

Motor Vehicle Crash Case Definitions and How They Impact Injury Surveillance

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BACKGROUND Motor vehicle crashes are a leading cause of injury in North Carolina. Motor vehicle crash injury surveillance that relies on hospital diagnostic codes alone may underestimate injury. Our objective was to describe how motor vehicle crash injury case definitions can impact results when using hospital data.

METHODS We received motor vehicle crash-related emergency department visits from 1 large metropolitan county in North Carolina for the year 2013. Emergency department visits were categorized based on 3 mutually exclusive case definitions: motor vehicle crash injuries identified using external cause-of-injury codes, text searches for motor vehicle crash-related key words in triage notes or chief complaint fields, and motor vehicle crash injuries identified using both text searches and external cause-of-injury codes. Descriptive statistics were used to examine differences in patient characteristics according to case definition.

RESULTS Most emergency department visits contained both motor vehicle crash text and motor vehicle crash external cause-of-injury codes (N = 13,422, 76%). Patients identified using external cause-of-injury codes only were more likely to be male, arrive by ambulance, and be admitted to the hospital compared to patients identified by text searches or both text and external cause-of-injury codes. Twenty-eight percent of the patients (N = 5,021) received non-injury related diagnoses in the emergency department. Among these patients, the most frequently used first diagnoses were for vague or chronic pain conditions.

LIMITATIONS We relied on secondary data and were unable to perform medical chart reviews; hospital data have limited information surrounding the crash event.

CONCLUSION The choice of case definition used for motor vehicle crash surveillance impacts the picture of motor vehicle crash injury severity. It is important for researchers to be aware of the impact case definition has on their results.

Motor vehicle crashes (MVCs) are a leading cause of death in the United States [1]. According to data collected by the Fatality Analysis Report System (FARS) and the National Automotive Sampling System-General Estimates System (NASS-GES), 90 people are killed and 6,405 are injured from MVCs each day in the United States [2]. In North Carolina, 1,260 people were killed and over 108,000 were injured from MVCs in 2013 [3]. Given the substantial impact of MVCs on public health, it is important that systems are in place to effectively monitor MVC injuries for future injury prevention strategies.

MVC injury surveillance is typically reported using International Classification of Disease Clinical Modification (ICD-CM) diagnostic codes, FARS, or NASS-GES data. Injury mechanism codes are used to capture motor vehicle injury by hospitals and emergency departments (EDs). MVC injuries were captured using E-codes in the *International Classification of Diseases, Ninth Revision, Clinical Modification* (ICD-9-CM) [4], and by V-codes in the *International Classification of Diseases, Tenth Revision, Clinical Modification* (ICD-10-CM). However, injury mechanism reporting is not mandated by the Health Insurance Portability and Accountability Act (HIPAA) and these codes are not reimbursed in North Carolina [5]. Thus, regardless of the ICD version, hospitals are not incentivized to report injury mechanism codes, and using ICD injury mechanism coding alone could underreport MVC injury [4, 6, 7]. FARS collects detailed information regard-

ing both the crash and injury for fatal crashes occurring on public roadways [8]. Given that less than 1% of crashes result in fatality [2], use of FARS alone provides a limited snapshot of MVC injury. Lastly, NASS-GES is a nationally representative sample of police crash reports that is used to produce crash summary statistics for nonfatal crashes [9]. NASS-GES defines injury using the police-defined "KABCO" reporting system, which has been found to overestimate injury severity [10]. KABCO defines injury severity using a 5-point scale: fatal (K), serious injury (A), moderate injury (B), minor injury (C), and no injury (O).

Within hospital data, MVC injury can be identified using injury mechanism codes (E-codes or V-codes) and through text searches of triage notes or chief complaint fields. Triage notes and chief complaints are free text variables used to capture the patient's initial reason for the visit and are commonly used in conjunction with ED diagnostic codes for syndromic surveillance [11]. Traditionally, ED syndromic surveillance has focused on health threats and emerging infectious diseases [12]. Recently, research has found that syndromic research using text searches in combination with E-codes is a viable

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method for capturing injury surveillance [13-15].

