Quantification of health benefits from cycling: the Health Economic Assessment Tool (HEAT) for cycling

Christian Schweizer
World Health Organization Regional Office for Europe
European Centre for Environment and Health

With acknowledgements to:
Nick Cavill, Cavill Associates, United Kingdom
Harry Rutter, National Obesity Observatory England, United Kingdom
Hywell Dinsdale, South-East Public Health Observatory, United Kingdom
Sonja Kahlmeier, WHO Regional Office for Europe
Francesca Racioppi, WHO Regional Office for Europe
Pekka Oja, UKK Institute for Health Promotion Research

THE PEP Workshop on safe and healthy walking and cycling in urban areas
Batumi, Georgia, 30 September – 1 October 2010
Often urban environments / land use planning favour motorized transport...
... and hinder walking and cycling
Why cycling and walking?

- Helps to address many of the transport-related health problems.
- It can have a big impact!
  - In Europe, many car trips are short:
    - about 10% of trips not longer than 1km
    - About 30% not longer than 3km
  - Shifting some of these trips to active transportation can help to:
    - Reduce congestion
    - Improve road safety
    - Improve air quality and noise
    - Reduce energy consumption and CO2
    - Co-benefits: e.g. health effects, more livable communities etc.
- It’s easy!
  - Avoids dependence on facilities for sports
  - Most people can do it - equitable and easily accessible options
Why economic assessment of walking and cycling?

- Economic valuation is standard tool of transport planners
  → helps health sector to speak “their” language

- Public health benefits are likely to be great, esp. if inactive persons can be reached

- Increasingly applied to cycling and walking but not always in a transparent way based on a robust methodology
Integration of health effects in transport assessments: challenges

- Complex methodological questions for transport planners:
  - which health endpoints to include?
  - form of the relationship between exposure and effect?
  - activity substitution
  - which costs to include?
  - how to calculate costs?
  - which time lag periods to apply before benefits/costs occur?
  ➞ easy to apply guidance and tools needed
WHO guidance and tool for economic assessment of cycling (and walking)
Collaborative project

Core group
Nick Cavill, Harry Rutter, Sonja Kahlmeier, Hywell Dinsdale, Francesca Racioppi, Pekka Oja

Contributors
Lars Bo Andersen, Finn Berggren, Hana Bruhova-Foltynova, Fiona Bull, Andy Cope, Maria Hagströmer / Michael Sjöström, Eva Gleissenberger / Robert Thaler, Brian Martin, Irina Mincheva Kovacheva, Hanns Moshammer, Bhash Naidoo, Kjartan Saelensminde, Peter Schantz, Thomas Schmid, Heini Sommer, Jan Sørensen, Sylvia Titze, Ardine de Wit / Wanda Wendel Vos, Mulugeta Yilma

In collaboration with:

Acknowledgements
Austrian Federal Ministry of Agriculture, Forestry, Environment and Water Management
The Swedish Expertise Fund / Karolinska Institute, Sweden
National Institute for Health and Clinical Excellence (NICE)
University of Graz, Austria
The question

If $x$ people cycle a distance of $y$ kilometers on most days, what is the economic value of the health benefits that occur as a result of the reduction in mortality due to their physical activity?
Figure 1. Basic workings of the HEAT for Cycling

Number of trips/day
X
Distance /trip

Data entered by user for study area
Figure 1. Basic workings of the HEAT for Cycling

Number of trips/day
Distance /trip

Data entered by user
for study area

\( x \)

Days cycled per year

Local parameters
Figure 1. Basic workings of the HEAT for Cycling

1. Number of trips/day × Distance /trip
2. Data entered by user for study area
3. Days cycled per year
4. Local parameters
5. Distance cycled per year in study area
Figure 1: Basic workings of the HEAT for Cycling

Number of trips/day \times Distance/tip

\[ \times \]

Days cycled per year

Local parameters

Distance cycled per year in study area

Relative risk of death among cyclists in study area calculated based on risk in Copenhagen study of 0.72 for 3 hours per week (for an estimated 36 weeks/year) assuming a linear dose response relationship
Figure 1: Basic workings of the HEAT for Cycling

Number of trips/day $\times$ Distance /trip

Data entered by user for study area

$\times$

Days cycled per year

Local parameters

$=$

Distance cycled per year in study area

Relative risk of death among cyclists in study area calculated based on risk in Copenhagen study of 0.72 for 3 hours per week (for an estimated 36 weeks/year) assuming a linear dose response relationship

Estimate of economic savings based on reduced mortality among cyclists in the study area
Health Economic Assessment Tool for Cycling

Fill in the two fields in Step 1 with your values and read the corresponding results in Step 3. You can use the default parameters supplied in Step 2 or adjust them according to your needs. The population parameters used to calculate the results are displayed at the bottom of the sheet.

