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Making the most of injury surveillance data: Using narrative text to identify exposure information in case-control studies

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Abstract

Introduction—Free-text fields in injury surveillance databases can provide detailed information beyond routinely coded data. Additional data, such as exposures and covariates can be identified from narrative text and used to conduct case-control studies.

Methods—To illustrate this, we developed a text-search algorithm to identify helmet status (worn, not worn, use unknown) in the U.S. National Electronic Injury Surveillance System (NEISS) narratives for bicycling and other sports injuries from 2005 to 2011. We calculated adjusted odds ratios (ORs) for head injury associated with helmet use, with non-head injuries representing controls. For bicycling, we validated ORs against published estimates. ORs were calculated for other sports and we examined factors associated with helmet reporting.

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Conflict of Interest statement

Authors have no conflicts of interest to declare

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Results—Of 105,614 bicycling injury narratives reviewed, 14.1% contained sufficient helmet information for use in the case-control study. The adjusted ORs for head injuries associated with helmet-wearing were smaller than, but directionally consistent, with previously published estimates (e.g., 1999 Cochrane Review). ORs illustrated a protective effect of helmets for other sports as well (less than 1).

Conclusions—This exploratory analysis illustrates the potential utility of relatively simple text-search algorithms to identify additional variables in surveillance data. Limitations of this study include possible selection bias and the inability to identify individuals with multiple injuries. A similar approach can be applied to study other injuries, conditions, risks, or protective factors. This approach may serve as an efficient method to extend the utility of injury surveillance data to conduct epidemiological research.

Keywords

Head injuries; Epidemiology; Case-control study; Helmet; Recreation/sports; Narrative text

INTRODUCTION

Administrative health and injury surveillance databases often include narrative text fields that provide additional detailed information beyond routinely coded data. Researchers use free text to validate coded data retrospectively or to obtain supplemental information about patients, illnesses, injuries, comorbidities, outcomes, or health services received.^{1–6} Secondary use of data from free text illustrates one way to extend the value of electronic health information for application in clinical research, quality improvement, or public health surveillance.⁷ To our knowledge, however, researchers have not used narratives or free text to obtain additional information for a case-control study.

The National Electronic Injury Surveillance System (NEISS) is an electronic database of injury information from a national probability sample of U.S. emergency departments (EDs), managed by the Consumer Product Safety Commission (CPSC). NEISS provides coded information on body part injured and injury type and has been widely used in epidemiological studies to analyze injury mechanisms for many sports. NEISS does not systematically capture information on known risk factors (e.g. alcohol use) or protective factors (e.g. helmets or other protective equipment). However, since January 1, 2002, NEISS data have included 142-character narratives that provide additional detail on the injury and circumstances around its occurrence. For some injuries such as bicycling, narrative text may provide important etiological information about the injury and whether protective gear was used. Although some studies have used NEISS narrative data to ascertain the activity at the time of injury, they have not been widely used to evaluate the prevalence or effectiveness of protective devices, such as helmets.

Many head injuries can be prevented through improved use of protective gear, especially helmets. Several landmark case-control studies have shown that in bicycling, appropriate helmet use reduces head injuries by up to eighty-five percent^{8–10}. These studies provide “gold standards” for estimates of the protective effect of helmets.

The primary objective of this study was to validate the use of narrative-derived exposure information by comparing odds ratios (ORs) for the association between bicycle helmet use and ED-reported head injuries obtained from NEISS with ORs previously reported in the literature. As an exploratory analysis, we also estimated ORs for head injuries associated with helmet use for sports-related injuries with NEISS narratives that report helmet use. Finally, we investigated the factors associated with report of helmet information in the narrative text.

METHODS

We obtained NEISS data from the Consumer Product Safety Commission for sports-related injuries that presented to NEISS hospital emergency departments from 2005 to 2011. Injury information provided by NEISS includes age, sex, ethnicity, body part, diagnosis, discharge disposition, location of incident, consumer product(s) associated with injury, and 142-character narrative text field. Diagnosis code refers to the “most severe and specific diagnosis” given by the attending physician and is classified into one of thirty categories.¹¹

Study subjects included patients with any injury reported in the NEISS database between 2005 and 2011 that involved activity, apparel, or equipment associated with bicycling and other sports that typically involve helmets (skateboarding, in-line skating, snow skiing, snowboarding, horseback riding, unpowered scooters, ice hockey, football, lacrosse, mopeds (including motorized mini-bikes, scooters, or skateboards), all-terrain vehicles (ATVs), or two-wheeled, powered, off-road motorized bikes (motocross)). If two sports were listed for an injury, the narrative was reviewed by authors (JMG and JMW) to determine the attributable cause of injury.