One previous study conducted by Seil and colleagues [15] found that the use of MVC E-codes resulted in a higher number of injury cases compared to using MVC text searches. However, the study used 2 different hospital data sources to compare the 2 MVC case definitions [15]. To our knowledge, no prior study has examined the impact of case definition on MVC injury surveillance using ED visit data. We hypothesized that the combination of both injury mechanism codes and text searches would provide a more complete picture of MVC injury than using either injury mechanism codes or text searches alone. The primary objective of this study was to describe how MVC case definition can impact MVC surveillance using ED visit data.

Methods

Data Source

We received all MVC-related ED visits for patients visiting 1 of the 8 EDs located in Wake County and all MVC-related ED visits made by Wake County residents during the 2013 calendar year. MVC-related ED visit data were obtained from the North Carolina Disease Event Tracking and Epidemiologic Collection Tool (NC DETECT). NC DETECT is North Carolina's statewide syndromic surveillance system and was created in collaboration between the North Carolina Division of Public Health (NC DPH) and the Carolina Center for Health Informatics in the University of North Carolina at Chapel Hill (UNC) Department of Emergency Medicine. NC DETECT captures real-time ED visit data, including chief complaint, triage notes, and diagnostic codes from all civilian acute care hospital-affiliated EDs located in North Carolina [16]. Data were obtained under a data use agreement between NC DPH and UNC. The study was approved by the UNC Institutional Review Board.

After we received data from NC DETECT, we reviewed the data to verify that each record was related to an MVC. MVC-related ED visits were identified using E-codes (E810-E825) and text searches of triage and chief complaint notes. Exact key words, including abbreviations, used in the text search were: "MVC, MVTA, MVTC, MVA, MCTC, MCTA, MCC, MCA, motor vehicle, motorcycle, car accident, motorcycle accident, car crash, motorcycle crash, car wreck, motorcycle wreck, pedestrian, auto accident, automobile accident, automobile roll, and moped." After our initial review, 147 observations were removed after reviewing the triage and chief complaint fields of visits that had non-MVC related E-codes and those that were missing E-codes (eg, plane crash, adverse complications due to surgery for previous MVC injury, mention of MVC that happened many years in the past, mention of family member involved in MVC crash). Therefore, we had a total of 17,670 observations in the final study.

MVC Case Definitions

Once we verified that ED visits were directly related to an MVC injury, we divided the data into 3 mutually exclusive

categories based on how the record was identified as MVC related. ED visits were identified as pertaining to an MVC by searching E-codes (E810-E825) and by searching for MVC text words in either triage or chief complaint fields. The 3 mutually exclusive case definitions used to define MVC-related ED visits were: ED visits that only contained MVC E-codes and no MVC text in the chief complaint or triage notes; ED visits that only contained MVC text in either the triage or chief complaint fields and no corresponding MVC E-code; and ED visits that contained both MVC E-codes and MVC text in the triage or chief complaint fields (see Figure 1).

Injury Diagnosis

Injury diagnosis was our primary outcome of interest in the study. Injury was classified based on the Barell Injury Matrix, which categorizes injuries into 12 categories based on ICD-9-CM codes in the 800-959 range [17]. Injury diagnoses were classified as fractures (ICD-9-CM: 800-829), dislocations (ICD-9-CM: 830-839), sprains (ICD-9-CM: 840-848), internal injuries (ICD-9-CM: 850-854, 860-869, 952), open wounds (ICD-9-CM: 870-884, 890-894), amputation (ICD-9-CM: 885-887, 895-897), blood vessel injuries (ICD-9-CM: 900-904), contusions (ICD-9-CM: 910-924), crush injuries (ICD-9-CM: 925-929), burns (ICD-9-CM: 940-949), nerve injury (ICD-9-CM: 950, 951, 953-957), and unspecified injury (ICD-9-CM: 959). The injury categories are not mutually exclusive since patients involved in serious crashes often have multiple injuries in more than one category. We further examined the extent of injuries by summing the number of injuries: none listed (based on the Barell Matrix), 1 injury, 2 injuries, and 3 or more injuries.

