Beyond aging: the role of frailty in crash-related injuries
Overview

- Background
- Objectives/research question
- Data source/methods
- Results
- Discussion
- Conclusion
Older drivers are an area of particular interest in injury research
- Aging population
- Co-morbidities
- Complications
- Longer lengths of stay and higher medical charges
What is frailty?

- Commonly used term, but difficult to define objectively

- Recent efforts have focused on identification of clinical syndrome causally related to, but distinct from, disability and comorbidity
What is frailty? (cont’d)

- Fried Model (2001), five components:
  - Weight loss
  - Exhaustion
  - Low physical activity
  - Weakness
  - Slowness

- Women’s Health Initiative (1991-2006)
  - Vitality and physical functioning scores (SF-36) used to assess weakness, slowness, and exhaustion
Biological and psychosocial exposures across the life course in relation to frailty and its adverse outcomes

(Adapted from Ben-Shlomo, Kuh 2002)
Previous CIREN Analyses
Background

- Aging of the driving population
- Decreased MVC mortality $\rightarrow$ focus on non-fatal outcomes
- Literature suggests: older adults $\rightarrow$ poor outcome
- Unclear what factors affect recovery potential
- Need for standardized measures
Background

  - SF-36 physical and mental component summary scores
  - lower one year post-MVC compared to general population
  - Excluded cases >60 years

- Ameratunga et al. (2006):
  - compared drivers hospitalized following MVC to drivers not injured in a MVC
  - 10-fold increased chance of worse self-reported health (as indicated on the SF-36) at 18-months post-injury.
Objectives I

To examine the differences in self-reported health, as measured in domains of the Short-Form-36 (SF-36), between young (ages 18-64) and old (age ≥65) individuals prior to a MVC injury and at 6- and 12-months post-injury.
To determine the independent effect of advanced age, comorbidity (the presence of 2 or more medical conditions), and the person’s pre-injury self-reported functional status on the respective post-injury outcomes
Methods

- Two sites of the Crash Injury Research and Engineering Network (CIREN) study
  - Sites chosen based on the completeness of SF-36 data
- CIREN case occupants ≥18 years old
- Exclusions: missing baseline or follow up SF-36 values
# Main Measures

## Main outcome variables:
- SF-36 Scales: Physical Functioning, Vitality, and Mental Health (All on 0-100 scale)
- Initial interview in hospital 6 and 12 month interview by phone

## Main predictor variable:
- Age: 18-64 vs. 65+
Measures (covariates)

- **Comorbidity:**
  - evidence of $\geq 2$ categorized disease classes present at the injury hospital admission

- **Injury Severity Score (ISS):**
  - Minor (1-8)
  - Mild (9-15)
  - Moderate (16-24)
  - Severe (25+)
SF-36: Short Form 36 Health Survey

- Validated, widely used generic measure of health related quality of life
  - 8 Domains
    - Scored 0-100; age; gender adjusted norms
  - 2 Summary Scores
    - Physical Component
      - Measures how decrements in physical function affect day to day activities
      - Impact of physical impairment/disability
    - Mental Component
      - Impact of mental affect, symptoms of pain
  - Facilitates comparison with other disease states
SF-36

**Physical component**
- Physical function
- Role physical
- Bodily pain
- General health

**Mental component**
- Vitality
- Social function
- Role emotion
- Mental health
Physical Functioning

The following items are about activities you might do during a typical day. Does your health now limit you in these activities? If so, how much?

Yes, Limited A Lot
Yes, Limited A Little
No, Not Limited At All
Activities

- Vigorous activities such as running, lifting heavy objects, participating in strenuous sports
- Moderate activities, such as moving a table, pushing a vacuum cleaner, bowling or playing golf
- Lifting or carrying groceries
- Climbing several/one flight of stairs
- Bending, kneeling, or stooping
- Walking more than a mile/several blocks/one block
- Bathing or dressing yourself
Vitality

During the past 4 weeks....

