**WA TRAFFIC SAFETY COMMISSION**

# Linkage of the Comprehensive Hospital Abstract Reporting System (CHARS) and Washington Emergency Medical Services Information System (WEMSIS) Databases

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The Washington State Department of Health Washington Emergency Medical Services Information System (WEMSIS) program staff, with support of a grant from the Washington Traffic Records Governance Council, developed a linking protocol using Link King for pre-hospital (WEMSIS) and hospital (CHARS) records. This report summarizes the methodology, the quality of the linkage, and the identification of patients with motor vehicle crash-related injuries.

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data linkage, Link King, EMS records, emergency medical services, traffic records, motor vehicle crash, inpatient hospital records

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**Report on the Linkage of the Comprehensive Hospital Abstract Reporting System (CHARS) and Washington Emergency Medical Services Information System (WEMSIS) Databases**

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Increasing data interoperability is an element of the Department of Health's 2020 Strategic Plan, and is a primary goal for the WEMSIS Team. EMS data that is compatible with other Department of Health data systems can help inform decision-making and better identify, address, and prevent public health issues. In particular, linking WEMSIS to CHARS will allow for improved observation of EMS and hospital treatment and outcomes.

The purpose of this report is to discuss methods, challenges, and early findings in linking WEMSIS and CHARS datasets for 2017, 2018, and 2019. The linked dataset resulting from this process will later be used to assess the outcomes of Motor Vehicle Crashes (MVCs). In this report, we summarize indicators of the quality of the linkage, as well as our ability to identify patients with MVC-related injuries in WEMSIS and CHARS separately versus a linked dataset where each system informs the other. We discuss our approach to linking the two record-level data systems, the fields used to identify MVCs, and the records available for outcomes analysis.

1. Unique Incident Identification and Linkage Methodology

EMS and hospitalization datasets present a challenge when linking due to the record-level structure of the data. In either dataset, a single patient may appear multiple times. This occurs if a patient requires an EMS response or hospitalization at multiple points over a given period of time. In addition, each EMS response or hospitalization incident can result in more than one patient record. For example, a patient could be treated by more than one EMS unit or transferred from one hospital to another.[1] For our purposes, we define an incident as one or more patient records pertaining to the same individual over a set period of time.[2] The resulting linked dataset will contain matched WEMSIS-CHARS incidents, but also incidents containing only matched EMS records or only matched CHARS records.

The Link King, a free add-on to SAS, is the linking software currently used by the WEMSIS team. This software allows for deterministic and probabilistic matching across several fields with simple controls. The patient information we used for matching was their first name, middle initial, last name, date of birth, social security number, gender, and either incident or admission date. The linkages were conducted separately for each year of the data to reduce both processing time and the need for manual match review. We used the strictest pre-defined linkage settings, including "high", "very high", and "highest possible" probability matches. We manually reviewed the software's estimated nicknames and misspelled names to ensure appropriate matching. We also suppressed unusually common birthdates and social security numbers, such as the birthdate "1/1/00" or the social security number ending "6789". As a slight change from standard matching weights, we excluded negative weights for the

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[1] It is also possible for a patient to be released from a hospital and readmitted due to the same incident, either when returning for further care or due to a worsening condition.
[2] Due to limited availability of hospital admission time in observation records, we consider records occurring within one day of each other to be the same incident.

incident date flex variable. This allowed for improved matching for records around the same date, while not penalizing the match probability when multiple incidents occur throughout the year.

After accounting for unmatchable records, a total of 2,244,707 WEMSIS records and 2,292,067 CHARS records were used for all three analysis years. Of the EMS records, the linkages identified 1,818,361 incidents containing one or more records. This suggests that an average of 1.23 units respond to each EMS incident reported to WEMSIS. Responses per EMS incident has also increased between 2017 and 2019, suggesting that the increase in reporting to WEMSIS over this period has resulted in increased documentation of incidents more often than reporting of new incidents. Of the EMS incidents, a total of 491,355 incidents were matched to one or more hospitalization records. Table 1 breaks these linkage results into separate years.

