Health impact assessment of active transportation: a systematic review

Project: Physical Activity through Sustainable Transport Approaches (PASTA)

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PASTA project  http://pastaproject.eu/home/

• Aims at studying how active transportation can lead to a happier more physically active population while at the same time improving air quality

• Longitudinal study in 7 European cities 14,000 people reporting their transportation behavior and experiences

• WP4 development of state-of-the-art HIA tool to quantify health impacts of AT
  • existing HIA models, PASTA survey, knowledge gaps identified in review
Health Impact Assessment (HIA)

- HIA estimates (un)intended health benefits and risks of public policies in order to increase health gains and prevent harms (Mindell et al. 2003)
- Predictive rather than empirical research tool (Parry and Stevens, 2001)
- Mode shift to active transportation (walking, cycling, public transport and any other ‘active’ mode; AT) has potential to alter determinants of health, which underpins importance of HIA
Health pathways associated with active transportation

Physical activity

Air pollution

Traffic noise

Traffic incidents
Health benefits of active transportation

Evidence exists on AT health benefits

Health benefits are believed to be greater than associated detrimental effects

However, a systematic summary of quantified health benefits and risks of a mode shift to AT does not yet exist!

de Hartog et al. 2010
Systematic review - Methods

- Review quantitative HIA studies of a mode shift to AT on grounds of associated health benefits and risks
- Database searches of MEDLINE, Web of Science and TRID
- Eligibility criteria:
  - Mode shift to AT
  - Quantitative HIA methodology
  - Quantitative change in health pathway exposure distribution
  - Quantitative change in health outcome

- Outcome: Benefit-risk or benefit-cost relationship
Flow chart of study search (Feb 2014 – Dec 2014)

30 HIA studies of a mode shift to AT with quantified health benefits and risks
Results

• 12 comparative risk assessments
• 12 cost-benefit analyses
• 4 benefit assessments
• 2 risk assessments (traffic safety)

• Interventions that produced mode shift were ‘pull’ interventions (e.g. bike-sharing system) or ‘push’ interventions (e.g. fuel price increase)

• Studies covered a range of populations partially stratified by age, sex, ethnicity and population density
<table>
<thead>
<tr>
<th>Author(year)</th>
<th>Method</th>
<th>Study setting</th>
<th>Active transportation modeshift scenarios</th>
<th>Health pathways</th>
<th>Health endpoints</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rojas-Rueda et al. (2011)</td>
<td>CRA</td>
<td>Barcelona (Spain); 25,426 Bike-sharing users; age 16-64 years</td>
<td>Bike-sharing users replace all car trips with bicycle</td>
<td>Physical activity; traffic incidents; air pollution; AcT</td>
<td>Adipose tissue; activity-restriction days; Mortality</td>
</tr>
<tr>
<td>Rabl and Nazelle (2012)</td>
<td>CBA</td>
<td>Amsterdam (Netherlands); Paris (France)</td>
<td>Replace car trips 5 km with bicycle (S1); 2.5 km with walking (S2)</td>
<td>Physical activity; traffic incidents; air pollution; AcT; GP; noise</td>
<td>Health costs (€; mortality</td>
</tr>
<tr>
<td>Grabow et al. (2012)</td>
<td>BA</td>
<td>11 Metropolitan areas (USA); population of 31.1 million</td>
<td>Replace 50% of car round-trips ≤8 km with bicycle to improve air quality</td>
<td>Physical activity; air pollution; GP</td>
<td>Health costs (SUS; mortality, morbidity, activity-restriction; productivity-loss); mortality; morbidity; activity-restriction days</td>
</tr>
<tr>
<td>Olabarria et al. (2012)</td>
<td>BA</td>
<td>Catalonia (Spain); population of 80,552; age ≥17 years; stratification by sex</td>
<td>Replace car and motorcycle trips ≤5 min with walking</td>
<td>Physical activity</td>
<td>Health costs (€; mortality; mortality</td>
</tr>
<tr>
<td>Jarrett et al. (2012)</td>
<td>CBA</td>
<td>England and Wales (UK); urban areas with population of ≤200-000</td>
<td>Replace car trips 3.4 km (S1); 1.7 km (S2) with walking, bicycle and PT</td>
<td>Physical activity; traffic incidents</td>
<td>Health costs (€; health care costs)</td>
</tr>
<tr>
<td>Stipdonk and Reurings (2012)</td>
<td>RA</td>
<td>Netherlands; age ≥18 years; stratification by sex; age</td>
<td>Replace 10% of car trips ≤7.5 km with bicycle</td>
<td>Physical activity; traffic incidents; air pollution</td>
<td>Fatalities and injuries</td>
</tr>
<tr>
<td>Holm et al. (2012)</td>
<td>CRA</td>
<td>Copenhagen (Denmark); work/school commuters; age 15-69 years</td>
<td>Replace 50% of car trips 2-10 km and 33% of car trips 10-15 km with bicycle</td>
<td>Physical activity; traffic incidents; air pollution; AcT</td>
<td>DALYs</td>
</tr>
</tbody>
</table>
Health pathways