- Did you feel full of pep?
- Did you have a lot of energy?
- Did you feel worn out?
- Did you feel tired?
  - All of the time
  - Most of the time
  - A Good Bit of the time
  - Some of the time
  - A little of the time
  - None of the time
Statistical Analyses

- Demographic and health characteristics comparison by age group (< 65 and ≥ 65) using Pearson’s chi-square statistics

- Unadjusted effect of age group on outcome measures at 6 months and 12 months for each of 3 domains of the SF-36 → Student’s t-tests

- Multiple linear regression → association between age group and outcome while adjusting for covariates
Results
Unadjusted Age Differences in SF-36 Scores

Baseline | 6-Month | 12-Month
--- | --- | ---
Young | Old | Young | Old | Young | Old
Physical Functioning | vitality | mental health

Baseline scores indicate the health status at the start of the study, while the 6-month and 12-month scores reflect the changes in health status over time.
# Physical Functioning

<table>
<thead>
<tr>
<th>Variable</th>
<th>6 month</th>
<th></th>
<th>12 month</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Estimate</td>
<td>P-</td>
<td>Estimate</td>
<td>P-</td>
</tr>
<tr>
<td><strong>Age 18-64 (ref)</strong></td>
<td></td>
<td></td>
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<tr>
<td>65+</td>
<td>0.81</td>
<td>0.84</td>
<td>0.92</td>
<td>0.79</td>
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<tr>
<td><strong>Comorbid No (ref)</strong></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>-12.6</td>
<td>&lt;.001</td>
<td>-10.67</td>
<td>&lt;.001</td>
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<tr>
<td><strong>Baseline SF-36 PF</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>ISS&lt;8 (ref)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9-15</td>
<td>-6.34</td>
<td>0.16</td>
<td>-1.635</td>
<td>0.66</td>
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<tr>
<td>16-24</td>
<td>-1.11</td>
<td>0.82</td>
<td>3.315</td>
<td>0.41</td>
</tr>
<tr>
<td>25+</td>
<td>-9.60</td>
<td>0.05</td>
<td>-3.558</td>
<td>0.38</td>
</tr>
</tbody>
</table>

Ref=referent; ISS = Injury Severity Scale; Estimate refers to the parameter estimate in multivariate linear regression models

*Refers to the baseline value for the respective outcome measure in each analysis
Limitations

- CIREN selection criteria and methodology:
  - Not a random sample
- Non-inclusion of other CIREN sites
- Lack of SES adjustment
- Secondary data analyses
  - Limited by available data
  - Unable to compare age groups among “older adults”
Conclusion

- SF-36 trajectories similar for the two age groups
- Advanced age was associated with worse self-reported health in physical functioning and vitality
- Age association not a significant indicator of outcomes when comorbidities, pre-injury health status, and injury severity were considered
Conclusion

- Pre-injury self-reported physical functioning, vitality score, mental health and comorbidities influenced the self-reported functional status at 6 and 12 months post-injury

- Injury severity influenced the physical functional status at 6 months only
Discussion

- Age itself is not a significant predictor of the potential for recovery when other age-associated conditions are considered!!!!

- Age differences in outcomes mediated by comorbidities and pre-injury functional status:
  - Need to be accounted for in functional outcome research following vehicular injuries

- Older patients require rehabilitation efforts focused more on physical domains of functioning

Presented to AAAM, October 20, 2010
ROLE OF FRAILTY IN INJURY CAUSATION??
The purpose of this analysis was to examine the role of frailty in injury causation.
Research Question

- Case / Control (frail/non-frail)
  
  - Are the crash, occupant, vehicle and injury characteristics among those who are frail different than among those who are not frail?
  
  - Is frailty associated with physical characteristics (age, BMI) or specific injuries (fractures, TBI)?
Data Source

- CIREN dataset

- Baseline SF-36 scores
  - Within 2 weeks of admission date
  - Physical functioning (PF) score < 75
Data Limitations

- All subjects are injured in at least one body region
- Incomplete data capture
  - Varies by enrolling center
  - Baseline evaluation ranges from date of admission to 4 months post-admission
  - Could not include all centers in analysis
  - Unable to identify baseline values for all cases
Study definition of frailty

- CIREN is unable to account for weight loss or low physical activity
- SF-36 metrics previously used
  - Vitality
  - Physical functioning
- This study evaluated physical functioning alone as a frailty marker
Definition of frailty marker

- Higher correlation found between lower physical functioning scores and crash circumstances
  - Comparing low PF only, low VS only, low PF and low VS, all normal
CIREN Population

- Total CIREN cases = 4,380
  - PFS<75 only = 116 (2.7%)
  - VS<55 only = 174 (4.0%)
  - PVS<75 and VS<55 = 121 (2.8%)
  - Both above = 1,325 (30.2%)
  - Missing baseline score = 2,644 (60.4%)

- Total with baseline PFS = 1,747
# Frailty Categories
(N=1,736)

