CEMSIS and Trauma Data Linkage Initiative: Emergency Medical Services Authority Preventive Health and Health Services Block Grant (PHHSBG)

Emergency Medical Services Authority

California Health and Human Services Agency

May 2024

Elizabeth Basnett, Director

Hernando Garzon, MD, Acting Chief Medical Officer

Brian Aiello, Chief Deputy Director

Tom McGinnis, EMS Systems Chief

EMSA Publication #SYS 100-17

ACKNOWLEDGEMENTS

This report was prepared by the California Emergency Medical Services Authority staff:

Michelle McEuen, CEMSIS Data Specialist

Victoria Lupinetti, CEMSIS Specialist (former)

Adrienne Kim, Data and Quality Improvement Manager

This report was reviewed and approved by the California Emergency Medical Services Authority Executives:

Elizabeth Basnett, Director

Hernando Garzon, MD, Acting Chief Medical Officer

Brian Aiello, Chief Deputy Director

Tom McGinnis, EMS Systems Chief

If you have any questions or comments about this report, please contact:

Michelle McEuen
CEMSIS Data Specialist
(916) 903-9624
EMSData@emsa.ca.gov

CONTENTS

Background 4
Purpose 5
Methodology 6
Step One 6
Step Two 10
Step Three 10
Results for TRA-2 Denominator and Numerator 11
Incident Demographics and Characteristics 13
Limitations 24
Conclusion 25

BACKGROUND

Under the provisions of the Preventive Health and Health Services Block Grant (PHHSBG), the California Emergency Medical Services Authority (EMSA) attempts to link robust prehospital emergency medical services (EMS) data and hospital data to inform future research and policy decision making. Accurate linkage of EMS and other patient-centered health care records is essential to identify rates and preventive measures for illness and injury; patient health outcomes; expense and resource utilization; and efficacy of pre-hospital interventions.

This report is part 2 on identifying which criteria affects the variable outcomes and the efficacy of matching EMS and hospital data. To access the report on part 1, please visit EMSA's website or utilize the direct link: California-Emergency-Medical-Services-Information-System-and-Trauma-Data-Linkage-Initiative.pdf. Part 1 focused on obtaining as many records and matches as possible by minimizing the use of filters in the data reports. There was a 69% match rate for a one-to-one EMS and hospital trauma records for this attempt. Data collected represented a period (January-December 2019) from all designated trauma hospitals in California. Data was extracted from the California Emergency Medical Services Information System (CEMSIS) and the hospital Patient Registry, which are both managed by the software ImageTrend.

Part 2, as described in this report, focused on obtaining as many records and matches as possible with the use of filters in the data reports. EMSA utilized the California EMS System Core Quality Measures Project specifications to filter trauma patients meeting the Center for Disease Control and Prevention (CDC) Field Trauma Triage Criteria Steps 1 or 2 or 3 that were transported to a designated trauma center. The transportation of trauma patients to a trauma center, defined by measure TRA-2 in the Core Quality Measures Project, is a key metric used by EMSA and the local emergency medical services agencies (LEMSAs) to evaluate how EMS providers identify, treat, and transport patients with suspected or diagnosed traumatic injuries. The results demonstrate the effects on data and record linkage by using various data elements and comparing specific criteria.

PURPOSE

1. Maximize the number of matched records between two databases.
2. Provide summary statistics for EMS and hospital matched trauma records and outcomes of care.
3. Identify a sample population where each patient has an EMS record linked to a hospital record.
4. Analyze the population through various statistics.
5. Summarize results and their implications for further research regarding EMS and other data linkage opportunities.

METHODOLOGY

This report used filters that were intended to distinguish possible trauma patients from medical patients. It is an overview of how EMS and trauma data are linked and what can be gleaned from the results and analysis. The goal of this study is to identify any patterns or characteristics of matched and unmatched records. Below is a summary of methods used by EMSA to collect, analyze, and present the linked EMS and hospital trauma data for the calendar year 2019. Of the 33 LEMSAs, 32 reported data for the 2019 reporting year. Two datasets were queried from CEMSIS to separately match with the Patient Registry hospital records. One data set was the TRA-2 measure denominator which identifies trauma patients meeting the CDC Field Trauma Triage Criteria Steps 1 or 2 or 3 and the other was the TRA-2 measure numerator which identifies trauma patients meeting CDC Field Trauma Triage Criteria Steps 1 or 2 or 3 that were transported to a designated trauma center. These criteria are compliant with the National Emergency Medical Services Information System (NEMSIS) version 3.4.0. data standard, which was the version used by EMSA and all LEMSAs participating in CEMSIS in 2019.

As discussed in the previous matching report, EMSA attempted to find a unique identifier that would yield a high match rate for EMS and trauma records. Ideally, criteria like first and last names, dates of birth, and social security numbers are the most unique, but only dates of incident and dates of birth were accessible across these two databases. EMSA determined that those were the most viable and accessible data elements for these databases. The following are the steps, additional criteria, and data elements that were used to query the sample populations.

STEP ONE

EMSA implemented the criteria that identifies the transport of trauma patients to trauma centers (TRA-2 description) per the guidelines set forth for quality improvement of EMS data. This report did two separate analyses: one for the denominator population and one for the numerator population. The denominator is the number of trauma patients meeting CDC Field Trauma Triage Criteria Step 1 or 2 or 3 originating from a 911 response. The numerator is the number of trauma patients meeting CDC Field Trauma Triage Criteria Step 1 or 2 or 3 transported to a trauma center originating from a 911 response. Trauma center is defined by the CEMSIS data element "Hospital Capability

(eDisposition.23)". Please refer to the California EMS System Core Quality Measures Project webpage to learn more about the measures and view the full measure specifications. The CEMSIS filtering criteria included in this report were as follows:

1). Denominator (total population)

1. Type of Service Requested (eResponse.05) is equal to 911 response (scene) and
2. Injury Trauma Center Criteria List (eInjury.03) contains any of the following: "Amputation proximal to wrist or ankle, or pulseless extremity, Chest wall instability or deformity, Glasgow Coma Score, Open or depressed skull fracture, Paralysis, Pelvic fractures, All penetrating injuries to head, Respiratory rate <10 or >29 bpm, Systolic Blood Pressure <90mmHg, Two or more proximal long-bone fractures" or
3. Injury Vehicular Pedestrian or Other Risk Factor List (eInjury.04) contains any of the following "Auto v. Pedestrian, Fall Adults >20 ft, Fall Children >10 ft, Crash Death in Same Passenger Compartment, Crash Ejection (partial or complete) from automobile, Crash Intrusion >12", Crash Vehicle Telemetry Data (AACN) Consistent with High Risk of Injury, Motorcycle Crash > 20 MPH"

2). Numerator (subpopulation with additional parameters)

1. Type of Service Requested (eResponse.05) is equal to 911 response (scene) and
2. Injury Trauma Center Criteria List (eInjury.03) contains any of the following: "Amputation proximal to wrist or ankle, or pulseless extremity, Chest wall instability or deformity, Glasgow Coma Score, Open or depressed skull fracture, Paralysis, Pelvic fractures, All penetrating injuries to head, Respiratory rate <10 or >29 bpm, Systolic Blood Pressure <90mmHg, Two or more proximal long-bone fractures" or
3. Injury Vehicular Pedestrian or Other Risk Factor List (eInjury.04) contains any of the following: "Auto v. Pedestrian, Fall Adults >20 ft, Fall Children >10 ft, Crash Death in Same Passenger Compartment, Crash Ejection (partial or complete) from automobile, Crash Intrusion, Crash Vehicle Telemetry Data (AACN) Consistent with High Risk of Injury, Motorcycle Crash >20 MPH" and
4. Disposition Hospital Capability (eDisposition.23) is in "Trauma Center Level 1 or 2 or 3 or 4"

