Health impact assessment of active transportation: a systematic review

Project: Physical Activity through Sustainable Transport Approaches (PASTA)

Natalie Mueller

Centre for Research in Environmental Epidemiology (CREAL) Barcelona, Spain
Supervisors: Prof. Mark Nieuwenhuijsen & Dr. David Rojas-Rueda

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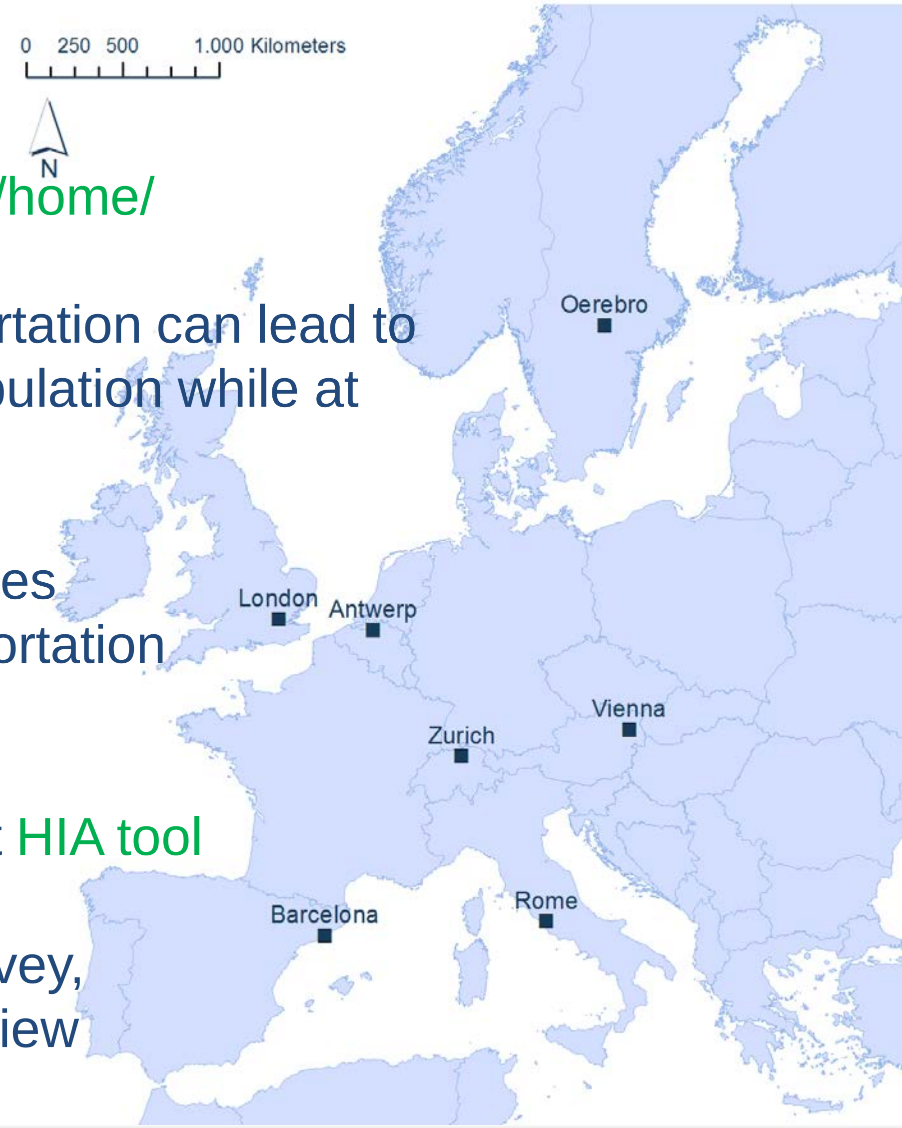

- Aims at studying how active transportation can lead to a happier more physically active population while at the same time improving air quality
- Longitudinal study in 7 European cities 14,000 people reporting their transportation behavior and experiences
- WP4 development of state-of-the-art HIA tool to quantify health impacts of AT
  - existing HIA models, PASTA survey, knowledge gaps identified in review

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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

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Health pathways associated with active transportation

Physical activity

Air pollution

Traffic noise

Traffic incidents

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Health benefits of active transportation

Review

Do the Health Benefits of Cycling Outweigh the Risks?

