CDC estimates for annual rates of TBI in the United States*

At least 1.7 million TBIs occur in the United States each year (based on 2002-2006)

52,000 Deaths
275,000 Hospitalizations
1,365,000 Emergency Department Visits

What About Prevalence of TBI in the General Population?

• Disability due to TBI

• Lifetime TBI as “exposure”
  – Prevalence?
  – Consequences?

Prevalence of Disability Due to TBI
CDC estimates for annual rates of TBI in the United States*

- At least 1.7 million TBIs occur in the United States each year (based on 2002-2006)
- 52,000 Deaths
- 275,000 Hospitalizations
- 1,365,000 Emergency Department Visits
- ??? Receiving Other Medical Care or No Care

Prevalence of Disability Due to TBI

- Projected from 1 year outcomes following hospitalization
- Datasets did not include children
- Made assumptions about persistence of disability and mortality

- In 1996, based on Colorado data: 2.0%
- In 2005, based on South Carolina data: 1.1%


Survey Data & Disability Due to TBI

CDC estimates for annual rates of TBI in the United States*:

- 52,000 Deaths
- 275,000 Hospitalizations
- 1,365,000 Emergency Department Visits
- ??? Receiving Other Medical Care or No Care

At least 1.7 million TBIs occur in the United States each year (based on 2002-2006).

Survey Data & Disability Due to TBI

- Whiteneck et al.: if disability is not limited to TBIs requiring hospitalization, rate could be 3 x larger.

- Jourdan et al. from the French National Disability and Health Survey: 0.7%
Summary: Prevalence of Disability Due to TBI

- Estimates have ranged from 0.7%–2.0%
- US studies likely underestimates due to:
  - Starting with disability 1 year after hospitalization
  - Having to make assumptions about permanence and mortality
  - Not including TBIs occurring in childhood
- What if the effect of the TBI is not apparent immediately but in time results in disability?

Prevalence of “Exposure” to TBI

The study of toxic exposures considers the nature of the relationship between exposure and effect:

- what is the relationship between dose and effect?
- does a single exposure of any dose cause the effect?
- can there be cumulative effects of repeated exposures?
- how does development interact with both exposure and the manifestation of the effect?
Conceptualizing “Exposure” to TBI

- Has a person’s head been exposed to sufficient forces to result in TBI?
- Has a person ever had altered consciousness due to external forces—i.e., ever had a TBI?
- Has a person ever had a TBI of a certain magnitude of altered consciousness—i.e., severity?
- How many TBIs has a person had?
- What was the timing of those TBIs?
- When developmentally did these TBIs occur?

What do we know about prevalence of exposure to TBI?

- Not enough!
- Research on exposure to g forces is marked by inconsistencies and will be impractical for getting lifetime prevalence data
- Research on lifetime TBI is mostly based on single item elicitation of “yes/no” using a variety of case definitions
- Use of standardized instruments for elicitation has been limited, at least to date.

Prevalence in Single Item Surveys

10% (1998), 13% (1999) – New Hampshire BRFSS “ever diagnosed with a concussion or a brain injury that was the result of trauma or drowning?”
37% – 2001 Colorado BRFSS “how many times have you ever been injured where you were knocked out or unconscious?”
9% – New Haven Connecticut “experienced a severe head injury that was associated with a LOC or confusion?”
17% – 2011 Ontario survey “head injury that resulted in being unconscious (knocked out) for at least 5 minutes, or requiring a stay in the hospital for at least one night?”
6% – 2 Australian cities “TBI in your lifetime that resulted in 15 minutes or longer LOC?”

John D. Corrigan, PhD
Ohio State University
**Lifetime History of TBI in General Population**

Surveys using Standardized Instruments

**Colorado:** CDC funded survey of 2,701 adult, non-institutionalized residents of Colorado ≥ 18 years old. Conducted from 2008-2010 and weighted to 2010 census data. CATI of the OSU TBI Identification Method Research version.

**Ohio:** State optional module included in 2014 BRFSS administered to 6,998 adult, non-institutionalized Ohioans ≥ 18 years old. Used adapted OSU TBI Identification Method.

