Supplementary Online Content

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eReferences.

This supplementary material has been provided by the authors to give readers additional information about their work.

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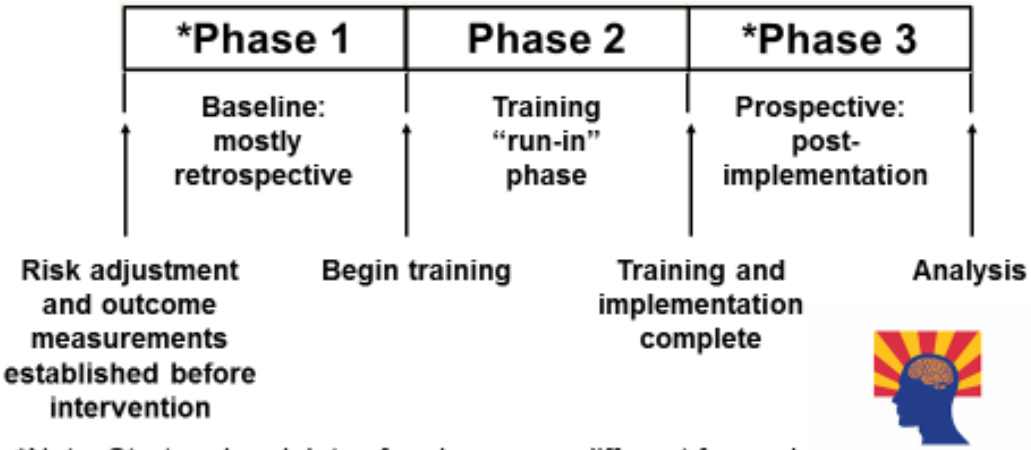
eFigure 1: EPIC Study Design
Before-After System Evaluation



*Note: Start and end dates for phases are different for each EMS agency

EPIC-TBI
Excellence in Prehospital Injury Care Traumatic Brain Injury Project

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eTable 1: EPIC Prehospital EMS Dataset

This table represents some of the key EMS data elements in the EPIC Database. This list is not comprehensive. Many of these elements are timed/dated and can be repeated multiple times (e.g., systolic blood pressure), thus allowing chronological sequencing of patient assessment and treatment.

ASTR Parent Records (This contains pertinent fields to confirm match between EMS and Trauma Center record)
Patient case number
Patient first name
Patient last name
Date of birth
Gender
Primary EMS agency responding
ZIP code of injury incident
City of incident
Street location
Incident time/date
Inter-facility Transfer
Trauma Center Destination
EMS Incident (This is the base record for the initiation of a PCR review, there may be 1-4 EMS incidents per individual patient with 1-4 separate PCRs [e.g., first responding agency, air medical transport agency])
Transporting Agency
Incident time/date
Chief Complaint
Loss of Consciousness
Incident narrative
Patient Pregnant
Due date
Use of seatbelt
Use of helmet
Airbag deployed
Evidence of Alcohol
On-scene interval
Patient weight
Post-traumatic seizure
EMS Vitals (There is no maximum number of vitals per incident. Each documented number is entered)
Time/Data
Systolic blood pressure
Diastolic blood pressure
Respiratory rate

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Breathing quality
Lung sounds
Heart Rate
O_2 Saturation
Blood glucose
Capillary refill time
Skin color
Skin temperature
Skin moisture
GCS motor response
GCS verbal response
GCS eye response
GCS total
Revised Trauma Score (auto-calculated by database)
$ETCO_2$ measured
Assisted breathing
Agonal breathing
Peak inspiratory pressure
Airway Deployment
Airway type (e.g., endotracheal intubation, laryngeal mask airway, King Airway)
Successful/unsuccessful
Number of attempts
$ETCO_2$ detector used
Passive Ventilation (e.g., non-rebreather mask, nasal cannula, blow by)
Device type
O_2 flow rate (actual or “high-flow”)
Active Ventilation (BVM, Auto-vent, mechanical ventilator)
Device type
Use of pressure/flow controlled ventilation bag
Use of ventilation rate timer
O_2 flow rate
CPAP or PEEP employed
CPAP or PEEP pressure utilized
Tidal volume
FIO_2 percent
O_2 saturation measured response to treatment
$ETCO_2$ measured response to treatment
Fluid Infusion
Total volume infused
Delivery method (e.g., IV, Intraosseous)

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Fluid type
Infusion rate, if specified.
Drug Administration
Drug
Dosage
Method of delivery
Agency (each agency caring for the patient is specified to identify which study phase the patient was in at the time of the incident)
EPIC training start date
EPIC training end date

Abbreviations: ASTR, Arizona State Trauma Registry; PCR, patient care record; GCS, Glasgow Coma Scale; $ETCO_2$, End Tidal CO_2; CPAP, continuous positive airway pressure device; PEEP, positive end-expiratory pressure

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eTable 2: Arizona State Trauma Registry (ASTR)—Data Elements

Notes: The Level I trauma centers in Arizona are all required to enter all data elements. This table is not the complete list of data elements in the ASTR, but a shortened list of examples.

Arizona State Trauma Registry (ASTR) Field Name/Data Element Description
DEMOGRAPHIC DATA ELEMENTS
Reporting Facility Site ID
Registration Number
Medical Record Number
Hospital Admission Date
Admission Status
Patient Last Name
Patient First Name
Patient Middle Initial
Social Security Number
Date of Birth
Age
Units of Age
Gender
Race (Primary)
Race (Secondary)
Ethnicity
Zip Code of Residence
City of Residence
County of Residence
State of Residence
Country of Residence
Alternate Home Residence
Co-Morbid Conditions (Pre-Existing)

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INJURY DATA ELEMENTS

Injury Date
Injury Time
Actual versus Estimated Injury Time
Injury Location ICD-9-CM E-code (E849)
Street Location of Injury
Zip Code of Injury
City of Injury
County of Injury
State of Injury
Country of Injury
Primary ICD-9-CM E-code Injury Descriptor
Additional ICD-9-CM E-code Injury Descriptor
Trauma Type
Work-Related
Patient Occupational Industry
Patient Occupation
Position in Vehicle / Vehicle Type
Injury Event Details (required 2009 forward)
Protective Devices
Child Specific Restraint
Airbag Deployment Details
Safety Equipment Issues

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PREHOSPITAL/TRANSPORT DATA ELEMENTS

Transport Type
Transport Mode (Into Reporting Facility)
Other Transport Modes
Prehospital EMS Agency
Run Sheet Available?
Run Sheet Date
Run Sheet Number (required 2009 forward)
Transported From (Origin)
Transported From (Referring Hospital)
Date EMS Provider Notified
Time EMS Provider Notified
Date EMS Provider Left for Scene
Time EMS Provider Left for Scene
Date EMS Provider Arrived at Scene
Time EMS Provider Arrived at Scene
Date of EMS Patient Contact
Time of EMS Patient Contact
Date EMS Provider Departed Scene
Time EMS Provider Departed Scene
Date of Arrival at Destination
Time of Arrival at Destination
EMS Destination
EMS Agency Response Time (Minutes)
EMS Agency Scene Time (Minutes)
Transport Time - EMS Agency Scene to Destination (Minutes)
Total EMS Agency Time (Minutes)
System Access (Inclusion Criteria)
Triage Criteria
Date of Measurement of Vital Signs
Time of Measurement of Vital Signs
Initial Field Pulse Rate
Initial Field Respiratory Rate
Initial Field Oxygen Saturation
Field Airway Management Details
Field Intubation Status
Field Paralytic Agent in Effect
Initial Field Systolic Blood Pressure
Initial Field GCS – Eye Opening
Initial Field GCS – Verbal Response
Initial Field GCS – Motor Response
Initial Field GCS – Total

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ED/TRAUMA DATA ELEMENTS

ED/Hospital Arrival Date
ED/Hospital Arrival Time
ED Exit Date
ED Exit Time
Length of Stay in ED (Hours)
Complete Trauma Team Arrival Time
ED Discharge Disposition
ED Discharge Destination Hospital
ED Discharge Transport Agency
ED Discharge Transfer Reason
ED/Hospital Initial Pulse Rate
ED/Hospital Initial Respiratory Rate
ED/Hospital Initial Respiratory Assistance
ED/Hospital Initial Oxygen Saturation
ED/Hospital Initial Supplemental Oxygen
ED/Hospital Intubation Status
ED/Hospital Paralytic Agent in Effect
ED/Hospital Initial Systolic Blood Pressure
ED/Hospital Initial GCS – Eye Opening
ED/Hospital Initial GCS – Verbal Response
ED/Hospital Initial GCS – Motor Response
ED/Hospital Initial GCS – Total
ED/Hospital Initial GCS Assessment Qualifiers
ED/Hospital Initial Temperature
ED/Hospital Initial Units of Temperature
ED/Hospital Initial Temperature Route
ED/Hospital Initial Revised Trauma Score
Alcohol Use Indicator
Blood Alcohol Content (mg/dl)
Drug Use Indicator
Toxicology Substances Found

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DISCHARGE DATA ELEMENTS

Hospital Discharge Date
Hospital Discharge Time
Hospital Admission Length of Stay (Days)
Total Length of Hospital Stay – ED plus Admission (Days)
Final Outcome – Dead or Alive
Total ICU Length of Stay (Days)
Total Ventilator Days
Autopsy Identification Number
Injury Diagnoses – ICD-9-CM N-codes
Severity Code(s) for ICD-9-CM Diagnosis
Body Region(s) of Injury for ICD-9-CM Diagnosis
Injury Severity Score for ICD-9-CM Diagnoses
ED/Hospital Procedure Location
ED/Hospital Procedure Start Date
ED/Hospital Procedure Start Time
ED/Hospital ICD-9-CM Procedure Codes
Hospital Complications
Primary Method of Payment
Secondary Method of Payment

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eTable 3.