### Step 1: enter your data
(all users must fill in the red fields)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of trips per day</td>
<td>300,000</td>
</tr>
<tr>
<td>Mean trip length (km)</td>
<td>3.2</td>
</tr>
</tbody>
</table>

### Step 2: check the parameters

- Mean number of days cycled per year: 124
- Proportion of trips that are one part of a return journey (or 'round trip'): 0.3
- Proportion undertaken by people who would not otherwise cycle: 0.5
- Mean proportion of working age population who die each year: 0.003847
- Value of life (in Euros): EUR 1,500,000
- Discount rate: 5.0%

### Notes on how to use this tool
For additional instructions, hold the mouse over any red triangle.

- How many trips are observed (or are estimated) on the specific route; across a city; or on a network, in any direction?
- What is the mean trip length (estimated or measured)?
- The default parameters in green are based on best available evidence and are to be changed only if local data available.
- The estimated number of days per year that people cycle
- What proportion of these observed cyclists do you expect will also be making a return trip later in the day?
- Proportion of these cyclists that are new users DIRECTLY as a result of the new infrastructure or policy
- See local parameters page for explanation.
- What is the standard value of a statistical life used in the country of study?
- Discount rate used for future benefits. This is only used for the 'Present value of mean annual benefits', see step 3.

### Step 3: read the economic savings resulting from reduced mortality

<table>
<thead>
<tr>
<th>Benefit Type</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum annual benefit</td>
<td>EUR 101,015,000</td>
</tr>
<tr>
<td>Savings per km cycled per individual cyclist per year</td>
<td>EUR 0.81</td>
</tr>
<tr>
<td>Savings per individual cyclist per year</td>
<td>EUR 612</td>
</tr>
<tr>
<td>Savings per trip</td>
<td>EUR 2.72</td>
</tr>
<tr>
<td>Mean annual benefit</td>
<td>EUR 75,256,000</td>
</tr>
<tr>
<td>Present value of mean annual benefit</td>
<td>EUR 54,801,000</td>
</tr>
</tbody>
</table>

Based on:
- 5% discount rate
- 5 year build-up of benefit and 1 year build-up of uptake, averaged over 10 years

### Population parameters used to calculate results

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Population that stands to benefit</td>
<td>92560</td>
</tr>
<tr>
<td>Mean proportion of working age population who die each year</td>
<td>0.003847</td>
</tr>
<tr>
<td>Expected deaths in the local population</td>
<td>482.35</td>
</tr>
<tr>
<td>Protective benefit, according to actual distance traveled</td>
<td>0.14</td>
</tr>
<tr>
<td>Lives saved</td>
<td>67.34</td>
</tr>
</tbody>
</table>

This reflects the relative risk of all cause mortality in the age groups that are most likely to cycle
Yearly deaths expected among the population of cyclists (assuming they are aged 25-64)
Relative risk of death among cyclists, adjusted for the actual distance cycled (assuming regular trips per year)
Reduction in number of deaths expected due to the modelled increase in cycling

Click here to change local parameters
Click here to view underlying study parameters

Click here to change the timeframe used in calculation
Click here to view full calculation, graphs and adjust error

Reset all default values
### Step 1: enter your data (all users must fill in the red fields)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of trips per day</td>
<td>13,000</td>
</tr>
<tr>
<td>Mean trip length (km)</td>
<td>2</td>
</tr>
</tbody>
</table>

### Step 2: check the parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean number of days cycled per year</td>
<td>160</td>
</tr>
<tr>
<td>Proportion of trips that are one part of a return journey (or 'round trip')</td>
<td>0.005113</td>
</tr>
<tr>
<td>Proportion undertaken by people who would not otherwise cycle</td>
<td>1.000000</td>
</tr>
<tr>
<td>Mean proportion of working age population who die each year</td>
<td>0.0005113</td>
</tr>
<tr>
<td>Value of life (in Euros)</td>
<td>EUR 700,000</td>
</tr>
<tr>
<td>Discount rate</td>
<td>5.0%</td>
</tr>
</tbody>
</table>