Jeroen Johan de Hartog,[1] Hanna Boogaard,[1] Hans Nijland,[2] and Gerard Hoek[1]

[1]University of Utrecht, Institute for Risk Assessment Sciences, Utrecht, the Netherlands; [2]Netherlands Environmental Assessment Agency, Bilthoven, the Netherlands

BACKGROUND: Although from a societal point of view a modal shift from car to bicycle may have beneficial health effects due to decreased air pollution emissions, decreased greenhouse gas emissions, and increased levels of physical activity, shifts in individual adverse health effects such as higher exposure to air pollution and risk of a traffic accident may prevail.

OBJECTIVE: We describe whether the health benefits from the increased physical activity of a modal shift for urban commutes outweigh the health risks.

DATA SOURCES AND EXTRACTION: We have summarized the literature for air pollution, traffic accidents, and physical activity using systematic reviews supplemented with recent key studies.

DATA SYNTHESIS: We quantified the impact on all-cause mortality when 500,000 people would make a transition from car to bicycle for short trips on a daily basis in the Netherlands. We have expressed mortality impacts in life-years gained or lost, using life table calculations. For individuals who shift from car to bicycle, we estimated that beneficial effects of increased physical activity are substantially larger (3–14 months gained) than the potential mortality effect of increased inhaled air pollution doses (0.8–40 days lost) and the increase in traffic accidents (5–9 days lost). Societal benefits are even larger because of a modest reduction in air pollution and greenhouse gas emissions and traffic accidents.

CONCLUSIONS: On average, the estimated health benefits of cycling were substantially larger than the risks relative to car driving for individuals shifting their mode of transport.

KEY WORDS: air pollution, biking, cycling, life table analysis, modal shift, physical activity, traffic accidents. *Environ Health Perspect* 118:1109–1116 (2010). doi:10.1289/ehp.0901747 [Online 30 June 2010]

In the quantitative comparison between car driving and cycling, we considered air pollution, traffic accidents, and physical activity as main exposures. We summarize the relevant evidence of health effects related to air pollution, traffic accidents, and physical activity separately. For these sections, we made use of published (systematic) reviews, supplemented with more recent key studies.

Health effects related to air pollution, traffic accidents, and physical activity differ—for example, traffic accidents resulting in injuries and physical activity affecting cardiovascular disease. Therefore, we compare potential effects of these exposures (in conjunction with driving or cycling) on mortality rather than morbidity. In addition, epidemiologic evidence of associations of these exposures with mortality is stronger than associations with other outcomes, particularly for physical activity. All three exposures have been associated with mortality, so a common metric can

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

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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

