Factors driving intersection pedestrian crash risk in concentrated urban environments

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Aim

What factors are associated with pedestrian crash risk at intersections in concentrated urban environments?
Road Trauma Chain

ENTITIES
- Humans
- Vehicles
- Roads

ELIGIBILITY
- Licensed
- Registered
- Roads opened

ROAD USE
- Crossing
- Travel
- Distance
- Time

ENERGY
- Speed
- Mass

CRASH
- Hazards
- System failure
- Human error

PEDESTRIAN CRASH RISK
ROAD USE EXPOSURE
Haddon Matrix

- **Pre-Crash**
  - Human (Road User)
  - Physical Environment
  - Vehicle

- **Crash**
  - Human (Road User)
  - Physical Environment
  - Vehicle

- **Post-Crash**
  - Human (Road User)
  - Physical Environment
  - Vehicle
Hierarchy of pedestrian data needs

Human
  - Behaviour
  - Socioeconomy
  - Demography
  - Fleet composition

Vehicle
  - Technology
  - Crash avoidance
  - Speed adaptation
  - Pedestrian detection

Physical Environment
  - Urban planning
  - Land use
  - Transport system
  - Environment
  - Built roadway
  - Public transport
  - Road hierarchy
  - Traffic management
  - Clutter
  - AADT
  - Travel speed

Exposure
  - Micro
  - Macro
  - Road crossing
  - Vehicle volume

Lawfulness
  - Lawfulness
  - Cognitive capabilities
  - Employment
  - Income
  - Education

Speeding
  - Speeding
  - Jaywalking
### Pedestrian Data Needs Matrix

<table>
<thead>
<tr>
<th>Pedestrian Data Needs Matrix</th>
<th>Human</th>
<th>Vehicle &amp; Equipment</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Behaviour, e.g. Illegal Behaviours</td>
<td>Vehicle Fleet Composition</td>
</tr>
<tr>
<td></td>
<td>Cognitive and Physical Capabilities</td>
<td>Vehicle design and technologies</td>
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<tr>
<td></td>
<td>Safety Awareness</td>
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<td></td>
<td>Population (Numbers, Density, Mix)</td>
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<tr>
<td></td>
<td>Employment and Income Level</td>
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<td></td>
<td>Education &amp; Ethnicity</td>
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<tr>
<td>Physical Environment</td>
<td>Urban Planning</td>
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<tr>
<td></td>
<td>Neighbourhood Type</td>
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<td></td>
<td>Specific Designs for Vulnerable Road Users</td>
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<tr>
<td></td>
<td>Motorisation Level</td>
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<tr>
<td>Land use</td>
<td>Space and Capacity of Land Uses</td>
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<tr>
<td></td>
<td>Land Use Mix</td>
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<td>Transport System</td>
<td>Built Roadway</td>
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<td></td>
<td>Road Hierarchy</td>
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<td></td>
<td>Road Geometry (Intersection, Roundabout)</td>
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<tr>
<td></td>
<td>Geometric Design Variables</td>
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<td>Posted &amp; Travelling Speed</td>
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<td></td>
<td>Measures of Clutter</td>
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<tr>
<td>Public Transport</td>
<td>Public transport supply (stops, routes)</td>
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<td>Facilities characteristics</td>
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<tr>
<td>Environment</td>
<td>Light Conditions</td>
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<td>Atmospheric Conditions</td>
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<tr>
<td>Exposure</td>
<td>Micro</td>
<td></td>
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<tr>
<td></td>
<td>Volume</td>
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<tr>
<td></td>
<td>Duration and Distance of Road Use</td>
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<tr>
<td></td>
<td>Macro</td>
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<td></td>
<td>Trips (Duration and Distance)</td>
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<td></td>
<td>Population-based Measures</td>
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</tbody>
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Rationale

Physical Environment
- Land use mix (Alcohol, Crossroads of shopping strips, Official, Recreational, Residential)
- Specific road designs

Transport System
- Transport modes (bicycle/motorcycle, tram, heavy vehicles, horse-drawn carriage)
- Speed