<table>
<thead>
<tr>
<th></th>
<th>PFS&lt;75 only (%)</th>
<th>VS&lt;55 only (%)</th>
<th>Both less (%)</th>
<th>Both over (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Age</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;50</td>
<td>32.8</td>
<td>76.4</td>
<td>34.7</td>
<td>68.2</td>
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<tr>
<td><strong>Gender</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>34.5</td>
<td>43.7</td>
<td>34.7</td>
<td>48.6</td>
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<tr>
<td><strong>BMI</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Underweight/Normal</td>
<td>32.0</td>
<td>39.7</td>
<td>34.7</td>
<td>44.2</td>
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<td><strong>Comorbidities</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3+</td>
<td>56.9</td>
<td>34.5</td>
<td>62.8</td>
<td>20.5</td>
</tr>
<tr>
<td><strong>Injury Type</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Femur fracture</td>
<td>12.1</td>
<td>16.1</td>
<td>17.4</td>
<td>15.6</td>
</tr>
<tr>
<td>Multiple rib fractures</td>
<td>37.9</td>
<td>23.0</td>
<td>42.2</td>
<td>25.2</td>
</tr>
</tbody>
</table>
Final definition

- Use PFS < 75 to identify cases with frailty markers

- Compare those ‘frail’ case occupants with all others
  - Crash characteristics
  - Injuries sustained
Results

- Crash/vehicle circumstances
  - Delta V
  - Crash type
  - Restraint use
<table>
<thead>
<tr>
<th></th>
<th>PFS&lt;75 (%)</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Delta V</strong></td>
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<td></td>
</tr>
<tr>
<td>&lt;45</td>
<td>17.4</td>
<td></td>
</tr>
<tr>
<td>45+</td>
<td>9.0</td>
<td>&lt;0.01</td>
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<tr>
<td><strong>Crash Type</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Frontal</td>
<td>15.9</td>
<td></td>
</tr>
<tr>
<td>Near side</td>
<td>11.6</td>
<td></td>
</tr>
<tr>
<td>Far side</td>
<td>14.6</td>
<td></td>
</tr>
<tr>
<td>Rollover</td>
<td>6.9</td>
<td>0.02</td>
</tr>
<tr>
<td><strong>Belt Use</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>13.5</td>
<td></td>
</tr>
<tr>
<td>No</td>
<td>14.0</td>
<td>NS</td>
</tr>
</tbody>
</table>
Results

- Person/injury circumstances
  - Age
  - Gender
  - BMI
  - Comorbidities (number)
  - ISS
  - MAIS
### Descriptive Statistics: Occupant
(N=1,747)

<table>
<thead>
<tr>
<th></th>
<th>PFS&lt;75 (%)</th>
<th>P-value</th>
</tr>
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<tbody>
<tr>
<td><strong>Age</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;55</td>
<td>8.5</td>
<td></td>
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<tr>
<td>55+</td>
<td>27.1</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td><strong>Gender</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>16.8</td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>10.3</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td><strong>Comorbidities</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0-1</td>
<td>11.6</td>
<td></td>
</tr>
<tr>
<td>2+</td>
<td>46.7</td>
<td>&lt;0.01</td>
</tr>
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</table>
## Descriptive Statistics: Occupant

(N=1,747)

<table>
<thead>
<tr>
<th>BMI</th>
<th>PFS&lt;75 (%)</th>
<th>P-value</th>
</tr>
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<tbody>
<tr>
<td>Underweight</td>
<td>17.1</td>
<td></td>
</tr>
<tr>
<td>Normal</td>
<td>10.6</td>
<td></td>
</tr>
<tr>
<td>Overweight</td>
<td>11.6</td>
<td></td>
</tr>
<tr>
<td>Obese</td>
<td>19.3</td>
<td></td>
</tr>
<tr>
<td>Extremely obese</td>
<td>24.4</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Normal/Overweight</td>
<td>11.0</td>
<td></td>
</tr>
<tr>
<td>Underweight/Obese/Extremely obese</td>
<td>20.1</td>
<td>&lt;0.01</td>
</tr>
</tbody>
</table>
# Descriptive Statistics: Injury

(N=1,747)

<table>
<thead>
<tr>
<th>ISS</th>
<th>PFS&lt;75 (%)</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;16</td>
<td>14.6</td>
<td></td>
</tr>
<tr>
<td>16+</td>
<td>12.9</td>
<td>NS</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>MAIS 3+</th>
<th>PFS&lt;75 (%)</th>
<th>P-value</th>
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</thead>
<tbody>
<tr>
<td>Head</td>
<td>10.1</td>
<td>0.04</td>
</tr>
<tr>
<td>Face</td>
<td>9.3</td>
<td>NS</td>
</tr>
<tr>
<td>Neck</td>
<td>0.0</td>
<td>0.03</td>
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<tr>
<td>Thorax</td>
<td>15.0</td>
<td>NS</td>
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<td>Abdomen</td>
<td>10.7</td>
<td>NS</td>
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<tr>
<td>Spine</td>
<td>9.3</td>
<td>0.04</td>
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<tr>
<td>Upper Extremity</td>
<td>13.4</td>
<td>NS</td>
</tr>
<tr>
<td>Lower Extremity</td>
<td>14.6</td>
<td>NS</td>
</tr>
</tbody>
</table>
Recap