Case ascertainment

We defined cases as head injuries and controls as non-head injuries. NEISS provides coded data for body part affected. Head injuries included any injury to the head, face, mouth, eye, or ear. Non-head injuries included injury to any other body part (neck, extremity, trunk, multiple body parts or the entire body, or not recorded).

Exposure ascertainment

For this study, exposure was defined as use of a helmet and was ascertained from NEISS free text. Narratives were reviewed using text-search algorithms in Microsoft Excel (Microsoft Corporation, Redmond, WA) to identify those containing possible iterations of the word *helmet*, including abbreviations, truncations, and common misspellings (Appendices). In narratives identified as containing helmet information, algorithms then differentiated between narratives describing a “helmeted,” “unhelmeted,” or “helmet use unknown.” For example, if the prefix “unhel-” was identified in the narrative, the narrative was classified as unhelmeted. The category “helmet use unknown” described narratives that included mention of helmet but lacked detail as to whether a helmet was worn or not, for example: “helmet NS” (helmet not specified), “helmet?”, “unknown if hel-”. After categorization of narratives, a 10% random sample of all narratives containing the word *helmet* was reviewed by authors (JMG and JMW) to evaluate and improve the performance

of the text-search algorithms. We also reviewed a 1% random sample of narratives that did not contain the word *helmet* to confirm that the algorithms were not systematically missing narratives where helmets were mentioned. Narratives that suggested *definitive* helmet use were those that indicated the individual as either helmeted or unhelmeted.

Statistical analysis

Helmet reporting (any helmet mention vs. no mention) and helmet status (helmeted, unhelmeted, or helmet use unknown) were described across injury types. These data were not weighted by population weights and do not produce national estimates.

For bicycling injuries, unadjusted and adjusted ORs and 95% confidence intervals were calculated using logistic regression for the effect of helmet use compared with non-use. We used multiple logistic regression to adjust for age and sex using STATA/MP 13.0 (College Park, TX). ORs and 95% confidence intervals were compared to previously published OR estimates for bicycling head injuries and helmet use^{8–10}.

As an exploratory analysis, we reviewed narratives for motorized and non-motorized sports in which participants typically use helmets, as defined above. For sports with at least 10% of narratives indicating definitive helmet use (helmeted or unhelmeted), we calculated unadjusted and adjusted ORs for head injury.

Proportions were used to compare definitive helmet use in NEISS narratives. These descriptors were calculated for bicycling injuries and injuries from other sports for which at least 10% of narratives indicated definitive helmet use. Variables included patient age, sex, body part, diagnosis, and discharge disposition. Ethnicity and location of incident were not included as factors due to high percentages of missing data (e.g., 27% of bicycling injuries were missing race data).

We conducted one sensitivity analysis. Rather than including “body location not recorded” as a separate category, we excluded these observations, reran analyses, and compared results to full models for bicycle injuries.

This study was exempt from human subjects review by our institutional board because it was performed using publicly available, de-identified data.

Results

Bicycling injuries

There were 105,614 bicycling injury narratives reported in NEISS from 2005 to 2011, of which 14,925 (14.1%) referenced helmet use. Of narratives that referenced helmets, 5,270 (35.3%) were categorized as helmeted, 7,287 (48.8%) as unhelmeted, and 2,368 (15.9%) with helmet mentioned but use unknown.

A 10% random sample of bicycling injury narratives containing the word *helmet* resulted in 1,493 narratives, all of which were reviewed for validation of the text-search algorithm. Among the reviewed narratives, 1,486 (99.5%) mentioned the word *helmet* in the context of riding a bicycle. Four narratives did not contain the word *helmet* (the algorithm identified

misspellings of other words), and three mentioned helmet but not in the context of riding a bicycle (e.g., bicycle helmet fell off shelf resulting in injury). Among the remaining 1,486 narratives, the text-search algorithm correctly classified 92.2% (κ : 0.87, 95% CI: 0.85–0.89). A review of the 1% of bicycling injury narratives in which the algorithm did not identify the word *helmet* (N=907) showed that all narratives (100%) were correctly classified.