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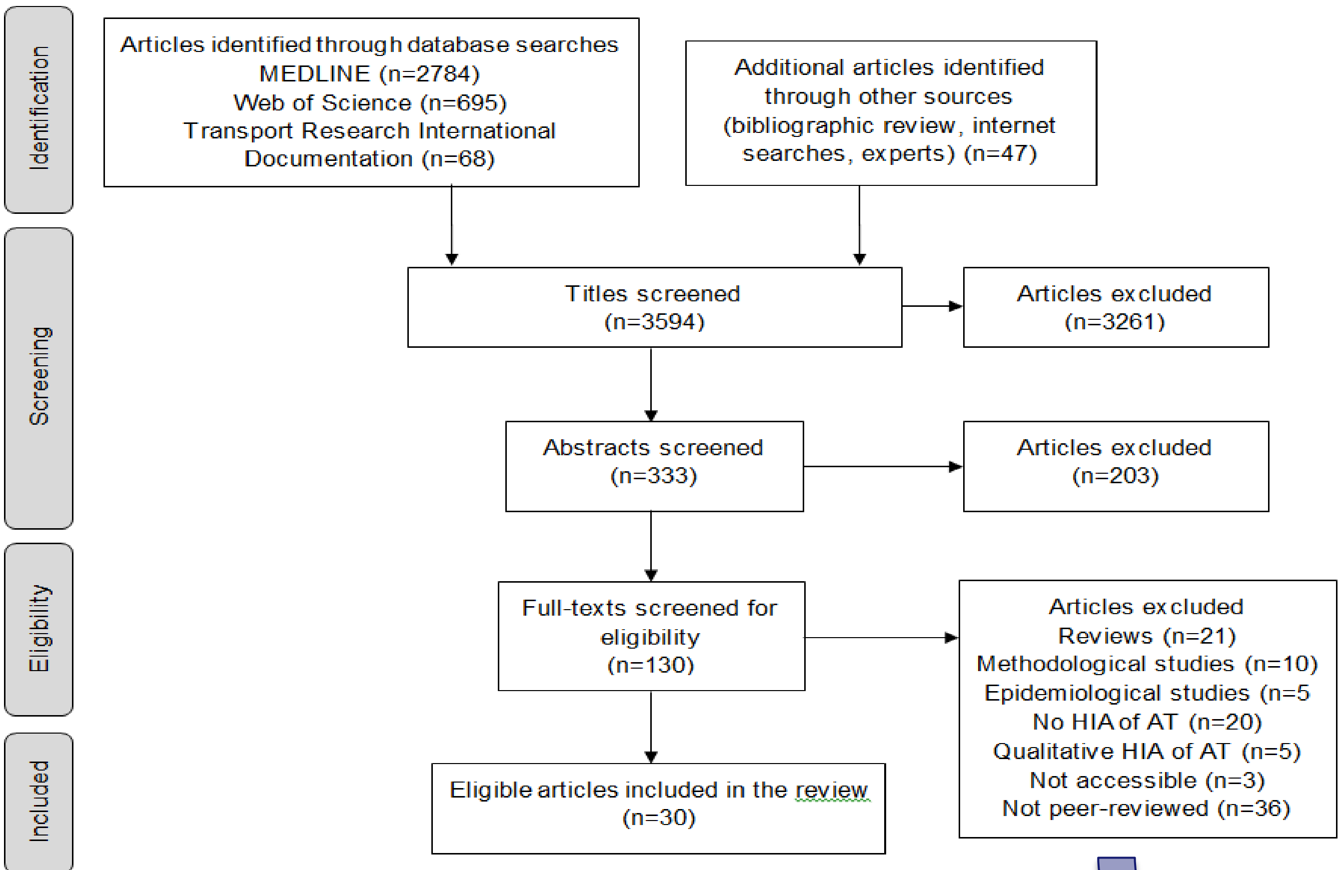
Flow chart of study search (Feb 2014 – Dec 2014)



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

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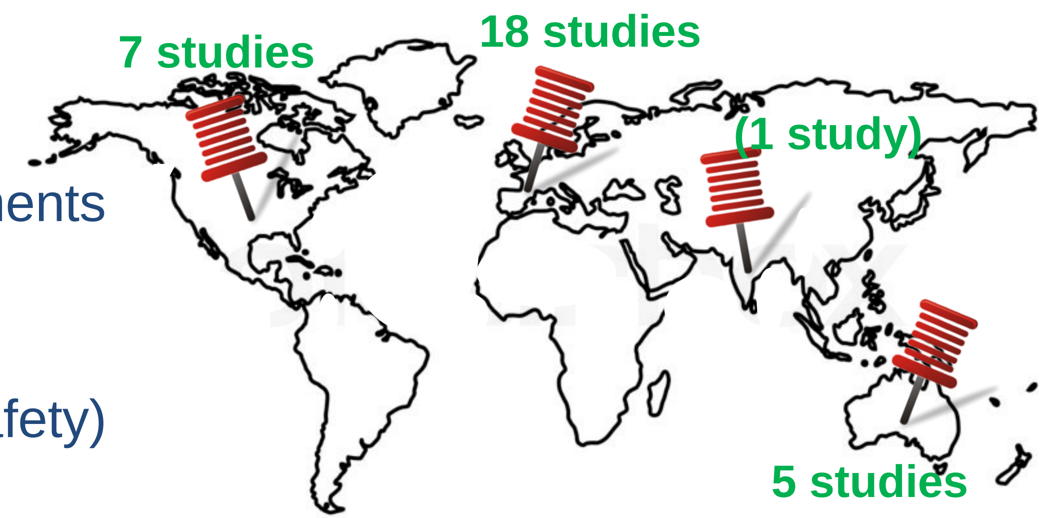
Results



