TBI as a Chronic Health Condition

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Disclosures

This research was supported by an interagency agreement between the US Department of Health and Human Services (HHS) Centers for Disease Control and Prevention (CDC), and the US Department of Education’s National Institute on Disability and Rehabilitation Research (NIDRR). Additional support was provided to the Traumatic Brain Injury Model Systems National Data and Statistical Center (grant no. H133A110006), the research was also supported by Traumatic Brain Injury Model System Center grants from NIDRR to Ohio State University (grant no. H133A120086) and Indiana University (grant no. H133A120035).
Learning Objectives

At the conclusion of this presentation participants will be able to:

1. delineate sources of increased mortality following moderate or severe TBI;
2. describe change in the first 5 years following moderate or severe TBI; and
3. discuss components of a disease management approach to chronic TBI and the research needed to implement same.
NIDILRR TBI National Database

• Form I – 14,663 cases (as of 3/31/2016)
• Form II – 49,468 follow-ups* - 18% attrition (4%**)
  – Year 1 – 13,988 – 14% attrition (2%**)
  – Year 2 – 12,464 – 15% attrition (5%**)
  – Year 5 – 9,642 – 17% attrition (5%**)
  – Year 10 – 5,371 – 19% attrition (6%**)
  – Year 15 – 2,043 – 15% attrition (8%**)
  – Year 20 – 551 – 14% attrition (0%**)
  – Year 25 – 127 – 9% attrition (0%**)

*There are some follow-ups in database that were performed at 3, 4, and 6 years post-injury.

**Additional percent attrition due to loss of center funding.
VA TBI National Database

• Form I – 924 cases (as of 9/6/2016)
• Form II – 660 follow-ups (as of 6/30/2015)
  – 9.5% attrition overall
    – Year 1 – 453 – 9.1% attrition
    – Year 2 – 378 – 11.8% attrition
    – Year 5 – 73 – 3.6% attrition
    – Year 10 – 28 – 0.0% attrition
    – Year 15 – 2 – 0.0% attrition
    – Year 20 – 1 – 0.0% attrition
Representativeness of the TBI Model Systems National Dataset

• 700+ peer reviewed articles generated by TBI Model Systems funding; 167 using the National Dataset.

• What confidence that TBIMS findings generalize to the U.S. population receiving rehabilitation for TBI?

• Reporting of data to intermediaries as of 2001 allowed direct testing of the question.
Few Differences between TBI Model Systems and U.S. Population Once Age Accounted For

16-64 year olds

- Vocational Status
  - Employed

- Rehab Length of Stay
  - 1-9 days

65 and older

- Age
  - 65-69
  - 80-89

- Vocational Status
  - Employed
  - Retired

- Primary Payment Source
  - Private Insurance
  - Medicare

- Rehab Length of Stay
  - 1-9 days

Yellow font = TBIMS had more
Determining U.S. Population Estimates

- TBIMS NDB subjects admitted for rehabilitation on 10/01/2001 or later and discharged by 12/31/2007 (5-year outcomes) or 12/31/2010 (2-year outcomes).

- Applied raking and weight-trimming to represent 99,438 (2001-2007) and 156,447 (2001-2010) individuals 16+ years old admitted during the same time period to U.S. inpatient rehabilitation facilities with a primary diagnosis of TBI.

- Represent an estimated annual average population of 20,000 (2001-2010) individuals.
Representativeness of the Traumatic Brain Injury Model Systems National Database

John D. Corrigan, PhD; Jeffrey P. Cuthbert, MPH, MS; Gale G. Whiteneck, PhD; Marcel P. Dijkers, PhD; Victor Coronado, MD, MPH; Allen W. Heinemann, PhD; Cynthia Harrison-Felix, PhD; James E. Graham, PhD


Jeffrey P. Cuthbert, MPH, MS; John D. Corrigan, PhD; Gale G. Whiteneck, PhD; Cynthia Harrison-Felix, PhD; James E. Graham, PhD; Jeneita M. Bell, MD, MPH

