Hospitalization Outcomes of Motor Vehicle Crashes using linked Washington Emergency Medical Services Information System (WEMSIS) and Comprehensive Hospital Abstract Reporting System (CHARS) Databases

Report Prepared by:

Adam Rovang

Washington State Department of Health

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14. ABSTRACT
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 linkage results (2017-2019) and uses this linked data to analyze demographics and patterns among motor vehicle crash involved patient outcomes using odds-ratio regression.

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Report on the Hospitalization Outcomes of Motor Vehicle Crashes using linked EMS (WEMSIS) and Hospital (CHARS) Databases

Adam Rovang, Research Investigator
Washington State Department of Health

Increasing data interoperability is an element of the Department of Health's 2020 Strategic Plan and 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 allows for improved observation of EMS and hospital treatment and outcomes.

The purpose of this report is to analyze the outcomes of Motor Vehicle Crashes (MVCs) using a linked WEMSIS-CHARS dataset for 2017, 2018, and 2019. In this report, we summarize the results of the linkage, and discuss the demographics for MVCs relative to all matched incidents and the patterns in outcomes of these demographics. We also analyze the outcomes using odds-ratio regression, comparing all MVCs to those with a higher severity. Finally, we present the findings and limitations of the analysis, and suggest changes to improve future surveillance efforts.

1. WEMSIS and CHARS Linkage Summary

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, such as when 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, was used to conduct the linkage, allowing for deterministic and probabilistic matching across several fields with simple controls. The patient information used for matching was their first name, middle initial, last name, date of birth, social security number, gender, and either incident or admission date. We used the strictest pre-defined linkage settings, including only "high", "very high", and "highest possible" probability matches.[3]

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

[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.
[3] For mor information on the linkage process, please see our report summarizing linkage methodology and results, which is available by contacting WEMSIS@doh.wa.gov.

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. 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. When further narrowing the incidents to where the patient was injured in an MVC, matches were identified for 18-19% of MVC records. As the linkage does not include ED data, we suspect this lower match rating is related to differences in ED visits vs. hospitalization. We recommend continued research into this discrepancy.

The MVC incidents we identified fall into five general categories. There are WEMSIS incidents with no CHARS record, and CHARS incidents with no WEMSIS record. Then, for linked EMS-hospitalization incidents, an MVC can be identified in WEMSIS only, in CHARS only, or in both datasets.[4] Table 2 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.

[4] For more information on how records were identified as MVCs, see Appendix A.

Table 2: Motor Vehicle Crashes identified in either WEMSIS or CHARS

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
Among all WEMSIS-CHARS matched incidents:			
MVCs identified in WEMSIS field only	495	619	689
MVCs identified in CHARS field only	942	1,071	1,067
MVCs identified 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 identified 4,883 MVC incidents where the injury details indicated an MVC in one data source but not the other. The majority of these incidents either have no injury code reported or contain other information related to the response, while some contain conflicting information on whether an incident is traffic-related. We've provided a list of common injury codes for these incidents in Appendix B.

In summary, 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.

2. Descriptive Statistics of Motor Vehicle Crash Hospitalizations

Prior to discussing MVC hospitalization demographics and outcomes, it is important to cover the caveats and limitations of the data. The data used in analysis includes EMS response and hospitalization records, and not records of treatment in an ED. As a result, the data is missing outcome information for patients treated in an emergency room and not either admitted to the hospital or kept for observation. Therefore, the study population for this limited to patients treated by EMS and then hospitalized from injuries related to an MVC, or "MVC hospitalizations." Table 3 provides some detail on the representation of MVC injuries among patient care data sources.

