CYCLING SAFETY IN AN ADOLESCENT POPULATION

A RETROSPECTIVE AND PROSPECTIVE STUDY

dr. Vanparijs Jef

Promotors: prof. B. de Geus & prof. R. Meeusen, prof. L. Int Panis
OVERVIEW

1. Introduction to cycling safety
2. Measuring exposure
3. Exposure & Infrastructural correlates in adolescent population
4. Crash characteristics
5. Discussion
CHAPTER 2
EXPOSURE

Accident Analysis and Prevention

Exposure measurement in bicycle safety analysis: A review of the literature

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2. MEASURING EXPOSURE

• Exposure to traffic in **time, distance, number of trips, number of Motorized Vehicles**

• **RQ1:** How is cycling exposure measured?
• **RQ2:** What is the outcome for studies including exposure?
RESULTS

Prospective – longitudinal (n=4):
- Detailed exposure information
- Time consuming
- Small sample size

Retrospective (n=16):
- Fast data collection
- Large sample size
- General data
• Cohort incidence ≠ cohort exposure
  • Age 18-70 yrs
• Exposure data is often based on census data

RESULTS

• General dichotomized outcomes
  • Male vs female
  • Helmet vs no helmet
  • One way bicycle track vs two way bicycle track
• Equipment has no significant effect on crash risk (Bacchieri et al. 2012)

• Behavior and age of cyclists affects safety significantly (Bacchieri et al. 2012; Rodgers et al. 1995; Mindell et al. 2012)

• Discrepancies between different communes/regions → necessity of special differentiated policy (Vandenbulcke et al. 2009)

• A lack of drivers awareness towards cyclists (Johnson et al. 2010)

• Increased risk over time (Tin Tin et al. 2010)
CONCLUSION

• Few studies include exposure
• No studies with adolescents
• General use of census data
• Discrepancies between regions → exposure measurement in different regions is necessary
• Continuous need to measure exposure in cycling safety research

• A prospective design, including a follow-up method, will collect the most accurate data in terms of exposure
CHAPTER 3

EXPOSURE MEASUREMENT IN ADOLESCENTS

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Cycling exposure and infrastructural correlates in a Flemish adolescent population

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3. EXPOSURE AND CORRELATES IN ADOLESCENT POPULATION

• Traffic behavior is different between ages
• Improved infrastructure could reduce the trend to give up cycling in adolescents
• No exposure data of adolescents available

• RQ1. How much do adolescents cycle?
• RQ2. Where do adolescents cycle?
• RQ3. Are there infrastructural characteristics that could increase cycling in an adolescent population?

Combined prospective and retrospective:

- Detailed cycling route to school
- Large sample size

8 schools → 76 classes → 2 contact moments
METHODS: TIMELINE

October

Travel routes and diary

May

Feedback: exposure matrix
EXAMPLE FOR EXPOSURE DATA COLLECTION

Open Street Maps (OSM)

Travel routes and diary
EXAMPLE FOR EXPOSURE DATA COLLECTION

Travel routes and diary

- Presence of bicycle path
- Traffic density
- Speed limit

All information tags for the segments were collected through Open Street Maps (OSM) and visually controlled for Kounadi, O. 2009
## METHODS: MEASURES

<table>
<thead>
<tr>
<th>Traffic density (TS)</th>
<th>Bicycle infrastructure</th>
<th>Speed limit (SL)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low density: AAWT ≤ 2,500 pcu/day</td>
<td>Yes</td>
<td>Low speed: speed limits up to 30 km/h</td>
</tr>
<tr>
<td>Moderate density: AAWT 2,500 - 10,000 pcu/day</td>
<td>No</td>
<td>Moderate speed: speed limited to 50 km/h</td>
</tr>
<tr>
<td>High density: AAWT ≥ 10,000 pcu/day</td>
<td></td>
<td>High speed: speed limit above 50 km/h</td>
</tr>
</tbody>
</table>

AAWT: annual average weekday traffic  
Pcu: person car unit
How many days a week did you use each transport mode on average to go to school? Fill out the table for each period.

