World Health Organization
REGIONAL OFFICE FOR Europe

Development of the health economic assessment tools (HEAT) for walking and cycling

Meeting report of the consensus workshop in Bonn, Germany, 1–2 October 2013

World Health Organization

REGIONAL OFFICE FOR Europe

Development of the health economic assessment tools (HEAT) for walking and cycling

Meeting report of the consensus workshop in Bonn, Germany, 1–2 October 2013

Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety

THE PEP Transport, Health and Environment Pan-European Programme

UNITED NATIONS ECONOMIC COMMISSION FOR EUROPE

World Health Organization REGIONAL OFFICE FOR Europe

Address requests about publications of the WHO Regional Office for Europe to:
Publications
WHO Regional Office for Europe
UN City, Marmorvej 51
DK-2100 Copenhagen Ø, Denmark
Alternatively, complete an online request form for documentation, health information, or for permission to quote or translate, on the Regional Office website (http://www.euro.who.int/pubrequest).

Contents

Executive summary 3

Acknowledgements 4

1 Introduction and background 5

2 Welcome, introductory presentations and core principles 6

3 Review of epidemiological literature on the relative risk of all-cause mortality associated with cycling and walking 7

3.1 Systematic reviews 7
3.2 Meta-analyses 8
3.3 Discussion 10

4 Review of epidemiological literature on air pollution and all-cause mortality and suggestions for integration into HEAT 16

4.1 Introduction of review results and proposed approach 16
4.2 Discussion 17

5 OECD approach for mortality risk valuation in environment, health and transport policies and options for integrating it into HEAT 18

5.1 Introduction of approach and options 18
5.2 Discussion 18

6 Conclusions, next steps and closing 21

References 22

Annex 1. Workshop programme 24

Annex 2. List of participants 25

Executive summary

The promotion of active transport (cycling and walking) for everyday physical activity is an important approach to address the challenge of high levels of physical inactivity in most regions of the world. This requires building effective partnerships with the transport and urban planning sectors, whose policies are highly influential in providing appropriate conditions for such behavioural changes to take place and be maintained. Economic appraisal is an established practice in transport planning. However, until recently the health effects of transport interventions have seldom been taken into account in such analyses. The Health Economic Assessment Tool (HEAT) for Walking and Cycling provides guidance and a practical, web-based tool for economically assessing the health effects of walking and cycling. It is based on the evidence on the association between walking and cycling and all-cause mortality.

The third consensus meeting was convened to achieve scientific consensus on updating the relative risk functions for cycling and walking and the economic valuation of mortality and on an approach to integrate the influence of air pollution on mortality in HEAT. The meeting was attended by 24 experts from public health, transport and environmental sciences as well as economics, advocacy and practice and four WHO staff members of the WHO Regional Office for Europe.

Meta-analysis of seven cycling studies suggests an all-cause reduction in mortality risk of 10–16% depending on the dose–response relationship used (rate ratio (RR) = 0.90 (95% confidence interval (CI) = 0.87–0.94) and RR = 0.84 (95% CI = 0.79–0.90)). These risk reductions correspond to an exposure to cycling of 11.25 metabolic equivalent of task (MET) hours (or 675 MET minutes) per week and are adjusted for other physical activity. Meta-analysis of the 14 walking studies suggests a risk reduction of 10–11% depending on the dose–response relationship used, also based on 11.25 MET hours per week and adjusted for other physical activity. The 11.25 MET hours per week was chosen based on 150 minutes of moderate-intensity physical activity per week, recommended as the minimum by the WHO global recommendations on physical activity and health. Although the workshop achieved consensus on the new proposed relative risks and corresponding exposure for both cycling and walking, it entrusted a subgroup to prepare a final proposal after the workshop on the approach to be taken regarding the exact shape of the dose–response curve (linear or log-linear) and capping benefits. After further discussion, the subgroup recommended adopting a linear dose–response curve for both cycling and walking and capping the benefits based on the lowest relative risk reported in published studies.

Further, a possible approach for including air pollution effects was presented at the workshop, based on the inhaled dose of particulate matter (particulate matter with an aerodynamic diameter of 10 µm or less (PM_{10}) or 2.5 µm or less ($PM_{2.5}$)) per day in different activity modes, an available relative risk function, the attributable fraction among those exposed and available mortality rates. Participants welcomed the proposed method as a good basis for developing a separate, optional air pollution module to calculate the effects of air pollution on cyclists and walkers. However, it was concluded that, currently, inclusion into the HEAT model is conditional on further insight on several issues that need to be explored further.

A recent report from the Organisation for Economic Co-operation and Development (OECD) that proposed a comprehensive, updated European value of a statistical life (VSL) derived from a meta-analysis of about 80 studies was presented, based on which a median VSL of US$ 3.6 million, with a range from US$ 1.8 million to US$ 5.4 million (all 2005 US dollars), was calculated for the EU27 countries. The workshop achieved consensus on adopting the OECD approach to develop a new average WHO European Region VSL for applying in HEAT; this was calculated subsequently to be €2.5 million (in 2011); new average values for the EU-27 and EU-28 countries (including Croatia) were also calculated. The possibility to enter a local value would also be retained, and a list of country-specific values and result range, as derivable, would also be provided.

The workshop concluded with an outlook on future HEAT-related activities.

