NATIONAL TRANSPORTATION SAFETY BOARD

Office of Research and Engineering
Washington, DC

Injury Group Chairman Factual Report

January 20, 2016

Mary Pat McKay, MD, MPH
Chief Medical Officer

A. ACCIDENT: DCA15FMR010

Accident Type:	Train Derailment
Location:	Philadelphia, PA
Date:	May 12, 2015
Time:	9:21 pm (EDT)
Train#1:	188
Carrier #1:	Amtrak

B. GROUP IDENTIFICATION:

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C. DETAILS OF INVESTIGATION

1. Purpose

   This report was developed to describe the injuries sustained by the occupants of the Philadelphia, PA Amtrak train derailment.

2. Background and Methods

The autopsy reports, accident photographs, EMS records from occupants transported from the scene, and medical records from the injured occupants treated at area hospitals were reviewed and combined with some information obtained from occupant interviews.

Identification of Injured Occupants

In the days following the accident, the NTSB's Transportation Disaster Assistance Division compiled a list of passengers and train crew who visited local hospitals with injuries. The information came from many sources including (but not limited to): Amtrak, the Philadelphia Office of Emergency Management, the American Red Cross, the Philadelphia Medical Examiner's Office, the Philadelphia Police Department, and various hospitals (Temple University Hospital, Jefferson, Hahnemann, Aria Torresdale, Einstein Medical Center, and Penn Presbyterian Medical Center).

The compiled information regarding occupants who received local hospital treatment immediately following the accident was used to subpoena medical records as described below. No information was collected on any occupants who may have sought medical care outside the local area, at non-hospital locations (like urgent care centers or physician offices), or who may have sought care after the 13th of May.

Medical Records

For each identified occupant, the NTSB subpoenaed the following items from the hospitals where treatment occurred:

> (1) Complete emergency department records (physician and nursing notes, medication administration record, procedural notes, radiology readings, laboratory results);
>
> (2) If admitted, the admission note, any physician transfer notes, final radiology reports, any operation notes, and the discharge summary; and
>
> (3) For all patients, the discharge or transfer instructions and billing records (to include coded information such as ICD-9, E&M, or CPT codes, but may exclude financial information).

Hospitals provided a variety of typewritten, computerized, and handwritten documents in response to the NTSB subpoenas. In this accident, 20 subpoenaed medical records were not obtained, generally because of discrepancies in names or dates that could not be resolved. The information for these injured persons is not included in this report.

Demographic Data and Notes

The demographic data (age, sex, height, and weight) came from information in the medical records. In some cases, the height and weight were noted to be estimates. Train car locations were established by interviews with the occupants by police or investigators

related to the NTSB. Notes included in Attachment A are descriptions of what happened to the individual that were recorded in the medical records.

Injury Description and Coding

The Abbreviated Injury Scale (AIS) was used to code the injury information. [1] The AIS system provides a scientific coding method for identifying and describing injuries. Coders require specific training in using this method. NTSB contracted with three trained, certified AIS coders from the Army Research Laboratory (Aberdeen, MD) to provide expert assistance and ensure valid coding using the 2005/Update 2008 version of AIS. In addition, the AIS assigns a specific, six digit code as well as an AIS severity score of 1 (minimal) to 6 (fatal) to each injury. When there is insufficient information to determine the degree of injury, an AIS severity score of 9 was assigned.

For each of the injured occupants, AIS codes were assigned to each injury diagnosed by treating health care providers, as recorded in the medical records. In some cases, occupants complained of pain in areas where no injury was formally diagnosed. These complaints were recorded in narrative format but no AIS code was assigned. Where there were discrepancies, such as multiple providers describing the same injury differently, the final radiology reading (if available) was used to determine presence or absence of injuries. In cases where the radiology reading used words like "possible" or "clinical correlation required," notes from the physician staff and their diagnoses were used to define whether or not the specific injury was present. Of note, no radiological images were obtained and no direct discussion with health care providers regarding specific injuries was carried out. In addition, AIS coding was only performed for occupants who survived long enough to have a complete hospital evaluation of their injuries. AIS coding was not performed for deceased occupants as their injury descriptions were less complete and specific than the information obtained on survivors.