Table 3: Share of Incidents Related to Motor Vehicle Crashes by Data Source

Source of Data	2017	2018	2019
Percent of EMS Incidents Related to MVCs	4.54%	5.02%	4.92%
Percent of EMS Hospital Transports Related to MVCs	3.50%	3.55%	3.44%
Percent of Matched Incidents Related to MVCs	2.24%	2.29%	2.13%
Percent of Hospitalizations Related to MVCs	0.82%	0.84%	0.84%

In total, MVCs account for 4.8% of all EMS incidents and 3.5% of all patients transported to a hospital or ED. Looking at continued care, MVCs account for around 2.2% of patients treated by EMS and hospitalized. As each of these groups is a subset of the previous group, the decrease in MVC representation at each step of care suggests that MVC patients were less likely to require transport than other EMS patients, and less likely to require hospitalization than other transported patients. MVCs also account for only 0.8% of all hospitalizations.

As the first step in the outcomes analysis, we now consider the representation of demographic groups. Table 4 shows the distribution of each demographic among MVC hospitalizations compared to all EMS hospitalizations. To be clear, the measurements do not translate to a relative likelihood of getting into an MVC, but strictly the representation of each group within the EMS hospitalization data.

Table 4: Demographics of Motor Vehicle Crashes compared to All Matched Incidents

Distribution by Age Group	**MVCs**	**All Matched Incidents**
Ages 0-15	4.4%*	2.7%
16-25	15.3%*	4.0%
26-35	15.3%*	6.1%
36-45	12.3%*	6.5%
46-55	14.6%*	10.3%
56-64	15.2%	15.4%
65+	23.0%*	55.0%
Distribution by Gender		
Male	63.3%*	49.4%
Female	36.7%*	50.6%
Undetermined	<0.1%	<0.1%
Distribution by Race and Ethnicity		
White	79.0%*	80.8%
American Indian or Alaskan Native	2.4%*	1.6%
Asian	3.7%	3.4%
Hawaiian or Other Pacific Islander	0.9%	0.9%
Black or African American	4.9%	5.1%
Multiple Races	1.2%*	0.8%
No Race Specified	7.9%*	7.4%
Hispanic	8.0%*	4.4%
Non-Hispanic	88.7%*	92.1%
No Ethnicity Specified	3.3%	3.5%
Distribution by Primary Payer		
Medicare	17.1%*	54.9%
Medicaid	25.5%*	17.8%
Self-Pay	4.3%*	1.8%
Other Health Insurance	53.1%*	25.5%

* Statistically significant difference in representation among hospitalizations ($p<0.05$)

The difference between MVC representation within the data and relative likelihood of getting into an MVC is most apparent when considering age groups. Ages 0-15 through 46-55 had a higher representation in MVC hospitalizations, while ages 65+ have a lower representation. This is due to a greater prevalence of hospitalizations for other reasons for the 65+ age group. Other factors affecting each group's representation could be risk aversion, choice to seek care, income, or underlying health.

In addition to those 55 and younger, males have a higher representation in MVC hospitalizations despite an even distribution of gender in all matched hospitalizations. Those identifying as Hispanic, American Indian or Alaskan native, with more than one race specified, or with no race specified have a higher representation in MVC hospitalizations. Those identifying as white consist of 79% of MVC hospitalizations, slightly lower than their representation in all hospitalizations, though close to the overall share of the population of Washington that identify as white at 78.7%.[5] Similar to ages 65+, those covered by Medicare were underrepresented in MVC hospitalizations compared to all hospitalizations. Health coverage by Medicaid or other health insurance, and self-pay, or paying for your own care, all have a higher representation in MVC hospitalizations.

3. Hospital Discharge Statistics

Within hospitalization data, there are a few possible fields to categorize hospital stay and outcome. First, the type of stay is split between Observation and Inpatient visits. Second, the type of admission is separated into Emergency, Urgent, Elective, and Trauma visits. For our purposes, we aggregate type of admission into Trauma and Non-trauma visits. Lastly, the possible entries in the patient's discharge status include many options of transfer to other care, such as skilled nursing facility or intermediate care facility, as well as routine discharge, left against medical advice, and whether the patient expired. In categorizing discharge, we grouped incidents into those who expired, those transferred to continued care, and routine discharge, which includes those who left against medical advice. We also considered the discharge status of the subsequent hospitalization records when multiple records were matched to the same incident.