- 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

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Mode shift scenarios

TABLE 1 (CONTINUED)

Author (year)	Method	Study setting[a]	Active transportation mode shift scenarios[b]	Health pathways[c]	Health endpoints[d]
					adipose tissue; activity-restriction days
Rojas-Rueda et al. (2011)	CRA	Barcelona (Spain); 25,426 Bike-sharing users; age 16-64 years	Bike-sharing users replace all car trips with bicycle	Physical activity; traffic incidents; air pollution AcT	Mortality
Rabl and de Nazelle (2012)	CBA	Amsterdam (Netherlands); Paris (France)	Replace car trips 5 km with bicycle (S1); 2.5 km with walking (S2)	Physical activity; traffic incidents; air pollution AcT+GP; noise	Health costs (€; mortality
Grabow et al. (2012)	BA	11 Metropolitan areas (USA); population of 31.1 million	Replace 50% of car round-trips ≤8 km with bicycle to improve air quality	Physical activity; air pollution GP	Health costs ($US; mortality, morbidity, activity-restriction, productivity-loss); mortality; morbidity; activity-restriction days
Olabarria et al. (2012)	BA	Catalonia (Spain); population of 80,552; age ≥17 years; stratification by sex	Replace car and motorcycle trips ≤5 min with walking	Physical activity	Health costs (€; mortality mortality
Jarrett et al. (2012)	CBA	England and Wales (UK); urban areas with population of ≥200 000	Replace car trips 3.4 km (S1); 1.7 km (S2) with walking, bicycle and PT	Physical activity; traffic incidents	Health costs (£; health ca obesity costs)
Stipdonk and Reurings (2012)	RA	Netherlands; age ≥18 years; stratification by sex, age	Replace 10% of car trips ≤7.5 km with bicycle	Traffic incidents	Fatalities and injuries
Holm et al. (2012)	CRA	Copenhagen (Denmark); work/school commuters; age 15-69 years	Replace 50% of car trips 2-10 km and 33% of car trips 10-15 km with bicycle	Physical activity; traffic incidents; air pollution AcT	DALYs