Epidemiology of Adults Receiving Acute Inpatient Rehabilitation for a Primary Diagnosis of Traumatic Brain Injury in the United States

Jeffrey P. Cuthbert, PhD, MPH, MS; Cynthia Harrison-Felix, PhD; John D. Corrigan, PhD; Scott Kreider, MS; Jeneita M. Bell, MD, MPH; Victor G. Coronado, MD, MPH; Gale G. Whiteneck, PhD

US Population Estimates of Health and Social Outcomes 5 Years After Rehabilitation for Traumatic Brain Injury

John D. Corrigan, PhD; Jeffrey P. Cuthbert, PhD, MPH, MS; Cynthia Harrison-Felix, PhD; Gale G. Whiteneck, PhD; Jeneita M. Bell, MD, MPH; A. Cate Miller, PhD; Victor G. Coronado, MD, MPH; Christopher R. Pretz, PhD

Life Expectancy following Inpatient Rehabilitation for Traumatic Brain Injury in the United States

Cynthia L. Harrison-Felix, Christopher R. Pretz, Flora Hammond, Jeffrey Cuthbert, Jeneita Bell, John D. Corrigan, A. Cate Miller, Juliet Haarbauer-Krupa

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**Objective:** To estimate the number of adults in the United States from 2006 to 2012 who manifest selected health and social outcomes 5 years following a traumatic brain injury (TBI) that required acute inpatient rehabilitation. **Design:** Secondary data analysis. **Setting:** Acute inpatient rehabilitation facilities. **Participants:** Patients 16 years and older receiving acute inpatient rehabilitation for a primary diagnosis of TBI. **Main Outcome Measures:** Mortality, functional independence, societal participation, subjective well-being, and global outcome. **Results:** Annually from 2001 to 2007, an average of 13,700 patients aged 16 years or older received acute inpatient rehabilitation in the United States with a primary diagnosis of TBI. Approximately 1 in 5 patients had died by the 5-year postinjury assessment. Among survivors, 12% were institutionalized and 50% had been rehospitalized at least once. Approximately one-third of patients were not independent in everyday activities. Twenty-nine percent were dissatisfied with life, with 8% reporting markedly depressed mood. Fifty-seven percent were moderately or severely disabled overall, with 39% having deteriorated from a global outcome attained 1 or 2 years postinjury. Of those employed preinjury, 55% were unemployed. Poorer medical, functional, and participation outcomes were associated with, but not limited to, older age. Younger age groups had poorer mental and emotional outcomes. Deterioration in global outcome was common and not age-related. **Conclusions:** Significant mortality and morbidity were evident at 5 years postinjury. The deterioration in global outcomes observed regardless of age suggests that multiple influences contribute to poorer outcomes. Public health interventions intended to reduce post-acute inpatient rehabilitation mortality and morbidity rates will need to be multifaceted and age-specific. **Keywords:** cranioencebral trauma, epidemiology, outcomes, prevalence, rehabilitation, traumatic brain injury
Outcomes for Adults in the U.S. Five Years after Rehabilitation for TBI

- TBI Model Systems subjects admitted to rehabilitation 10/01/2001 to 12/31/2007

- Status 5 years later (weighted for national population characteristics):
  - 84.4% known outcome
  - 10.0% lost to follow-up
  - 5.7% withdrew/refused/unknown

  for 1 in 4, the known outcome is “dead”
21.7% dead within 5 years

Of the average annual 13,700 admissions to U.S. IRF’s* with a primary diagnosis of TBI, an estimated annual average of more than 2,965 died in the first five years after injury.

