Building the tools for estimating the global burden of injuries

Kavi Bhalla
Harvard Initiative for Global Health

This work is supported by a grant from the World Bank Global Road Safety Facility
Summary: Estimating road traffic injuries in developing countries

Key Ideas:

- Make the most of existing sources of information

- Boldly make estimates in the face of poor quality data
Talk Outline

1. Building **country estimates** of the burden of injuries from road traffic crashes
   - Estimates for 2 developing countries: Iran, Mexico
   - Example of the technical challenges
     - Estimating the external causes of injuries from the injuries recorded in hospital databases

2. Building **global estimates** of the burden of injuries
   - Data sources in all countries
   - Global Burden of Disease Injuries Expert Group
Country estimates of road traffic injuries in developing countries
Harvard-WB* RTI metrics project

A standardized cross-national database for road traffic injuries and covariates

Country Data
- Road Traffic Injury Data
  - police, hospitals, crematoriums, surveys, …
- Covariates of Road Traffic Injuries
  - transport variables, mortality variables, policies, …

Data Translation Algorithms
- Adjustment for different sources
- Scale up: local ➔ national
- Fatalities ↔ Non fatal injuries
- Breakdown by age, gender, victim-type, etc.

Extrapolation Models
- Estimate RTI based on vehicles, roads, pop density, urbanization, regional fatality rates

Burden of Injury Calculations
- YLL, YLD ➔ Disability Adjusted Life Years lost

Road Traffic Injury Database
- Country level estimates: deaths, injuries, victim type, age, gender, threat type, burden of injuries

*World Bank Global Road Safety Facility
<table>
<thead>
<tr>
<th>M. East &amp; N. Africa</th>
<th>Sub Saharan Africa</th>
</tr>
</thead>
<tbody>
<tr>
<td>Iran (done)</td>
<td>Kenya</td>
</tr>
<tr>
<td>Egypt</td>
<td>Ghana</td>
</tr>
<tr>
<td><strong>Latin America</strong></td>
<td>Mozambique</td>
</tr>
<tr>
<td>Mexico (done)</td>
<td><strong>East Asia &amp; Pacific</strong></td>
</tr>
<tr>
<td>Argentina</td>
<td>China</td>
</tr>
<tr>
<td>Colombia (done)</td>
<td>Thailand</td>
</tr>
<tr>
<td><strong>South Asia</strong></td>
<td>Vietnam</td>
</tr>
<tr>
<td>India</td>
<td><strong>Europe &amp; C. Asia</strong></td>
</tr>
<tr>
<td>Sri Lanka</td>
<td>Poland</td>
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<tr>
<td><strong>High Income</strong></td>
<td>Armenia</td>
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<tr>
<td>Greece</td>
<td>Russian Federation</td>
</tr>
<tr>
<td>USA</td>
<td></td>
</tr>
</tbody>
</table>
Road traffic injuries in Iran
Iran – building a national snapshot

DEATHS

Death Registration System
Remaining 29 provinces
Forensic medicine
Tehran
Iran – building a national snapshot

“Extrapolate” : apply age-sex-victim type incidence rates to entire population
Iran – building a national snapshot

**DEATHS**
- Death Registration System
- Remaining 29 provinces
- Forensic medicine
- Tehran

**HOSPITAL ADMISSIONS**
- Hospital Registry
- 12 provinces, 4 weeks ➔ Extrapolate

**EMERGENCY ROOM VISITS**
- Hospital Registry
- 12 provinces, 4 days ➔ Extrapolate

“Extrapolate”: apply age-sex-victim type incidence rates to entire population
Iran – building a national snapshot

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  - Death Registration System
  - Remaining 29 provinces
  - Forensic medicine, Tehran

- **HOSPITAL ADMISSIONS**
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  - 12 provinces, 4 weeks → Extrapolate

- **EMERGENCY ROOM VISITS**
  - Hospital Registry
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- **HOME CARE**
  - Demographic & Health Survey

“Extrapolate”: apply age-sex-victim type incidence rates to entire population
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**Deaths**
- Death Registration System
- Remaining 29 provinces
- Forensic medicine
  - Tehran

**Hospital Admissions**
- Hospital Registry
- 12 provinces, 4 weeks ➔ Extrapolate

**Emergency Room Visits**
- Hospital Registry
- 12 provinces, 4 days ➔ Extrapolate

**Home Care**
- Demographic & Health Survey

**Broken down by**
- age and sex groups
- urban/rural
- institutional care received
- injury severity
- victim mode (pedestrian, motorcycle, car occup, etc)
- impacting vehicle
- injuries (head, limb, etc)
- time of day
- type of road
Results