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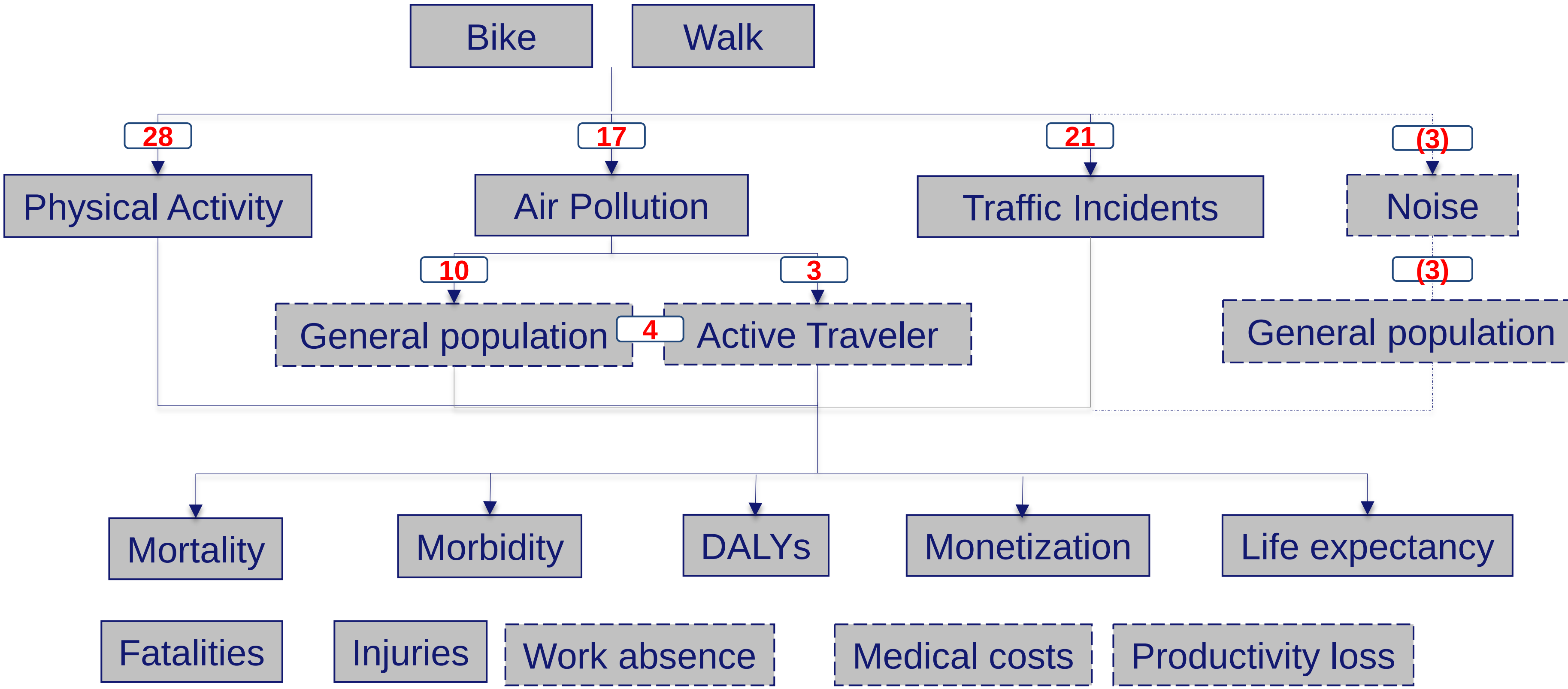
Health pathways



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HIA modeling assumptions

Bike | Walk

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

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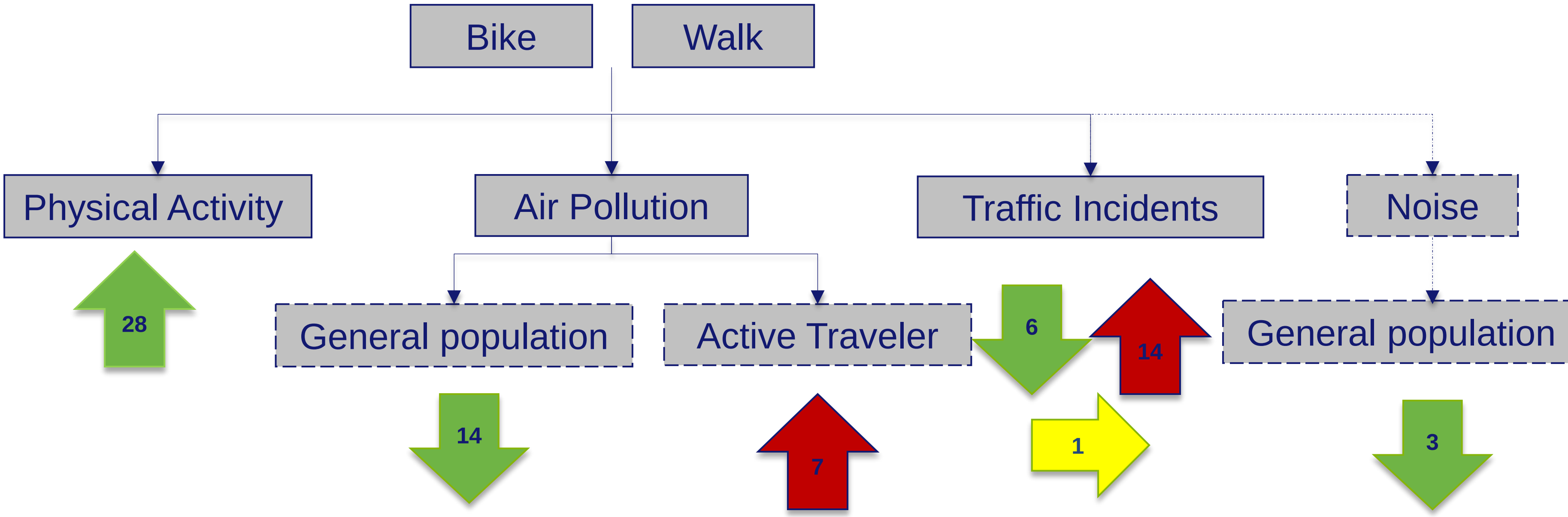
Benefits > Risks