Acknowledgments

The workshop was organized by the WHO Regional Office for Europe and supported by the German Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety. It was carried out in close collaboration with the European network for the promotion of health-enhancing physical activity (HEPA Europe) and the Transport, Health and Environment Pan-European Programme (THE PEP).

1 Introduction and background

Given the magnitude of the physical inactivity problem in most global regions, classical health promotion approaches, although an important part of the solution, will not be sufficient to eliminate the problem. Regular cycling and walking, for example, as part of trips to work and back, might facilitate the integration of physical activity into an already busy day. The promotion of active transport (cycling and walking) is a win-win approach since it not only promotes health but can also lead to positive environmental effects especially if cycling and walking replace particularly short and later possibly also medium-length car trips. There is a large potential for active travel in European urban transport systems, since many car trips are short and could be substituted, at least partly, by trips undertaken on foot or by bicycle. This requires building effective partnerships with the transport and urban planning sectors, whose policies are highly influential in providing appropriate conditions for such behavioural changes to take place and be maintained.

Transport is an essential component of life, providing access to services, goods and activities. Different modes of transport are associated with specific effects on society, one being health effects. Fully appraising these effects is an important basis for evidence-informed policy-making. Economic appraisal is an established practice in transport planning. However, until recently, such analyses have seldom considered the part of the health effects of transport interventions related to physical activity.

Valuing health effects is a complex undertaking, and transport planners are often not well equipped to fully address the methodological complexities involved. The Health Economic Assessment Tool (HEAT) for Walking and Cycling, launched by the WHO Regional Office for Europe through a collaborative project in 2007, provides guidance and a practical, web-based approach for economically assessing the health effects of walking and cycling *(1–4)*.

The HEAT tool and its accompanying guidance are open to further developments with the aims of:

- keeping the tool abreast of relevant scientific developments (such as in relation to the emergence of new epidemiological studies that provide improved relative risk function on relevant health effects);
- expanding the functionality of the tool in response to the priority needs of users and improved scientific knowledge; and
- improving the guidance offered to the users.

A core group of eight members and relevant international experts invited ad hoc manage the implementation of this activity. The project has been developed through a systematic review of the published literature and a comprehensive consensus-building process, followed by a practical application based on the consensus achieved. The third consensus workshop was attended by 24 experts from public health, transport and environmental sciences as well as economics, advocacy and practice and four staff members of the WHO Regional Office for Europe.

This technical workshop was convened to achieve scientific consensus on:

- the possible need to update the relative risk functions for cycling and walking based on recent reassessment of the relevant literature;
- the opportunity to improve the economic valuation of mortality, by integrating the results of recent work carried out by the Organisation for Economic Co-operation and Development (OECD);
- the opportunity to integrate the influence of air pollution on mortality in HEAT, based on the best available evidence, feasibility and state-of-the-art knowledge.

The specific objectives of the workshop were:

- to discuss the main findings of a review of relative risks of all-cause mortality for cycling and walking;

- to discuss the main findings of a review of relative risks of all-cause mortality for air pollution exposure while walking and cycling;
- to discuss the proposed approach for the VSL from the OECD for mortality risk valuation in environment, health and transport policies;
- to discuss and achieve consensus on the proposed changes to HEAT to incorporate the three above issues into HEAT for walking and cycling; and
- to discuss other possible future improvements that could be considered for implementation in HEAT, such as possibilities to consider cause-specific mortality or morbidity, various metrics for the economic valuation and others.

Annex 1 shows the programme of the workshop.

Ahead of the workshop, the advisory group received background documentation prepared by the project core group, including:

Annex 1: Four discussion papers presenting:
1.1 a systematic review and meta-analysis of reduction in all cause mortality from cycling;
1.2 a systematic review and meta-analysis of reduction in all cause mortality from walking;
1.3 epidemiological literature on air pollution and all-cause mortality and suggestions for integration into HEAT;
1.4 options for updating the module on economic valuation used in HEAT; and
Annex 2: the current HEAT for Walking and Cycling tool (www.heatwalkingcycling.org) and guidance, to familiarize with the approach taken to support the evaluation of the health effects of walking and cycling.

2 Welcome, introductory presentations and core principles

Francesca Racioppi welcomed the participants and thanked them for their availability to support this important project step to further improve the HEAT. Michal Krzyzanowski was elected as chair and Sonja Kahlmeier as rapporteur of the workshop.

Francesca Racioppi reminded participants of the key principles of HEAT: they are designed as practical tools for transport and urban planners to provide them with an evidence-informed, transparent, conservative, adaptable and modular approach to the economic valuation of the health benefits of cycling and walking. HEAT can be used when planning new projects, to evaluate past projects or for modelling purposes. She also explained that more sophisticated approaches to health impact assessment of cycling and walking had been developed to satisfy advanced research needs, HEAT was mainly developed to facilitate the inclusion of health effects in economic transport valuation aimed at transport planners and practitioners, particularly in settings without ready access to specialized epidemiological and economic expertise, and to provide an indication of the order of magnitude of effects.

Nick Cavill reported on the lessons learned from HEAT since 2008. HEAT was mainly disseminated through presentations at relevant meetings and conferences; in addition, HEAT has won awards or has been commended in award schemes. Since it was launched in May 2011, the HEAT website has been visited more than 22 000 times. Through a call for contributions, case studies on applications have been collected. Since November 2012, web-based training sessions have also been provided; to date, about 350 experts have been trained. Based on existing experience, uptake of the tool seems strongest among advocates and planners and by academe, and Sweden and the United Kingdom have adopted it as part of official transport valuation toolboxes so far. Evidence of policy impact has been more limited. Participants commented that HEAT seems to be mostly perceived as tool for economic valuation and that its potential use as simple health impact assessment tool is less widely known. Additional promotion and marketing of the tools, in particular to a health audience, was noted as one of the future tasks for the project.

