MONTANA TRAUMA REGISTRY ANNUAL REPORT 2021

A Summary of 2020 Trauma Data

PublicHealth IN THE 406

MONTANA
EMS, TRAUMA SYSTEMS & INJURY PREVENTION PROGRAM

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EXECUTIVE SUMMARY

We are pleased to present *A Summary of 2020 Trauma Data*, an aggregate and comprehensive report on traumatic injury in Montana and the first report to include linked EMS and trauma registry data. We acknowledge the extraordinary work of those individuals across the state who review trauma case reports and enter this important data into the Montana Trauma Registry. Without their work, this report would not be possible.

The intent of this report is to create a baseline for important trauma system measures that can be tracked and improved over time. These measures will assist facilities in their efforts to describe and improve the care of Montanans suffering from injury.

KEY FINDINGS OF THIS REPORT INCLUDE THE FOLLOWING:

- Montana's trauma centers have a robust interfacility transportation process - indicative of a well-functioning trauma system, however, 30% of patients seen in trauma centers arrive by personal vehicle, not an ambulance
- There is significant variation in the frequency that trauma team activation is recorded between the three trauma regions, particularly for patients age 65 and above
- Several pre-hospital triage criteria are reliable predictors of high injury severity scores
- Montana data align with national crash data – lack of restraint use and the use of alcohol and drugs result in more severe injury

OPPORTUNITIES:

- Documentation of key data elements by both trauma registrars and prehospital providers will improve our understanding of trauma in Montana. For example, mode of transport was missing for 20% of interfacility transfers. Linked data revealed that for over 50% of TBI patients, head injury was not specified in the prehospital documentation.
- Trauma centers should ensure that pre-hospital triage criteria are given proper weight when considering trauma team activation
- Patients aged 65 and older make up a large component of the trauma population but are under-represented in trauma team activation numbers.

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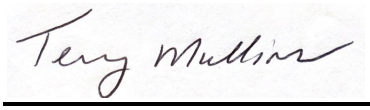

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OVERVIEW

The objective of Montana's trauma system is to match trauma patient needs to the appropriate resources in a timely manner throughout the continuum of care. A systems approach requires the cooperation of many stakeholders, and results in increased efficiency and improved trauma patient outcomes. The Montana trauma system's authorizing legislation was passed in 1995 (2-15-2216), which called for the formation of a State Trauma Care Committee (STCC) and three specified trauma regions, based upon patient referral patterns. This legislation allowed adoption of administrative rules regarding trauma center designation, classification, data collection, and triage criteria, and gave legal protection for using trauma data for performance improvement surrounding trauma care.

The Montana Trauma Registry (MTR) is a repository of trauma data from across the state that was established in 1990 to guide the state's trauma care performance improvement activities. All facilities are required to report data to the trauma registry within 60 days from the end of the quarter. Smaller volume facilities enter data directly into a web-based application on the centralized server, while larger facilities enter data into locally hosted software applications and upload their files to the centralized registry. MTR data are used regularly by the three regional trauma advisory committees (RTACs) and STCC to enhance the quality of patient care by using pre-identified audit filters. Registry data are also used for research, routine surveillance, and to identify opportunities for injury prevention. Selected data are submitted on a regular basis to the National Trauma Data Bank (NTDB) and the Trauma Quality Improvement Program (TQIP).

This annual report includes:

- Description of Montana's trauma facilities and records submitted to MTR during 2020
- Demographics of traumatic injury patients
- Magnitude of traumatic injuries categorized by injury type, cause (mechanism and intent), and injury severity score (ISS)
- Focused analysis of major topics including falls, transportation, firearm, traumatic brain injury (TBI), and work-related injury
- Outcomes of injured patients including case fatality rates and inpatient length of stay
- Performance of prehospital response, trauma team activation, interfacility transfer
- Linkage between EMS and trauma registry records

Limitations

- These data do NOT represent all traumatic injuries in the state- only those patients who reach a hospital and meet MTR inclusion criteria (see **APPENDIX 2. Montana Trauma Registry 2020 Inclusion Criteria**). Trauma that results in death at the scene and no transport of the patient is not part of the reported data.
- If a traumatic injury occurs in MT but the patient is treated in an out-of-state facility, the case is not included in MTR data. Border areas are thus under-represented in this report.

MONTANA TRAUMA FACILITIES

There are 4 Regional Trauma Centers (American College of Surgeons (ACS) Level 2), 4 Area Trauma hospitals (ACS Level 3), 11 Community Trauma Facilities (ACS Level 4), and 24 Trauma Receiving Facilities (ACS Level 5). There are 25 non-designated facilities, 16 of which are not submitting data. Montana does not have any ACS Level 1 trauma centers.

See **APPENDIX 1. List of Facilities.**

Figure 1. Count of trauma facilities by designation level

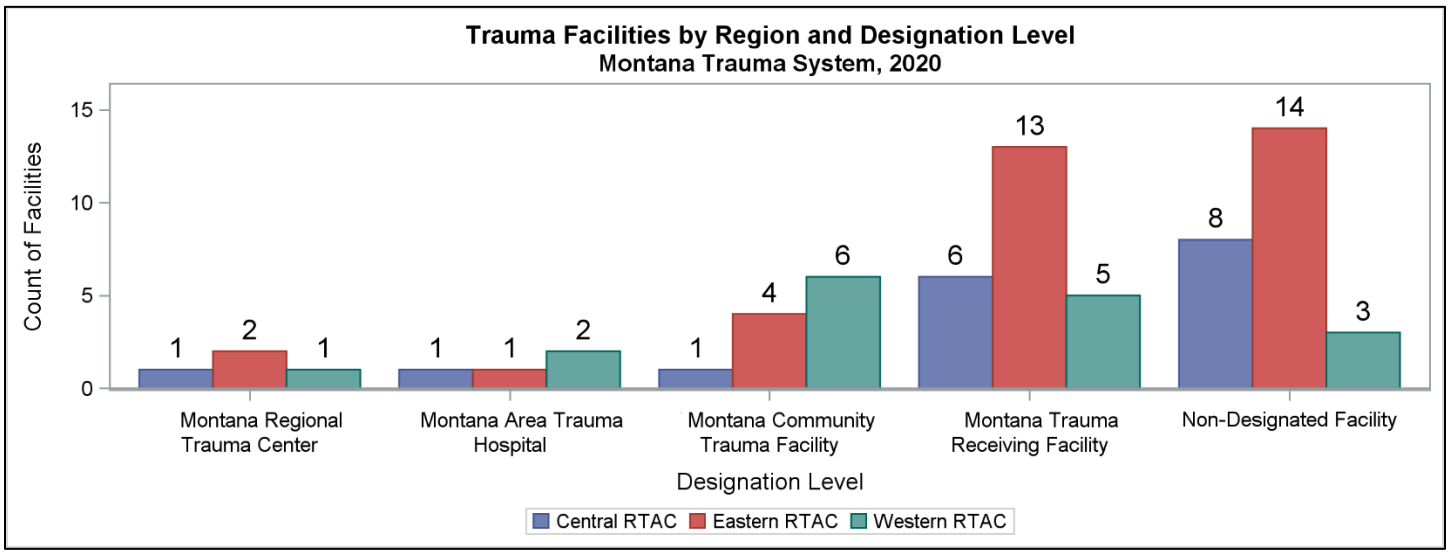
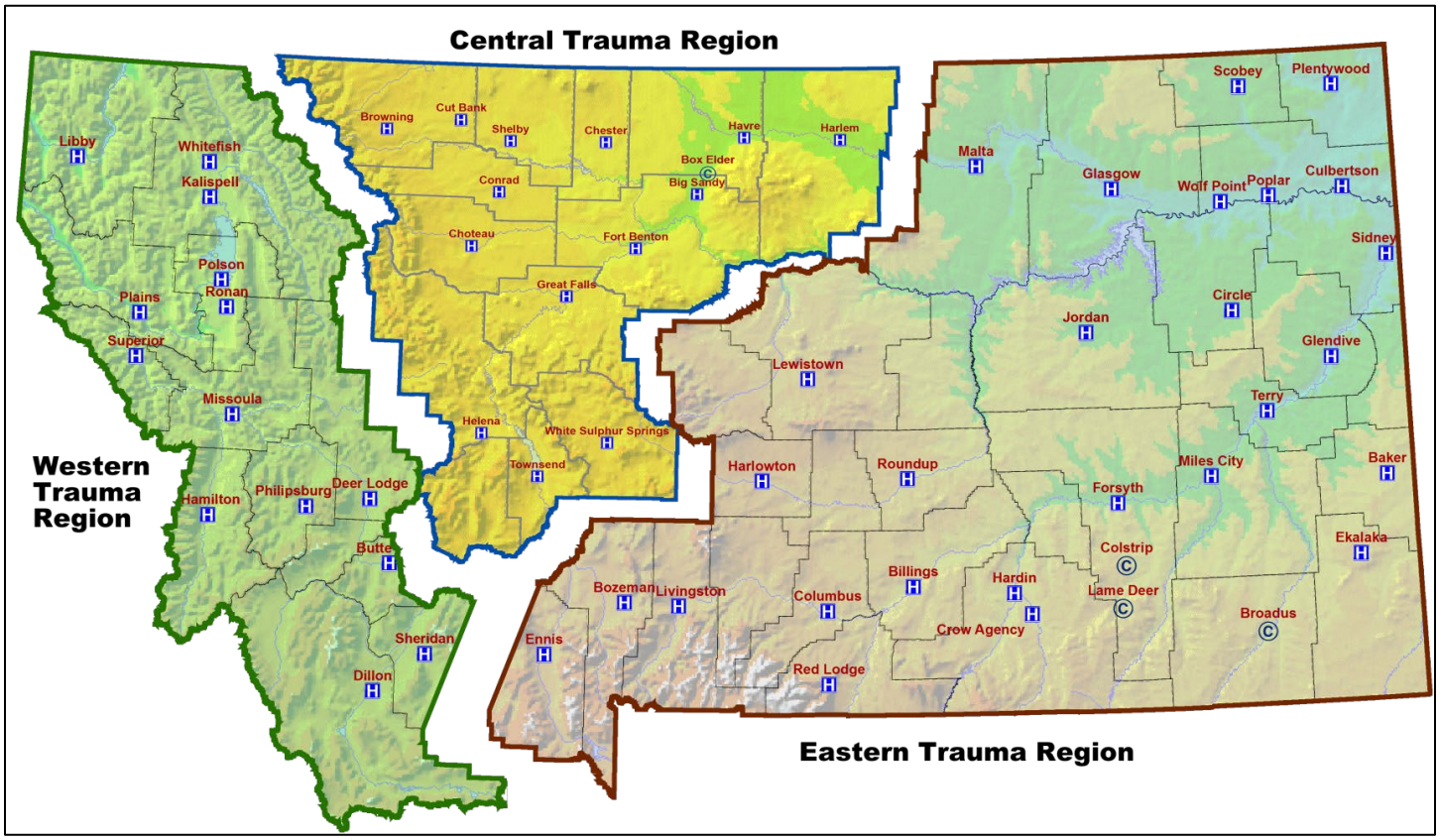


Figure 2. Map of Montana Trauma Regions



METHODOLOGY

This report includes MTR records for the period 1/1/2020 through 12/31/2020. Data utilized for this report was extracted on 5/26/2021. Any calendar year 2020 data received after this date was not included in the report.

See **APPENDIX 2. Montana Trauma Registry 2020 Inclusion Criteria** and **APPENDIX 3. 2020 MTR analysis dataset inclusion/exclusions flowchart.**

UNITS OF ANALYSIS

Throughout this report, trauma data are presented in two ways:

- **Total trauma records**: All records reported to the trauma registry are counted individually. If a patient was transferred between two or more facilities, that case will be represented twice if both the smaller (sending) and larger (receiving) facility submit a record to the registry. This unit of analysis is useful for describing facility-specific factors and outcome measures such as trauma team activation or ED length of stay. The number of total trauma records reflects total episodes of care in reporting facilities and is greater than the number of patients treated.
- **Unique trauma cases**: Records pertaining to the same patient case are grouped together, by matching trauma records based on patient name, birth date, gender, last 4 digits of SSN, and facility discharge/arrival date. (See **APPENDIX 4. Trauma Dataset De-duplication**). This unit of analysis is useful for describing patient-specific factors and outcomes such as demographics and case fatality rates (where double counting a transfer patient would be misleading). Except if noted otherwise, unique trauma cases are analyzed based on the data from the last facility where the patient received care.

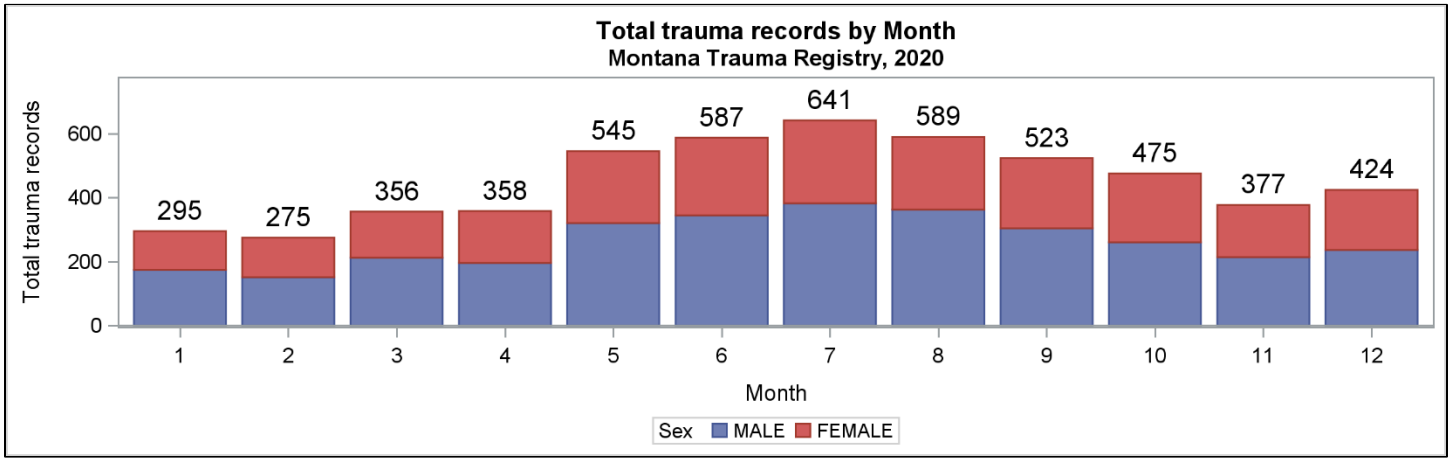
MONTANA TRAUMA REGISTRY RECORDS

There were 5,445 total trauma records comprising 4,836 unique trauma cases included in this report (**Table 1**). Of 5,445 trauma records, 43% were submitted by facilities in the Eastern trauma region (ERTAC), followed by 36% from the Western trauma region (WRTAC), and 21% from the Central trauma region (CRTAC). The ERTAC is the state's largest and most spread-out trauma region. An average of 453 records were received by MTR each month (**Figure 3**).