### Step 3: read the economic savings resulting from reduced mortality

**Maximum annual benefit:**

<table>
<thead>
<tr>
<th>Benefit Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Savings per km cycled per individual cyclist per year</td>
<td>EUR 0.66</td>
</tr>
<tr>
<td>Savings per individual cyclist per year</td>
<td>EUR 212</td>
</tr>
<tr>
<td>Savings per trip</td>
<td>EUR 133</td>
</tr>
</tbody>
</table>

**Mean annual benefit:**

**EUR 2,054,000**

**Present value of mean annual benefit:**

**EUR 1,496,000**

Based on the following assumptions (see user guide for details):

- 5% discount rate
- 5 year build-up of benefit and 1 year build-up of uptake, averaged over 10 years

### Population parameters used to calculate results

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Population that stands to benefit</td>
<td>13000</td>
</tr>
<tr>
<td>Mean proportion of working age population who die each year</td>
<td>0.005113</td>
</tr>
<tr>
<td>Expected deaths in the local population</td>
<td>66.47</td>
</tr>
<tr>
<td>Protective benefit, according to actual distance traveled</td>
<td>0.06</td>
</tr>
<tr>
<td>Lives saved</td>
<td>3.94</td>
</tr>
</tbody>
</table>
HEAT is very conservative

- Only effects from physical activity
- Only mortality
- No co-benefits considered
Applications

- Project website visited over 7000 times, products downloaded over 650 times
Selected applications

- **Czech Republic**: used HEAT for cycling used to calculate potential benefits from cycling in the city of Pilsen
  - **USD 1.2 million** if 2% of population took up regular cycling

- **Swedish Government**: adopted HEAT for cycling as part of official toolbox for the economic assessment of cycling infrastructure

- **UK/England DfT**: adopted HEAT for cycling as part of official toolbox for the economic assessment of cycling infrastructure

- **UK/Scotland**: HEAT used to estimate benefit from reaching cycling targets
  - **USD 1.5-3 billion** per year if modal share goal of 13% reached
  - Recommended that Scottish Transport Appraisal Guidance should include health benefits from cycling and walking

- **New Zealand**: University of Auckland used HEAT to value adding cycling and pedestrian facilities to the Auckland Harbour Bridge
  - **900,000 USD** per 1000 regular bike commuters

- **United States**: adaptation of tool for the US underway (by CDC)

- **Austria**: used HEAT for cycling to calculate current savings from cycling in Austria
Now also in Russian

- Thanks to the German Federal Environment Agency and Federal Ministry for the Environment, Nature Conservation and Nuclear Safety
New developments: HEAT for walking (2009-2011)

Development of HEAT walking:

- Supported by:
  - UK donor consortium – represented by Natural England
  - Swiss Federal Office of Public Health

- Preliminary estimates of the $$$$ benefits much greater than for cycling!

- Relevance for some countries much higher than cycling:
  - Walking is a universal behaviour;
  - Fewer barriers (infrastructure, safety, culture, attitudes)
Costs: Economic valuation of transport-related health effects

- Selection of health effects in adults and children
- Relationships between exposure and health effect
- Estimated fraction of exposure coming from transport
- Assign costs to health effects
- Practical guidance for quantification of health effects of air pollution, injuries, noise and physical inactivity
## Example data from Switzerland