Finally, Michal Krzyzanowski reminded participants to consider three main points with regard to the way of working at the workshop: (1) the content being proposed needs to withstand scientific scrutiny and any assumption made needs to be made fully transparent; 2) the way of presentation needs to follow the HEAT core principles; and (3) any changes made to the methods need to be based on user needs.

3 Review of epidemiological literature on the relative risk of all-cause mortality associated with cycling and walking

3.1 Systematic reviews

Paul Kelly presented the results of two systematic reviews on the reduced relative risk of all-cause mortality from regular cycling and walking.

The search included publications since January 1991. Searches were conducted in February 2013 using the following health databases of publications: Embase (OvidSP), Medline (OvidSP), Web of Knowledge, CINAHL, SCOPUS and SPORTDiscus.

Studies were included if:

- they were prospective cohort studies;
- the exposure to regular walking or cycling (such as duration, distance and MET equivalent) was reported;
- all-cause mortality rates or risk reductions (outcome) were reported; and
- the risks were reported independent of, or adjusted for, other physical activity.

Publications were to be excluded if:

1. the cohort was defined by a medical condition or set of conditions, such as people with diabetes; and
2. the assessment of walking or cycling and other physical activity was for life-course or historical activity rather than activity levels at baseline

A total of 8901 titles were identified, and 431 full texts were screened. The quality of the included studies was assessed using the Newcastle-Ottawa quality assessment scale for cohort studies. The risk of publication bias was investigated using standard funnel plot methods; no indication for publication bias was found for either review.

Cycling and all-cause mortality
For cycling, seven studies were retained for data extraction and analysis. Six of the seven studies come from western Europe (four of which from Denmark), and one study came from China. The studies contained 187 000 individuals and represented 2.1 million person-years. The aggregated mean age of participants was 56.6 years. Cycling to work was the most common domain assessed. Six studies showed either a statistically significant or a nonsignificant but still negative association between cycling and all-cause mortality (more cycling leading to lower all-cause mortality). One study showed a small nonsignificant positive association between cycling and all-cause mortality. The studies were generally high quality; three scored 9 of 9 possible points, two scored 8, two scored 7 and one scored 6 based on the Newcastle-Ottawa quality assessment scale for cohort studies.

Walking and all-cause mortality
For walking, 14 studies were retained for data extraction and analysis. Seven came from western Europe, four from the United States, two from China and one from Japan. Most studies showed a reduced risk of all-cause mortality from walking. The 14 studies included for analysis contained 280 000 individuals and represented 2.6 million person-years. The aggregated mean age of participants was also 56.6 years. Again, the walking studies were generally of high quality: four scored 9 points, six scored 8 and four scored 7, respectively, based on the Newcastle-Ottawa quality assessment scale for cohort studies.

3.2 Meta-analyses

The shape of the dose–response relationship influences the rate at which benefits are received as well as the threshold for maximal benefits. The initial HEAT cycling model, which was based on a single study, assumed a linear dose–response relationship *(3)*. This relationship is often used in health studies but assumes that each increase in cycling has the same effect on the risk of mortality. However, this may not represent the reality of increasing (or decreasing) activity between different levels of physical activity. The relationship used by the HEAT models was later adjusted to a log-linear relationship to keep the results between 0% and 100%; in addition, a cap was introduced to keep achievable risk reductions at a level corresponding to the realistic ranges of exposure *(4)*.

For the current round of HEAT updates, it had been decided to carry out an updated review of the literature on walking, cycling and all-cause mortality. Based on the results of the studies, two meta-analyses were carried out: one for cycling and one for walking. For this purpose, the differences in exposure of the studies were converted to a common metric, based on MET-hours per week for different intensities of cycling and walking. Further, a common exposure (and point estimate for risk reduction) was calculated.

Cycling
MET-hours per week, were assigned to different intensities of cycling to transform the differences in exposure to cycling in the studies to a common metric. When none was described in the study, 6.8 METs was used as the average level of intensity; 4.0 METs was used for slow cycling and 10 METs for fast cycling. The exposure chosen to conduct the meta-analysis was 11.25 MET-hours per week (and point estimate for risk reduction).

This exposure was directed by the WHO physical activity recommendations of 150 minutes of moderate intensity activity per week.[1] Moderate intensity activity is generally considered to be 3–6 METs. Taking the mid-point of moderate intensity at 4.5 METs, the recommendations translate to 11.25 MET-hours per week or 675 MET-minutes per week.

The most recent and comprehensive meta-analysis of non-vigorous physical activity by Woodcock et al. *(5)* used a similar approach, so this choice allows comparison of the results at the same exposure level. Choosing a common exposure metric for both reviews also allows direct comparison to the walking meta-analysis results.