1. Pedestrian hub
2. Walking promotion
   - Ped crash clusters
   - Over-represented road user

Road User
- Over-representation of young and male
- Tourists
- Walking under influence
- Distraction
Case study

Central Business District (CBD) of Melbourne
Dependent variable
1  CBD intersection crashes (2000-2009)
2  Weekday crashes
3  Daytime (07-18)
4  Hours of darkness (19-06)
Exposure

\[ P \times V \]

\[ (P \times V)^{0.5} \]

15 m
Explanatory Variables

- Vehicle (% heavy vehicles)
- Land use
- Public transport
- Built roadway
- Human (Socio-demography)
- Spatial
Spatial data

Distance walked for different purposes
Victorian Integrated Survey of Travel and Activity (VISTA)
Land use

- Office
- Entertainment/recreation (indoor/outdoor)
- House, institutional accommodation, residential apartment, student apartment
- All retails

Floor space area

Capacity

- Amusement and gaming centre
- Bar, tavern, pub, night club
- Cinema, theatre, concert hall, stadium
- Commercial accommodation, hostel, backpacker
- House, townhouse, residential apartment, serviced apartment, student apartment
- Café, restaurant, bistro, food court
Public transport

- Bus/Tram
  - Stops
  - Routes
  - Stops × Routes

- Train
  - Distance form the nearest railway station

Sociodemography

- Number of employed people
- Population
Built roadway

Geometric design
- Lanes (major/minor)
- Left/Right turn lanes
- Grade
- Divided/undivided
- Tram tracks

Road hierarchy
- Major/Minor
- Intersection
- Number of ways

Traffic management
- Clearance distance of on-street car parks
- Exclusive bus/bicycle lanes
- Hook-turn possibility
- Posted speed (major road)

Clutter
- Number of street signs
- Legs fronted with shops
Method

1. Standard Poisson/Negative Binomial
2. Entering exposure (rate; fixed; normal)
3. Forward stepwise (Likelihood ratio)
4. Zero-inflation (ZIP; ZINB; Vuong’s test)
5. Akaike Information Criterion (AIC)
6. Spatial autocorrelation

CBD: Moran’s I; Semiovariogram
Corridor: Generalised Estimating Equations (GEE)
Results
<table>
<thead>
<tr>
<th>Vehicle</th>
<th>Land Use</th>
<th>Built Roadway</th>
<th>Public Transport</th>
<th>Socio-demography</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1. Restaurant, café, bar, pub, club (FS - 800m)</td>
<td>1. Minor intersections</td>
<td>1. Bus routes (500m)</td>
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</tr>
<tr>
<td></td>
<td>2. Accommodation (C - 150m)</td>
<td>2. Non-divided</td>
<td>2. Distance from the nearest main railway station (Closer INTs)</td>
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<tr>
<td></td>
<td>3. Cinema, theatre, concert hall (C - 300m)</td>
<td>3. Hook-turn possibility</td>
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<td></td>
<td>4. Amusement and gaming areas (C - 900m)</td>
<td>4. More legs fronted with shops</td>
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<tr>
<td></td>
<td>5. More left-turn movements (%)</td>
<td>5. More left-turn movements (%)</td>
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</tbody>
</table>
Key messages

1. Temporal and spatial variety of risk
2. Blanket interventions and Safe System
3. Interventions: concentrated vs area-wide
4. Risk factor types: immediate/future developments planning
Further research

1. Human/vehicle factors
2. Serious (MAIS3+) injuries
3. Spatial/temporal validations
Questions?
Select the dependent variable (DV)

\[ DV = \frac{\text{Pedestrian crashes}}{\text{Exposure}} \]

Enter the exposure variable as an offset variable

Enter the independent variables (Stepwise)

1

Check the significance of the variables and the goodness-of-fit of the model

Enter the exposure variable as a forced inclusion in the model and then enter the other independent variables (Stepwise)

Enter the exposure variable and the other independent variables at the same time (Stepwise)

No

Selected variables correlate with the exposure variable?

Yes

Remove the correlating variables and re-model

No

The Exposure variable is selected

Yes

Select the model with the best fit