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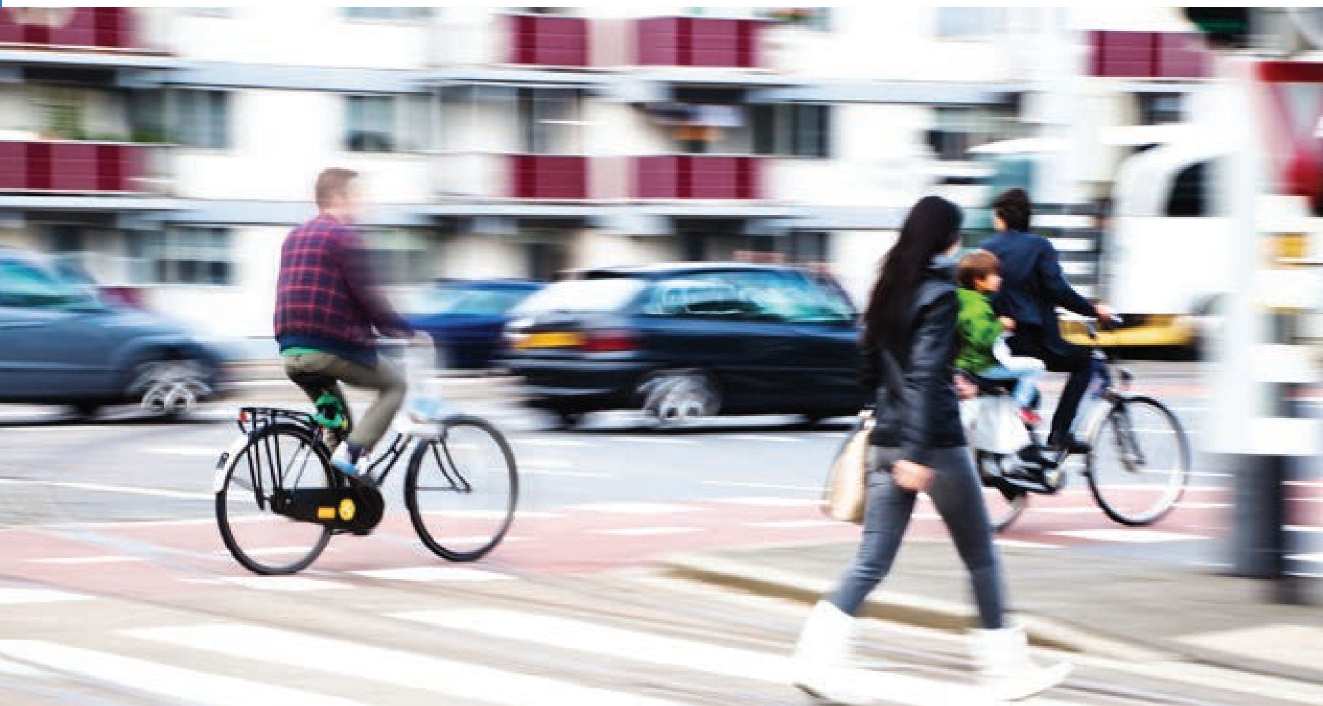
Health economic assessment tools (HEAT) for walking and for cycling



Methods and user guide, 2014 update

ECONOMIC ASSESSMENT OF TRANSPORT INFRASTRUCTURE AND POLICIES

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The views expressed herein can in no way be taken to reflect the official opinion of the European Union.

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Health economic assessment tools (HEAT) for walking and for cycling

Methodology and user guide, 2014 update

ECONOMIC ASSESSMENT OF TRANSPORT INFRASTRUCTURE AND POLICIES

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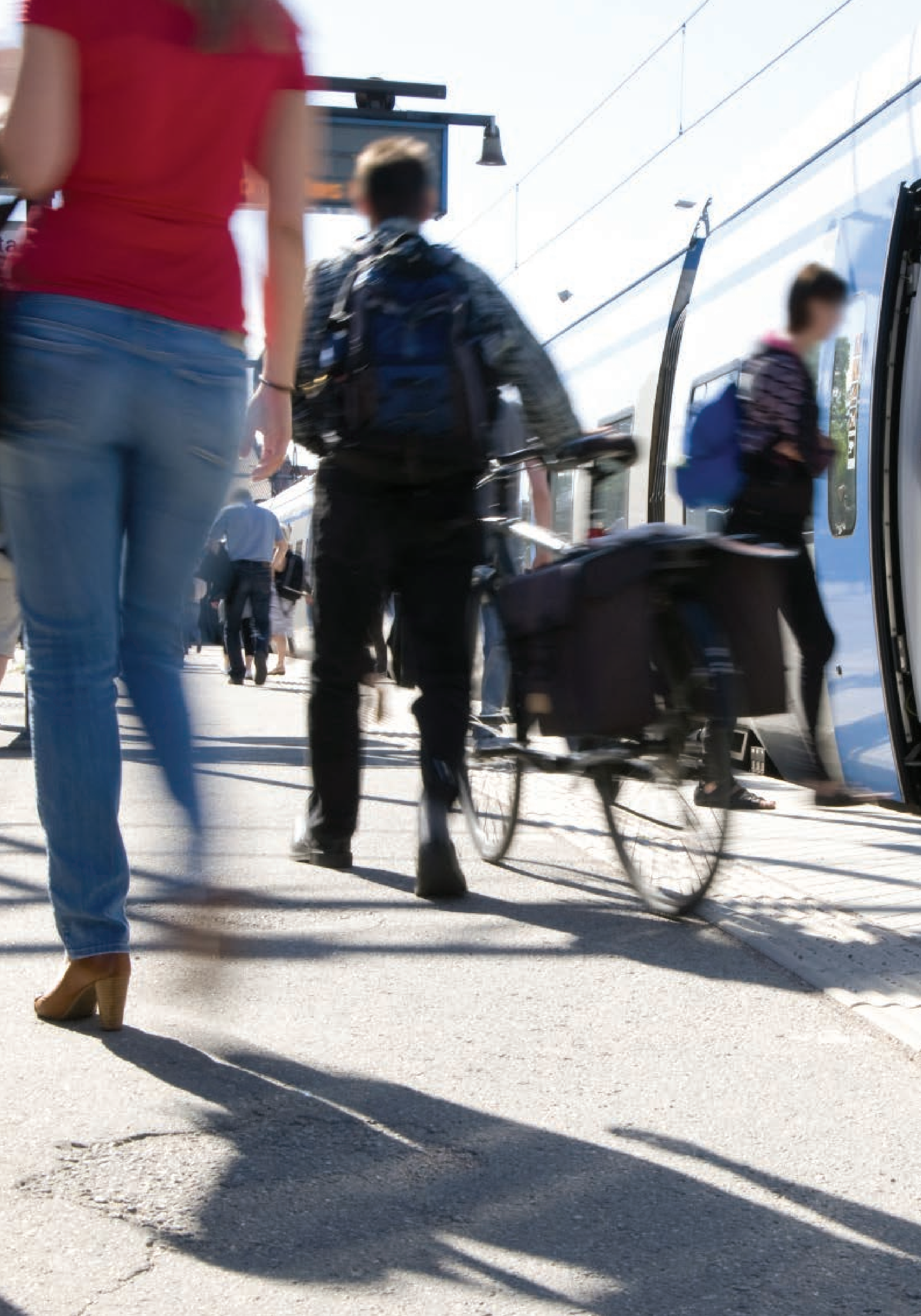
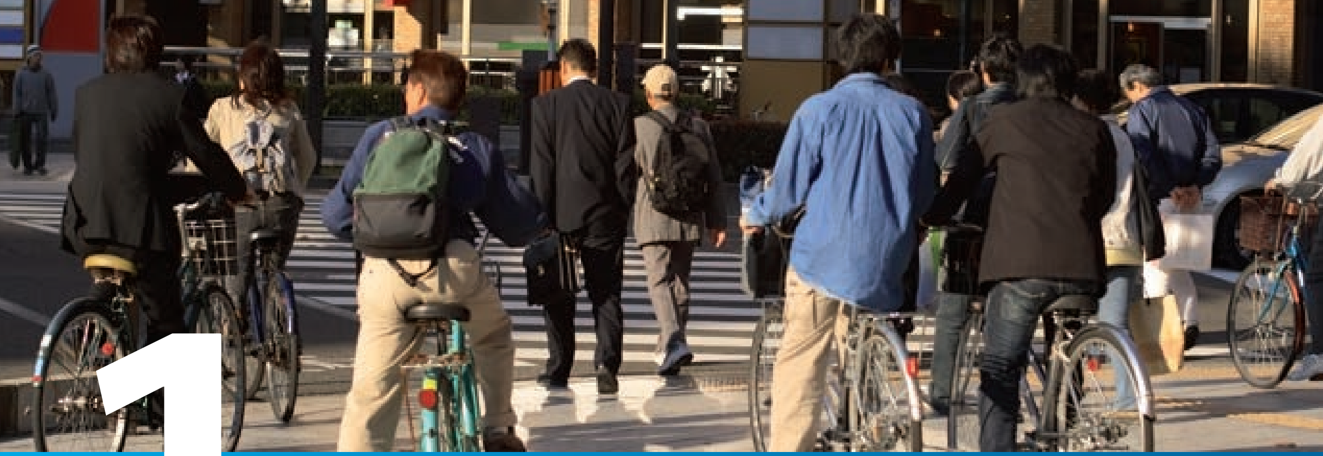




1 Introduction

Physical inactivity is a significant public health problem in most regions of the world, which is unlikely to be solved by classical health promotion approaches alone. The promotion of active transport (cycling and walking) for everyday physical activity is a win-win approach; it not only promotes health but can also lead to positive environmental effects, especially if cycling and walking replace short car trips. Cycling and walking can also be more readily integrated into people's busy schedules than, for example, leisure-time exercise. These forms of physical activity are also more practicable for groups of the population for which sport is either not feasible because of physical limitations or is not an accessible leisure activity for economic, social or cultural reasons. There is a large potential for active travel in European urban transport, as many trips are short and would be amenable to being undertaken on foot or by bicycle. This, however, requires effective partnerships with the transport and urban planning sectors, whose policies are key driving forces in providing appropriate conditions for such behavioural changes to take place. This has been recognized by a number of international policy frameworks, such as the Action Plan for implementation of the European Strategy for the Prevention and Control of Noncommunicable Diseases 2012–2016, adopted by the WHO Regional Committee for Europe *(1)*. The strategy identifies the promotion of active mobility as one of the supporting interventions endorsed by WHO Member States to address this high-priority topic in the European Region, as do other international policy frameworks such as the Toronto Charter for Physical Activity launched in May 2010 as a global call for action *(2)*.

Transport is an essential component of life and a basis for providing access to goods and services. Different modes of transport are associated with specific impacts on society, including health, environment and social effects. Fully appraising these effects is an important basis for evidence- based policy-making. Economic appraisal is an established practice in transport planning. However, techniques for assessing the economic value of the benefits to health of cycling and walking have historically been applied less systematically than the approaches used for assessing the other costs and benefits of new infrastructure.

Valuing health effects is a complex undertaking, and transport planners are often not well equipped to fully address the methodological complexities involved. A few countries in Europe, such as those working through the Nordic Council (Denmark, Finland, Iceland, Norway and Sweden), have carried out pioneering work in trying to assess the overall costs and benefits of transport infrastructures taking health effects into account, and guidance for carrying out such assessments has been developed. Nevertheless, important questions have remained.

Coordinated by WHO, three project phases were carried out aimed at developing guidance and practical tools for economic assessments of the health effects from (a) cycling and (b) walking. First published in 2007 and officially launched in 2009, a methodological guidance report *(3)* and a health economic assessment tool (HEAT) for cycling *(4)* were presented. In 2011, an updated online version of the HEAT for cycling and a HEAT for walking *(5)* were published. In 2014, the HEAT for walking and cycling were again updated *(6)*.