Table 1. Total trauma records and unique trauma cases by RTAC, 2020

RTAC	Total Trauma Records		Unique Trauma Cases	
	N	%	N	%
Central RTAC	1,154	21.2%	1,005	20.8%
Eastern RTAC	2,335	42.9%	2,057	42.5%
Western RTAC	1,956	35.9%	1,774	36.7%
Statewide	**5,445**	**100.0%**	**4,836**	**100%**

Figure 3. Total trauma records by month, 2020

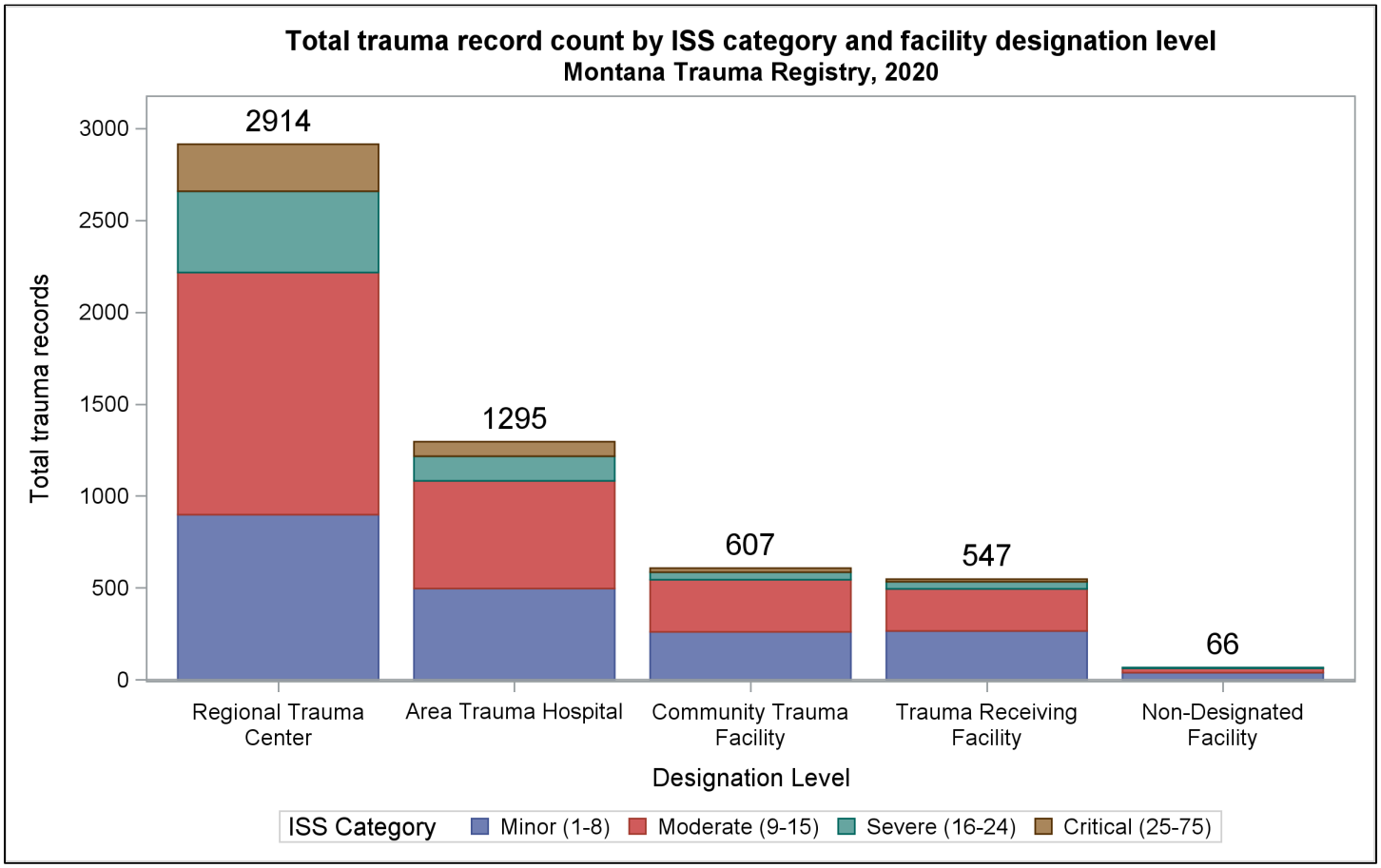


Montana's Regional Trauma Centers submitted the largest volume of trauma records (N=2,915), 24% of which had an ISS>15. Comparatively, 16% of records from Area Trauma Hospitals had an ISS>15, 10.3% for Community Trauma Facilities, and 9.5% for Trauma Receiving Facilities (**Table 2**).

Table 2. Total trauma records by facility designation level and ISS category, 2020

ISS Category	Designation Level										All	
	Regional Trauma Center		Area Trauma Hospital		Community Trauma Facility		Trauma Receiving Facility		Non-Designated Facility			
	N	%	N	%	N	%	N	%	N	%	N	%
Missing	1	0.0%			4	0.7%	10	1.8%	1	1.5%	**16**	**0.3%**
Minor (1-8)	898	30.8%	496	38.3%	260	42.6%	265	47.6%	38	56.7%	**1,957**	**35.9%**
Moderate (9-15)	1,318	45.2%	586	45.3%	284	46.5%	229	41.1%	24	35.8%	**2,441**	**44.8%**
Severe (16-24)	442	15.2%	134	10.3%	41	6.7%	39	7.0%	4	6.0%	**660**	**12.1%**
Critical (25-75)	256	8.8%	79	6.1%	22	3.6%	14	2.5%			**371**	**6.8%**
All	**2,915**	**100.0%**	**1,295**	**100.0%**	**611**	**100.0%**	**557**	**100.0%**	**67**	**100.0%**	**5,445**	**100.0%**

Figure 4. Total trauma record count by ISS Category and Facility Designation Level, 2020



MODE OF ARRIVAL

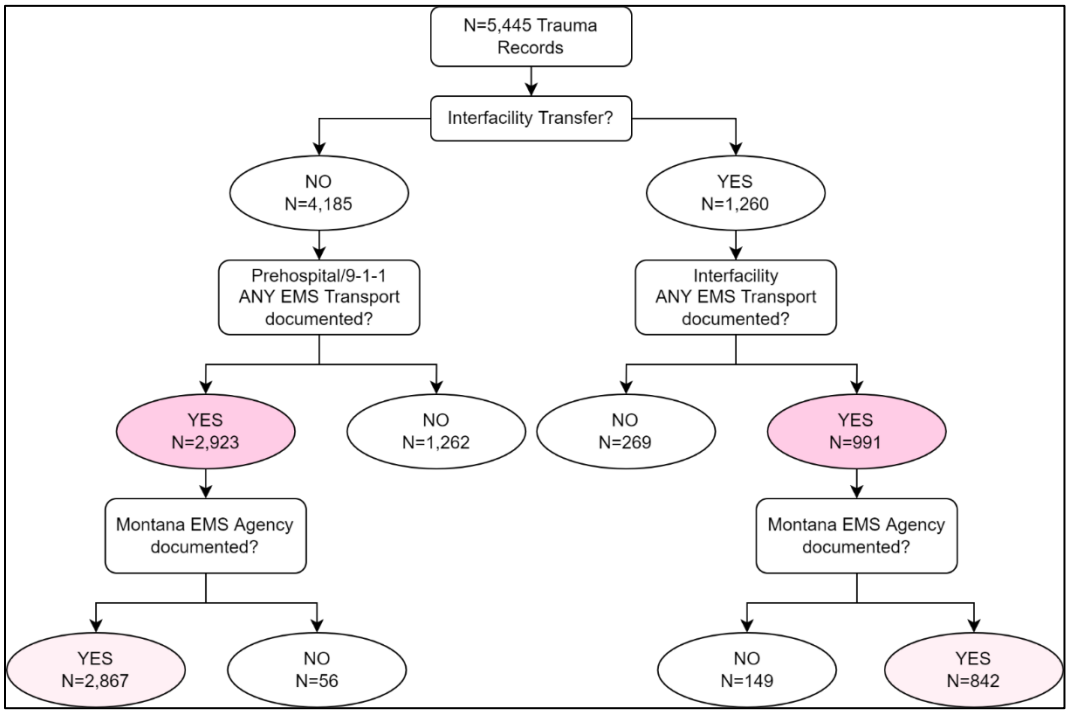
Of 5,445 total trauma records, 77% (N=4,185) were initial arrivals while 23% (N=1,260) arrived as interfacility transfers. Most initial arrivals came by ground ambulance (65%, N=2,740), and 29% (N=1,229) arrived by private vehicle. Among interfacility transfers, 40% (N=504) arrived by ambulance, 20% (N=247) arrived by helicopter, and 18% (N=227) arrived by fixed wing. Nearly 20% of interfacility transfers were missing data on mode of arrival (**Table 3**).

Table 3. Total trauma record count by mode of arrival to facility, 2020

Mode of arrival	Initial Arrivals		Interfacility Transfer Arrivals	
	N	Column %	N	Column %
Ground ambulance	2,740	65.5%	504	40.0%
Private vehicle	1,229	29.4%		
Helicopter	152	3.6%	247	19.6%
Ambulance & helicopter	29	0.7%	4	0.3%
Fixed wing			227	18.0%
Ambulance & fixed wing			8	0.6%
Police/law enforcement	13	0.3%	24	1.9%
Other	4	0.1%		
Missing	18	0.4%	246	19.5%
All	**4,185**	**100.0%**	**1,260**	**100.0%**

In addition to arrival mode, MTR allows for documentation of the specific EMS agency/agencies that transported the patient. 68% of initial arrivals (N=2,867) and 67% of interfacility transports (N=842) specified a Montana ground or air EMS agency as the transporting agency (**Figure 5**, **Table 4**). This is important to inform how many trauma records would be expected to link with an EMS record.

Figure 5. Mode of arrival flowchart, Total trauma records, MTR 2020



TOTAL TRAUMA RECORDS AND LINKAGE TO EMS RECORDS

Table 4 shows the number of total trauma records by submitting facility, the number transported by any EMS (includes records without a specific EMS agency documented), and the number transported by a Montana EMS agency. The linkage rate of trauma records with EMS records was 99.0% when using any EMS transport as the denominator (Table 4 column B). The linkage rate was 104.5%[1] using MT EMS transport as the denominator (Table 4 column C).

See APPENDIX 5. Trauma to EMS record linkage.

Table 4. Total trauma record count and linkage to EMS records by reporting facility, 2020

Facility	RTAC	(A) Total Trauma Records	(B) Transported to facility by any EMS	(C) Transported to facility by MT EMS	(D) Linked with EMS record
		N	N	N	N
St. Vincent's Healthcare, Billings	ERTAC	802	578	507	570
Billings Clinic, Billings	ERTAC	798	654	555	570
Benefis Healthcare, Great Falls	CRTAC	661	446	445	504
Providence St. Patrick Hospital, Missoula	WRTAC	654	481	478	510
Kalispell Regional Medical Center, Kalispell	WRTAC	469	354	351	362
St. Peter's Hospital, Helena	CRTAC	292	220	210	217
Bozeman Health, Bozeman	ERTAC	267	187	185	176
St. James Healthcare, Butte	WRTAC	267	187	181	186
Community Medical Center, Missoula	WRTAC	129	64	64	69
North Valley Hospital, Whitefish	WRTAC	98	71	67	70
Holy Rosary Health Center, Miles City	ERTAC	84	50	49	53
Northern Montana Hospital, Havre	CRTAC	78	58	58	43
Barrett Hospital and Healthcare, Dillon	WRTAC	67	35	35	30
Marcus Daly Memorial Hospital, Hamilton	WRTAC	65	37	37	38
Big Horn County Hospital, Hardin	ERTAC	65	46	46	45
Providence St. Joseph Hospital, Polson	WRTAC	58	37	37	37
Beartooth Billings Clinic, Red Lodge	ERTAC	49	30	30	30
St. Luke Community Healthcare, Ronan	WRTAC	48	37	37	37
Trinity Hospital, Wolf Point	ERTAC	31	25	25	27
Pioneer Medical Center, Big Timber	ERTAC	31	21	21	21
Clark Fork Valley Hospitals, Plains	WRTAC	30	24	24	24
Community Hospital of Anaconda, Anaconda	WRTAC	30	21	21	21
Madison Valley Medical Center, Ennis	ERTAC	29	17	17	15
Livingston Healthcare, Livingston	ERTAC	27	19	17	18
Roundup Memorial Healthcare, Roundup	ERTAC	24	14	14	10

[1] Percentage >100% indicates that in some cases no EMS agency was specified for patients arriving by ambulance

Facility	RTAC	(A) Total Trauma Records	(B) Transported to facility by any EMS	(C) Transported to facility by MT EMS	(D) Linked with EMS record
		N	N	N	N
Great Falls Clinic, Great Falls	CRTAC	24	2	2	2
Northern Rockies Medical Center, Cut Bank	CRTAC	23	17	17	17
Pondera Medical Center, Conrad	CRTAC	21	15	15	15
Central Montana Medical Center, Lewistown	ERTAC	20	14	14	12
Benefis-Teton Medical Center, Chouteau	CRTAC	20	15	15	15
Deer Lodge Medical Center, Deer Lodge	WRTAC	20	16	15	14
Mineral Community Hospital, Superior	WRTAC	18	16	16	16
Stillwater Billings Clinic, Columbus	ERTAC	17	12	12	13
Sidney Health Center, Sidney	ERTAC	16	10	10	10
Mountainview Medical Center, White Sulphur	CRTAC	16	12	12	11
Northeast Montana Health Services, Poplar	ERTAC	16	11	11	11
Marias Medical Center, Shelby	CRTAC	11	8	8	8
Daniels Memorial Hospital, Scobey	ERTAC	10	4	4	4
Frances Mahon Deaconess, Glasgow	ERTAC	9	8	6	8
Rosebud Healthcare, Forsyth	ERTAC	8	7	7	7
Dahl Memorial Healthcare, Ekalaka	ERTAC	7	4	4	4
Sheridan Memorial Hospital, Plentywood	ERTAC	6	6	6	6
Wheatland Memorial Hospital, Harlowton	ERTAC	5	3	3	0
Phillips County Medical Center, Malta	ERTAC	5	5	5	4
Liberty County Hospital, Chester	CRTAC	5	3	3	3
Roosevelt Memorial Hospital, Culbertson	ERTAC	4	3	3	2
Ruby Valley Hospital, Sheridan	WRTAC	3	2	2	2
Big Sandy Medical Center, Big Sandy	CRTAC	3	3	3	3
McCone County Health Center, Circle	ERTAC	3	3	3	3
Prairie Community Hospital, Terry	ERTAC	1	1	1	1
Glendive Medical Center, Glendive	ERTAC	1	1	1	1
All	**Statwide**	**5,445**	**3,914**	**3,709**	**3,875**

TRAUMA TEAM ACTIVATION

Trauma team activation (TTA) refers to the automatic activation of a hospital's trauma team based on the injured patient's mechanism of injury, physiologic criteria, anatomic criteria, or special considerations. Individual hospitals have their own predefined activation criteria, and hospital staff may rely on a report from EMS or the presenting symptoms of a patient arriving by personal vehicle to trigger trauma team activation. Some trauma centers have a single level of trauma activation while others may have multiple tiers, usually two or three. All levels are based specifically on the hospital resources available to the trauma patient and the patient's physiological status. Physiologic activation criteria are met if any two of the following are true:

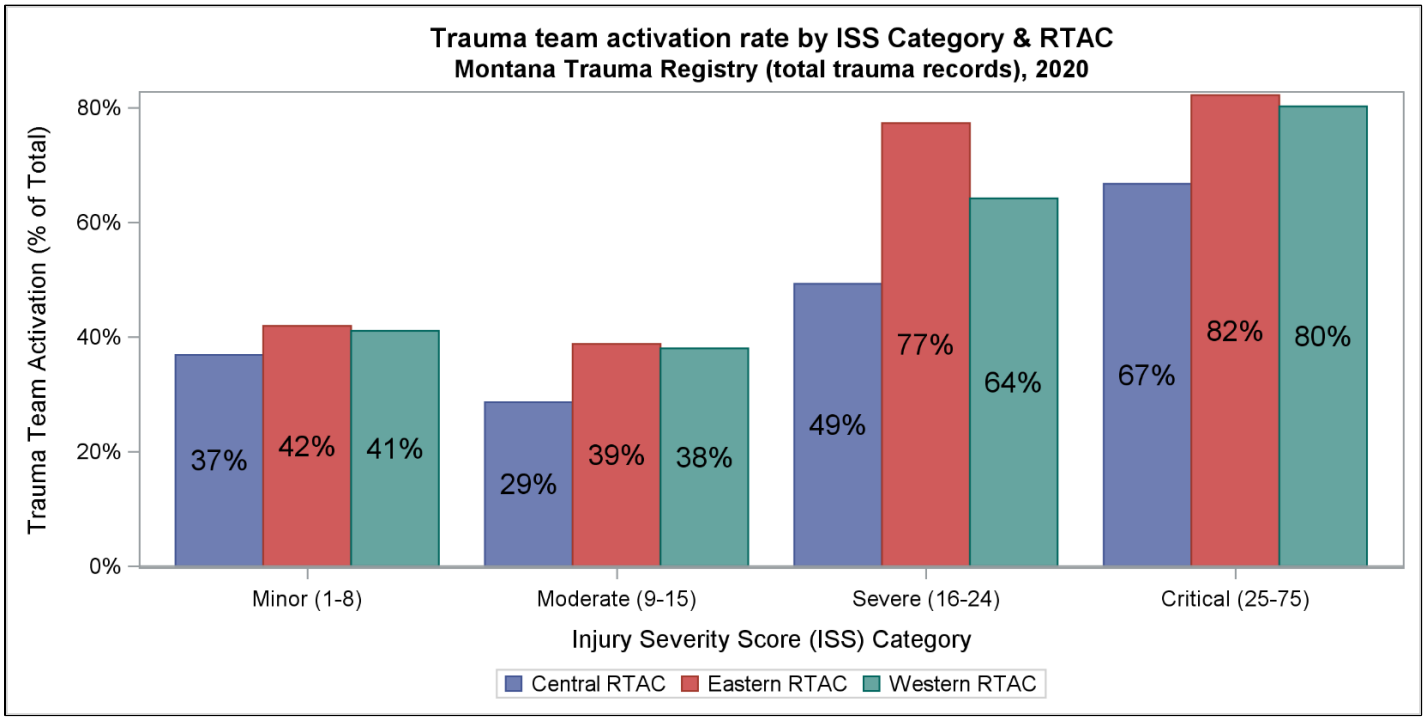
- Any SBP <90 mmHg
- Any GCS ≤13
- Any respiration assistance=Yes
- Any abnormal RR (<20 for infants ≤1 year of age, <10 or >29 for all other ages)
- Any abnormal HR (<60 or >130 for infants <=1 year of age, <80 or >120 for children 1-8 years of age)

TTA is expected to occur more often among severely injured patients (ISS>15). **Table 5** and **Figure 6** show the TTA rate within ISS category. CRTAC facilities activated on 55.1% of severely injured patients, ERTAC facilities activated 79.2%, and WRTAC facilities activated 69.5%. All rates were calculated from total trauma records.