OUTLINE: EMS AND TRAUMA VARIABLES

1. Selected timeframe: January 1, 2019 through December 31, 2019
2. Selected inclusion criteria for CEMSIS transactional report:
    a. Incident date is not blank
    b. Date of Birth (DOB) is not blank
    c. Data elements:
        i. Incident date
        ii. Patient date of birth (ePatient.17)
        iii. Patient age (ePatient.15)
        iv. Patient gender (ePatient.13)
        v. Patient race (ePatient.14)
        vi. LEMSA
        vii. Response EMS agency (eResponse.02)
        viii. Situation primary complaint statement (eSituation.04)
        ix. Situation primary provider impression (eSituation.11)
        x. Situation possible injury (eSituation.02)
        xi. Situation initial patient acuity (eSituation.13)
        xii. Situation primary symptom (eSituation.09)
        xiii. Disposition EMS transport method (eDisposition.16)
        xiv. Disposition transport mode from scene (edisposition.17)
        xv. Disposition reason for choosing destination (eDisposition.20)
        xvi. Cause of injury (eInjury.01)
        xvii. Injury trauma center criteria list (eInjury.03)
        xviii. Incident dispatch notified time (eTimes.02)
        xix. Incident unit notified by dispatch time (eTimes.03)
        xx. Incident unit en route time (eTimes.05)
        xxi. Incident unit arrived on-scene time (eTimes.06)
        xxii. Incident unit left scene time (eTimes.09)
        xxiii. Incident unit patient transfer of care time (eTimes.12)
        xxiv. Response type of turnaround delay (eResponse.12)
        xxv. Response type of scene delay (eResponse.10)
        xxvi. Response time: incident unit arrived on-scene minus incident unit notified by dispatch
        xxvii. Scene time: incident unit left scene (eTimes.09) minus incident unit arrived on-scene(eTimes.06)
        xxviii. Ambulance Patient Offload Time (APOT): incident destination transfer of care (eTimes.12) minus incident patient arrived at destination (eTimes.11)

3. Selected inclusion criteria for the Patient Registry transactional report
    a. Incident date is not blank
    b. Date of Birth (DOB) is not blank
    c. Data elements:
        i. Incident date
        ii. Patient DOB
        iii. Patient gender
        iv. Patient race
        v. Patient ethnicity
        vi. EMS unit notified time
        vii. EMS unit arrived on-scene time
        viii. EMS unit left scene time
        ix. EMS unit at destination time
        x. Injury Severity Score (ISS) calculated
        xi. ICD-10 injury description
        xii. ICD-10 injury detailed description
        xiii. Trauma type with ICD-10 COI codes
        xiv. Trauma triage criteria (Steps 1 and 2)
        xv. Trauma triage criteria (Steps 3 and 4)
        xvi. ED/Acute care disposition
        xvii. Hospital discharge disposition
        xviii. Facility name
        xix. Transport to your facility
        xx. Probability of survival
        xxi. Ventilator days-total

    Yielded

    d. CEMSIS TRA-2 Denominator **32,496 unique records**
    42,617 total: 3,628 (no DOB), 8,819 (duplicates)

    e. CEMSIS TRA-2 Numerator **10,544 unique records**
    12,447 total: 883 (no DOB), 2,431 (duplicates)

    f. Patient Registry produced **71,579 unique records**
    87,388 total: 15,809 (duplicates)

4. Generated and exported the reports to Excel as ".csv" files, which were then converted into two ".xlsx" files

STEP TWO

Matched and queried both tables using SAS Enterprise Guide

1. Imported both files into SAS Enterprise Guide
2. Linked the tables using an inner join (only incident date and date of birth criteria from both are used in determining matches)
3. Exported matched data to Excel to clean and analyze

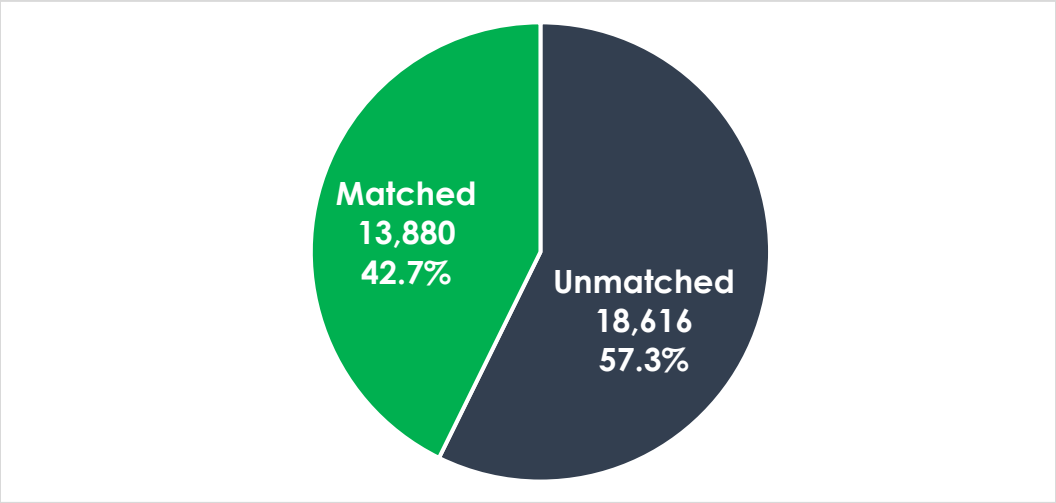
STEP THREE

Cleaned and standardized data in Excel

1. Verified records for accuracy and completeness
    a. Manually entered missing ages
    b. Cleaned up and abbreviated variable names and record names for brevity
    c. Deleted duplicate columns that were unnecessary
    d. Converted dates and times to be consistent
2. Manually verified if there were more viable matching records
    a. Checked for date transpositions, incorrect or misspelled words, insertions, omissions, etc.

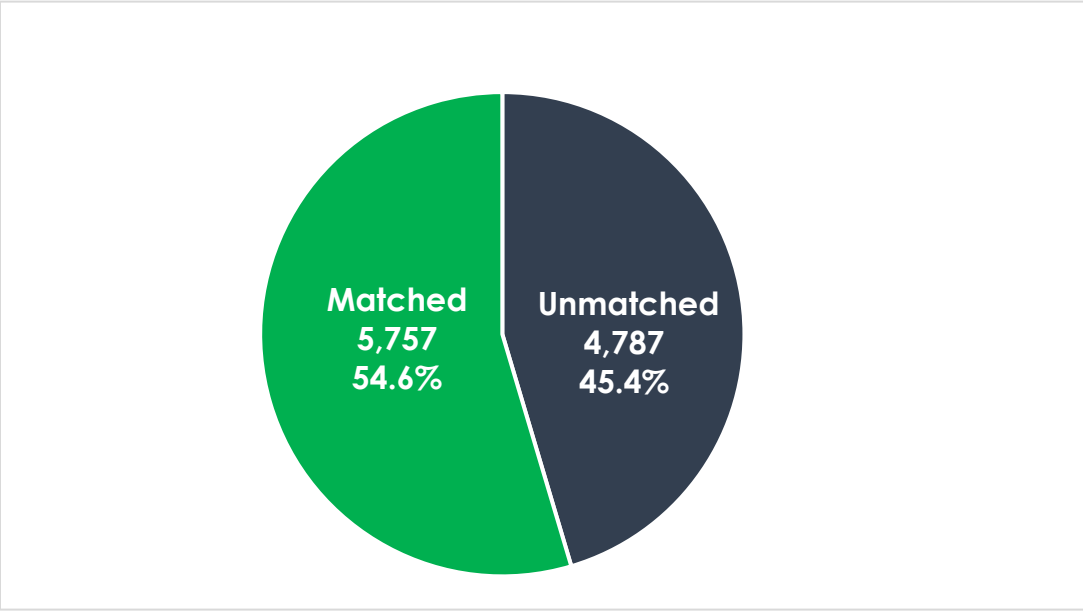
RESULTS FOR TRA-2 DENOMINATOR AND NUMERATOR

FIGURE 1: NUMBER AND PERCENTAGE OF SUCCESSFUL AND UNSUCCESSFUL MATCHED RECORDS FOR TRA-2 DENOMINATOR



TRA-2 Denominator Results: 13,880 out of 32,496 EMS records identified in CEMSIS for trauma patients who met CDC Trauma Triage Criteria Steps 1, 2, and 3, were successfully matched to records in the Patient Registry. This yielded a 42.7% match rate.

FIGURE 2: NUMBER AND PERCENTAGE OF SUCCESSFUL AND UNSUCCESSFUL MATCHED RECORDS FOR TRA-2 NUMERATOR



TRA-2 Numerator Results: 5,757 out of 10,544 EMS records identified in CEMSIS for trauma patients that met CDC Trauma Triage Criteria Steps 1, 2, and 3, and were transported to a trauma center, successfully matched to records in the Patient Registry. This yielded a 54.6% match rate.