**Table 1: WEMSIS Record and Incident Counts, and Linkage Results**

| WEMSIS Records | 2017 | 2018 | 2019 |
|---|---|---|---|
| Records analyzed | 501,734 | 803,824 | 939,149 |
| Unique incidents identified | 433,596 | 646,308 | 738,457 |
| WEMSIS Records per Incident | 1.16 | 1.24 | 1.27 |
| Incidents matched to a CHARS record | 126,599 | 169,316 | 195,440 |
| | | | |
| **Match Rating** | | | |
| Records with a matching CHARS record | 150,802 | 225,879 | 267,340 |
| WEMSIS-CHARS match percentage | 30.1% | 28.1% | 28.5% |
| Records with a matching CHARS record where the patient was transported to a hospital or ED | 145,007 | 208,943 | 259,242 |
| Hospital/ED transport WEMSIS-CHARS match percentage | 36.7% | 35.8% | 36.4% |
| MVC hospital/ED transport records with a matching CHARS record | 2,539 | 4,218 | 4,829 |
| MVC hospital/ED transport WEMSIS-CHARS match percentage | 18.2% | 18.5% | 18.6% |

To assess the quality of the linkage, we considered how many EMS records were matched to one or more hospitalization records. In preliminary deterministic matching conducted on 2017 data, matches were identified for 19% of EMS records. When all matchable EMS records are included in the match rating, the linkage identified matches for 28-30% of records. This measure is fairly consistent across linkage years despite large increases in reporting each year. If we narrow the measure to only those incidents where the patient was transported by an EMS unit to an emergency department (ED) or hospital, around 36% of incidents contain a matched hospitalization record. Further narrowing of the incidents to where the patient was injured in an MVC shows that matches were identified for 18-19% of MVC records. We were unable to determine the reason for a lower MVC transport match rate, and will continue the research this finding in the MVC outcomes assessment.

2. Identifying MVC Incidents in WEMSIS

The primary field for identifying MVC records in WEMSIS, as well as the national database, NEMSIS, is the Complaint Reported by Dispatch field (eDispatch.01). Complaint Reported is a mandatory field, meaning that an entry is required for every record and entries such as "Not Recorded" or "Not Applicable" are not allowed. We used the following entries to identify MVC records:

- Auto vs. Pedestrian
- Automated Crash Notification
- Motor Vehicle Crash
- Motorcycle Collision
- Traffic/Transportation Incident

Table 2 below presents the numbers of incidents that fall into these categories, as well as the percent of these incidents with a matching hospitalization record. The fact that multiple EMS units may respond and report to the same patient also allows for more information to be provided on a patient's condition from subsequent patient care records. For this reason, we also search for the Complaint Reported entries above within any of the records contained in incident to which multiple EMS units respond. As a result, incidents may be identified as an MVC by more than one record, and each of the Complaint Reported counts may not sum to the total number of MVC incidents.

Table 2: WEMSIS Motor Vehicle Crash Counts identified by Complaint Reported

| Complaint Reported by Dispatch Entries | 2017 | 2018 | 2019 |
|---|---|---|---|
| Auto vs. Pedestrian | 12 (8%) | 40 (27%) | 50 (20%) |
| Automated Crash Notification | 410 (31%) | 346 (26%) | 321 (24%) |
| Motor Vehicle Crash | 0[3] (--) | 114 (11%) | 110 (5%) |
| Motorcycle Collision | 6 (33%) | 15 (27%) | 34 (24%) |
| Traffic/Transportation Incident | 13,906 (9%) | 26,759 (8%) | 30,262 (8%) |
| **Total Motor Vehicle Crash Incidents** | **14,332** (10%) | **27,272** (8%) | **30,762** (8%) |

The differences in match percentages could be due to a number of factors, such as quality of documentation, severity of the injury, source of payment for medical treatment, and patient demographics. We hope to include elements of each of these factors in our MVC outcomes analysis.

While the requirement to enter Complaint Reported is an advantage to using WEMSIS for MVC purposes, the available MVC-related entries provide limited detail on the circumstances of each incident. In addition, there is not a comparable field for identifying MVC records within CHARS. To supplement the information contained in Complaint Report, we compiled a list of 133 ICD-10 codes related to MVCs. This list allowed us to identify MVC records in CHARS, and compare Complaint Reported to injury records within the Cause of Injury Code field (eInjury.01) in WEMSIS. Though this field is not required,[4] it allowed us to identify additional MVC records that were not identified through Complaint Reported. As an example, an MVC caused by the sudden onset of a medical condition may be recorded as a one of the Complaint Reported entries above or by an entry related to the medical

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[3] The "Motor Vehicle Crash" entry in eDispatch.01 was not utilized until after 2017.
[4] In 2020, Cause of Injury Code (eInjury.01) was present in only 14.4% of EMS records.

condition. Table 3 presents the number of MVC incidents identified by Cause of Injury Code aggregated into broader categories. As in Table 2, we also include the percent of these incidents with matches. For details on which ICD-10 codes were used to identify MVCs, see the appendix on page 6.