The WHO physical activity recommendations also include 75 minutes of vigorous physical activity as an alternative to moderate-intensity physical activity (or an equivalent combination of the two). Although different forms of cycling can be of moderate or vigorous intensity, cycling is generally considered to occur more often in the vigorous spectrum. Using an average intensity for cycling of 6.8 METs, this exposure represents approximately 100 minutes of cycling per week. This agrees well with recommendations for 150 minutes of moderate intensity physical activity (3–6 METs) or 75 minutes of vigorous physical activity (6+ METs), considering the range of intensity at which cycling can occur even within one trip. More information can be found in the workshop background document *(6)*. In addition, sensitivity analysis using different MET levels found these calculations to be robust: for example, using 8 METs for cycling intensity only had a 1% effect on the final meta-analysis.

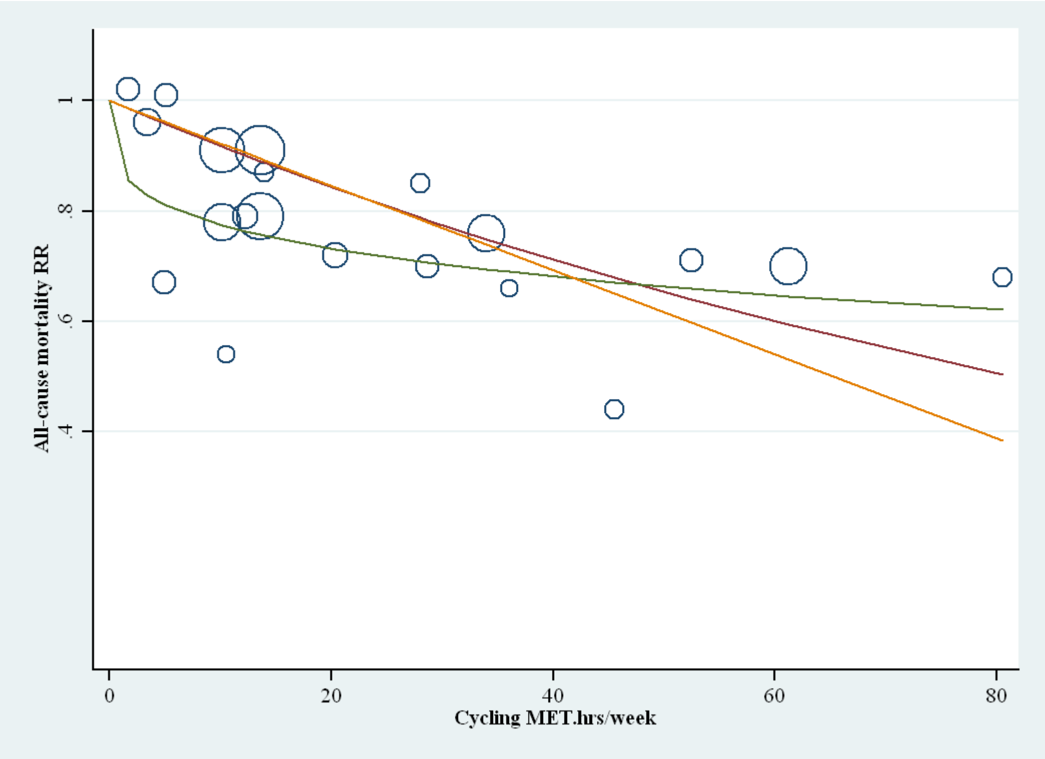
Three possible dose–response relationships were calculated for cycling (as well as for walking, see below): linear; log-linear and 0.25 power (Fig. 1).

Meta-analysis of the seven cycling studies suggests a risk reduction of 10–16% depending on the dose–response relationship used (RR = 0.90 (95% CI = 0.87–0.94) and RR = 0.84 (95% CI = 0.79–0.90)). These risk reductions correspond to an exposure to cycling of 11.25 MET-hours per week and are independent of other physical activity. Goodness of fit for each model to the data was tested by weighted root mean squared error, leading to 0.12 for the linear model, 0.16 for the log-linear model and 0.10 for the 0.25 power model.

[1] http://www.who.int/dietphysicalactivity/factsheet_adults/en/index.html

Although the 0.25 power model has the best fit (a lower number indicates a slightly better fit), the differences are not substantial.

Fig. 1. Relative risk for all-cause mortality versus cycling in MET-hours per week: results from seven studies, with linear (orange), log-linear (purple) and 0.25 power transformation (green) fit lines



Relative risk estimates are weighted by the inverse of the reported standard error.

