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Comparing alcohol involvement among injured pedalcycle and motorcycle riders across three national public-use datasets

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ABSTRACT

Background: Annually since 2008; over 38% of fatally injured motorcycle riders and 20% of pedalcyclists involved in traffic crashes were under the influence of alcohol, yet public health surveillance of alcohol involvement in these injuries is underdeveloped. This study determined alcohol involvement among fatally and non-fatally injured pedalcycle and motorcycle riders and compared findings across three national public-use datasets.

Methods: Using the 2019 National Emergency Medical Services Information System (NEMSIS), the Fatality Analysis Reporting System (FARS), and National Electronic Injury Surveillance System (NEISS) datasets, we identified alcohol involvement in fatal and non-fatal injuries to pedalcycle and motorcycle riders (≥21 years). Alcohol involvement was positive based on the clinician's evaluation of alcohol at the scene (NEMSIS) or within the ED record (NEISS); or when Blood Alcohol Content (BAC) values were ≥.01 (FARS). Pedalcycle and motorcycle injuries were identified across datasets using: 1) ICD10 codes for pedalcycle (V10-V19) or motorcycle (V20-V29) within the cause of injury and EMS respondent's impression of the encounter variables (NEMSIS); 2) product codes for bicycles or moped/power-assisted cycle/minibike/two-wheeled, powered, off-road vehicles (NEISS); and 3) American National Standard Institute's classifications for pedalcycle and motorcycle in the person and vehicle type variables (FARS). The descriptive epidemiology was compared across datasets.

Results: There were 26,295 pedalcyclist and 50,122 motorcycle rider injuries resulting in an EMS response within NEMSIS data; 10.2% and 8.5% of these injuries respectively involved alcohol. These estimates were greater than the 7.3% of pedalcyclist and 6.1% of moped/power-assisted cycle/minibike/two-wheeled, powered, off-road vehicle injuries involving alcohol among patients who presented to an ED within the NEISS dataset. Based on FARS data, alcohol was involved in 27.0% of pedalcyclist and 42.0% of motorcyclist fatal injuries. Regardless of the data source, pedalcyclist and motorcycle fatal and non-fatal injuries were more likely to involve alcohol among middle-aged adults compared to older and early aged adults, and for men compared to women, with proportions that were generally 3-8% higher for men.

Conclusions: Measures for pedalcycle and motorcycle injuries and alcohol involvement vary substantially across national public-use datasets. Standardized, valid, and feasible methods are needed to accurately inform injury prevention efforts.

Introduction

Alcohol consumption among motorcyclists and bicyclists is of increasing concern given the rising prevalence of registered motorcyclists and growth in the personal and shared bicycle industry (National Association of City Transportation Officials 2020; U.S. Department of Transportation 2023; National Association of City Transportation Officials 2022; Teoh 2023). Since at least 2008; more than 38% of motorcycle riders and 20% of pedalcyclists who died in traffic crashes were under the influence of alcohol, and motorcyclists consistently show the highest prevalence of alcohol use during fatal traffic crashes compared to any other motor vehicle driver (Vargos et al. 2015; National Center for Statistics and Analysis 2021a; National Center for Statistics and Analysis 2021b). As the availability and demand for motorcycles and bicycles rises across US cities and deaths continue to rise among these vulnerable road users, national, city, and state government officials have called for greater policy and research attention to help

protect their safety (Rimer 2020; Jiao and Bai 2020; National Transportation Safety Board 2022a; Herron 2023; Council Member Mackenzie Kelly and District 6 6 2023; McLeod 2024).