Although the TRA-2 numerator is a smaller overall sample population compared to the denominator, the criteria resulted in a higher match rate with the inclusion of data element eDisposition.23 Disposition Hospital Capability.

INCIDENT DEMOGRAPHICS AND CHARACTERISTICS

FIGURE 3: COUNT BY GENDER OF MATCHED RECORDS FOR TRA-2 DENOMINATOR AND NUMERATOR

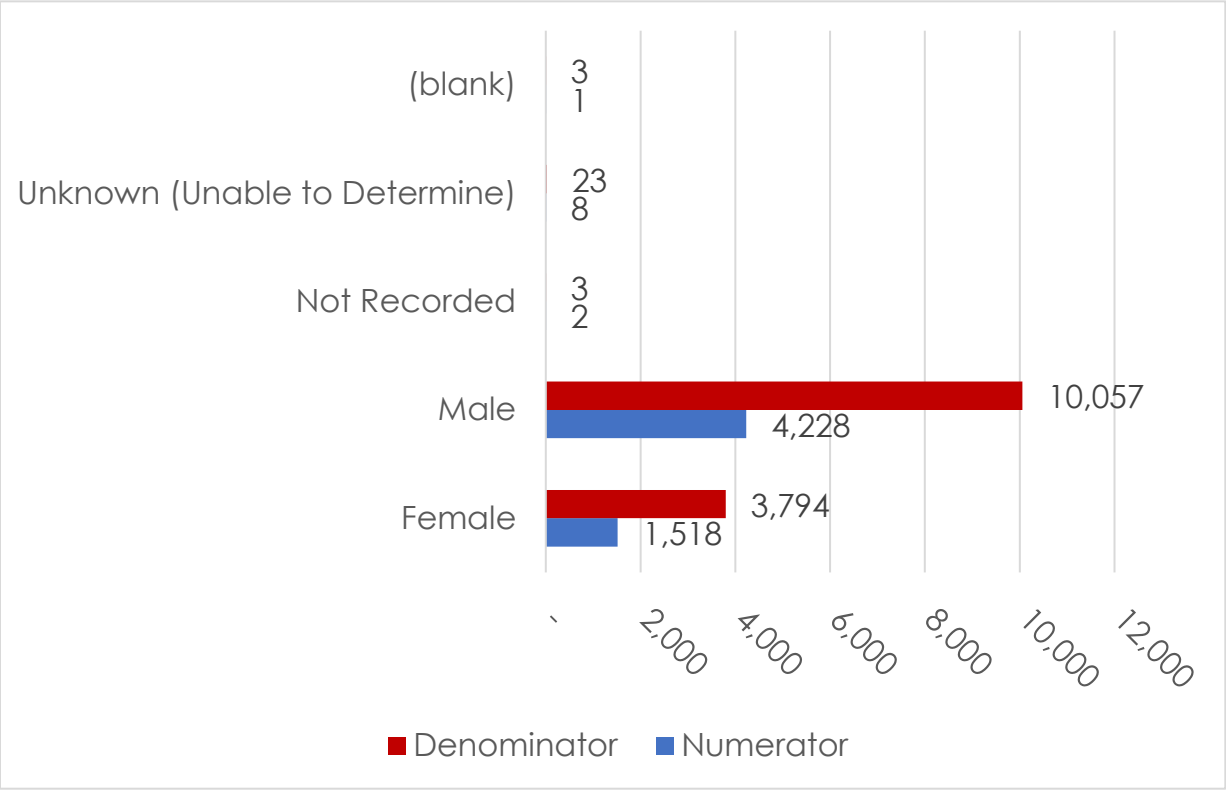


FIGURE 4: COUNT BY RACE OF MATCHED RECORDS FOR TRA-2 DENOMINATOR AND NUMERATOR

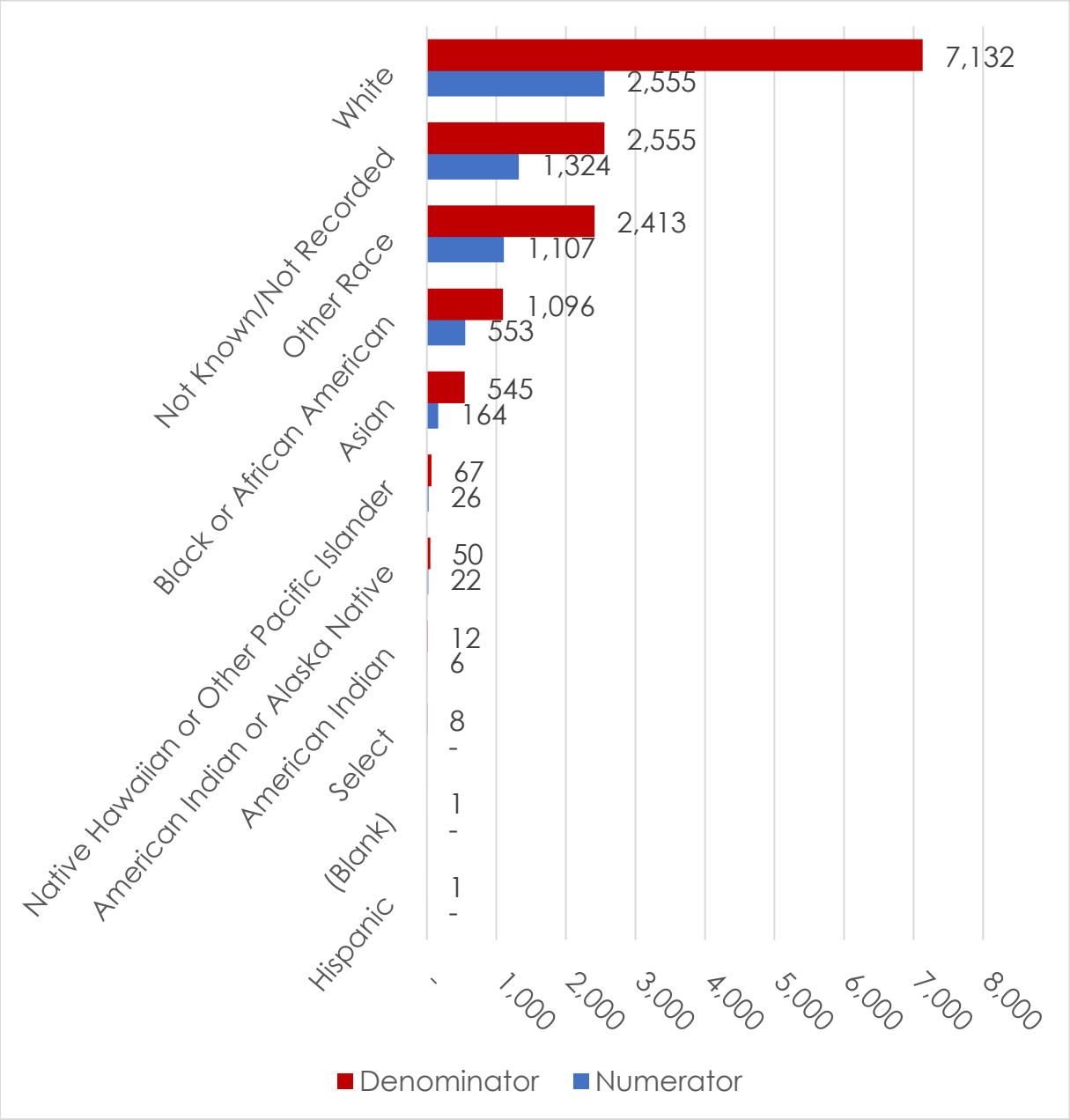
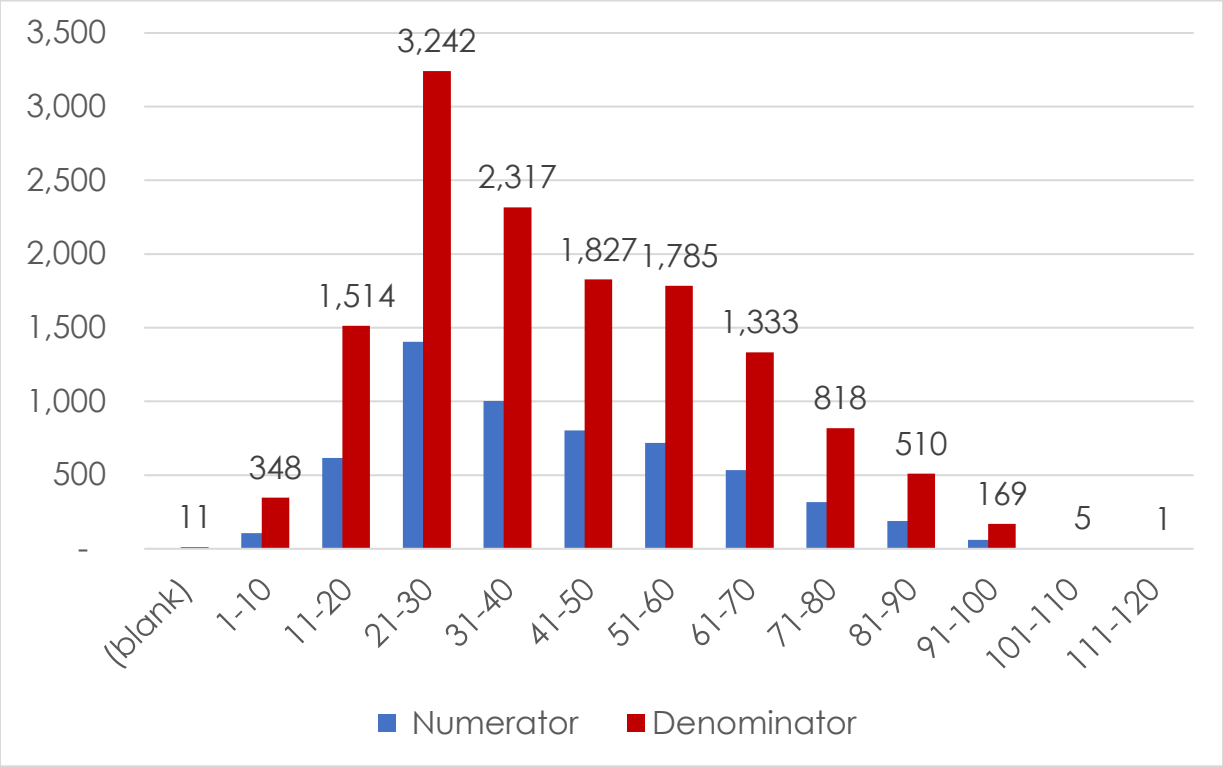