Table 5. TTA Rate by ISS Category and RTAC, Total trauma records, MTR 2020

RTAC	ISS <=15		ISS >15		Missing ISS		All Records	
	TTA (N)	TTA Rate (%)	TTA (N)	TTA Rate (%)	TTA (N)	TTA Rate (%)	TTA (N)	TTA Rate (%)
Central RTAC	308	32.4%	109	55.1%	2	40.0%	419	36.3%
Eastern RTAC	753	40.2%	361	79.2%	2	50.0%	1,116	47.8%
Western RTAC	618	39.3%	262	69.5%	6	85.7%	886	45.3%
Statewide	**1,679**	**38.2%**	**732**	**71.0%**	**10**	**62.5%**	**2,421**	**44.5%**

Figure 6. Trauma team activation rate by ISS Category and RTAC, Total trauma records, 2020



When entering data into MTR, trauma registrars may come across cases where the trauma team should have been activated but it was not. Tracking "missed activations" is an important component of quality improvement. **Table 6** looks at several types of missed activations. Among all patients who met physiologic activation criteria (N=548), approximately 12% (N=67) did not receive a trauma activation. Among patients with ISS>15, 29% (N=1,031) did not receive a trauma activation, varying from 20.8% in Eastern RTAC, to 30.5% in Western RTAC, and 44.9% in Central RTAC. Patients older than 65 years are high risk for undertriage, so lower physiologic thresholds for TTA are used. Among patients older than 65 who had SBP <110 mmHg or GCS ≤13, 43% (N=115) did not receive a trauma activation (37% in Central, 42% in Western, and 48% in Eastern RTAC).

Table 6. Missed Trauma Team Activations by RTAC, Total trauma records, 2020

RTAC	Met physiologic activation criteria			ISS >15			Age >65 SBP<110 or GCS≤13		
	No TTA*	Total	% Missed	No TTA*	Total	% Missed	No TTA*	Total	% Missed
Central RTAC	15	111	13.5%	89	198	44.9%	25	68	36.8%
Eastern RTAC	27	231	11.7%	95	456	20.8%	49	102	48.0%
Western RTAC	25	206	12.1%	115	377	30.5%	41	97	42.3%
Statewide	67	548	12.2%	299	1,031	29.0%	115	267	43.1%

*No TTA was defined as:
if E_ADMTYPE = "Trauma consult", "Readmission", "Non-trauma service", "Direct admit") then NOTTA=1
if E_ADMTYPE = Unknown, N/A, or Missing AND if INCL_SRC= "Retrospective review" then NOTTA=1

POST-FACILITY DISPOSITION

77.4% (N=4,216) of total trauma records were discharged from inpatient care at the facility. 16.6% (N=902) were transferred to another facility directly from the ED while 1.6% (N=85) were first admitted and then transferred to another facility. N=159 died while admitted to the facility and N=62 died in the ED (**Figure 7**, **Table 7**).

Figure 7. Disposition at submitting facility, Total trauma records, 2020

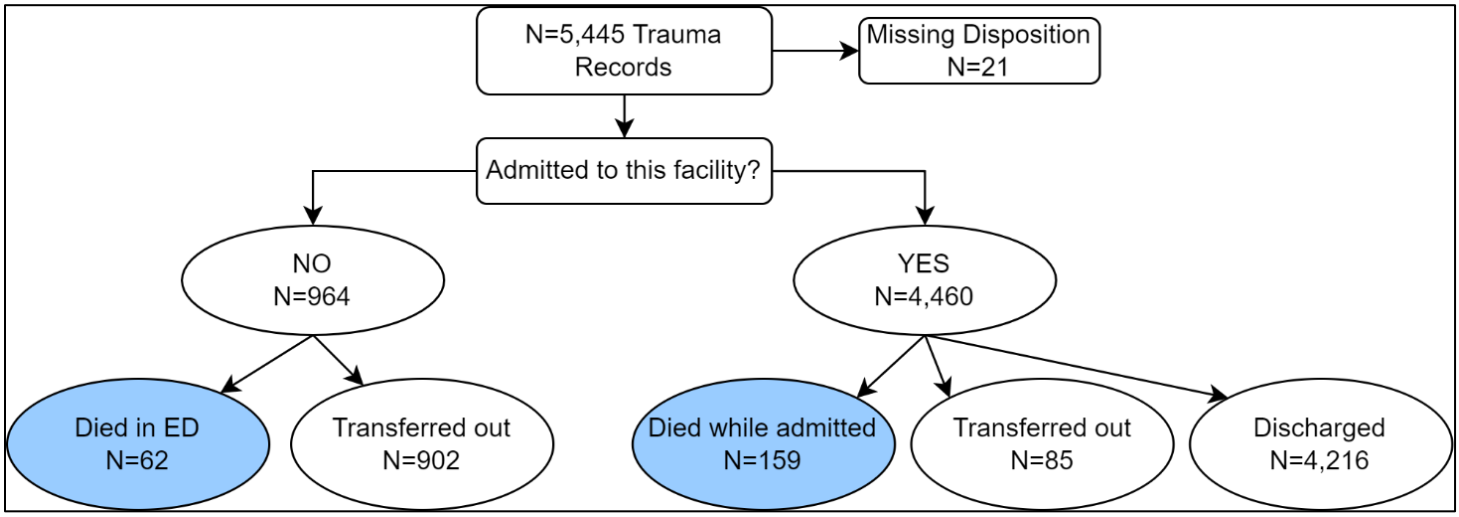


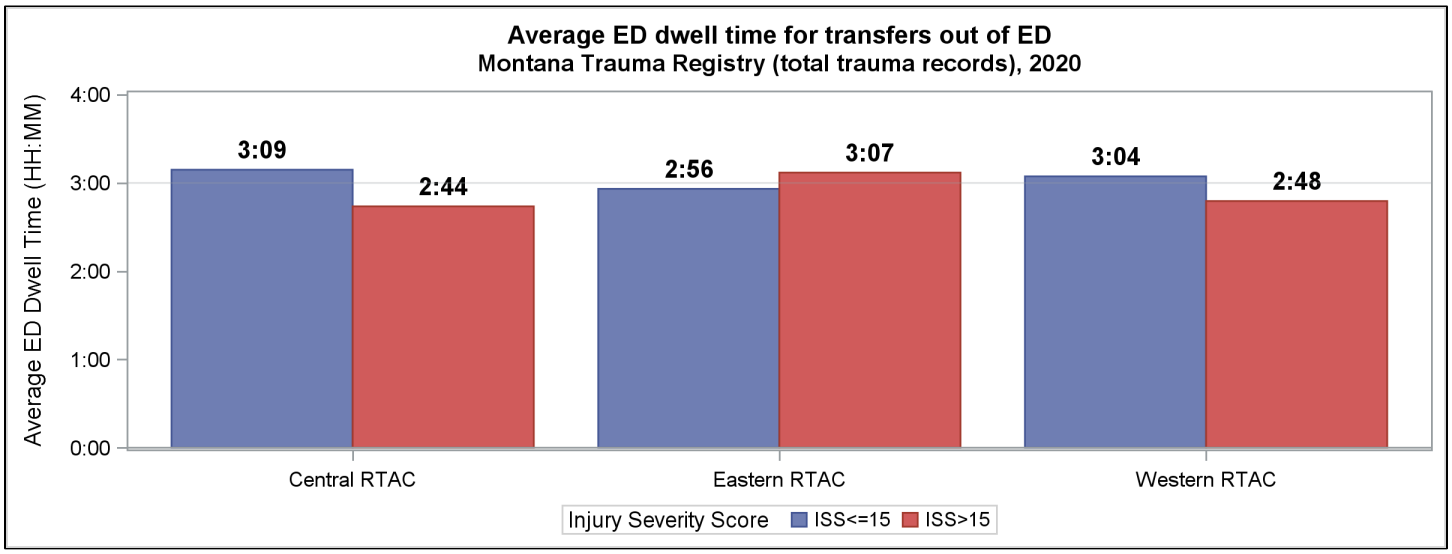
Table 7. Disposition at submitting facility by RTAC, Total trauma records, MTR 2020

Disposition	Central RTAC	Eastern RTAC	Western RTAC	Statewide
Transferred out from ED (to continue acute care)	217	359	326	**902**
Died in ED	15	24	23	**62**
Admitted to this facility, then transferred out (to continue acute care)	16	38	31	**85**
Died while admitted to this facility	29	74	56	**159**
Discharged from inpatient care or left against medical advice	875	1,836	1,505	**4,216**
Missing Disposition	2	4	15	**21**
All	**1,154**	**2,335**	**1,956**	**5,445**

ED DWELL TIME

Ideally, patients stay in the initial facility's ED less than 3 hours when being transferred to another facility. The average ED dwell time for N=902 patients transferred out from the ED was 2 hours 59 minutes (median=2:41). **Figure 8** shows average ED dwell time for these patients by ISS category and RTAC. ED dwell times for ISS <=15 versus ISS >15 were not significantly different[2]. For N=85 patients that were admitted first and then transferred to another facility, the average ED dwell time was 3 hours 16 minutes (median=2:47), and average total time at facility was 3.7 days (median=25:54).

Figure 8. ED dwell time for transfers out of ED, Total trauma records, 2020

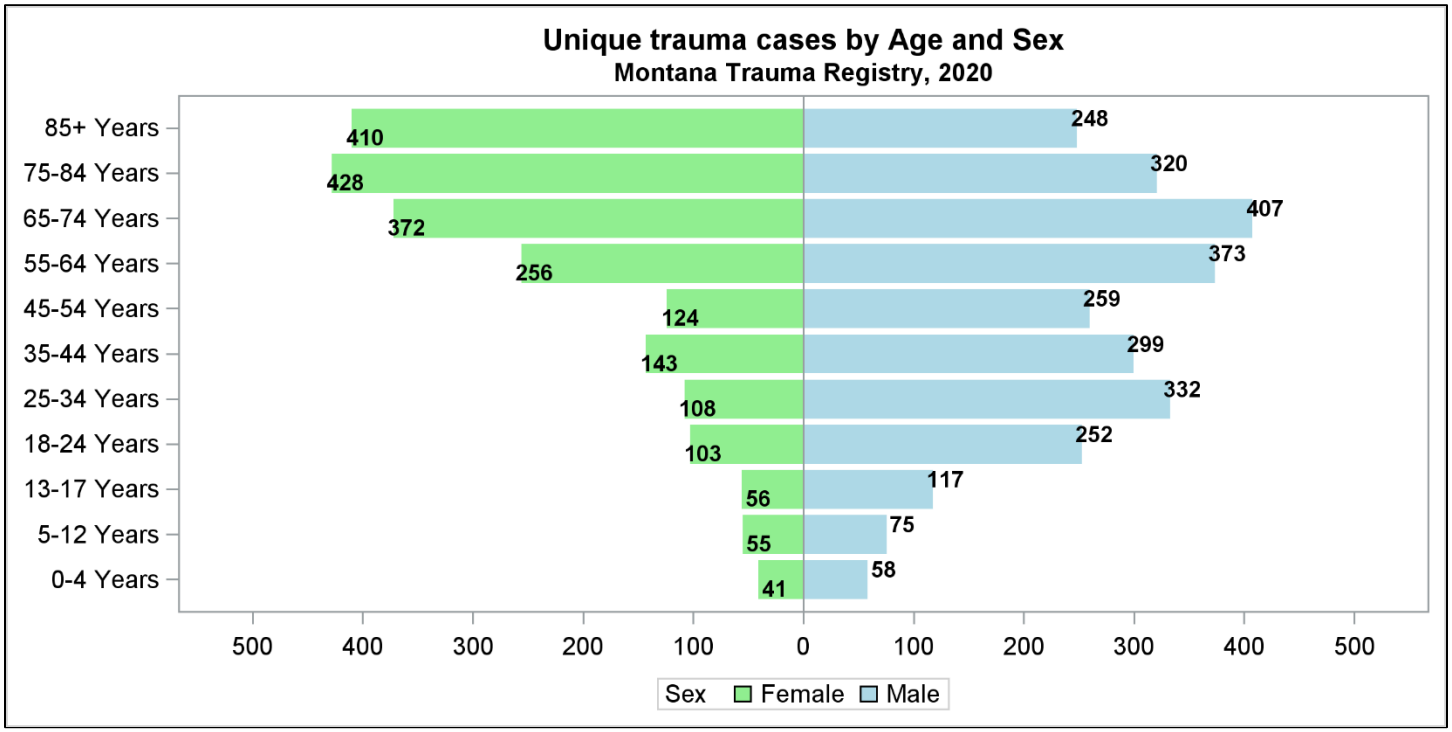


[2] CRTAC p=0.08, ERTAC p=0.50, WRTAC p=0.19

PATIENT DEMOGRAPHICS

Of 4,836 unique trauma cases, 56.7% were male and 43.3% were female. Patients 55 and older made up nearly 60% of cases. Table 8 shows the number and proportion of unique trauma cases by first-listed race.

*Figure 9. Age-sex pyramid, Unique trauma cases, 2020**



*See APPENDIX 6. Montana Population Age-Sex Pyramid

Table 8. Unique trauma cases by first listed race, 2020

First-listed race	N	%
White	4,219	87.2%
American Indian	503	10.4%
Other	40	0.8%
Unknown	29	0.6%
Black	22	0.5%
Asian	18	0.4%
Native Hawaiian or Other Pacific Islander	5	0.1%
All	**4,836**	**100.0%**

OUTCOMES

CASE FATALITY RATE

There were 221 fatal trauma cases during 2020 (Figure 10) for a case fatality rate (CFR) of 4.6% (221/4,836). The CFR was 5.4% among males and 3.4% for females. Figure 11 shows variation in CFR by age and sex, and Figure 12 shows variation by ISS category.

Response time, on-scene time, and transport time[3], of the first EMS 911 responder were not statistically significant predictors of in-hospital mortality (P = 0.07, 0.61 and P = 0.44, respectively) in a model that adjusted for patient age and sex, while EMS lowest GCS score and higher ISS both predicted increased risk of mortality (P<0.0001 and P<0.0001, respectively).

