Team Members:

- Samir M. Fakhry, MD, Principal Investigator
- Anne Rizzo, MD, Co-Principal Investigator
- Refaat Hanna, M.D., M.A., Epidemiologist
- Christine Burke, CIREN Study Coordinator
- Greg Stadter, Crash Reconstructionist
- Rodney W. Rudd, Ph.D. CIREN Study Consultant
- Christopher Sherwood, Auto Safety Lab, University of VA
- Capt. Christine Woodard, Fairfax County Fire and Rescue
- Detective J.J. Banachoski, Fairfax County Police CRU
- Lt. Scott McLean, Prince William County Fire and Rescue
Pedestrian Injuries: Analysis of the Burden with Case Illustrations
CIREN Pedestrian Study Objectives

- Address the unmet needs of the “walking” population
- Identify patterns of injuries among pedestrians to better understand mechanism of injury and develop efficient prevention methods
- Identify vehicle features that cause or mitigate injuries
- Educate pre-hospital healthcare providers to conduct on-scene triage based on specific crash criteria and injury criteria
Burden of Pedestrian Injuries

- Each year in the United States, there are 8,000 pedestrians killed and another 100,000 injured in traffic crashes.

- This accounts for 13% of the nation’s total traffic fatalities and 5% of injuries (FARS, NASS, GES).

- On average, a pedestrian injury occurs every six minutes and a pedestrian fatality occurs every 107 minutes in the United States (1).

- The proportion of pedestrian fatalities is a greater concern in many other countries, such as Japan, where pedestrians account for nearly 27% of total traffic fatalities, and in Europe, where the percentage reaches nearly 30% in the United Kingdom (2).

2. Jason A. Stammen Roger A. Saul, National Highway Traffic Safety Administration
Pedestrian Injuries in the Washington DC Metropolitan Region

(DCMR)
For the purposes of this study, the DC Metro Region (DCMR) is defined as the counties and municipalities of:

- Virginia (Northern Virginia)
- District of Columbia (DC)
- Maryland (Central Maryland)

The following data sets were available and analyzed for the years 1999-2004:

- Police car crash data
- Injury related hospital discharge data
- Injury mortality data
- The rates are calculated using 2000 population data obtained from US Census Bureau.
Summary

• Approximately 3000 pedestrians are involved in crashes with motor vehicles every year in the DC Metro region.

• The vast majority (92%) sustained one or more injuries.

• A significant percentage of these (17%) required hospitalization of 24 hours or longer.

• Average hospital charges of $17,000 to $30,000 per patient depending on the region.

• Approximately 80 pedestrians die each year.
Making left or right turn was the most common maneuver prior to pedestrian crashes by buses in both Northern Virginia and DC.
Pedestrian crashes involving trucks and buses resulted in 11% and 10% mortality in both Northern Virginia and DC respectively.
Pedestrian crashes are higher during weekdays with the peak on Friday (Northern Virginia and Central Maryland)

Honda Inova Fairfax Hospital CIREN Center
Time of the Crash

Pedestrian Crashes by Time of Day
Central Maryland 2000 to 2003

Pedestrian Crashes by Time of Day
Northern Virginia Police Crash Data 1999 to 2003

Pedestrian Crashes by Time of Day
DC 2000 to 2004

Honda Inova Fairfax Hospital CIREN Center
Fifty-percent of the pedestrian injured in Washington DC are non-residents of the city.

Honda Inova Fairfax Hospital CIREN Center
Children in DC aged 5 to 9 years were more than twice as likely as the same age group in both Northern Virginia and Central Maryland to be involved in a pedestrian crash.

In Washington DC, pedestrian hospitalizations are significantly higher among children aged 0 to 9, compared to the same age group in both Northern VA and Central MD.

In Washington DC, pedestrian deaths are significantly higher among children aged 0 to 9, compared to the same age group in both Northern VA and Central MD.