FIGURE 5: COUNT BY AGE CATEGORY OF MATCHED RECORDS FOR TRA-2 NUMERATOR AND DENOMINATOR



The average age for the numerator and denominator population is 42 years.

FIGURE 6: COUNT BY TRAUMA TYPE OF MATCHED RECORDS FOR TRA-2 NUMERATOR AND DENOMINATOR

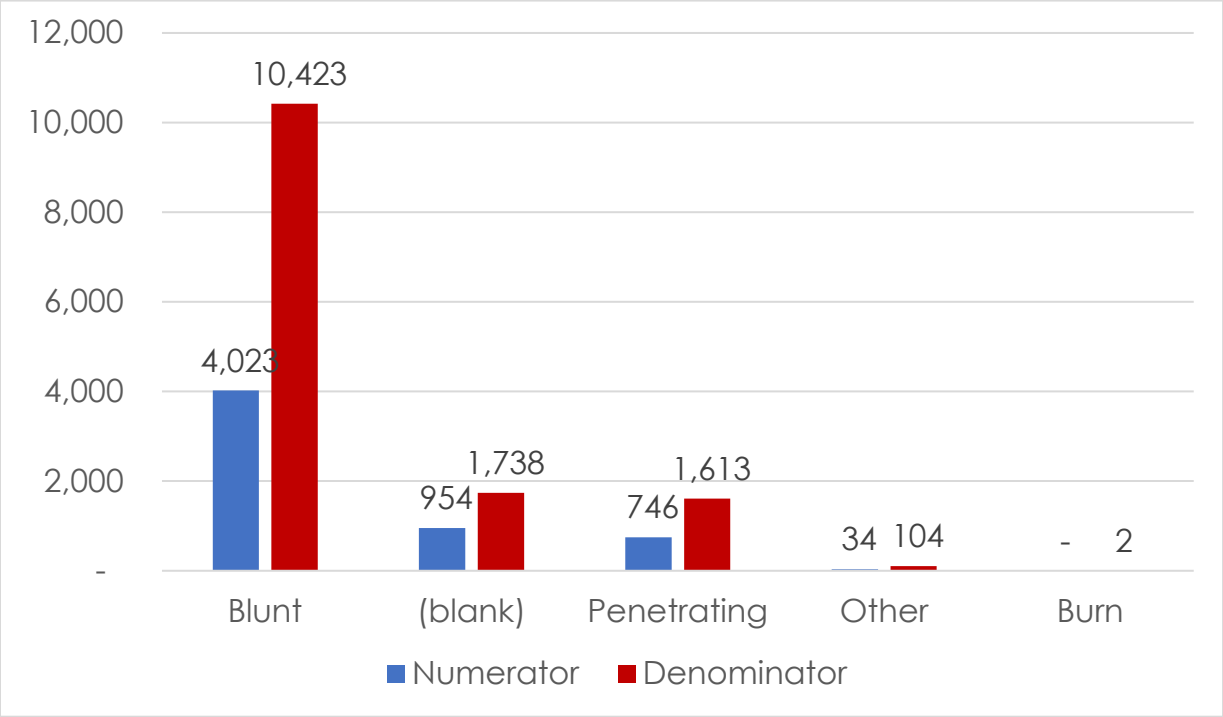
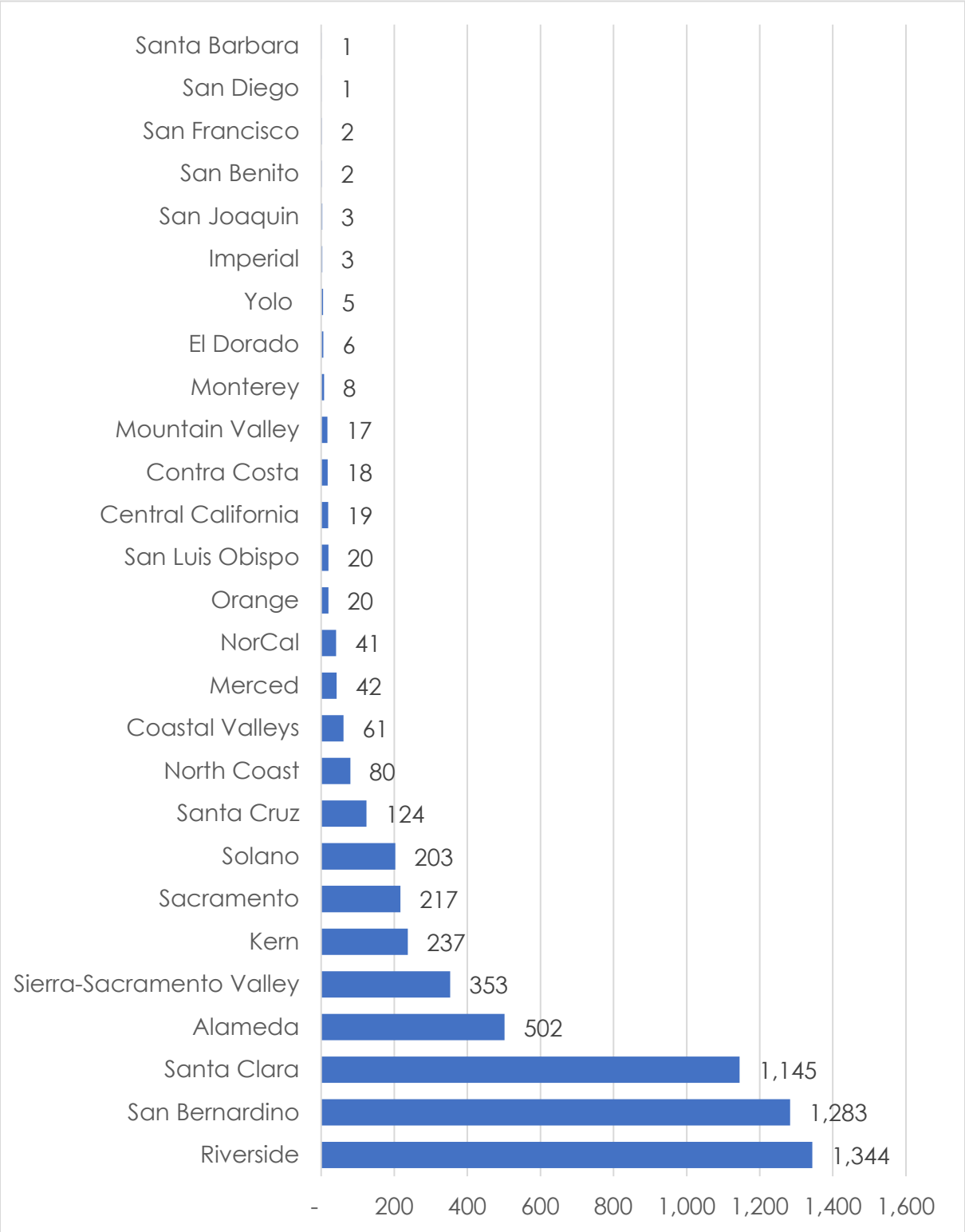
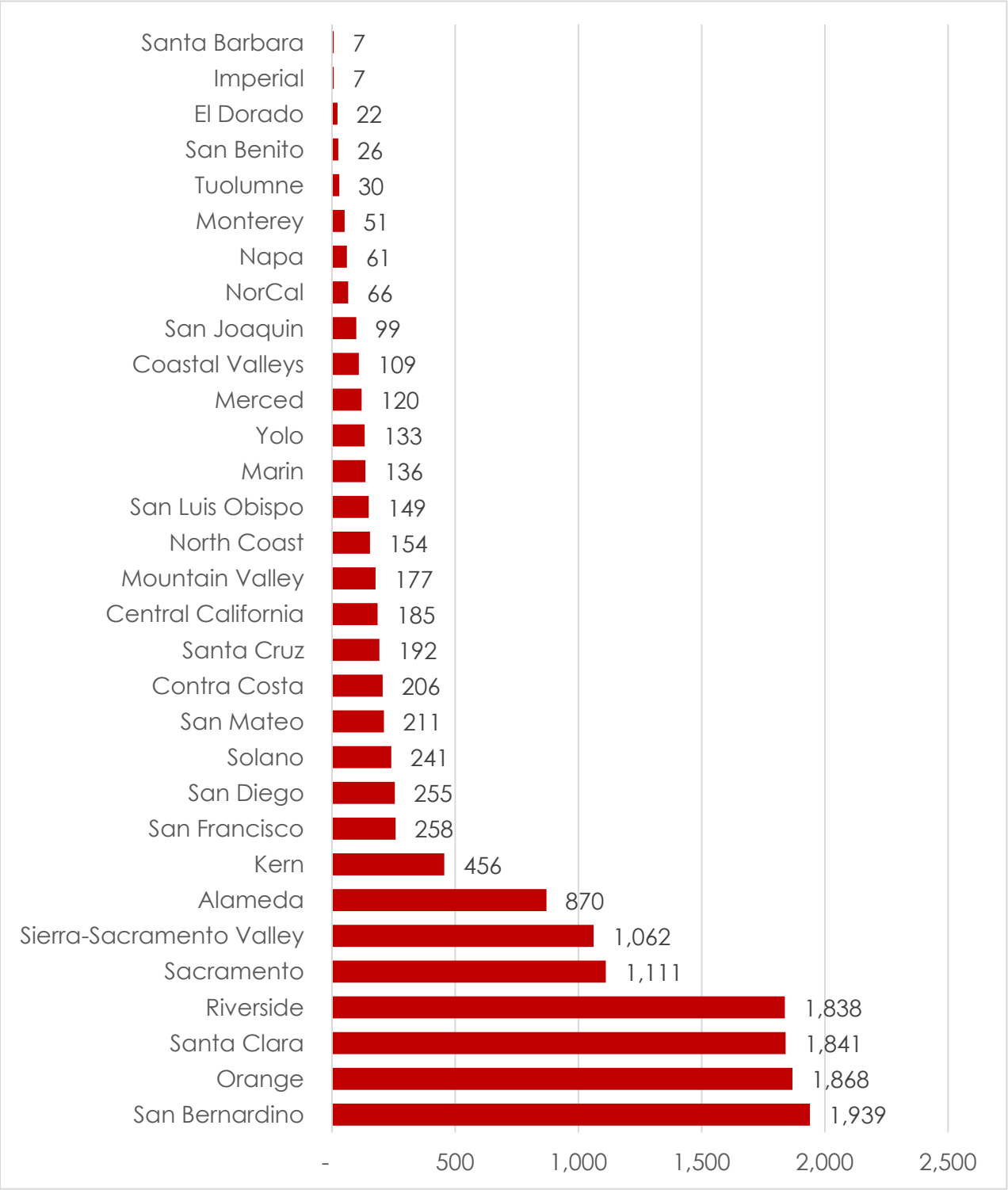