Along with each AIS code and AIS severity score, a narrative description of each injury is provided in Attachment A: Occupant Injuries, at the end of this report. This information includes any available specifics, such as left or right, upper or lower arm, and the loss of height quoted on the radiology reports of spinal fractures. It also includes the narrative description of signs or symptoms that could not be coded. Figures are included throughout this report that were created by the Army Research Laboratory personnel using VisualAID, a tool developed by them to support AIS coding and results demonstration.[2]

NTSB Injury Severity

The NTSB also codes people with injuries into four severity codes: fatal, serious, minor, and none. According to Title 49, Code of Federal Regulations, Section 830.2, serious injuries are defined as an injury which is sustained by a person in an accident and which:

> Requires hospitalization for more than 48 hours, commencing within seven days from the date the injury was received;
> Results in a fracture of any bone (except fractures of fingers, toes, or nose);

Involves lacerations which cause severe hemorrhage, nerve, muscle, or tendon damage;
Involves injury to any internal organ;
Involves second or third-degree burns, or any burns affecting more than five percent of the body surface;

If a person dies within 30 days as a result of injuries sustained in an NTSB investigated accident, they are coded as "fatal." Survivors with injuries that do not meet the "serious" definition are coded as "minor." If no injury diagnosis is made, the person is coded as having no injury.

Non-injury diagnoses such as pre-existing co-morbid diseases (like high blood pressure or diabetes), complications of hospitalization (such as pneumonia, blood clots, or urinary tract infections), and psychological trauma were not included.

Injury Severity Scores

In addition, an Injury Severity Score (ISS) was calculated for each occupant whose injuries were AIS coded. The ISS predicts the likelihood of survival among traumatically injured patients and can be used to compare the severity of injury among individuals. In order to calculate the ISS, the AIS coded injuries are divided into six regions: 1) head/neck, 2) face, 3) chest, 4) abdominal and pelvic contents, 5) extremities and pelvic bones, and 6) external. ISS is then calculated by adding together the squares of the highest AIS scores for each of the three highest scoring body regions:

$$ISS = (\text{highest AIS region}A)^2 + (\text{highest AIS region}B)^2 + (\text{highest AIS region}C)^2$$

The maximum survivable ISS is 75.[3] Injuries with unknown severity are coded to a severity of 9. If there were other known injuries, the injury coded to 9 was removed and an ISS calculated using known severities for the other injuries.

Injury severity scores are routinely divided into four groups: minor (ISS 1-8), moderate (ISS 9-15), severe (ISS 16-24), and very severe (ISS >25); the results below are presented in these groups.[4]

Emergency Medical Response and Victim Transportation

The Philadelphia Fire Department (PFD) provided the NTSB with a copy of the operational procedure for mass casualty incidents in place at the time of the accident (OPS#35-11, See Attachment B; Attachment C is the updated version of OPS#35 developed following this accident). According to this document, an incident of this size (requiring at least 30 ambulances) meets the PFD classification for a mass casualty disaster.

According to the operational procedure, injured persons in a large mass casualty incident were to be triaged into four categories: Priority 1 (RED), Priority 2 (YELLOW), Priority 3 (Green) and DEAD (BLACK). A color coded triage tag was to be affixed to each injured person to identify that they had been triaged and their triage category. An

individual identified as the Patient Transportation Group Supervisor was to, "Ensure that victims are transported to appropriate hospitals. Whenever possible, Priority 1 (Red) Tag patients should be distributed to trauma centers. If there are entrapped Priority 1 (Red) tag patients, consideration may be given to holding beds at the closest trauma center(s) for them. Priority 3 (Green) tag patients can be transported to more distant hospitals. Do not overload any individual hospital, if possible. (Section 3.18.1g)"

In addition, an individual was to have been identified as the Medical Communications Coordinator. This person's responsibility was to establish the status of hospital/medical center availability and communicate that information with the Transport Coordinator in order to ensure no one institution was overwhelmed and that patients were distributed appropriately among available resources.