Implementation of the projects was steered by a core project group, which worked in close collaboration with advisory groups of international experts (see the list of contributors above). These experts were specifically selected to represent an interdisciplinary range of professional backgrounds and expertise, including health and epidemiology, health economics, transport economics, a practice and/or advocacy perspective, and policy development and implementation. Close coordination also took place with the Transport, Health and Environment Pan-European Programme (THE PEP) and HEPA Europe (the European network for the promotion of health-enhancing physical activity).

The key project steps were as follows.

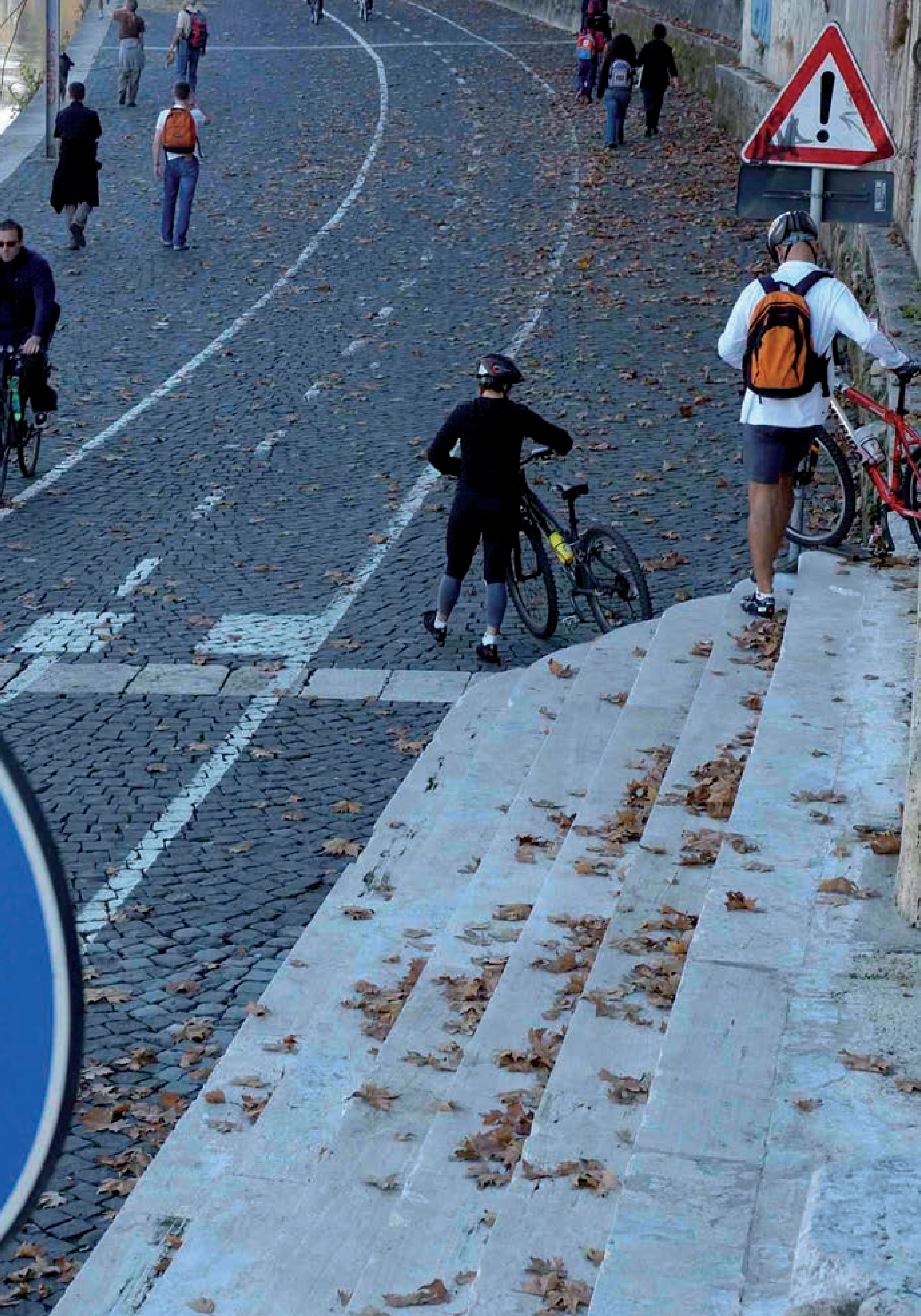
- The project core group commissioned systematic reviews (a) of published economic valuations of transport projects, including a physical activity element (2007 *(7)* and 2010) and (b) of epidemiological literature with regard to health effects from cycling and walking, particularly for transport (2010 and 2013).
- The results of these reviews were considered by the core group and used to propose options for and guidance towards a more harmonized methodology.
- Draft methodological guidance and practical tools for cycling and for walking were developed and tested, and piloted by members of the advisory group.
- International consensus meetings with the advisory groups on walking and on cycling, respectively, were held in 2007, 2010 and 2013 to facilitate discussion and the achievement of scientific consensus on the options proposed in the draft methodological guidance and tools.
- Based on the meeting recommendations, further bilateral discussions with different members of the advisory group and extensive pilot testing by additional experts, the products of each project phase were approved for publication. These included: a guidance document *(3)* and a methodology and user guide *(5)*, an online tool for walking and for cycling *(6)* (based on a previous, Excel-based version for cycling only *(4)*) and this publication. Scientific publications include a systematic review of the economic literature *(7)*, a publication on HEAT for cycling applications *(8)* and a publication on the initial HEAT cycling methods *(9)*.

This publication represents a summary of these products. Chapter 2 presents the main conclusions on the methods for economic assessment of transport infrastructure and policies regarding inclusion of the health effects of walking and cycling. Chapter 3 contains the main results of systematic reviews of economic and health literature.

The principles outlined in the guidance have been applied in two web-based, practical calculation tools, showing how the methodology can be used to assess health effects related to walking or to cycling, respectively. The main principles are outlined in Chapter 4. The tools are available online *(6)*. If you are mainly looking for guidance on applying the HEAT tools, please go directly to Chapter 4 and then read Chapter 5 and/or Chapter 6, which contain detailed user guides with instructions for walking and cycling, respectively, and outline potential limitations of the approach. Further hints and tips can be found online.

Knowledge of the health effects of cycling and walking is evolving rapidly. These projects represent important steps towards agreed harmonized methods. In developing these tools, on several occasions the advisory groups made expert judgements based on the best available information and evidence. Therefore, the accuracy of results of the HEAT calculations should be understood as estimates of the order of magnitude, much like many other economic assessments of health effects. Further improvements will be made as new knowledge becomes available.

Feedback to further improve the tools and maximize their user-friendliness is welcome at: heat@euro.who.int.



2 Methodological guidance on economic appraisal of health effects related to walking and cycling

This chapter summarizes the key methodological issues concerning the economic appraisal of health effects related to walking and cycling. A more extensive discussion of these issues, including options for and guidance towards a more harmonized methodology for the economic appraisal of the health effects of walking and cycling, has been published previously *(3)*. The conclusions of this earlier report were updated in 2010 and 2013 in view of new evidence (see also Chapter 3).

2.1. Walking and cycling data

The quality of economic appraisals is highly dependent on the validity and reliability of the walking and cycling data used. In many countries, systematic long-term surveys of cycling and walking are not yet available or they do not provide local-level data, which are often needed for the appraisal of a local transport intervention or infrastructure.

When using data from local surveys, it must be ensured that they are representative for the population assessed with the HEAT. The studies should have been carried out over a sufficient period of time and across sufficient locations to adjust for temporal and spatial variations in cycling or walking.

2.2. Time needed to reach full level of walking or cycling

Transport interventions can take various lengths of time to influence a particular type of behaviour. For example, a certain new cycle path might result in immediate uptake, while it might take a year or more to see levels of use increase on another. Transport appraisals should allow for different assumptions about the speed or level of uptake of cycling or walking after such interventions.

2.3. Interactions between transport-related physical activity, air pollution and road traffic injuries

Transport-related health effects include possible negative effects from exposure to ambient air pollution or road traffic injuries. Possible interactions between the positive effects of exercise through active transport and such negative effects need to be considered. To date, no comprehensive review of active transport and physical activity is available that takes the possible negative effects of ambient air pollution into account.

Regarding road traffic injuries, evidence suggests that, if promotion of active travel is accompanied by suitable transport planning and safety measures, active commuters are likely to benefit from a "safety in numbers" effect *(10)*: with increasing levels of active travel, walking and cycling become safer. Such measures could, at the same time, lead to less exposure to air pollution if more cycling occurs away from main roads.

Two recent scenario analyses showed that, in most cases, especially in western Europe, the positive health effects of cycling are likely to greatly outweigh the negative effects of air pollution and road traffic accidents suffered by cyclists *(11,12)*. Also, the use of all-cause mortality estimates (see also below) rather than cause- specific ones has the advantage of incorporating the possible detrimental effects associated with walking or cycling. Nevertheless, developing modules to incorporate the health effects related to air pollution and injuries have been identified as items for further refining HEAT.

2.4. Mortality or morbidity?

Physical activity has beneficial effects on many aspects of morbidity such as coronary heart disease, stroke, diabetes, some types of cancer, musculoskeletal health, energy balance and aspects of mental health (including anxiety and depression) and improving functional health in elderly people *(13)*. From a public health point of view, these benefits materialize more rapidly than reductions in mortality. They can also be important in motivating individuals to walk and/or cycle, as people may be more likely to increase their physical activity to improve their immediate health and well-being than to prolong their life. Nevertheless, the current evidence on morbidity, both for walking and for cycling, is more limited than that on mortality. Thus including the impact of morbidity in an economic appraisal leads to greater uncertainty. The consensus meetings therefore recommended, for the time being, focusing only on all-cause mortality for HEAT for walking and for cycling. It should be noted that this method is likely to produce conservative estimates, since it does not account for disease-related benefits.