Table 5 displays the shares of MVCs that fit into each type of stay and admission compared to all matched incidents. While the proportions of inpatient and observation stays are similar when comparing MVC to all incidents, trauma admissions account for a much higher share of MVC hospitalizations. Inpatient-trauma incidents comprise 33.6% of MVC hospitalizations. As this group consists of the patients with greater need for care, we give them special attention in our analysis.

Table 5: Type of Hospital Visit for Motor Vehicle Crashes compared to All Matched Incidents

Distribution by Type of Hospital Visit	MVCs	All Matched Incidents
Observation	**17.0%**	**16.4%**
Non-Trauma	79.6%*	98.6%
Trauma	20.4%*	1.4%
Inpatient	**83.0%**	**83.6%**
Non-Trauma	59.5%*	97.8%
Trauma	40.5%*	2.2%

[5] From WA Office of Financial Management data available here.

As mentioned previously, this analysis is missing information on patients transported to, treated at, and released from the ED before admission to the hospital. Because of this, we are likely missing any death that occurs in the emergency room, and any outcome statistic reviewed here is limited to the patient having survived until admission to the hospital. However, WEMSIS records contain some information on survival of patients on scene. Table 6 shows the percent of MVC incidents where the patient was reported "Dead at Scene" for each analysis year, which is consistently around 0.5%.

Table 6: Share of MVC Incidents where the Patient was Reported "Dead at Scene"

Incident Year	2017	2018	2019
Percent of Patients reported "Dead at Scene"	0.54%	0.51%	0.55%

Prior to the outcomes assessment, we should consider what we expect to find within the data. The underlying health of the patient is expected to be a large factor in both survival-to-discharge and whether a patient is transferred for continued care. Because the data lacks any indicator of underlying health, we expect large differences in the percent expired and percent transferred for continued care by patient age group, with these proportions increasing with age. Interpreting the impact of primary payer for medical care presents a challenge. Health coverage through Medicare is heavily correlated with age and will likely include some of the effect of lower health, though the impact will also include Medicare recipients who are younger than 65 and have disabilities. The remaining categories of primary payer are likely to be a proxy for income, with other insurance representing higher income and Medicaid representing lower income. Self-pay is also an indicator of lower income while also potentially representing higher tolerance for risk. Differences in attitude toward risk and health care will likely result in differences in outcome for between genders, races, and ethnicities. However, we expect differences in outcome to disappear once we account for the severity of the incident, as this would indicate equal care being provided regardless of gender, race, or ethnicity.

Table 7 on the following page shows the distribution of outcomes for all MVC hospitalizations.[6] In total, 2.8% of patients died and 26.9% were transferred for other care. As expected, the percent of patients who died and percent transferred for other care are closely related to age. Transfer to other care was less common than average for all patient groups younger than 55, and the share transferred decreasing with age. Patients older than 55 were transferred to other care more often than average, and patients 65 and older were transferred to other care in 48% of MVC hospitalizations, which is as often as they were routinely discharged. Deaths were nearly twice as common among patients 65 and older. Transfer to other care was less common for males than for females, but neither group had a larger proportion that died than average. White patients were transferred to other care at higher proportions than average, and a lower proportion of Asian patients died than average. For those with no specified race, a lower proportion than average were transferred to other care and a higher proportion died. However, this is likely due to patients being unable to relay their race in cases of severe MVC incidents. Patients who identify as Hispanic were transferred for other care less often than the average. Similar to those with no specified race, a lower proportion were transferred to other care and a higher proportion died among patients with no specified ethnicity, which further indicates the issue of collecting information from severe MVC incidents.