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**Prevalence of TBI in the Adult, General Population**

<table>
<thead>
<tr>
<th></th>
<th>Colorado</th>
<th>Ohio</th>
</tr>
</thead>
<tbody>
<tr>
<td>% with Any TBI</td>
<td>42.5%</td>
<td>n/a</td>
</tr>
<tr>
<td>% with Loss of Consciousness</td>
<td>24.4%</td>
<td>21.7%</td>
</tr>
<tr>
<td>% with Moderate or Severe TBI</td>
<td>6.0%</td>
<td>2.6%</td>
</tr>
<tr>
<td>% with Loss of Consciousness before age 15</td>
<td>6.7%</td>
<td>9.1%</td>
</tr>
<tr>
<td>% either LOC &lt; 15 or mod/sev TBI</td>
<td>11.5%</td>
<td>10.8%</td>
</tr>
</tbody>
</table>

---

**Summary: Prevalence of TBI Exposures**

- “Exposure” is a paradigm shift in previous approaches to prevalence
- Accounts for effects of TBI that are not immediate and continuous
- May be more important when considering the public burden of TBI
- Do not know much about prevalence of exposure
- What do we know about consequences of lifetime exposure?
Consequences of Exposure to TBI

Province of Ontario (Ilie et al. 2015a,b,c)
Lifetime history of TBI with ≥ 5 minutes loss of consciousness or hospital stay
- More likely to smoke cigarettes (AOR=2.15) use cannabis (AOR=2.80) and use nonprescription opioids (AOR=2.90)
- More likely to be experiencing psychological distress (AOR=1.97)
- More likely to screen + for ADHD (AOR=2.49) or have been diagnosed with ADHD (AOR=2.64)
- More likely to have had a motor vehicle crash with injuries (AOR=1.79)
- More likely to have engaged in serious driver aggression during past 12 months (AOR=4.39)
*Adjusted for sex, age and education

Colorado: 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)
Health-related Behaviors Associated with a History of TBI

<table>
<thead>
<tr>
<th>Study</th>
<th>Method</th>
<th>Health-related Behavioral Consequences</th>
</tr>
</thead>
<tbody>
<tr>
<td>Colorado, USA</td>
<td>Population Survey</td>
<td>poor physical health, headaches, fatigue, balance problems, poor vision, concentration problems, sensitivity to noise/light</td>
</tr>
<tr>
<td>Ontario, Canada</td>
<td>Population Survey</td>
<td>smoking, diagnosed with ADHD, involved in a motor vehicle crash</td>
</tr>
<tr>
<td>Ohio, USA</td>
<td>Population Survey</td>
<td>overall health, days of pain, current smoker, times injured in fall last year, ever diagnosed with a chronic disease, worried about money for food &amp; housing</td>
</tr>
<tr>
<td>Christchurch, NZ</td>
<td>Birth cohort (at age 25)</td>
<td></td>
</tr>
<tr>
<td>Northern Finland</td>
<td>Birth cohort (at age 33)</td>
<td></td>
</tr>
<tr>
<td>Sweden</td>
<td>Population registry (to age 36)</td>
<td>premature mortality</td>
</tr>
</tbody>
</table>

Psychiatric Problems Associated with a History of TBI

<table>
<thead>
<tr>
<th>Study</th>
<th>Method</th>
<th>Psychiatric Consequences</th>
</tr>
</thead>
<tbody>
<tr>
<td>Colorado, USA</td>
<td>Population Survey</td>
<td>experiencing distress, uses marijuana, uses non-prescription opiods</td>
</tr>
<tr>
<td>Ontario, Canada</td>
<td>Population Survey</td>
<td>overall mental health, lifetime depression, days last 30 tense or anxious, days last 30 sad or depressed, binge drinking, heavy drinking</td>
</tr>
<tr>
<td>Ohio, USA</td>
<td>Population Survey</td>
<td>alcohol or drug dependence</td>
</tr>
<tr>
<td>Christchurch, NZ</td>
<td>Birth cohort (at age 25)</td>
<td>psychiatric hospitalization</td>
</tr>
<tr>
<td>Northern Finland</td>
<td>Birth cohort (at age 33)</td>
<td>outpatients psychiatric treatment, suicide</td>
</tr>
<tr>
<td>Sweden</td>
<td>Population registry (to age 36)</td>
<td>psychiatric hospitalization, outpatient psychiatric treatment, suicide</td>
</tr>
</tbody>
</table>
### Criminality & Aggression Associated with a History of TBI