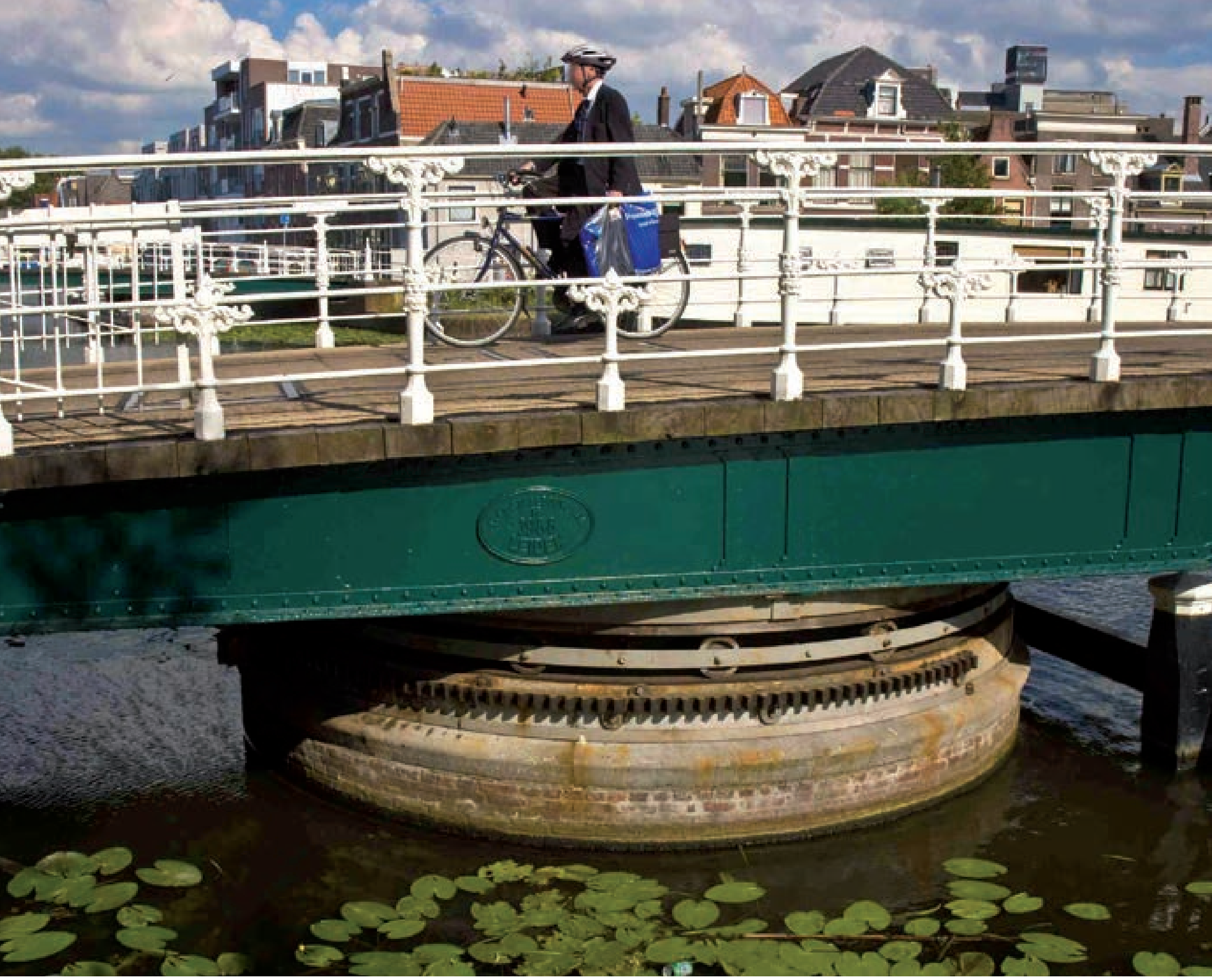
Nevertheless, addressing morbidity was identified as another important item for later refinement to broaden the tool's appeal (see also section 3.2).

2.5. The nature of the relationship between physical activity and health

Epidemiological studies report relationships between different categories or levels of exposure and health outcomes. For example, a comparison of sedentary people with people who are active beyond a specific threshold (such as 150 minutes of activity per week) may show that active people are healthier. However, there is a strong consensus that physical activity has a continuous dose–response relationship with most health outcomes, i.e. each increase in physical activity is associated with additional health benefits *(13,14)*. This has also been shown by studies looking specifically at walking or cycling *(15,16)*.

To develop a method to quantify the health effects of active transport, a dose–response relationship needs to be incorporated. For many health outcomes, the exact shape of the curve is still uncertain *(13)* but, for mortality, literature suggests that the relationship is most likely non-linear *(17–19)*. Meta-analyses on the risk of all-cause mortality and cycling and walking carried out as part of the HEAT updating process in 2013–2014 *(20,21)* supported this finding (see also section 3.2). However, they also showed that differences between various dose–response curves were small and that a linear function would represent a good fit of the data.

Based on this, the international advisory group concluded that, overall, a linear dose–response function is the most suitable one to use for



HEAT. In this way, users do not have to know the baseline level of physical activity of their subjects, and a constant absolute risk reduction can be applied for all HEAT applications within the range of exposure for which an incremental reduction of mortality risk can be observed (see Chapter 4). An approach based on a non-linear relationship could be adopted as part of future updates of HEAT, when suitable data on the baseline level of physical activity in different populations are available to provide default values for HEAT.

In general, appraisals should consider the distribution of physical activity in the population in question. In particular, caution should be exercised in interpreting the results of modeling walking or cycling benefits in groups disproportionately comprising sedentary or very active individuals, as this could lead to a small overestimation of benefits in already active groups of the population and a small underestimation in less active ones.

There is some limited evidence of a stronger association between the perceived intensity (pace) of walking and health effects than for volume of walking *(16,22)*. However, these studies did not correct for the fitness of the participants or the true distance covered and it remains difficult to assess their relative importance. In general, taking account of walking or cycling pace might lead to a more accurate assessment of the health effects, for example by differentiating between the different paces in leisure and transport walking or cycling, but it will also lead to more complicated models and additional uncertainties. HEAT does not take into account differences in the pace (or intensity) of walking or cycling, or the possibility that less well-trained individuals may benefit more and better-trained individuals may benefit less from the same amount of walking or cycling.

2.6. Age groups

Ideally, economic analysis would be able to take account of the differential effects of physical activity on children and adults, and on adults of different ages. However, the vast majority of epidemiological studies have been conducted on adults, mainly because the most commonly studied disease end-points such as coronary heart disease or death are rare in children, and studies on adults are easier to carry out. Thus the evidence base for the chronic health effects of physical activity on young people is not as large as that for adults. The advisory group concluded that the evidence for children and adolescents was insufficient, and that economic appraisals should focus on adults only in the first instance.

Studies find that risk reduction differs by age; for example, increased activity might yield higher benefits in older age groups than in younger age groups. Differentiating risk reduction by age groups could further enhance the results of economic appraisals. However, this would require cycling and walking data by age groups, which is so far usually not available. The availability of transport data by age group should be further improved.

Age is also very relevant for the mortality rates used. Mortality rates vary substantially by age, and thus the choice of age range for the rate used in an economic appraisal can have a significant impact on the calculated benefits.

Therefore, the age groups to which the results may be applied and for which mortality rates were used should be made explicit. If any model is subsequently applied to children or older adults, any related assumptions should also be made explicit.

2.7. Sex

The review of the epidemiological evidence did not find obvious differences between the sexes in the effects on all-cause mortality (see section 3.2) that would warrant different relative risk estimates for men and women.

Active transport behaviour can differ between men and women; for example, women often walk and cycle more than men. Ideally, economic analyses should take account of such gender differences.

2.8. Time needed for health benefits to build up

The epidemiological evidence on the effects on health of physical activity *(13,14)* implies that economic analysis should be carried out for habitual walking and cycling behaviour.

It is important to recognize that there will be a delay between increases in physical activity and measurable benefits to health. Based on the best available evidence, it was concluded that five years was a reasonable assumption to use for such "newly induced physical activity" to reach full effect, with an increment of 20% in benefits each year.

2.9. Activity substitution

This guidance is concerned with the effect on health of transport infrastructure and other types of transport interventions that are expected to result from walking or cycling. However, most of the literature on risk of disease relates to total physical activity, usually a composite index expressing overall energy expenditure (often measured as kilocalories (kcal) per week) or time spent active, including a wide range of non-transport activity such as leisure-time and occupational activity. The approach therefore needs to address the issue of a potential substitution of one form of activity for another, which could occur in two ways.

1. Does an observed increase in rates of walking and cycling necessarily mean there has been an increase in total physical activity? For example, people may have stopped jogging when they started cycling or walking to work. While this is theoretically possible, none of the involved experts was aware of any evidence that would support such a pattern. Nevertheless, intervention studies should consider, for example, that a new cycle path may lead to a user's new journey actually being shorter than before.

2. The results of studies on walking or cycling could be confounded by other forms of physical activity, such as leisure- time activities. This could lead to an overestimation of the health effects of walking or cycling if those people who cycle or walk were actually more active through other forms of physical activity. It is recommended that activity substitution is accounted for in economic analyses as far as possible. This means not assuming that any increase in cycling or walking automatically leads to a similar increase in total physical activity, and using studies that correct for non-transport- related forms of physical activity.

2.10. Seasonality and regional differences in cycling and walking

Cycling and walking behaviour may depend somewhat on location and culture, and climate and seasonality may also influence the total annual amount of walking and cycling. To date, very few published studies have explained how exposure was controlled for the effects of seasonality or climate *(21)*. The available evidence does not yet enable a consolidated approach to be developed to address this issue. It is recommended to use local data on walking and cycling levels to take into account context-specific effects of seasonality, culture or climate.

2.11. Static versus life tables approach

Since economic appraisals evaluate benefits over a period of time, several parameters may not stay constant over the time of the analysis. For example, the mortality rate in the population may change, owing to an increase in walking or cycling or other factors. The evaluated populations also represent a broad age range and health effects may vary by age. Life table calculations constitute a methodology to address these issues.

Recent scientific appraisals of health benefits from physical activity have applied such approaches. However, since introducing life-table calculations in HEAT would increase the complexity for its target users and since the potential improvement in accuracy appears to be small compared with the remaining uncertainties in various other parameters of such appraisals, the international advisory group concluded that life-table calculations should not be introduced in HEAT at this stage.

2.12. Costs applied

To conduct an economic appraisal of walking and cycling, it is necessary to agree on a method of valuing health (or life). There are a number of ways in which this can be done.

- **A standard value of a statistical life (VSL)** This is often used in transport appraisals. It is most commonly derived using a method called willingness to pay. The willingness to pay shows how much a representative sample of the population (who, in this instance, are potential victims) would be willing to pay (in monetary terms) for example for a policy that would reduce their annual risk of dying from 3 in 10 000 to 2 in 10 000.

- **Cost of illness**
  This applies costs (for example costs to the national health service or loss of earnings) to each specific disease.

- **Years of life lost (or gained**)
  This allows a more comprehensive assessment of health effects, as it takes the life expectancy of the participants into account.

- **Quality-adjusted life-years**
  These are derived from years of life spent in ill health, multiplied by a weight measuring the relative undesirability of the illness state.

- **Disability-adjusted life-years" (DALYs)**
  These measure the overall disease burden, expressed as the number of years lost due to ill health, disability or early death.

Different economic end-points are preferred by different audiences – transport planners often prefer VSL, while health experts prefer years of life lost or health care costs. As this project was aimed primarily at transport appraisals, the VSL approach was used, as this is more common in transport appraisals.

A recent review has found an average VSL of US$ 3.6 million for the EU27 countries *(23)* (see also section 3.1). This is substantially higher than earlier commonly used values in Europe, such as the €1.5 million proposed by the UNITE study *(24),* which was previously used by HEAT *(5)*. Thus, internationally, VSL differs substantially *(23–25)*; it is therefore recommended to use either a current, internationally agreed VSL or a local VSL, where available.

Other methods, such as an approach based on QALYs, could be adopted if data were available to permit a more comprehensive assessment and to broaden the appeal for a health audience. However, this would be challenging given the difficulties of assessing the effects of walking and cycling on morbidity (see also section 2.4) and would require more substantial changes to the design of HEAT.

2.13. Discounting

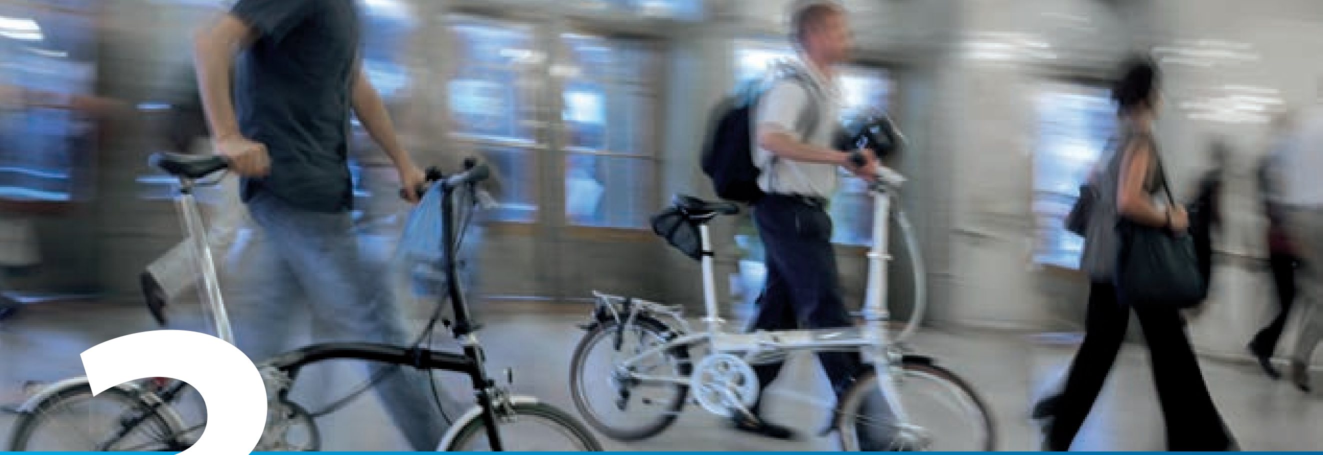
Since benefits occurring in the future are generally considered less valuable than those occurring in the present, economists apply a so called "discount rate" to future benefits. In many cases, the economic appraisal of health effects related to walking and cycling will be included as one component into a more comprehensive cost–benefit analysis of transport interventions or infrastructure projects. The final result of the comprehensive assessment would then be discounted to allow a calculation of the net present value.