The Barell Injury Diagnosis Matrix for Traumatic Brain Injury[1]

			ICD-9-CM codes	FRACTURE 800-829	INTERNAL 850-854,860-869 952, 995.55	NERVES 950-951 953-957
Traumatic Brain Injury	1	Type 1 TBI	800,801,803,804(.1-.4,.6-.9), (.03-.05,.53-.55) 850(.2-.4), 851-854, 950(.1-.3), 995.55	800,801,803,804(.1-.4,.6-.9) 800,801,803,804(.03-.05,.53-.55)	850(.2-.4) 851-854*, 995.55	950.1-.3
	2	Type 2 TBI	800,801,803,804(.00,.02,.06,.09) (.50,.52,.56,.59) , 850(.0,.1,.5,.9)	800,801,803,804(.00,.02,.06,.09), 800,801,803,804(.50,.52,.56,.59)	850(.0,.1,.5,.9)	
	3	Type 3 TBI	800,801,803,804(.01, .51)	800,801,803,804(.01,.51)	/	/

Based upon ICD-9 CM Injury Codes
Version used throughout the EPIC Study for inclusion: Updated November 2005 (available at the CDC website: http://www.cdc.gov/nchs/injury/ice/barell_matrix.htm)

REFERENCE

1. Barell V, Aharonson-Daniel L, Fingerhut LA, et al. An introduction to the Barell body region by nature of injury diagnosis matrix. Injury prevention : journal of the International Society for Child and Adolescent Injury Prevention 2002;8:91-6.

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eTable 4. EMS Care of moderate and severe TBI Treatment and Monitoring Guidelines/Protocols—ADULTS

--Definitions:

--Adults: Age ≥18

--The prehospital identification of moderate or severe TBI: Anyone with physical trauma and a mechanism consistent with the *potential* to have induced a brain injury and:

--Any injured patient with loss of consciousness, especially those with GCS <15 or confusion

OR

--Multisystem trauma requiring intubation whether the primary need for intubation was from TBI or from other potential injuries

OR

--Post-traumatic seizures whether they are continuing or not

--Overall approach to monitoring and continuous evaluation:

Continuous O_2 saturation (sat) via pulse oximetry, continuous quantitative end-tidal CO_2 ($ETCO_2$) monitoring in intubated patients, and systolic blood pressure (SBP) every 3-5 minutes.

--Specific, guideline-based therapy:

I. Management of airway/oxygenation:

--CLINICAL AXIOM: A *single* non-spurious O_2 sat of <90% is *independently* associated with a *doubling* of mortality. Hypoxia kills neurons!

A. Management is initiated by continuous high-flow O_2 for all potential TBI cases. Emphasis is placed on prevention, identification, and treatment of hypoxia (O_2 sat <90% and/or cyanosis). If high-flow O_2 fails to correct hypoxia, basic maneuvers for airway repositioning will be attempted, followed by reevaluation. If this does not restore O_2 sat to 90% or greater, or if there is inadequate ventilatory effort, bag-valve-mask ventilation will be performed using appropriate airway adjuncts (e.g., oropharyngeal airway).

B. If airway compromise or hypoxia persists after these interventions, ETI will be performed when an experienced ALS provider is available. Following ETI, tube placement will be confirmed via multiple means including $ETCO_2$ detection and/or capnography.

II. Management of ventilation: Special emphasis is placed on identifying and treating hypoventilation as well as preventing hyperventilation when assisting ventilation.

--CLINICAL AXIOM: In intubated patients, hyperventilation is *independently* associated with *at least* a doubling of mortality and some studies have shown that *even moderate* hyperventilation can increase the risk of dying by *six* times. Hyperventilation kills neurons!

--COROLLARY: It has been shown repeatedly that inadvertent hyperventilation happens *reliably* if not meticulously prevented by proper external means. No one, no matter how experienced, can properly ventilate without ventilatory adjuncts (Pressure-Controlled Bags-PCBs, Ventilation Rate Timers (VRTs), $ETCO_2$ monitoring, ventilators). PCBs/VRTs should be used immediately after intubation and until the patient can be placed on a mechanical ventilator even if this will only take 3-5 minutes (note: that's all the hyperventilation it takes to begin killing neurons).

A. Hypoventilation (ineffective respiratory rate, shallow or irregular respirations, or periods of apnea): If there is evidence of hypoventilation despite high-flow O_2 therapy, assisted ventilation will be performed via BVM (PCB/VRT) and, if ineffective, ETI will be performed if an experienced ALS provider is present.

B. Intubated patients: After ETI, PCB/VRT is used immediately for ventilation and $ETCO_2$ levels will be strictly maintained between 35 and 45 mmHg when monitoring is available (target = 40).

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1. All agencies are strongly encouraged to use PCBs/VRTs. In agencies without $ETCO_2$ monitors, maintain a respiratory rate of 10 breaths per minute to prevent inadvertent hyperventilation. Agencies with $ETCO_2$ monitors should use PCBs/VRTs for the *initial* rate of manual ventilation and then gently modify the ventilation to obtain the target $ETCO_2$ of 40 mmHg. Beware of the tendency to only use the $ETCO_2$ monitor to verify tube placement and then to fail to carefully maintain $ETCO_2$ in target range.
2. Ventilators will be used post-intubation whenever available to optimize ventilatory mechanics and O_2 therapy. This is the *best* way to care for an intubated TBI patient. PCBs/VRTs should be used immediately after intubation and until the patient is placed on the ventilator even if this will only take several minutes.
   --Target tidal volume (TV) will be 7cc/kg with vent rates adjusted to keep the $ETCO_2$ within target range (35-45 mmHg). This is consistent with the National TBI guidelines and with the recent literature showing that intrathoracic pressure, lung mechanics, hemodynamics, and ICP are optimized by this TV compared to the "classical" 10-12 cc/kg that remains common in many settings.

C. Impending cerebral herniation:
--The EPIC guidelines do not encourage even mild hyperventilation for "impending cerebral herniation" for the following reasons:
--There is *no evidence* that it improves outcome in *any* setting
--There is *much evidence* that even mild hyperventilation harms moderate and severe TBI patients
--The "practical application" of this "treatment" is that many patients who *do not have* actual impending herniation end up being hyperventilated since the real-world interpretation often ends up thinking…"The worse a TBI is, the faster you should ventilate." Thus, many patients who will be *harmed* by hyperventilation may end up with the misapplication of this "treatment."

D. Non-intubated patients: All relevant monitoring/treatment will be applied except $ETCO_2$ monitoring.

III. Management of blood pressure: In patients with a *potential* for TBI, SBP ≥ 90 mmHg should be maintained. Strong emphasis is placed on preventing and *aggressively* treating even a *single* episode of SBP <90 mmHg.
--CLINICAL AXIOM: A *single* episode of SBP <90 is *independently* associated with *at least* a doubling of mortality. Amazingly, repeated episodes of hypotension can increase the risk of dying by as much as *eight* times. Hypotension kills neurons!

A. Treatment of hypotension: Even a *single* SBP measurement <90 mmHg will initiate intravenous (IV) fluid resuscitation with an initial bolus of 1 liter of normal saline or Ringer's Lactate. This will be followed by IV administration of isotonic fluids at sufficient rate and volume to keep SBP ≥90 mmHg. If the rapid infusion of the first liter of crystalloid does not correct the hypotension, there should be no hesitation to continue aggressive fluid resuscitation.
--Note: Do not wait for the patient to become hypotensive. If the SBP is dropping, or if there are any other signs of compensated shock such as increasing heart rate with decreasing SBP, begin aggressive treatment *before* the patient becomes hypotensive.
--Intraosseous access should be attempted if all three of the following criteria are met: 1) there is hypotension or other signs of shock, 2) peripheral venous access cannot be quickly established, and 3) the patient's mental status is such that they can tolerate the procedure without undue pain.

B. Treatment of hypertension: In TBI, treatment of acute *hyper*tension is *not* recommended. However, IV fluids should be restricted to a minimal "keep open" rate in patients with SBP ≥140 mmHg.

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IV. Assessment and management of hypoglycemia: In patients with any alteration in mental status, *always* check for hypoglycemia early in the clinical course. Hypoglycemia can *mimic* TBI as a cause of altered mental status. It can also can *cause* TBI (e.g., Diabetic on insulin who misses a meal → low blood sugar → leads to decreased LOC → leads to a motor vehicle crash in a hypoglycemic driver).

--Obtain fingerstick or serum glucose level. If <*70mg/dl* then:

1. Administer 50ml 50% dextrose (D50) IV
2. Repeat blood sugar in 10 minutes and, if still <70mg/dl, repeat dose x 1.
   --If no response then contact medical direction
3. If IV access unsuccessful, dextrose may be given IO.
4. If IV and IO unsuccessful, administer glucagon 1.0 mg IM

--NOTE:

--If there are differences between your regional/agency protocols/standing orders for treating hypoglycemia in the setting of TBI, you may use either the EPIC protocol above or your regional/local protocol. If in doubt, check with your medical director.