<table>
<thead>
<tr>
<th>Transport Mode</th>
<th>Sept-Dec</th>
<th>Jan-March</th>
<th>April-June</th>
</tr>
</thead>
<tbody>
<tr>
<td>Foot</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Bicycle</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Car</td>
<td>5</td>
<td>5</td>
<td>4</td>
</tr>
<tr>
<td>Public transport</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>
RESULTS

369 daily bicycle commuters
267 occasional bicycle commuters

Trip distance to school

Distance cycling route (meters)

Frequency

267 occasional bicycle commuters
369 daily bicycle commuters
RESULTS

Total exposure

100%

Exposure to bicycle path

Yes: 33.5%

No: 66.5%

Exposure Traffic Density

L 5.7%
M 10.5%
H 17.0%

L 45.1%
M 16.8%
H 4.9%
RESULTS

Total exposure

Exposure to bicycle path

Yes: 33.5%

Exposure to Speed Limit

30 km/h: 0.8%
50 km/h: 21.2%
>50 km/h: 11.5%

No: 66.5%

30 km/h: 7.4%
50 km/h: 43.1%
>50 km/h: 16.0%
## RESULTS - DAILY CYCLISTS

<table>
<thead>
<tr>
<th></th>
<th>COMBINED (SPEED-CYCLING INFRASTRUCTURE) MODEL OR (95% CI)</th>
<th>COMBINED (TRAFFIC DENSITY- CYCLING INFRASTRUCTURE) MODEL OR (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>DISTANCE</td>
<td>0.90 (0.87–0.94)**</td>
<td>0.90 (0.86–0.93)**</td>
</tr>
<tr>
<td>% HIGH SPEED LIMIT &amp; NO CYCLING INFRASTRUCTURE</td>
<td>0.99 (0.98–1.00)*</td>
<td>N.A.</td>
</tr>
<tr>
<td>% LOW TRAFFIC DENSITY &amp; WITH CYCLING INFRASTRUCTURE</td>
<td>N.A.</td>
<td>1.02 (1.00–1.04)*</td>
</tr>
<tr>
<td>% HIGH TRAFFIC DENSITY &amp; NO CYCLING INFRASTRUCTURE</td>
<td>N.A.</td>
<td>0.98 (0.96-1.00)†</td>
</tr>
<tr>
<td>% LOW TRAFFIC DENSITY</td>
<td>1.01 (1.00–1.02)*</td>
<td>N.A.</td>
</tr>
<tr>
<td>% MODERATE SPEED LIMIT</td>
<td>N.A.</td>
<td>1.01 (1.00–1.02)**</td>
</tr>
</tbody>
</table>

† $0.10 > p > 0.05$; * $p < 0.05$, ** $p < 0.001$; N.A. not applicable
DISCUSSION: EXPOSURE

16% exposure $\rightarrow$ without infrastructure & +50 km/h

No bicycle specific infrastructure & + 50 km/h in Flanders & low traffic intensity: rural roads

The “Waze” roads
DISCUSSION: CORRELATES

• **Distance:** 5.7 km ± 4.5 km and 8.5 km ± 6.0 km for daily and occasional cyclists respectively in contrast to 3 km found by D’Haese et al.

• Lower **traffic density** increased the odds of daily bicycle commuting:
  → safe?
  → ease of mind?

• **speed limits** (above 50 km/h) → odds of daily bicycle commuting decrease unless:
  → dedicated cycle lane

• **No** infrastructure or traffic correlates for **occasional** bicycle commuters: distance
IMPLICATIONS AND LIMITATIONS

Typical built up environment:
• Dense road network
• Very few altitude differences (favors the use of a bicycle).
→ Not generalizable to other regions

16% exposure → no bicycle infrastructure & +50 km/h considered as high risk infrastructure and should be avoided.

Bere, E. and Bjorkelund, L.A., 2009
Characteristics of bicycle crashes in an adolescent population in Flanders (Belgium)

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b Flemish Institute for Technological Research (VITO), Mol, Belgium
c Transportation Research Institute (IMOB), Hasselt University, Diepenbeek, Belgium
4. CRASH CHARACTERISTICS

- Necessary for better understanding → effective countermeasures
- Today → use of official statistics (police databases)
- No details available

RQ1: What are the bicycle crash causes in an adolescent population

RQ2: Can we avoid the “tip of the iceberg” problem in bicycle crash data

Shaw, L., et al., 2012
DATA COLLECTION

Schools
- Voluntary
- Questionnaires to students age 14-18 years

Insurance companies
- Ethias (& KBC)
- Questionnaires send to victims of bicycle crashes (age 14-18 years)
QUESTIONNAIRE

What kind of infrastructure were you cycling on?
Were you alone or with other cyclists?
Where did the bicycle crash happen?
What was the weather at the time of the bicycle crash?
Describe in detail how the crash happened.