The PFD operational procedure describes using available PFD ambulances for transport of the injured, followed by non-municipal ambulances with an existing memorandum of understanding, followed by out-of-county ambulances, with a procedure for vetting each type of transport. The procedure allows for use of non-ambulance mass transit vehicles including Septa buses, if needed (PFD OPS#35 2011, Addendum #2 in Attachment B).

Trauma Center Designation

In Pennsylvania, the Pennsylvania Trauma Systems Foundation[5] accredits hospitals as trauma centers, separated into four distinct levels (I-IV). Level I Trauma Centers provide multidisciplinary treatment and specialized resources for at least 600 major trauma patients per year and must perform trauma research and train surgeons. Level II trauma centers provide similar medical services to at least 350 major trauma patients per year but do not perform the research and training components. Level III trauma centers may care for moderately injured trauma patients and both Level III and IV trauma centers have the capacity to stabilize and transfer seriously injured patients to a higher level of trauma care. Some hospitals may be able to provide trauma care but have not undergone the formal process to obtain a trauma designation.

Transport of Injured Patients by Police in Philadelphia

In Philadelphia, since 1987, a policy has been in place that allows police department personnel to transport victims of penetrating trauma to trauma centers. In part, this practice has been supported by research performed in Philadelphia that demonstrated at least equivalent survival outcomes for victims of penetrating trauma transported by police and EMS between 1986 and 1992[6] and again from 2003 to 2007.[7] According to this literature, published by physicians practicing in Philadelphia, there are hundreds of police transports of injured patients to emergency departments each year, with little to no medical care provided *en route*.[7]

3. Results

Occupant Injury Severity

Medical treatment records or autopsy reports were obtained and reviewed for a total of 172 train occupants. Of these, eight passengers died as a result of the accident, 43 met the NTSB definition of serious injury. An additional 113 occupants had minor injuries. A total of 7 occupants were evaluated without any diagnosis of an injury, and one left the hospital without being seen and is included as not having an injury. (See Table 1.) These occupants ranged in age from 12 to 79 with a median age of 39 year (quartiles 30, 54) and 88 of them (51.2 percent) were male.

Table 1. Occupants NTSB Injury Severity

	Number	Percent
Fatal	8	4.6
Serious	43	25.0
Minor	113	65.7
None	8	4.7
Total	172	100.0

No AIS coding was performed for the eight fatally injured passengers or the eight occupants who were uninjured. Eight other occupants' medical records lacked sufficient information to calculate an injury severity code (ISS), either because no diagnosis was made or because the AIS code(s) assigned had a severity level of 9 (unknown). (See Table 2.) The ISS score ranged from 0 to 57.

Table 2. Injury Severity Scores for Train Occupants

ISS Severity	Number	Percent
Minor (1-8)	124	72.0
Moderate (9-15)	12	7.0
Severe (16-24)	6	3.5
Very Severe (>25)	6	3.5
ISS not calculated	24	14.0
Total	172	100

Injuries by Train Car Location

Train car locations for 80 occupants were obtained by interview. Some occupants were unable to give an interview or unwilling to speak with investigators. Others left the area before providing information. Some occupants did not know their location and others were unsure of their exact location on the train. If they were unsure, this uncertainty is reflected in Table 3, below. Eleven people held business class tickets and were presumed to have been riding in the first passenger car, which was the only business class car in the train consist.