Figure 10. Deaths by facility designation level, Unique trauma cases, 2020

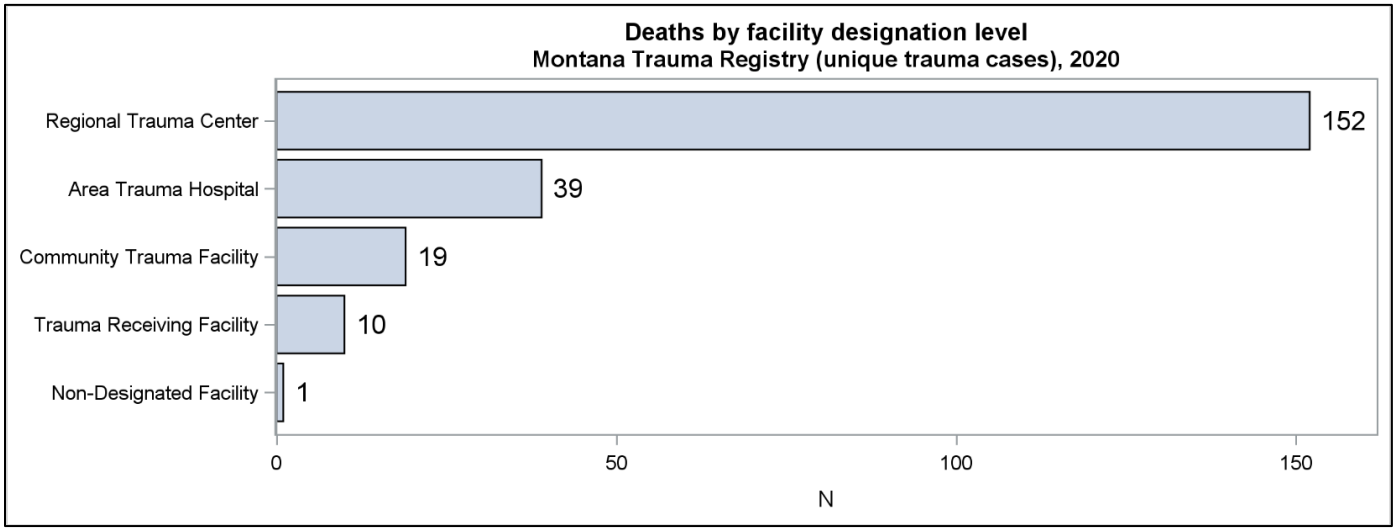
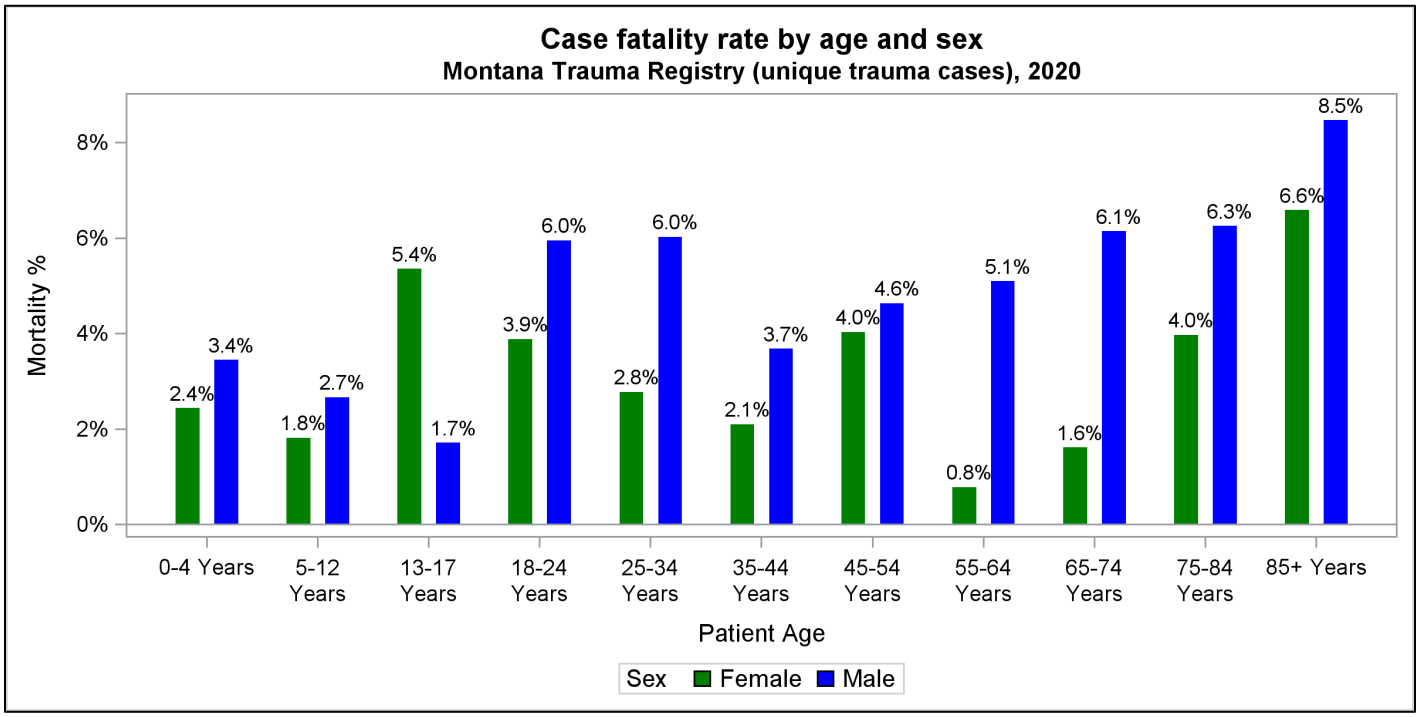
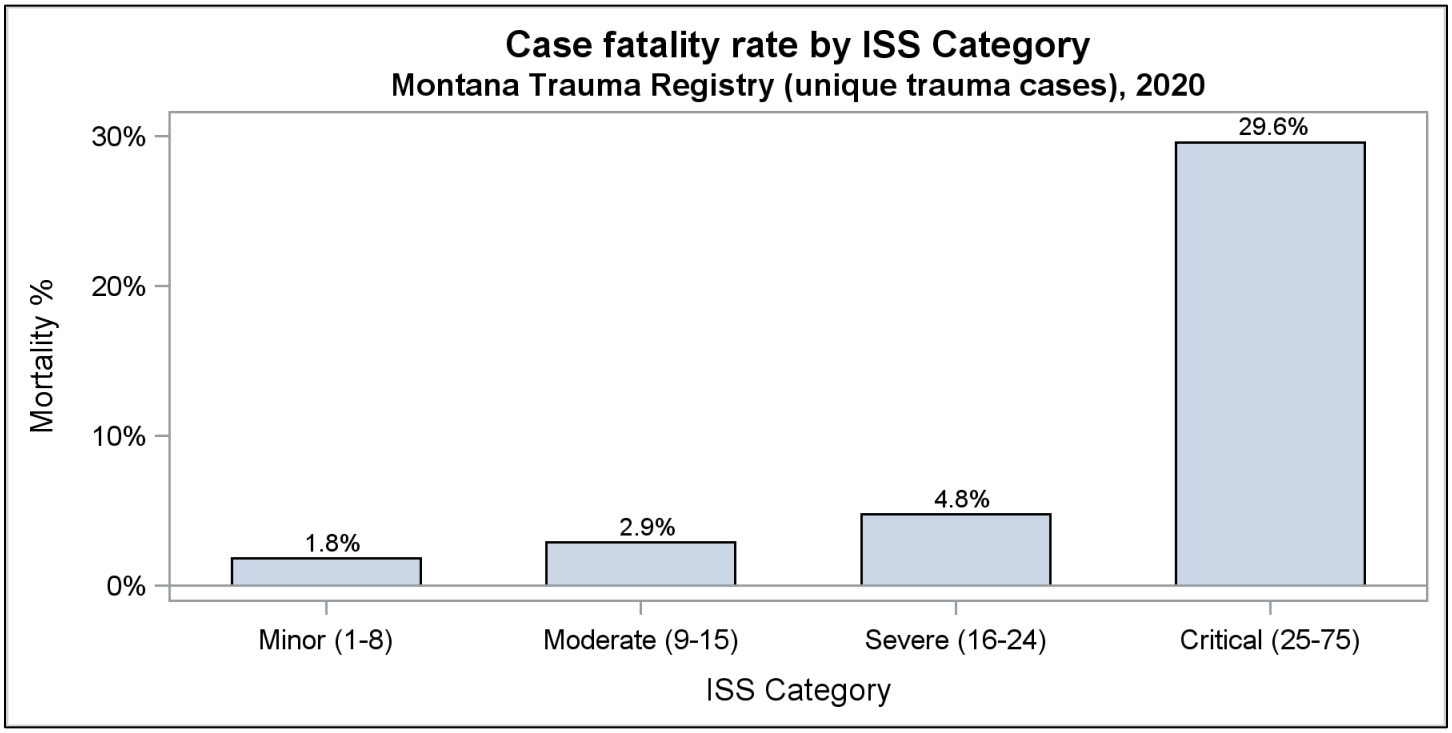


Figure 11. Case fatality rate by age and sex, Unique trauma cases, 2020



[3] Unit notified by dispatch to unit on scene; unit on-scene to unit left scene; unit left scene to unit arrived at the receiving hospital

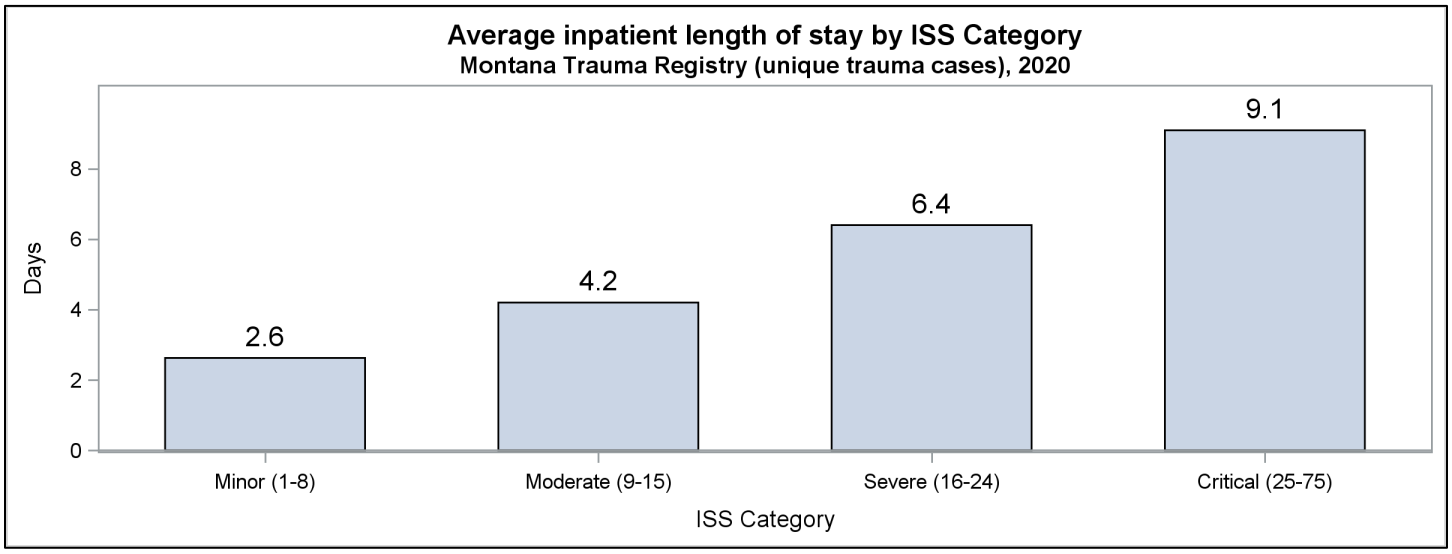
Figure 12. Case fatality rate by ISS category, Unique trauma cases, 2020



INPATIENT LENGTH OF STAY

The average inpatient length of stay (LOS) for unique trauma cases at the final treatment facility was 4.21 days. Higher ISS was correlated with longer length of stay (F=130.95, <0.0001) (**Figure 13**).

Figure 13 Average LOS by ISS category, Unique trauma cases, 2020.



INJURY INFORMATION

INJURY TYPE

The majority of injuries (>90%) in the Montana trauma registry are blunt traumas. Penetrating trauma makes up around 5%, and burns comprise around 1%.

Table 9. Total trauma record and unique trauma case count by primary injury type, 2020

Injury Type	Total trauma records		Unique Trauma cases*	
	N	%	N	%
Blunt	4,994	91.7%	4,447	92.0%
Penetrating	290	5.3%	246	5.1%
Burn	48	0.9%	47	1.0%
Other and/or Unspecified	87	1.6%	74	1.5%
Not Classified	8	0.1%	7	0.1%
Missing	18	0.3%	15	0.3%
All	**5,445**	**100.0%**	**4,836**	**100.0%**

*Type of injury information taken from primary external cause code of last facility the patient received care at

INJURY CAUSE

We used Trauma Quality Improvement Program (TQIP) standards to categorize injuries by mechanism and intent, based on the primary external cause code (99.7% completeness). Unintentional fall was the top cause of injury, accounting for just over 50% of all unique trauma cases (**Table 10**). Among patients aged 0-17 years and patients aged 18-64 years, unintentional falls made up 30% of cases, compared to 80% among those 65 years and older. Unintentional MVT-Occupant was the second leading cause of injury overall, accounting for 12.6% of all cases (**Table 10**). MVT-Occupant made up 16% of cases for patients aged 0-17 years, 19% for those aged 18-64 years, and 5% for those aged 65 and older.

Table 10. Top 10 causes of injury, Total trauma records and unique trauma cases, 2020

Cause of injury (TQIP)		Total trauma records		Unique Trauma cases*	
		N	%	N	%
1	Unintentional-Fall	2,761	50.7%	2,556	52.9%
2	Unintentional-MVT- Occupant	713	13.1%	610	12.6%
3	Unintentional-Other Transport	345	6.3%	304	6.3%
4	Unintentional-MVT- Other	285	5.2%	195	4.0%
5	Unintentional-Struck By/Against	163	3.0%	145	3.0%
6	Unintentional-MVT- Motorcyclist	149	2.7%	139	2.9%
7	Assault/Homicide-Struck By/Against	122	2.2%	109	2.3%
8	Unintentional-Natural/Environmental- Other	108	2.0%	82	1.7%
9	Unintentional-Pedal Cyclist- Other	101	1.9%	92	1.9%
10	Unintentional-Other Specified- Classifiable	97	1.8%	84	1.7%
	All Top 10	4,844	89.0%	4,316	89.2%
	Other	583	10.7%	505	10.4%
	Missing	18	0.3%	15	0.3%
	Total	**5,445**	**100.0%**	**4,836**	**100.0%**

Patients aged 65 and older accounted for over two-thirds (69%) of all unintentional fall-related trauma cases. Patients younger than 45 accounted for 60% of motor vehicle traffic-related trauma cases. Nearly 4 out of 5 (79%) of the self-harm injuries were among those younger than 45, and similarly 73% of all assault injuries were among those aged 45 years or younger (**Table 11**).

Table 11. Unique trauma cases by major causes of injury and age group, 2020

Age group	Unintentional Injuries												Intentional Injuries			
	Falls		Motor Vehicle Traffic		Other Transport		Struck by/ Against		Natural/ Environmental		All Other Unintentional		Self-harm		Assault	
	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%
0-17 years	126	4.9%	101	9.9%	74	17.3%	32	22.1%	12	11.9%	30	12.2%	11	15.9%	11	4.9%
18-44 years	199	7.8%	509	49.8%	139	32.6%	47	32.4%	26	25.7%	94	38.4%	45	65.2%	153	68.6%
45-64 years	456	17.8%	241	23.6%	125	29.3%	25	17.2%	26	25.7%	74	30.2%	6	8.7%	52	23.3%
65+ years	1,775	69.4%	172	16.8%	89	20.8%	41	28.3%	37	36.6%	47	19.2%	7	10.1%	7	3.1%
All	**2,556**	**100%**	**1,023**	**100.0%**	**427**	**100%**	**145**	**100%**	**101**	**100%**	**245**	**100.0%**	**69**	**100%**	**223**	**100%**

Table 12. Unique trauma cases by injury mechanism and intent, 2020

Mechanism (TQIP)	Intent (TQIP)					All
	Unintentional	Self-harm/ Suicide	Assault/ Homicide	Other/ Undetermined	Missing	
	N	N	N	N	N	N
Cut/Pierce	39	18	62	4		**123**
Fall	2,556	7		2		**2,565**
Fire/Flame	38					**38**
Hot Object or Substance	8			1		**9**
Firearm	29	26	36	13		**104**
Machinery	22					**22**
MVT- Occupant	610	1				**611**
MVT- Motorcyclist	139					**139**
MVT- Pedal Cyclist	10					**10**
MVT- Pedestrian	64					**64**
MVT- Other	195	2				**197**
MVT- Unspecified	5					**5**
Pedal Cyclist- Other	92					**92**
Pedestrian- Other	31					**31**
Other Transport	304					**304**
Natural/Environmental- Other	82					**82**
Overexertion	9					**9**
Struck By/Against	145		109	6		**260**
Suffocation/Asphyxiation		6	1			**7**
Other Specified- Classifiable	84		6	1		**91**
Other Specified, Not Elsewhere Classifiable	16	9		5		**30**
Natural/Environmental- Bites and Stings	19					**19**
Unspecified			9			**9**
Missing					15	**15**
All	**4,497**	**69**	**223**	**32**	**15**	**4,836**

INJURY SEVERITY

Injury severity score (ISS) is an anatomical scoring system that provides an overall score for patients with multiple injuries. The ISS has values from 1-75 with 1-9 as mild, 10-15 as moderate, 16-24 as severe, and over 24 as critical. ISS was missing for less than one percent of the records (**Table 13**).

Table 13. Injury severity score, Unique trauma cases, 2020

ISS category	N	%
Minor (1-8)	1,749	36.2%
Moderate (9-15)	2,159	44.6%
Severe (16-24)	588	12.2%
Critical (25-75)	331	6.8%
Missing	9	0.2%
All	**4,836**	**100.0%**

Certain causes of injury resulted in consistently more severe injuries, including self-harm, intentional firearm injuries, and motorcyclist injuries (**Table 14**).