When the health effects are to be considered alone, it is important that the methodology allows for discounting to be applied to this result as well.

2.14. Sensitivity analysis

Carrying out economic appraisals of the health effects of transport behaviour is a complex undertaking and will invariably involve a number of assumptions and expert judgements, as outlined above.

It is strongly recommended that the uncertainties around an assessment are made explicit, and that the calculations are carried out with high and low estimates of the main variables in order to gain a better understanding of the possible range of the final results.



3 Reviews of the literature: summary

3.1. Economic literature

To inform the development of the first version of HEAT for cycling, a systematic review of economic analyses of cycling and walking projects was carried out in 2007, in collaboration with the National Institute for Health and Care Excellence (NICE) in the United Kingdom *(7,26)*. The review aimed:

- to identify relevant publications through expert consultation and tailored searches of the literature;
- to review the approaches taken to including health effects in economic analyses of transport interventions and projects; and
- to propose recommendations for the further development of a harmonized methodology, based on the approaches developed to date.

To be included in this review, a study was required to:

- present the findings of an economic valuation of an aspect of transport infrastructure or policy;
- include data on walking and/or cycling in the valuation;
- include health effects related to physical activity in the economic valuation; and
- be in the public domain.

A total of 16 papers were included from an original list of 4267 titles. These covered a range of approaches to economic analysis, the majority being cost–benefit analyses of cycling projects or programmes. Quality was variable: using the quality scale adopted by NICE, only three of the studies were classified as “high quality” with a high probability that the observed relationship is causal (2++), six as “well conducted” with a moderate probability that the relationship is causal (2+) and seven “low quality” (2–).

Generally, the economic analyses showed positive benefit–cost ratios, the median being 5:1 with a range from –0.4 to 32.5. However, owing to the different methods applied in the studies, this value has to be viewed with caution. Some studies estimated the value attributed to each new walker or cyclist; these ranged from about €120 to €1300.

The review found wide variation in the approaches taken to including health effects of physical activity in economic analyses of transport projects. This was not helped by a lack of transparency in the methods used in many of the studies reviewed. The studies used various sources of data as the basis for their calculations, there appeared to be no consensus on the diseases to be included in mortality calculations, and few studies included a measure of morbidity.

One of the most significant challenges identified was the relationship between observed cycling or walking and total physical activity. Studies had to: use modeling to make assumptions about how cycling or walking might influence total physical activity; assume that all observed cyclists or walkers could be classed as sufficiently active (and therefore had a reduced risk and/or reduced medical costs); or make some sort of estimate of the scale of benefit somewhere between these two extremes. One study used an approach based on the relative risk of all-cause mortality among cyclists compared to non-cyclists. It appeared to have the greatest potential for further development towards a more uniform approach. This methodology was proposed as the basis for the development of the first version of HEAT for cycling *(4)*.

As part of the work on developing HEAT for walking and updating HEAT for cycling in 2010, an update was carried out of this systematic review designed to find papers published on the same topic since 2006 *(27)*. The same protocol was used for this search. Of over 1800 hits, 8 publications met the inclusion criteria.

The studies included in this review indicated that there did not appear to have been a significant methodological advance in valuing the health benefits of active travel. Methods remained variable, with limited transparency and reliance on numerous assumptions. As noted in the previous review, in most cases the health benefits of cycling and walking were based on the literature on physical activity in general, requiring assumptions on the health effects of cycling and walking being equivalent to other forms of physical activity as well as regarding the absence of "activity substitution".

Although excluded from the review on technical grounds for not including an economic assessment, the approach by Woodcock et al. *(28)* appeared to be the most systematic and methodologically robust. The core group was also made aware of studies in progress that used approaches involving QALYs or DALYs. While these approaches have many inherent advantages, the primary target audience for the HEAT for walking is transport planners (see also sections 2.12 and 4.2) and they are familiar with calculations based on VSL. Studies based on metrics used predominantly in the health sector, such as DALYs, are not directly applicable to this target audience.

It was concluded that the literature review supported developing a HEAT for walking using a similar approach as for the HEAT for cycling: estimating the value of reduced risk among walkers based on VSL. The 2013 consensus meeting also confirmed this general approach.

As explained in section 2.12, HEAT uses the VSL method to economically quantify the health benefits of reduced mortality from walking or cycling. Due to the dearth of official VSL studies, HEAT previously suggested using either a default value of €1.574 million *(5,24)* or a national VSL.

The Organisation for Economic Co-operation and Development (OECD) recently published a comprehensive review of VSL studies *(23)*. Studies were only included if they were based on a representative population sample of at least 200 subjects (or 100 for subsamples of larger studies) and provided information on the size of the risk change in question. About 400 values were selected to calculate the VSL for adults in 38 countries around the world. For the EU27 countries, an average VSL of US$ 3.6 million with a range from US$ 1.8 million to US$ 5.4 million (2005 US dollars).

Although the international advisory group acknowledged that other projects were underway aiming at developing a European VSL, it concluded that the OECD report represented the best currently available evidence. The international advisory group recommended using an updated European VSL, based on the OECD method. In addition to the EU27 value, a new European average value as well as country-specific default values will be provided (see sections 5.2 and 6.2).

3.2. Epidemiological literature

3.2.1. Cycling

The strongest evidence at the time of the first project on the health effects of cycling was the relative risk data from two combined Copenhagen cohort studies *(29)*. This study included 6954 20–60-year-old participants, followed up for average of 14½ years. It found a relative risk of all-cause mortality among regular commuter cyclists of 0.72 (95% confidence interval (CI): 0.57–0.91) compared to non-cycling commuters, for 3 hours of commuter cycling per week. It controlled for the usual socioeconomic variables (age, sex, smoking, etc.) as well as for leisure- time physical activity. As recommended *(3,7)*, it also adjusted for the possibility that observed associations between commuter cycling and mortality might have been caused (or inflated) by higher levels in leisure-time activity among cyclists.

In 2010, the evidence with regard to cycling was reassessed and, again, it was not possible to carry out a meta-analysis as there were insufficient relevant studies on cycling. A systematic review by Oja et al. *(15)* found only three prospective population studies on cycling and all-cause mortality.

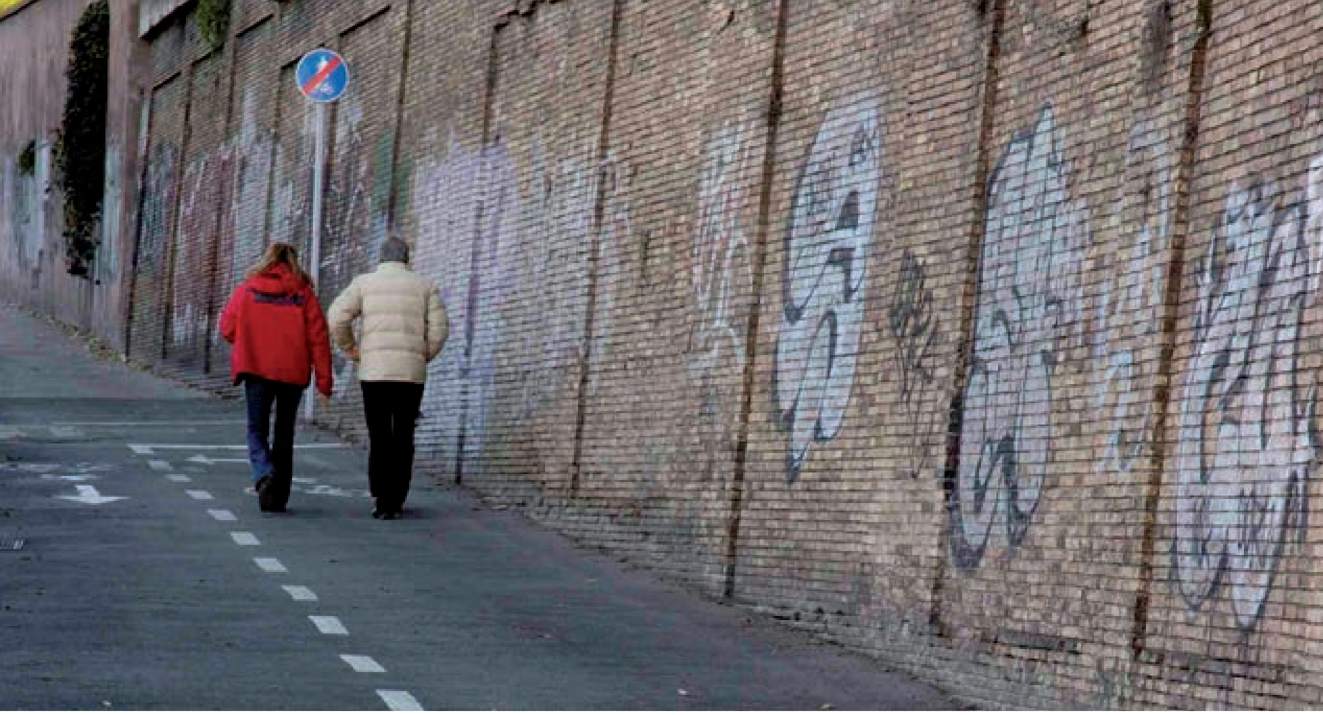
In 2013, a new systematic review on the reduced relative risk of all-cause mortality from regular cycling was carried out *(20)*.

To be included in this review, a study was required:

- to be a prospective cohort study;
- to report the level of regular walking or cycling (such as duration, distance or MET equivalent);
- report all-cause mortality rates or risk reductions as outcome; and
- report results independent of (that is, adjusted for) other physical activity.

A total of 8901 titles were identified, and 431 full texts were screened. Seven cycling studies met the inclusion criteria. Based on the Newcastle-Ottawa quality assessment scale for cohort studies, the studies were generally of high quality, scoring between 6 to 9 of 9 possible points. A meta-analysis was carried out, combining the results of these seven studies *(20)*.

Since the available studies used a range of different exposures, to conduct the meta-analysis it was necessary to estimate for each study the reduced risk at a common exposure level. For this purpose, the different cycling exposures used in the studies were converted into MET-hours per week (assuming a linear dose-response relationship and an average intensity of 6.8 METs for cycling if not otherwise stated). The common exposure level was set at 11.25



MET-hours per week. This value was derived from the global physical activity recommendations as corresponding to the recommended level of at least 150 minutes of moderate-intensity physical activity per week *(14)* using 4.5 METs as an average for moderate-intensity physical activity. Using 6.8 METs as an average intensity for cycling, this exposure represents about 100 minutes of cycling per week.