Table 3. Occupant NTSB Injury Severity by Train car (if known)

	NTSB Injury Severity				
Train Car	**Fatal**	**Serious**	**Minor**	**None**	**Total**
Locomotive	0	0	1	0	1
1	3	7	1	0	11
2	0	5	6	1	12
2 or 3	0	0	1	0	1
3	0	3	12	0	15
3 or 4	0	0	2	0	2
4	0	1	6	1	8
4 or 5	0	0	1	0	1
5	0	2	8	0	10
5 or 6	0	0	2	0	2
6	0	1	7	0	8
6 or 7	0	0	3	0	3
7	0	3	14	0	17
Unknown	5	21	49	6	81
Total	8	43	113	8	172

Emergency Medical Response

Seven train occupants did not survive and were not transported from the scene. One person was transported to Temple Hospital and died in the emergency department. The large majority of the injured were transported to the hospital by the police department using police cars, police vans, and paddy wagons. Septa buses were also used to transport some of the injured. Some train occupants may have been triaged by emergency medical services (EMS) personnel before being transported by police or bus but none had hospital emergency treatment record that reflected an EMS mass casualty triage tag was present on arrival.

The Philadelphia Fire Department provided NTSB with ambulance (EMS) transport charts for 12 train occupants transported from the scene to a hospital emergency department by ambulance; these included records of one person who died at the hospital. In addition, they reported another 12 people were transported by EMS but the charts for these transports were missing. Without a record of transport including the occupant's name, these could not be combined with the injury information from the hospital records.

Table 4 shows the relationship between having an EMS transport chart (for those 12 cases where EMS charts were available) and the NTSB definition of injury severity while Table 5 demonstrates the relationship with ISS (among those with a calculated ISS).

Table 4. Transportation to Hospital by NTSB Injury Severity

	Fatal	Serious	Minor	None	Total
EMS Transport Chart	1	3	7	1	12
No EMS Chart	0	40	106	7	153
Total	1	43	113	8	165

Table 5. Transportation to Hospital by Injury Severity Score (ISS)

	Minor (1-8)	Moderate (9-15)	Severe (16-24)	Very Severe (25+)	Total
EMS Transport Chart	7	1	0	2	10
No EMS Chart	117	11	6	4	138
Total	124	12	6	6	148

Train occupants were transported to ten local hospitals from the accident scene; those hospitals are identified by their trauma level in Table 6.

Table 6. Hospitals' Trauma Center Level Designation

Hospital Name	Trauma Center Designation Level
Aria Frankford	none
Aria Torresdale	II
Einstein	I
Episcopal	none
Hahnemann	I
Holy Redeemer	none
Hospital of the University of Pennsylvania (HUP)	none
Jefferson	I
Penn Presbyterian*	I
Temple	I

*According to the Pennsylvania Trauma Systems Foundation, the Level I trauma center designation moved within the Penn medical system at HUP to Penn Presbyterian on February 4, 2015.

Occupants were identified by the hospital who provided records. In three cases, those records described a transfer from an outside (previous) hospital but it was not clear which hospital had transferred the injured occupant. Tables 7 (NTSB severity) and 8 (ISS) demonstrate the injury severity according to the hospital primarily treating the occupant. Figure 1 demonstrates the ISS information graphically.

Table 7. Treating Hospitals by NTSB Injury Severity

	Trauma Center Designation Level	Fatal	Serious	Minor	None	Total
Aria Frankford	none	0	1	14	0	15
Aria Torresdale	II	0	4	18	3	25
Einstein	I	0	2	5	0	7
Episcopal	none	0	0	10	0	10
Hahnemann	I	0	11	17	3	31
Holy Redeemer	none	0	0	5	0	5
HUP	none	0	0	3	0	3
Jefferson	I	0	8	14	2	24
Penn Presbyterian	I	0	2*	0	0	2
Temple	I	1	15*	27	0	43
Total		1	43	113	8	165

* Two people at Penn Presbyterian and one person treated at Temple were initially seen at another emergency department and transferred.