*October 1, 2001 and December 31, 2007
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Abstract
This study characterized life expectancy after traumatic brain injury (TBI). The TBI Model Systems (TBIMS) National Database (NDB) was weighted to represent those ≥16 years of age completing inpatient rehabilitation for TBI in the United States (US) between 2001 and 2010. Analyses included Standardized Mortality Ratios (SMRs), Cox regression, and life expectancy. The US mortality rates by age, sex, race, and cause of death for 2005 and 2010 were used for comparison purposes. Results indicated that a total of 1325 deaths occurred in the weighted cohort of 6913 individuals. Individuals with TBI were 2.23 times more likely to die than individuals of comparable age, sex, and race in the general population, with a reduced average life expectancy of 9 years. Independent risk factors for death were: older age, male gender, less-than-high school education, previously married at injury, not employed at injury, more recent year of injury, fall-related TBI, not discharged home after rehabilitation, less functional independence, and greater disability. Individuals with TBI were at greatest risk of death from seizures; accidental poisonings; sepsis; aspiration pneumonia; respiratory, mental/behavioral, or nervous system conditions; and other external causes of injury and poisoning, compared with individuals in the general population of similar age, gender, and race. This study confirms prior life expectancy study findings, and provides evidence that the TBIMS NDB is representative of the larger population of adults receiving inpatient rehabilitation for TBI in the US. There is an increased risk of death for individuals with TBI requiring inpatient rehabilitation.
Methods

• 7,366 TBI Model Systems National Database subjects admitted for rehabilitation on 10/01/2001 or later and discharged by 12/31/2010 with vital status tracked until 12/31/2011. (20,314 person-years of data)

• Weighted for national population characteristics to represent 156,447 individuals admitted to U.S. inpatient rehabilitation facilities with a primary diagnosis of TBI ages 16+ during same time period.

• Used U.S. population mortality rates from 2005 and 2010 to calculate standardized mortality ratios and life expectancy.
### Overall Results

<table>
<thead>
<tr>
<th></th>
<th>Observed Deaths</th>
<th>Expected Deaths</th>
<th>Standardized Mortality Ratio (SMR)</th>
<th>95% Confidence Interval</th>
</tr>
</thead>
<tbody>
<tr>
<td>All participants</td>
<td>1,325.4</td>
<td>594.7</td>
<td>2.23</td>
<td>2.11, 2.35</td>
</tr>
<tr>
<td>If alive 1 year post-injury</td>
<td>879.2</td>
<td>570.7</td>
<td>1.54</td>
<td>1.44, 1.64</td>
</tr>
</tbody>
</table>

- Individuals with TBI were 2.23 times more likely to die compared to individuals in US general population of similar age, gender and race.

- Excess mortality decreased for those who survived at least until their 1 year post-injury anniversary.
## Age

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<tr>
<th>Age at injury (years)</th>
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<th>Expected Deaths</th>
<th>SMR</th>
<th>95% Confidence Interval</th>
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<tr>
<td>15-19</td>
<td>7.6</td>
<td>0.7</td>
<td>11.58</td>
<td>3.37 - 19.79</td>
</tr>
<tr>
<td>20-24</td>
<td>17.1</td>
<td>2.5</td>
<td>6.86</td>
<td>3.60 - 10.11</td>
</tr>
<tr>
<td>25-34</td>
<td>26.9</td>
<td>3.3</td>
<td>8.24</td>
<td>5.12 - 11.35</td>
</tr>
<tr>
<td>35-44</td>
<td>46.6</td>
<td>4.9</td>
<td>9.56</td>
<td>6.82 - 12.31</td>
</tr>
<tr>
<td>45-54</td>
<td>104.2</td>
<td>12.2</td>
<td>8.55</td>
<td>6.91 - 10.19</td>
</tr>
<tr>
<td>55-64</td>
<td>107.5</td>
<td>21.3</td>
<td>5.04</td>
<td>4.09 - 5.99</td>
</tr>
<tr>
<td>65-74</td>
<td>245.1</td>
<td>55.6</td>
<td>4.41</td>
<td>3.86 - 4.96</td>
</tr>
<tr>
<td>75-84</td>
<td>530.0</td>
<td>200.8</td>
<td>2.64</td>
<td>2.41 - 2.86</td>
</tr>
<tr>
<td>85+</td>
<td>240.3</td>
<td>293.5</td>
<td>0.82</td>
<td>0.72 - 0.92</td>
</tr>
</tbody>
</table>