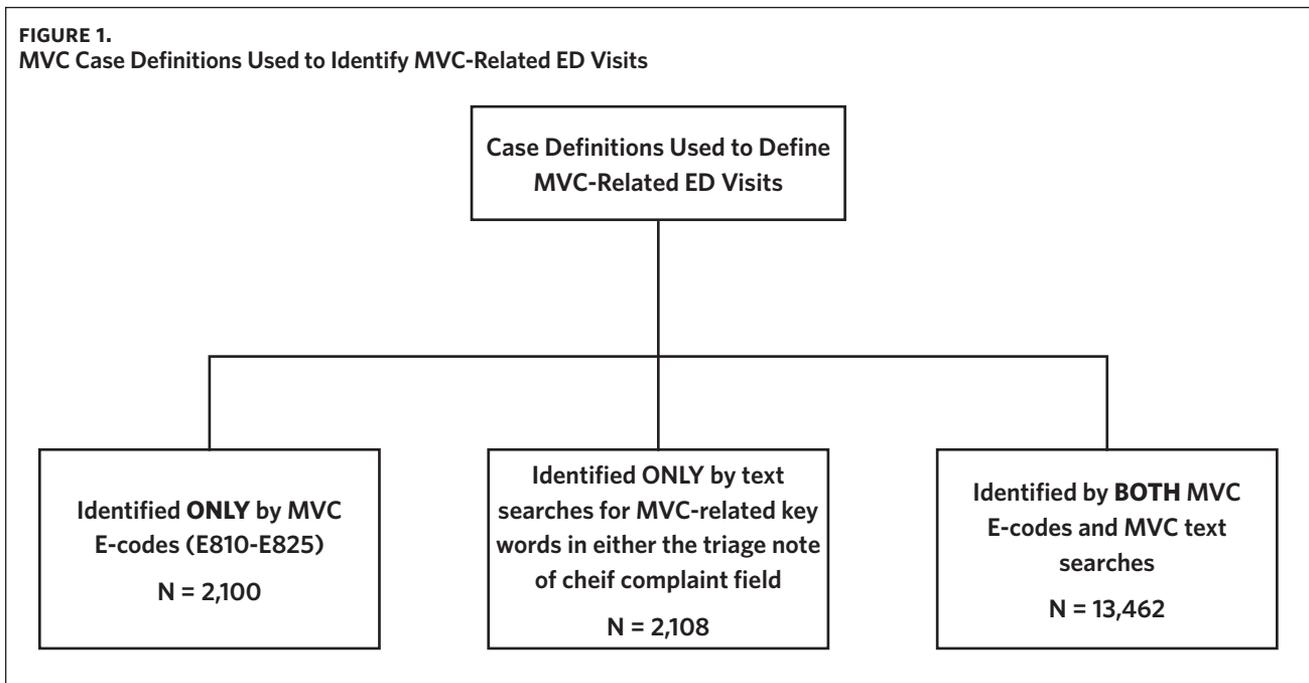
Covariates

Covariates were identified from the ED visit data. Demographic variables included sex and age (0-15, 16-20, 21-35, 36-55, 56+). Disposition was the manner in which patients were originally discharged from the ED: discharged to home, transferred to another unit, left without being seen or against medical advice, admitted to the hospital, other, or died. Transport mode was the manner in which patients presented to the ED: ambulance, walk-in, other, and unknown. Payer source was the expected form of payment for the emergency visit: private insurance, Medicare, Medicaid, self-pay, or other. Visit time was categorized as follows: 12 AM—5:59 AM, 6 AM—11:59 AM, 12 PM—5:59 PM, 6 PM—11:59 PM.

Analysis

Text searches for MVC-related key words in chief complaint and triage notes were conducted using text search functions in SAS Version 9.4 (Cary, NC). Descriptive statistics were used to describe differences in patient characteristics and injury diagnosis based on the case definition used to identify MVC injury. P values and 95% confidence intervals were not calculated since we were using entire population

FIGURE 1.
MVC Case Definitions Used to Identify MVC-Related ED Visits



data rather than a sample. Analyses were conducted using SAS (SAS Institute Inc., Cary, NC) and Microsoft Excel 2007.