In Washington DC, hospital charges are significantly higher for children aged 5 to 14 years.
Pedestrian Injury By Race

“Other” Races refers to: Hispanics, Native Hawaiian, Pacific Islander, American Indian, Alaska Native, Middle Eastern and Asians (in Central Maryland)
Young drivers aged 15 to 24 were the third highest age group to be involved in pedestrian crashes.
Drivers Violation Prior to Pedestrian Crash
Northern Virginia 1999 to 2003

<table>
<thead>
<tr>
<th>Violation</th>
<th>Percent (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>None</td>
<td>48</td>
</tr>
<tr>
<td>Driver inattention</td>
<td>13</td>
</tr>
<tr>
<td>Hit and run</td>
<td>11</td>
</tr>
<tr>
<td>Did not have right-of-way</td>
<td>8</td>
</tr>
<tr>
<td>Other violations</td>
<td>9</td>
</tr>
<tr>
<td>Not stated</td>
<td>5</td>
</tr>
<tr>
<td>Improper backing</td>
<td>3</td>
</tr>
<tr>
<td>Exceeded speed limit</td>
<td>1</td>
</tr>
</tbody>
</table>

Honda Inova Fairfax Hospital CIREN Center
Pedestrian Injuries are the second most costly injuries after firearms.

Medicaid and Self-Pay accounted for about 50% of payers in both Washington DC and Central Maryland.

Source: Inova Regional Trauma Center

D.C. African American Population

- 6%
- 20%
- 46%
- 64-71%
- 88-97%

D.C. Poverty

- Poverty rate 16.9%
  - National Avg.: 12.5%
- Unemployment 7.7%
  - National Avg.: 5.8%

Methodology

• Case Selection Criteria
  – Admitted to the trauma center
  – MAIS 2+ injury
  – Struck by the front of the vehicle
  – Upright when struck
  – Hit by a passenger car, SUV, minivan or small pickup truck
  – Pedestrians struck by a large vehicle such as a bus or tractor trailer, were run over or were sitting/lying down when they were struck are excluded from the study
Methodology

• Enrollment & Consent
  – Eligible patients and families are approached by hospital personnel to obtain “Informed Consent”
  – Police contacted to obtain a crash report to identify vehicle owner/driver
  – Vehicle owner is visited to obtain “Informed Consent”
  – Medical information and vehicle information is required to complete case
Methodology

• Data Collection
  – Medical
    • Pre-crash data from EMS reports and interviews
    • Full hospital medical records
    • Patient interview
    • Photographs of injuries
    • Anthropometric measurements
    • 6 & 12 month follow-up health survey
    • Injuries & procedures are reviewed and coded
      – AIS, ICD-9, CPT codes
Methodology

• Data Collection
  – Vehicle & Crash
    • Data is collected along Pedestrian Crash Data Study (PCDS) protocols
    • Police report (vehicle & owner information, scene diagram & photos)
    • Impact speed estimation (skid mark analysis, throw distance calculation)
    • Vehicle inspection (damage/deformation profile, contact marks)
Methodology

- Reconstruction & Simulation
  - MADYMO multi-body modeling
    - Pedestrian Model (anthropomorphic measurements)
    - Vehicle Model (facet or ellipsoid model, UVA database)
  - Simulation Matrix
    - Multiple orientations & speeds to match witness marks and injury outcome

<table>
<thead>
<tr>
<th>Component Contacted</th>
<th>Body Region</th>
<th>Evidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hood edge</td>
<td>Hip</td>
<td>Bent</td>
</tr>
<tr>
<td>A pillar</td>
<td>Shoulder</td>
<td>Scratched</td>
</tr>
<tr>
<td>Windshield</td>
<td>Head</td>
<td>Broken</td>
</tr>
<tr>
<td>Left side folding mirror</td>
<td>Shoulder</td>
<td>Broken/bent</td>
</tr>
</tbody>
</table>
Challenges

• Case Enrollment
  – 47 Cases Investigated
  – Socioeconomic challenges
    – Homelessness
    – Physiological and dependency issues
  • Legal concerns & other repercussions
  • Inability to consent
  – Vehicle owner consent is very difficult
    • Concerned about legal issues
    • Guilt over the event
    • Vehicles are often repaired soon after the event
    • Necessary to inspect the vehicle
      – Currently necessary vehicle data and photos are obtained from police when inspection is not possible
Case Illustrations
Case #1

- Male age 17 attempting to cross at an intersection against the light at 22:40. Clear & dry condition on a Saturday evening in the fall.
- Driver of 2003 Chrysler Town & Country van did not observe pedestrian until impact.
- The pedestrian was struck on his left side.
Pedestrian Wrap Measurements