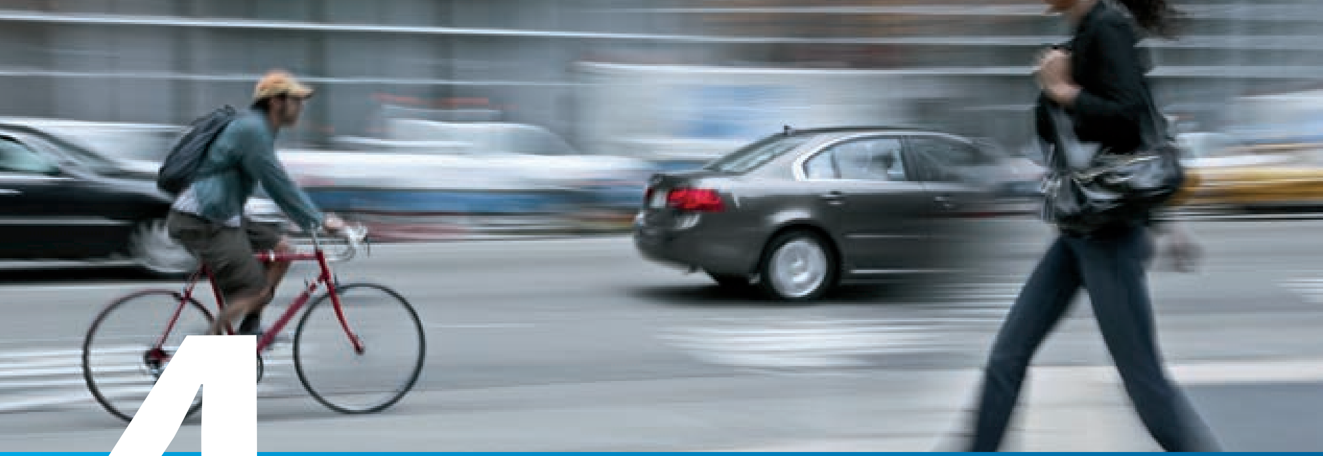
The sensitivity of the results to various possible shapes of dose–response relationships was tested. As explained in section 2.5, the differences between the various curves were small and the difference in the final risk estimate was no more than 6%. The international advisory group recommended that, for HEAT, a linear dose–response curve based on a relative risk of 0.90 (CI 0.87–0.94) for cycling and applying a constant absolute risk reduction would be the most suitable approach given its good fitting of the data and the simplicity of implementing it in HEAT.

3.2.2. Walking

In 2010, a systematic review to derive a risk estimate to be used for HEAT for walking was carried out *(5,27)*. The review found nine studies meeting the inclusion criteria. These studies were combined in a pooled-analysis to calculate an aggregated risk, weighted by sample size. The resulting relative risk estimate was 0.78 (95% CI: 0.64–0.98) for a walking exposure of 29 minutes, 7 days a week, which was used for the first HEAT walking.

In 2013, an updated systematic review and meta-analysis for walking was carried out similar to the one on cycling described in the previous section. Fourteen studies on walking and all-cause mortality met the inclusion criteria, also yielding high quality scores of 7 to 9 out of 9 possible points on the Newcastle-Ottawa Quality assessment scale for cohort studies. As for cycling, a meta-analysis was carried out, converting the different walking exposures into a common metric and using 11.25 MET-hours per week as common reference level for the risk reductions. Using an average intensity 4.0 METs for walking, this exposure represents 168 minutes of walking per week. Depending on the shape of the dose–response curve used, a risk reduction of 10–11% was found.

For the HEAT walking, the advisory group also recommended using a linear dose–response curve based on a relative risk of 0.89 (CI 0.83–0.96).



4 The HEAT for walking and for cycling: introduction

The principles and guidance set out in Chapter 2 have been developed into a practical tool for walking and for cycling, known as HEAT *(6)*. The tool estimates the maximum and the mean annual benefit in terms of reduced mortality as a result of walking or cycling. It can be applied in a number of situations, as further described in section 4.4, such as:

- when planning a new piece of cycling or walking infrastructure, helping to make the case for investment;
- to value the reduced mortality from past and/or current levels of cycling or walking; or
- to provide input into more comprehensive economic appraisal exercises or prospective health impact assessments.

It will help to answer the following question:

If x people cycle or walk for y minutes 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?

4.1. General principles of the tool

The following core principles for the HEAT tool were agreed upon by the international advisory groups. The tool should be:

- robust and based on the best available evidence;
- fully transparent regarding assumptions;
- based in general on a conservative approach
- (low-end estimates and default values); and
- as user-friendly as possible.

4.2. Who is the tool for?

The tool is based on the best available evidence and transparent assumptions. It is intended to be simple to use by a wide variety of professionals at both national and local levels. These include primarily:

- transport planners;
- traffic engineers; and
- special interest groups working on transport, walking, cycling or the environment.

The tool is also of interest to health economists, physical activity experts or health promotion experts. However, due to the use of transport-specific methods such as VSL, the results of HEAT in its current form might need to be accompanied with additional information and explanations for such audiences.

4.3. What can the tool be used for?

The tool can be used in a number of different situations.

- It can be used when planning a new piece of cycling or walking infrastructure. HEAT attaches a value to the estimated level of cycling or walking when the new infrastructure is in place. This can be compared to the costs of implementing different interventions to produce a cost–benefit ratio (and help to identify the most cost-effective investment).
- It can be used to evaluate the reduced mortality from past and/or current levels of cycling or walking, such as to a specific workplace, across a city or in a country. It can also be used to illustrate the economic consequences of a potential future change in levels of cycling or walking.
- It can be used to provide input to more comprehensive economic appraisal exercises, or prospective health impact assessments, such as to estimate the mortality benefits from achieving targets to increase cycling or walking or from the results of an intervention project.

The tool provides an estimate of the economic benefits accruing from walking or cycling as a result of lower death rates. Ideally, for a comprehensive assessment, it would be supplemented with data on other potential health outcomes from walking or cycling (morbidity) and combined with other transport-related outcomes such as less congestion, reduced journey times or fewer road traffic injuries. These and other enhancements will be considered for inclusion in future versions of the tool.

4.4. What should the tool not be used for?

Before using HEAT, the following should be considered carefully to make sure HEAT is applicable.

1. HEAT is to be used for assessments at the <u>population level</u>: for groups of people and not for individuals.

2. The tool is designed for <u>habitual walking or cycling behaviour</u>, such as for commuting or regular leisure-time activities. In particular, it should not be used for the evaluation of one-day events or competitions (such as walking days), since these are unlikely to reflect long-term average activity behaviour.

   In addition, HEAT for walking is meant to be applied for <u>walking of at least moderate pace</u>, i.e. about 3 miles/hour (4.8 km/hour), which is the walking speed of the studies in the meta-analysis, where available. This is also consistent with the minimum walking pace necessary to require a level of energy expenditure considered to bring health benefits (*13*); for cycling, this level is usually achieved even at low speed. If the walking pace in the study population is unknown, HEAT will assume that it is 4.8 km per hour.

3. HEAT is designed for <u>adult populations</u>. For HEAT for cycling, the recommended applicable age range is approximately 20–64 years and for HEAT for walking, approximately 20–74 years (see also section 4.5). HEAT should not be applied to

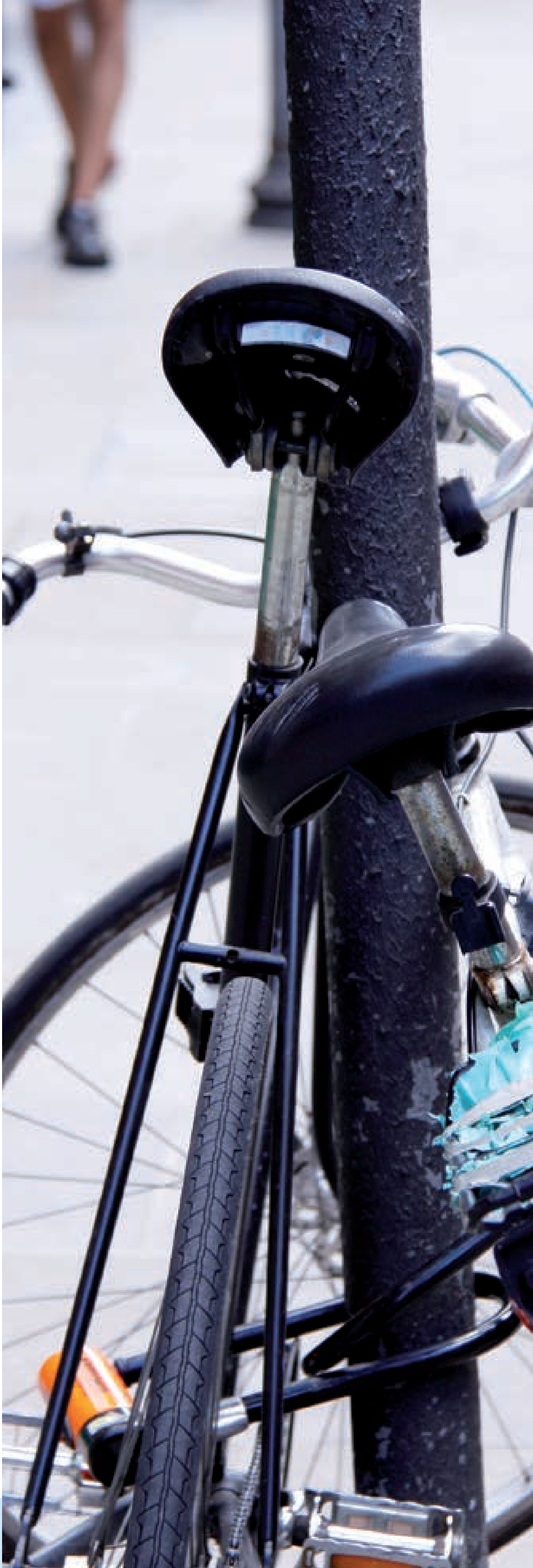
populations of children, very young adults or older people since the available evidence was not sufficient to derive a relative risk for these age groups (see also section 2.6).

4. HEAT should not be used in populations with high average levels of physical activity.

   Studies on the benefits of physical activity for decreasing premature mortality have typically been conducted in the general population, where very high average levels of physical activity are uncommon. The exact shape of the dose–response curve is uncertain, but it seems to level off above physical activity levels that are the equivalent of about 1 hour of brisk walking or cycling per day. Therefore, the tool is not suitable for populations with high average levels of walking or cycling (such as professional athletes, postal delivery workers or bicycle couriers) that exceed the activity levels common in an average adult population. Caution also has to be applied when using the tool in predominantly sedentary populations, since the underlying risk estimates were derived from populations with a broad distribution of activity levels. HEAT could therefore slightly underestimate the effect in very sedentary population groups.

5. The accuracy of the HEAT calculations should be understood as estimates of the order of magnitude of the expected effect rather than as precise estimates.

Knowledge of the health effects of walking and cycling is evolving rapidly. These projects represent first important steps towards agreed harmonized methods. In developing these tools, on several occasions the international advisory group made expert judgements based on the best available information and evidence. Users should bear in mind the approximate nature of the results,



much like for many other economic assessments of health effects. Further improvements will be made as new knowledge becomes available.

4.5. Basic functioning of the tool

Assessments can be carried out with two main types of data: (a) data from a single point in time; and (b) before and after data.

The former option is used when assessing the status quo, such as evaluating current levels of walking and cycling in a city. The latter is used when assessing the impact of an actual intervention or hypothetical scenarios; before and after data are required and the tool evaluates the difference in levels of walking and cycling between the two.

The tool is based on relative risk data from published studies (see section 3.2). As recommended (*3,7*), the included studies controlled for leisure-time physical activity as well as the usual socioeconomic variables (age, sex, smoking, etc.). This means that the relative risks reported for walking or cycling and mortality were independent of other forms of physical activity.