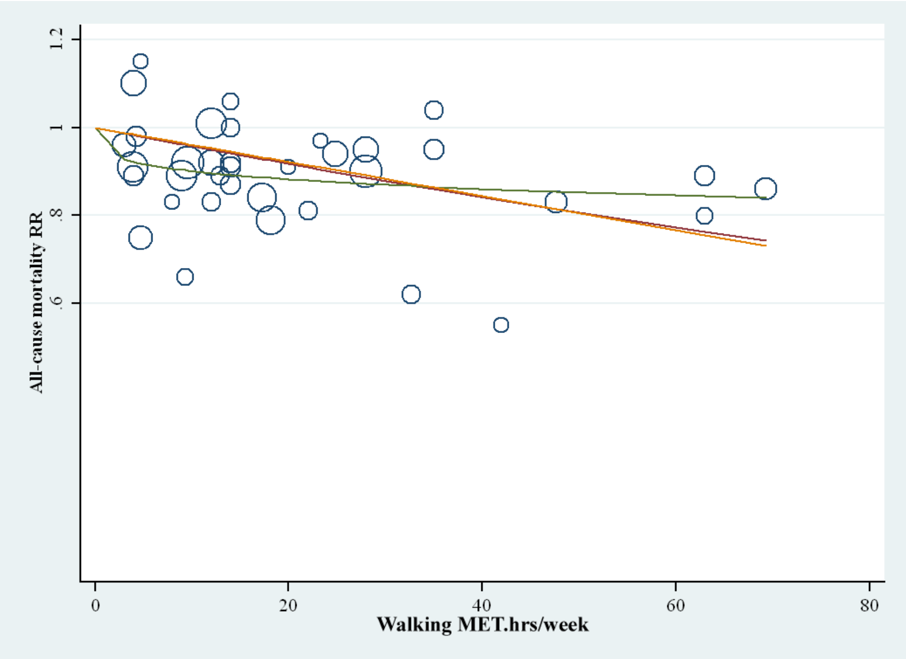
Walking

For walking, the same metric of 11.25 MET-hours per week (or 675 MET-minutes per week) used in the cycling analysis was chosen, and the same conversion methods were adopted. An average intensity of 4.0 METs was used for walking when none was described in a study. This would normally correspond to a walking speed of about 3.3 mph or 5.3 km/h.

Considering an average intensity for walking of 4.0 METs, this exposure represents approximately 170 minutes of walking per week. This agrees well with the recommendation for 150 minutes of moderate intensity physical activity (3–6 METs), considering the range of intensities at which walking can occur even within one trip.

Regarding the dose–response relationship, the same principles as used in the cycling analysis were applied. Fig. 2 shows the three different dose–response curves against the data from the 14 included studies. Meta-analysis of these studies suggests a risk reduction of 10–11% depending on the dose–response relationship used. The goodness-of-fit results are even closer here, with 0.06 for the linear model, 0.05 for the log-linear model and 0.05 for the 0.25 power model.

Fig. 2. Relative risk for all-cause mortality versus walking MET-hours per week: results from 14 studies, with linear (orange), log-linear (purple) and 0.25 power (green) lines



Relative risk estimates are weighted by the inverse of the reported standard error.

3.3 Discussion

Participants welcomed the cycling and walking reviews and in particular acknowledged that they will enable building the next version of the HEAT models on a much broader evidence base, especially for cycling, which so far had been based on one large cohort study. The final version of the background document will reflect several minor comments and adjustments and be shared with all participants. It was also suggested to use MET-minutes rather than MET-hours as a metric, as this is more frequently used and would further enhance simplicity and comprehension.

Comparison with previous studies and previous HEAT versions

In addition to the results provided, the authors of the background paper also compared their results to previous studies. The original HEAT for cycling model used a relative risk of 0.72 (confidence interval (CI) 0.57–0.91) *(4)*. However, this risk reduction corresponded to an exposure of 3 hours of cycling per week, which translates to 20.4 MET-hours per week. The exposure for the new estimates is 11.25 MET-hours per week, so one would expect a lower effect. The results of the new studies are also comparable to another recent meta-analysis, since the new estimates are only based on studies that control for other physical activity and are carried out among previously healthy subjects *(6)*.

The current HEAT for walking model uses a risk reduction of 22% (RR = 0.78 (95% CI = 0.64–0.98)) *(2,4)*. This risk reduction corresponded to approximately 200 minutes of walking per week, whereas the new estimates are based on about 15% lower exposure of 170 minutes of walking. Second, studies based on disease groups were excluded in the new risk reduction, whereas the previous review covered studies including people with diabetes. Third, the new estimate is only based on studies that control for other physical activity. This means that, similar to the cycling results, the resulting risk reductions are adjusted for other physical activity such as team sport.

Fig. 3 and Fig. 4 further illustrate this, showing the dose–response curves used by the original HEAT cycling model, the current models for walking and cycling and the new proposed dose–response curves (assuming a cap of 50%).

Fig. 3. Relative risk estimates by amount of cycling for former, current and two new proposed dose–response relationships