FIGURE 7: COUNT BY LEMSA OF MATCHED RECORDS: TRA-2 NUMERATOR



27 of 32 reporting LEMSAs had a matching EMS to hospital trauma record for the numerator population.

FIGURE 8: COUNT BY LEMSA OF MATCHED RECORDS: TRA-2 DENOMINATOR



31 of 32 reporting LEMSAs had a matching EMS to hospital trauma record for the denominator population.

FIGURE 9: ED/ACUTE CARE DISPOSITION OF MATCHED RECORDS: TRA-2 NUMERATOR

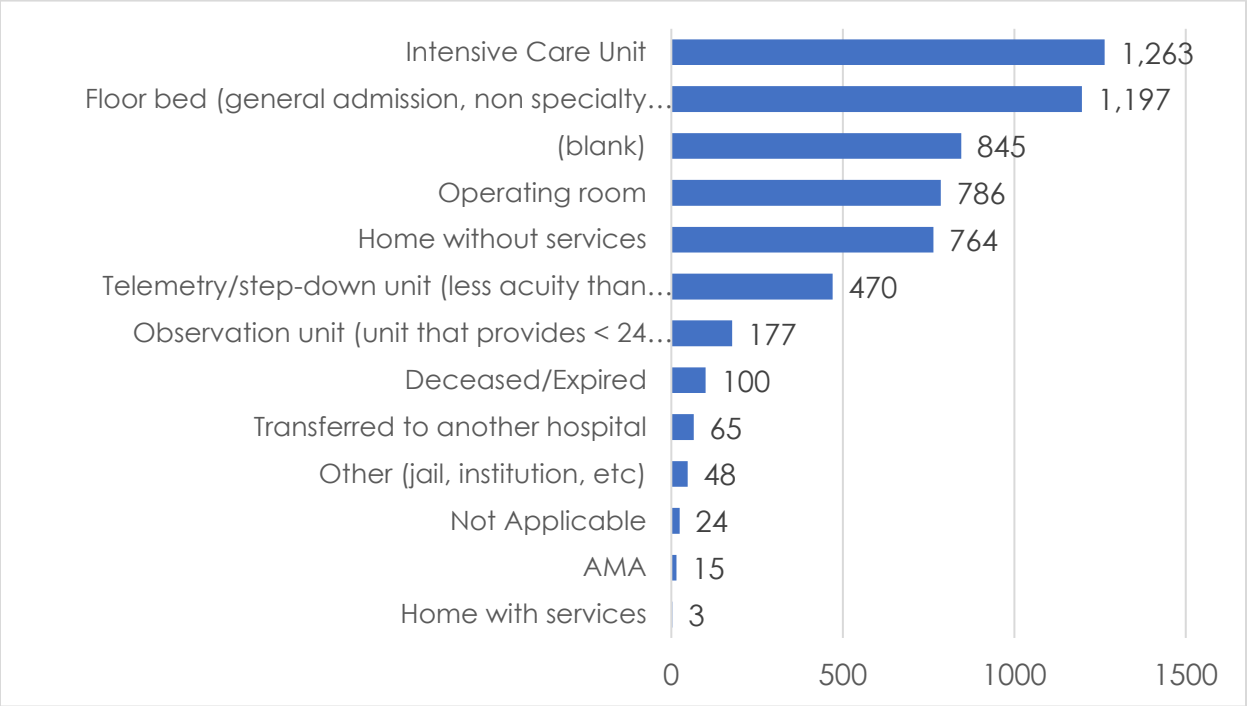


FIGURE 10: ED/ACUTE CARE DISPOSITION OF MATCHED RECORDS: TRA-2 DENOMINATOR

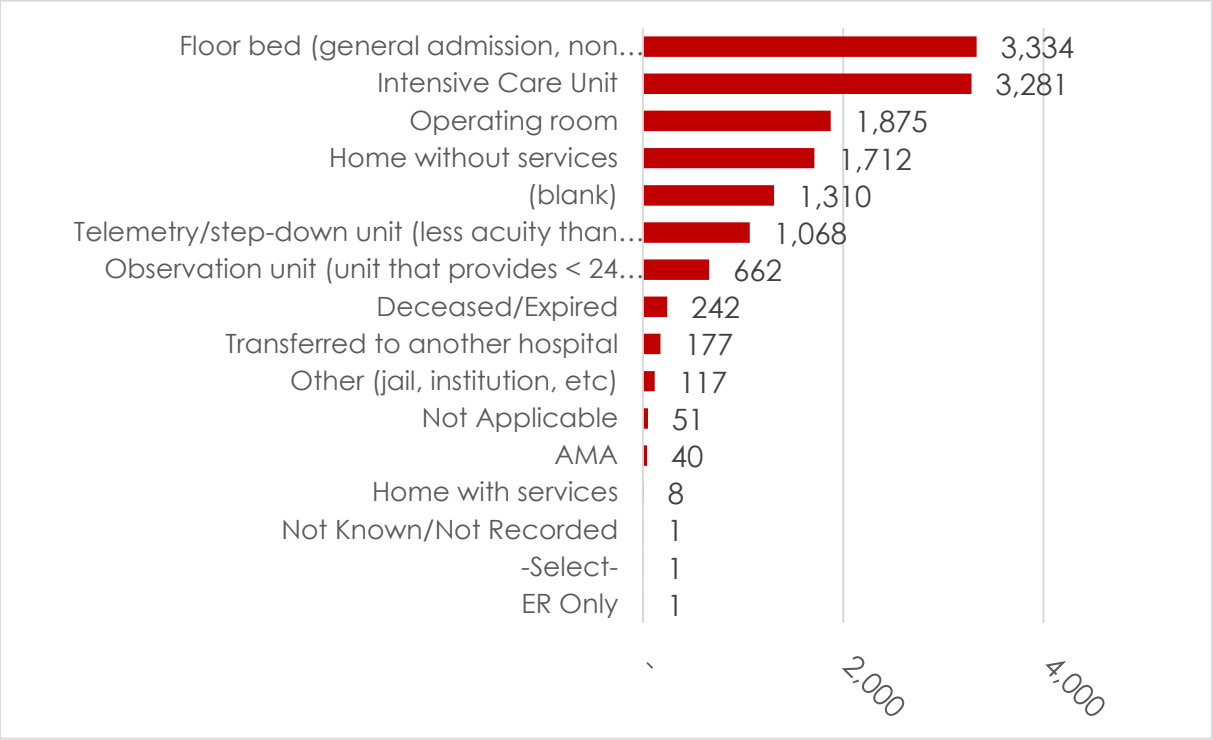


FIGURE 11: HOSPITAL DISCHARGE DISPOSITION OF MATCHED RECORDS: TRA-2 NUMERATOR

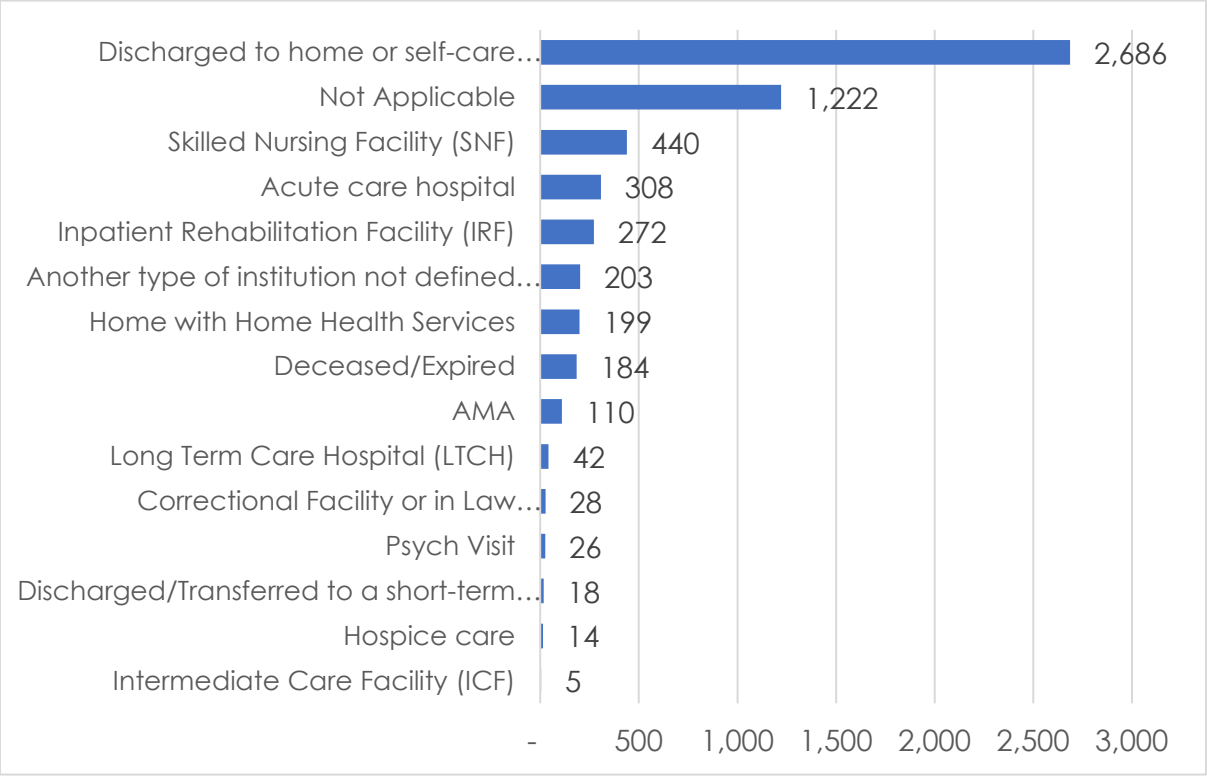


FIGURE 12: HOSPITAL DISCHARGE DISPOSITION OF MATCHED RECORDS: TRA-2 DENOMINATOR

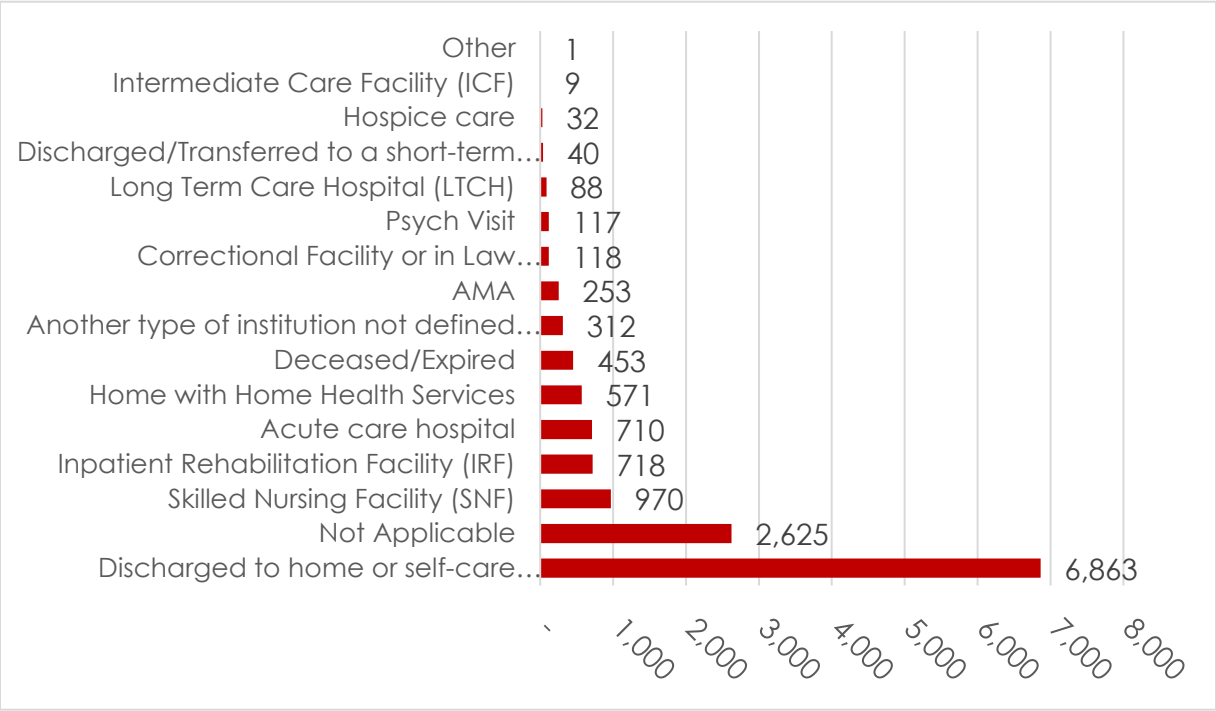


FIGURE 13: RESPONSE PRIMARY ROLE OF UNIT OF MATCHED RECORDS: TRA-2 NUMERATOR

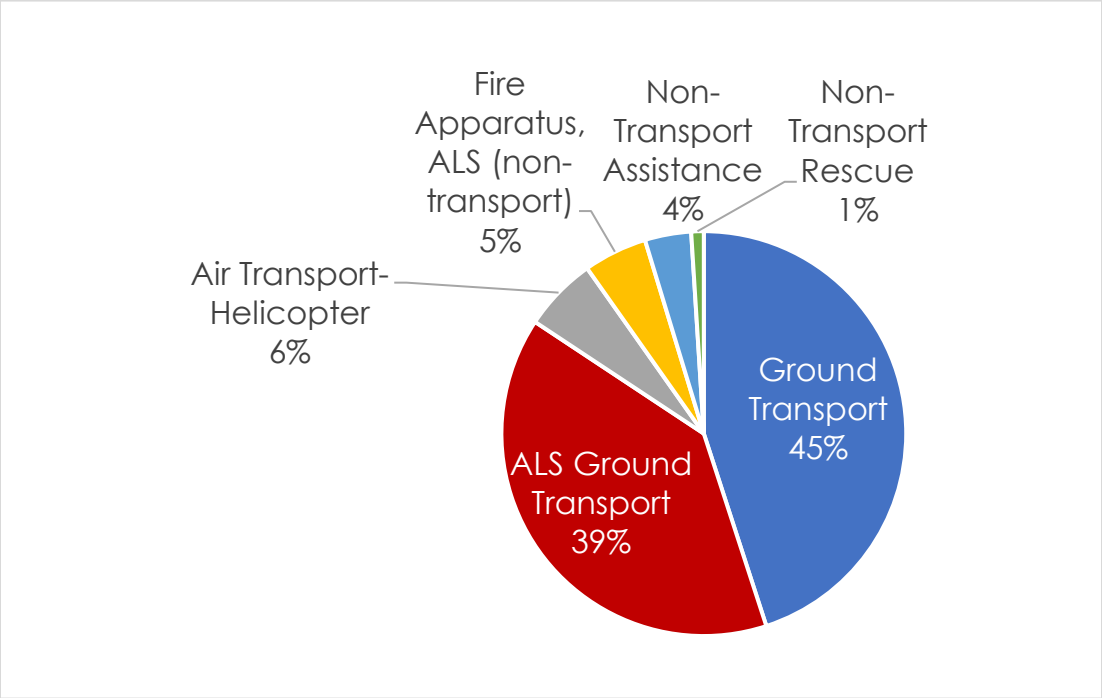


FIGURE 14: RESPONSE PRIMARY ROLE OF UNIT OF MATCHED RECORDS: TRA-2 DENOMINATOR

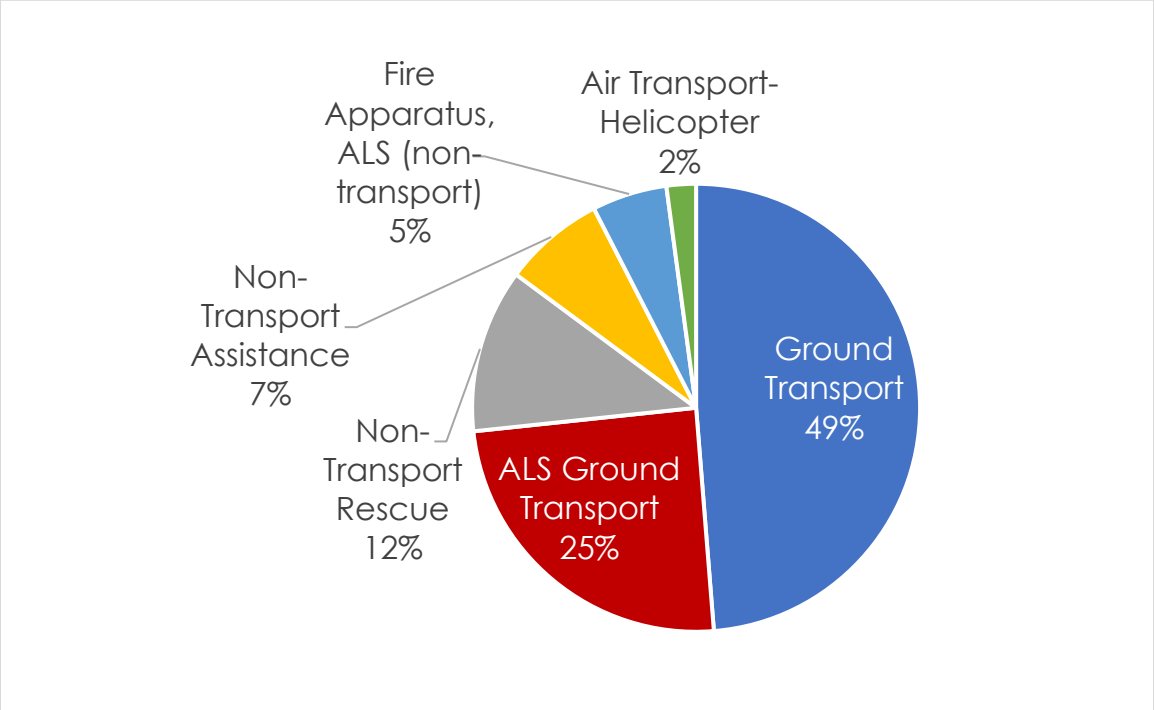


FIGURE 15: DISPOSITION TRANSPORT MODE FROM SCENE OF MATCHED RECORDS: TRA-2 NUMERATOR

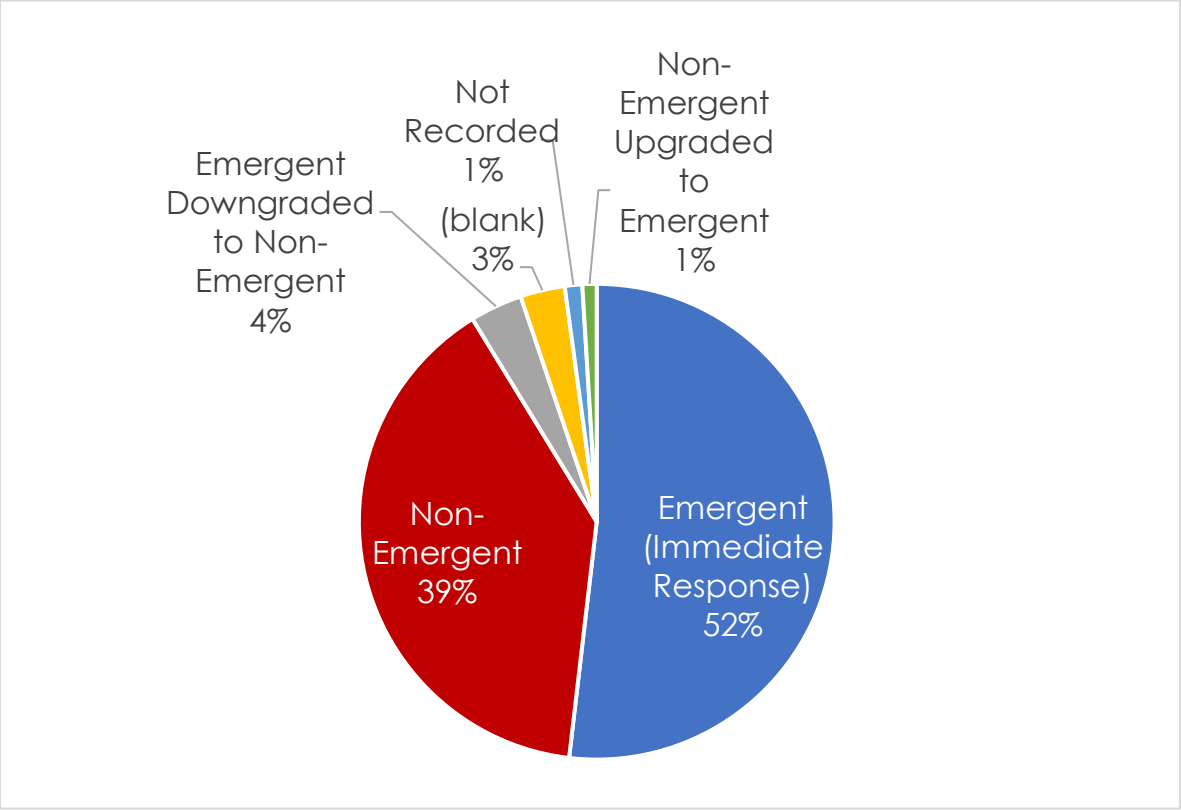


FIGURE 16: DISPOSITION TRANSPORT MODE FROM SCENE OF MATCHED RECORDS: TRA-2 DENOMINATOR

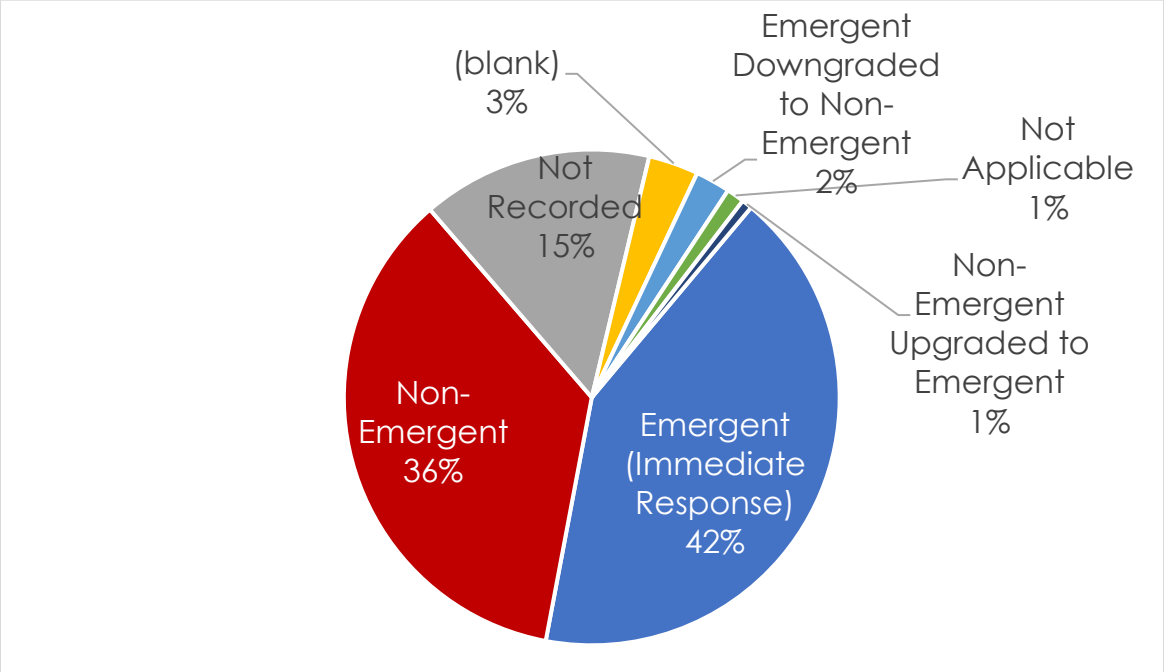


TABLE 1: CEMSIS SOFTWARE NAME AND CREATOR OF MATCHED RECORDS: TRA-2 NUMERATOR

Software Name	Count	Software Creator	Count
Elite	4,224	ImageTrend, Inc.	4,224
ePCR	430	ESO Solutions	542
ESO EHR	406	ZOLL	430
HealthEMS	236	Stryker	236
Street EMS	224	W.A.T.E.R.	224