Epidemiological surveillance data for alcohol involvement in pedalcycle and motorcycle injuries, especially for crashes that did not involve a motor vehicle, are lacking. We found only two studies examining alcohol involvement and motorcycle injuries which both used National Trauma Data Bank (NTDB) data (Ahmed et al. 2020; Brockhus et al. 2024). Brockhus et al. (2024) included all patients who were injured in a motorcycle crash and found 18% tested positive for alcohol use whereas Ahmed et al. (2020) examined only patients that were tested for alcohol, and showed that 32% tested positive for blood alcohol concentration (BAC) (Ahmed et al. 2020; Brockhus et al. 2024). To our knowledge, the only national-level sample to examine alcohol use and bicycle injuries found that among the 270,571 persons with bicycle injuries who presented to an emergency department (ED) in 2019; alcohol use was implicated in 7% of these injuries (Namiri et al. 2020).

A primary reason for the sparse evidence on the prevalence of alcohol involvement in pedalcycle and motorcycle injuries is due to methodological limitations across injury surveillance systems. An essential first step to developing effective interventions and policies to reduce the risk of alcohol-related vulnerable road user injuries and deaths is to have robust and reliable surveillance and epidemiological data to characterize the burden of these injuries and identify high-risk populations.

There at least three sources of surveillance data. The Fatality Analysis Reporting System (FARS) (National Highway Traffic Safety Administration 2024) and National Electronic Injury Surveillance System (NEISS) (U.S. Consumer Product Safety Commission n.d.) are two public health surveillance tools that can be used for vulnerable road user fatal and non-fatal injury surveillance. FARS only collects data on motor vehicle-involved traffic crashes (National Highway Traffic Safety Administration 2024). NEISS is a probability sample of 96 US hospitals that collect data on consumer product-related injuries and deaths resulting in an ED discharge or admission and excludes motor vehicles (e.g., motorcycles) as a product type (U.S. Consumer Product Safety Commission n.d.). These systems also use varying data coding standards for vulnerable road users. FARS uses the Model Minimum Uniform Crash Criteria (MMUCC) guidelines based on the American National Standard Institute's (ANSI) Manual on Classification of Motor Vehicle Traffic Crashes (National Highway Traffic Safety Administration 2017; American National Standard 2017), while NEISS uses consumer product codes that the US Consumer Product Safety Commission (CPSC) has jurisdiction over (U.S. Consumer Product Safety Commission 2019). This particular issue has risen to national attention, as highlighted by a recent report from the National Transportation Safety Board (NTSB), which cited data coding standardization across injury surveillance systems as the primary reason for the poor

understanding of emerging micromobility devices (e.g., e-scooter and e-bike) associated injuries and fatalities (National Transportation Safety Board 2022b). The National Emergency Medical Services Information System (NEMSIS) public-use research dataset, which uses Emergency Medical Services (EMS) clinical and administrative data, may be a means of surveillance data for measuring alcohol involvement in vulnerable road user injuries, but no studies have used NEMSIS to describe these patterns.

The primary objective of this study was to determine the role of alcohol involvement among fatally and non-fatally injured pedalcycle and motorcycle riders and to compare these findings across the 2019 NEMSIS, NEISS, and FARS national public-use datasets. This study draws conclusions on the utility and validity as sources of information on this increasingly important public health issue.

Methods

Study design

This cross-sectional study used data collected from three 2019 national public-use datasets: 1) NEMSIS Public-Release Research Dataset; 2) the US CPSC NEISS; and 3) the National Highway Traffic Safety Administration (NHTSA) FARS data. We did not use more recent versions of these datasets in order to avoid the impact of the COVID-19 pandemic.

Data sources

National emergency medical services information system (NEMSIS)

NEMSIS is the national system to collect and standardize data from EMS agencies across the US. The NHTSA Office for EMS provides the NEMSIS data as a public use, de-identified, Health Insurance Portability and Accountability Act exempt dataset hosted by the University of Utah, therefore further institutional review board (IRB) review was not requested (https://nemsis.org/using-ems-data/) (Dawson 2006; Ehlers et al. 2023). All EMS data entry into NEMSIS must abide by the standards set forth by the NHTSA Office of EMS and outlined in the NEMSIS data dictionary (https://nemsis.org/media/nemsis_v3/release-3.5.0/DataDictionary/PDFHTML/EMSDEMSTATE/index.html) (V3 Data Dictionaries & XSD – NEMSIS 2024).