[6] Each distribution by demographic is calculated independently, and statistical significance may change when considered jointly.

Outcomes distributions along primary payer provide compelling insight into the patients' situation. Outcomes for Medicare patients closely follow those of patients who were 65 and above. Patients covered by Medicaid died no more or less than the average, but were less commonly transferred for other care. Self-paying patients were the group that was least often transferred for other care, and 4.7% of self-paying patients died. Patients covered by other health insurance were transferred to other care slightly less than average, and a smaller percent died than average.

Table 7: Motor Vehicle Crash Hospitalization Outcomes by Demographic

	Routine Discharge	Discharge/Transfer to other care	Expired
Overall Outcome Distribution	70.3%	26.9%	2.8%
Distribution by Age Group			
Ages 0-15	90.1%*	9.3%*	0.6%*
16-25	84.1%*	13.9%*	2.1%*
26-35	81.5%*	16.7%*	1.8%*
36-45	78.4%*	19.4%*	2.2%
46-55	72.8%*	25.0%*	2.2%
56-64	66.9%*	30.8%*	2.3%
65+	46.2%*	48.4%*	5.4%*
Distribution by Gender			
Male	71.6%*	25.4%*	3.0%
Female	68.1%*	29.5%*	2.4%
Undetermined	---	---	---
Distribution by Race and Ethnicity			
White	69.1%*	28.1%*	2.8%
American Indian or Alaskan Native	73.3%	23.3%	3.5%
Asian	74.6%	24.4%	1.0%*
Hawaiian or Other Pacific Islander	77.8%	19.2%	3.0%
Black or African American	74.0%	24.3%	1.7%
Multiple Races	69.4%	28.4%	2.2%
No Race Specified	76.6%*	19.2%*	4.2%*
Hispanic	80.1%*	17.2%*	2.6%
Non-Hispanic	69.4%*	28.0%*	2.7%
No Ethnicity Specified	71.0%	22.1%*	6.9%*
Distribution by Primary Payer			
Medicare	45.1%*	49.2%*	5.7%*
Medicaid	78.7%*	18.9%*	2.4%
Self-Pay	85.0%*	10.3%*	4.7%*
Other Health Insurance	73.2%*	24.9%*	1.9%*

* Statistically significant difference in outcome from the overall distribution of MVC hospitalizations. $p<0.05$

Table 8: Motor Vehicle Crash Hospitalization Outcomes for Inpatient-Trauma Visits by Demographic

	Routine Discharge	Discharge/Transfer to other care	Expired
Overall Outcome Distribution	66.3%	28.8%	4.9%
Distribution by Age Group			
Ages 0-15	87.4%*	11.0%*	1.7%*
16-25	79.4%*	17.0%*	3.6%
26-35	78.0%*	18.7%*	3.4%*
36-45	70.6%*	25.7%	3.6%
46-55	66.8%	29.4%	3.8%
56-64	62.4%*	34.0%*	3.7%
65+	31.8%*	55.9%*	12.3%*
Distribution by Gender			
Male	68.4%*	26.8%*	4.9%
Female	61.8%*	33.1%*	5.1%
Undetermined	---	---	---
Distribution by Race and Ethnicity			
White	65.7%	29.5%	4.9%
American Indian or Alaskan Native	72.1%	23.1%	4.8%
Asian	70.5%	27.1%	2.5%
Hawaiian or Other Pacific Islander	73.3%	23.3%	3.3%
Black or African American	65.7%	31.5%	2.8%
Multiple Races	65.0%	31.7%	3.3%
No Race Specified	69.1%	21.2%*	9.7%*
Hispanic	73.3%*	21.8%*	4.9%
Non-Hispanic	65.6%*	29.8%*	4.6%*
No Ethnicity Specified	63.7%	21.2%	15.0%*
Distribution by Primary Payer			
Medicare	38.3%*	49.7%*	12.1%*
Medicaid	75.3%*	20.9%*	3.8%*
Self-Pay	76.7%*	13.6%*	9.7%*
Other Health Insurance	66.7%	29.7%	3.6%*