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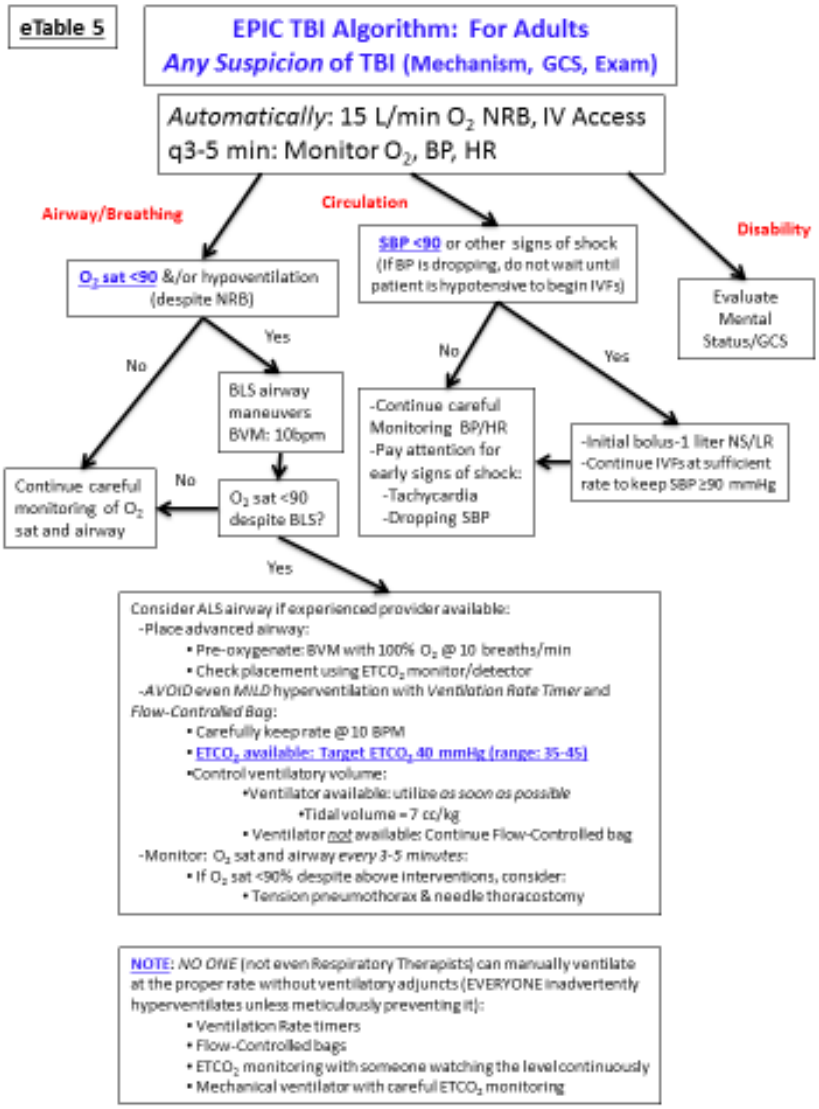
eTable 5



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eTable 6: EMS Care of moderate and severe TBI Treatment and Monitoring Guidelines/Protocols—Infants and Children

--Definitions:

--Age Definitions for Monitoring and Management:

--"Infant": Age 0-24 months

--"Child": Age 2-14 years

--"Late adolescence": 15-17 years

--The prehospital identification of moderate or severe TBI: Anyone with physical trauma and a mechanism consistent with the *potential* to induce a brain injury and:

--Any injured patient with loss of consciousness, especially those with GCS <15 or confusion

OR

--Multisystem trauma requiring intubation whether the primary need for intubation was from TBI or from other potential injuries

OR

--Post-traumatic seizures, whether they are continuing or not

OR

--In infants (where GCS may be difficult to obtain or interpret), decreased level of consciousness, decreased responsiveness, or *any* deterioration of mental status.

--Overall approach to monitoring and continuous evaluation:

--Continuous O_2 saturation (sat) via pulse oximetry, continuous quantitative end-tidal CO_2 ($ETCO_2$) monitoring in intubated patients and systolic blood pressure (SBP) every 3-5 minutes.

--Specific, guideline-based therapy:

I. Management of airway/oxygenation:

--CLINICAL AXIOM: A *single* non-spurious O_2 sat of <90% is *independently* associated with a *doubling* of mortality. Hypoxia kills neurons!

A. Management is initiated by continuous high-flow O_2 for all *potential* TBI cases. Emphasis is placed on prevention, identification, and treatment of hypoxia (O_2 sat <90% and/or cyanosis). If high-flow O_2 fails to correct hypoxia, basic maneuvers for airway repositioning will be attempted, followed by reevaluation. If this does not restore O_2 sat to 90% or greater, or if there is inadequate ventilatory effort, bag-valve-mask (BVM) with a pressure-controlled bag (PCB) and a ventilation rate timer (VRT) will be performed using appropriate airway adjuncts (e.g., oropharyngeal airway). It should be noted that most infants and children can have their airway managed well using basic maneuvers and BVM.

B. If airway compromise or hypoxia persists after these interventions, ETI will be performed when an experienced ALS provider is available. Following ETI, tube placement will be confirmed via multiple means including $ETCO_2$ detection and/or capnography.

II. Management of ventilation: Special emphasis is placed on identifying and treating hypoventilation as well as preventing hyperventilation when assisting ventilation.

--CLINICAL AXIOM: In intubated patients, hyperventilation is *independently* associated with *at least* a doubling of mortality and some studies have shown that *even moderate* hyperventilation can increase the risk of dying by *six* times. Hyperventilation kills neurons!

--COROLLARY: It has been shown repeatedly that inadvertent hyperventilation happens *reliably* if not meticulously prevented by proper external means. No one, no matter how experienced, can properly ventilate without ventilatory adjuncts (Pressure-Controlled Bags-PCBs, Ventilation Rate Timers—VRTs, $ETCO_2$ monitoring, ventilators). PCBs/VRTs should be used immediately after intubation and until the patient can be placed on a mechanical ventilator even if this will only take 3-5 minutes (note: that's all the hyperventilation it takes to begin killing neurons).

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A. Hypoventilation [ineffective respiratory rate for age, shallow or irregular respirations, periods of apnea, or measured hypercarbia (elevated $ETCO_2$)]: If there is evidence of hypoventilation despite high-flow O_2 therapy, assisted ventilation will be performed via BVM and, if ineffective, ETI will be performed if an experienced ALS provider is present.

B. Intubated patients: After ETI, use PCB/VRT immediately for ventilation and $ETCO_2$ levels will be strictly maintained between 35 and 45 mmHg when monitoring is available (target = 40)

1. All agencies are strongly encouraged to use PCBs/VRTs. In agencies without $ETCO_2$ monitors, maintain age-appropriate ventilatory rates and decrease the risk of inadvertent hyperventilation. Agencies with $ETCO_2$ monitors should use PCBs/VRTs for the *initial* rate of manual ventilation and then gently modify the ventilation to obtain the target $ETCO_2$ of 40 mmHg. Beware of the tendency to only use the $ETCO_2$ monitor to verify tube placement and then to fail to carefully maintain $ETCO_2$ in target range.
   --Target ventilatory rates from the National TBI Guidelines:
      --Infants: (age 0-24 months): 25 breaths per minute (bpm);
      --Children: (age 2-14): 20 bpm;
      --Older adolescents: (age 15-17): 10 bpm (same as adults)
2. Whenever possible, ventilators should be used post-intubation to optimize ventilatory parameters and O_2 therapy. This is the *best* way to care for an intubated TBI patient. PCBs/VRTs should be used immediately after intubation and until the patient is placed on the ventilator even if this will only take several minutes.
   --Target tidal volume (TV) will be 7cc/kg with rates adjusted to keep the $ETCO_2$ within target range (35-45 mmHg).
      --Note: This is consistent with the TBI guidelines and the recent literature showing that intrathoracic pressure, lung mechanics, hemodynamics, and ICP are optimized by this TV compared to the "classic" 10-12 cc/kg that remains common in many settings.

C. Impending cerebral herniation:
--The EPIC guidelines do not encourage even mild hyperventilation for "impending cerebral herniation" for the following reasons:
   --There is *no evidence* that it improves outcome in *any* setting
   --There is *much evidence* that even mild hyperventilation harms moderate and severe TBI patients
   --The "practical application" of this "treatment" is that many patients who *do not have* actual impending herniation end up being hyperventilated since the real-world interpretation often ends up thinking…"The worse a TBI is, the faster you should ventilate." Thus, many patients who will be *harmed* by hyperventilation may end up with the misapplication of this "treatment."

D. Non-intubated patients: All relevant monitoring/treatment will be applied except $ETCO_2$ monitoring.

III. Management of blood pressure: In patients with a *potential* for TBI, strong emphasis is placed on preventing and *aggressively* treating even a *single* episode of hypotension.
   --CLINICAL AXIOM: A *single* episode of hypotension is *independently* associated with *at least* a doubling of mortality. Amazingly, repeated episodes of hypotension can increase the risk of dying by as much as *eight* times. Hypotension kills neurons!
--Hypotension will be defined as systolic blood pressure (SBP) below the 5th percentile for age. This will be estimated using the following formula:
   --Infants/children age <10: 70 mmHg + (age X 2)
   --Children age ≥10: 90 mmHg (same as adults)
   --Good "rules of thumb" to remember:
      --Infant = 70 mmHg

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--5 year old = 80 mmHg
--10 and older = 90 mmHg

A. Treatment of hypotension: Even a *single* hypotensive measurement (for age) will initiate intravenous (IV) fluid resuscitation. For hypotension or other signs of shock, IV normal saline will be given. Sufficient volume (via 20cc/kg boluses every 5 minutes) will be given to return SBP to at least the 5th percentile estimate.
--Once hypotension has been corrected, IV administration of NS should occur at sufficient rate to keep the patient non-hypotensive.
--Note: If the rapid infusion of the initial bolus of crystalloid does not correct the hypotension, do not hesitate to continue aggressive fluid resuscitation.
--Note: Do not wait for the patient to become hypotensive. If the SBP is dropping, or if there are any other signs of compensated shock such as increasing heart rate with decreasing SBP, begin aggressive treatment *before* the patient becomes hypotensive.
--Intraosseous access should be attempted if all three of the following criteria are met: 1) there is hypotension or other signs of shock, 2) peripheral venous access cannot be quickly established, and 3) the patient's mental status is such that they can tolerate the procedure without undue pain.