National electronic injury surveillance system (NEISS)

NEISS is a nationally representative stratified probability sample of 96 hospitals in the US and its territories that contain at least six beds and an ED (U.S. Consumer Product Safety Commission n.d.). The stratified sample is based on hospital size and geographic location. Each of the cases from the 2019 NEISS data is assigned a weight to provide nationally representative estimates of injuries that resulted in an ED discharge. NEISS data are de-identified, publicly available, and do not require IRB approval.

Fatality analysis reporting system (FARS)

The NHTSA FARS database includes all crashes involving a motor vehicle traveling on a traffic way customarily open to the public that resulted in the death of at least one person (vehicle occupant or non-motorist) within 30 days of the crash (National Highway Traffic Safety Administration 2024). We included FARS data from the NHTSA Fatality and Injury Reporting System Tool (FIRST), an online query system available for public use that provides de-identified data and analysis (Fatality and Injury Reporting System Tool (FIRST)) 2024).

Variable coding

Figure 1 presents variables and codes and/or definitions for pedalcycle, motorcycle, and alcohol across the NEMSIS, NEISS, and FARS datasets as of 2019.

Sociodemographic data

The NEMSIS variables ePatient.13 and ePatient.15 were used to define patient sex and age, and we used raw sex and age variables from the NEISS dataset. Across all datasets, we defined adult age groups using the FARS classifications of age groups within the auxiliary person dataset (21-24, 25-34, 35-44, 45-64, 65+) (National Highway Traffic Safety Administration 2021; Fatality and Injury Reporting System Tool (FIRST)) 2024) and also used in NHSTA reports. We only examined persons ≥21 years old within analyses, the minimum legal drinking age in the US (National Institute of Alcohol Abuse and Alcoholism 1984).

NEMSIS variable coding

Pedalcycle and motorcycle

For the NEMSIS dataset, the EMS responder's judgment on the cause of any injury suffered by the patient is documented *via* the International Statistical Classification of Diseases and Related Health Problems 10th Revision (ICD10) codes in the NEMSIS eInjury.01 variable. The EMS responder's overall impression of the encounter is documented *via* ICD10 codes in the eSituation.11 and eSituation.12 variables. We included

any patient record for the eInjury.01, eSituation.11, and eSituation.12 variables that included an ICD10 code for pedalcyclist injury (V10-V19) or motorcycle rider injury (V20-V29) during transport accidents (traffic, non-traffic, unspecified). As previously described in Rundle et al. (2023), we excluded records in the NEMSIS dataset if the eDisposition.12 or Disposition of the response was coded as Canceled (codes 4212007, 4212009, 4212011), Standby-No Services or Support Provided (code 4212039), or Transport Non-patient (code 4212043) or eResponse.15 variable was coded as Interfacility Transport (code 2205003) or Medical Transport (code 2205007) (Rundle et al. 2023). These codes were excluded as the EMS team did not deliver health care or an existing patient was transported between healthcare facilities.

Alcohol

The NEMSIS variable eHistory.17 contains data on the EMS clinician's evaluation of whether alcohol or drugs were involved in an incident. Figure 1 describes the responses and codes we operationalized as "alcohol involvement" using the eHistory.17 variable. As there was often more than one code for "alcohol involvement" assigned to a patient, any record that noted one of the indicated codes assigned the patient to this category to remove duplicate records for patients. Patient Admits to Drug Use (311707), Not Applicable (7701001), Not Recorded (7701003), None Reported (88010015), Refused (8801019), and Unable to Complete (8801023) were categorized into "no alcohol involvement."

NEISS variable coding

Pedalcycle and motorcycle

The NEISS dataset does not record "motorcycle" as a product code because it is considered a motor vehicle (U.S. Consumer Product Safety Commission 2019) and thus this specific vehicle type is not included within the "motorcycle" umbrella term within NEISS data. However, as both NEMSIS and FARS classification schemes include minibikes, two-wheeled off-road vehicles, and mopeds within the "motorcycle" definition, we chose to report these product codes for within our analyses.