* Statistically significant difference in outcome from the overall distribution of MVC hospitalizations. $p<0.05$

To compare the outcome distributions for more severe MVC incidents, Table 8 above shows the distribution of outcomes for inpatient-trauma MVC hospitalizations. Of these patients, 4.9% died and 28.8% were transferred for other care. For more severe incidents, only the younger three age groups, ages 35 and younger, were transferred to other care less often than average. As before, patients older than 55 were transferred to other care more often than average, and patients who were 65 and older died in higher proportions. For severe incidents, 12.3% of patients who were 65 and older died.

Transfers to other care were slightly less common for males than females. Differences in outcome distribution for those with a specified race were no longer significant when accounting for severe incidents. A much greater proportion of patients without a specified race or ethnicity died than average, again highlighting issues recording information of severe patients. Hispanic patients were transferred to other care less often than those who were non-Hispanic.

Outcomes by primary payer for inpatient-trauma MVCs follow a similar pattern as all MVCs, with Medicare patients being transferred or dying more often than average, and Medicaid and self-paying patients being transferred less than average. However, patients with other health insurance were transferred for other care as often as the average in severe incidents, and patients covered by Medicaid or other health insurance both died in lower proportions than average. Much higher than the average, 9.7% of self-paying patients died.

Table 9 displays the odds-ratios of dying following an MVC where the patient was hospitalized. In these models, the odds-ratio regressions jointly consider the relationships between demographics and likelihood of death. We interpret the relationships as correlations of differences in likelihood of death, rather than as causes. More information and further analysis would be required to imply causality. Additionally, the odds-ratios are calculated relative to a base group: non-Hispanic, white males between the ages of 36 and 45 with general health insurance. Differences from 1 indicate a lower or higher likelihood of dying relative to the base group. Separate regressions are presented to consider differences between all MVC hospitalizations and inpatient-trauma MVC hospitalizations.

When considering all MVCs, the odds of the base group dying from an MVC while hospitalized were 0.0164 to 1, or around 1.61% of incidents. Females and the youngest age group, ages 0-15, were the only groups with significantly lower odds of dying. Age groups from 16 to 64 have no significant difference in likelihood of death than the base group. Patients 65 and older have nearly three times the odds of dying as the base group. In terms of race and ethnicity, only those who were Asian had lower odds of dying. Patients covered by Medicare had higher odds of dying from a MC while hospitalized, and those covered by Medicare due to a disability were equally likely to die as other Medicare recipients. Both Medicaid and self-pay patients had higher odds of dying.

Focusing on inpatient-trauma MVC hospitalizations, the odds of the base group dying were 0.0277 to 1, or around 2.69%. For inpatient-trauma patients, there was no difference in odds of dying across gender, race, or ethnicity. This follows our expectation that care does not depend on these factors. The only differences odds of dying were related to age and primary payer for care. Those 65 and older had nearly 4 times the odds of dying relative to the base group. As in the all MVC model, inpatient-trauma patients covered by either Medicaid or self-pay had increased odds of dying. In both models, self-pay is correlated with an increase in odds of dying at a similar scale as being 65 year of age or older. This suggests that those who do not have insurance, either due to choice or ability to afford insurance, had comparable odds of dying to those who were 65 or older. Comparing the two models via pseudo R^2, the model of containing all MVC hospitalization accounts for 4.7% of the variation in outcome, while the inpatient-trauma model accounts for 6.7% of variation. This suggests that adding information that is not present in the available data, such as direct measures of income or health levels, would improve our estimates.