The tool uses these relative risks and applies them to the amount of walking or cycling entered by the user, assuming a linear relationship between walking or cycling and mortality. To illustrate this, the relative risk from the meta-analysis used for the updated version of HEAT for cycling is 0.90 for regular commuter cycling for 100 minutes per week for 52 weeks of the year (equivalent to 87 hours of cycling per year) (see also section 3.2). Thus, in any given year, regular cyclists receive a protective benefit of 10% (1.00 minus 0.90) – that is, they are 10% less likely to die from any cause than non-cyclists. If the user enters a cycling volume equivalent to 29 hours per year (i.e. three times less), the protective benefit of this amount of cycling will be roughly 3%. If the user enters 174 hours (twice the time cycled in the reference population), the resulting protective benefit is 20%. This is twice the protective benefit of the reference population.

To avoid inflated values at the upper end of the range, the risk reduction available from the HEAT is capped. Inspection of the data points of the new meta-analyses suggested that, after about 45% risk reduction for cycling and 30% for walking, no significant further risk reductions were achieved. These limits were also confirmed by a large cohort study found through purposive review *(18)*. On this basis, the advisory group recommended using these caps in the updated HEAT. Thus, HEAT will apply a maximum 45% risk reduction in the risk of mortality for cycling (corresponding to 450 minutes per week) and a maximum 30% risk reduction (corresponding to 458 minutes per week) for walking.

HEAT then uses population-level mortality data to estimate the number of adults who would normally be expected to die in any given year in the target population. Next, it calculates the reduction in expected deaths in this population that cycle or walk at the level specified by the user, using the adjusted relative risk. Finally, the tool produces an estimate of economic savings

Summary of basic values used for HEAT

Mode	Applicable age range	Relative risk	Volume	Benefits capped at
Walking	20-74 years	0.89 (CI 0.83–0.96)	168 minutes/week	30% (458 minutes)
Cycling	20-64 years	0.90 (CI 0.87–0.94)	100 minutes/week	45% (450 minutes)

CI: confidence interval.

from this calculated reduction in deaths, as well as discounted and average savings.

The basic functioning of the tool is shown in fig. 1.

4.5.1. Applicable age range

HEAT for cycling is designed for analyses of adult populations aged about 20–65 years. This is because HEAT should be used for regular behaviour such as commuting, and the retirement age is about 65 years in most countries. After retirement, physical activity behaviour (especially that related to commuting) often changes. In addition, many mortality databases give mortality rates for up to 64-year-olds. For HEAT for walking, the international advisory group recommended that this relative risk be applicable for an age range of approximately 20–74 years, as walking behaviour seems to be more sustained than cycling. These earlier conclusions were confirmed by the 2013 consensus meeting.

If the age distribution in the assessed population is significantly different (much younger, much older), HEAT may underestimate or overestimate the resulting benefits. In such cases, it is important to adjust the mortality rate used, which depends strongly on the age of the assessed population. However, HEAT should not be applied to populations of children, very young adults or older people, since the available evidence was not sufficient to derive a relative risk, especially for younger age groups, and the mortality rates would differ significantly for older age groups (see also sections 2.6 and 3.2).

4.6. What input data are needed?

To use HEAT, the following data are needed:

- an estimate of how many people are walking or cycling, which might come from route user surveys, population surveys or roadside counts, or could be estimates from scenario analyses (for more information on the use of surveys, see section 4.7); and
- an estimate of the average time spent walking or cycling in the study population, which can again come from surveys or estimates and can be entered in a number of ways:
  - duration (average time walked or cycled per person, e.g. 30 minutes walked on average per day), which is the most direct data entry route;
  - distance (average distance walked or cycled per person, e.g. 10 km cycled on average per day);
  - trips (average per person or total observed across a population, e.g. 250 bicycle trips per year); or
  - steps (average number of steps taken per person, e.g. 9000 steps per day).

A number of default values are provided in HEAT; these have been derived from the literature and agreed on as part of the expert consensus process. They should be used unless more relevant data are available that more accurately reflect the situation under study, for the following variables:

- mortality rate (a European average can be used or a national rate from the WHO European Detailed Mortality Database *(30)* for an average population (about 20–74 years old), a younger average population (about 20–45 years old) or a predominantly older average population (about 46–74 years old), or the local mortality rate can be entered);
- VSL (values commonly used across Europe are provided in the model but users may adapt this value by, for example, adopting agreed values for their own country; for more information see section 2.12);

Fig. 1. Basic functioning of HEAT

Volume of walking/cycling per person
duration/distance/trips/steps
(entered by user)

↓

Protective benefit (reduction in mortality as a result of walking/cycling) =

$$(1 - RR^{\dagger}) * \left(\frac{\text{Volume of walking/cycling}}{\text{Reference volume of walking/cycling}^{\dagger\dagger}} \right)$$

↓

Population that stands to benefit
(entered by user or calculated
from return journeys)

↓

General parameters
Intervention effect, build-up period, mortality rate, time frame (changeable default values)

↓

Estimate of economic savings
using VSL
(changeable default value)

†RR = relative risk of death in underlying studies (walking: 0.89 and cycling: 0.90 *(20)*).

††Volume of cycling per person calculated based on 100 minutes per week for 52 weeks per year at an estimated speed of 14 km/hour. Volume of walking based on 168 minutes per week at 4.8 km/hour.

- the period of time over which average benefits are to be calculated; and
- a discount rate, if so wished (see also section 2.13); the default value supplied can be used or an alternative rate can be entered.

In addition, details of the cost of promoting cycling or walking can be entered, which can be used to calculate a benefit–cost ratio.

Along the way, some assumptions may need to be taken where no data are available, such as on the supposed impact of an intervention on newly induced levels of walking and cycling. Input is provided for such assumptions, wherever possible with default values (and their sources). Explanations and further information on the different steps of the tool as well as a section with frequently asked questions are provided on the web site (see also Chapters 5 and 6).

4.7. Data sources

Input data for the model may come from a number of sources, including:

- route user surveys;
- population-level travel behaviour surveys;
- destination-based behaviour travel surveys (e.g. commuter behaviour); and
- traffic counts.

Alternatively, informed estimates may serve as surrogates for empirical data, such as in scenario calculations. In all cases, it is important to use the most reliable data possible and to validate these with secondary sources where available.

Ultimately, the quality of economic appraisals will depend entirely on the accuracy of the walking and cycling data used. A few considerations will help to make the best use of the available data and avoid mistakes.

4.7.1. Use of short-term counts and surveys

The main concern with short-term counts is that they do not accurately capture variations in walking or cycling over time (i.e. time of the day, day of the week, season or weather). If counts are done on a sunny day, larger numbers may be seen than on a rainy day. Cycling also typically declines in the winter months compared with spring and summer in many countries. Since HEAT assumes that the entered data reflect long-term average levels of walking or cycling, data from short-term counts may distort the results.

This issue will affect single-site evaluations (such as a footpath or a bridge) where counts are conducted at the site itself, or community- wide evaluations that are based on surveys conducted only during a certain time of the year.

Short-term counts may also be adjusted for temporal variation to better reflect long-term levels of walking or cycling. An example for how this can be done is provided by the national bicycle and pedestrian documentation project in the United States *(31)*.

Not affected by this issue are assessments based on large surveys conducted on a rolling basis, such as national travel surveys, or automated continuous counts.

4.7.2. Use of data from a few locations

Spatial variation, particularly in walking, may affect evaluations that are based on counts at a single or a few locations. The choice of location may strongly influence the count numbers, which may not be representative of the wider level of walking (or cycling). Results need to be interpreted carefully, and should in general not be extrapolated beyond the locations where actual data were collected.

Not affected by this issue are evaluations based on surveys that sample subjects randomly from a defined area (such as large household surveys) and, to a lesser extent, count-based evaluations on linear facilities such as trails.

4.7.3. Use of trip or count data

In HEAT, trip or count data need to be combined with an estimate of average trip length in order to calculate the volume of walking or cycling. An example is provided by counts conducted on a bridge, where it remains unknown how far people walk or cycle beyond the bridge. Average trip distance estimates may be derived from user surveys on a specific facility or from travel surveys.

There are several methods of estimating cycling and walking distances.

- Cyclists or pedestrians can be asked to draw their route on a map and to measure the distance *(32,33)*.

- Cyclists and pedestrians can be asked to provide their starting and finishing points and to multiply the straight-line distance between the two points with a correction factor. One study has suggested a factor of 1.26 *(33)*.

- Another method is based on subjective estimates of distance travelled, although this has been shown to lead to distances being overestimated and not to be always reliable *(33)*. Thus, if subjective measures are used, it is recommended that a correction be made for overestimation; a correction factor of 0.88 has been suggested *(33)*.

- Making use of global positioning systems (GPS) has been shown to overestimate the distance; a correction factor of 0.95 has therefore been suggested *(33)*.

- Making use of shortest- or fastest-route algorithms in geographical information systems has been shown to overestimate distance by between 12% and 21%, depending on the algorithm used *(33)*. This corresponds to correction factors of 0.89 and 0.83, respectively.

4.7.4. Use of pedometer data

If assessments are based on pedometer data, it should be ensured that the number of steps used is predominantly composed of intentional brisk walking. Some pedometers have a function that excludes steps that are not deliberate walking.. Another approach could be to include only intentional walking steps at a rate of about 100 steps per minute *(34)* or to make an assumption of the proportion of total steps falling into this category.

4.8. What data will the tool produce?

The tool will produce an estimate of the following outputs:

- maximum annual benefit;

- mean annual benefit; and

- net present value of mean annual benefit.

The maximum annual benefit is the total value of reduced mortality due to the level of walking or cycling entered by the user. This is a maximum value, as it assumes that the maximum possible benefits to health will have occurred as a result of the entered level of walking or cycling. In reality, the health benefits are likely to accrue over time.

The mean annual benefit is therefore the key output of the model. It adjusts the maximum annual benefit (total value of lives saved due to the level of walking or cycling entered by the user) by three main factors:

- an estimate of the time it takes for the health benefits from regular walking or cycling to occur;

- a build-up period for uptake of walking or cycling, which allows the user to vary the projections in uptake if valuing a specific intervention such as for a new cycle path, and varies for full usage occurring between 1 and 50 years; and

- the net present value of mean annual benefit, which adjusts the above outputs to take the diminishing value of current savings over time into account (the model suggests a discount rate of 5% but this can be varied).

[2] The default value used in HEAT is five years, based on expert consensus achieved with the international advisory group. As this period is based on the physiological mechanism of physical activity behaviour with an impact on health, it cannot be changed by the user.

5 HEAT for walking: instructions for users

5.1. How to access the tool

The tool is available on the WHO Regional Office for Europe web site at www.euro.who.int/HEAT *(6)* or directly from the HEAT site www.heatwalkingcycling.org

5.2. How to use the tool: five simple steps

5.2.1. General features of the HEAT web site

HEAT is composed of 16 questions in total; depending on the route taken, some questions will be skipped. On the left-hand side of the screen, the flow chart of questions helps users to orientate where they are in the assessment process.

Click on "next question" or "back" to move between questions; <u>do not use the back-button of your internet browser</u>. You can also go back to a previous question by clicking on it in the flow chart of questions on the left-hand side of the screen. If you make changes, click on "save changes" before you continue.

On all HEAT screens, by hovering with the mouse over an entry option, the relevant "hints and tips" box or boxes will be highlighted on the right- hand side of your screen.

There is also a section with frequently asked questions, where further hints and tips can be found.

Step 1: entering walking data

First of all, the scope of the use of HEAT needs to be considered to make sure that it is applicable for an assessment (see also section 4.1).

If HEAT is right for the study in question, a decision needs to be taken as to which of the two possible data types is going to be used for the assessment.

- Data from a single point in time are used when assessing the status quo, such as valuing current levels of walking in a city, or if data on the results of an intervention only are available (no "before" data).
- Before and after data are used when assessing the impact of an actual intervention or hypothetical scenarios. Before and after data are required, and the tool evaluates the difference in levels of walking between the two.