Table 14. Cause of injury with average ISS >15, Unique trauma cases, 2020

Cause of injury (TQIP)	Total N	Mean ISS
Other/Undetermined-Firearm	13	21.5
Self-harm/Suicide-Other Specified- Not Elsewhere Classifiable	9	19.2
Self-harm/Suicide-Firearm	26	16.9
Unintentional-MVT- Motorcyclist	139	16.3
Self-harm/Suicide-Fall	7	16.3
Assault/Homicide-Firearm	36	16.3

There were N=2,715 unique trauma cases linked with an EMS 911 response record, and 21% of these (N=570) had an ISS >15. Using the linked dataset, we found that several EMS field triage criteria correlated with a greater probability of ISS >15 (major trauma) in multivariate analysis ($p<0.05$) adjusted for patient age and sex. This is important because it demonstrates that utilizing the CDC field triage criteria can assist EMS providers in accurately identify severely injured patients in the field.

Table 15. EMS-documented field triage criteria associated with increased probability of major trauma (adjusted model), Unique trauma cases linked with EMS, 2020

Code	Field Triage Criteria	Total N	N with ISS >15	Odds Ratio	P-Value
2903005	Chest wall instability or deformity (e.g., flail chest)	22	14	3.72	0.01
2903007	Glasgow Coma Score <= 13	151	88	3.00	<.0001
2903019	Systolic Blood Pressure <90 mmHg	31	21	2.92	0.01
2904003	Fall Adults: > 20 ft. (one story is equal to 10 ft.)	23	11	2.58	0.04
2904009	Crash Ejection (partial or complete) from automobile	61	33	2.13	0.01
2904015	Motorcycle Crash > 20 MPH	50	24	2.08	0.02

WORK-RELATED INJURY

Work-related trauma is defined as an injury that occurs during paid employment. There were 155 work-related trauma cases (3.2% of all unique trauma cases), including 5 fatalities. **Table 16** shows the industry associated with the patient's work environment for work-related unique trauma cases. Construction is the largest industry category (31.6%), followed by agriculture/forestry/fishing (21.9%) (**Table 16**). Falls were the most common cause of injury, accounting for 43.9% of work-related trauma cases (**Table 17**).

Table 16. Work-related unique trauma cases by industry, 2020

Occupational Industry	Unique Trauma Cases		Fatalities	
	N	%	N	%
Construction	49	31.6%	1	20.0%
Agriculture, Forestry, Fishing	34	21.9%		
Other Services	24	15.5%	2	40.0%
Transportation and Public Utilities	15	9.7%	1	20.0%
Unknown	9	5.8%		
Retail Trade	5	3.2%		
Professional and Business Services	4	2.6%	1	20.0%
Leisure and Hospitality	4	2.6%		
Natural Resources and Mining	3	1.9%		
Finance, Insurance, and Real Estate	3	1.9%		
Government	2	1.3%		
Manufacturing	1	0.6%		
Information Service	1	0.6%		
Wholesale Trade	1	0.6%		
All	**155**	**100.0%**	**5**	**100.0%**

Table 17. Work related unique trauma cases by cause of injury, 2020

Cause of injury	N	%
Unintentional-Fall	68	43.9%
Unintentional-Motor Vehicle Traffic	16	10.3%
Unintentional-Other Transport	14	9.0%
Unintentional-Other Specified- Classifiable	13	8.4%
Unintentional-Struck By/Against	13	8.4%
Unintentional-Natural/Environmental- Other	12	7.7%
Unintentional-Machinery	8	5.2%
Unintentional-Cut/Pierce	5	3.2%
Unintentional-Pedestrian- Other	4	2.6%
Unintentional-Fire/Flame	1	0.6%
Assault/Homicide-Cut/Pierce	1	0.6%
All	**155**	**100.0%**

UNINTENTIONAL TRANSPORTATION-RELATED TRAUMA[4]

Unintentional transportation incidents were the leading cause of fatal injury in Montana from 2009-2018. In 2020, MTR captured 1,113 unique trauma cases involving a motor vehicle (MV) occupant injury, and an additional 350 transportation-related cases including animal riders (N=131), pedal cyclists (N=103), and pedestrians (N=98).

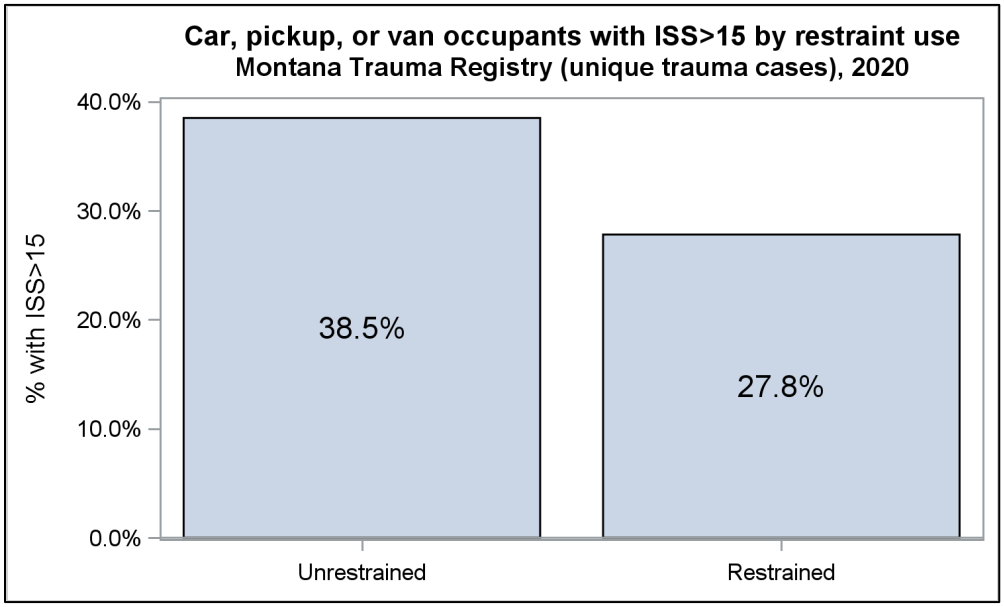
Table 18. Unintentional transportation related injury by person type, Unique trauma cases, 2020

Mechanism	Motor Vehicle Occupant	Other Person Type	Total N	Average ISS
MOTOR VEHICLE-NONTRAFFIC	317		317	11.61
3- or 4-wheeled ATV	*97*			
Car	*94*			
Motorcycle	*53*			
Pick-up truck or van	*27*			
Dirt bike or motocross bike	*22*			
Three-wheeled motor vehicle	*15*			
Heavy transport vehicle	*5*			
Unspecified vehicle	*4*			
MVT-MOTORCYCLIST	139		139	16.34
MVT-OCCUPANT	617		617	13.71
Car	*459*			
Pick-up truck or van	*99*			
3- or 4-wheeled ATV	*32*			
Heavy transport vehicle	*11*			
Unspecified vehicle	*5*			
Other special all-terrain or off-road motor vehicle	*3*			
Three-wheeled motor vehicle	*3*			
Bus	*2*			
Special agricultural vehicle	*1*			
Snowmobile	*1*			
Dirt bike or motocross bike	*1*			
OTHER LAND TRANSPORT	40	132	172	10.92
Animal Rider		*131*		
Other special all-terrain or off-road motor vehicle	*23*			
Snowmobile	*14*			
Special agricultural vehicle	*2*			
Special industrial vehicle	*1*			
Unspecified Vehicle		*1*		
OTHER TRANSPORT	0	17	17	11.35
Air transport		*9*		
Water transport		*7*		
Other specified		*1*		
MVT-PEDAL CYCLIST		10	10	14.20
PEDAL CYCLIST, OTHER		93	93	10.02
MVT-PEDESTRIAN		67	67	15.51
PEDESTRIAN, OTHER		31	31	13.29
All	**1,113**	**350**	**1,463**	**12.99**

[4] MTR final facility record's first or second external cause of injury code = ICD-10-CM codes V01-V99

Of 679 car, pick-up truck, or van occupants, 41.8% were restrained (N=284), 45.5% were unrestrained (N=309), and 12.7% (N= 86) had unknown restraint use. Among those with known restraint status, 38.5% of unrestrained occupants had ISS>15 versus 27.8% of restrained occupants (X^2= 7.61, p < 0.0058) (**Figure 14**).

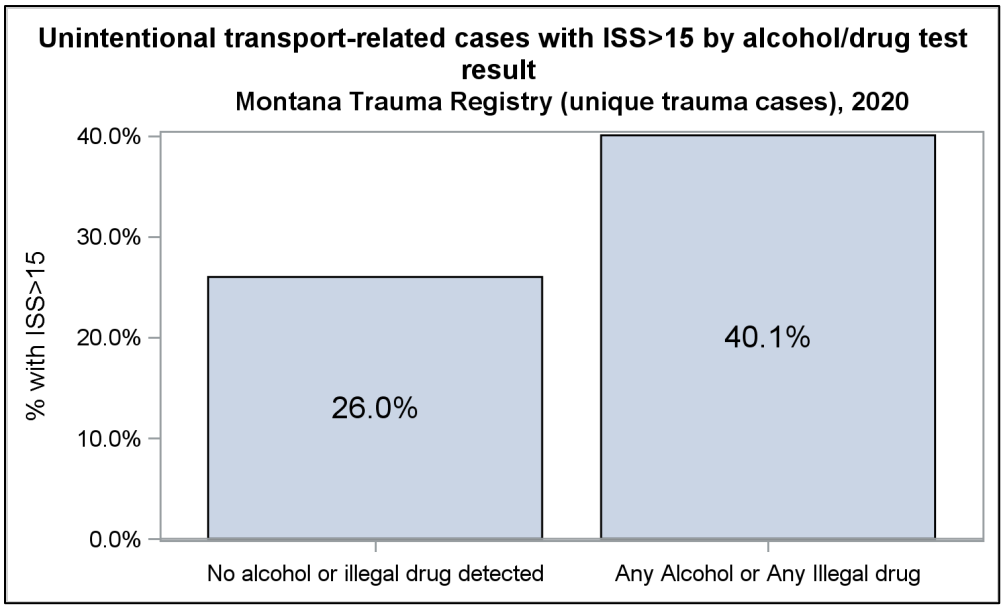
Figure 14. Percent of car, pick-up truck, or van occupants with ISS>15 by restraint use, 2020



Alcohol (any amount) was detected in 32.2% (N=471) of unintentional transport-related trauma cases, while levels above the legal limit were detected in 23.6% (N=345) of cases. 36.4% were negative for alcohol upon testing, and 31.3% of cases were not tested for alcohol **(Figure 16)**.

40.2% of cases (N=589) had any alcohol or illegal drugs detected with testing. Cases with alcohol or drugs were more likely to have ISS>15 versus those with no alcohol or drugs (40.1% versus 26.0% respectively) (X^2= 32.16, p < 0.0001) **(Figure 15)**.

Figure 15. Percent of unintentional transportation-related unique trauma cases with ISS>15 by alcohol/drug test result, 2020



Cannabis was found in 15.3% of all cases, and in 28.2% of cases where alcohol was also detected. Alcohol and cannabis was the most common poly-substance combination, followed by alcohol and opioids, then alcohol, cannabis, amphetamine, and methamphetamine (**Figure 16**, **Figure 17**).

Figure 16. Alcohol and drugs detected in transportation-related unique trauma cases, 2020

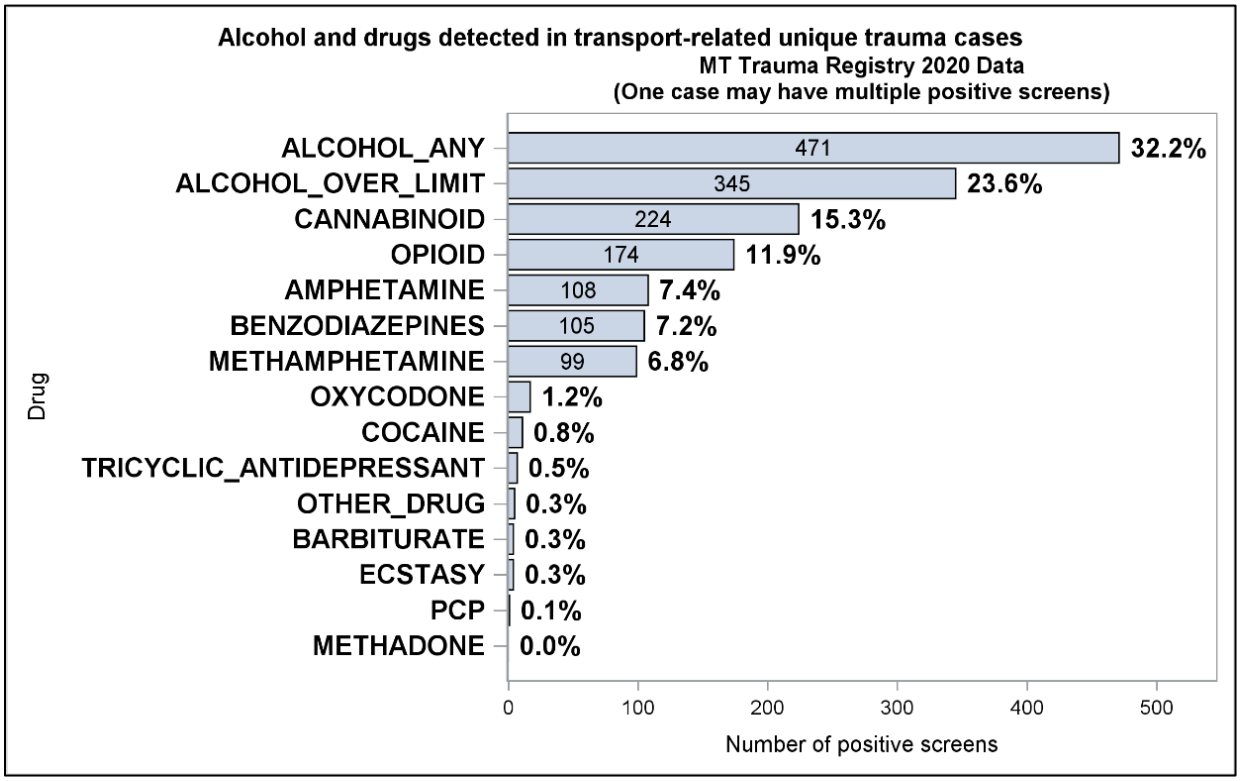
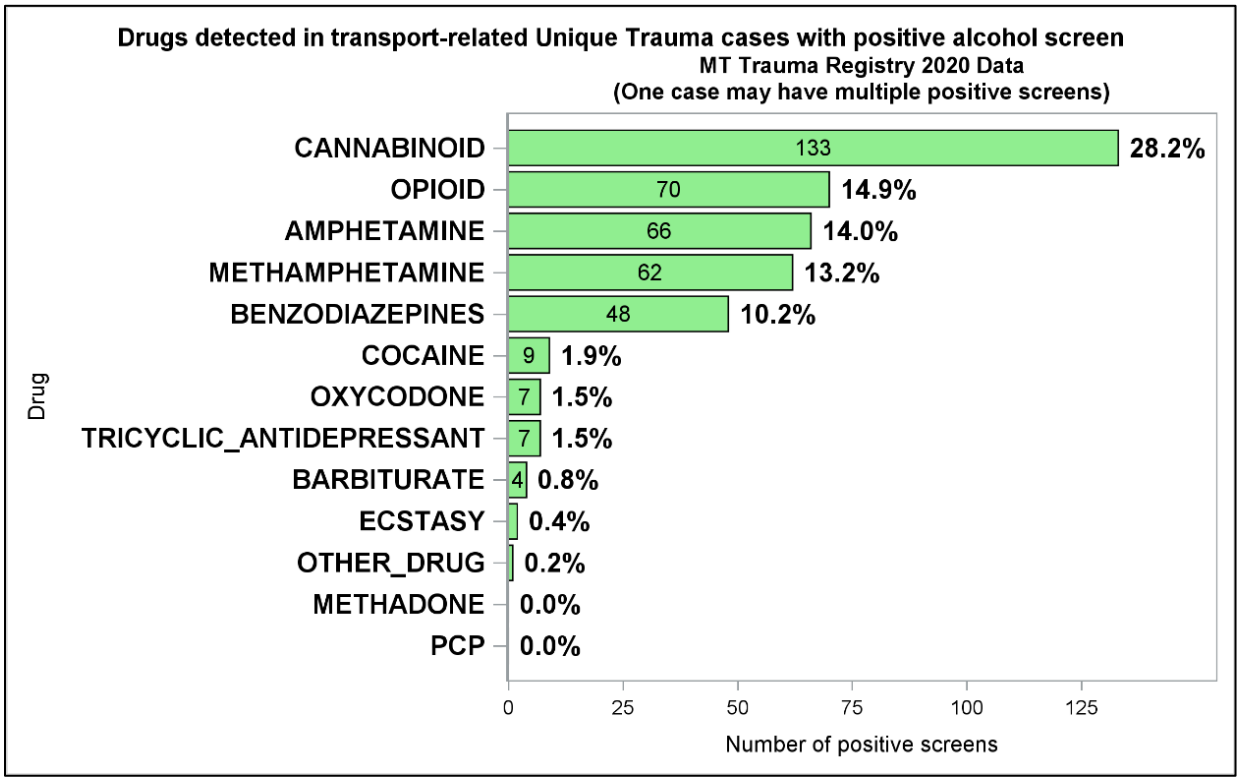


Figure 17. Drugs detected in transportation-related unique trauma cases with positive alcohol screen, 2020



FIREARM-RELATED TRAUMA[5]

Firearm related injuries were the second most common fatal injury mechanism in Montana from 2009-2018. In 2020, MTR captured 107 firearm-related trauma cases, 27 of which died in the health facility resulting in a CFR of 25.2%.