Alcohol

As shown in Figure 1, alcohol is a raw variable in the NEISS dataset, and alcohol involvement was noted as positive if the patient's ED record indicated that the patient consumed alcohol prior to or during the incident; otherwise, the record was coded a "no alcohol involvement."

FARS variable coding

Pedalcycle and motorcycle

The person type and vehicle body type raw variables from the FARS auxiliary datafiles were used to define pedalcycle and motorcycle, respectively. These auxiliary definitions are widely used in National Center for Statistics and Analysis (NCSA) publications and research including the 2019 annual reports on Traffic Safety Facts for Motorcycles and

Figure 1. Pedalcycle, motorcycle, and alcohol variable data coding across the 2019 NEMSIS, NEISS, and FARS datasets.

Pedalcycles (FARS and GES Auxiliary Datasets Q and A 2010; National Center for Statistics and Analysis 2021a; National Center for Statistics and Analysis 2021b)

Alcohol

The FARS crash-level (MIDRVACC) and person-level (MIPER) alcohol datasets, which include 10 imputed values of Blood Alcohol Content (BAC) for each record, were used to classify estimates of alcohol use. The NHTSA uses a multiple imputation model to estimate BAC for fatalities when BAC is unknown (Subramanian 2002; Fell et al. 2009; National Highway Traffic Safety Administration 2024). We used the NHSTA method for analyzing the imputed data files, and is used within NHTSA's FIRST, which classifies the crash as "alcohol involved" when BAC values are ≥.01 or "alcohol impaired" when BAC values are ≥.08 g/dL (Fatality and Injury Reporting System Tool (FIRST)) 2024).

Statistical analysis

Descriptive analyses included total counts with proportions, and data were cross tabulated by age and sex. For NEISS data, we used the R package 'survey' to generate stratified, weighted, nested survey estimates, and also reported 95% confidence intervals (Package 'Survey' 2023). NHTSA's FIRST was used for analyses of FARS data, a web-based tool that allows users to query FARS data (Fatality and Injury Reporting System Tool (FIRST)) 2024). Analyses of NEMSIS and NEISS data were performed using R Statistical Software (v4.3.1; R Core Team 2023).

Results

Table 1 shows the descriptives characteristics for adult (≥21 years) pedalcyclist fatal and non-fatal injuries across the 2019 NEMSIS, NEISS, and FARS datasets by alcohol involvement. Among US adults, we identified 26,295 pedalcyclist injuries that required an EMS response in the 2019 NEMSIS dataset, and alcohol involvement was noted in 10.2% of these injuries (n = 2,690). Using the NEISS dataset, there were an estimated 253,186 (95% CI 191,580 to 314,802) pedalcycle injuries with 7.3% (95% CI 5.8 to 9.0) involving alcohol. FARS data revealed a total of 770 pedalcyclists fatalities from traffic crashes, and 27% of these fatalities indicated alcohol involvement (BAC of .01 g/dL or higher). For pedalcyclist injuries as reported by both NEMSIS and NEISS datasets, across each age category, adults ages 45-64 had the highest proportion of alcohol-related injuries (13% and 11%, respectively) compared to all other age groups. For fatally injured pedalcyclists in traffic crashes, the 25-34 age group had the highest prevalence of alcohol involvement (36%), closely followed by the 45-65 age group (33%). Across all three datasets, men had a higher prevalence of alcohol involvement compared to women for pedalcyclist injuries resulting in an EMS response (11.8% vs 5.3%), when treated at an ED (8.7%, 95% CI 7.0 to 11.0 vs 3.1%, 95% CI 1.9 to 5.0), or for fatalities following a crash (27% vs 23%).