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

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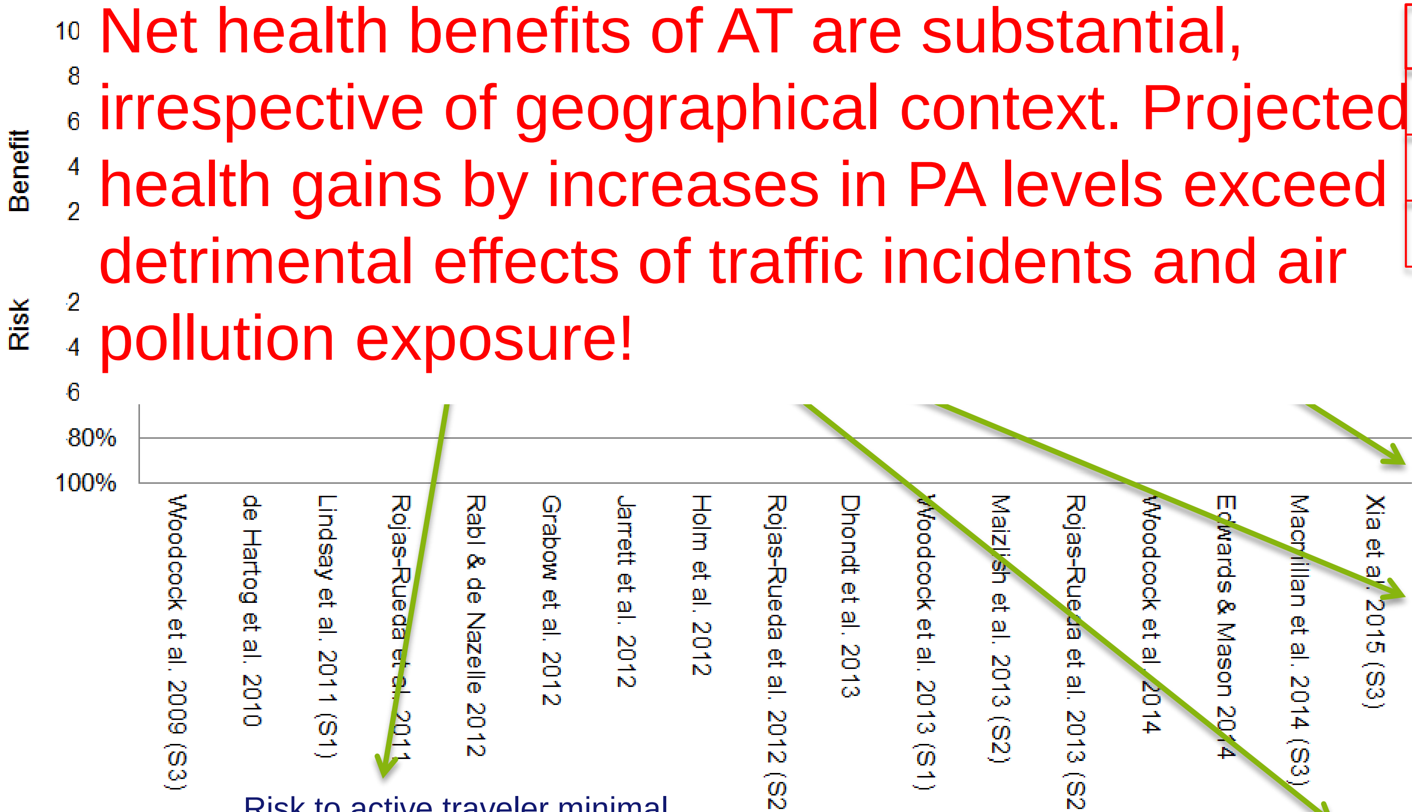
Estimated health impact of a mode shift to AT

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!