Results

A total of 17,670 patients reported to EDs in North Carolina due to an MVC-related injury in 2013 (see Figure 1). The majority of ED visits had both MVC-related text and MVC E-codes (N = 13,462, 76%, see Table 1). Slightly more females than males visited the ED during the study period (54% versus 46%, respectively). The majority of patients were aged 21-35 (N = 6,536, 37%) and 36-55 (N = 5,380, 30%). While transport mode to the ED was missing for nearly 40% of the visits, for those visits with a code for transport, 69% of patients arrived by their own means (walk-ins) while only 14% arrived by ambulance (ground or air). Forty-five percent of the patients expected to self-pay for the visit out of pocket (N = 7,816).

The most common injuries diagnosed were sprains (40%, N = 7,087) and contusions (28%, N = 5,020). Twenty-eight percent of patients were classified as having no injury based on the Barell Matrix, given that the Matrix only captures injuries occurring in the ICD-9-CM diagnosis code range 800-959 (N = 5,021). The most common first listed diagnosis code for those patients classified with no injury according to the Barell Matrix were: backache (14%, ICD-9-CM: 724.5), neck pain (12%, ICD-9-CM: 723.1), and lumbago (11%, ICD-9-CM: 724.2, see Table 2).

Differences in Injury Based on Case Definition

When comparing demographics by case definition, male patients constituted a higher proportion of ED visits identified using MVC E-codes alone (56%, N = 1,181) compared to text searches alone (46%, N = 976) or both criteria (45%,

N = 6,018). Patients identified using text searches had a higher proportion of patients in the 36-55 (34%, N = 726) and 56+ (15%, N = 317) age groups compared to patients identified using E-codes or both text and E-codes (30% and 13%, 30% and 11%, respectively, see Table 1).

ED disposition and transport mode differed according to MVC case definition. Patients identified using both E-codes and text were more likely to be discharged to their homes (95%, N = 12,554) compared to patients identified using text searches only (83%, N = 1,686) or MVC E-codes only (76%, N = 1,560). Patients identified using E-codes had a higher proportion of patients admitted to the hospital (23%) compared to patients identified using text or both E-codes and text (10% and 3%, respectively). Similarly, patients identified using E-codes had a higher proportion of patients arrive to the ED via ambulance (28%, N = 375) compared to patients identified using text searches (10%, N = 126) or both text and E-codes (13%, N = 1,065). The expected source of payment did not vary between case definitions. The most common expected form of payment for all the case definitions was self-pay. Finally, most ED visits occurred during working hours for all case definitions; however, there was a slightly higher proportion of visits between midnight and 6 AM for patients identified with E-codes (11%, N = 222) compared to patients identified with text (7%, N = 145) or both E-codes and text (6%, N = 824).

The number of injuries diagnosed in the ED varied according to case definition (see Figure 2). The number of patients with 3 or more injury diagnoses was higher for patients identified with E-codes (31%, N = 259) compared to patients identified with text searches (7%, N = 56). However, the reverse was found for patients identified with text searches. A higher proportion of patients identified with text searches

had no injury diagnosis according to the Barell matrix (30%, N = 1,509) compared to patients identified with E-codes (5%, N = 249).

Discussion

We found that choice of MVC case definition impacts MVC injury surveillance. When comparing 3 different MVC

injury case definitions, use of E-codes alone captured more acute, severe injuries compared to injuries identified using text searches. Patients identified with E-codes were more likely to be male, arrive by ambulance, and be admitted to the hospital compared to patients identified with text searches or with a combination of both text and E-codes. Our results suggest a more complete picture of MVC injury surveillance

TABLE 1.
Comparison of MVC-Related ED Visits According to MVC Case Definition, N (%)