Table 8. Treating Hospitals by Injury Severity Score

	Trauma Center Designation Level	Minor (1-8)	Moderate (9-15)	Severe (16-24)	Very Severe (25+)	Total
Aria Frankford	none	14	0	0	0	15
Aria Torresdale	II	18	1	0	2	21
Einstein	I	7	0	0	0	7
Episcopal	none	10	0	0	0	10
Hahnemann	I	21	3	2	1	27
Holy Redeemer	none	5	0	0	0	5
HUP	none	3	0	0	0	3
Jefferson	I	17	1	1	0	19
Penn Presbyterian	I	1*	0	0	1*	2
Temple	I	28	6	3	2*	39
Total		124	12	6	6	148

* Two people at Penn Presbyterian and one person treated at Temple were initially seen at another emergency department and transferred.

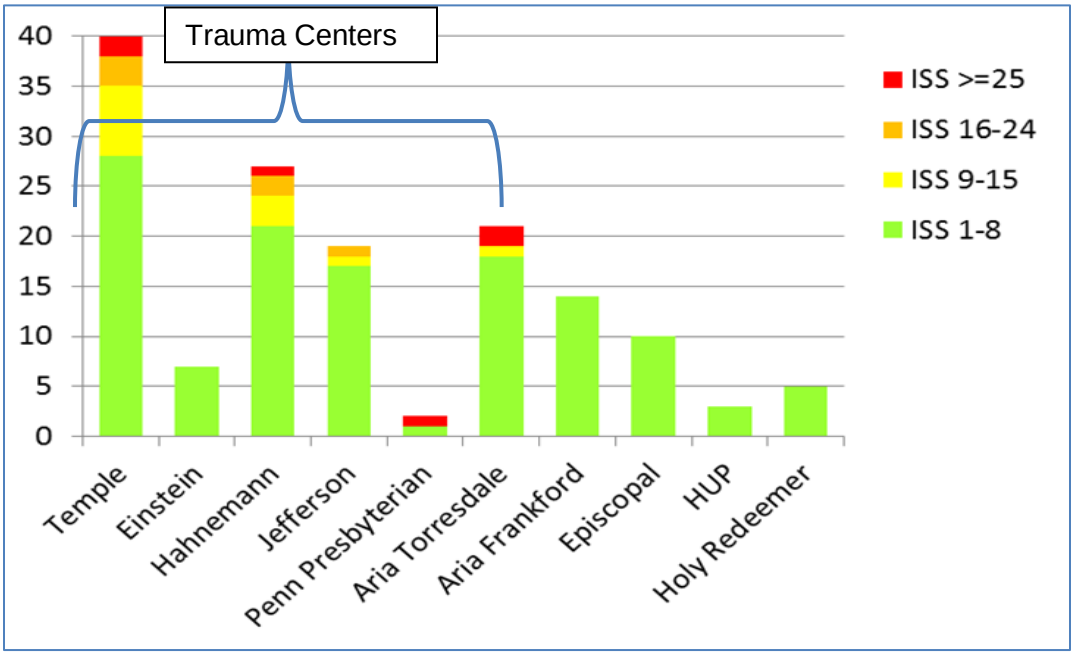

Figure 1. Number of Injured and their Injury Severity Scores at the Treating Hospitals

Time of Arrival to Emergency Departments

The accident occurred at 9:21 pm local time. Specific transport times could not be determined for the majority of transported train occupants because they did not have EMS charts. As a result, the initial time stamp present in occupants' hospitals records was used to describe the time of arrival.[a] Three occupants were transferred, and, as a result, the initial time stamp at the first hospital was used for this description.

For 6 surviving occupants, the initial time of arrival could not be determined from available records, and for two transferred occupants, the initial hospital location could not be determined. These individuals are not included in the following description. Among the remaining 156 occupants, the first time stamp was at 9:57 pm (36 minutes after the accident) and the last person arrived at a hospital at 1:02 am on May 13th, 2015 (3 hours, 41 minutes after the accident). The median time of hospital arrival was 11:15 pm (25th quartile 10:47 pm and 75th quartile 11:35 pm). Table 9 demonstrates the timing of arrivals at each hospital by hour. Overall, among the injured occupants transported to hospitals with available data, 139 (89.1%) had been registered into an emergency department by midnight, about two and a half hours after the train derailed.