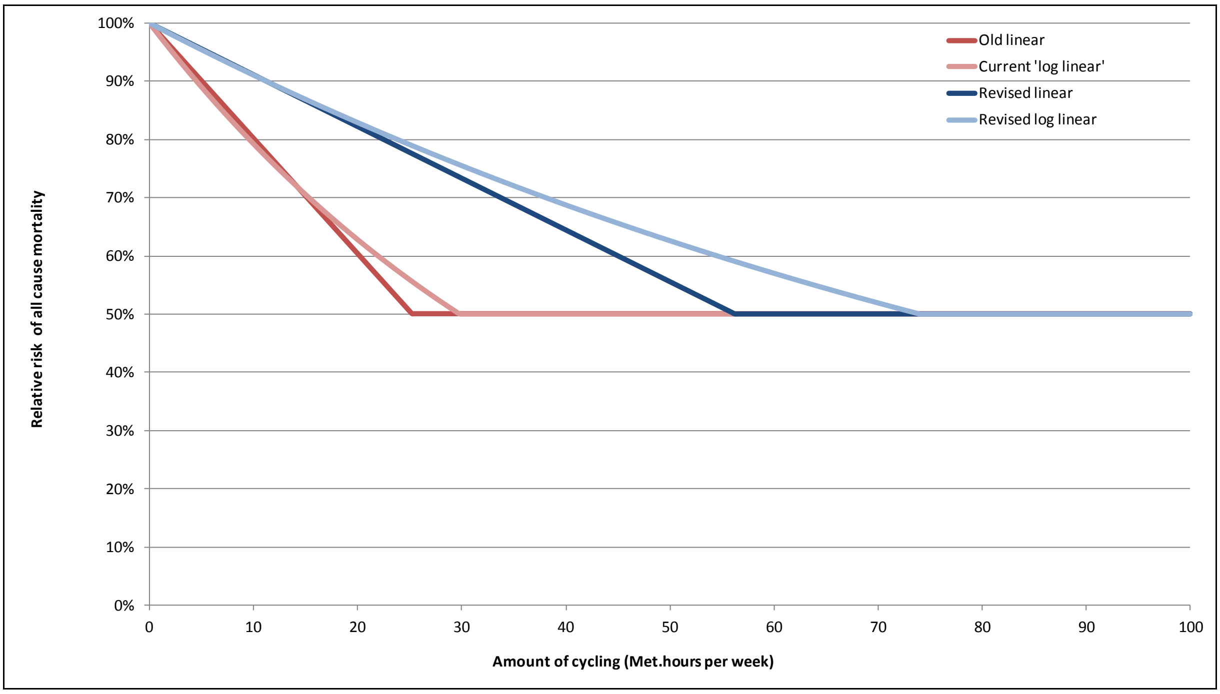
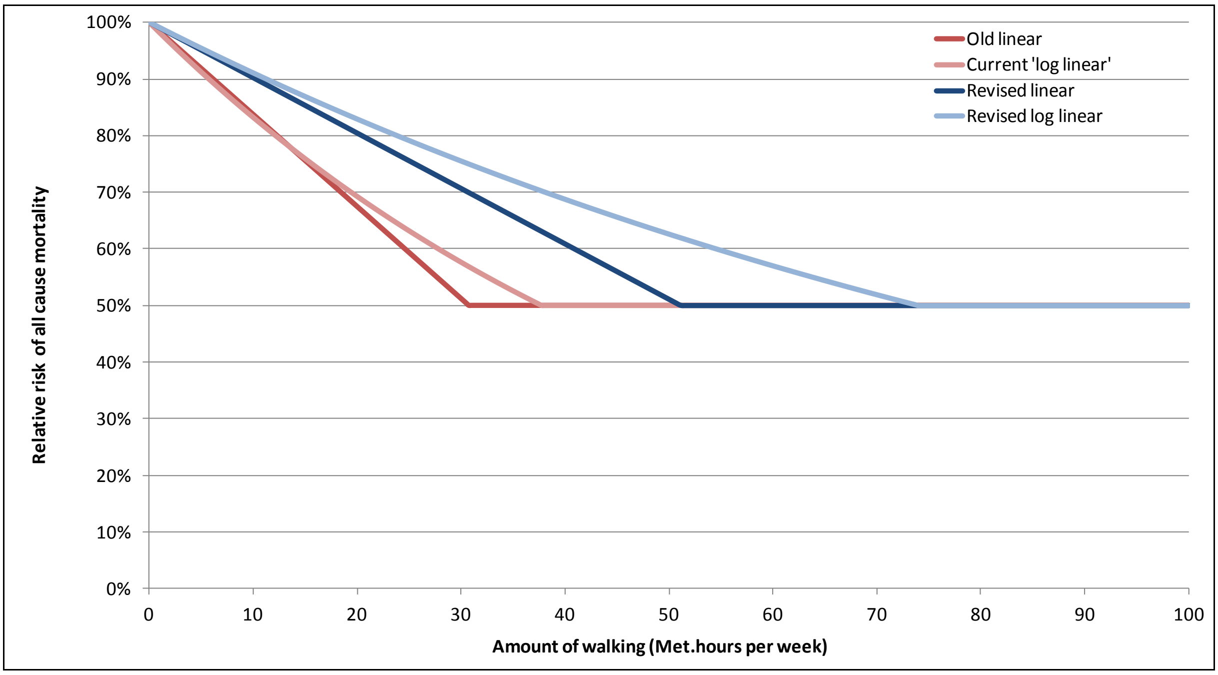


Fig. 4. Relative risk estimates by amount of walking for former, current and two new proposed dose–response relationships



Morbidity benefits
It was also acknowledged that the benefits of walking and cycling are underestimated by only considering mortality. By omitting morbidity reductions, and especially mental health benefits, the true value of active mobility remains unknown. However, including morbidity benefits requires more substantial changes to the design of HEAT for walking and cycling and will be addressed in future updates.

Age and sex differences
Studies find risk reductions differing by age: for example, increased activity in older age groups is likely to yield higher benefits than in young age groups. Using different risk reductions for different age groups and possibly also by sex might further enhance the results. However, given the target audience and foreseen applications of HEAT in a transport setting, where input data are not usually available by age and sex subgroups, such an approach would be unsuitable for this particular tool at this stage. Nevertheless, it will be important to inform transport planners about these issues and the need to address them in the future to the extent possible.

An additional important aspect to consider is related to the significant difference in mortality rates by age: if HEAT is applied to specific population groups, such as young adults using cycling facilities near universities or older adults walking on new pedestrian infrastructure, the results of the analysis might be overestimated for the younger population and underestimated for the older population groups. For such applications, a recommended new feature of HEAT would include adding the option of selecting mortality rates for specific age ranges in case of analysis performed in specific age groups.