Nearly 90% (N=94) of firearm-related trauma cases were males. 65.4% (N=70) involved a handgun, 14.0% (N=15) involved a rifle, shotgun, or larger firearm, and 20.6% were other or unspecified firearms. There were no significant variations in case fatality rate by sex or type of firearm.

64% of the cases (N=68) were intentional injuries, including self-harm, assault, and legal/war (**Table 19**). The case fatality rate was highest for self-harm injuries at nearly 60% (X^2=25.3, p<0.0001). Self-harm cases also had the lowest mean initial GCS of 6.5. Legal/war firearm injuries resulted in the highest injury severity on average (29.6), as well as the lowest functional independence measures (FIM)[6]. Assault injuries resulted in the longest average inpatient stays of 7.7 days (**Table 19**).

Table 19. Firearm injury outcomes by intent, unique trauma cases, 2020

Intent	Total N	Deaths	Case Fatality Rate	Mean ISS	Mean Inpatient LOS (Days)	Mean Initial ED GCS	FIM Score at discharge
Unintentional	31	1	3.2%	9.9	3.3	13.7	11.3
Self-harm/Suicide	26	15	57.7%	16.9	2.3	6.5	11.5
Assault/Homicide	37	6	16.2%	16	7.7	12.5	10.9
Undetermined	8	3	37.5%	16.4	2.9	10.5	12.0
Legal/War	5	2	40.0%	29.6	5.3	6.8	7.0
All	**107**	**27**	**25.2%**	**15.1**	**4.9**	**11.1**	**11.0**

[5] MTR final facility record external cause of injury codes contains ICD-10-CM firearm injury code

[6] MTR uses a truncated form of the FIM score, including three items (self-feeding, locomotion, and verbal expression), each graded on a scale of 1 to 4 (1-full functional dependence, 2-partially dependent, 3-independent with device, 4-independent). A score of 12 would indicate fully independent.

UNINTENTIONAL FALL-RELATED TRAUMA[7]

There were 2,623 unintentional fall-related unique trauma cases in 2020 in MTR. 54% (N=1,416) were females, and 82% (N=2,157) were aged 55 or older. There were 118 in-hospital deaths due to falls for a CFR of 4.5% (3.4% for females and 5.8% for males). 53 patients had two or more separate fall-related cases captured in MTR during 2020 (the maximum for a single patient was 4). Most (92%) of the repeat fall patients were aged 55 and older. About 1 in 5 (N=528) fall-related cases involved an interfacility transfer. **Table 20** shows outcomes for fall-related cases by interfacility transfer status.

Table 20. Outcomes for unintentional fall-related unique trauma cases, MTR 2020

Transfer status	Total N	Deaths	Case Fatality Rate	Mean ISS*	Mean Inpatient LOS (Days)*	Mean Initial ED GCS*	Mean FIM Score at Discharge*
Interfacility transfer	528	30	5.7%	11.2	4.7	13.8	10.3
No interfacility transfer	2,095	88	4.2%	8.7	4.4	14.6	10.4
All	**2,623**	**118**	**4.5%**	**9.2**	**4.5**	**14.1**	**10.4**

*at final treatment facility

Among patients aged 55 and older, over 60% of trauma cases were due to same-level falls and slipping, tripping, or stumbling (**Table 21**). 32.1% (N=693) of falls among age 55 and older involved a hip fracture and 22.0% (N=474) involved a traumatic brain injury (TBI). Over 75% of major trauma (ISS>15) fall injuries among patients age 55 and older involved a TBI.

Table 21. Types of Falls among patients age 55 and older, Unique trauma cases, 2020

	Type of Fall	N	%
1	Fall on same level from slipping, tripping and stumbling	1,038	48%
2	Other slipping, tripping and stumbling and falls	312	14%
3	Unspecified fall	226	10%
4	Fall on and from stairs and steps	183	8%
5	Fall on and from ladder	89	4%
6	Fall due to ice and snow	72	3%
7	Fall from bed	52	2%
8	Other fall from one level to another	51	2%
9	Fall from chair	41	2%
10	Fall from non-moving wheelchair, nonmotorized/motorized scooter	27	1%
	All Top 10	2,091	97%
	Other	66	3%
	Total	**2,157**	**100%**

[7] MTR final facility record contains ICD-10-CM code for unintentional falls, or Intent/Mechanism fields indicate unintentional fall

Overall, 23.4% of fall cases were activated on at the final treatment facility, with variation by age group. Comparing TTA rates (**Figure 18**) and case fatality rates (**Figure 19**) by age group reveals that older age groups (75-84, 85+) have the lowest TTA rates despite having higher CFRs.

Figure 18. TTA rate for fall-related trauma by age group, Unique trauma cases, 2020

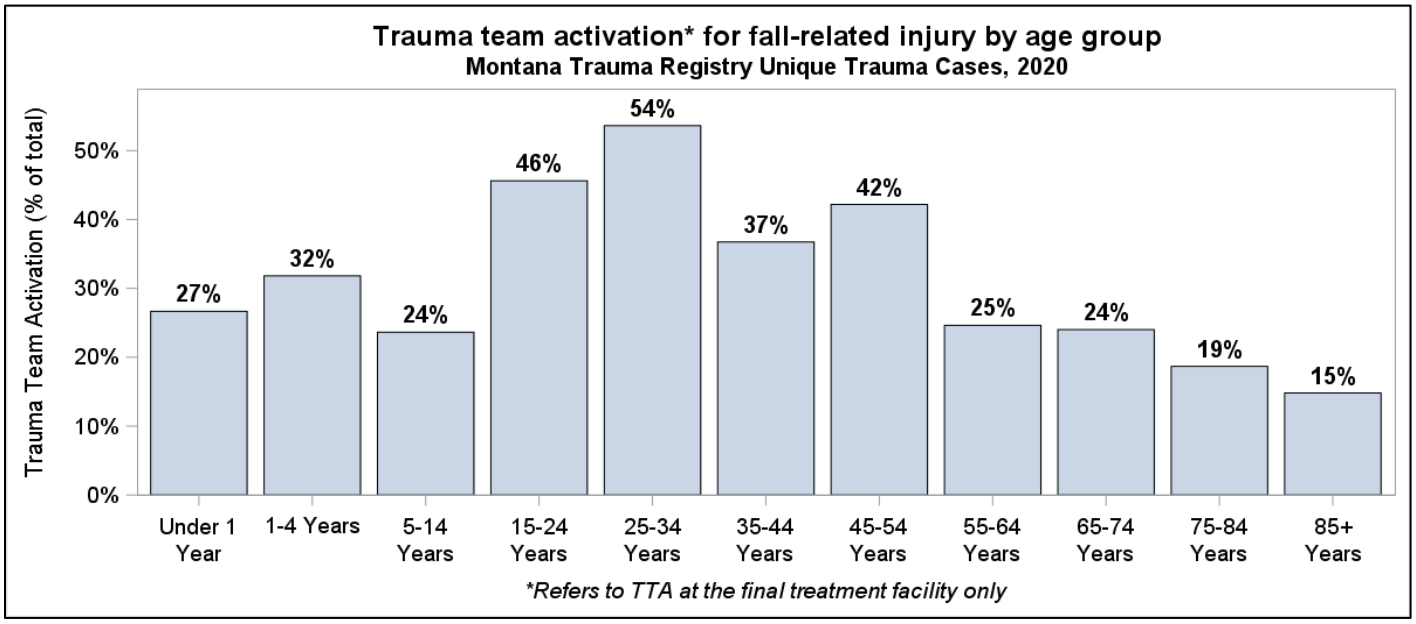
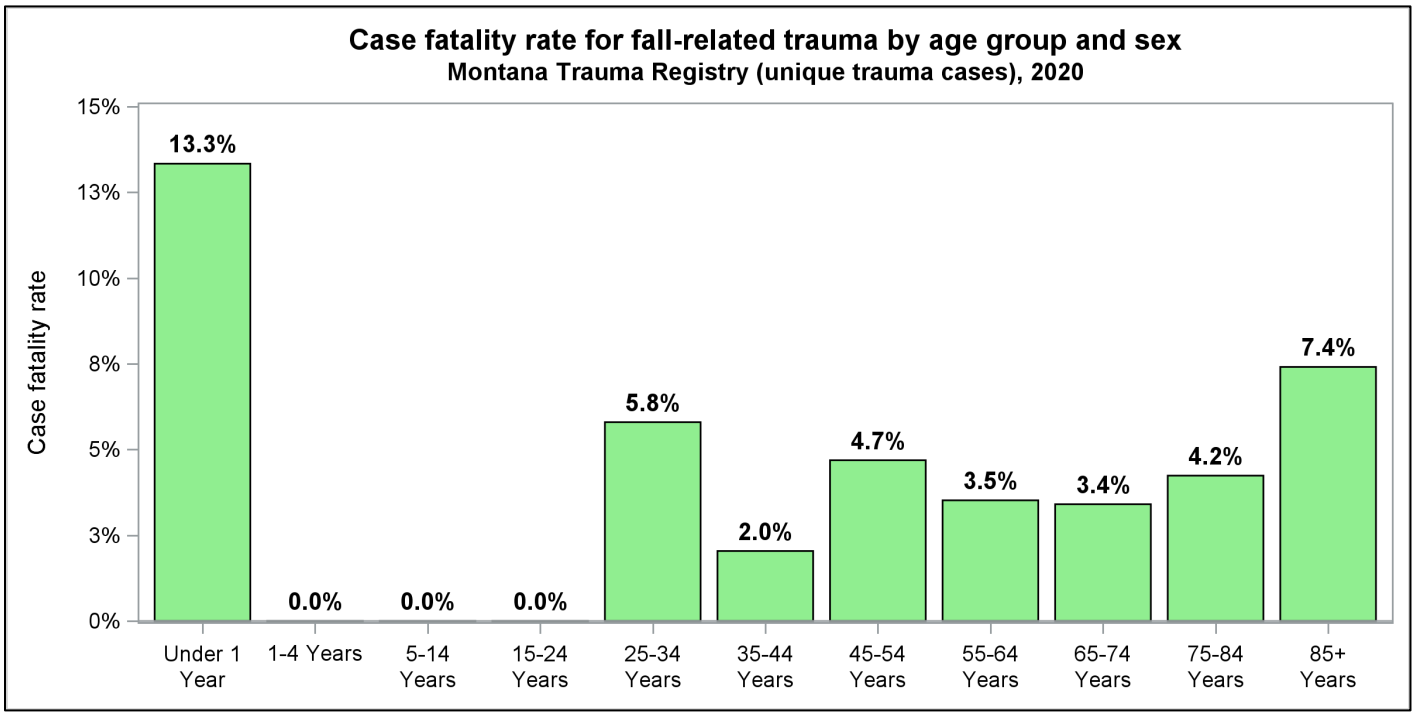


Figure 19. Case fatality rate for fall-related trauma by age group, Unique trauma cases, 2020



TRAUMATIC BRAIN INJURY (TBI)[8]

There were 1,247 TBI-related unique trauma cases reported in MTR during 2020 with 115 fatalities, resulting in a CFR of 9.2%. Table 22 shows variation in CFR and other outcome measures by TBI severity level[9]. **Figure 20** shows variation in survival rates by TBI severity level.

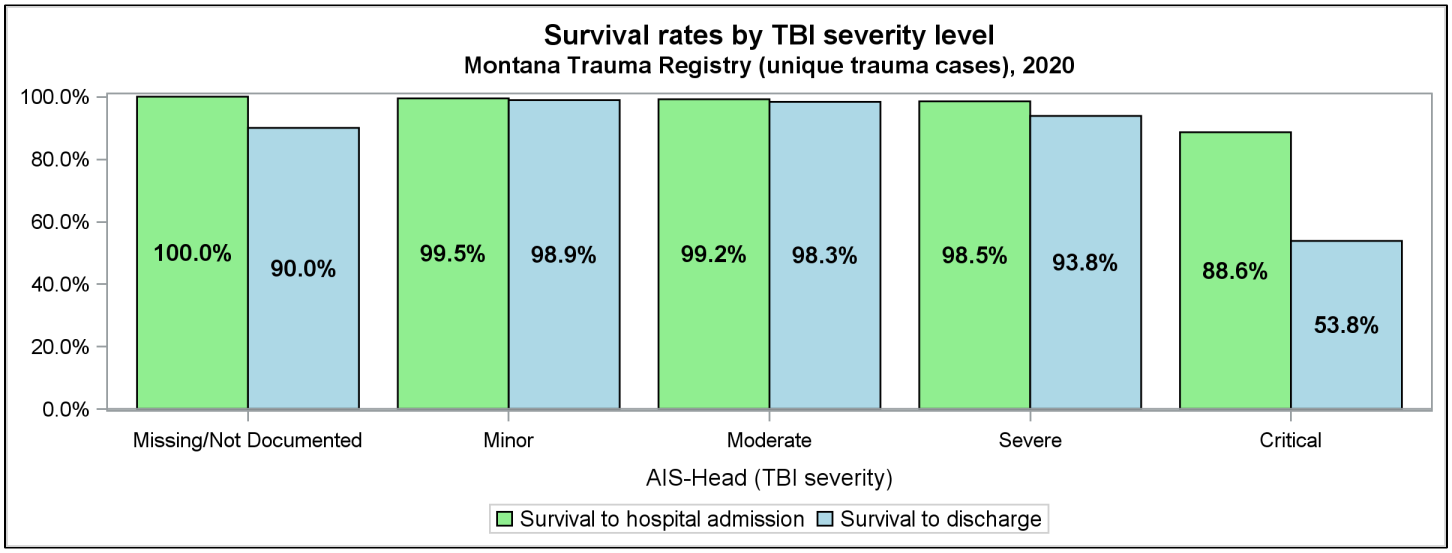
The main injury mechanisms leading to TBI were unintentional falls (49.8%), and unintentional transportation-related injuries (38.1%).

Table 22. Outcomes for TBI-related unique trauma cases by severity level, 2020

TBI severity	Total N	Deaths	Case fatality rate	Mean ISS*	Mean Inpatient LOS (Days)*	Mean Discharge GCS*	Mean FIM Score at Discharge*
Not documented	10	1	10.0%	19.6	4.3	15.0	12.0
Minor	182	2	1.1%	8.0	3.3	14.9	11.0
Moderate	362	6	1.7%	10.2	3.2	14.2	10.7
Severe	535	33	6.2%	15.5	4.3	14.2	10.1
Critical	158	73	46.2%	29.3	7.5	8.0	6.9
All	**1,247**	**115**	**9.2%**	**14.6**	**4.2**	**14.2**	**10.4**

*at final treatment facility

Figure 20. Survival rates by TBI severity, Unique trauma cases, 2020



944 TBI-related unique trauma cases were linked with at least one EMS record. EMS provider impression indicated a TBI-specific code in 43% of the linked cases (N=410). Among EMS records without a TBI-specific code, other commonly documented codes included “Injury-NOS (T14.90)”, “Acute pain due to trauma (G89.11)”, “Neuro/LOC-Altered Mental Status (R41.82)”. This can inform improved TBI surveillance using the EMS dataset.