Table 9. Time of Hospital Arrival, by Hour

	Before 11 pm	11pm - midnight	After midnight	Total
Aria Frankford	13	2	0	15
Aria Torresdale (TC)	2	18	4	24
Einstein (TC)	5	2	0	7
Episcopal	5	1	4	10
Hahnemann (TC)	6	21	3	30
Holy Redeemer	0	2	3	5
HUP	0	2	1	3
Jefferson (TC)	5	17	0	22
Penn Presbyterian (TC)*	0	0	0	0
Temple (TC)	23	15	2	40
Total	59	80	17	156

* Both occupants treated at Penn Presbyterian were transferred from an initial hospital.

Figure 2 is a map based description of the number and severity of the victims at each hospital at approximately 1:30 am on May 13th.

[a] Because of the need to register patients into the hospital, there may be a delay between patients' physical arrival time and the initial time stamp in the medical record; this may be longer if multiple patients arrive simultaneously.

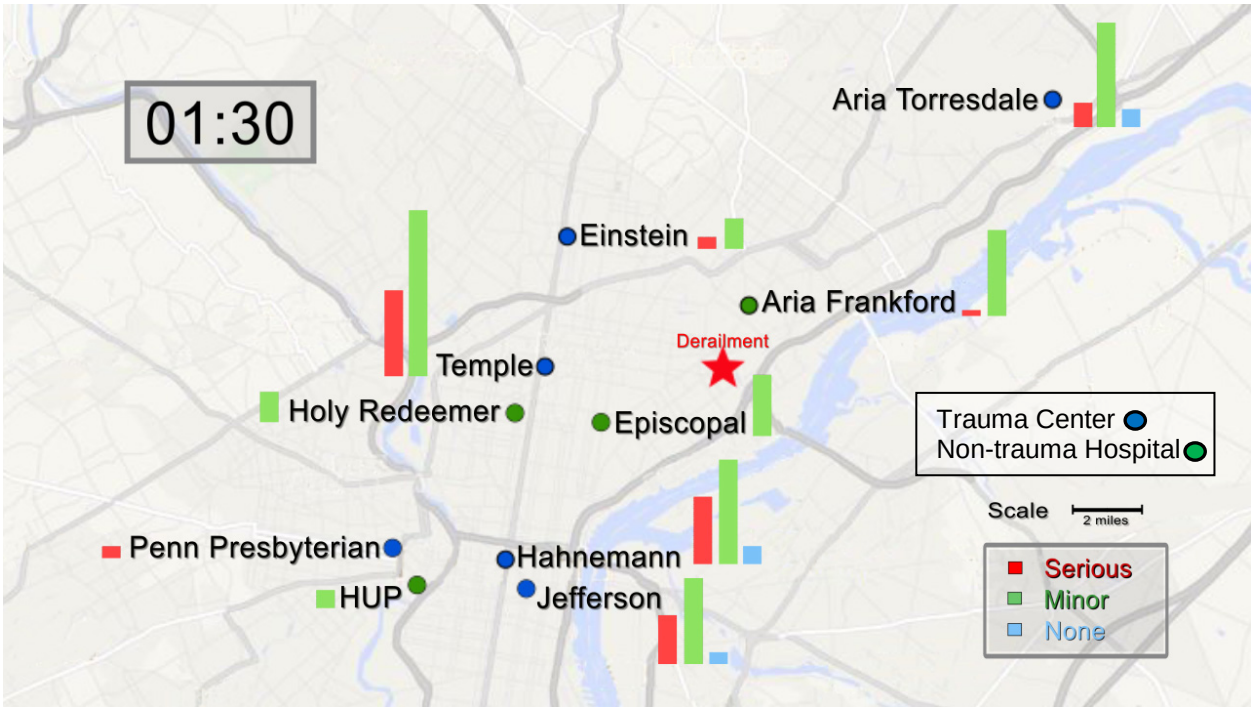

Figure 2. Map of Relative Numbers of Patients Treated in Hospitals at 1:30 am

Injuries

The 156 injured but surviving occupants with medical records available to the NTSB had a total of 597 individually described injuries; of these, 538 were AIS coded. A description of each injury including those to the deceased occupants is provided in Attachment A to this report.