Generally, as age at injury increased, excess mortality decreased, but still remained elevated to age 84.
Gender

<table>
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<tr>
<th>Gender</th>
<th>Observed Deaths</th>
<th>Expected Deaths</th>
<th>SMR</th>
<th>95% Confidence Interval</th>
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</thead>
<tbody>
<tr>
<td>Male</td>
<td>871.1</td>
<td>335.7</td>
<td>2.60</td>
<td>2.42 - 2.77</td>
</tr>
<tr>
<td>Female</td>
<td>454.2</td>
<td>259.1</td>
<td>1.75</td>
<td>1.59 - 1.92</td>
</tr>
</tbody>
</table>

Males had greater excess mortality than females.
Independent risk factors for death

- Older age at injury
- Being male
- Divorced, widowed or separated
- Unemployed
- Less education
- Fall related TBI
- Later year of injury
- Not having a spinal cord injury
- Not discharged home
- Lower functional independence
- Greater disability
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<td>23.15, 76.84</td>
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<td>Accidental Poisoning</td>
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<td>1.9</td>
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<td>92.8</td>
<td>23.7</td>
<td>3.91</td>
<td>3.12, 4.71</td>
</tr>
<tr>
<td>Vehicular</td>
<td>17.6</td>
<td>5.1</td>
<td>3.44</td>
<td>1.83, 5.05</td>
</tr>
<tr>
<td>Suicide</td>
<td>10.1</td>
<td>3.83</td>
<td>2.64</td>
<td>1.01, 4.27</td>
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<tr>
<td>All Respiratory</td>
<td>176.6</td>
<td>67.5</td>
<td>2.62</td>
<td>2.23, 3.00</td>
</tr>
<tr>
<td>Mental/Behavioral</td>
<td>47.4</td>
<td>21.8</td>
<td>2.17</td>
<td>1.55, 2.79</td>
</tr>
<tr>
<td>Nervous System</td>
<td>63.8</td>
<td>35.9</td>
<td>1.78</td>
<td>1.34, 2.21</td>
</tr>
<tr>
<td>Digestive</td>
<td>27.4</td>
<td>18.2</td>
<td>1.51</td>
<td>0.94, 2.07</td>
</tr>
<tr>
<td>Circulatory</td>
<td>340.8</td>
<td>239.8</td>
<td>1.42</td>
<td>1.27, 1.57</td>
</tr>
</tbody>
</table>
Deaths due to Accidental Poisoning

<p>| | |</p>
<table>
<thead>
<tr>
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</thead>
<tbody>
<tr>
<td>Opiate primary</td>
<td>55%</td>
</tr>
<tr>
<td>Opiate involved</td>
<td>64%</td>
</tr>
<tr>
<td>Alcohol primary</td>
<td>23%</td>
</tr>
<tr>
<td>Alcohol involved</td>
<td>41%</td>
</tr>
</tbody>
</table>
Outcomes for Adults in the U.S. Five Years after Rehabilitation for TBI

- TBI Model Systems subjects admitted to rehabilitation 10/01/2001 to 12/31/2007

- Status 5 years later (weighted for national population characteristics):
  - 84.4% known outcome
  - 10.0% lost to follow-up
  - 5.7% withdrew/refused/unknown

  For 1 in 4, the known outcome is “dead”
Final Analyses

Re-weighted outcomes to reflect the U.S. population who were over the age 15 when they received inpatient rehabilitation with a primary diagnosis of TBI and are still alive 5 years later.
12.3% are institutionalized 5 years post-injury

Of the average annual 13,700 admissions to U.S. IRF's* with a primary diagnosis of TBI, an estimated annual average of more than 1,680 were institutionalized 5 years after injury.

*October 1, 2001 and December 31, 2007
32.3% need assistance in at least one area of physical functioning 5 years post-injury

Of the average annual 13,700 admissions to U.S. IRF’s* with a primary diagnosis of TBI, an estimated annual average of more than 4,420 required assistance in at least 1 area of physical functioning 5 years post-injury.