In 2021, EMSTS initiated training for EMS agencies and hospitals on new TBI treatment, EPIC-MT. EPIC trains providers to avoid the 3 H’s (hyperventilation, hypoxia, and hypotension). EMS, as well as

[8] MTR final facility record diagnosis codes must include: S02.0, S02.1, S02.8X, S02.80, S02.81, S02.82, S02.91, S04.02, S04.03, S04.04, S06, S07.1 (7th character of A, B, or missing (reflects initial encounter, active treatment)
In the FY 2017 (effective Oct 1, 2016), S02.8 was expanded to include several subcodes (S02.80, S02.81, and S02.82) and the parent code S02.8X was retired. These subcodes should be included in the selection criteria for the indicator if using data for hospital discharges after Oct 1, 2016. In FY 2020 (effective Oct 1, 2019), S02.8 was expanded again to include S02.83, S02.84 and S02.85. These subcodes are NOT considered to be TBI (fractures to the medial/lateral orbital wall, or unspecified fractures of the orbit)
[9] TBI severity level based on Abbreviated Injury Scale (AIS)-Head: 1=Minor, 2=Moderate, 3-4=Severe, 5-6=Critical

facility-based care providers, are trained to recognize and manage these conditions to improve outcomes in severely injured TBI patients. To establish a baseline for assessing improvements over time, we used linked EMS and trauma data to assess documentation of hypotension and hypoxia across the care continuum. The figures below show differences in the level of hypotension and hypertension captured in the prehospital versus the MTR datasets. In most cases, using linked EMS and MTR data resulted in more complete results.

Figure 21. Percent of TBI-related trauma cases with at least one instance of Hypotension, by data source, Unique trauma cases linked with EMS, 2020

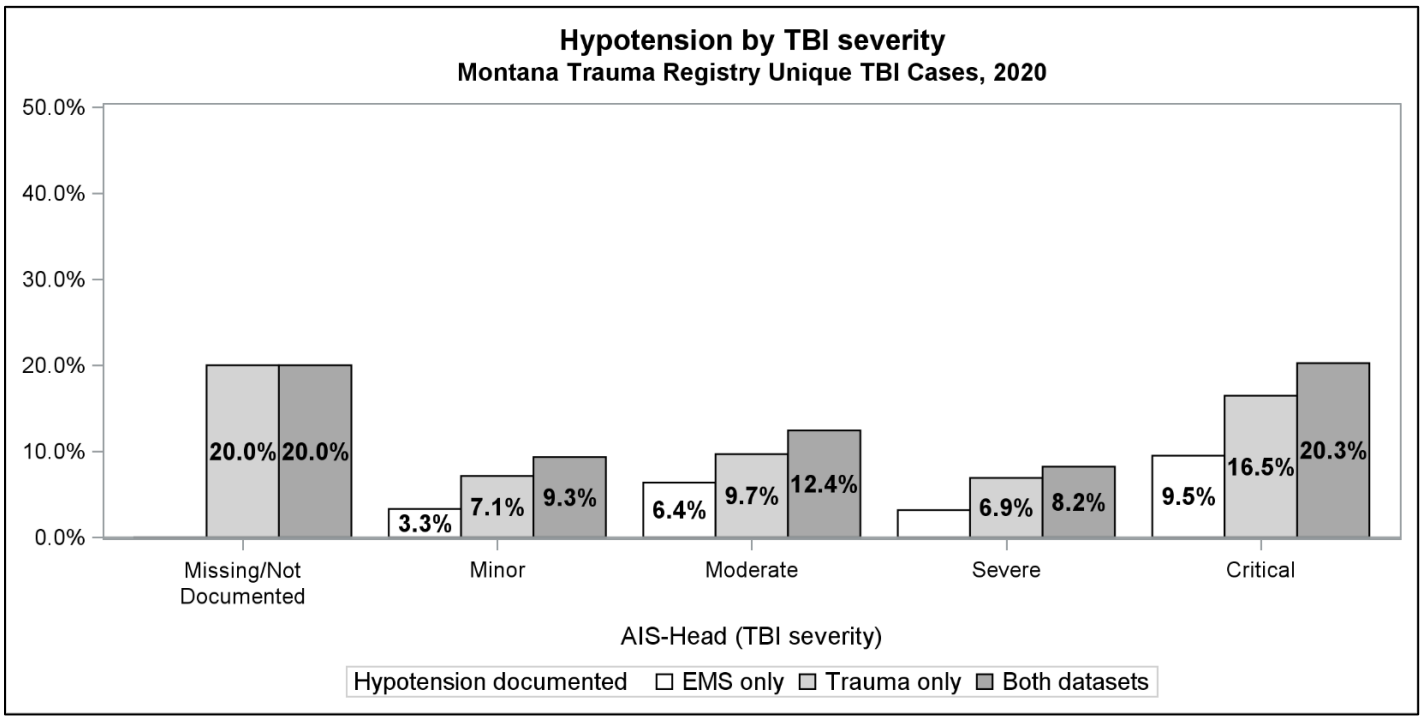
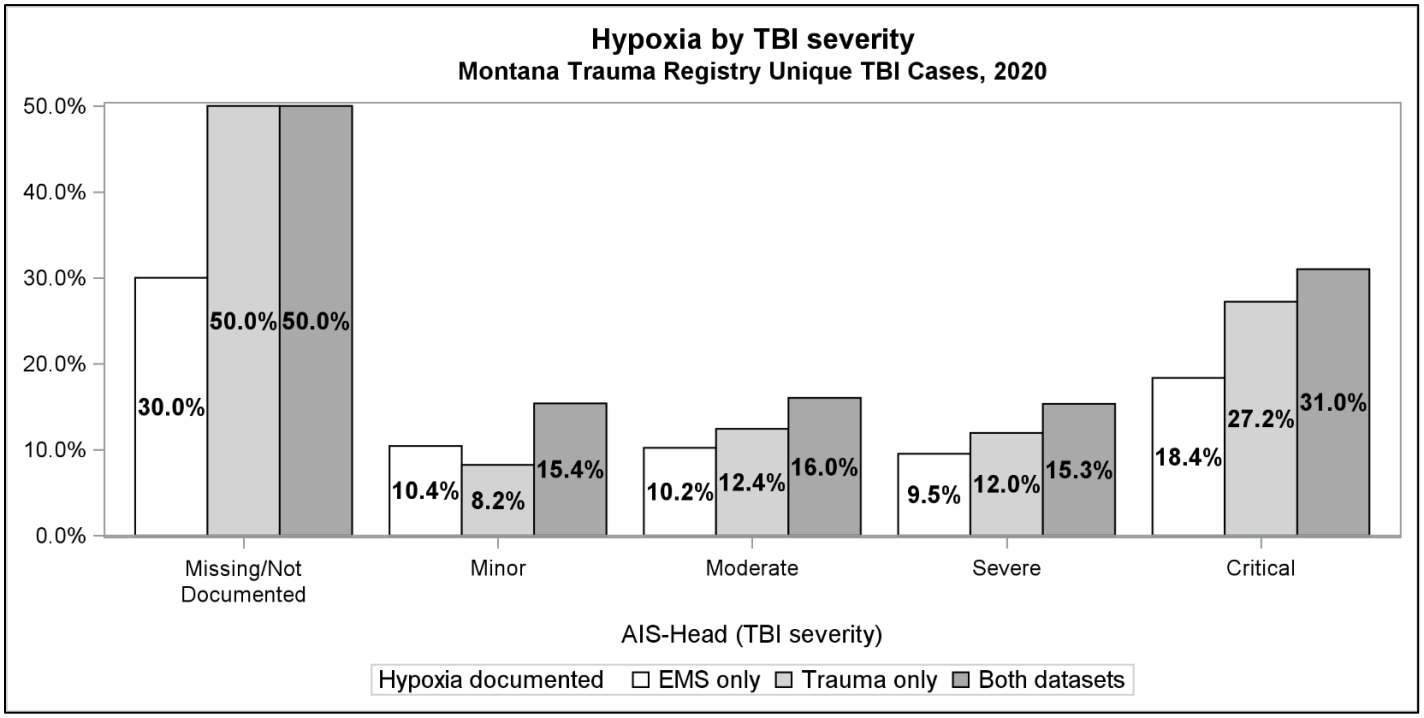


Figure 22. Percent of TBI-related trauma cases with at least one instance of Hypoxia, by data source, Unique trauma cases linked with EMS, 2020

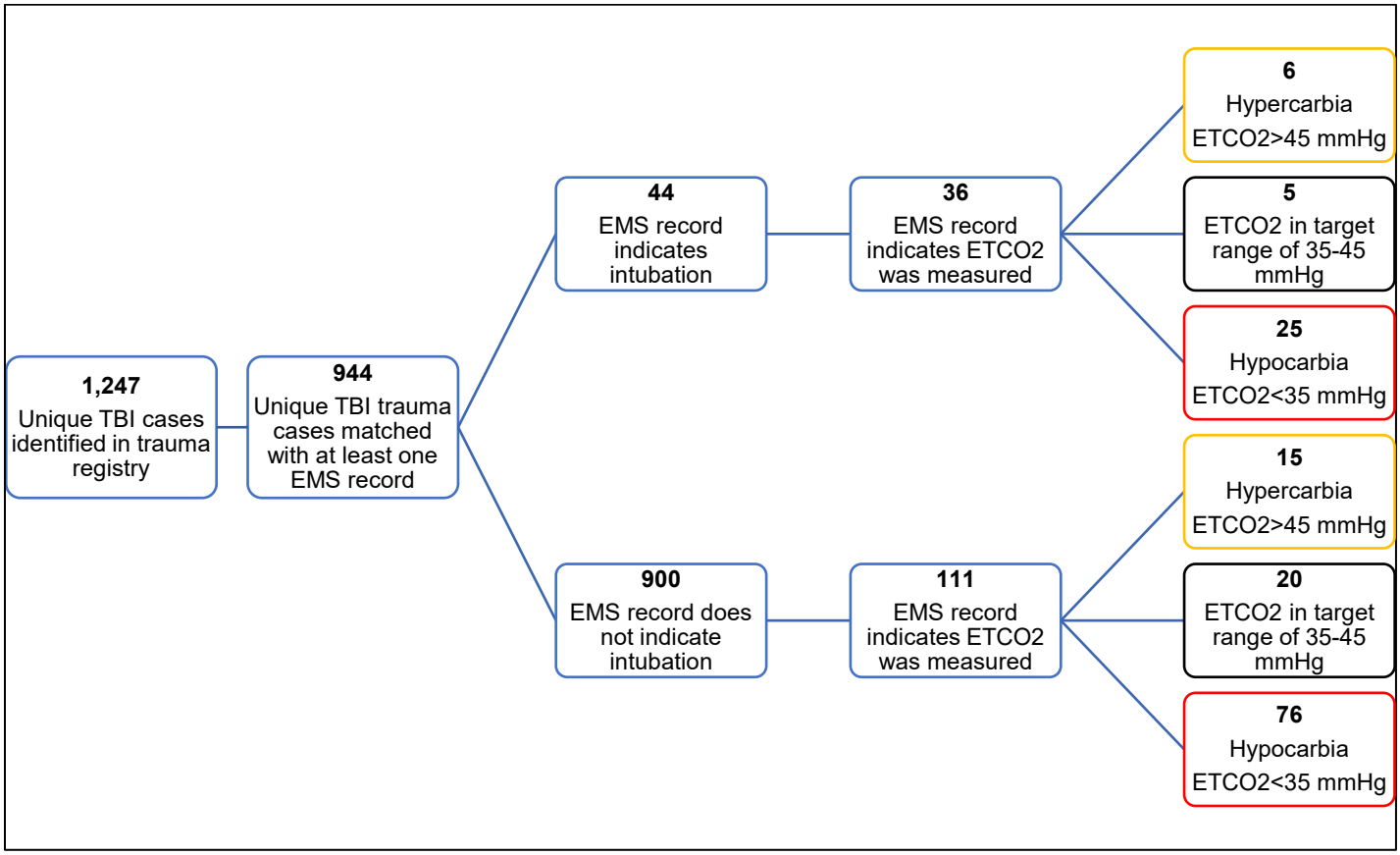


Hypotension is indicated by systolic blood pressure <90 mmHg. Among moderate TBI patients (N=362), 12.4% (N=45) had at least one instance of hypotension using linked EMS/trauma data (versus 9.7% using trauma dataset only, and 6.4% using EMS dataset only), while 8.2% of severe TBI patients (N=44/535) and 20.3% of critical TBI patients (N=32/158) had at least one hypotensive reading (using the linked dataset) (**Figure 21**).

Hypoxia is indicated by oxygen saturation below 90%. Among moderate TBI patients, 16.0% (N=58) had at least one instance of hypoxia (12.4% trauma data, 10.2% EMS data) (**Figure 22**). Using linked data, 15.3% (N=82) of severe TBI and 31.0% (N=49) of critical TBI patients had at least one instance of hypoxia.

Hyperventilation is indicated by end tidal carbon dioxide readings under 35 mmHg (hypocarbia, ETCO2 < 35 mmHg). Ideally, ventilation should be titrated to achieve ETCO2 between 35 and 45 mmHg. ETCO2 readings are not collected in the trauma registry dataset, therefore data from the linked EMS records are used to assess hyperventilation. Of 944 TBI cases linked to EMS records, 44 EMS records indicated that the patient was intubated, 36 of which had ETCO2 measured, and hypocarbia was seen in 69.4% (N=25/36). Among the 900 EMS records that did not indicate intubation, 111 had ETCO2 measurements documented and 68.5% had hypocarbia (N=76/111) (**Figure 23**).

Figure 23. Unique TBI-related trauma cases with EMS intubation and ETCO2 measurement, 2020



APPENDIX 1. List of Facilities

Central Region

Facility	Designation Level
Benefis Healthcare, Great Falls	Regional Trauma Center
St. Peter's Hospital, Helena	Area Trauma Hospital
Northern Montana Hospital, Havre	Community Trauma Hospital
Liberty County Hospital, Chester	Trauma Receiving Facility
Marias Medical Center, Shelby	Trauma Receiving Facility
Mountainview Medical Center. White Sulphur	Trauma Receiving Facility
Pondera Medical Center, Conrad	Trauma Receiving Facility
Benefis Teton Medical Center, Chouteau	Trauma Receiving Facility
Big Sandy Medical Center, Big Sandy	Not Designated
*Broadwater Health Center, Townsend	Not Designated
Missouri River Medical Center, Fort Benton	Not Designated
Northern Rockies Medical Center, Cut Bank	Trauma Receiving Facility
*PHS Indian Hospital - Browning	Not Designated
*PHS Indian Hospital - Harlem	Not Designated
*PHS Indian Hospital - Rocky Boy	Not Designated
Great Falls Clinic - Great Falls	Not Designated
*Shodair Children’s Hospital	Not Designated

Western Region

Facility	Designation Level
Providence St. Patrick Hospital, Missoula	Regional Trauma Hospital
Kalispell Regional Medical Center, Kalispell	Area Trauma Hospital
St. James Healthcare, Butte	Area Trauma Hospital
Clark Fork Valley Hospitals, Plains	Community Trauma Hospital
North Valley Hospital, Whitefish	Community Trauma Hospital
Community Medical Center, Missoula	Community Trauma Hospital
Community Hospital of Anaconda, Anaconda	Community Trauma Hospital
Providence St. Joseph Hospital, Polson	Community Trauma Hospital
St. Luke Community Healthcare, Ronan	Community Trauma Hospital
Barrett Hospital and Healthcare, Dillon	Trauma Receiving Facility
Deer Lodge Medical Center, Deer Lodge	Trauma Receiving Facility
Mineral Community Hospital, Superior	Trauma Receiving Facility
Ruby Valley Hospital, Sheridan	Trauma Receiving Facility
*Cabinet Peaks Medical Center, Libby	Not Designated
*Granite County Medical Center, Philipsburg	Not Designated
Marcus Daly Memorial Hospital, Hamilton	Trauma Receiving Facility
*Montana State Hospital	Not Designated

Eastern Region

Facility	Designation Level
Billings Clinic, Billings	Regional Trauma Center
St. Vincent's Healthcare, Billings	Regional Trauma Center
Bozeman Health, Bozeman	Area Trauma Hospital
Central Montana Medical Center, Lewistown	Community Trauma Hospital
Livingston Healthcare, Livingston	Community Trauma Hospital