**Table 3: WEMSIS Motor Vehicle Crash Counts identified by Cause of Injury Code**

| Cause of Injury Code Category | 2017 | 2018 | 2019 |
|---|---|---|---|
| V00-V09: Pedestrian injured in transport accident | 1,037 (20%) | 1,679 (19%) | 1,781 (19%) |
| V10-V19: Pedal cycle rider injured in transport accident | 173 (13%) | 447 (12%) | 550 (10%) |
| V20-V39: Motorcycle rider or occupant of 3-wheeled motor vehicle injured in transport accident | 752 (27%) | 1,376 (30%) | 1,732 (28%) |
| V40-V49: Car occupant injured in transport accident | 9,674 (8%) | 13,841 (7%) | 17,334 (7%) |
| V50-V79: Occupant of pick-up truck, van, heavy transport or bus injured in transport accident | 159 (13%) | 378 (14%) | 489 (12%) |
| V80-V89, X81-Y32: Other land transport accidents or Misc. Motor Vehicle Crash | 777 (20%) | 678 (17%) | 919 (15%) |
| **Total Motor Vehicle Crash Incidents** | **12,489** (10%) | **18,210** (11%) | **22,528** (10%) |

In using two fields, MVCs may be identified by either field or both. Table 4 presents the total MVC counts and match percentages by identification field. We identified a total of 87,493 unique MVC incidents, of which 9% were matched to a hospitalization record.

**Table 4: WEMSIS Motor Vehicle Crashes Identified by either field**

| Complaint Reported by Dispatch Entries | 2017 | 2018 | 2019 |
|---|---|---|---|
| MVCs identifiable by Complaint Reported only | 6,636 (9%) | 14,088 (6%) | 13,542 (6%) |
| MVCs identifiable by Cause of Injury Code only | 4,793 (11%) | 5,026 (11%) | 5,308 (11%) |
| MVCs identifiable by both | 7,696 (10%) | 13,184 (10%) | 17,220 (10%) |
| **Total Motor Vehicle Crash Incidents** | **19,125** (10%) | **32,298** (9%) | **36,070** (9%) |

3. Identifying MVC Incidents in CHARS

As mentioned above, the only method available for identifying MVCs within CHARS is through ICD-10 codes. We used the same list of MVC ICD-10 codes found in Cause of Injury to identify MVC incidents in CHARS. Table 5 presents the number of MVC incidents identified in CHARS aggregated into broader categories. We identified 17,228 MVC-related hospitalization incidents.

<p align="center"><strong>Table 5: CHARS Motor Vehicle Crashes by Cause of Injury Code</strong></p>

| Cause of Injury Code Category | 2017 | 2018 | 2019 |
|---|---|---|---|
| V00-V09: Pedestrian injured in transport accident | 652 (39%) | 740 (54%) | 687 (62%) |
| V10-V19: Pedal cycle rider injured in transport accident | 444 (40%) | 592 (55%) | 567 (60%) |
| V20-V39: Motorcycle rider or occupant of 3-wheeled motor vehicle injured in transport accident | 993 (40%) | 937 (57%) | 942 (60%) |
| V40-V49: Car occupant injured in transport accident | 2,476 (44%) | 2,322 (62%) | 2,271 (65%) |
| V50-V79: Occupant of pick-up truck, van, heavy transport or bus injured in transport accident | 199 (43%) | 209 (63%) | 227 (61%) |
| V80-V89, X81-Y32: Other land transport accidents or Misc. Motor Vehicle Crash | 1,039 (36%) | 1,088 (48%) | 1,177 (52%) |
| **Total Motor Vehicle Crash Incidents** | **5,706** (41%) | **5,773** (56%) | **5,749** (60%) |

The match rating from the perspective of CHARS data suggests a higher quality match than the WEMSIS match rating, and shows the improvements made from increased WEMSIS participation. While matches were found for 18% of EMS MVC patients transported by EMS to a hospital in 2019, the percent of MVC-related hospitalization incidents with a matching EMS record is 60%. This percentage increased by 19 percentage points from 2017 to 2019.