<table>
<thead>
<tr>
<th>Study</th>
<th>Method</th>
<th>Disability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Colorado, USA</td>
<td>Population Survey</td>
<td></td>
</tr>
<tr>
<td>Ontario, Canada</td>
<td>Population Survey</td>
<td>aggressive driving past 12 months</td>
</tr>
<tr>
<td>Ohio, USA</td>
<td>Population Survey</td>
<td></td>
</tr>
<tr>
<td>Christchurch, NZ</td>
<td>Birth cohort (at age 25)</td>
<td>any arrest, arrest for violent crime</td>
</tr>
<tr>
<td>Northern Finland</td>
<td>Birth cohort (at age 33)</td>
<td></td>
</tr>
<tr>
<td>Sweden</td>
<td>Population registry (to age 36)</td>
<td>conviction for violent criminal offense</td>
</tr>
</tbody>
</table>

### Disability Associated with a History of TBI

<table>
<thead>
<tr>
<th>Study</th>
<th>Method</th>
<th>Disability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Colorado, USA</td>
<td>Population Survey</td>
<td>work limitation, disability status</td>
</tr>
<tr>
<td>Ontario, Canada</td>
<td>Population Survey</td>
<td></td>
</tr>
<tr>
<td>Ohio, USA</td>
<td>Population Survey</td>
<td>vision, mobility, self-care, cognition, community independence</td>
</tr>
<tr>
<td>Christchurch, NZ</td>
<td>Birth cohort (at age 25)</td>
<td></td>
</tr>
<tr>
<td>Northern Finland</td>
<td>Birth cohort (at age 33)</td>
<td></td>
</tr>
<tr>
<td>Sweden</td>
<td>Population registry (to age 36)</td>
<td>disability pension</td>
</tr>
</tbody>
</table>

### Ohio BRFSS Methodology

- State optional module included in 2014 Behavioral Risk Factor Surveillance System (BRFSS)
- BRFSS does random digit dialing of landlines and cell phones
- Administered to 6,998 adult (≥ 18 years old), non-institutionalized Ohioans
- Used adapted OSU TBI Identification Method
- TBIs without loss of consciousness were not detected
Adjusted Odds* of Unemployment by Severity of Worst Lifetime TBI

Adjusted Odds* of Income by Severity of Worst Lifetime TBI

Adjusted Odds* for Educational Attainment by Severity of Worst Lifetime TBI

*Compared to Ohioans with no TBI with loss of consciousness, adjusted for age, gender and race/ethnicity
John D. Corrigan, PhD
Ohio State University

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Adjusted Odds* of Unhealthy Conditions 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
**4th quartile vs 1st + 2nd quartile

---

Adjusted Odds* of Unhealthy Conditions 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
**4th quartile vs 1st + 2nd quartile

---

Adjusted Odds* of Unhealthy Conditions 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
**4th quartile compared to 1st quartile
Adjusted Odds* for Financial Worries** 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
**Always vs. never worries about enough money

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

Swedish Population Registry

- 1.1 million Swedish citizens born between 1973 and 1985 and followed to 2013
- 9.1% had a medically treated TBI by age 25
- Compared outcomes to general population, siblings without TBI and persons with orthopedic injuries
- Looked at likelihood of the following outcomes:
  - psychiatric treatment
  - disability from work
  - psychiatric hospitalization
  - receiving welfare benefits
  - premature mortality
  - low educational attainment

John D. Corrigan, PhD
Ohio State University
### Adjusted Odds of Negative Consequences Compared to Uninjured Siblings

<table>
<thead>
<tr>
<th></th>
<th>Any TBI</th>
<th>Mild TBI</th>
<th>Mod/Sev TBI</th>
<th>Recurrent TBI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Disability pension</td>
<td>1.49</td>
<td>1.36</td>
<td>2.06</td>
<td>2.22</td>
</tr>
<tr>
<td>Psychiatric visit</td>
<td>1.31</td>
<td>1.31</td>
<td>1.34</td>
<td>1.24</td>
</tr>
<tr>
<td>Psychiatric hospitalization</td>
<td>1.57</td>
<td>1.51</td>
<td>1.75</td>
<td>1.53</td>
</tr>
<tr>
<td>Premature mortality</td>
<td>1.40</td>
<td>1.26</td>
<td>1.92</td>
<td>1.59</td>
</tr>
<tr>
<td>Low education</td>
<td>1.28</td>
<td>1.25</td>
<td>1.37</td>
<td>1.28</td>
</tr>
<tr>
<td>Welfare recipiency</td>
<td>1.19</td>
<td>1.18</td>
<td>1.21</td>
<td>1.13</td>
</tr>
</tbody>
</table>