Head injuries (cases) constituted the majority (53.6%) of bicycling narratives with definitive helmet use information (Table 2). The proportion of narratives with definitive helmet use information was significantly lower among cases than controls ($p<0.001$). Multiple logistic regression showed a significant association between head injury and narratives indicating helmet use (Table 3). Using NEISS data, helmeted bicyclists had a 37% reduction in the odds of head injury (OR: 0.63; 95% CI: 0.58–0.67) compared with unhelmeted bicyclists, after adjusting for age and sex. Compared with previously published studies, this OR estimate represents a smaller effect size (OR: 0.26, 95% CI: 0.14–0.49 and OR: 0.31, 95% CI: 0.23–0.42)^{8,10}. Stratified results show a protective effect across age groups in NEISS data, consistent with previously reported results (Table 3); however, the OR estimates from this analysis were consistently more conservative⁹.

Other sports

For sports other than bicycling that potentially might involve helmet use, 2.3% to 18.0% of NEISS narratives referenced definitive helmet use (Table 4). More than 10% of the narratives referenced definitive helmet use for the following sports: ATVs (12.1%), mopeds/motorbikes (15.3%), motocross (13.2%), skiing (18.0%), snowboarding (10.9%). Adjusted ORs, controlling for age and sex, suggest a protective effect of helmet use for all of these sports except skiing (Table 5).

Reporting of definitive helmet use

Descriptive, bivariate analyses show the factors that may be associated with reporting of definitive helmet exposure (compared with not reporting helmet use) in NEISS narratives across the following sports: bicycling, ATVs, mopeds/motorbikes, motocross, skiing, snowboarding (Table 6). Patient sex showed no significant association with definitive helmet reporting, except for bicycling (chi-squared tests, $p<0.01$). Across all sports, patients with definitive helmet information more commonly experienced head or neck injuries (48% and 3%, respectively) than individuals without definitive helmet information (24% and 2%, respectively). Individuals with definitive helmet information were more often admitted, held for observation, or transferred (19%) than individuals who did not have definitive helmet information reported in their narrative (8%), across all sports.

Sensitivity analysis

Reanalyzing the helmet use data after excluding observations that lacked information on body part (classified as “not recorded” in NEISS, N=93) did not result in a change in magnitude or significance of results in Table 3.

DISCUSSION

This study utilized oft-overlooked narrative text fields in a national injury surveillance database to identify and code supplemental information (in this case exposure data) for use in an illustrative case-control study. This approach can potentially be used on any free text data, such as administrative data or medical records, to extend the utility of this information in an efficient and economical manner. This exploratory case-control study of bicycling head injuries and helmet use resulted in estimates that are directionally consistent, but more conservative than estimates derived from prospectively collected data.

The purpose of this study was to illustrate a technique, rather than provide epidemiological evidence on the effectiveness of helmets to prevent head injury. NEISS data do not require or systematically capture helmet information, resulting in 88% of definitive helmet exposure data to be missing. If helmet status is not reported in the narrative, regardless of whether the patient wore a helmet or not, non-differential misclassification bias could occur, which, on average, would bias the risk estimate towards the null.¹² Differential misclassification bias might also account for slightly smaller effect sizes in our study than comparison studies. In order for helmet status to be mentioned in NEISS narratives, first either the patient (or witness) must volunteer this information or the treating provider must inquire about use at the time of the exam, then the provider must deem this fact important enough to include in chart notes, and finally, the coder must report helmet status in the narrative. Variability in the reporting at any of these steps might account for smaller effect sizes in our study than comparison studies. Similarly, for non-head or less severe injuries, the patient, provider, or coder may not deem helmet use a relevant factor to report. Indeed, our results show that nature of injury may contribute to the reporting of helmet use (Table 6). If the helmet status of helmeted, non-head injured patients was not mentioned in the narrative, these patients would not be categorized as definitively reporting helmet use, and would not be included in our study sample. Not capturing these patients in our sample would bias the odds ratio away from the null, indicating a greater protective effect of helmets.