Table 9: Odds-Ratios of Probability of Death for MVC Hospitalizations

VARIABLES	(1) All MVCs	(2) Inpatient-Trauma MVCs
Age 0-15	0.294*	0.494
	(0.181)	(0.320)
Age 16-25	1.008	1.045
	(0.262)	(0.348)
Age 26-35	0.812	0.888
	(0.216)	(0.296)
Age 46-55	1.020	1.057
	(0.264)	(0.357)
Age 56-64	1.078	1.024
	(0.278)	(0.353)
Age 65+	2.932**	3.935**
	(0.774)	(1.340)
Female	0.757*	0.957
	(0.0966)	(0.163)
American Indian/Alaskan Native	1.344	0.992
	(0.470)	(0.492)
Asian	0.357*	0.432
	(0.180)	(0.247)
Black/African American	0.648	0.622
	(0.224)	(0.293)
Hawaiian/Pacific Islander	1.192	0.781
	(0.701)	(0.787)
Multiple Races	0.962	0.807
	(0.567)	(0.598)
Hispanic	1.071	1.098
	(0.245)	(0.306)
Medicare & Under 65	1.442	1.383
	(0.468)	(0.641)
Medicare	1.684**	1.732*
	(0.309)	(0.439)
Medicaid	1.842**	1.571*
	(0.323)	(0.357)
Self-Pay	3.119**	3.727**
	(0.764)	(1.102)
Constant	0.0164**	0.0277**
	(0.00360)	(0.00776)
Observations	10,867	3,649
Pseudo R^2	0.0472	0.0670

Note: Odds-Ratios relative to a white, non-Hispanic male, age 36-45 with general health insurance. Robust standard errors in parenthesis. ** p<0.01, * p<0.05

4. Summary and Discussion

The WEMSIS team conducted a linkage of EMS and hospitalization data for the purpose of assessing the outcomes of motor vehicle crashes (MVCs). The process identified 10,867 MVC EMS incidents with matching hospitalization records for the years 2017-2019. The prevalence of MVC hospitalizations was higher among those aged 55 and younger compared to their overall hospitalization rate. While 55% of matched hospitalizations were for patients 65 and older, they account for only 23% of matched MVC hospitalizations. MVC hospitalization was also more common among males, American Indian/Alaskan Natives, and those identifying as multiple races or as Hispanic, though it is unclear whether this is due to differences in choice to seek care rather than differences in behavior. Of all MVC incidents responded to by EMS, around 0.5% of patients were reported as "dead at scene."

Severity of the incident is an important factor, as a larger share of MVC hospitalizations were related to trauma than all hospitalizations. Before controlling for severity of the incident, higher proportions of certain groups died or were transferred for continued care. However, this finding is likely related to differences in income, health coverage, and choice to seek care between groups. Most differences in outcome disappear when demographics are considered jointly or when focused on inpatient-trauma incidents. Females and those identified as Asian had reduced odds of dying, but had no difference in outcome when only considering inpatient-trauma MVCs. Once the severity of the incident was accounted for, only age group and health insurance status were significantly correlated with outcomes. This meets the expectation that outcome does not depend on gender, race, or ethnicity. Further analysis by race or ethnicity should account for missing data in severe incidents.

Source of health coverage and old age were related to outcome in all stages of analysis. In both severe and non-severe cases, transfers for other care were more common among Medicare patients and less common among Medicare and self-pay patients. Patients 65 and older had nearly 3 times the odds of dying from an MVC while hospitalized than white, non-Hispanic males with general health insurance, and nearly 4 times the odds of dying in severe incidents. Patients younger than 65 but covered by Medicare due to a disability had no difference in outcome on average than those who were 65 and older. Medicaid patients also had increased odds of dying relative to the base group. As this group is assumed to have lower incomes, this may be related to reluctance to seek medical care due to cost.