Table 10, below, outlines the AIS coded injuries by their ISS body region. In the head and neck region, there were 23 head injuries where the severity could not be coded. All of these were cases where the healthcare provider had simply noted "head injury" without further descriptors or diagnosis. In each of these cases, the occupant had undergone a CT scan that was negative for any intracranial pathology. The remainder of the head and neck injuries included cervical strains, concussions, head injuries with headaches, and one linear skull fracture (AIS 3). In the cervical spine, there were six transverse process fractures as well as one articular process and one facet fracture. One person had bilateral jumped cervical facets and a spinal cord injury (AIS 5). No survivors had any significant intracranial bleeding or swelling.

Table 10. Injuries by Body Region

Body Region	AIS Severity						
	1	2	3	4	5	9	Total
Head/neck	20	12	1	0	1	23	57
Face	7	2	0	0	0	0	9
Chest	2	35	26	6	1	0	70
Abdominal/pelvic contents	3	32	2	1	0	0	38
Extremities/pelvic girdle	31	36	5	0	2	0	74
External	284	6	0	0	0	0	290
Total	347	123	34	7	4	23	538

The occupants' facial injuries consisted primarily of fractured noses and teeth. There was one corneal abrasion and one fracture of the posterior wall of the maxillary sinus.

Twenty four survivors had 68 AIS level 2 or higher chest injuries including people with flail chests (3), pulmonary contusions (9), multiple rib fractures (15), and a fractured sternum (1). There were hemothoraces (3), pneumothoraces (11), and two hemopneumothoraces. In addition, there were two lung lacerations and one ruptured diaphragm. There were 15 fractures of the spinous process or transverse process of the thoracic vertebrae (in 6 people) and 6 fractures of the endplate of the thoracic vertebrae (in four people) but no vascular injuries in the chest and no thoracic spinal cord injuries. In addition, one person was diagnosed with contused ribs and one with a contusion of the sternum.

Among the injuries to abdominopelvic contents, there were 22 lumbar spine fractures but these included 19 transverse process fractures, one spinous process fracture, one fracture of the anterior superior corner, and a single 30% compression fracture of the body of the vertebra. In addition, there was one extraperitoneal bladder rupture, one liver contusion, three splenic lacerations, two kidney injuries, one retroperitoneal hemorrhage from an unknown source, three bowel injuries, and a lumbar strain.

The extremity and pelvic injuries were primarily fractures and dislocations, some of which were open. The two AIS level 5 injuries were two very severe pelvic fractures. The five AIS level 3 injuries included a pelvic fracture, two complex ankle fractures (one open), and two femur fractures.

Overall, 43 victims fractured at least one bone. Figure 3 demonstrates the areas of fracture (note, left and right are not accounted for in this figure).