The amount of free text information captured in current injury surveillance datasets is limited (e.g. NEISS allows 142 characters to describe the injury circumstances), but efforts to train the clinicians/staff who enter data to include both presence and absence of relevant protective equipment could improve the utility of surveillance data for case-control studies. As surveillance systems are upgraded over time, the addition of a field for entering whether protective equipment was used, and if so, what type(s), could also improve the value of such datasets for research purposes. Streamlining any additions to minimize the burden upon the coders would be important.

Finally, we found that individuals with definitive helmet use information in their narratives more often had a head or neck injury than those without definitive helmet information. A review by Attewell and colleagues showed a slight, positive association between helmet use and neck injuries (OR 1.36; 95% CI: 1.00–1.86) although our prior study found no effect of helmet use on neck injuries^{13,14}. If helmets increase the risk of neck injury, including neck injuries in our control group may have attenuated the effect of helmets compared with other studies.

For skiing injuries, our results suggest that the odds of head injury was not significantly different between helmeted and unhelmeted skiers, unlike other sports in which helmet use was significantly protective of head injuries. A published review and meta-analysis of the effectiveness of ski and snowboard helmets produced an odds ratio of 0.65 (95% CI: 0.55–0.79) indicating a protective effect¹⁵. Chance, lack of adjustment for variables (such as ability and experience), and potential helmet use misclassification among non-head injured, but helmeted skiers may have resulted in our null finding.

This study has several limitations. First, a large proportion of observations were missing helmet exposure data, limiting the scope of our analysis. Multiple imputation is one approach to account for this, however, the assumptions required by this method (e.g., data missing at random) could not reasonably be met¹⁶ and multiple imputation was not used. Second, injury classification in NEISS is limited to one injury; individuals with multiple injuries may be classified as only head injured or non-head injured, depending on the location of the most serious injury. One would not expect this, however, to bias the results of this study. Also, despite trying to control for the same covariates and stratifying by age in the same way, the population in this study may be different than the prospectively conducted case-control studies. Finally, the time period assessed in this study occurred up to two decades after the comparison studies. It is unlikely, however, that helmet effectiveness has changed significantly since the early 1990s, given the relatively limited changes in helmet design, composition and certification standards¹⁷.

This study illustrates a novel way to extend the utility of injury surveillance data by coding variables from free text. While NEISS narratives have been used to understand injury context and severity and describe circumstances around injuries¹, to our knowledge, this study is the first to use text-search algorithms to ascertain helmet use for the conduct of a case control study. We have shown that use of text-search algorithms in Microsoft Excel is a reliable way to search narratives and believe this approach can be applied to study other injuries and risk or protective factors.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Table 1

Characteristics of bicycling injuries reported to the U.S. NEISS from 2005 to 2011.

	All narratives (N=105,614)	Narrative referenced helmet use ^b (N=14,925)	Narrative referenced definitive helmet use ^c (N=12,557)
Male, N (%)^a	77,026 (72.9)	11,324 (75.9)	9,505 (75.7)
Age in years, mean (SD)	22.0 (17.9)	23.8 (17.8)	23.6 (17.9)
Body part injured, N (%)			
Head (including face and ears)	31,992 (30.3)	7,310 (49.0)	6,733 (53.6)
Neck	1,567 (1.5)	360 (2.4)	614 (2.5)
Extremities	58,147 (55.1)	5,704 (38.2)	4,277 (34.1)
Trunk	12,278 (11.6)	1,509 (9.6)	1,121 (8.9)
Other	1,630 (1.5)	121 (0.8)	112 (0.9)
Helmet use, N (%)			
Helmeted	5,270 (5.0)	5,270 (35.3)	5,270 (42.0)
Unhelmeted	7,287 (6.9)	7,287 (48.8)	7,287 (58.0)
Helmet use mentioned, unknown	2,368 (2.2)	2,368 (15.9)	
Helmet use not mentioned	90,689 (85.9)		

Abbreviations: NEISS, National Electronic Injury Surveillance System

^a Column values may not sum to total due to rounding or missing data.