- Frailty $\rightarrow$ Injury
- CIREN does not have a control group (uninjured people)

Analytical approach

1. Frailty $\rightarrow$ delta $v$ for specific injuries (adjusting for crash and occupant characteristics):
   - Head
   - Rib fractures
   - Femur fracture
### Frailty association with log delta v: Head

<table>
<thead>
<tr>
<th></th>
<th>Coefficient</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Head (AIS 3+)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age</td>
<td>-0.175</td>
<td>0.145</td>
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<tr>
<td>Gender</td>
<td>-0.097</td>
<td>0.368</td>
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<tr>
<td>Comorbidity count</td>
<td>0.048</td>
<td>0.814</td>
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<tr>
<td>BMI</td>
<td>-0.116</td>
<td>0.451</td>
</tr>
<tr>
<td>Frailty</td>
<td>-0.245</td>
<td>0.259</td>
</tr>
</tbody>
</table>

Belted occupants, frontal crash only  
Comorbidity count 0-2 vs 3+  
Frailty (PF<75 vs 75+)  
Agegrp (<55 vs 55+)  
Gender (men vs women)  
BMI (normal/overweight vs other)
Frailty association with log delta v: Multiple ribs

<table>
<thead>
<tr>
<th>Multiple rib fractures</th>
<th>Coefficient</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>-0.00174</td>
<td>0.21</td>
</tr>
<tr>
<td>Gender</td>
<td>-0.01839</td>
<td>0.79</td>
</tr>
<tr>
<td>Comorbidity count</td>
<td>-0.00174</td>
<td>0.99</td>
</tr>
<tr>
<td>BMI</td>
<td>0.00098</td>
<td>0.99</td>
</tr>
<tr>
<td>Frailty</td>
<td>-0.18775</td>
<td>0.04*</td>
</tr>
</tbody>
</table>

Belted occupants, frontal crash only
Comorbidity count 0-2 vs 3+
Frailty (PF<75 vs 75+)
Agegrp (<55 vs 55+)
Gender (men vs women)
BMI (normal/overweight vs other)
Frailty association with log delta v: Multiple ribs

- For person with multiple rib fractures:
  - PFS ≥ 75 (n=102)  mean dV = 47.1
  - PFS < 75 (n=26)  mean dV = 39.1
  - p = .03

Frontal crashes, belted occupants

Similar trend for Head AIS3+ injuries but n is much smaller for selection group
Frailty association with log delta v: Femur

<table>
<thead>
<tr>
<th>Femur fracture</th>
<th>Coefficient</th>
<th>P-value</th>
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<tbody>
<tr>
<td>Age</td>
<td>-0.032</td>
<td>0.71</td>
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<tr>
<td>Gender</td>
<td>-0.047</td>
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<tr>
<td>BMI</td>
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</tr>
<tr>
<td>Frailty</td>
<td>-0.099</td>
<td>0.35</td>
</tr>
</tbody>
</table>

Belted occupants, frontal crash only
Comorbidity count 0-2 vs 3+
Frailty (PF<75 vs 75+)
Agegrp (<55 vs 55+)
Gender (men vs women)
BMI (normal/overweight vs other)
Discussion

- Although unable to identify frail occupants
  - Use low PF scores as a marker
    - Higher correlation than VS
    - Need better identifiers for frailty and more complete data
Conclusions

- Frailty metrics are crucial and difficult to apply
- Systems with detailed injury and kinematics data should capture frailty indices for evaluation
- Physical functioning scores, while correlated with frailty characteristics, are not significantly associated with injury outcomes
Implications

- Focus on mitigating crash and injury characteristics that more likely will occur among the growing number of frail vehicular occupants.

- Need to develop more objective anatomic/physiologic correlates of frailty that could better account for putative association.
Future Directions

- Larger sample / Improve SF-36 completion rates
- Collaboration with other facilities for follow-up
- More robust measures, including biochemical markers for prospective analyses
- Predictive models of poor long-term outcomes in older MVC victims
Questions??

THANK YOU
Frailty association with delta v within ISS groups

**p<0.01  Breslow-Day = NS
Frailty association with delta v within ISS groups

- Delta v is significantly associated with frailty
  - A higher proportion of people injured at the lower delta v were frail

- This association exists at all levels of ISS