	MVC E-code only N = 2,100	MVC text only N = 2,108	Both E-code and text N = 13,462	Total N = 17,670
<i>Gender</i>				
Male	1,181 (56.2)	976 (46.3)	6,018 (44.7)	8,175 (46.3)
<i>Age (years)</i>				
0-15	224 (10.7)	170 (8.1)	1,412 (10.5)	1,806 (10.2)
16-20	223 (10.6)	159 (7.5)	1,532 (11.4)	1,914 (10.8)
21-35	751 (35.8)	736 (34.9)	5,049 (37.5)	6,536 (37.0)
36-55	639 (30.4)	726 (34.4)	4,015 (29.8)	5,380 (30.4)
56 +	263 (12.5)	317 (15.0)	1,454 (10.8)	2,034 (11.5)
<i>Disposition</i>				
Discharged to home	1,560 (75.7)	1,686 (82.6)	12,554 (94.7)	15,800 (91.0)
Left without being seen or against medical advice	15 (0.7)	134 (6.6)	231 (1.7)	380 (2.2)
Admitted or transferred to another unit	465 (22.5)	201 (9.9)	437 (3.3)	1,103 (6.4)
Other ^a	22 (1.1)	19 (0.9)	37 (0.3)	78 (0.4)
<i>Transport mode</i>				
Ambulance (air or ground)	375 (27.7)	126 (10.4)	1,065 (12.7)	1,566 (14.3)
Walk-in	859 (63.5)	893 (73.4)	5,785 (69.1)	7,537 (68.9)
Other	119 (8.8)	197 (16.2)	1,527 (18.2)	1,843 (16.8)
Missing or unknown	747	892	5,085	6,724
<i>Payor source</i>				
Insurance	670 (32.1)	618 (30.1)	4,418 (33.0)	5,706 (32.6)
Medicare	179 (8.6)	172 (8.4)	711 (5.3)	1,062 (6.1)
Medicaid	333 (16.0)	250 (12.2)	1,509 (11.3)	2,092 (11.9)
Self-pay	800 (38.4)	897 (43.8)	6,119 (45.7)	7,816 (44.6)
Other ^b	102 (4.9)	113 (5.5)	624 (4.7)	839 (4.8)
<i>Visit time</i>				
12 AM—5:59 AM	222 (10.6)	145 (6.9)	824 (6.1)	1,191 (6.7)
6 AM—11:59 AM	473 (22.5)	528 (25.0)	2,946 (21.9)	3,947 (22.3)
12 PM—5:59 PM	808 (38.5)	837 (39.7)	5,154 (38.3)	6,799 (38.5)
6 PM—11:59 PM	597 (28.4)	598 (28.4)	4,538 (33.7)	5,733 (32.4)
<i>Month of visit</i>				
Winter (December-February)	468 (22.3)	504 (23.9)	3,178 (23.6)	4,150 (23.5)
Spring (March-May)	504 (24.0)	543 (25.8)	3,310 (24.6)	4,357 (24.7)
Summer (June-August)	548 (26.1)	520 (24.7)	3,167 (23.5)	4,235 (24.0)
Fall (September-November)	580 (27.6)	541 (25.7)	3,807 (28.3)	4,928 (27.9)
<i>Injury diagnosis^c</i>				
Fracture	503 (24.0)	127 (6.0)	809 (6.0)	1,439 (8.1)
Sprain	670 (31.9)	251 (11.9)	6,166 (45.8)	7,087 (40.1)
Internal	281 (13.4)	56 (2.7)	385 (2.9)	722 (4.1)
Open wound	350 (16.7)	62 (2.9)	525 (3.9)	937 (5.3)
Contusion	766 (36.5)	214 (10.2)	4,040 (30.0)	5,020 (28.4)
Unspecified	355 (16.9)	115 (5.5)	1,552 (11.5)	2,022 (11.4)
Other ^d	68 (3.2)	29 (1.4)	131 (1.0)	228 (1.3)

Note. ED, emergency department; MVC, motor vehicle crash.

^aIncludes patients who died.

^bOther payor includes other government insurance and workers' compensation.

^cInjuries were classified according to the Barell Injury Matrix. There were 5,021 patients that did not receive a specific injury diagnosis code according to the matrix.

^dIncludes amputation, blood vessels, crush, burn, nerves, and dislocate.