^b “Narrative referenced helmet use” includes cases where helmet use was indicated not known (categorized as “helmet use unknown”).

^c Definitive helmet use is defined as unambiguous reference of helmet use in narratives (helmeted or unhelmeted).

Table 2

Descriptive characteristics of cases and controls with definitive helmet use from narrative review of bicycling injuries reported to the U.S. NEISS from 2005 to 2011.

	Head injury (Cases) (N=5,824)	Non-head injury (Controls) (N=6,733)	Total (N=12,557)
Male, N (%)^a	5,111 (75.9)	4,394 (75.5)	9,505 (75.7)
Age in years, mean (SD)	21.8 (18.0)	25.8 (17.6)	23.6 (17.9)
Body part injured, N (%)			
Head (including face and ears)	6,733 (100)	0 (0)	6,733 (53.6)
Neck	0 (0)	614 (5.4)	614 (2.5)
Extremities	0 (0)	4,277 (73.4)	4,277 (34.1)
Trunk	0 (0)	1,121 (19.3)	1,121 (8.9)
Other	0 (0)	112 (1.9)	112 (0.9)
Injury diagnosis, N (%)			
Concussion	1,024 (15.2)	0 (0)	1,024 (8.2)
Other TBI	2,790 (41.4)	0 (0)	2,790 (22.2)
Contusion/abrasion	700 (10.4)	1,610 (27.6)	2,310 (18.4)
Fracture	454 (6.7)	2,168 (37.2)	2,622 (20.9)
Laceration	1,389 (20.6)	443 (7.6)	1,832 (14.6)
Dental injury	230 (3.4)	0 (0)	230 (1.8)
Other internal organ injury	0 (0)	150 (2.6)	150 (1.2)
Sprain/strain	0 (0)	973 (16.7)	973 (7.8)
Missing	43 (0.6)	303 (5.2)	346 (2.8)
Other*	103 (1.5)	177 (3.0)	280 (2.2)
ED discharge disposition, N (%)			
Released	5,404 (80.3)	4,853 (83.3)	10,257 (81.7)
Transferred	69 (1.0)	44 (0.8)	113 (0.9)
Admitted or held for observation	1,212 (18.0)	866 (14.9)	2,078 (16.6)
Left without being seen	47 (0.7)	61 (1.0)	108 (0.9)
Helmet use, N (%)			
Helmeted	2,418 (35.9)	2,852 (49.0)	5,270 (42.0)
Unhelmeted	4,315 (64.1)	2,972 (51.0)	7,287 (58.0)

Abbreviations: ED, emergency department; SD, standard deviation; TBI, traumatic brain injury

^aPercentages may not sum to 100% due to rounding.

Table 3

Odds Ratios for Head Injury in Helmeted Vs. Unhelmeted Bicyclists; Comparison of Risk Estimates Derived from Narratives to Those Previously Reported.

	Head injury N (%)	Non-head injury N (%)	Unadjusted		Adjusted ^d	
			OR	95% CI	OR	95% CI
NEISS narrative review	N=6,733	N=5,824				
Helmeted, all ages	2,418 (35.9)	2,852 (49.0)	0.58	0.54, 0.63	0.63	0.58, 0.67
Thompson, et al. 1989^a	N=235	N=433				
Helmeted, all ages	17 (7.2)	103 (23.8)			0.26	0.14, 0.49
Thompson, et al. 1999^b						
Helmeted, all ages					0.31	0.23, 0.42
NEISS narrative review	N=6,733	N=5,824				
Helmeted, age <6 y	248 (38.9)	96 (55.5)	0.51	0.36, 0.72	0.51	0.37, 0.72
Helmeted, age 6–12 y	673 (30.0)	622 (39.5)	0.66	0.57, 0.75	0.66	0.58, 0.76
Helmeted, age 13–19 y	317 (24.6)	382 (33.1)	0.66	0.55, 0.79	0.66	0.55, 0.79
Thompson, et al. 1996^c	N=757	N=2633				
Helmeted, age <6 y	24 (27.6)	96 (58.2)	0.27	0.15, 0.50	0.27	0.16, 0.50
Helmeted, age 6–12 y	65 (23.1)	479 (51.3)	0.28	0.21, 0.39	0.30	0.22, 0.41
Helmeted, age 13–19 y	22 (18.5)	153 (35.9)	0.40	0.24, 0.69	0.41	0.25, 0.68