- Iran
- USA
- UK
- Canada
- Australia
- New Zealand
- Germany
- World
- High income
- High income & Pacific
- Europe & C. Asia
- Latin Am. & Carib.
- M.East & N.Africa
- S. Asia
- Sub-Sahfrica

RTI death rate, per 100000

World regions

High income countries
## Iran: RTI deaths vs other causes

<table>
<thead>
<tr>
<th>Rank</th>
<th>Cause of Death</th>
<th># of deaths</th>
<th>% total deaths</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Myocardial infarction</td>
<td>68892</td>
<td>23%</td>
</tr>
<tr>
<td>2</td>
<td>Cerebral vascular diseases</td>
<td>33922</td>
<td>11.3%</td>
</tr>
<tr>
<td>3</td>
<td>Road traffic injuries</td>
<td>30721</td>
<td>10.3%</td>
</tr>
<tr>
<td>4</td>
<td>Other cardiac diseases</td>
<td>11459</td>
<td>3.8%</td>
</tr>
<tr>
<td>5</td>
<td>Stomach cancer</td>
<td>7799</td>
<td>2.6%</td>
</tr>
<tr>
<td>6</td>
<td>Chronic lung &amp; bronchus disease</td>
<td>5297</td>
<td>1.8%</td>
</tr>
<tr>
<td>7</td>
<td>Cancer of trachea,bronchus &amp; lung</td>
<td>4596</td>
<td>1.5%</td>
</tr>
<tr>
<td>8</td>
<td>Disorders related to short gestation &amp; low birth weight</td>
<td>4443</td>
<td>1.5%</td>
</tr>
<tr>
<td>9</td>
<td>Pneumonia</td>
<td>4413</td>
<td>1.5%</td>
</tr>
<tr>
<td>10</td>
<td>Intentional self- harm</td>
<td>4344</td>
<td>1.5%</td>
</tr>
</tbody>
</table>
RTI deaths: Police vs death registration

- Our estimates: national RTI deaths in Iran
- Our estimates: on-scene national RTI deaths
- Police: on-scene deaths

Police reported

Our estimate (based on VR)
Iran: victim mode of transport

Deaths

- Pedestrian: 29%
- Car: 37%
- Motorized Two Wheeler: 15%
- Bus: 2%
- Truck: 4%
- Other: 13%
Iran: victim mode of transport

**Deaths**
- Pedestrian: 29%
- Motorized Two Wheeler: 15%
- Car: 37%
- Truck: 4%
- Bus: 2%
- Other: 13%

**Hospital admissions**
- Pedestrian: 20%
- Motorized Two Wheeler: 54%
- Car: 21%
- Truck: 1%
- Bus: 2%
- Other: 2%
- Motorized Two Wheeler: 54%
Road traffic injuries in Mexico
Mexico – building a national snapshot

- **DEATHS**
- **HOSPITAL ADMISSIONS**
- **EMERGENCY ROOM VISITS**
- **HOME CARE**

**Envelopes from surveys:**
- Further breakdown
- Using hospital registry (selected provinces)
- Using Ministry of Health and IMSS Hospitals*

**Broken down by:**
- age and sex groups
- urban/rural
- institutional care received
- injury severity
- victim mode (pedestrian, motorcycle, car occup, etc)
- impacting vehicle
- injuries (head, limb, etc)
- time of day
- type of road

*IMSS does not report external causes*
Estimating external causes from injuries

Problem:
• Hospitals record injuries
  (skull fx, ACL tear)
• But policy makers want external causes
  (Road traffic injuries, fall, drownings)

Solution:
• Estimate external causes from injuries
What we want ...

INPUT

Victim

AGE: 29 years
SEX: Male
STATE: Oaxaca
TIME: 1645 hrs
...