Physical Activity through Sustainable Transport Approaches

Bike
Walk

Air Pollution
Traffic Incidents
Noise

General population
Active Traveler

Mortality
Morbidity
DALYs
Monetization
Life expectancy

Fatalities
Injuries
Work absence
Medical costs
Productivity loss

Results

Health impact assessment of active transportation
**Results**

**HIA modeling assumptions**

**Physical Activity**
- 28
- **Dose-response function**
  - 8 linear
  - 7 HEAT (WHO) log-linear/threshold
  - 3 linear/threshold
  - 4 curvilinear
  - baseline PA
  - 6 RR categories
- **Health Outcome**
  - All-cause mortality, CVD, Diabetes, Weight gain, Cancer, Falls, Mental health

**Air Pollution**
- 17
- **Dose-response function**
  - 17 linear
  - 1 log-linear (Delhi)
- **Health Outcome**
  - All-cause mortality, Respiratory disease, CVD, Cancer, Birth outcomes, Activity-restriction, Productivity

**Traffic Incidents**
- 21
- **Dose-response function**
  - 13 linear distance/time
  - 8 non-linear
    - 'safety in numbers', traffic volume, modal split, conflict types, kinetic energies, speed, road, age, sex
- **Health Outcome**
  - Fatality, Injury

**Noise**
- (3)
- **Dose-response function**
  - 3 linear traffic volume, cost-function for vehicle-km
- **Health Outcome**
  - NA
27 studies estimated net benefits
Benefit-risk/ benefit-cost ratios: (-2) – 360 (median=9)
3 studies estimated negative effects, but were distinctive:
  2 studies on exclusively traffic safety (incident increase)
  1 study compared health benefits to excessive intervention costs
Estimated health impact of a mode shift to AT

Net health benefits of AT are substantial, irrespective of geographical context. Projected health gains by increases in PA levels exceed detrimental effects of traffic incidents and air pollution exposure!

Health impact assessment of active transportation
Intra-population benefit differences

- Older people (typically ≥45 years) estimated to benefit greater from AT than younger people

- The benefits of physical activity are estimated to greater outweigh the detriments of traffic incidents and air pollution exposure due to increased risk for chronic disease

- Physical activity benefits are presumed to be long-term in nature and physical activity can reduce absolute risk for disease development

- Inconclusive whether older people benefit differently from same physical activity exposure compared to younger people

Woodcock et al. 2014
Intra-population benefit differences – traffic safety

Low injury risk settings:
Younger people experience traffic safety gain

Table 4. Traffic deaths per age category per billion passenger kilometers by bicycle and by car in the Netherlands.\textsuperscript{a}