Abbreviations: CI, confidence interval; NEISS, National Electronic Injury Surveillance System; OR, odds ratio

^a Values refer to head injuries ("Model 1" in their Table 5). Adjusted OR comparing head-injured patients to emergency department controls; adjusted for age, sex, household income, education level of head of household, amount of cycling, severity of crash, and hospital. ¹⁵

^b Summary odds ratio reported for three head injury studies with emergency department controls. ¹³

^c Values compare emergency department patients with bicycling-related injuries. Adjusted OR controls for motor vehicle involvement. ¹⁴

^d Adjusted OR in NEISS narrative review controls for age and sex.

Table 4

Results of narrative reviews for injuries reported to the U.S. NEISS for sports that typically involve helmets (other than bicycling)

	All narratives (N=214,905)	Narratives that referenced definitive helmet use (N=15,683)	
	N	Helmeted N (%)	Unhelmeted N (%)
All-terrain vehicles	23,720	1,323 (46.1%)	1,548 (53.9%)
Football	99,793	5,508 (91.4%)	520 (8.6%)
Horseback riding	12,428	466 (82.8%)	97 (17.2%)
Ice hockey	4,262	279 (96.9%)	9 (3.1%)
Inline skating	3,935	54 (59.3%)	37 (40.7%)
Lacrosse	3,755	172 (96.6%)	6 (3.4%)
Mopeds/motorbikes	3,944	262 (43.4%)	342 (56.6%)
Motocross	11,369	1,091 (72.6%)	411 (27.4%)
Non-motorized scooter	11,683	201 (36.2%)	354 (63.8%)
Skateboarding	24,219	261 (33.2%)	525 (66.8%)
Skiing	7,000	786 (62.5%)	471 (37.5%)
Snowboarding	8,797	572 (59.6%)	388 (40.4%)

Abbreviations: NEISS, National Electronic Injury Surveillance System

Shaded cells indicate those sports with over 10% of narratives referencing definitive helmet use.

Table 5

Odds of head injury among helmeted and unhelmeted sports participants for sports with over 10% of narratives referencing definitive helmet use.

	Head injury N (%)	Non-head injury N (%)	Unadjusted		Adjusted ^a	
			OR	95% CI	OR	95% CI
All-terrain vehicles	N=1,258	N=1,613				
Helmeted, all ages	431 (34.3)	892 (55.3)	0.42	0.36, 0.49	0.40	0.34, 0.47
Mopeds	N=266	N=338				
Helmeted, all ages	94 (35.3)	168 (49.7)	0.55	0.40, 0.77	0.55	0.40, 0.77
Motocross	N=529	N=973				
Helmeted, all ages	333 (63.0)	758 (77.9)	0.49	0.39, 0.61	0.45	0.36, 0.57
Skiing	N=364	N=893				
Helmeted, all ages	228 (62.6)	558 (62.5)	1.01	0.78, 1.30	0.90	0.70, 1.17
Snowboarding	N=353	N=607				
Helmeted, all ages	188 (53.3)	384 (63.3)	0.66	0.51, 0.86	0.63	0.48, 0.82

Abbreviations: CI, confidence interval; NEISS, National Electronic Injury Surveillance System; OR, odds ratio

^a Adjusted OR controls for age and sex.

Table 6

Demographic and injury characteristics and helmet reporting (definitive vs. non-definitive helmet use reported in NEISS narrative).