B. Treatment of hypertension: In TBI, treatment of acute hypertension is not recommended. However, IV fluids will be restricted to a minimal "keep open" rate in infants/young children with SBP ≥100 mmHg and in older children/adolescents with SBP ≥130 mmHg.

IV. Assessment and management of hypoglycemia: In patients with any alteration in mental status, *always* check for hypoglycemia early in the clinical course. Hypoglycemia can *mimic* TBI as a cause of altered mental status.
--Obtain fingerstick or serum glucose level. If glucose level is <*70mg/dl* then:

1. Administer dextrose IV:
   --Newborn (birth to 2 months):
      --Administer 5ml/kg of D10 solution IV
   --Infants and toddlers (3 months to 3 years):
      --Administer 2ml/kg of D25 solution, max dose = 100ml (25 g).
   --Children age 4 and older:
      --Administer 1ml/kg of D50 solution, max dose = 50ml
2. Repeat blood sugar in 10 minutes and, if still <70mg/dl, repeat dose x 1.
   --If no response then contact medical direction
3. If IV access unsuccessful, dextrose may be given IO.
4. If IV and IO unsuccessful, administer Glucagon 0.03mg/kg IM, max dose 1mg

--NOTES:

A. If there are differences between your regional/agency protocols/standing orders for treating hypoglycemia in the setting of TBI, you may use either the EPIC protocol above or your regional/local protocol. If in doubt, check with your medical director.
B. All dosing of dextrose and glucagon may be determined by length-based resuscitation tape rather than weight estimations if that is preferred by the agency/medical director
C. Mix D25 or D10 using either your regional/local protocols or the following:
   --D25: Make D25 by removing 25CC from a 50CC bag and inject 25 CCs of D50 into the bag. Then remove an appropriate amount of the D25 and administer volume according to weight.
   --D10: Make D10NS by removing 50CC from a 250CC bag of NS and then injecting one amp (50CC) of D50 into the bag. Then remove an appropriate amount of the D10NS and administer volume according to weight.

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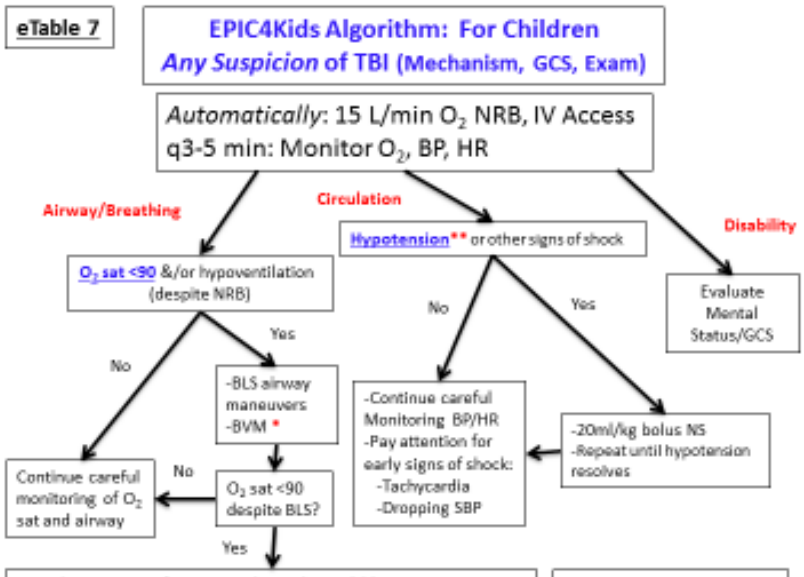
eTable 7



Consider ALS airway if experienced provider available:
- -Place advanced airway:
  - Pre-oxygenate: BVM with 100% O_2 @ age-appropriate rate *
  - Check placement using $ETCO_2$ monitor/detector
- *-AVOID even MILD hyperventilation with Ventilation Rate Timer and Flow-Controlled Bag:*
  - Carefully keep rate @ age-appropriate rate *
  - $ETCO_2$ available: Target $ETCO_2$ 40 mmHg (range: 35-45)
  - Control ventilatory volume:
    - Ventilator available: utilize as soon as possible
      - Tidal volume = 7 cc/kg
    - Ventilator *not* available: Continue Flow-Controlled bag
- -Monitor: O_2 sat and airway *every 3-5 minutes*:
  - If O_2 sat <90% despite above interventions, consider:
    - Tension pneumothorax & needle thoracostomy

NOTE: NO ONE (not even Respiratory Therapists) can manually ventilate at the proper rate without ventilatory adjuncts (EVERYONE inadvertently hyperventilates unless meticulously preventing it):
- Ventilation Rate Timers
- Flow-Controlled Bags
- $ETCO_2$ monitoring with someone watching the level continuously
- Mechanical ventilator with careful $ETCO_2$ monitoring

* ***Ventilation Rates***:
-Infants: (0-24 mo.):
-25 breaths/min (bpm)
-Children: (2-14 yrs):
-20 bpm
-Adolescents: (15-17 yrs):
-10 bpm (same as adults)

** ***Identifying Hypotension in children***
0-9 yrs: 70 + (age x 2)
≥10 yrs: <90mmHg
-*Rules of thumb*:
Newborn: <70mmHg
5 year old: <80mmHg
10 and older: <90mmHg →
(Same as adults)

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eTable 8: Important Risk Factors and Potential Confounders Used in the Final Models

--Age (years)
--Sex
--Race
--Ethnicity
--Head Region Severity Score (RSS-H):
    --The International Classification of Diseases-Version 9 (ICD9)-based Head Region Severity Score. This method is parallel to the Abbreviated Injury Scale system with scores between 1 (mild-to-moderate) and 6 (critical/extremely severe)[1-5]
--Injury Severity Score (ISS):
    --The quadratic sum of the regional severity scores of the patient's three most severely injured body regions
--Trauma Type:
    --Blunt or penetrating
--Direct transport versus transfer to a trauma center
--Payment source
--Multi-system injury:
    --TBI (see inclusion criteria) plus injury to at least one other body region with a Regional Severity Score ≥3
--Prehospital CPR (cardiopulmonary resuscitation)
--Treating trauma center:
    --The Level I Trauma Center that cared for the patient (10 total, statewide)

--Note:
    These risk-adjusters/covariates were all included, *a priori*, in the model regardless of statistical significance, based on the extant trauma literature and the previous observational studies published from the pre-implementation EPIC cohort.[6-8]

References at end of online Supplement on Page 37

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eTable 9: Changes in Rates of Hypoxia in the Field Versus on Arrival at the Trauma Center Among Prehospital-Intubated Patients

Level of Hypoxia[+]	EMS[&]		TC[#]		Absolute Change*		
	Pre	Post	Pre	Post	Pre	Post	p-value
O_2 Saturation <90%	26.1%	32.9%	9.7%	12.0%	-16.0%	-20.2%	0.040
O_2 Saturation <80%	10.9%	17.1%	3.7%	3.9%	-6.8%	-11.9%	0.001
O_2 Saturation <70%	4.5%	7.9%	1.5%	1.2%	-2.6%	-5.7%	0.004

+ Threshold for defining a given patient as having hypoxia
& Lowest documented prehospital oxygen saturation (SpO_2)
# TC = Initial SpO_2 on arrival at the Trauma Center
* The absolute change in the rate of prehospital hypoxia compared to the rate of hypoxia on arrival at the Trauma Center
--"Pre" = Study Phase 1, "Post" = Study Phase 3
--Hypoxia rate estimation includes all prehospital-intubated subjects with documentation of at least one prehospital SpO_2 data (N=3,111; P1=2,226; P3=885) or with initial Trauma Center data (N=2,785; P1=1,878; P3=907). The comparison analysis includes all prehospital-intubated patients with documentation of at least one prehospital SpO_2 and the corresponding initial Trauma Center value (N= 2492; P1=1670; P3= 822)
--The p-values reflect the comparison of the decrease in hypoxia rate on arrival at the trauma center in P1 versus P3 and is obtained from a generalized estimating equation (GEE) model for binary outcome with identity link and exchangeable working correlation matrix.