EHR	136	emsCharts	90
emsCharts	90	Inspironix, Inc.	8
EMS Outfielder Web	8	Intermedix	2
TripTix	2	Emergency Reporting	1
Emergency Reporting	1		
Grand Total	**5,757**	**Grand Total**	**5,757**

TABLE 2: CEMSIS SOFTWARE NAME AND CREATOR OF MATCHED RECORDS: TRA- 2 DENOMINATOR

Software Name	Count	Software Creator	Count
Elite	9,354	ImageTrend, Inc.	9,354
MEDS	1,083	ESO Solutions	1,300
ePCR	1,007	American Medical Response	1,083
ESO EHR	956	ZOLL	1,007
HealthEMS	403	Stryker	403
EHR	344	W.A.T.E.R.	302
Street EMS	302	American Ambulance	254
Simon	254	emsCharts	67
emsCharts	67	Inspironix, Inc.	57
EMS Outfielder Web	57	Inspironix	30
EMS Outfielder N3	30	Emergency Reporting	10
Emergency Reporting	10	Forte Holdings	10
iPCR	10	Intermedix	2
TripTix	2	Eos Logic	1
EOS ePCR	1		
Grand Total	**13,880**	**Grand Total**	**13,880**

73.3% of the numerator records and 67.3% of the denominator records were matched using the ImageTrend, Inc. Elite software. This is also the most widely used ePCR software for CEMSIS records. We did not find any other correlation between matched records and software type.

LIMITATIONS

There are several limitations to linking EMS and hospital trauma records that restrict data matching efforts including:

- Missing, inaccurate, or inconsistent data entered in the databases (CEMSIS and Patient Registry)
    - Poor documentation of data elements, including eInjury.03 (Trauma Center Criteria), eInjury.04 (Vehicular, Pedestrian, or Other Injury Risk Factor), and eDisposition.23 (Hospital Capability) is a significant barrier to capturing trauma patients that