Reduced motorized traffic volume
'safety in numbers'; safer modes

est benefits come from PA

Mode shift to public transport and car passenger

'High risk modes' ; increase in single-mode incidents (slipping)

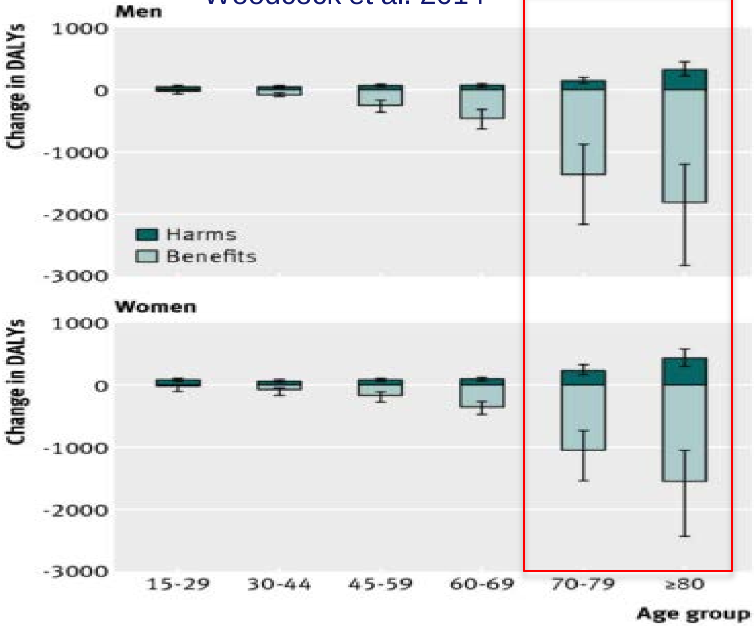
Risk to active traveler minimal

Reduced motorized traffic volume

Not possible if 1 health pathway, incomparable units, health impacts not untangled from environmental and economic impacts

Intra-population benefit differences

Woodcock et al. 2014



- 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

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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.[a]

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

Data from CBS (2008).
[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.

de Hartog et al. 2010

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

Effects of switching from auto to bicycle commuting on the U.S. traffic fatality rates and death rates per 100,000 in 2009.

Age	Added by bicycle commuting [1]	Subtracted by no auto commuting [2]	Sum [1] + [2] [3]	Baseline all-cause death rate [4]	Percent change [3] ÷ [4] [5]
20–24	7.8	−2.3	5.5	88.0	6.2
25–29	7.5	−2.3	5.3	98.0	5.4
30–34	5.8	−1.0	4.8	111.0	4.3
35–39	7.6	−0.7	6.9	144.0	4.8
40–44	10.1	−0.6	9.6	214.0	4.5
45–49	12.8	−0.9	11.9	335.0	3.6
50–54	12.3	−0.8	11.5	506.0	2.3
55–59	14.1	−0.7	13.4	716.0	1.9
60–64	17.9	−0.8	17.1	1035.0	1.6

Edwards and Mason 2014

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)

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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

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Natalie Mueller
CREAL

Barcelona Biomedical Research Park (PRBB)
Doctor Aiguader, 88 | 08003 Barcelona, SPAIN
nmueller@creal.cat | +34 93214 7314

Mark Nieuwenhuijsen
David Rojas-Rueda
Tom Cole-Hunter
Audrey de Nazelle
Evi Dons
Regine Gerike
Thomas Götschi
Luc Int Panis
Sonja Kahlmeier
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