Facility	Designation Level
Beartooth Billings Clinic, Red Lodge	Trauma Receiving Facility
Big Horn County Hospital, Hardin	Trauma Receiving Facility
*Colstrip Medical Center, Colstrip	Not Designated
Madison Valley Medical Center, Ennis	Trauma Receiving Facility
Pioneer Medical Center, Big Timber	Trauma Receiving Facility
Prairie Community Hospital, Terry	Trauma Receiving Facility
Roosevelt Memorial Hospital, Culbertson	Trauma Receiving Facility
Sheridan Memorial Hospital, Plentywood	Trauma Receiving Facility
Stillwater Billings Clinic, Columbus	Trauma Receiving Facility
Trinity Hospital, Wolf Point	Trauma Receiving Facility
Northeast Montana Health Services, Poplar	Trauma Receiving Facility
Wheatland Memorial Hospital, Harlowton	Trauma Receiving Facility
Roundup Memorial Healthcare, Roundup	Trauma Receiving Facility
Holy Rosary Health Center, Miles City	Community Trauma Hospital
Daniels Memorial Hospital, Scobey	Trauma Receiving Facility
Rosebud Healthcare, Forsyth	Not Designated
Phillips County Medical Center, Malta	Not Designated
Dahl Memorial Healthcare, Ekalaka	Not Designated
*Fallon Medical Complex, Baker	Not Designated
*PHS Indian Hospital, Crow Agency	Not Designated
Frances Mahon Deaconess, Glasgow	Community Trauma Hospital
*Garfield County Medical Center, Jordan	Not Designated
Glendive Medical Center, Glendive	Not Designated
*Lame Deer Clinic, Lame Deer	Not Designated
McCone County Health Center, Circle	Not Designated
Sidney Health Center, Sidney	Not Designated
*Bozeman Health, Big Sky Medical Center	Not Designated
*Advanced Care Hospital of Montana	Not Designated
*Rehabilitation Hospital of Montana	Not Designated

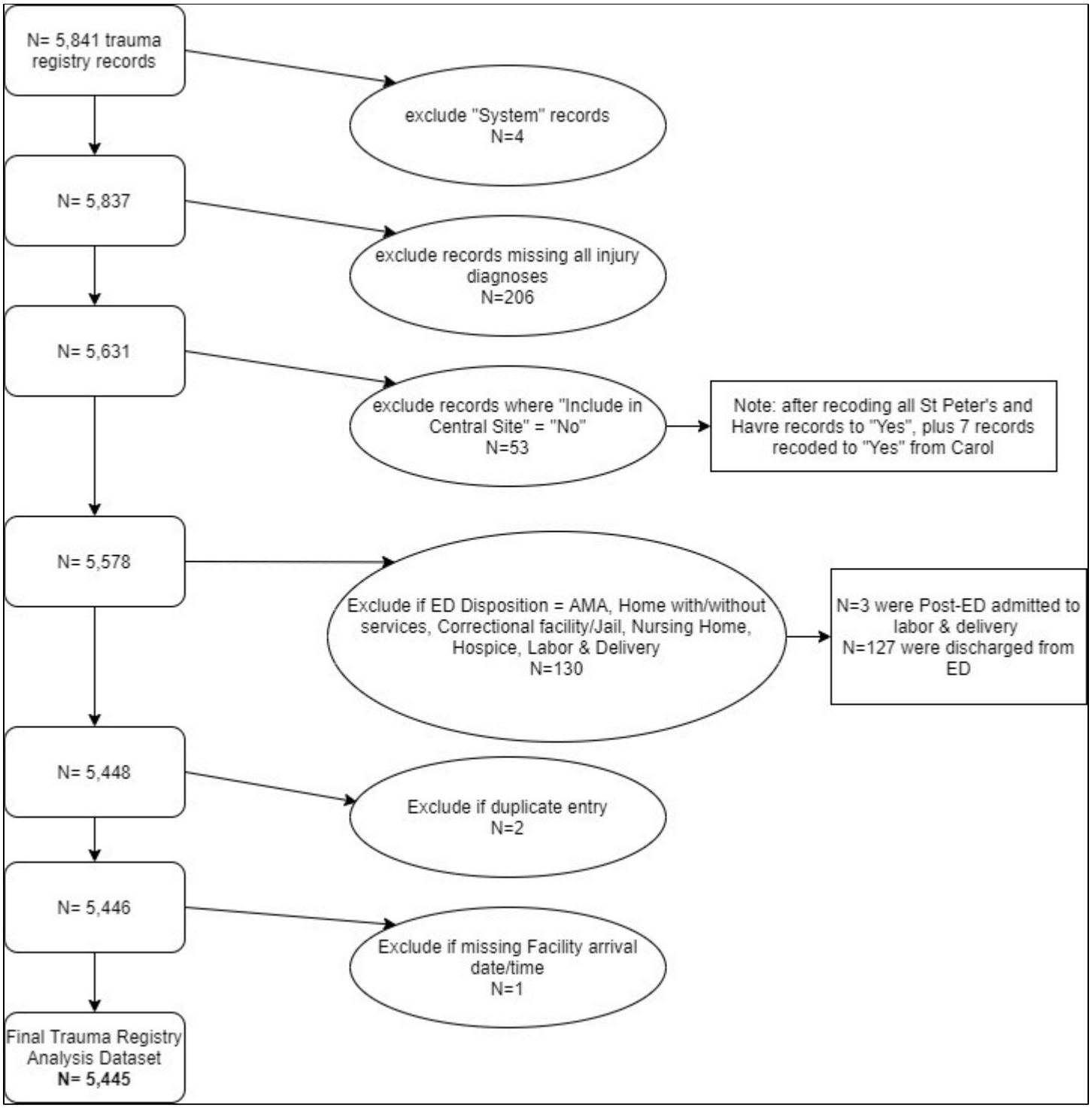
* denotes facility is not reporting

APPENDIX 2. Montana Trauma Registry 2020 Inclusion Criteria

All of the following conditions must be met for inclusion in MTR:

- Injury sustained within 14 days of initial encounter at health facility
- Assigned at least one of the following ICD-10-CM injury diagnosis codes
    - S00-S99 with 7th character modifiers of A, B, or C ONLY (anatomic injury – initial encounter)
        - Exclude if the only injury code is S00, S10, S20, S30, S40, S50, S60, S70, S80, S90 (isolated superficial injury)
    - T07 (unspecified multiple injuries)
    - T14 (injury to unspecified body region)
    - T20-T28 with 7th character modifier of A only (burns by specific body parts – initial encounter)
    - T30-T332 (burns by TBSA percentages)
    - T79.A1-T79.9A with 7th character modifier of A only (traumatic compartment syndrome)
- Must include one of the following:
    - Admitted as in-patient or observed patient for trauma
        - Exclude if admitted for monitoring a medical condition
        - Exclude if dismissed to home from ED
    - In-facility death resulting from traumatic injury
    - Patient transfer from one acute care hospital to another acute care hospital
        - Exclude transfer patients directly admitted with isolated injuries for elective and/or planned surgical intervention

APPENDIX 3. 2020 MTR analysis dataset inclusion/exclusions flowchart



APPENDIX 4. Trauma Dataset De-duplication

MTR receives records from facilities of various sizes across the state. In the case of an interfacility transfer, both the smaller (sending) and larger (receiving) facility may submit a record pertaining to the same patient. In order to avoid double-counting, we used MatchPro to de-duplicate the MTR dataset, linking together any records that represented the same patient case. Of 5,445 records, 23% (N=1,260) indicated that the patient was an incoming interfacility transfer patient meaning that there could be additional records in the registry for that patient case.

The fields used for linkage and method for computing similarity score (comparator) are shown below:

Receiving facility	Sending Facility	Comparator	Threshold Value (TV)	LProb	Summation
Immediate referring facility (R_FAC, R_FACLNK)	Submitting facility (TRK_FAC, TRK_FACLNK)	Jaccard (1)	0.80	0.75	Additive only
Facility arrival date (TRK_A_DATE)	Discharge date (O_D_DATE)	Date (Strict)	0.75	0.96	Additive only
Patient first name* (Z_NAME_F)	Patient first name (Z_NAME_F)	First Name	0.78	0.96	Default
Patient last name* (Z_NAME_L)	Patient last name (Z_NAME_L)	Last Name	0.78	0.94	Default
Patient middle name* (Z_NAME_M)	Patient middle name (Z_NAME_M)	Middle Name	0.78	0.50	Default
Last 4 digits of social security number (Z_SSN4)	Last 4 digits of social security number (Z_SSN4)	SSN	0.76	0.95	Default
Patient gender (D_GENDER)	Patient gender (D_GENDER)	Exact	1.00	0.98	Default
Patient birth date (D_DOB)	Patient birth date (D_DOB)	Date	0.75	0.96	Default

*For name comparison, we allowed for name shuffle (similarity threshold = 0.87) to catch cases where the first, middle, and/or last names were swapped. Names were not assigned value specific weights.

Field comparisons generating a similarity score below the TV were assigned the full disagreement (negative) score, while comparisons with a similarity score of 1 were assigned the full agreement (positive) score. Comparisons with a similarity score between the TV and 1 were given a partial score. Agreement and disagreement scores were weighted by the probability that two values agree/disagree for a pair of records that truly refer to the same entity (LProb), versus the probability that they agree/disagree for a pair of records that do not refer to the same entity (RProb, estimated based on frequencies observed in the data). Finally, scores across all fields were summed to give the linkage score for the record pair. Field comparisons using additive summation only affected the total linkage score if greater than or equal to zero, while those using default summation always affected the total.

Every record pair that agreed on at least 1 of the blocking keys (last 4 digits of SSN [SSN], first name [Soundex], last name [Soundex], birth date [Date: Year, Month + Day]) and that met the cutoff linkage score was included in the results set for manual review. The cutoff linkage score, or minimum score that a pair of records must achieve for the pair to be included in the results set, was dynamically adjusted by MatchPro based on an expected match percentage of 50% and desired PPV of 0.50. These parameters were selected to maximize sensitivity (avoid missing any true matches). Blocking reduces the number of record comparisons performed.

There were 786 record pairs, or potential matches, in the results set generated by MatchPro. These were manually reviewed to remove any non-matches or duplicate matches and identify double transfers (matches involving three records). The linkage process identified 603 record pairs indicating the patient was seen in two trauma centers and 3 triplets indicating the patient was seen in three trauma centers, resulting in a total of 4,836 unique trauma cases in the de-duplicated MTR dataset.

APPENDIX 5. Trauma to EMS record linkage

We used probabilistic record linkage to link 2020 trauma registry records with 2020 EMS transport records. The probabilistic method attempts to simulate human reasoning by comparing several elements from the two datasets. The 2020 EMS dataset contained N=90,537 patient transport records and MTR contained N=5,445 nonduplicate records, with 3,914 indicating any EMS transport and 3,709 specifying a MT EMS agency transported the patient to the facility.

The linking variables we used were: NAME8 (first four characters of first name and last name), First Name, Last Name, DOB, Birth Year, Birth Month, Birth Day, Age (years), Sex, last 4 digits of SSN.

First we calculated the random matching probability $P_{(agree|unmatch)}$ with a lower bound of 1/N for each linking variable, or the probability that two randomly paired records matched on the respective variable. Simple random sampling without replacement was used to select N=400 trauma records and N=400 EMS records. Every record in the random trauma sample dataset was compared with every record in the random EMS sample dataset exactly once, to give a total of 79,800 random record pairs.

Next, we calculated the linked matching probability $P_{(agree|match)}$ with an upper bound of 1-1/N for each linking variable, or the probability that two deterministically linked records matched on respective variables. For the deterministic link, record pairs were required to match on the trauma record's submitting facility and EMS record's destination facility, and the trauma record's facility arrival date/time (trk_a_dt) had to be within same hour of EMS record's arrived at destination date/time (eTimes_11). In addition, at least 3 out of 4 (first name, last name, DOB, last 4 digits of SSN) had to match exactly. This resulted in N=3,273 deterministically linked record pairs.

Agreement and disagreement point values for each linking variable were calculated:

- Agreement points: $Log2[P_{(agree|match)}/ P_{(agree|unmatch)}]$
- Disagreement points: $Log2[P_{(Disagree|match)}/ P_{(Disagree|unmatch)}]$

If two records agree on a particular linking variable, that provides evidence that the two records refer to the same entity and the record pair is assigned some positive number of "agreement points". Fields with many distinct values, such as names or dates of birth, are worth more points than fields with few values, such as sex or race. If two records disagree on a linking variable, that is evidence that the two records do not refer the same entity, and the pair is assigned some negative number of "disagreement points". For disagreement points, fields that are very accurate/clean/reliable carry more weight. If one of the records in a pair is missing data on a linking variable, that provides no evidence either way (zero points are assigned for that field).

Linking variable	Matching probability Random pairs $P_{(agree|unmatch)}$	Matching probability Deterministically linked pairs $P_{(agree|match)}$	Disagreement points	Agreement Points
NAME8	0.00001	0.96700	-4.92149	16.23570
First Name	0.00261	0.96211	-4.71844	8.52790
Last Name	0.00035	0.96700	-4.92100	11.42830
DOB	0.00001	0.97676	-5.42713	16.25020
Birth Year	0.01154	0.99083	-6.75144	6.42370
Birth Month	0.08434	0.99450	-7.37804	3.55970
Birth Day	0.03207	0.98654	-6.16862	4.94320
Age (years)	0.01175	0.98839	-6.41141	6.39380
Sex	0.50984	0.98524	-5.05346	0.95040
SSN	0.00007	0.96357	-4.77869	13.84930

The next step was to perform the probabilistic record linkage. Every MTR record was compared with every EMS record, within the blocking parameters. For blocking, MTR "submitting facility" and EMS record "destination facility" must match, and MTR "facility arrival date" must be within 1 day before/after EMS record "incident date". For a given record pair, the comparison vector contained six values representing similarity between the two records on each of the six linking variables shown below:

MTR	EMS	Comparator Function	Threshold Value (TV)	Scoring Method	Summation
Name 8 characters (Z_NAME8)	Name 8 characters (NAME8)	Fx_GED SS= [1-(Generalized Edit Distance/Cutoff)]^3 Cutoff=500	0.2	Linear	Default
Last Name (Z_NAME_L)	Last Name (ePatient_02)	Fx_char_exact SS= 1- Levenshtein edit distance Cutoff=1	1	Binary	Additive only
Birth date (D_DOB)	Birth Date (ePatient_17)	Fx_Date_Compare SS= (year*log2(100)+month*log2(12)+day*log2(30))/ (log2(100)+log2(12)+log2(30)) where: year= 1 if match, 0 if non-match, month= 1 if match, 0 if non-match, day= 1 if match, 0 if non-match	0.5	Linear	Default
Age in years (D_AGE_INT)	Age in years (ePatient_15)	Only counted if DOB score is missing			
Sex (D_GENDER)	Sex (Ems_sex_numeric)	Fx_num_exact SS= **1**-(min(**1**,abs(param1-param2)))	1	Binary	Default
Last 4 digits of SSN (Z_SSN4)	Last 4 digits of SSN (SSN4)	Fx_GED SS= [1-(Generalized Edit Distance/Cutoff)]^3 Cutoff=200	0.1	Linear	Default

The value from the trauma registry was compared to the value from the EMS registry for each linking variable using the comparator function, which produced a similarity score (SS) ranging from 0 to 1 (where 1= exact match). The SS was then compared to the TV. With the linear scoring method, a partial agreement score is assigned for partial matches as long as SS ≥ TV. With the binary scoring method, the full agreement score is assigned to record pairs where SS ≥ TV. For both scoring methods, the full disagreement score is given if the threshold is not met (if SS < TV). Default score contribution means the score will always affect the total linkage score, and with additive score contribution, the score will only affect the total linkage score if it is a positive number. Finally, the 6 scores were summed to get the total match score for the record pair.

There were N=4,725 record pairs where Total_score >0 and N=4,206 record pairs where total score>13 (cut-off determined by manual review). Among these, there were N=363 duplicate matches (1 MTR record paired with multiple EMS records). The best match was selected with the following algorithm:

1. Select the pair where EMS record facility arrival time (eTimes_11) is closest to trauma arrival time (TRK_A_DT)
2. Select the pair with the highest total_score for probabilistic record linkage
3. Select the pair where EMS record incident time (incident_date_time) is closest to trauma arrival time (TRK_A_DT)
4. Select the pair with the least number of missing data elements

After removing duplicates there were N=3,843 unique trauma/EMS record pairs. This left 1,602 unmatched trauma records: 49 were interfacility transfer arrivals transported by a MT EMS agency, while 143 were 911/initial arrivals transported by an EMS agency. We then re-ran the same linkage algorithm for both types of unmatched trauma records, with different blocking parameters (EMS “response type” must match trauma record interfacility/initial arrival, and MTR “facility arrival date/time” must be within the same hour before/after EMS “arrived at destination date/time”). 19 interfacility matches and 13 initial arrival matches were found. The total number of unique trauma/EMS record pairs was 3,875.

- Matching Rate (any_ems): 3,875/3,914=99.0%
- Matching Rate (MT_ems): 3,875/3709=104.5%

Final trauma facility (A)	Trauma facility (B)	Trauma facility (C)	EMS (A)	EMS (B)	EMS (C)	N
X	X	X	X	X	X	1
X	X	X	X	X		2
X	X		X	X		412
X	X		X			162
X	X			X		12
X	X					17
X			X			2,870
X						1,360
Total						**4,836**

APPENDIX 6. Montana Population Age-Sex Pyramid