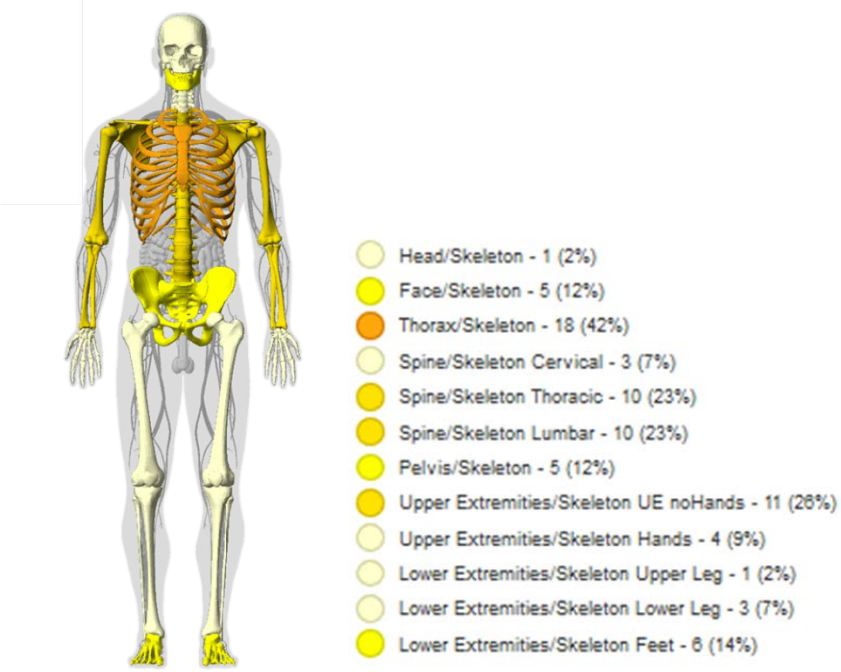

Figure 3. Heat Chart of Fractures by location

The external injuries were primarily abrasions and contusions; those that were AIS level 2 severity were lacerations that were very large or had arterial bleeding described.

Overall, 48 train occupants had injuries at AIS level 2 or higher (Figure 4). These diagrams highlight that the majority of serious injuries in the survivors in this accident were to the chest; there were few in the head and neck.

D. SUMMARY OF INJURY FINDINGS

With 253 people on the train at the time of the derailment, 7 died of injuries at the scene, one died in the emergency department, and 185 were reported to have been seen in 10 local hospitals. Of these, the NTSB obtained medical records for 165 surviving train occupants and reviewed the autopsy findings of the eight deceased occupants. Overall, among the survivors in this accident there was one moderately severe head injury (AIS 3) but no intracranial hemorrhages, a single cervical spinal cord injury (AIS 5), and twenty four occupants with 68 significant (AIS 2+) chest injuries.

Review of the records demonstrated the large majority of injured occupants were transported for medical care by police vehicle or Septa bus. Only 3 of 43 people with serious injuries had an ambulance transport chart. The injured were distributed unevenly across nearby Trauma Centers and local hospitals.

E. ATTACHMENTS

Attachment A: Occupant Injury Descriptions, Amtrak Derailment, 2015

Attachment B: Philadelphia Fire Department Operational Procedure: Multiple Patient / Mass Casualty Incidents (June 2011)

Attachment C: Philadelphia Fire Department Operational Procedure: Multiple Patient / Mass Casualty Incidents (September 2015)

References

[1] AIS 2005 Update 2008. Association for the Advancement of Automotive Medicine, Barrington, IL 2008.
[2] Visual Anatomical Injury Descriptor (VAID), Version 3.9, Army Research Laboratory, United States Department of Defense.
[3] Baker SP, O.N.B., Haddon W, et al., The Injury Severity Score: a method for describing patients with multiple injuries and evaluating emergency care. J Trauma, 1974. 14: p. 187-196.
[4] American College of Surgeons. National Trauma Data Bank 2013 Annual Report. Accessed 12/13/2015. Available from: http://www.facs.org/trauma/ntdb/pdf/ntdb-annual-report-2013.pdf
[5] Pennsylvania Trauma Systems Foundation. What is a Trauma Center? http://www.ptsf.org/index.php/our-trauma-centers/whats-trauma. Accessed 1/8/2016.
[6] Branas CC, Sing RF, Davidson SJ. Urban trauma transport of assaulted patients using nonmedical personnel. Acad Emerg Med. 1995;2(6):486-93.
[7] Band RA, Pryor JP, Gaieski DF, Dickinson ET, Cummings D, Carr BG. Injury-adjusted mortality of patients transported by police following penetrating trauma. Acad Emerg Med. 2011;18(1):32-7.