All assessments require two main parameters to be entered:

1. the amount of walking done in the study area as duration (the most direct entry route), distance, trips or steps (more information on data sources is given in section 4.7); and

2. the number of people benefiting from this amount of walking.

Amount of walking: select the desired option for input data

The amount of walking can be entered per day, week, month or year as follows.

Duration

Enter the average time spent walking per person.

Distance

Enter the average distance walked per person.

Trips

If data are entered as trips, the average number of trips per person can be entered or the total number of trips observed in the study area (e.g. from a count of pedestrians passing a sample point). If the total number of trips includes trips by modes of transport other than walking, the mode share option can be used to take account of this by specifying the proportion of these trips that are walking trips.

Then, either the total number of people taking these walking trips or the proportion of these trips that are return journeys needs to be entered. For example, if 1000 trips a day are observed at a sample point, this could correspond to 1000 individuals each counted once or 500 individuals each counted twice (as they make a return journey), or some combination of the two. Whenever possible, it is strongly recommended to use the actual number of people walking. This is because alternative methods involve a number of assumptions, which would reduce the accuracy of the results. If the total number of people taking these trips is unknown, the tool will use the proportion of return journeys to estimate the number of individuals taking the trips. As the HEAT website assumes that the trip data you have entered relates to a regular (i.e. daily or near-daily) pattern of walking, the number of individual walkers is calculated from the proportion of return journeys, using the daily average number of trips. On the HEAT for walking web site, input is given to derive the best proportion of return journeys for different types of count data.

Finally, the duration or distance of the walking trips has to be entered.

Steps

The average number of steps walked per person per day, week, month or year and the average step length can be entered. Otherwise, the default value of 71.5 cm (28.15 inches) can be used, which is the average of values often used for men and for women.

If data from a single point in time are assessed, the user can then enter the general parameters. Otherwise, users will be asked to enter the after-intervention data. They can choose to use a different metric for the after data (e.g. duration for the before data and distance for the after data).

Number of people benefiting

The tool requires information on the number of individuals doing the amount of walking entered in the previous questions.

In many cases, this figure will be the number of walkers in the study area, city or country, or the number of people who stand to benefit from the reported levels of walking entered if the data were entered as walking trips (see above).

In some cases, walking data may have been derived from a survey based on a representative sample of a larger population, where the findings apply to the whole population. For example, in the case of a national travel survey that is representative of the whole population, the total population should be used rather than the sample size of the travel survey.

It is important to ensure that the correct population figure is entered, as this can substantially affect the resulting calculations.

Step 2: checking the walking summary
HEAT will now show a summary of the entries, allowing you to make corrections or to change entries. HEAT will also show the likely reduction in the risk of mortality in the study population, based on the entries (see also section 4.5).

Warning messages will appear here in two cases: (a) if levels of walking have been entered that are above the suggested scope of HEAT of about 1 hour of brisk walking; and (b) if levels of walking have been entered that would theoretically lead to very high reductions in the mortality rate.

Specifically, if an equivalent of 120 minutes or more of walking per day is entered, users are requested to consider whether their entered volume of walking truly represents long-term behaviour in an average adult population, as this is what HEAT is designed for (see also section 4.4). To avoid inflated values, the risk reduction available from the HEAT walking is capped at 30% (see also section 4.5).

Step 3: impact of an intervention or all current walking?
In this step, users can decide whether they want to quantify the benefits of a current situation (or a scenario analysis) in a country, in a community or on a specific infrastructure. This means that HEAT will provide an estimate of the value of all the walking data entered (and no build-up period for the health benefits to accrue will be applied, see also section 4.8).

If instead "impact of an intervention" is selected, the tool will ask for an estimate of the proportion of the walking that can be attributed to the intervention. When assessing the impact of an intervention, it is prudent to assume that not all the walking or increase in walking observed is newly induced.

Data to estimate the proportion of newly induced walking are rarely available. Therefore, the proportion of walking to be attributed to the intervention (i.e. to be evaluated) needs to be estimated to the best of the user's knowledge. For guidance on this estimation, see the "hints and tips" box on this page.

<u>It is strongly advised to calculate various scenarios with higher and lower percentages</u>, as this number significantly affects the results.

Note that if users wish to assess the value of an increase in walking over time without a particular intervention, 100% should be entered.

Time needed to reach full level of walking
This allows adjustment for the estimated time it will take to reach the full level of walking entered. This can be particularly useful when assessing interventions. For example, if a new footpath is built and it is estimated it will take 5 years for usage to reach a steady state, this figure should be changed to 5. The default value has been set at 1 year.

Step 4: checking the parameters
The parameters in step 4 have been set by the expert advisory group according to the best information currently available. They should be changed only if reliable local data are available, as changes to these parameters can have a significant impact on the final values. Nevertheless, local values for the following two parameters should be used where available:

- For the *value of a statistical life* (in local currency), the standard value of a statistical life used in the country of study should be entered; the preferred currency can be chosen. This will form the basis of the cost savings in the

model. Whenever possible, enter a country-specific value or use a country value from the drop-down menu (not available for Andorra, Monaco and San Marino). If this is not known, European default values of €2.487 million (WHO European Region), €3.387 million (EU-27 countries) or €3.371 million (EU-28 countries including Croatia) can be used (see section 2.12). These are based on a study by the OECD *(23)* that calculated an average VSL of US$ 3.6 million for the EU-27 countries for 2005. This value was adjusted for income level differences across countries, inflation and income growth over time and conversion of the currency from USD to local currency, using purchasing power parity–adjusted exchange rates *(35)*. Regional default values were derived using the population-weighted average of the country-specific VSL estimates.

- The annual rate of the working-age population that dies each year (deaths per 100 000 people per year in the respective age group) can be derived from published mortality data for people of working age for the study country. The default value is set at the last available average for the WHO European Region according to the WHO European Detailed Mortality Database *(30)*. HEAT also provides national values as available in the WHO European Detailed Mortality Database *(30)*. Users have the option to select default mortality rates for an average population (about 20–74 years old), a younger average population (about 20–45 years old) or a predominantly older average population (about 46–74 years old). It is suggested that the most recently available local rate be used wherever possible.

Users can also enter their own value. In this case, it is suggested to use the local crude annual death rate, as it reflects the age- and sex-specific mortality rates and the age and sex distribution of the population. Enter the number of deaths per year per 100 000 people aged 20–74 years. This allows the tool to focus on the age groups most likely to walk and reflects the relative risk of all-cause mortality in that age group (see also sections 3.2 and 4.5). If the age distribution in the assessed population is significantly different (much younger or much older), HEAT may overestimate or underestimate the resulting benefits. In such cases, it is important to adjust the age range of the mortality rate used. It must be noted, however, that HEAT is not appropriate for populations consisting mainly of children, very young adults or older people, as the underlying relative risk would not be appropriate.

The time frame for calculating mean annual benefit is the period over which the discounted mean annual benefit will be calculated. This is usually standardized within each country; the default value has been set at 10 years.

If it is known how much it costs to promote walking in a particular case (such as a specific promotion project or new infrastructure), and the user would like the tool to calculate a benefit–cost ratio for the local data, costs can be entered here. It needs to be made sure that the costs include all relevant investments. For example, to assess the benefit–cost ratio of a promotion campaign for walking, costs for the walking infrastructure used by the target audience, which may be borne by the local administration, will also need to be included. The time frame entered to calculate the benefit-cost ratio can differ from the time frame entered to calculate the average annual benefit (see above).

For the discount rate, the rate to be used for calculating future benefits can be entered. Savings that occur in future years will be discounted by this percentage per year, and will be shown in the "present value" section of step 5. A rate of 5% has been set as the default value. Common discount rates are usually available from government agencies; one option is to use interest rates on long-term government bonds.

Step 5: reading the economic savings resulting from reduced mortality
Results are presented in three different ways.

The average annual benefit is the value of lives saved (mortality only) per year. It averages the benefit over the time frame entered to calculate the benefits. This takes into account the time periods selected for uptake of walking and the build up of health benefits (see also section 5.3).

In addition, the total benefit accumulated over the time period entered for averaging the result is given as well as the maximum annual benefit achieved when both health benefits and uptake of walking have reached the maximum levels. These should always be quoted as maximum rather than average values.

The current value of the average annual benefit is the second main output of the model, using the discount rate from step 4 to calculate the net present value, taking into account the reduced value of benefits over time.

The current value of the total benefits accumulated over the time period entered is also shown.

If costs are entered, HEAT also provides a benefit–cost ratio.

5.3. Assumptions

The results of the assessment depend on a number of assumptions, which were agreed at the consensus meeting.

The build-up of benefits is the estimated time it will take for walkers in the model to realize the benefits in terms of mortality of the walking entered at step 1. The default value is 5 years, based on expert consensus (see also section 2.8).

If a steady-state situation is assessed (selecting "all current walking"), no build-up period for the health benefits is applied.

The average walking speed is set at 4.8 km/h (or 3 miles/hour). This is in line with the walking speed of the studies in the meta-analysis (where available) and equivalent to the minimum walking pace necessary to require an energy expenditure that is considered to be necessary for health benefits *(13)*.

The relative risk data from the meta-analysis, which includes studies from China, Europe, Japan and the United States (see also section 3.2), can be applied to walkers in other settings.

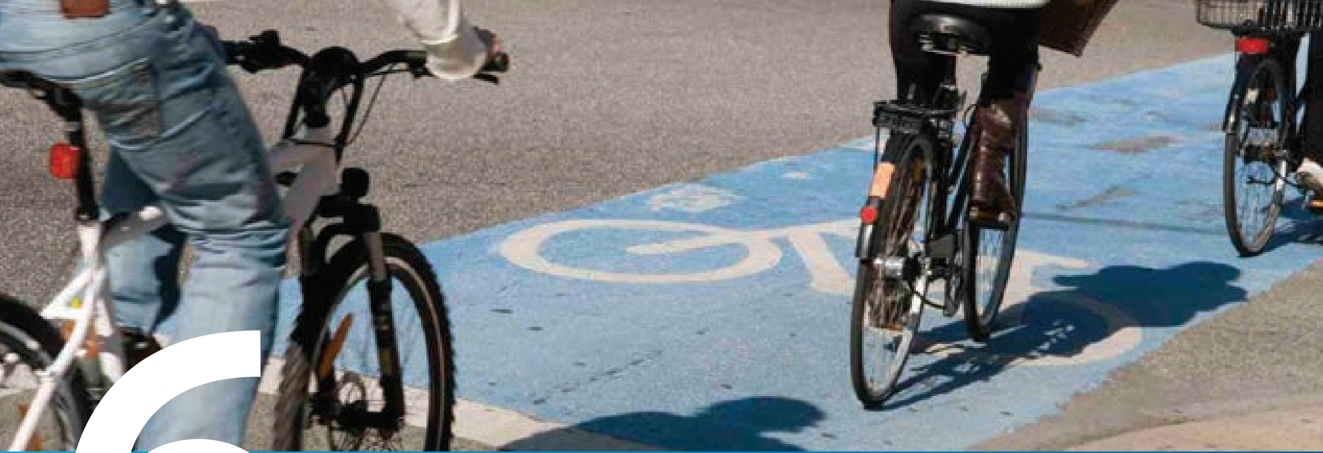
There is a linear relationship between risk of death and walking duration (assuming a constant average speed), in other words, each dose of walking leads to the same absolute risk reduction.

No thresholds have to be reached to achieve health benefits.

Men and women have approximately the same level of relative risk reduction.

It is important to remember that many of the variables used within this HEAT calculation are estimates and therefore liable to some degree of error.