Seasonality and regional differences
The consensus workshop raised the issues of study location and the possible influence of climate and seasonality. These are important issues, since location and culture may influence walking and cycling levels, and climate and seasonality may influence the levels of annual exposure. For example, do walking and cycling have the same effect in central Shanghai, suburban Copenhagen or the rural United States? This is obviously an important consideration before combining the evidence for a global tool.

Very few of the studies refer to seasonality or how their assessment of exposure controlled for seasonal differences. For example, one study that did report such consideration was Johnsen et al. in Denmark, a classic northern Europe climate *(7)*. In this study, to be classified as active in walking or cycling, the participants had to report at least 1 hour of the respective behaviour in both summer and winter. However, despite this consideration of season, this still left large assumptions to be made for exposure assessment. The "active" category in this study did not define an upper bound, and thus assumptions had to be made to define the dose in these active groups *(6)*. This is a good demonstration of the crude exposure assessments often used in studies to classify walking or cycling and how seasonality is just one aspect among many that limits measurement of walking or cycling for epidemiological study.

More information was provided to the participating experts after the workshop, as shown below. Table 1 gives an overview of the locations where the included walking studies were carried out, and
Table 2 gives the overview for the included cycling studies.

Table 1. Locations for walking studies

Study author	Cohort	Location, country or city for study population	Global region
Johnsen et al. *(7)*	Danish Diet, Cancer and Health Cohort	Denmark	Northern Europe
Wang et al. *(8)*	Shanghai Men's Health Study	Shanghai, China	Eastern Asia
Sabia et al. *(9)*	Whitehall II Study	London, United Kingdom	Northern Europe
Nagai et al. *(10)*	Ohsaki National Health Insurance Cohort Study	Ohsaki, Japan	Eastern Asia

Stamatakis et al. *(11)*	Scottish Health Survey participants	Scotland, United Kingdom	Northern Europe
Besson et al. *(12)*	European Prospective Investigation into Cancer (Germany)	Germany	Northern Europe
Matthews et al. *(13)*	Shanghai Women's Health Study	Shanghai, China	Eastern Asia
Schnohr et al. *(14)*	Copenhagen City Heart Study	Copenhagen, Denmark	Northern Europe
Smith et al. *(15)*	Rancho Bernado California Community Cohort	California, United States	North America
Lee & Paffenbarger *(16)*	Harvard Alumni Health Study	United States	North America
Bath & Morgan *(17)*	Nottingham Longitudinal Study of Activity and Ageing	Nottingham, United Kingdom	Northern Europe
Hakim et al. *(18)*	Subset of Cooperative Lipoprotein Phenotyping Study (people of Japanese ancestry living in Hawaii)	Hawaii, United States	Asia and the Pacific
Wannamethee et al. *(19)*	British Regional Heart Study	United Kingdom	Northern Europe
La Croix et al. *(20)*	Random sample of men and women aged 65 or older enrolled in the Group Health Cooperative of Puget Sound	United States	North America

Table 1 shows that, of the 14 walking studies, seven were located in northern Europe, three in North America, three in eastern Asia and one in Asia and the Pacific. The exposure-adjusted risk reductions do not appear to follow a pattern according to the study location groups. The variation or heterogeneity within broad global locations appears to be as great as that existing between studies. For example, the one study showing a (nonsignificant) positive effect for walking was among men from Denmark *(7)*. However, the same study reported a result among women in accordance with the majority of other reductions.

Table 2. Locations for cycling studies

Study	**Cohort**	**Location, country or city for study population**	**Global region**
Sahlqvist et al. (under review)	European Prospective Investigation into Cancer (United Kingdom)	United Kingdom	Northern Europe
Johnsen et al. *(7)*	Danish Diet, Cancer and Health Cohort	Denmark	Northern Europe
Andersen & Cooper *(21)*	Copenhagen City Heart Study	Copenhagen, Denmark	Northern Europe
Schnohr et al. *(22)*	Copenhagen City Heart Study	Copenhagen, Denmark	Northern Europe
Besson et al. *(12)*	European Prospective Investigation into Cancer (Germany)	Germany	Northern Europe
Matthews et al. *(13)*	Shanghai Women's Health Study	Shanghai, China	East Asia
Andersen et al. *(23)*	Glostrup Population Study and Copenhagen Male Study	Denmark	Northern Europe
Bijnen et al. *(24)*	Zutphen Elderly Study	Netherlands	Northern Europe

Table 2 shows that, of the seven cycling studies, six were located in northern Europe and one was located in eastern Asia. The one cycling study that showed a (nonsignificant) positive effect for cycling was from

Germany, in northern Europe *(12)*. The study from China was similar to the remaining five from northern Europe that showed reductions of 6–15% (exposure adjusted).

The issue of geographically different cycling and walking patterns is clearly of great importance to the HEAT model. However, there is not yet a sufficient body of studies to investigate this aspect further before considering inclusion into HEAT. A possible approach when more results are available could be to carry out a meta-regression to investigate possible associations between risk reduction and study-level variables such as location, climate or seasonality effects.

For the time being, although HEAT users will continue to be encouraged to use local data on cycling and walking levels and whenever available, there is no strong basis to modify the present HEAT default value on the average number of days cycled, which is based on the average number of days cycled in Stockholm.