	Bicycling (N=105,601) ^a		ATV's (N=23,718)		Mopeds (N=3,944)		Motocross (N=11,366)		Skiing (N=6,970)		Snowboarding (N=8,767)		All sports (N=160,423)	
	Non- definitive	Definitive	Non- definitive	Definitive	Non- definitive	Definitive	Non- definitive	Definitive	Non- definitive	Definitive	Non- definitive	Definitive	Non- definitive	Definitive
N	93,057 (88%)	12,557 (12%)	20,849 (88%)	2,871 (12%)	3,340 (85%)	604 (15%)	9,867 (87%)	1,502 (13%)	5,743 (82%)	1,257 (18%)	7,837 (89%)	960 (11%)	140,693 (88%)	19,751 (12%)
Sex														
Male	73%	76%	70%	71%	68%	71%	90%	92%	60%	62%	74%	72%	73%	75%
Female	27%	24%	30%	29%	32%	29%	10%	8%	40%	38%	26%	28%	27%	25%
Age														
Under 6 years	11%	6%	4%	4%	4%	2%	1%	2%	1%	2%	0%	0%	8%	5%
6–12 years	33%	30%	13%	17%	21%	21%	16%	20%	15%	19%	14%	21%	26%	26%
13–20 years	20%	21%	25%	34%	21%	27%	38%	42%	26%	29%	51%	53%	24%	27%
21–60 years	32%	38%	21%	44%	44%	44%	44%	36%	52%	44%	35%	26%	37%	39%
Over 60 years	4%	4%	6%	1%	10%	6%	0%	0%	6%	7%	0%	0%	4%	3%
Body part injured														
Extremities	58%	34%	53%	32%	62%	43%	71%	46%	71%	55%	71%	48%	59%	37%
Head	27%	54%	21%	44%	21%	44%	12%	35%	14%	29%	14%	37%	24%	48%
Neck	1%	3%	3%	5%	2%	3%	2%	3%	2%	3%	2%	4%	2%	3%
Trunk	12%	9%	21%	18%	13%	8%	14%	15%	12%	12%	13%	11%	14%	11%
Other	2%	1%	1%	1%	2%	2%	1%	1%	0%	0%	0%	0%	1%	1%
Diagnosis														
Fracture	21%	21%	25%	26%	26%	25%	32%	30%	29%	27%	37%	30%	24%	23%
Concussion or TBI	9%	30%	9%	29%	9%	26%	6%	25%	7%	21%	9%	42%	8%	29%
Internal organ injury	0%	1%	1%	3%	1%	1%	1%	2%	1%	1%	1%	1%	1%	1%
Other injury	63%	45%	58%	38%	59%	46%	56%	40%	57%	48%	49%	33%	61%	43%
Missing	7%	3%	7%	4%	5%	2%	5%	3%	6%	3%	5%	3%	6%	3%
ED Discharge disposition														
Released	92%	82%	85%	70%	87%	80%	87%	78%	93%	90%	95%	93%	91%	81%
Admitted, held for observation, or transferred	7%	17%	14%	30%	12%	30%	12%	21%	7%	10%	4%	7%	8%	19%

	Bicycling (N=105,601) ^a		ATV/s (N=23,718)		Mopeds (N=3,944)		Motocross (N=11,366)		Skiing (N=6,970)		Snowboarding (N=8,767)		All sports (N=160,423)	
	Non- definitive	Definitive	Non- definitive	Definitive	Non- definitive	Definitive	Non- definitive	Definitive	Non- definitive	Definitive	Non- definitive	Definitive	Non- definitive	Definitive
N	93,057 (88%)	12,557 (12%)	20,849 (88%)	2,871 (12%)	3,340 (85%)	604 (15%)	9,867 (87%)	1,502 (13%)	5,743 (82%)	1,257 (18%)	7,837 (89%)	960 (11%)	140,693 (88%)	19,751 (12%)
Left without being seen or missing	1%	1%	1%	1%	1%	1%	1%	1%	0%	0%	1%	0%	1%	1%

Abbreviations: ED, emergency department; ATV's, all-terrain vehicles.

Values represent percentages of narratives that reported non-definitive (helmet not mentioned or helmet use characterized as unknown) or definitive helmet use.

Head category includes injuries to the head, face, mouth, eye, or ear. “Other injury” may include the following injury diagnoses: sprain, strain, contusion, abrasion, laceration, dislocation, dental injury, ingestion or aspiration of a foreign object, burns, amputation, crushing injury, injury involving a foreign body, hematoma, nerve damage, puncture, anoxia, hemorrhage, electric shock, poisoning, drowning, avulsion, or dermatitis.

Abbreviations: NEISS, National Electronic Injury Surveillance System; TBI, Traumatic brain injury

^aColumn totals may not sum to 100% due to rounding or missing data.