Table 2 show the descriptives characteristics for adult (≥21 years) motorcycle rider fatal and non-fatal injuries across the 2019 NEMSIS, NEISS, and FARS datasets by alcohol involvement. In total, there were 50,122 motorcycle rider injuries resulting in an EMS response in the 2019 NEMSIS dataset, and 8.5% of these injuries were reported to involve alcohol (n = 4,643). This was slightly larger than the 6.1% (95% CI 4.6 to 8.2) of moped/power-assisted cycle/minibike/two-wheeled, powered, off-road vehicle injuries to persons treated in the ED among the estimated 46,398 (95% CI 37,046 to 55,749) total injuries in the NEISS dataset. FARS data revealed that among the 4,534 motorcycle rider fatalities from traffic crashes, 42% involved alcohol (BAC of .01 g/dL or higher), and 34% were alcohol impaired (BAC of .08 g/dL or higher). Early middle-aged adults (35-44 age groups) had the highest proportion of alcohol involvement in motorcycle rider injuries resulting in EMS response (9.8%) and motorcycle rider fatalities in traffic crashes (50%) compared to all other age groups as reported by the NEMSIS and FARS datasets. Early and late-middle aged adults (35-44 and 45-64 age groups) had the highest proportions for alcohol involvement in moped/power-assisted cycle/minibike/two-wheeled, powered, off-road vehicle injuries for those admitted to an ED (9.5% and 10.3%, respectively). The proportions were all higher for males compared to females for alcohol involvement in motorcycle rider injuries with EMS response (9.1% vs 6.0%), moped/power-assisted cycle/minibike/two-wheeled, powered, off-road vehicle injuries with ED visits (6.9%, 95% CI 5.1 to 9.3 vs 1.8%, 95% CI 0.34 to 9.1), and motorcycle rider fatalities from automobile crashes (42% vs 34%).

Discussion

This is the first study to use the NEMSIS national public-use dataset for describing the burden of motorcycle and pedalcycle injuries from transport crashes involving both motorized and non-motorized vehicles, and to compare findings with two other national public-use datasets by alcohol consumption status. Overall, about 10% and 8.5% of EMS responses for injured pedalcyclists and motorcycle riders, respectively, involved alcohol. These were larger estimates compared to the 7.3% of pedalcyclist and 6.1% of moped/power-assisted cycle/two-wheeled, powered, off-road vehicle injuries involving alcohol among adult patients treated at an ED. However, the proportions for pedalcycle and motorcycle riders who were fatally injured in motor vehicle traffic crashes that involved alcohol were much greater (27% and 42%, respectively). Pedalcycle and motorcycle fatal and non-fatal injuries among middle aged adults and men were more likely to involve alcohol compared to older adults and early aged adults and women.

Differences in estimates across these datasets may be explained by sources of bias and error in the sample populations and measures for pedalcycles, motorcycles, and alcohol across these national public-use datasets (Figure 1). Selection bias is a limitation of these findings as FARS only

Table 1. Descriptives characteristics for adult (≥21 years) pedalcyclist fatal and non-fatal injuries across three 2019 national public-use datasets by alcohol involvement.