None of the variables except for transport mode were missing more than 2% of the data

TABLE 2.
List of 10 Most Common First-Listed Diagnosis Codes Among Patients with Non-Injury ICD-9-CM Diagnosis

Diagnosis	ICD-9-CM		
	Code	N	%
Backache, unspecified	724.5	482	13.8
Cervicalgia (neck pain)	723.1	396	11.3
Lumbago	724.2	382	10.9
Headache	784	318	9.1
Joint pain, shoulder	719.41	127	3.7
Limb Pain	729.5	95	2.7
Tobacco use disorder	305.1	94	2.7
Joint pain, lower leg	719.46	81	2.3
Myalgia and myositis (muscle pain or inflammation)	729.1	74	2.1
Chest pain	786.52	71	2.0

Note. These are the patients that did not have a specific injury diagnosis code according to the Barell Injury Matrix (N = 5,021). 1,524 patients did not have a first listed diagnoses code in the ED.

is obtained using both E-codes and text searches of chief complaint and triage notes.

To our knowledge, this is the first study to examine the impact of MVC case definition on MVC injury surveillance when using ED data. One prior study conducted by Siel and colleagues compared the daily counts of MVC injury patients using emergency department syndromic surveillance data and hospital discharge data [15]. The authors found little difference in the number of MVC patients identified using text searches of syndromic data and the number of MVC patients identified using E-codes in the discharge data. However, the authors were not able to compare individual patients and therefore were not able to examine how the picture of MVC injury differed between the 2 definitions. In our study, we found that MVC patients identified with E-codes had a higher proportion of 3 or more injury diagnoses compared to the patients identified with text only or both text and E-codes. Results suggest that injury case definition can greatly impact the picture of MVC injury identified when using ED data. Researchers should keep their specific research question in mind when deciding on case definitions. For instance, if a study is more interested in capturing acute injury it may be sufficient to use E-codes alone compared to using text searches.

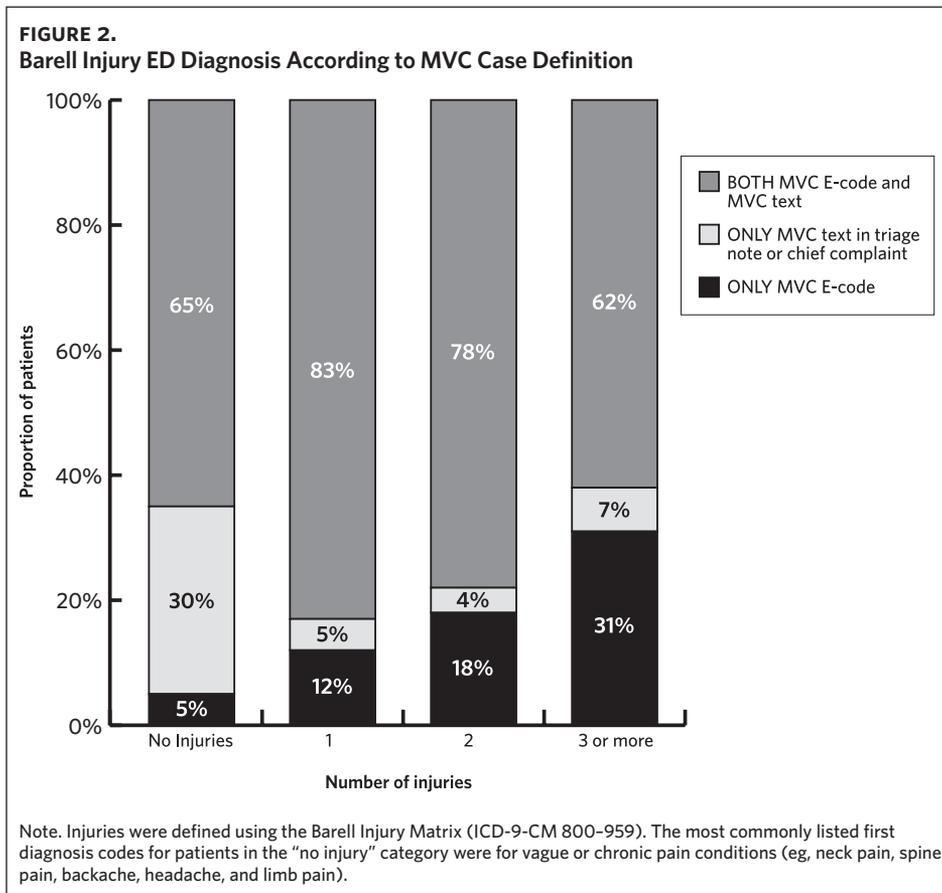
Since the completion of our study, hospitals and EDs have switched over to using the 10th version of the ICD-CM. One of the most significant changes between the 9th version and the 10th version is the specificity and number of injury mechanism codes. The number of ICD-CM codes increased from an estimated 14,000 codes in the 9th edition to almost 70,000 codes in the 10th edition [18]. Therefore, a single ICD-9-CM code often maps to multiple ICD-10-CM codes [19, 20]. Fortunately, resources exist to help map ICD-9-CM mechanism codes to ICD-10-CM codes [19, 20, 21].