You are reminded that the HEAT tools provide you with an approximation of the level of health benefits. To get a better sense for the possible range of the results, you are <u>strongly advised to rerun the model</u>, entering slightly different values for variables where you have provided a "best guess", such as entering high and low estimates for such variables.



6 HEAT for cycling: instructions for users

6.1. How to access the tool

The tool is available on the WHO Regional Office for Europe web site at www.euro.who.int/HEAT *(6)* or directly from the HEAT site www.heatwalkingcycling.org.

6.2. How to use the tool: five simple steps

6.2.1. General features of the HEAT web site

HEAT is composed of 16 questions in total; depending on the route you take, some questions will be skipped. On the left-hand side of the screen you will see the flow chart of questions to help you orientate where you are in the assessment process.

Click on "next question" or "back" to move between questions; do not use the back-button of your internet browser. You can also go back to a previous question by clicking on it in the flow chart of questions on the left-hand side of the screen. If you make changes, click on "save changes" before you continue.

On all HEAT screens, by hovering with the mouse over an entry option, the relevant "hints and tips" box or boxes will be highlighted on the right-hand side of your screen.

There is also a section with frequently asked questions, where further hints and tips can be found.

Step 1: entering cycling data

First of all, the scope for the use of HEAT needs to be considered to make sure that is applicable for an assessment (see also section 4.4).

If HEAT is right for the study in question, a decision needs to be taken as to which of the two possible data types is going to be used for the assessment.

- Data from a single point in time are used when assessing the status quo, such as valuing current levels of cycling in a city, or if data on the results of an intervention only are available (no "before" data).
- Before and after data are used when assessing the impact of an actual intervention or hypothetical scenarios. Before and after data are required, and the tool evaluates the difference in levels of cycling between the two.

All assessments require two main parameters to be entered:

1. the amount of cycling done in the study area as duration (the most direct entry route), distance or trips per day (more information on data sources is given in section 4.7); and

2. the number of people benefiting from this amount of cycling.

Amount of cycling: select the desired option for input data

Duration

Enter the average time spent cycling per person per day.

Distance

Enter the average time spent cycling per person per day.

Trips

If data are entered as trips, the average number of trips per person per day can be entered or the total number of trips observed in the study area (e.g. from a count of cyclists passing a sample point). If the total number of trips includes trips by modes of transport other than cycling, the mode share option can be used to take account of this by specifying the proportion of these trips that are cycling trips.

Then, either the total number of people taking these cycling trips or the proportion of these trips that are return journeys needs to be entered. For example, if 1000 trips a day are observed at a sample point, this could correspond to 1000 individuals each counted once or 500 individuals each counted twice (as they make a return journey), or some combination of the two. Whenever possible, it is strongly recommended to use the actual number of people cycling. This is because alternative methods involve a number of assumptions, which would reduce the accuracy of the results. If the total number of people taking these trips is unknown, the tool will use the proportion of return journeys to estimate the number of individuals taking the trips. As the HEAT web site assumes that the trip data you have entered relates to a regular (i.e. daily or near-daily) pattern of cycling, the number of individual cyclists is calculated from the proportion of return journeys, using the daily average number of trips. On the HEAT for cycling web site, input is given to derive the best proportion of return journeys for different types of count data.

Finally, the duration or distance of the cycling trips has to be entered.

For all entry options, the user also has to enter how many days per year this amount of cycling is done. If this amount is done every day (or represents an average value per year, e.g. from a travel survey), 365 should be entered. However, most individuals do not cycle every day. If no long-term data are used and users are unsure how many days they cycled in a year, 124 is recommended as a default, which is the observed number of days in Stockholm *(36)*. This is a conservative value, which should be changed only if reliable local data are available, as it will influence the final calculation.

If data from a single point in time are assessed, the user can then enter the general parameters. Otherwise, users will be asked to enter the after-intervention data. They can choose to use a different metric for the after data (e.g. duration for the before data and distance for the after data).

Number of people benefiting

The tool requires information on the number of individuals doing the amount of cycling entered in the previous questions.

In many cases, this figure will be the number of cyclists in the study area, city or country, or the number of people who stand to benefit from the reported levels of cycling entered if the data were entered as cycling trips (see above).

In some cases, cycling data may have been derived from a survey based on a representative sample of a larger population, where the findings apply to the whole population. For example, in the case of a national travel survey that is representative of the whole population, the total population should be used here rather than the sample size of the travel survey.

It is important to ensure that the correct population figure is entered, as this can substantially affect the resulting calculations.

Step 2: checking the cycling summary
HEAT will now show a summary of the entries, allowing you to make corrections or to change entries. HEAT will also show the likely reduction in the risk of mortality in the study population, based on the entries (see also section 4.5).

Warning messages will appear here in two cases: (a) if levels of cycling have been entered that are above the suggested scope of HEAT for cycling of about 1 hour of cycling per day (see also section 4.4); and (b) if levels of cycling have been entered that would theoretically lead to very high reductions in the mortality rate.

Specifically, if an equivalent of 120 minutes or more of cycling per day is entered, users are requested to consider whether their entered volume of cycling truly represents long-term behaviour in an average adult population, as this is what HEAT is designed for. To avoid inflated values, the risk reduction available from the HEAT is capped at 45% (see also section 4.5).

Step 3: Impact of an intervention or all current cycling?
In this step, users can decide whether they want to quantify the benefits of a current situation (or a scenario analysis) in a country, in a community or on a specific infrastructure. This means that HEAT will provide an estimate of the value of all the cycling data entered (and no build-up period for the health benefits to accrue will be applied, see also section 4.8).

If instead "impact of an intervention" is selected, the tool will ask for an estimate of the proportion of the cycling that can be attributed to the intervention. When assessing the impact of an intervention, it is prudent to assume that not all the cycling or increase in cycling observed is newly induced.

Data to estimate the proportion of newly induced cycling are rarely available. Therefore, the proportion of cycling to be attributed to the intervention (i.e. to be evaluated) needs to be estimated to the best of the user's knowledge. For guidance on this estimation, see the "hints and tips" box on this page.

<u>It is strongly advised to calculate various scenarios with higher and lower percentages</u>, as this number significantly affects your results.

Note that if users wish to assess the value of an increase of cycling over time without a particular intervention, 100% should be entered.

Time needed to reach full level of cycling
This allows adjustment for the estimated time it will take to reach the full level of cycling entered. This can be particularly useful when assessing interventions. For example, if a new cycle path is built and it is estimated it will take 5 years for usage to reach a steady state, this figure should

be changed to 5. The default value has been set at 1 year.

Step 4: checking the parameters
The parameters in step 4 have been set by the expert advisory group according to the best information currently available. They should be changed only if reliable local data are available, as changes to these parameters can have a significant impact on the final values.

Nevertheless, local values for the following two parameters should be used where available:

- For the *value of a statistical life* (in local currency), the standard value of a statistical life used in the country of study should be entered; the preferred currency can be chosen. This will form the basis of the cost savings in the model. Whenever possible, enter a country-specific value or use a country value from the drop-down menu (not available for Andorra, Monaco and San Marino). If this is not known, European default values of €2.487 million (WHO European Region), €3.387 million (EU-27 countries) or €3.371 million (EU-28 countries including Croatia) can be used (see section 2.12). These are based on a study by the OECD *(23)* that calculated an average VSL of US$ 3.6 million for the EU-27 countries for 2005. This value was adjusted for income level differences across countries, inflation and income growth over time and conversion of the currency from USD to local currency, using purchasing power parity–adjusted exchange rates *(35)*. Regional default values were derived using the population weighted average of the country-specific VSL estimates.

- The *annual rate of the working-age population that dies each year* (deaths per 100 000 people per year in the respective age group) can be derived from published mortality data for people of working age for the study country. The default value is set at the last available average for the WHO European Region according to the WHO European Detailed Mortality Database *(30)*. HEAT also provides national values as available in the WHO European Detailed Mortality Database *(30)*. Users have the option to select default mortality rates for an average population (about 20–64 years old), a younger average population (about 20–45 years old) or a predominantly older average population (about 46–64 years old). It is suggested that the most recently available local rate be used wherever possible.

Users can also enter their own value. In this case, it is suggested to use the local crude annual death rate, as it reflects the age- and sex-specific mortality rates and the age and sex distribution of the population. Enter the number of deaths per year per 100 000 people aged 20–64 years. This allows the tool to focus on the age groups most likely to cycle and reflects the relative risk of all-cause mortality in that age group (see also sections 3.2 and 4.5). If the age distribution in the assessed population is significantly different (much younger or much older), HEAT may overestimate or underestimate the resulting benefits. In such cases, it is important to adjust the age range of the mortality rate used. However, it must be noted that HEAT is not appropriate for populations consisting mainly of children, very young adults or older people, as the underlying relative risk would not be appropriate.

The time frame for calculating mean annual benefit is the period over which the discounted mean annual benefit will be calculated. This is usually standardized within each country; the default value has been set at 10 years.

If it is known how much it cost to promote cycling in a particular case (such as a specific promotion project or new infrastructure), and the user would like the tool to calculate a benefit–cost ratio for the local data, *costs* can be entered here. The costs must include all relevant investments. For example, to assess the benefit–cost ratio of a promotion campaign for cycling, costs for the cycling infrastructure used by the target audience, which may be borne by the local administration, will also need to be included. The time frame entered to calculate the benefit-cost ratio can differ from the time frame entered to calculate the average annual benefit (see above).

For the discount rate, the rate to be used for calculating future benefits can be entered. Savings that occur in future years will be discounted by this percentage per year, and will be shown in the "present value" section of Step 5. A rate of 5% has been set as the default value. Common discount rates are usually available from government agencies; one option is to use interest rates on long-term government bonds.

Step 5. Reading the economic savings resulting from reduced mortality
Results are presented in three different ways.

The average annual benefit is the value of lives saved (mortality only) per year. It averages the benefit over the time frame entered to calculate the benefits. This takes into account the time periods selected for uptake of cycling and the build up of health benefits (see also section 5.3).

In addition, the total benefit accumulated over the time period entered for averaging the result is given as well as the maximum annual benefit achieved when both health benefits and uptake of cycling have reached the maximum levels. These should always be quoted as maximum rather than average values.

The *current* value of the average annual benefit is the second main output of the model, using the discount rate from Step 4 to calculate the net present value, taking into account the reduced value of benefits over time.

The current value of total benefit s accumulated over the time period entered is also shown.

If costs are entered, HEAT also provides a benefit–cost ratio.

6.3. Assumptions

The results of the assessment depend on a number of assumptions, which were agreed at the consensus meetings.

- The build-up of benefits is the estimated time it will take for cyclists in the model to realize the benefits in terms of mortality of the cycling entered at step 1. The default value is 5 years, based on expert consensus (see also section 2.8). If a steady-state situation is assessed (selecting "all current cycling"), no build-up period for the health benefits is applied.

- The average cycling speed is set at 14 km/h. This value is based on commuting time per week from a study in Copenhagen *(29)*, combined with data from the Stockholm commuting studies on the number of trips per week over the year, distance and duration *(37,38)*. Based on an estimated average of 4 km per trip, the observed distance–speed relationship produces an estimated average speed of 14 km/h *(38)*.

- The relative risk data from the meta-analysis, which includes studies from China and Europe (see also section 3.2), can be applied to cyclists in other settings.

- There is a linear relationship between risk of death and cycling duration (assuming a constant average speed), in other words, each dose of cycling leads to the same absolute risk reduction.

- No thresholds have to be reached to achieve health benefits.
- Men and women have approximately the same level of relative risk reduction.

It is important to remember that many of the variables used within this HEAT calculation are estimates and therefore liable to some degree of error.

You are reminded that the HEAT tools provide you with an approximation of the level of health benefits. To get a better sense for the possible range of the results, you are strongly advised to rerun the model, entering slightly different values for variables where you have provided a "best guess", such as entering high and low estimates for such variables.

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