### Adjusted Odds of Negative Consequences Compared to Uninjured Siblings x Age at 1st Injury

#### Ages 0-4

<table>
<thead>
<tr>
<th></th>
<th>Ages 0-4</th>
<th>Ages 5-9</th>
<th>Ages 10-14</th>
<th>Ages 15-19</th>
<th>Ages 20-24</th>
</tr>
</thead>
<tbody>
<tr>
<td>Disability pension</td>
<td>1.04</td>
<td>1.29</td>
<td>1.28</td>
<td>1.49</td>
<td>1.73</td>
</tr>
<tr>
<td>Psychiatric visit</td>
<td>1.02</td>
<td>1.11</td>
<td>1.28</td>
<td>1.24</td>
<td>1.53</td>
</tr>
<tr>
<td>Psychiatric hospitalization</td>
<td>1.00</td>
<td>1.07</td>
<td>1.42</td>
<td>1.62</td>
<td>1.92</td>
</tr>
<tr>
<td>Premature mortality</td>
<td>1.28</td>
<td>1.34</td>
<td>1.26</td>
<td>1.24</td>
<td>1.59</td>
</tr>
<tr>
<td>Low education</td>
<td>1.00</td>
<td>1.10</td>
<td>1.22</td>
<td>1.41</td>
<td>1.34</td>
</tr>
<tr>
<td>Welfare recipiency</td>
<td>1.03</td>
<td>1.07</td>
<td>1.19</td>
<td>1.20</td>
<td>1.24</td>
</tr>
</tbody>
</table>
### Adjusted Odds of Negative Consequences Compared to Uninjured Siblings x Age at 1st Mild TBI

<table>
<thead>
<tr>
<th></th>
<th>Ages 0-4</th>
<th>Ages 5-9</th>
<th>Ages 10-14</th>
<th>Ages 15-19</th>
<th>Ages 20-24</th>
</tr>
</thead>
<tbody>
<tr>
<td>Disability pension</td>
<td>1.01</td>
<td>1.21</td>
<td>1.17</td>
<td>1.28</td>
<td>1.79</td>
</tr>
<tr>
<td>Psychiatric visit</td>
<td>1.02</td>
<td>1.10</td>
<td>1.27</td>
<td>1.27</td>
<td>1.67</td>
</tr>
<tr>
<td>Psychiatric hospitalization</td>
<td>1.01</td>
<td>1.07</td>
<td>1.40</td>
<td>1.66</td>
<td>1.98</td>
</tr>
<tr>
<td>Premature mortality</td>
<td>1.08</td>
<td>1.01</td>
<td>1.16</td>
<td>1.03</td>
<td>1.14</td>
</tr>
<tr>
<td>Low education</td>
<td>0.97</td>
<td>1.10</td>
<td>1.21</td>
<td>1.40</td>
<td>1.36</td>
</tr>
<tr>
<td>Welfare recipiency</td>
<td>1.03</td>
<td>1.07</td>
<td>1.18</td>
<td>1.21</td>
<td>1.26</td>
</tr>
</tbody>
</table>

### Summary
- Significant associations between lifetime history of TBI and health and social consequences supports an “exposure” approach to examining the public health burden of TBI.
- There is much to learn about the “dose/effect” relationship.
- Research on how to measure exposure will be needed.
- BRFSS data will contribute to a body of research that will advance our knowledge of TBI exposure.
- Using state optional modules in the BRFSS may be an avenue to both useful information for state planning and advocacy.

### Adults in Ohio
- 1.6 million Ohio adults have had at least 1 TBI with loss of consciousness (LOC)
- 230,000 at least 1 moderate or severe TBI
- 600,000 at least 1 TBI with LOC before the age of 15
- ¾ million Ohioans are at risk for health and behavior problems due to the effects of prior TBI
- TBI with LOC more than doubles the risk of disability
- ¼ of Ohioans with disability have had a TBI with LOC