INJURIES:
MCL rupture
tibia fx
skull fx

Computer Algorithm

OUTPUT

Fall
Firearm
Drowning
Poisoning
Fire
Road traffic crash
Pedestrian
Bicyclist
Motorcyclist
Car occup.
Bayesian Inference

- Bayes theorem: updates prior knowledge (probability) using new knowledge

- For e.g.
  - Prior knowledge:
    - 10% of hospital admissions are from RTI
    - 80% of RTI victims have femur fractures
    - 20% of hospital admissions have femur fractures
  - New information: victim has a femur fracture
  - Bayes: $p(\text{victim was an RTI}) = \frac{80 \times 10}{20} = 40\%$

$$p(\text{external.cause}_i | \text{injury}_j) = \frac{p(\text{injury}_j | \text{external.cause}_i) p(\text{external.cause}_i)}{p(\text{injury}_j)}$$
Implementing with Hospital Data

• Mexico MOH hospital dataset (injury cases)
  – Contains both injuries and external causes
  – Divide into two equal parts:
    1. Training dataset (~ 50,000 cases)
    2. Test dataset (remaining ~ 50,000 cases)
  – Use Training dataset to derive prior probabilities
    • Computed as a function of age and sex of victim
  – Predict external causes in Test dataset
  – Compare prediction with known answer
Validation Results:
fraction of poisonings assigned correctly

- Pedestrian
- Bike
- TwoWheeler
- Car
- ThreeWheeler
- Bus
- Truck
- Van
- AnimalRider
- Transport-non-RTI
- Drownings
- Falls
- Fires
- Firearm
- Poisons venoms bites
- Other unintentional

Fraction of true poisonings in Test data:
- Bayes
- Proportional (age, sex)
Validation Results:
fraction of drownings assigned correctly

<table>
<thead>
<tr>
<th>Category</th>
<th>Fraction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pedestrian</td>
<td>0.00</td>
</tr>
<tr>
<td>Bike</td>
<td>0.00</td>
</tr>
<tr>
<td>TwoWheeler</td>
<td>0.00</td>
</tr>
<tr>
<td>Car</td>
<td>0.00</td>
</tr>
<tr>
<td>ThreeWheeler</td>
<td>0.00</td>
</tr>
<tr>
<td>Bus</td>
<td>0.00</td>
</tr>
<tr>
<td>Truck</td>
<td>0.00</td>
</tr>
<tr>
<td>Van</td>
<td>0.00</td>
</tr>
<tr>
<td>AnimalRider</td>
<td>0.00</td>
</tr>
<tr>
<td>Transport-non-RTI</td>
<td>0.00</td>
</tr>
<tr>
<td>Drownings</td>
<td>0.00</td>
</tr>
<tr>
<td>Falls</td>
<td>0.00</td>
</tr>
<tr>
<td>Fires</td>
<td>0.00</td>
</tr>
<tr>
<td>Firearm</td>
<td>0.00</td>
</tr>
<tr>
<td>Poisons venoms bites</td>
<td>0.00</td>
</tr>
<tr>
<td>Other unintentional</td>
<td>0.00</td>
</tr>
</tbody>
</table>

Bayes
Proportional (age,sex)
Validation Results:
fraction of falls assigned correctly
Validation Results:
fractio of car occup. assigned correctly

Fraction of true car occupant in Test dat:

- Bayes
- Proportional (age,sex)
### Rankings by frequency of occurrence

<table>
<thead>
<tr>
<th>ICD code</th>
<th>Nature of Injuries</th>
<th>Falls</th>
<th>RTI-Pedestrian</th>
<th>RTI-Car</th>
</tr>
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<tbody>
<tr>
<td>S069</td>
<td>Intracranial injury, unspecified</td>
<td>1</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>S828</td>
<td>Fractures of other parts of lower leg</td>
<td>2</td>
<td>6</td>
<td>11</td>
</tr>
<tr>
<td>S822</td>
<td>Fracture of shaft of tibia</td>
<td>3</td>
<td>2</td>
<td>5</td>
</tr>
<tr>
<td>S729</td>
<td>Fracture of femur, part unspecified</td>
<td>4</td>
<td>5</td>
<td>4</td>
</tr>
<tr>
<td>S720</td>
<td>Fracture of Neck of femur</td>
<td>5</td>
<td>13</td>
<td>17</td>
</tr>
<tr>
<td>S527</td>
<td>Multiple fractures of forearm</td>
<td>6</td>
<td>&gt;50</td>
<td>20</td>
</tr>
<tr>
<td>S424</td>
<td>Fracture of lower end of humerus</td>
<td>7</td>
<td>&gt;50</td>
<td>41</td>
</tr>
<tr>
<td>S423</td>
<td>Fracture of shaft of humerus</td>
<td>8</td>
<td>7</td>
<td>8</td>
</tr>
<tr>
<td>S528</td>
<td>Fracture of other parts of forearm</td>
<td>9</td>
<td>32</td>
<td>31</td>
</tr>
<tr>
<td>S525</td>
<td>Fracture of lower end of radius</td>
<td>10</td>
<td>50</td>
<td>43</td>
</tr>
</tbody>
</table>
Conclusions about Bayesian Inference