were transported to a trauma center. Ongoing revisions to the TRA-2 measure that utilizes these data elements should improve the accuracy, consistency, and completeness of data collection. Revisions include updates to the NEMSIS v3.5.0 data standard, transition to the 2021 American College of Surgeons National Guideline for the Field Triage of Injured Patients, inclusion of eDisposition.02 (Destination/Transferred To, Code) to determine if the receiving facility is a trauma center, and personnel training to improve documentation in ePCRs.
- Partial system representation of data by EMS providers or designated hospital trauma facilities
- Reports with the same parameters that yield different results; oftentimes there is a difference of thousands of records
- Lack of unique identifiers across databases (CEMSIS and Patient Registry)
- Determining the most appropriate data filtering criteria
    - This report did not filter Transport Mode Hospital Arrival (TR8.8) in the Patient Registry in order to obtain the largest population sample possible. Filtering to include EMS mode of arrival only may be necessary in other data analysis and research contexts.

CONCLUSION

The purpose of the CEMSIS and Trauma Data Linkage Initiative is to maximize the number of matched records between two databases; provide summary statistics for EMS and hospital matched trauma records and outcomes of care; identify a sample population where each patient has an EMS record linked to a hospital record; analyze the population through various statistics; and summarize results and their implications for further research regarding EMS and other data linkage opportunities. Through part 2 of this initiative, EMSA successfully matched the following patient records:

- 13,880 out of 32,496 CEMSIS records were successfully matched to the Patient Registry using the TRA-2 denominator criteria, yielding a 42.7% match rate.
- 5,757 out of 10,544 CEMSIS records were successfully matched to Patient Registry records using the TRA-2 numerator criteria, yielding a 54.6% match rate.

The main difference between the two datasets was that hospital capability (trauma level 1, 2, 3, or 4) was identified and used in the filtering criteria in the numerator dataset. This was the first attempt at comparative analysis between two different CEMSIS datasets with separate limiting criteria for the numerator and denominator. There was a 12% difference in how many records were matched, which is a significant finding for this report and previous attempts at data linkage. There were no other significant findings to demonstrate what data variables and criteria are more viable than others. A unique identifier is still the preferred method of matching patient health care records across multiple databases. While many challenges exist in linking EMS and hospital data, improving health care data interoperability supports clinical decision making, quality improvement, and outcome measurement for individual patients and across systems of care. EMSA will continue data linkage efforts to improve data integration, health information exchange and to close the patient care data loop.