local cyclists were more likely to be injured in the street and by motor vehicle accidents (p<0.001). Extremity injuries were less common in local evaluations (p<0.001). However, local cyclists had lower average injury severity score (p<0.001), higher Glasgow Coma Scale (GCS) upon emergency room arrival (p=0.0168), and shorter length of hospital stay (p<0.001).

DISCUSSION

Bicycle injuries today remain high in number and can cause significant morbidity and mortality. Especially controversial is the effect of helmets in preventing severe injury [5-7]. Demographic groups such as children and the elderly are especially at risk, and efforts must be made to identify modifiable risk factors in order to reduce bicycle injuries [3]. It is possible that bicycle injury patterns vary with demographic and behavioral factors, and that prevention strategies can be differentially adjusted for each target population.

The comparison of national and local trauma databases is an important objective of this study. Recent literature has shown that large databases used in trauma research may sample different populations and produce different conclusions [19]. Therefore, we hypothesized that our local trauma database population could also differ and produce different conclusions than the National Trauma Data Bank. When creating policy toward public safety, it could be difficult to choose between national data that is generalized and supported by a large sample size, versus local data that is more relevant but much smaller in sample size. In the present study, the local data differed from the national data not only in demographics, but also in helmet-wearing status and injury patterns. Therefore, it is advisable to analyze local data when available, so as to note any unique patterns of the regional population.

Our results show the number of bicycle injuries reported in the U.S. remains high, with around a third caused by motor vehicle accidents. Our results indicate that helmets offer effective injury prevention for cyclists, and that the level of compliance was lowest in teenagers and highest in the elderly. Alcohol and drug use were common in injured cyclists, and these behaviors were associated with worse outcomes.

There are several limitations to this study. First, as a retrospective, observational study, it is not able to uncover any causative relationships or make predictions. Second, the local database is from a single center and may not be representative of other regions. The region surrounding the local trauma center does not have any helmet laws, whereas areas surrounding other trauma centers may have distinct regulations. Third, the local database is not independent of the national database because it contributes annually to the national database. Lastly, state and local bicycle and helmet laws vary by region, and cyclist compliance with any existing laws is unknown. The present study summarizes data from a national trauma database, which unifies areas with differing laws through de-identification of trauma centers. Therefore, given this data, it is impossible to determine the effect of existing bicycle laws around the country on helmet wearing compliance and injury characteristics.

CONCLUSIONS

Efforts to improve availability of cyclist-friendly infrastructure, compliance with helmet-wearing, and cyclist injury awareness should be continued or increased to reduce the number of bicycle-related injuries. National databases may not be representative of local populations, and local policy could be informed by looking at regional data, if available.

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