Despite the increase in specificity, we believe that use of ICD mechanism codes alone will still underreport the actual number of MVC-related injuries since cause of injury reporting is not mandated by all states. Additionally, there will

most likely be errors in the ICD-10-CM injury reporting while coders are getting adjusted to the new system. Regardless of the ICD version, we suggest using external cause codes in conjunction with text searches of triage and chief complaint fields to capture the most overall picture of MVC injury. If we excluded text searches from our case definition, we would have missed 11% of the MVC-related ED visits.

Twenty-eight percent of the patients received non-injury related diagnoses in the ED. Among these patients, the most frequently used first diagnosis was for vague or chronic pain conditions (eg, neck pain, spine pain, backache, headache, limb pain). It may be that patients presenting to the ED with no obvious physical injury (eg, fracture, laceration) are more likely to receive one of these vague, ill-defined diagnoses. Previous research has found that chronic pain is often a reason for frequent ED visits [22]. While we attempted to remove people presenting to the ED complaining of past MVC injuries, our data may have included ED visits by patients who were repeat visitors to the ED for chronic pain related to past MVCs. We were unable to determine if the same person returned to the ED multiple times due to data constraints. Future studies including direct identifiers or linking ED visit data with crash data could help distinguish frequent ED visitors from those patients who are presenting to the ED with acute injury directly related to MVCs.

One of the frequently listed first diagnosis codes among patients with no injuries was tobacco use disorder (ICD-9-CM: 305.1). This is a commonly used diagnosis code among North Carolina EDs. Since this diagnosis was not directly related to an MVC, we reviewed the secondary diagnosis codes among these patients to verify that they were related to MVC injury. The most commonly mentioned secondary diagnosis codes were lumbago or backache (37%), neck pain (10%), headache (5%), and joint pain (5%). Results suggest that the first listed diagnosis code may not correspond to the severity of injury. Future studies may want to consider examining more than one diagnosis code in order to capture the best picture of MVC injury.



Limitations

Although this is the first study to examine the impact MVC case definitions have on MVC injury surveillance using ED data, there are some limitations to the results. First, we were unable to verify the accuracy of the ED diagnoses by manual medical chart review and were subject to missing data due to the secondary nature of the data. Second, there was no way to determine temporality between the time of the crash and the time of the ED arrival. Future studies would benefit from linking MVC crash data with ED visit data to better capture the temporality of the ED visit and the crash. Third, chief complaint and triage notes are subject to human error because they are entered via free text and are prone to abbreviations and misspelling. While we tried to include known abbreviations and likely misspellings in our text search criteria, we may have missed some of the MVC-related text in the triage and chief complaint.

Conclusion

In the past, ED syndromic surveillance has been limited to infectious disease or epidemics [12]. Recently, several studies, including this one, have highlighted the benefit of expanding the typical syndromic surveillance methods to include injuries [13-15]. In this study, if we had identified MVC injuries using E-codes alone we would have missed just over 2,000 patients who presented to the ED with an

MVC injury that did not receive an E-code. When developing a research question or surveillance project, it is important that public health researchers and practitioners consider the impact case definition has on their results. We suggest using a combination of both MVC E-codes and text searches of chief complaint and triage notes when conducting future MVC injury surveillance. Additionally, we suggest expanding the case definition to include all diagnostic and mechanism codes (not just the first listed) to capture a more complete picture of the injury. Results from this study can be used to develop MVC case definitions for future MVC research studies to help increase the awareness of MVC injury for prevention efforts. **NCMJ**

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