Perhaps the most intriguing finding centers on patients paying for their own care. Self-pay patients had similar odds of dying to those aged 65 and above in both severe and non-severe incidents. Self-pay was also more than twice as common among MVC hospitalizations than all others, making it one of the largest disparities between MVC and non-MVC hospitalizations. Some of this disparity may be explained by self-pay patients being covered by the liability insurance of a driver at fault in the MVC. Thus, the outcomes of self-pay patients may be related to serious driver error rather than an attribute of those who do not have health coverage. Any further analysis of outcomes by payer should look into whether coverage by liability insurance is related to self-pay status.

As the linkage was only conducted between EMS and hospitalization data, the analysis is missing information on the outcomes of patients who received emergency department care and were discharged afterwards. Future analyses should seek to include EMS, emergency department, trauma registry, and hospitalization records. A linkage between these four systems would provide a more complete picture of the continuum of care each patient receives, and would greatly improve the DOH's ability to monitor quality of care.

Appendix A

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 of 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.

Appendix B

In the process of identifying MVCs through CHARS and WEMSIS, an incident may be classified as an MVC by one data source but not the other. This discrepancy may be due to missing or incomplete information, or due to other issues that are related to the incident. For example, "Traumatic Injury" is a common WEMSIS entry for MVCs identified through CHARS. In total, 1,803 MVC incidents were identified in CHARS but not in WEMSIS, and 3,080 MVC incidents were identified in WEMSIS but not in CHARS.

Tables B-1 and B-2 list common injury codes or complaints reported for MVCs identified in one data source but not the other. CHARS injury codes pertain to the first injury code listed. WEMSIS entries pertain to the first injury code listed or, if missing, the Complaint Reported by Dispatch for the first EMS unit on scene. Incidents with an initial complaint reported of "Transfer/Interfacility/Palliative Care" were excluded from outcomes analysis regardless of CHARS injury code, as this indicates a second incident for a single MVC. The majority of incidents identified as an MVC by one source but not the other either have no injury code reported or contain other information related to the response. Among MVCs identified only in CHARS, 6.9% were classified as a non-traffic MVC by the WEMSIS record. Similarly, among MVCs identified only in WEMSIS, 23.7% were classified as a non-traffic MVC by the CHARS record. Future reports should examine these incidents to assess whether one data source should be trusted over the other when identifying MVCs.

Table B-1: Common Injury Codes for MVCs Identified only by WEMSIS

CHARS Injury Code	Count
No Code Recorded	758
Other land transport accidents	227
Car occupant injured in transport accident	201
Supplementary factors related to causes of morbidity classified elsewhere	136
Pedestrian or pedal cycle rider injured in transport accident	118
Motorcycle rider injured in transport accident	108
Slipping, tripping, stumbling and falls	107
Exposure to inanimate mechanical forces	39
Accidental exposure to other specified factors	38
Medical devices associated with adverse incidents in diagnostic and therapeutic use	29
Assault	11
Entries with less than 10 occurrences	31
Total	1803

Table B-2: Common Injury Codes for MVCs Identified only by CHARS

WEMSIS Injury Codes or Complaint Reported	Count
Other and unspecified effects of external causes	507
Traumatic Injury	452
Slipping, tripping, stumbling and falls	335
No Other Appropriate Choice	281
Sick Person	203
Other land transport accidents	184
Pedestrian or pedal cycle rider injured in transport accident	163
Unknown Problem/Person Down	93
Assault	59
Falls	59
Breathing Problem	58
Unconscious/Fainting/Near-Fainting	34
Car or pick-up truck occupant injured in transport accident	36
Chest Pain (Non-Traumatic)	31
Stroke/CVA	24
Hemorrhage/Laceration	22
Other transport accidents	21
Abdominal Pain/Problems	20
Convulsions/Seizure	20
Psychiatric Problem/Abnormal Behavior/Suicide Attempt	19
Motorcycle rider injured in transport accident	15
Back Pain (Non-Traumatic)	13
Event of undetermined intent	13
Exposure to inanimate mechanical forces	12
Cardiac Arrest/Death	11
Entries with less than 10 occurrences	72
Total	3080