<table>
<thead>
<tr>
<th>Age category (years)</th>
<th>Bicycle</th>
<th>Car</th>
<th>Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 15</td>
<td>4.9</td>
<td>0.6</td>
<td>8.6</td>
</tr>
<tr>
<td>15–20</td>
<td>5.4</td>
<td>7.4</td>
<td>0.7</td>
</tr>
<tr>
<td>20–30</td>
<td>4.2</td>
<td>4.6</td>
<td>0.9</td>
</tr>
<tr>
<td>30–40</td>
<td>3.9</td>
<td>2.0</td>
<td>2.0</td>
</tr>
<tr>
<td>40–50</td>
<td>6.6</td>
<td>1.0</td>
<td>6.9</td>
</tr>
<tr>
<td>50–60</td>
<td>9.6</td>
<td>1.2</td>
<td>7.9</td>
</tr>
<tr>
<td>60–70</td>
<td>18.6</td>
<td>1.6</td>
<td>11.7</td>
</tr>
<tr>
<td>70–80</td>
<td>117.6</td>
<td>7.6</td>
<td>15.4</td>
</tr>
<tr>
<td>&gt; 80</td>
<td>139.6</td>
<td>8.1</td>
<td>17.1</td>
</tr>
<tr>
<td>Total average (all ages)</td>
<td>12.2</td>
<td>2.2</td>
<td>5.5</td>
</tr>
<tr>
<td>Total average (20–70 years of age)</td>
<td>8.2</td>
<td>1.9</td>
<td>4.3</td>
</tr>
</tbody>
</table>

Data from CBS (2008).
\textsuperscript{a}Estimated as age-specific and traffic mode–specific number of traffic deaths divided by amount of kilometers driven per age and traffic mode in the Netherlands for the year 2008.

Edwards and Mason 2014

de Hartog et al. 2010

High injury risk setting:
The proportional change in baseline mortality makes AT appear especially hazardous for younger people

Death and injury at younger ages translates into a larger burden of disease; delayed benefits from physical activity discourages AT for younger people
Intra-population benefit differences

- Males estimated to benefit more than females from mode shift to AT
- Males comply less with physical activity recommendations at baseline (Olabarria et al. 2012)
- Sexes have distinctive chronic disease incidence risk (Woodcock et al. 2014)
- Males benefit more from reduced motorized traffic incident risk (especially switching to low risk modes of public transportation and car-passenger) (Dhondt et al., 2013)
Intra-population benefit differences

• Disadvantaged ethnic sub-populations estimated to benefit more than general population (Lindsay et al., 2011)
• Pronounced benefits relate to increased chronic disease incidence (Fang et al., 2012; Lindsay et al., 2011)

Health Equity?

• AT land-use improvements mostly found in high income areas (Aytur et al., 2008).
• High-income neighborhoods report more AT facilities, more traffic safety and less crime (Sallis et al., 2011)
• Intrinsic motivations for AT engagement and intention-behavior relationships vary among different social classes (Conner et al., 2013)
Uncertainties in HIA of AT

- HIA modeling assumptions vary across studies
- Benefit-risk/ cost ratios only indicator of magnitude of impact
- Risk estimates taken from elsewhere – comparability?
- Uncertainty about shapes of DRF
- Behavior change (intrinsic motivations)
- Longevity of AT health benefits (time-lags, immediate vs long-term)
- Effects on health equity
Future HIA of AT

- Acute impacts of AT (quality of life, less back pain, mental well-being, happiness)
- Integration of impacts of new domains such as noise, diet, social capital, crime or productivity
- In-depth study of age, sex and social class effects
- Low and middle income settings
- Children
- Skates or e-bikes
HIA is valuable to improve the understanding of the inter-relationship between transportation and health.

Benefits of AT are substantial, irrespective of geographical context. Projected health gains by increases in PA levels exceed detrimental effects of traffic incidents and air pollution exposure.