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eTable 10: Rates of Patients Receiving Intravenous Fluid Boluses in P1 Versus P3

Cohort	P1				P3				p-value	Abs Incr	Rel Incr (%)
	n	Cases	Rate	95% CI	n	Cases	Rate	95% CI			
All patients	15228	842	0.055	0.052, 0.059	6624	434	0.066	0.060, 0.072	0.003	0.010	18.5
Direct to TC	10310	668	0.065	0.060, 0.070	4361	341	0.078	0.070, 0.087	0.004	0.013	20.7
Low EMS SBP <110 & Direct to TC	2436	293	0.120	0.108, 0.134	1101	147	0.134	0.114, 0.155	0.294	0.013	11.0
Low EMS SBP <100 & Direct to TC	1357	208	0.153	0.135, 0.174	670	110	0.164	0.137, 0.194	0.569	0.011	7.1
Low EMS SBP <90 & Direct to TC	731	136	0.186	0.159, 0.216	404	76	0.188	0.151, 0.230	0.995	0.002	1.1
Low EMS SBP <80 & Direct to TC	402	69	0.172	0.136, 0.212	244	47	0.193	0.145, 0.248	0.570	0.021	12.2

Legend:

--P1 = Study Phase 1
--P3 = Study Phase 3
--Rate = Proportion of patients receiving at least one intravenous fluid bolus in a given category
--Abs Incr = Absolute increase of rate from P1 to P3
--Rel Incr (%) = Relative percentage increase in rate from P1 to P3
--Low EMS SBP = Lowest recorded prehospital systolic blood pressure
--Direct to TC = Patients taken directly from the injury scene to the Level I Trauma Center. This category included only patients who do not have the potential complicating factor of receiving IV fluid/blood product resuscitation at a transferring hospital
--p-values comparing the rates between P1 vs. P3 are obtained from Chi-squared test or Fisher's exact as appropriate.
--Total N = 21,582, n-P1 = 15,228, n-P3 = 6,624

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eTable 11: Rates of Patients Receiving Various Total Prehospital Volumes of Isotonic Intravenous Fluid in P1 Versus P3

	P1			P3			p-value	Abs Incr	Rel Incr (%)
Cohort	**Cases**	**Rate**	**95% CI**	**Cases**	**Rate**	**95% CI**			
All patients (n-P1 = 15,228; n-P3 = 6,624)									
Vol ≥ 250	603	0.040	0.037, 0.043	311	0.047	0.042, 0.052	0.014	0.007	18.6
Vol ≥ 500	328	0.022	0.019, 0.024	181	0.027	0.024, 0.032	0.011	0.006	26.8
Vol ≥ 750	124	0.008	0.007, 0.010	71	0.011	0.008, 0.014	0.075	0.003	31.6
Vol ≥ 1000	87	0.006	0.005, 0.007	53	0.008	0.006, 0.010	0.063	0.002	40.0
Direct to TC (n-P1 = 10,310; n-P3 = 4,361)									
Vol ≥ 250	487	0.047	0.043, 0.052	247	0.057	0.050, 0.064	0.019	0.009	19.9
Vol ≥ 500	268	0.026	0.023, 0.029	137	0.031	0.026, 0.037	0.076	0.005	20.9
Vol ≥ 750	103	0.010	0.008, 0.012	53	0.012	0.009, 0.016	0.280	0.002	21.6
Vol ≥ 1000	71	0.007	0.005, 0.009	38	0.009	0.006, 0.012	0.283	0.002	26.5
Lowest EMS SBP <110 mmHg & Direct to TC (n-P1 = 2,436; n-P3 =1,101)									
Vol ≥ 250	225	0.092	0.081, 0.105	118	0.107	0.090, 0.127	0.188	0.015	16.1
Vol ≥ 500	132	0.054	0.046, 0.064	72	0.065	0.052, 0.082	0.213	0.011	20.7
Vol ≥ 750	49	0.020	0.015, 0.027	31	0.028	0.019, 0.040	0.172	0.008	40.0
Vol ≥ 1000	35	0.014	0.010, 0.020	22	0.020	0.013, 0.030	0.279	0.006	39.0
Lowest EMS SBP <100 mmHg & Direct to TC (n-P1 =1,357; n-P3 = 670)									
Vol ≥ 250	158	0.116	0.100, 0.135	89	0.133	0.108, 0.161	0.322	0.016	14.1
Vol >= 500	92	0.068	0.055, 0.083	56	0.084	0.064, 0.107	0.232	0.016	23.3
Vol ≥ 750	35	0.026	0.018, 0.036	26	0.039	0.026, 0.056	0.140	0.013	50.5
Vol ≥ 1000	26	0.019	0.013, 0.028	19	0.028	0.017, 0.044	0.245	0.009	48.0
Lowest EMS SBP <90 mmHg & Direct to TC (n-P1 = 731; n-P3 = 404)									
Vol ≥ 250	103	0.141	0.117, 0.168	63	0.156	0.122, 0.195	0.549	0.015	10.6
Vol ≥ 500	65	0.089	0.069, 0.112	41	0.102	0.074, 0.135	0.555	0.013	14.1
Vol ≥ 750	29	0.040	0.027, 0.056	21	0.052	0.032, 0.079	0.414	0.012	31.0
Vol ≥ 1000	22	0.030	0.019, 0.045	16	0.040	0.023, 0.064	0.496	0.010	31.6
Lowest EMS SBP <80 mmHg & Direct to TC (n-P1 = 402; n-P3 = 244)									
Vol ≥ 250	48	0.119	0.089, 0.155	40	0.164	0.120, 0.217	0.139	0.045	37.3
Vol ≥ 500	31	0.077	0.053, 0.108	29	0.119	0.081, 0.166	0.103	0.042	54.2
Vol ≥ 750	17	0.042	0.025, 0.067	15	0.061	0.035, 0.099	0.367	0.019	45.4
Vol ≥ 1000	13	0.032	0.017, 0.055	11	0.045	0.023, 0.079	0.538	0.013	39.4

--P1 = Study Phase 1
--P3 = Study Phase 3
--Rate = Proportion of patients receiving the specified intravenous fluid bolus volume
--Abs Incr = Absolute increase of rate from P1 to P3
--Rel Incr (%): Relative percentage increase in rate from P1 to P3
--Vol = Total volume of isotonic intravenous fluids infused [in milliliters (ml)] during prehospital care
--EMS SBP = Lowest recorded prehospital systolic blood pressure

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--Direct to TC = Patients taken directly from the injury scene to the Level I Trauma Center. This category included only patients who do not have the potential complicating/confounding factor of receiving IV fluid/blood product resuscitation at a transferring hospital
--p-values comparing the rates between P1 vs. P3 are obtained from Chi-squared test or Fisher's exact as appropriate.
--Total N = 21,582, n-P1 = 15,228, n-P3 = 6,624

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eTable 12: Rates of Intubation and Bag-Valve-Mask Airways Pre/Post-implementation

Airway Type	P1-All Patients	P1-Proportion With Procedure	P3-All Patients	P3-Proportion With Procedure	Absolute Change	Relative Change	p-value*
ETI	15228	19.1%	6624	16.6%	-2.6%	-13.4%	<0.0001
BVM	15228	3.5%	6624	4.9%	1.4%	39.9%	<0.0001

--ETI = Endotracheal Intubation
--BVM = Active Bag-Valve-Mask ventilation without any advanced airway intervention
--P1 = Study Phase 1
--P3 = Study Phase 3
*Chi squared test

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eTable 13: Proportions of Older Patients in P1 Versus P3 by Various Age Definitions

Outcome	P1			P3			Absolute Change	Relative Change (%)	p-value*
	n	Rate	95% CI	n	Rate	95% CI			
Age ≥50	6295	0.413	0.406, 0.421	3404	0.514	0.502, 0.526	0.100	24.3	<0.0001
Age ≥55	5334	0.350	0.343, 0.358	2973	0.449	0.437, 0.461	0.099	28.1	<0.0001
Age ≥60	4425	0.291	0.283, 0.298	2555	0.386	0.374, 0.398	0.095	32.7	<0.0001
Age ≥65	3634	0.239	0.232, 0.246	2102	0.317	0.306, 0.329	0.079	33.0	<0.0001
Age ≥70	2926	0.192	0.186, 0.199	1714	0.259	0.248, 0.269	0.067	34.7	<0.0001
Age ≥75	2296	0.151	0.145, 0.157	1357	0.205	0.195, 0.215	0.054	35.9	<0.0001
Age ≥80	1598	0.105	0.100, 0.110	968	0.146	0.138, 0.155	0.041	39.2	<0.0001

--P1 = Study Phase 1 (pre-implementation phase)
--P3 = Study Phase 3 (post-implementation phase)
--*Chi-squared test
--95% CI = 95% Confidence Interval
--Total N = 21,581, n-P1 = 15,227, n-P3 = 6,624

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eTable 14: Analysis of Adjusted Survival to Hospital Admission in Phase 3 Versus Phase 1

Variable	Levels	OR	95% CI	p-value
Intervention		1.70	(1.38, 2.09)	<0.0001
Male	No	---	---	0.609
	Yes	0.947	(0.769, 1.17)	
Race	Black	---	---	0.061
	Asian	0.636	(0.239, 1.69)	
	American Indian/Alaska Nat.	1.60	(0.798, 3.19)	
	White	0.823	(0.527, 1.28)	
	Other	0.719	(0.428, 1.21)	
	Unknown	0.500	(0.250, 1.00)	
Hispanic	No	---	---	0.830
	Yes	1.03	(0.797, 1.33)	
	Unknown	0.881	(0.551, 1.41)	
Payer	Private	---	---	<0.0001
	AHCCCS/Medicaid	1.42	(1.09, 1.85)	
	Medicare	1.04	(0.742, 1.46)	
	Self Pay	0.362	(0.284, 0.460)	
	Other	0.858	(0.543, 1.36)	
	Unknown	0.368	(0.220, 0.616)	
Trauma Type	Blunt	---	---	<0.0001
	Penetrating	0.241	(0.191, 0.304)	
Head Injury Severity Score (ICD)	1 to 3	---	---	<0.0001
	4	0.945	(0.609, 1.47)	
	5 to 6	0.189	(0.127, 0.282)	
Injury Severity Score (ICD)	1 to 14	---	---	<0.0001
	16 to 24	0.535	(0.254, 1.13)	
	25+	0.148	(0.073, 0.299)	
Body Region	Isolated TBI	---	---	<0.0001
	Multisystem TBI	0.602	(0.491, 0.738)	
Transfer	No	---	---	<0.0001
	Yes	7.42	(4.75, 11.6)	
	Unknown	1.32	(0.644, 2.73)	
CPR	No	---	---	<0.0001
	Yes	0.04	(0.032, 0.049)	
Hospital	Not Shown			<0.0001
Age (year)	Nonparametric function			0.011