...
DEFINING CRASH CAUSES

• Technique (e.g. failure of bicycle, shoelace in the sprocket)
• Distracted (e.g. talking with another bicyclist)
• Infrastructure in bad state (e.g. holes in the road)
• Bad maintained infrastructure (e.g. ice, snow, or other debris on the surface)
DEFINING CRASH CAUSES

- Traffic rule infringement of bicyclist (e.g. crossing road were not aloud, cycling on sidewalk)
- Third party crosses bicycle path (e.g. exiting driveway, turning at an intersection)
- Traffic rule infringement of third party if not crossing the bicycle path (e.g. opening door of car, hitting the bicyclist with the side mirror)
<table>
<thead>
<tr>
<th>Road type</th>
<th>Schools (n=86)</th>
<th>Insurance companies (n=77)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bicycle on road</td>
<td>62%</td>
<td>66%</td>
</tr>
<tr>
<td>Side walk</td>
<td>7%</td>
<td>0%</td>
</tr>
<tr>
<td>Separated bicycle path</td>
<td>24%</td>
<td>19%</td>
</tr>
<tr>
<td>No motorized vehicles</td>
<td>7%</td>
<td>15%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Road type</th>
<th>Schools (n=86)</th>
<th>Insurance companies (n=77)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Straight</td>
<td>56%</td>
<td>87%</td>
</tr>
<tr>
<td>Curve</td>
<td>16%</td>
<td>3%</td>
</tr>
<tr>
<td>Intersection</td>
<td>22%</td>
<td>10%</td>
</tr>
<tr>
<td>Other</td>
<td>6%</td>
<td>0%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Speed (km/h)</th>
<th>Schools (n=86)</th>
<th>Insurance companies (n=77)</th>
</tr>
</thead>
<tbody>
<tr>
<td>No cars</td>
<td>8%</td>
<td>8%</td>
</tr>
<tr>
<td>30 km/h</td>
<td>28%</td>
<td>43%</td>
</tr>
<tr>
<td>50 km/h</td>
<td>59%</td>
<td>44%</td>
</tr>
<tr>
<td>70 km/h</td>
<td>5%</td>
<td>5%</td>
</tr>
</tbody>
</table>
## CAUSES

<table>
<thead>
<tr>
<th>Predefined cause</th>
<th>Percent of cases</th>
<th>Injury severity ICISS*</th>
<th>Reported by police</th>
</tr>
</thead>
<tbody>
<tr>
<td>distracted</td>
<td>28.4%</td>
<td>0.9934</td>
<td>6%</td>
</tr>
<tr>
<td>infrastructure in bad state</td>
<td>5.5%</td>
<td>0.9858</td>
<td>0%</td>
</tr>
<tr>
<td>traffic rule infringement</td>
<td>6.1%</td>
<td>0.9685</td>
<td>10%</td>
</tr>
<tr>
<td>traffic rule infringement of third party</td>
<td>15.2%</td>
<td>0.9960</td>
<td>16%</td>
</tr>
<tr>
<td>third party crosses bicycle path (bicyclist not noticed)</td>
<td>28.4%</td>
<td>0.9786</td>
<td>17%</td>
</tr>
<tr>
<td>ice, snow, branches or other</td>
<td>15.2%</td>
<td>0.9928</td>
<td>12%</td>
</tr>
<tr>
<td>technique</td>
<td>0.6%</td>
<td>1</td>
<td>0%</td>
</tr>
</tbody>
</table>

* International Classification of Injury Severity Score (based on International Classification of Diseases and Survival Risk Ratio)
### SEVERITY