<table>
<thead>
<tr>
<th></th>
<th>Passenger transport</th>
<th>Freight transport</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Car</td>
<td>Public bus</td>
<td>Trolley</td>
</tr>
<tr>
<td>Costs in millions of US dollars</td>
<td>Road crashes</td>
<td>3675</td>
<td>53&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td></td>
<td>Air pollution</td>
<td>461</td>
<td>33</td>
</tr>
<tr>
<td></td>
<td>Noise</td>
<td>365</td>
<td>18</td>
</tr>
<tr>
<td>Total</td>
<td>4470</td>
<td>108&lt;sup&gt;a&lt;/sup&gt;</td>
<td>135</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Costs in US dollars per vehicle-km</th>
<th>Average</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Road crashes</td>
<td>0.071</td>
<td>0.177&lt;sup&gt;a&lt;/sup&gt;</td>
<td>1.12</td>
<td>0.449</td>
<td>2.99</td>
<td>0.095</td>
<td>0.076</td>
<td>0.079</td>
<td>0.077</td>
<td>7.7</td>
<td>0.094</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Air pollution</td>
<td>0.009</td>
<td>0.143</td>
<td>0.096</td>
<td>N.A.</td>
<td>0.073</td>
<td>0.009&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.010</td>
<td>0.038</td>
<td>0.124</td>
<td>0.129</td>
<td>7.2</td>
<td>0.015</td>
<td></td>
</tr>
<tr>
<td>Noise</td>
<td>0.007</td>
<td>0.08</td>
<td>0.007</td>
<td>0.022</td>
<td>0.08</td>
<td>0.007</td>
<td>0.010</td>
<td>0.022</td>
<td>0.080</td>
<td>0.080</td>
<td>4.5</td>
<td>0.013</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>0.087</td>
<td>0.361</td>
<td>1.273</td>
<td>0.701&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.115</td>
<td>0.14</td>
<td>0.283</td>
<td>0.286</td>
<td>18.9</td>
<td>0.122</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Find more information at:

- Quantification of health benefits of cycling and walking: [www.euro.who.int/transport/policy/20070503_1](http://www.euro.who.int/transport/policy/20070503_1)


- HEPA Europe (European network for promotion of health-enhancing physical activity): [www.euro.who.int/hepa](http://www.euro.who.int/hepa)

Thank you!
HEAT

Contributors

Lars Bo Andersen, Fiona Bull, Nick Cavill, Paul Fischer, Francesco Mitis, PierPaolo Mudu, Pekka Oja, Larissa Roux, Irene van Kemp, Erna van Balen, Rob Jongeneel, Hannah vd Bogaard

Advisory group

Anna Alberini, Peter Bickel, Charlotte Braun-Fahrländer, Olivier Chanel, Elisabetta Chellini, Göran Friberg, Max Herry, Nino Künzli, Charles Lloyd, Snejana Markovic-Chenais, Hans Nijland, Annette Prüss-Üstün, Andrea Ricci, Christian Schweizer, Marc Suhrcke, Pascale Scapecchi, Christoph Schreyer / Markus Maibach, Juliet Solomon

Reviewers

Tord Kjellström, Health and Environment International Trust, New Zealand

Michal Krzyzanowski, WHO Regional Office for Europe

Nathalie Simon, US.EPA National Centre for Environmental Economics

In collaboration with:

HEPA Europe
European network for the promotion of health-enhancing physical activity

Transport, Health and Environment Pan-European Programme THE PEP

Pollution reductions options network

World Health Organization

Regional Office for Europe
HEAT for cycling

Input data (Exposure)
- Trips/day
- Distance/trip

Relative risk estimate

Assumption of linear dose response

Health Outcomes
- All cause mortality

Economic Benefits
- Value of Lives saved (€€)

User

Audience

Caption
- Required user input
- Default values modifiable by user
- Non-modifiable

World Health Organization
REGIONAL OFFICE FOR Europe
HEAT for cycling

User → Input data (Exposure) → Health Outcomes → Economic Benefits → Audience

Required user input
- Trips/day
- Distance/trip
- Days cycled per year
- Proportion of return journeys
- Proportion of new cyclists
- Uptake time of cycling
- Time period of calculation

Default values modifiable by user
- Relative risk estimate
- Onset of health benefits
- Assumption of linear dose response

Default values for certain types of applications
- All cause mortality
- Value of statistical life
- Population mortality rate
- Discount rate for future benefits
- Value of Lives saved (€€)

Non-modifiable
- Assumption of linear dose response
- Relative risk estimate
- Onset of health benefits

Caption
- Required user input
- Default values modifiable by user
- Default values for certain types of applications
- Non-modifiable
Input data: health

Step 1: Traffic characteristics by mode of transport and type of vehicle

Step 2: Assessment of exposure (emissions → dispersion → concentrations)

Step 3: Estimated health effects
- identifying exposure–response functions
- and calculating the number of cases

Step 4: Economic valuation of health effects
- all effects valued in economic terms