--AHCCCS = Arizona Health Care Cost Containment System
--ICD = International Classification of Diseases-Version 9
--Isolated TBI: Cases that met TBI inclusion criteria but had no injury with Regional Severity Score ≥3 in any other (non-head) body region
--Multisystem TBI: Cases that met TBI inclusion criteria and also had at least one non-head region injury with Regional Severity Score ≥3
--CPR = Cardiopulmonary Resuscitation
--Note: Treating Trauma Center was also highly significant (p <0.0001). To protect the mandated anonymity of the participating hospitals, the numbers are not shown (preventing any possible identification or inference of facility-specific outcome differences)

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eTable 15: Logistic Regression Model for Survival with Random Agency Effects

Variable	Levels	OR	95% CI	p-value
Intervention		1.04	(0.913, 1.19)	0.549
Male	No	---	---	0.687
	Yes	1.03	(0.901, 1.17)	
Race	Black	---	---	0.007
	Asian	0.777	(0.411, 1.47)	
	American Indian/Alaska Nat.	0.73	(0.482, 1.10)	
	White	0.85	(0.610, 1.19)	
	Other	0.684	(0.466, 1.00)	
	Unknown	0.381	(0.213, 0.679)	
Hispanic	No	---	---	0.025
	Yes	1.15	(0.968, 1.37)	
	Unknown	0.702	(0.494, 0.998)	
Payer	Private	---	---	<0.0001
	AHCCCS/Medicaid	1.13	(0.952, 1.33)	
	Medicare	0.907	(0.736, 1.12)	
	Self Pay	0.468	(0.388, 0.565)	
	Other	0.815	(0.609, 1.09)	
	Unknown	0.312	(0.212, 0.460)	
Trauma Type	Blunt	---	---	<0.0001
	Penetrating	0.160	(0.130, 0.196)	
Head Injury Severity Score (ICD)	1 to 3	---	---	<0.0001
	4	0.832	(0.647, 1.07)	
	5 to 6	0.046	(0.036, 0.060)	
Injury Severity Score (ICD)	1 to 14	---	---	<0.0001
	16 to 24	0.442	(0.302, 0.649)	
	25+	0.181	(0.121, 0.269)	
Body Region	Isolated TBI	---	---	<0.0001
	Multisystem TBI	0.498	(0.431, 0.575)	
Transfer	No	---	---	<0.0001
	Yes	1.89	(1.57, 2.28)	
	Unknown	1.21	(0.766, 1.91)	
CPR	No	---	---	<0.0001
	Yes	0.029	(0.021, 0.040)	
Hospital	Not Shown	---	---	<0.0001
Age (year)	Nonparametric function			<0.0001

--AHCCCS = Arizona Health Care Cost Containment System
--ICD = International Classification of Diseases-Version 9
--Isolated TBI: Cases that met TBI inclusion criteria but had no injury with Regional Severity Score ≥3 in any other (non-head) body region
--Multisystem TBI: Cases that met TBI inclusion criteria and also had at least one non-head region injury with Regional Severity Score ≥3
--CPR = Cardiopulmonary Resuscitation
--Note: Hospital (Treating Trauma Center) was also highly significant (p <0.0001). To protect the mandated anonymity of the participating hospitals, the numbers are not shown (preventing any possible identification or inference of facility-specific outcome differences)

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eTable 16: Logistic Regression Model for Survival to Hospital Admission with Random Agency Effects

Variable	Levels	OR	95% CI	p-value
Intervention		1.73	(1.40, 2.13)	<0.0001
Male	No	---	---	0.657
	Yes	0.954	(0.774, 1.17)	
Race	Black	---	---	0.065
	Asian	0.627	(0.235, 1.68)	
	American Indian/Alaska Nat.	1.5	(0.749, 3.02)	
	White	0.777	(0.496, 1.22)	
	Other	0.699	(0.415, 1.18)	
	Unknown	0.476	(0.237, 0.957)	
Hispanic	No	---	---	0.807
	Yes	1.03	(0.799, 1.34)	
	Unknown	0.874	(0.546, 1.40)	
Payer	Private	---	---	<0.0001
	AHCCCS/Medicaid	1.44	(1.11, 1.88)	
	Medicare	1.03	(0.735, 1.45)	
	Self Pay	0.368	(0.289, 0.469)	
	Other	0.841	(0.532, 1.33)	
	Unknown	0.366	(0.219, 0.613)	
Trauma Type	Blunt	---	---	<0.0001
	Penetrating	0.243	(0.192, 0.306)	
Head Injury Severity Score (ICD)	1 to 3	---	---	<0.0001
	4	0.953	(0.613, 1.48)	
	5 to 6	0.193	(0.129, 0.289)	
Injury Severity Score (ICD)	1 to 14	---	---	<0.0001
	16 to 24	0.524	(0.248, 1.11)	
	25+	0.143	(0.071, 0.291)	
Body Region	Isolated TBI	---	---	<0.0001
	Multisystem TBI	0.598	(0.487, 0.733)	
Transfer	No	---	---	<0.0001
	Yes	6.62	(4.19, 10.5)	
	Unknown	1.26	(0.605, 2.62)	
CPR	No	---	---	<0.0001
	Yes	0.039	(0.031, 0.048)	
Hospital	Not Shown	---	---	<0.0001
Age (year)	Nonparametric function			0.017

--AHCCCS = Arizona Health Care Cost Containment System
--ICD = International Classification of Diseases-Version 9
--Isolated TBI: Cases that met TBI inclusion criteria but had no injury with Regional Severity Score ≥3 in any other (non-head) body region
--Multisystem TBI: Cases that met TBI inclusion criteria and also had at least one non-head region injury with Regional Severity Score ≥3
--CPR = Cardiopulmonary Resuscitation
--Note: Hospital (Treating Trauma Center) was also highly significant (p <0.0001). To protect the mandated anonymity of the participating hospitals, the numbers are not shown (preventing any possible identification or inference of facility-specific outcome differences)

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eTable 17: Logistic Regression Model for Survival with Systolic Blood Pressure Included by TRISS Category

Variable	Levels	OR	95% CI	p-value
Intervention		1.06	(0.930, 1.21)	0.370
Male	No	---	---	0.990
	Yes	1	(0.875, 1.14)	
Race	Black	---	---	0.027
	Asian	0.813	(0.426, 1.55)	
	American Indian/Alaska Nat.	0.76	(0.498, 1.16)	
	White	0.842	(0.599, 1.18)	
	Other	0.671	(0.452, 0.995)	
	Unknown	0.423	(0.234, 0.766)	
Hispanic	No	---	---	0.011
	Yes	1.16	(0.968, 1.38)	
	Unknown	0.653	(0.454, 0.938)	
Payer	Private	---	---	<0.0001
	AHCCCS/Medicaid	1.15	(0.964, 1.36)	
	Medicare	0.891	(0.720, 1.10)	
	Self Pay	0.489	(0.403, 0.593)	
	Other	0.804	(0.598, 1.08)	
	Unknown	0.337	(0.227, 0.499)	
Trauma Type	Blunt	---	---	<0.0001
	Penetrating	0.19	(0.153, 0.234)	
Head Injury Severity Score (ICD)	1 to 3	---	---	<0.0001
	4	0.864	(0.669, 1.12)	
	5 to 6	0.048	(0.037, 0.063)	
Injury Severity Score (ICD)	1 to 14	---	---	<0.0001
	16 to 24	0.431	(0.292, 0.634)	
	25+	0.18	(0.121, 0.270)	
Body Region	Isolated TBI	---	---	<0.0001
	Multisystem TBI	0.579	(0.499, 0.672)	
Transfer	No	---	---	<0.0001
	Yes	2.04	(1.72, 2.43)	
	Unknown	1.33	(0.841, 2.10)	
CPR	No	---	---	<0.0001
	Yes	0.053	(0.038, 0.074)	
SBP Category (TRISS/RTS)	≥90 mmHg	---	---	<0.0001
	76-89 mmHg	0.394	(0.311, 0.499)	
	50-75 mmHg	0.315	(0.242, 0.410)	
	40-49 mmHg	0.108	(0.043, 0.270)	
	Unknown	0.208	(0.168, 0.258)	
Hospital	Not Shown			<0.0001
Age (year)	Nonparametric function			<0.0001

--This sensitivity analysis evaluated the logistic regression model with the lowest prehospital SBP [stratified by the categories in TRISS/Revised Trauma Score (RTS) Methodology] incorporated as a risk-adjustment measure in the model
--AHCCCS = Arizona Health Care Cost Containment System
--ICD = International Classification of Diseases-Version 9
--Isolated TBI: Cases that met TBI inclusion criteria but had no injury with Regional Severity Score ≥3 in any other (non-head) body region
--Multisystem TBI: Cases that met TBI inclusion criteria and also had at least one non-head region injury with Regional Severity Score ≥3
--CPR = Cardiopulmonary Resuscitation
--Note: Hospital (Treating Trauma Center) was also highly significant (p <0.0001). To protect the mandated anonymity of the participating hospitals, the numbers are not shown (preventing any possible identification or inference of facility-specific outcome differences)