| Characteristic | NEMSIS, pedalcyclist injuries resulting in EMS response N=26,295 | | NEISS, estimated pedalcycle injuries to persons treated in hospital ED N=253,186 (95% CI¹ 191,580–314,802) | | | | FARS, pedalcyclists fatalities from traffic crashes N=770 | | |
	alcohol involved, N=2,690 (10.2%)	no notation of alcohol involvement, N=23,605 (89.8%)	alcohol involved, N=18,388 (7.3%, 95% CI 5.8–9.0)	95% CI	no notation of alcohol involvement, N=234,797 (92.7%, 95% CI: 91–94)	95% CI	alcohol involved (BAC .01–.07 g/dL) N=37 (5.0%)	alcohol-impaired (BAC .08+ g/dL) N=169 (22.0%)	no alcohol involvement (BAC .00 g/dL) N=563 (73.0%)
Age									
21–24	133 (6.7%)	1,864 (93.3%)	801 (4.2%)	2.3%, 7.4%	18,340 (95.8%)	93%, 98%	2 (5.0%)	6 (17%)	26 (79.0%)
25–34	475 (9.2%)	4,686 (90.8%)	3,025 (5.8%)	4.2%, 7.8%	49,325 (94.2%)	92%, 96%	8 (7.0%)	31 (29%)	68 (64.0%)
35–44	488 (10.8%)	4,020 (89.2%)	3,177 (7.8%)	5.4%, 11.0%	37,464 (92.2%)	89%, 95%	5 (5.0%)	22 (19%)	86 (76.0%)
45–64	1,432 (13.0%)	9,613 (87.0%)	10,731 (11.0%)	8.8%, 14.0%	87,181 (89.0%)	86%, 91%	18 (5.0%)	94 (28%)	226 (67.0%)
65+	162 (4.5%)	3,422 (95.5%)	654 (1.5%)	0.8%, 3.0%	42,487 (98.5%)	97%, 99%	5 (3.0%)	15 (9%)	155 (88.0%)
Unknown	0 (0.0%)	0 (0.0%)	0 (0.0%)	–	0 (0.0%)	–	0 (5.0%)	2 (38.0%)	2 (58.0%)
Sex									
Female	325 (5.3%)	5,823 (94.7%)	1,959 (3.1%)	1.9%, 5.0%	61,857 (96.0%)	95%, 98%	4 (3.0%)	22 (20.0%)	81 (76.0%)
Male	2,357 (11.8%)	17,679 (88.2%)	16,430 (8.7%)	7.0%, 11.0%	172,399 (89.3%)	89%, 93%	34 (5.0%)	146 (22.0%)	479 (73.0%)
Unknown	8 (7.2%)	103 (92.8%)	0 (0.0%)	–	0 (0.0%)	–	0 (0.0%)	0 (0.0%)	1 (100.0%)

Abbreviations: CI, Confidence Interval; NEMSIS, National Emergency Medical Services Information System; NEISS, National Electronic Injury Surveillance System; FARS, Fatality Analysis Reporting System; ED, Emergency Department; BAC, Blood Alcohol Content (grams/deciliter).

Table 2. Descriptives characteristics for adult (≥21 years) motorcycle rider fatal and non-fatal injuries across three 2019 national public-use datasets by alcohol involvement.

| Characteristic | NEMSIS, motorcycle rider injuries resulting in EMS response N=54,765 | | NEISS, moped/power-assisted cycle/minibike/two-wheeled, powered, off-road vehicle injuries to persons treated in hospital ED N=46,398 (95% CI 37,046–55,748) | | | | FARS, motorcycle rider fatalities from traffic crashes N=4,534 | | |
	alcohol involved, N=4,643 (8.5%)	no notation of alcohol involvement, N=50,122 (91.5%)	alcohol involved, N=2,853 (6.1%, 95% CI 4.6–8.2)	95% CI¹	no notation of alcohol involvement, N=43,544 (93.9%, 95% CI: 92–95)	95% CI¹	alcohol involved (BAC .01–.07 g/dL) N=379 (8.0%)	alcohol-impaired (BAC .08+ g/dL) N=1,554 (34.0%)	no alcohol (BAC .00 g/dL) N=2,601 (58.0%)
Age									
21–24	421 (6.7%)	5,854 (93.3%)	186 (2.2%)	0.75%, 6.1%	8,406 (97.8%)	94%, 99%	42 (10.0%)	139 (32.0%)	252 (58.0%)
25–34	1,294 (8.9%)	13,220 (91.1%)	580 (3.7%)	2.0%, 6.6%	15,159 (96.3%)	93%, 98%	100 (9.0%)	426 (37.0%)	617 (54.0%)
35–44	1,004 (9.8%)	9,194 (90.2%)	761 (9.5%)	5.5%, 16%	7,258 (90.5%)	84%, 94%	67 (8.0%)	335 (42.0%)	394 (49.0%)
45–64	1,738 (9.2%)	17,226 (90.8%)	1,309 (10.3%)	7.0%, 15%	11,394 (89.7%)	85%, 93%	139 (8.0%)	567 (34.0%)	975 (58.0%)
65+	186 (3.9%)	4,628 (96.1%)	18 (1.4%)	0.19%, 9.3%	1,326 (98.6%)	91%, 100%	32 (7.0%)	87 (18.0%)	364 (75.0%)
Unknown	0 (0.0%)	0 (0.0%)	0 (0.0%)	–	0 (0.0%)	–	0 (0.0%)	0 (0.0%)	0 (0.0%)
Sex									
Female	614 (6.0%)	9,661 (94.0%)	127 (1.8%)	0.34%, 9.1%	6,834 (98.2%)	91%, 100%	9 (6.0%)	46 (28.0%)	110 (67.0%)
Male	4,013 (9.1%)	40,221 (90.9%)	2,727 (6.9%)	5.1%, 9.3%	36,710 (93.1%)	91%, 95%	370 (8.0%)	1,506 (34.0%)	2,491 (57.0%)
Unknown	16 (6.3%)	240 (93.8%)	0 (0.0%)	–	0 (0.0%)	–	0 (0.0%)	2 (100.0%)	0 (0.0%)