• Bayesian inference allows a rapid estimate of the distribution of external causes in large hospital datasets

• Performance
  – Works well for causes with clearly defined injuries
  – Not so well when underlying injuries are similar

• We need to make the best use of existing data sources rather than wait for quality to improve
Mexico – building a national snapshot

**DEATHS**
- death registration

**HOSPITAL ADMISSIONS**
- Envelope from survey: further breakdown
- Using hospital registry (selected provinces)

**EMERGENCY ROOM VISITS**
- Envelope from survey: further breakdown
- Using Ministry of Health and IMSS Hospitals*

**HOME CARE**
- Surveys: World Health Survey, ENSANUT

* IMSS does not report external causes

Broken down by
- age and sex groups
- urban/rural
- institutional care received
- injury severity
- victim mode (pedestrian, motorcycle, car occup, etc)
- impacting vehicle
- injuries (head, limb, etc)
- time of day
- type of road
Mexico RTI death rates

High income countries

World Regions

RTI death rate, per 100000

Mexico, Iran, USA, UK, Canada, Australia, New Zealand, Germany, World, High income, E. Asia & Pacific, Europe & C. Asia, Latin Am. & Carib., M. East & N. Africa, S. Asia, Sub-Sah Africa
Iran and Mexico: RTI death rates by age

- **Mexico**
- **Iran**

<table>
<thead>
<tr>
<th>Age category</th>
<th>RTI death rate, per 100000</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 1</td>
<td></td>
</tr>
<tr>
<td>1-4</td>
<td></td>
</tr>
<tr>
<td>5-14</td>
<td></td>
</tr>
<tr>
<td>15-24</td>
<td></td>
</tr>
<tr>
<td>25-34</td>
<td></td>
</tr>
<tr>
<td>35-44</td>
<td></td>
</tr>
<tr>
<td>45-54</td>
<td></td>
</tr>
<tr>
<td>55-64</td>
<td></td>
</tr>
<tr>
<td>65-74</td>
<td></td>
</tr>
<tr>
<td>75-84</td>
<td></td>
</tr>
<tr>
<td>85+</td>
<td></td>
</tr>
</tbody>
</table>
Country assessment of road traffic injuries in Ghana
Data Sources Inventory

- World Health Survey
- Household RTI Survey (Kumasi and Brong-Ahafo)
- Hospital based death registration data
- Police and road traffic injury surveillance data
- Mortuary data
- Hospital based morbidity study
- DSS INDEPTH Sites - verbal autopsy of cause of death
Summary: Estimating road traffic injuries in developing countries

Key Ideas:

– Make the most of existing sources of information

– Boldly make estimates in the face of poor quality data
Estimating the Global Burden of Injuries
Welcome to the website of the Global Burden of Disease - Injury expert group

This site functions as a repository of the products of this group. Many of these products are works-in-progress. Each ongoing/complete group product is listed as a "Discussion topic". These are typically authored by one or more core members of the expert group, who periodically poll the entire expert group for feedback. The discussion topics usually evolve via email exchanges and are only periodically updated on this website. Please assume that the discussion listed here is at least a little out of date. If you are interested in a discussion topic, please contact its lead author to find out about current status.

About the project

What is GBD
What is the GBD Injury expert group
Who are the members of this expert group
How can you participate
What else have we been doing (group meetings and other activities)

Discussion topics

Current list of discussion topics

Active discussion topics

- Discussion 12 - External cause list
- Discussion 3 - Injury sequelae definitions
- Discussion 2 - Data hunt
- Discussion 13 - Disability prevalence
- Discussion 7 - Dealing with unspecified external cause categories
  - Discussion 7a - Use of dump codes in the WHO mortality database
  - Discussion 7b - Comparing dump codes in ICD-9 and ICD-10
GBD-Injury Expert Group: Discussion Topics

**Topic 1: Case definition**
John Langley, Ronan Lyons, Limor Aharonson-Daniel, Tim Driscoll, Caroline Finch

**Topic 3: Categories and definitions for GBD injury 'sequelae'**
James Harrison, Wendy Watson, Maria Segui-Gomez, Jed Blore, Belinda Gabbe, Fred Rivara, Saeid Shahraz, Phil Edwards, Pablo Perel