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eTable 18: Logistic Regression Model for Survival with Glasgow Coma Scale Included by TRISS Category

Variable	Levels	OR	95% CI	p-value
Intervention		1.01	(0.874, 1.16)	0.930
Male	No	---	---	0.990
	Yes	0.999	(0.867, 1.15)	
Race	Black	---	---	0.089
	Asian	0.703	(0.362, 1.36)	
	American Indian/Alaska Nat.	0.823	(0.534, 1.27)	
	White	0.887	(0.628, 1.25)	
	Other	0.725	(0.485, 1.08)	
	Unknown	0.485	(0.267, 0.882)	
Hispanic	No	---	---	0.012
	Yes	1.1	(0.915, 1.33)	
	Unknown	0.612	(0.423, 0.885)	
Payer	Private	---	---	<0.0001
	AHCCCS/Medicaid	1.12	(0.939, 1.34)	
	Medicare	0.886	(0.704, 1.12)	
	Self Pay	0.482	(0.394, 0.591)	
	Other	0.954	(0.700, 1.30)	
	Unknown	0.354	(0.236, 0.531)	
Trauma Type	Blunt	---	---	<0.0001
	Penetrating	0.207	(0.165, 0.259)	
Head Injury Severity Score (ICD)	1 to 3	---	---	<0.0001
	4	0.888	(0.683, 1.15)	
	5 to 6	0.082	(0.062, 0.108)	
Injury Severity Score (ICD)	1 to 14	---	---	<0.0001
	16 to 24	0.51	(0.344, 0.758)	
	25+	0.247	(0.164, 0.374)	
Body Region	Isolated TBI	---	---	<0.0001
	Multisystem TBI	0.641	(0.549, 0.748)	
Transfer	No	---	---	<0.0001
	Yes	2.26	(1.88, 2.72)	
	Unknown	1.07	(0.668, 1.70)	
CPR	No	---	---	<0.0001
	Yes	0.075	(0.055, 0.103)	
GCS Category (TRISS/RTS)	13-15	---	---	<0.0001
	9-12	0.425	(0.333, 0.543)	
	6-8	0.262	(0.204, 0.335)	
	4-5	0.126	(0.093, 0.171)	
	3	0.078	(0.065, 0.094)	
	Unknown	0.236	(0.171, 0.326)	
Hospital	Not Shown			<0.0001
Age (year)	Nonparametric function			<0.0001

--This sensitivity analysis evaluated the logistic regression model with the lowest prehospital Glasgow Coma Scale (GCS) [stratified by the categories in TRISS/Revised Trauma Score (RTS) methodology] incorporated as a risk-adjustment measure in the model
--AHCCCS = Arizona Health Care Cost Containment System
--ICD = International Classification of Diseases-Version 9
--Isolated TBI: Cases that met TBI inclusion criteria but had no injury with Regional Severity Score ≥3 in any other (non-head) body region
--Multisystem TBI: Cases that met TBI inclusion criteria and also had at least one non-head region injury with Regional Severity Score ≥3
--CPR = Cardiopulmonary Resuscitation
--Note: Hospital (Treating Trauma Center) was also highly significant (p <0.0001). To protect the mandated anonymity of the participating hospitals, the numbers are not shown (preventing any possible identification or inference of facility-specific outcome differences)

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eTable 19: Logistic Regression Model for Survival with Respiratory Rate Included by TRISS Category

Variable	Levels	OR	95% CI	p-value
Intervention		1.04	(0.907, 1.18)	0.600
Male	No	---	---	0.940
	Yes	1.01	(0.879, 1.15)	
Race	Black	---	---	0.0099
	Asian	0.692	(0.366, 1.31)	
	American Indian/Alaska Nat.	0.688	(0.450, 1.05)	
	White	0.808	(0.574, 1.14)	
	Other	0.658	(0.443, 0.978)	
	Unknown	0.380	(0.211, 0.684)	
Hispanic	No	---	---	0.029
	Yes	1.13	(0.942, 1.35)	
	Unknown	0.677	(0.473, 0.970)	
Payer	Private	---	---	<0.0001
	AHCCCS/Medicaid	1.12	(0.944, 1.34)	
	Medicare	0.934	(0.753, 1.16)	
	Self Pay	0.481	(0.397, 0.584)	
	Other	0.804	(0.596, 1.09)	
	Unknown	0.322	(0.217, 0.476)	
Trauma Type	Blunt	---	---	<0.0001
	Penetrating	0.176	(0.142, 0.218)	
Head Injury Severity Score (ICD)	1 to 3	---	---	<0.0001
	4	0.865	(0.668, 1.12)	
	5 to 6	0.052	(0.039, 0.068)	
Injury Severity Score (ICD)	1 to 14	---	---	<0.0001
	16 to 24	0.431	(0.291, 0.636)	
	25+	0.183	(0.121, 0.275)	
Body Region	Isolated TBI	---	---	<0.0001
	Multisystem TBI	0.518	(0.447, 0.601)	
Transfer	No	---	---	<0.0001
	Yes	1.88	(1.58, 2.23)	
	Unknown	1.39	(0.878, 2.21)	
CPR	No	---	---	<0.0001
	Yes	0.146	(0.093, 0.231)	
Respiratory Rate Category (TRISS/RTS)	10-29 breaths per minute	---	---	<0.0001
	≥30	0.746	(0.529, 1.05)	
	6-9	0.274	(0.219, 0.342)	
	1-5	0.239	(0.162, 0.354)	
	0	0.063	(0.033, 0.120)	
	Unknown	0.242	(0.186, 0.316)	
Hospital	Not Shown			<0.0001
Age (year)	Nonparametric function			<0.0001

--This sensitivity analysis evaluated the logistic regression model with the lowest prehospital respiratory rate [stratified by the categories in TRISS/Revised Trauma Score (RTS) methodology] incorporated as a risk-adjustment measure in the model
--AHCCCS = Arizona Health Care Cost Containment System
--ICD = International Classification of Diseases-Version 9
--Isolated TBI: Cases that met TBI inclusion criteria but had no injury with Regional Severity Score ≥3 in any other (non-head) body region
--Multisystem TBI: Cases that met TBI inclusion criteria and also had at least one non-head region injury with Regional Severity Score ≥3
--CPR = Cardiopulmonary Resuscitation
--Note: Hospital (Treating Trauma Center) was also highly significant (p <0.0001). To protect the mandated anonymity of the participating hospitals, the numbers are not shown (preventing any possible identification or inference of facility-specific outcome differences)

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eTable 20: Logistic Regression Model for Survival to Hospital Admission with Systolic Blood Pressure Included by TRISS Category

Variable	Levels	OR	95% CI	p-value
Intervention		1.76	(1.39, 2.21)	<0.0001
Male	No	---	---	0.590
	Yes	0.937	(0.742, 1.18)	
Race	Black	---	---	0.020
	Asian	0.417	(0.145, 1.20)	
	American Indian/Alaska Nat.	1.36	(0.625, 2.97)	
	White	0.598	(0.358, 1.00)	
	Other	0.505	(0.279, 0.913)	
	Unknown	0.434	(0.199, 0.949)	
Hispanic	No	---	---	0.670
	Yes	1.09	(0.817, 1.45)	
	Unknown	0.852	(0.505, 1.44)	
Payer	Private	---	---	<0.0001
	AHCCCS/Medicaid	1.77	(1.31, 2.39)	
	Medicare	1.07	(0.719, 1.59)	
	Self Pay	0.42	(0.320, 0.551)	
	Other	0.938	(0.556, 1.58)	
	Unknown	0.391	(0.224, 0.682)	
Trauma Type	Blunt	---	---	<0.0001
	Penetrating	0.271	(0.208, 0.353)	
Head Injury Severity Score (ICD)	1 to 3	---	---	<0.0001
	4	1.24	(0.767, 1.99)	
	5 to 6	0.246	(0.159, 0.381)	
Injury Severity Score (ICD)	1 to 14	---	---	<0.0001
	16 to 24	0.45	(0.205, 0.992)	
	25+	0.125	(0.059, 0.265)	
Body Region	Isolated TBI	---	---	0.045
	Multisystem TBI	0.787	(0.622, 0.995)	
Transfer	No	---	---	<0.0001
	Yes	4.87	(3.07, 7.72)	
	Unknown	1.88	(0.844, 4.17)	
CPR	No	---	---	<0.0001
	Yes	0.1	(0.079, 0.126)	
SBP Category (TRISS/RTS)	≥90 mmHg	---	---	<0.0001
	76-89 mmHg	0.343	(0.237, 0.496)	
	50-75 mmHg	0.237	(0.170, 0.330)	
	40-49 mmHg	0.14	(0.053, 0.373)	
	Unknown	0.043	(0.034, 0.055)	
Hospital	Not Shown			<0.0001
Age (year)	Nonparametric function			0.0005

--This sensitivity analysis evaluated the logistic regression model with the lowest prehospital systolic blood pressure [stratified by the categories in TRISS/Revised Trauma Score (RTS) methodology] incorporated as a risk-adjustment measure in the model
--AHCCCS = Arizona Health Care Cost Containment System
--ICD = International Classification of Diseases-Version 9
--Isolated TBI: Cases that met TBI inclusion criteria but had no injury with Regional Severity Score ≥3 in any other (non-head) body region
--Multisystem TBI: Cases that met TBI inclusion criteria and also had at least one non-head region injury with Regional Severity Score ≥3
--CPR = Cardiopulmonary Resuscitation
--Note: Hospital (Treating Trauma Center) was also highly significant (p <0.0001). To protect the mandated anonymity of the participating hospitals, the numbers are not shown (preventing any possible identification or inference of facility-specific outcome differences)