4. Identifying MVC Incidents through the WEMSIS-CHARS Linkage

The MVC incidents we identified fall into five general categories, each with their own potential for analysis. There are WEMSIS incidents with no CHARS record, and similarly, CHARS incidents with no WEMSIS record. Then for matched incidents, an MVC can be identified in WEMSIS only, in CHARS only, or in both datasets. Table 6 separates the total counts of MVC incidents across these categories. In the linked WEMSIS-CHARS data, we identified a total of 98,737 MVC incidents for analysis.

<p align="center"><strong>Table 6: Motor Vehicle Crashes identified in either WEMSIS or CHARS</strong></p>

| Source of Data Used to Identify Motor Vehicle Crash | 2017 | 2018 | 2019 |
|---|---|---|---|
| MVCs identified in WEMSIS with no matching CHARS record | 17,233 | 29,495 | 32,978 |
| MVCs identified in CHARS with no matching WEMSIS record | 3,367 | 2,518 | 2,279 |
| MVCs identified in matched incident using WEMSIS field only | 495 | 619 | 689 |
| MVCs identified in matched incident using CHARS field only | 942 | 1,071 | 1,067 |
| MVCs identified in matched incident using both fields | 1,397 | 2,184 | 2,403 |
| **Total Motor Vehicle Crash Incidents** | **23,434** | **35,887** | **39,416** |

Of the 491,355 linked EMS-hospitalization incidents, 10,867 incidents were MVC-related. These are the incidents we will use in assessing the outcomes for hospitalization following an EMS response to an MVC. In addition, we intend to analyze the 4,883 MVC incidents that were identified as an MVC by one data source but not the other, as this indicates differences in documentation between sources.

5. Summary

The purpose of this report is to identify methods, challenges, and early findings in identifying MVC patients with a linked WEMSIS-CHARS dataset. The linkage identified 491,355 incidents containing at least one WEMSIS and CHARS record. Among patients transported by EMS to a hospital, matching hospitalization records were found for 36% of incidents. When considering only MVC transport-to-hospital patients, matching hospitalization records were found for only 18% of incidents. However, of the MVC hospitalizations identified in CHARS, matching EMS records were found for 60% of incidents in 2019. Using datasets individually, we were able to identify 87,493 MVC-related EMS incidents in WEMSIS and 17,228 MVC-related hospitalization incidents in CHARS. Once linked, we were able to identify 98,737 MVC-related incidents, including 10,867 matched incidents between WEMSIS and CHARS. In total, MVCs account for 4.8% of all EMS incidents. Looking toward the MVC outcomes assessment, we intend to break these incidents down by hospital outcome and demographics, such as age and gender, as well as dig into the issues identified during the linkage process.

Appendix

For the purpose of identifying MVCs via ICD-10 code, we developed guidelines based on those used by the DOH's Rapid Health Information Network (RHINO) team. Due to lesser specificity in WEMSIS relative to RHINO data, we made slight changes to their list MVC codes. For example, the V43 code, "Car occupant injured in collision with car, pick-up truck or van", is considered an MVC for this analysis. While most of the more-specific codes within V43 also pertain to an MVC, the V43.1 code, "Car driver injured in collision with car, pick-up truck or van in nontraffic accident", may not be an MVC. Our method of identifying MVCs via ICD-10 code counts the V43 code while excluding the V43.1 code. The guidelines used to select which codes fit the description of an MVC are as follows:

1. If a motorized vehicle collides with another vehicle, either motorized or non-motorized, it is an MVC unless designated as not traffic-related.
2. If a motorized vehicle collides with a pedestrian or stationary object, and an occupant of the motorized vehicle is injured, it is an MVC. Exceptions are made in cases of non-traffic incidents and where it is clear the motorized vehicle was not in motion.
3. If a motorized vehicle collides with a pedestrian, and the pedestrian is injured, it is an MVC unless the ICD-10 code specifies that it was not traffic-related.

Given the detail within the ICD-10 codes it is possible to exclude incidents where a motor vehicle is not involved. For example, an incident may be reported as a "Traffic/Transportation Incident" but could be excluded if the Cause of Injury Code is not classified as an MVC. Because there may be traffic/transportation incidents we cannot exclude due to missing Cause of Injury Codes, we chose to include MVCs identified by either Complaint Reported or Cause of Injury Code within our analysis.