<table>
<thead>
<tr>
<th></th>
<th>Schools</th>
<th>Insurance Companies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hospital &gt; 24h</td>
<td>0%</td>
<td>3%</td>
</tr>
<tr>
<td>Hospital &lt; 24 h</td>
<td>2%</td>
<td>17%</td>
</tr>
<tr>
<td>Medical doctor</td>
<td>10%</td>
<td>57%</td>
</tr>
<tr>
<td>Personal medical attention</td>
<td>21%</td>
<td>21%</td>
</tr>
<tr>
<td>No medical attention</td>
<td>67%</td>
<td>2%</td>
</tr>
<tr>
<td>Absenteeism (Abs)**</td>
<td>98% no abs / 2% 1 day abs</td>
<td>43% no abs / 50% 1-5 days abs / 7% &gt; week abs.</td>
</tr>
<tr>
<td>ICISS*</td>
<td>0.99377</td>
<td>0.99023</td>
</tr>
</tbody>
</table>

*International Classification of Injury Severity Score (based on International Classification of Diseases and Survival Risk Ratio); ** p<0.001
## OFFICIAL STATISTICS

<table>
<thead>
<tr>
<th></th>
<th>bicycle crashes collected through schools &amp; reported by the police</th>
<th>bicycle crashes collected through insurance companies &amp; reported by the police</th>
<th>Weighted average</th>
</tr>
</thead>
<tbody>
<tr>
<td>Single bicycle crashes*</td>
<td>3%</td>
<td>16%</td>
<td>8%</td>
</tr>
<tr>
<td>Bicyclist</td>
<td>0%</td>
<td>5%</td>
<td>3%</td>
</tr>
<tr>
<td>Car *</td>
<td>5%</td>
<td>35%</td>
<td>17%</td>
</tr>
<tr>
<td>Pedestrian</td>
<td>50%</td>
<td>50%</td>
<td>50%</td>
</tr>
<tr>
<td>Motor cycle</td>
<td>/</td>
<td>50%</td>
<td>50%</td>
</tr>
<tr>
<td>**Total ***</td>
<td><strong>5%</strong></td>
<td><strong>21%</strong></td>
<td><strong>13%</strong></td>
</tr>
</tbody>
</table>

* sig. p<0.05
CONCLUSION

• No significant ≠ crash causes between schools and insurance data.

• Database insurance companies 5x larger compared to national statistics.

• “Distraction” & “not noticed by third party” are main causes (57%)
  → need for a new strategy to cope with this problem.

• Crashes, directly caused by infrastructure account for 21% of cases.
  • Ice, snow, debris, holes etc.

• Crashes registered at insurance companies seem to be more severe accordingly to the days of absenteeism but not accordingly to the ICISS.
CONCLUSION

• Potential data of insurance companies for national statistics: Better data → better policy decisions?

• Impact of human factor in bicycle crashes in adolescent population is high (distraction).

• Is there a role of infrastructure in these crashes?

• To improve bicycle safety and infrastructure, bicycle crash causes should be considered.
CHAPTER 5
GENERAL DISCUSSION & CONCLUSION
5. GENERAL DISCUSSION

• Improving safety begins with risk assessment for different pillars.

• Initiatives for international exposure data not enough → exposure should be measured in all bicycle safety studies where “risk” is an outcome.

• Exposure data is lacking.

DISCUSSION

• Combination between prospective and retrospective method looks promising for collecting exposure data.

• Exposure data in an adolescent population shows high exposure on potential dangerous infrastructure (the “Waze” roads).

• Low traffic density & dedicated cycling infrastructure increases the odd for daily bicycle commuting.

Vanparijs, J., et al., 2015; Poulos, R.G. et al., 2015
For the safe system approach, knowledge on crash causes is necessary

National database on crashes is limited in size and information

Insurance companies have a huge database potential
GENERAL CONCLUSION

• 79% of the bicycle crashes in an adolescent population are due to human failure.

• 66% of the bicycle crashes are on straight infrastructure and 64% of all crashes are on roads with no bicycle paths.

• 66% exposure in on roads with no bicycle paths.
GENERAL CONCLUSION

- Adolescents cycle on roads with low traffic density but high-speed limits and no bicycle paths which is potentially dangerous infrastructure.

- Insurance companies register 5 times more bicycle crashes compared to police statistics, including both minor and major bicycle crashes.
FUTURE PERSPECTIVES

• Legislative initiatives to collect data from insurance companies.

• Additional attention towards crash etiology.
Thank you for your attention