Abbreviations: CI, Confidence Interval; NEMSIS, National Emergency Medical Services Information System; NEISS, National Electronic Injury Surveillance System; FARS, Fatality Analysis Reporting System; ED, Emergency Department; BAC, Blood Alcohol Content (grams/deciliter).

collects BAC test results for motor vehicle crashes where there was a fatal injury, compared to NEISS and NEMSIS which primarily collect data on non-fatal injuries from all types of crashes (motor vehicle involved and not) and data are reported by clinicians. ED and EMS clinicians also do not routinely screen all patients for alcohol-intoxication (Chezem 2004). The small estimates we found for alcohol involvement in motorcycle and pedalcycle injuries (between 6.1%–10%) suggest that the limited alcohol screening results in a small subgroup being reported for alcohol involvement, who are likely the most severely injured patients as alcohol use by bicyclists and motorists is associated with more severe injury and death (Sethi et al. 2016; Ahmed et al. 2020).

The measures for assessing acute alcohol involvement also likely contribute to the selection bias in these findings and further induce measurement error. FARS collects BAC results from police administered breath-tests or toxicology reports from the Medical Examiner's office, whereas NEISS data includes the medical record report of alcohol consumption prior to or during the incident, which often include a BAC test result for the patient. However, NEMSIS uses the EMS clinician's evaluation of alcohol involvement at the scene, which is a subjective measure. The alcohol involvement measure in NEMSIS is likely a more sensitive test, as shown in the larger proportion estimates were found compared to the estimates using NEISS data. However, the objective measures for acute alcohol use reported in FARS and NEISS are more specific, which likely results in a higher proportion of true cases. Denial of coverage to patients, time constraints, safety, patient condition, and training are all potential barriers to routine screening for alcohol intoxication or use of breathalyzers to capture objective data in injury incidents that result in EMS response or treatment at an ED (Chezem 2004). To determine the true prevalence of alcohol involvement in vulnerable road user crashes, future work is needed to identify valid and feasible screening tools for acute alcohol involvement.

The various coding criteria for "motorcycles" and "pedalcycles" also result in measurement errors in these findings and may explain differences in estimates across datasets. For example, ANSI defines a motorcycle as a "motorcycle, moped, motor scooter, minibike, or pocket bike" compared to NEMSIS using ICD10 codes (V20-V29) codes, which include "mopeds, motor scooters, motorcycles, motorized bicycles, and speed-limited motor-drive cycles" transportation modes. While NEISS does not contain a specific motorcycle product code, "mopeds/power assisted cycles", "minibikes", and "two-wheeled powered off-road cycles" are collected and are listed under the ANSI or ICD10 umbrella terms for motorcycles. None of the 2019 datasets had specific codes for e-bikes and e-scooters so we did not examine these modes within our analyses. However, the 2023 NEISS coding manual now includes product codes for both e-bikes and e-scooters, as recommended by the NTSB (National Transportation Safety Board 2022b). Likewise, the 2021 and 2023 ICD10 codes were updated to include separate coding categories for injuries associated with e-bikes and e-scooters. Future research should determine the validity of ICD10

coding standards for micromobility modes to ensure accurate injury surveillance data is being collected.