**Topic 4: Dimensions of functioning relevant to injury**
Wendy Watson, Maria Segui-Gomez, Ronan Lyons, Sarah Derrett

**Topic 5: Dealing with multiple injuries**
Belinda Gabbe, Limor Aharonson-Daniel, Mohsen Naghavi, Theo Vos, Phil Edwards, Pablo Perel, Margaret Warner

**Topic 6: Implications for measurement of injury burden of method chosen to generate weights**
Ronan Lyons, Rebecca Spicer, Juanita Haagsma, Ed Van Beeck, Steven Macey
GBD-Injury Expert Group: Discussion Topics (contd)

Topic 7: Dealing with unspecified categories in case data sets
Kavi Bhalla, James Harrison, Lois Fingerhut, Margaret Warner, M. Naghavi

Topic 9: Recurrent injury
Caroline Finch, Ronan Lyons, Soufiane Boufous

Topic 10: Assumption that burden of a condition is independent of the mechanism that produced it
Maria Segui-Gomez, Belinda Gabbe, Limor Aharanson-Daniel

Topic 11: Mortality data
Lois Fingerhut, Kavi Bhalla, Mohsen Naghavi, Tim Driscoll

Topic 12: GBD External Cause List and Associated ICD Code Groups
James Harrison, Kavi Bhalla, Caroline Finch
Topic 13: Disability prevalence
Wendy Watson, Sarah Derrett

Topic 15: Making optimal use of police reported statistics
David Bartels, Kavi Bhalla

Topic 16: Sports injuries - are we ignoring a significant public health opportunity
Caroline Finch
GBD INJURY EXPERT GROUP

**Real World Data**
- High Income Countries
  - ????
- Low Income Countries
  - Environmental scan
  - Data Access

**Theoretical Input**
- List of Discussion Papers
  - Case Definition
  - GBD “Sequelae”
  - Multiple Injuries
  - Empirical Disability wts
  - Handling unspecified injuries
  - Recurrent injuries
  - ...
  - ...

**Data Analysis**

**Numbers**

**GBD ENGINE**

**Estimates**

**Sensible health priorities**
GBD-Injury Data Sources

Environmental scan of availability of:
• Death registries
• Hospital registries and
• Health surveys (with injury questions)

This ongoing environmental scan is publicly available on our expert group website
Environmental Scan

Availability of death registration data
Environmental Scan

Availability of hospital data
Environmental Scan

Availability of health surveys with injury ques.
There is no data shortage. There is a shortage of analysts!
Summary: Estimating road traffic injuries in developing countries

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– Make the most of existing sources of information

– Boldly make estimates in the face of poor quality data
Thanks!

Email: kavi_bhalla@harvard.edu

Website: http://www.globalhealth.harvard.edu
(click on Research => Road Traffic Injuries)

This work is supported by a grant from the World Bank Global Road Safety Facility
GBD-Injury Data Sources

Environmental scan of availability of:
• Death registries
• Hospital registries and
• Health surveys (with injury questions)
What Data Sources

1. Mortality
   1. Gold Standard: High Quality death registration data
   2. Alternate sources: police, mortuary, ?

2. Non-fatal Injuries:
   1. Health Surveys with injury questions
   2. Hospital and ER records

What Types of Data

1. Variables: Age, sex, external causes, nature of injuries
2. Degree of Aggregation:
   1. Unit record data (very nice but not essential)
   2. Tabulations in GBD injury and “sequelae” groups using our scripts (excellent)
   3. Detailed tabulations using other groupings (very good)
   4. Report or paper with summary tabulations (ok – better than nothing)
Maximizing Data Access (from low income countries)

1. Conduct Environmental Scan
   1. Scan published literature (ongoing)
   2. Google searches (ongoing)
   3. Ask expert group (ongoing)

2. Requesting Data Access
   1. Personal contacts
   2. Call for contributions in journal (ongoing)
   3. Circulate requests via World Bank, WHO field offices (not yet done)
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  - Discussion 7a - [Use of dump codes in the WHO mortality database](#)
  - Discussion 7h - [Comparing dump codes in ICD 9 and ICD 10](#)
Making optimal use of available data to fill in the information gaps

- Population based health surveys
- Administrative records from medical institutions
- Death registers