Honda Inova Fairfax Hospital CIREN Center
<table>
<thead>
<tr>
<th>Component Contacted</th>
<th>Body Region</th>
<th>Evidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Front bumper</td>
<td>Leg</td>
<td>Cracked</td>
</tr>
<tr>
<td>Headlight</td>
<td>Hip</td>
<td>Cracked</td>
</tr>
<tr>
<td>Hood edge</td>
<td>Hip</td>
<td>Bent</td>
</tr>
<tr>
<td>Front fender top surface</td>
<td>Hip</td>
<td>Bent</td>
</tr>
<tr>
<td>Front fender top surface</td>
<td>Hip</td>
<td>Scratched</td>
</tr>
<tr>
<td>A pillar</td>
<td>Shoulder</td>
<td>Scratched</td>
</tr>
<tr>
<td>Windshield</td>
<td>Head</td>
<td>Broken</td>
</tr>
<tr>
<td>Left side folding mirror</td>
<td>Shoulder</td>
<td>Broken/bent</td>
</tr>
<tr>
<td>Front fender top surface</td>
<td>Shoulder</td>
<td>Dented</td>
</tr>
</tbody>
</table>
Case Summary:
- On scene: pedestrian unconscious, fixed and dilated pupils,
- Transported by air to the trauma center - intubated by flight crew
- In trauma bay: pupils sluggishly reactive but equal, GCS 3T
- Physical examination notable for:
  - positive for alcohol consumption, contusions lower extremities
- Radiological examination significant for:
  - left frontoparietal and temporal subdural hematoma
  - right subdural and frontotemporal contusion
  - left lateral superior and inferior pubic rami & acetabulum fractures
- To OR for:
  - right-sided hemicraniectomy
  - evacuation of subdural hematoma
  - debridement of contused brain
Case Summary (continued):

- Admitted to TICU, remained intubated & sedated on TBI protocol
- HD # 5 underwent tracheostomy and PEG
- Slowly improved, sedation weaned down, to IMC on HD # 7
- Neurological status slowly improving, to floor on HD # 10
- Received cognitive evaluation along with PT and OT
- Returned to OR on HD # 58 for cranioplasty - reimplant bone flap
- Due to financial issues could not be transferred to rehabilitation
- Discharged home with family on HD # 62
- RLAS at discharge was VI; able to communicate in his native language, following some commands, able to ambulate with some assistance, able to eat a regular diet
- Hospital Charges: $151,736
<table>
<thead>
<tr>
<th>Injuries (ICD)</th>
<th>AIS Severity</th>
<th>Info Source</th>
<th>Aspect (R,L,bilat,etc)</th>
<th>Contact Area (door, seat,etc)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Subdural hematoma (852.25)</td>
<td>140654.5</td>
<td>CT</td>
<td>Right</td>
<td>A-Pillar &amp; contra coup injury</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Left</td>
<td></td>
</tr>
<tr>
<td>Temporoparietal contusion (851.05)</td>
<td>14608.4</td>
<td>CT</td>
<td>Right</td>
<td>A-pillar – contra coup injury</td>
</tr>
</tbody>
</table>

Honda Inova Fairfax Hospital CIREN Center
<table>
<thead>
<tr>
<th>Injuries (ICD)</th>
<th>AIS Severity</th>
<th>Info Source</th>
<th>Aspect (R,L,bilat,etc)</th>
<th>Contact Area (door, seat,etc)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hip contusion (924.01)</td>
<td>890402.1</td>
<td>Exam</td>
<td>Left</td>
<td>Fender</td>
</tr>
<tr>
<td>Pubic rami fracture (808.2)</td>
<td>852602.2</td>
<td>CT</td>
<td>Left – superior &amp; inferior</td>
<td>Fender</td>
</tr>
<tr>
<td>Acetabulum fracture (808.0)</td>
<td>852602.2</td>
<td>CT</td>
<td>Left</td>
<td>Fender</td>
</tr>
<tr>
<td>Injuries (ICD)</td>
<td>AIS Severity</td>
<td>Info Source</td>
<td>Aspect (R,L,bilat,etc)</td>
<td>Contact Area (door, seat,etc)</td>
</tr>
<tr>
<td>------------------------</td>
<td>--------------</td>
<td>-------------</td>
<td>------------------------</td>
<td>-------------------------------</td>
</tr>
<tr>
<td>Knee abrasion (916.0)</td>
<td>890202.1</td>
<td>Exam</td>
<td>Right</td>
<td>Ground</td>
</tr>
</tbody>
</table>

Honda Inova Fairfax Hospital CIREN Center
Case #2

- Male age 35 attempting to cross a 7-lane roadway at 19:00. Clear & dry conditions, on a Sunday evening in the winter.
- Driver of 1997 Honda Accord did not observe pedestrian until impact.
- Pedestrian was struck on his right side
Pedestrian Wrap Measurements