Total costs
- summing up the health effects multiplied by the cost figures

Input data: road traffic, environment and costs

Characteristics of road traffic (traffic volume, speed, density and infrastructure quality) by type of vehicle and mode of transport

Emissions of each type of vehicle and mode of transport
- Dispersion models and meteorological data

Economic cost figures, such as health costs per case or cost of life-years

World Health Organization
REGIONAL OFFICE FOR Europe
Underlying study: Copenhagen cohorts

- 6,954 regular cycle commuters
- Total study population of 30,640
- Followed up for an average of 14.5 years
- Mean journey time of 3 hours per week
- Relative risk of death 0.72 (95% CI 0.57-0.91)
- Adjusted for age, sex, educational status, leisure time physical activity, body mass index, blood lipid levels, smoking and blood pressure

Why has the health sector an interest in transport and urban development?

Transport and the urban environment play a role in several of the leading risk factors for health

<table>
<thead>
<tr>
<th>Risk factors related to transport/urban policies</th>
</tr>
</thead>
<tbody>
<tr>
<td>High blood pressure</td>
</tr>
<tr>
<td>Physical activity/diet</td>
</tr>
<tr>
<td>High Body Mass Index</td>
</tr>
<tr>
<td>Physical activity/nutrition</td>
</tr>
<tr>
<td>Respiratory diseases</td>
</tr>
<tr>
<td>Urban air pollution</td>
</tr>
<tr>
<td>Cardiovascular diseases</td>
</tr>
<tr>
<td>Urban air pollution, physical activity, diet</td>
</tr>
<tr>
<td>Cancer (some)</td>
</tr>
<tr>
<td>Diet, physical activity</td>
</tr>
<tr>
<td>Injuries</td>
</tr>
<tr>
<td>Road traffic</td>
</tr>
</tbody>
</table>
Collaborative project: econ valuation

Main partners:
- WHO Regional Office for Europe
- Ecoplan (Switzerland) – economic aspects
- RIVM (Netherlands) and contributors – epidemiological aspects

Contributors
Lars Bo Andersen, Norway; Fiona Bull, United Kingdom; Nick Cavill, United Kingdom; Luis Cifuentes, Chile; Paul Fischer, Rob Jongeneel, Erna van Balen, Hannah van den Bogaard, the Netherlands; Christoph Lieb, Switzerland; Francesco Mitis, Pierpaolo Mudu, WHO Regional Office for Europe; Pekka Oja, Sweden; Larissa Roux, Canada

- Advisory group of 18 experts from 10 countries and WHO
- 3 external reviewers
- Synergy with key related initiatives:
  - OECD/EC VERHI project
  - THE PEP/HEPA Europe project on quantification of health benefits of cycling and walking
  - ENHIS/WHO guidelines for HIA air pollution, noise

Supported by: World Health Organization
Health effects represent the largest part of the external costs of transport.

The external costs of transport are estimated at ca 8% of GDP in the EU(*).

Savings from improved health could be re-invested in other societal priorities;

## Why should the transport and urban development sectors have an interest in health?

<table>
<thead>
<tr>
<th>Which Goals</th>
<th>Whose Interest</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reduce emissions of:</td>
<td>Environment</td>
</tr>
<tr>
<td>– air pollutants</td>
<td>Health</td>
</tr>
<tr>
<td>– greenhouse gases</td>
<td>Transport</td>
</tr>
<tr>
<td>– noise</td>
<td>Urban Development</td>
</tr>
<tr>
<td>Reduce congestion</td>
<td>Transport</td>
</tr>
<tr>
<td>Reduce road traffic injuries</td>
<td>Transport</td>
</tr>
<tr>
<td>Reduce investments in infrastructure to cater for more cars</td>
<td>Transport</td>
</tr>
<tr>
<td>Improve accessibility and quality of urban life</td>
<td>Transport</td>
</tr>
<tr>
<td>Complement technological improvements to vehicles and fuels</td>
<td>Transport</td>
</tr>
<tr>
<td>Increase physical activity</td>
<td>Health</td>
</tr>
<tr>
<td>Facilitate access to healthy diets</td>
<td>Health</td>
</tr>
<tr>
<td>Promote tourism</td>
<td>Tourism and leisure industry, urban development</td>
</tr>
<tr>
<td>Creation of new jobs</td>
<td>Economy, welfare, labour, urban development</td>
</tr>
</tbody>
</table>