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eTable 21: Logistic Regression Model for Survival to Hospital Admission with Glasgow Coma Scale Included by TRISS Category

Variable	Levels	OR	95% CI	p-value
Intervention		1.63	(1.32, 2.01)	<0.0001
Male	No	---	---	0.690
	Yes	0.958	(0.774, 1.18)	
Race	Black	---	---	0.140
	Asian	0.56	(0.197, 1.59)	
	American Indian/Alaska Nat.	1.89	(0.950, 3.74)	
	White	0.974	(0.621, 1.53)	
	Other	0.891	(0.525, 1.51)	
	Unknown	0.732	(0.363, 1.48)	
Hispanic	No	---	---	0.820
	Yes	0.951	(0.731, 1.24)	
	Unknown	0.875	(0.542, 1.41)	
Payer	Private	---	---	<0.0001
	AHCCCS/Medicaid	1.42	(1.09, 1.86)	
	Medicare	0.93	(0.645, 1.34)	
	Self Pay	0.405	(0.316, 0.518)	
	Other	0.973	(0.616, 1.54)	
	Unknown	0.437	(0.257, 0.743)	
Trauma Type	Blunt	---	---	<0.0001
	Penetrating	0.331	(0.260, 0.420)	
Head Injury Severity Score (ICD)	1 to 3	---	---	<0.0001
	4	0.985	(0.618, 1.57)	
	5 to 6	0.345	(0.226, 0.525)	
Injury Severity Score (ICD)	1 to 14	---	---	0.0005
	16 to 24	0.778	(0.355, 1.70)	
	25+	0.34	(0.162, 0.713)	
Body Region	Isolated TBI	---	---	0.0013
	Multisystem TBI	0.706	(0.572, 0.872)	
Transfer	No	---	---	<0.0001
	Yes	8.03	(5.12, 12.6)	
	Unknown	1.2	(0.566, 2.54)	
CPR	No	---	---	<0.0001
	Yes	0.08	(0.065, 0.099)	
GCS Category (TRISS/RTS)	13-15	---	---	<0.0001
	9-12	0.156	(0.058, 0.421)	
	6-8	0.159	(0.059, 0.432)	
	4-5	0.05	(0.019, 0.129)	
	3	0.016	(0.007, 0.036)	
	Unknown	0.026	(0.011, 0.065)	
Hospital	Not Shown			<0.0001
Age (year)	Nonparametric function			0.0003

--This sensitivity analysis evaluated the logistic regression model with the lowest prehospital Glasgow Coma Scale [stratified by the categories in TRISS/Revised Trauma Score (RTS) methodology] incorporated as a risk-adjustment measure in the model
--AHCCCS = Arizona Health Care Cost Containment System
--ICD = International Classification of Diseases-Version 9
--Isolated TBI: Cases that met TBI inclusion criteria but had no injury with Regional Severity Score ≥3 in any other (non-head) body region
--Multisystem TBI: Cases that met TBI inclusion criteria and also had at least one non-head region injury with Regional Severity Score ≥3
--CPR = Cardiopulmonary Resuscitation
--Note: Hospital (Treating Trauma Center) was also highly significant (p <0.0001). To protect the mandated anonymity of the participating hospitals, the numbers are not shown (preventing any possible identification or inference of facility-specific outcome differences)

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eTable 22: Logistic Regression Model for Survival to Hospital Admission with Respiratory Rate Included by TRISS Category

Variable	Levels	OR	95% CI	p-value
Intervention		1.79	(1.43, 2.22)	<0.0001
Male	No	---	---	0.360
	Yes	0.903	(0.726, 1.12)	
Race	Black	---	---	0.035
	Asian	0.459	(0.167, 1.26)	
	American Indian/Alaska Nat.	1.51	(0.731, 3.10)	
	White	0.74	(0.463, 1.18)	
	Other	0.619	(0.357, 1.07)	
	Unknown	0.472	(0.228, 0.979)	
Hispanic	No	---	---	0.830
	Yes	1.03	(0.787, 1.36)	
	Unknown	0.874	(0.534, 1.43)	
Payer	Private	---	---	<0.0001
	AHCCCS/Medicaid	1.41	(1.07, 1.86)	
	Medicare	0.979	(0.683, 1.40)	
	Self Pay	0.38	(0.295, 0.491)	
	Other	0.931	(0.569, 1.52)	
	Unknown	0.398	(0.232, 0.681)	
Trauma Type	Blunt	---	---	<0.0001
	Penetrating	0.242	(0.189, 0.310)	
Head Injury Severity Score (ICD)	1 to 3	---	---	<0.0001
	4	0.979	(0.619, 1.55)	
	5 to 6	0.224	(0.147, 0.342)	
Injury Severity Score (ICD)	1 to 14	---	---	<0.0001
	16 to 24	0.51	(0.237, 1.10)	
	25+	0.16	(0.077, 0.332)	
Body Region	Isolated TBI	---	---	<0.0001
	Multisystem TBI	0.597	(0.481, 0.742)	
Transfer	No	---	---	<0.0001
	Yes	6.56	(4.12, 10.4)	
	Unknown	2	(0.927, 4.33)	
CPR	No	---	---	<0.0001
	Yes	0.115	(0.080, 0.165)	
Respiratory Rate Category (TRISS/RTS)	10-29 breaths per minute	---	---	<0.0001
	≥30	1.15	(0.575, 2.29)	
	6-9	0.408	(0.305, 0.546)	
	1-5	0.291	(0.193, 0.437)	
	0	0.133	(0.087, 0.203)	
	Unknown	0.063	(0.047, 0.084)	
Hospital	Not Shown			<0.0001
Age (year)	Nonparametric function			0.0008

--This sensitivity analysis evaluated the logistic regression model with the lowest prehospital respiratory rate [stratified by the categories in TRISS/Revised Trauma Score (RTS) methodology] incorporated as a risk-adjustment measure in the model
--AHCCCS = Arizona Health Care Cost Containment System
--ICD = International Classification of Diseases-Version 9
--Isolated TBI: Cases that met TBI inclusion criteria but had no injury with Regional Severity Score ≥3 in any other (non-head) body region
--Multisystem TBI: Cases that met TBI inclusion criteria and also had at least one non-head region injury with Regional Severity Score ≥3
--CPR = Cardiopulmonary Resuscitation
--Note: Hospital (Treating Trauma Center) was also highly significant (p <0.0001). To protect the mandated anonymity of the participating hospitals, the numbers are not shown (preventing any possible identification or inference of facility-specific outcome differences)

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eTable 23: Temporal Analysis of Survival Among Patients Arriving at Trauma Centers By Privately-Owned Vehicle

Outcome and sample	Patients brought to the Trauma Centers by POV After 12/31/2012 vs. Before		EPIC Study Subjects: After 12/31/2012 vs. Before	
	aOR	95% CI	aOR	95% CI
Survival (all subjects)	0.719*	0.248, 2.22	1.04	0.913, 1.19
Survival (RSS-Head severity 3/4)	0.553*	0.064, 3.92	2.04	1.51, 2.77
Survival (ISS 16-24)	0.570*	0.063, 4.46	1.51*	0.999, 2.35
SHA (all subjects)	0.469*	0.010, 14.1	1.7	1.38, 2.10

--POV = Privately-Owned Vehicle
--Survival = Survival to Hospital Discharge
--RSS-Head = ICD-based Regional Severity Score for the head region
--ISS = Injury Severity Score (ICD-based)
--SHA = Survival to Hospital Admission
*obtained by Firth's logistic regression (less than 200 subjects with or without the event); otherwise the logistic regression (at least 200 subjects with the event and at least 200 without)
--Deaths among the POV patients: Overall: 21 of 1486 died, RSS-H = 3/4: 7 of 1332 died; ISS 16-24: 6 of 596 died. 2 of 1486 died before hospital admission

--This analysis evaluates secular trends in TBI outcomes by comparing the adjusted odds of Survival and SHA for patients meeting EPIC diagnostic study criteria that arrived by POV at the Trauma Centers after 12/31/2012 versus those presenting before (1/1/2007-12/31/2012). Since POV patients did not receive EMS care, this provides an assessment of the temporally-parallel risk adjusted TBI outcomes at the Trauma Centers "untainted" by EPIC training and serves as a means to assess whether "general" TBI care and outcomes were improving/changing during the years that the EPIC study was being conducted.
--12/31/2012 was used as the cutoff date to reflect the "before/after" timing that paralleled the very rapid training/implementation that occurred between 2012 and 2013 among participating EMS agencies. Among all EPIC study subjects (Phase 1 and Phase 3 combined), the percentage cared for by EPIC-trained agencies went from 0% in the 1st quarter of 2012 to 98.3% in 2013. Thus, using 12/31/2012 as a date cutoff provides a before (2007-2012)/after (2013-2015) temporal approximation of outcomes for TBI patients (meeting study diagnostic inclusion criteria but never treated by EMS) arriving at the Trauma Centers by POV that parallels the timing of the EPIC training statewide.
--The "EPIC Study Subjects" column in this table compares adjusted survival among the EPIC study subjects brought to the Trauma Centers after 12/31/2012 (1/1/2013-6/30/2015) to those brought before (1/1/2007-12/31/2012). This analysis yields very similar results to the true Phase 3 vs. Phase 1 comparison (the EPIC Study proper) and confirms that 12/31/2012 is a reasonable cut-off date to define "early" vs. "late" POV patients and that it reflects a timeline similar to the overall statewide EPIC implementation.

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