172 cm
148 cm
100 cm
48 cm

270 cm
180 cm
78 cm
71 cm
50 cm
40 cm

Honda Inova Fairfax Hospital CIREN Center
Vehicle 1
Case Summary:

- On Scene: pedestrian found conscious and alert, deformities to the left arm & right lower extremity as well as laceration to the left scalp
- Immobilized and transported to the Trauma Center by air
- Physical examination notable for:
  - left temporal scalp laceration, swelling of right shoulder, deformed right lower extremity, positive for alcohol consumption
- Radiological examination identified:
  - right comminuted tibia and fibula fractures
  - right comminuted proximal humerus fracture
  - CT scan of head negative for intracranial injury
- Right lower extremity splinted, right arm placed in sling
- Admitted to IMC
- To the OR on HD # 2 for:
  - four-compartment fasciotomy
  - external fixator to the right lower extremity
Case Summary (continued):

- Remained stable, transfer to the ward on HD # 3
- Returned to the OR on HD # 4 for:
  - ORIF of the right proximal humerus fracture
  - debridement and irrigation of the right lower extremity
- Returned to the OR on HD # 10 for:
  - removal of external fixator
  - plating of the right fibula with wound closure
- PM&R evaluation diagnosed cerebral concussion - RLAS of VII
- Discharged home with home health services on HD # 15
- Hospital Charges: $78,965
<table>
<thead>
<tr>
<th>Injuries (ICD)</th>
<th>AIS Severity</th>
<th>Info Source</th>
<th>Aspect (R,L,bilat,etc)</th>
<th>Contact Area (door, seat,etc)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cerebral concussion</td>
<td>161000.2</td>
<td>Exam</td>
<td>Whole</td>
<td>Windshield</td>
</tr>
<tr>
<td>(850.0)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Scalp laceration</td>
<td>190602.1</td>
<td>Exam</td>
<td>Left</td>
<td>Windshield</td>
</tr>
<tr>
<td>(873.0)</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Injuries (ICD)</td>
<td>AIS Severity</td>
<td>Info Source</td>
<td>Aspect (R,L,bilat,etc)</td>
<td>Contact Area (door, seat,etc)</td>
</tr>
<tr>
<td>------------------------</td>
<td>--------------</td>
<td>-------------</td>
<td>------------------------</td>
<td>-------------------------------</td>
</tr>
<tr>
<td>Humerus fracture</td>
<td>752604.3</td>
<td>X-ray</td>
<td>Right</td>
<td>Cowl/base of windshield</td>
</tr>
<tr>
<td>(812.0)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Injuries (ICD)</td>
<td>AIS Severity</td>
<td>Info Source</td>
<td>Aspect (R,L,bilat,etc)</td>
<td>Contact Area (door, seat,etc)</td>
</tr>
<tr>
<td>--------------------------</td>
<td>--------------</td>
<td>-------------</td>
<td>------------------------</td>
<td>-------------------------------</td>
</tr>
<tr>
<td>Thigh abrasion</td>
<td>890202.1</td>
<td>Exam</td>
<td>Right</td>
<td>Leading edge of hood</td>
</tr>
<tr>
<td>(916.0)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tibia fracture</td>
<td>853422.3</td>
<td>X-ray</td>
<td>Right</td>
<td>Bumper</td>
</tr>
<tr>
<td>Fibula fracture</td>
<td>851606.2</td>
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<tr>
<td>(823.2)</td>
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</tr>
<tr>
<td>Heel contusion</td>
<td>890402.1</td>
<td>Exam</td>
<td>Right</td>
<td>Unknown</td>
</tr>
<tr>
<td>(928.20)</td>
<td></td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>
Examples of Lessons Learned

1. Head Injuries

- Comparison of PCDS and CIREN data
- Risk of head injury significantly decreases when the head strikes the center of the windshield
- Risk of head injury (AIS ≥ 2) is two (2) times more likely when the head strikes around the edge of the windshield

2. Humerus Fractures

- Comparison of PCDS and CIREN data could not be done for humerus fractures based on selection criteria
- CIREN pedestrians are at an increased risk for humerus fractures; 23% of CIREN pedestrian cases involve a humerus fracture compared with 7% of PCDS cases
Conclusion

We would like to thank the following agencies for making this project a success:

Honda R&D Co. Ltd
The Fairfax County Police Crash Reconstruction Unit
Fairfax County EMS
Prince William County EMS