Similar analyses of 2019 NEISS data using the same bicycle product codes (codes 5033 and 5040) also found that alcohol involvement in pedalcyclist injuries comprised 7.0% of ED visits among adult patients aged 18 and older (Namiri et al. 2020). Middle-aged adults and men were also similarly more likely to sustain an injury that involved alcohol compared to other age groups and women. In fact, our study found that regardless of the data source, men had between 3% to 8% points higher proportions of alcohol involvement among pedalcyclist and motorcyclist injuries compared to women, which may be explained by the higher prevalence of alcohol consumption among men (White 2020). However, our estimates for alcohol use and motorcyclist injuries were much lower than found by one study using the NTDB to examine adult patients (18 years and older) injured in motorcycle crashes, which found a positive BAC test in about one-third of patients who were tested for alcohol use (Ahmed et al. 2020). This estimate fell between the estimates from FARS and NEISS/NEMSIS, which may again be an indicator of selection bias, as patients included in the NTDB are only those admitted to a trauma center with serious injuries.

These analyses are subject to a number of important limitations. First, there are likely a large number of additional motorcycle and pedalcycle crashes involving alcohol where the pedalcyclist or motorcycle rider does not seek EMS or hospital care, perhaps due to concerns surrounding overconsumption. This likely has resulted in underestimations within the NEISS and NEMSIS findings. Second, we onlyexamined 2019 data due to the substantial impact on transportation patterns during the COVID-19 pandemic and that alcohol involvement data were only included in the NEISS dataset as of 2019; yet this will be important to examine in future research (U.S. Consumer Product Safety Commission 2019; Padmanabhan et al. 2021; Wada et al. 2023). We also did not include e-bikes or e-scooters because the included datasets did not yet have variables/codes for these vulnerable road users. As micromobility shared systems (e.g., docked and dockless bike shared systems) are being promoted by US cities and private companies (National Association of City Transportation Officials 2022; Council Member Mackenzie Kelly and District 6 6 2023; Transportation Alternatives 2024), typically in the same or adjacent areas where alcohol-serving venues and nightlife districts are being developed as part of urban economic development initiatives (Caulfield 2017; New York City Mayor's Office of Media and Entertainment and City of New York 2019; Alcorn and Jiao 2023; Dean and Zuniga-Garcia 2023), studies are needed to understand how these initiatives will impact alcohol-related pedalcyclist and motorcyclist injuries. While existing research has shown that more alcohol establishments are associated with alcohol-related driving crashes (Saeed et al. 2020) and pedestrian injuries (DiMaggio et al. 2016; Nesoff et al. 2018), the associations with injuries to bicyclists, motorcyclists, and other emerging modes of transportation have yet to be understood.

Conclusion

In conclusion, this study suggests that national estimates for the overall proportion of alcohol involvement in pedalcyclist and motorcyclist injuries were not easily comparable across national datasets. This can be explained by the biases generated in these findings from the existing measures of these modes of transportation and alcohol involvement. Standardized, valid, and feasible methods are needed. Improved methods will ultimately support the development of a robust, reliable injury surveillance system that can accurately inform vulnerable road user injury prevention interventions.

Disclosure statement

No potential conflict of interest was reported by the author(s).

Data availability statement

All datasets used in the present study are available in the supplement, and can also be found online at:

1. https://nemsis.org/using-ems-data/request-research-data/
2. https://www-fars.nhtsa.dot.gov/Requests/DataRequests.aspx
3. https://www.cpsc.gov/cgibin/NEISSQuery/home.aspx

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