*October 1, 2001 and December 31, 2007
14.2% misused alcohol in the 5 years since injury

Of the average annual 13,700 admissions to U.S. IRF’s* with a primary diagnosis of TBI, an estimated annual average of more than 1,945 have misused alcohol in the 5 years after injury.

*October 1, 2001 and December 31, 2007
8.4% have moderate to severely depressed mood 5 years post-injury

Of the average annual 13,700 admissions to U.S. IRF’s* with a primary diagnosis of TBI, an estimated annual average of more than 1,145 had moderate to severely depressed mood 5 years post-injury.

*October 1, 2001 and December 31, 2007
57.8% have moderate or severe disability at 5 years since injury.

Of the average annual 13,700 admissions to U.S. IRF’s* with a primary diagnosis of TBI, an estimated annual average of more than 7,920 had moderate or severe disability 5 years after injury.

*October 1, 2001 and December 31, 2007
38.8% declined from an earlier outcome to their status at 5 years post-injury.

Of the average annual 13,700 admissions to U.S. IRF’s* with a primary diagnosis of TBI, an estimated annual average of more than 5,320 declined from an earlier outcome to status at 5 years post-injury.

*October 1, 2001 and December 31, 2007
Possible Sources of Deterioration

• TBI triggers a progressive, degenerative process (i.e., Parkinson’s Disease, Alzheimer’s Disease, Chronic Traumatic Encephalopathy).

• TBI causes loss of functional independence which interacts with normal aging to increase poor health.

• Frontal lobe damage endemic to TBI causes changes in self-regulation which lead to death and disability from risky behaviors.

• Injury causes or exacerbates financial hardship, which in turn leads to poorer health.

• All of the above.
U.S. population more than 15 years old receiving rehabilitation for a primary diagnosis of TBI:

By 5 years after TBI:

- 2 in 10 die
- 3 in 10 deteriorate from recovery attained 1-2 years after injury
2009 Institute of Medicine Report
Gulf War and Health Volume 7:
Long-Term Consequences of
Traumatic Brain Injury
Traumatic Brain Injury: A Disease Process, Not an Event

Brent E. Masel¹ and Douglas S. DeWitt²

Traumatic Brain Injury as a Chronic Health Condition

John D. Corrigan, PhD,a,* Flora M. Hammond, MD,b,*
Managing TBI as a chronic health condition (IOM, 2010)

“The committee recommends that the Department of Veterans Affairs conduct research to determine the potential efficacy and cost-effectiveness of developing protocols for the long-term management of service members who have polytrauma and TBI. The approaches considered should include:

• prospective clinical surveillance to allow early detection and intervention for health complications;
Managing TBI as a chronic health condition (IOM, 2010)

(continued)

• protocols for preventive interventions that target high incidence or high risk complications;

• protocols for training in self-management aimed at improving health and well-being;

• access to medical care to treat complications; and

• access to rehabilitation services to re-optimize functional abilities.”
Designing a “Disease Management” approach to Chronic Brain Injury

1. Which brain injuries increase risk for negative outcomes?
CDC estimates for annual rates of TBI in the United States*

- 52,000 Deaths
- 275,000 Hospitalizations
- 1,365,000 Emergency Department Visits
- At least 1.7 million TBIs occur in the United States each year (based on 2002-2006)

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Colorado Adults: Relative Prevalence of Activity Limitations and Poor Physical Health

Compared to those with no injuries after controlling for age, gender, race and treatment received (i.e., hospital, ED, office, none)
Ohio Adults: Adjusted Odds* of Disability by Severity of Worst Lifetime TBI—PRELIMINARY FINDINGS

*Compared to Ohioans with no TBI with loss of consciousness, adjusted for age, gender and race/ethnicity
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1. Which brain injuries increase risk for negative outcomes?
2. What pre-existing conditions require management?
3. What conditions develop post-injury that could be prevented or detected early?
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<tr>
<td>Back pain</td>
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THANK YOU

corrigan.1@osu.edu