Dose–response curve and sensitivity analysis

Although there is not yet general agreement on the exact shape of the dose–response curve between physical activity and mortality, the literature suggests that the relationship is most likely nonlinear. Participants also acknowledged that, statistically, the 0.25 power dose–response curve would be the most fitting one. However, adopting this curve for HEAT would mean that the users would need to have information on the baseline level of physical activity of their subjects to determine which point of the curve to use to calculate the results. There was general agreement that this would add undue complexity to the HEAT models, without improving the precision of the results, since additional assumptions would need to be made regarding the underlying distribution of exposure, introducing additional complexity. Further, experience has shown that many users already have difficulty in determining the level of cycling or walking to enter into the HEAT models, and they would likely be unable to provide the additional information requested. In addition, using a linear dose–response function enables constant absolute risk reduction to be applied irrespective of the starting-point of the calculation. An approach based on a nonlinear relationship might be adopted later when suitable baseline data are available to provide default values, such as based on the results of the European Health Interview Survey (EHIS), which will include questions on cycling and on walking as of 2015.

In addition, the rather steep slope at the beginning of the nonlinear curve, especially for cycling (Fig. 2), would lead to potentially exaggerated benefits for the first few minutes of cycling; this would need to be addressed if a nonlinear curve were to be used. Several participants expressed an interest in assessing additional dose–response curves, such as 0.375 power or 0.5 power functions or a spline function; this could be addressed as part of a scientific publication separate from the core HEAT process.

The workshop participants achieved consensus on adopting the new relative risks for cycling and walking, based on the presented meta-analyses and that the final approach regarding the exact shape of the dose–response curve (linear or log-linear) was to be prepared by a smaller subgroup (consisting of Hywell Dinsdale, Charlie Foster, Thomas Götschi, Sonja Kahlmeier, Paul Kelly, Michal Krzyzanowski, Francesca Racioppi, Harry Rutter and James Woodcock).

Further, participants discussed the possibility of providing HEAT users with an upper and lower range of results in addition to a central estimate. For example, this could be calculated based on the confidence interval of the relative risk used. Although participants agreed that it would be ideal to calculate a range of results, using the confidence interval as a basis would be somewhat arbitrary, since the HEAT calculation includes inherently several assumptions and uncertainties on other steps of the calculation. It was therefore suggested that the current invitation to users to carry out their own sensitivity analysis using a range of different input values will be reinforced.

Capping benefits

The previous HEAT model capped benefits at 50% of the possible risk reduction. This cap was determined based on the then-available research evidence on total physical activity, indicating that after an equivalent of about 2 hours of brisk walking per day or 1.5 hours of cycling per day, respectively, no further health benefits in terms of reduced mortality had been observed *(4)*. Workshop participants agreed that the results should continue to be capped at a reasonable level, based on available data. However, using a cap of 50% or the previously used exposure levels would correspond to much higher exposure levels in the current model, since the new dose–response curves are less steep than the curves used in the current models. The development of the final approach to select a sensible cap for the new models was therefore likewise deferred to the subgroup. Possible exposure levels for choosing a cap could be 500 or 700 minutes of walking or cycling, respectively, after which some studies did not observe further benefits, but further studies will be assessed to derive an evidence-informed cap.

Final approach for the updated HEAT models
After the workshop, the subgroup addressed these two issues and proposed the following approach to the workshop participants.

- Use of a linear dose–response curve was proposed for the next version of HEAT cycling and walking, based on a relative risk of 0.90 (CI 0.87–0.94) for cycling and 0.89 (CI 0.83–0.96) for walking.
  The currently available evidence on various dose–response functions enables more careful assessment of possible functions and a more evidence-informed decision on the most appropriate and sensible approach within a HEAT context. Although a log-linear function might be closer to the underlying biological dose–response function, the log-linear and linear functions were very similar *(6)*. Overall, within a HEAT context, the linear function is the most suitable one since, in most cases, HEAT users will not know the baseline level of physical activity of their subjects, and a constant absolute risk reduction can be applied for all HEAT applications until the cap is reached.
- It is recognized that these assumptions require some attention when modelling walking or cycling benefits in groups composed disproportionately of sedentary or very active individuals. In such cases, applying HEAT would be likely to lead to a small overestimation of benefits in already active groups of individuals and a small underestimation in less active ones. If the population in question has a normal distribution of levels of physical activity, the effects are likely to be minimized. The new caps for HEAT were proposed to be determined based on the evidence from the cycling and walking studies used to derive the relative risks. Inspection of the data points in Fig. 1 and Fig. 2 suggested that no further risk reductions were achieved after about 45% reduction for cycling and 30% for walking. This would correspond to an exposure of about 500 minutes of walking or cycling, respectively. However, using the risk reductions would be preferable as basis for defining a cap rather than minutes of physical activity since it avoids assumptions around defining MET levels for moderate and vigorous intensity. These limits were confirmed by a large cohort study of about 400 000 individuals aged 20 years and older living in Taiwan *(25)*, found through purposive review. The study provides information on mortality reduction for total, moderate and vigorous activity and confirms no further benefits after a risk reduction of about 30% for moderate-intensity physical activity and of about 45% for vigorous-intensity physical activity. It was proposed to use these risk reductions as a cap for the updated HEAT.

The workshop participants adopted these proposals, and they will be applied in the updated HEAT models.

4 Review of epidemiological literature on air pollution and all-cause mortality and suggestions for integration into HEAT

4.1 Introduction of review results and proposed approach

David Rojas presented a possible approach for including air pollution effects, based on the inhaled dose of particulate matter (PM_{10} or $PM_{2.5}$) per day in various activity modes, an available relative risk function, the attributable fraction among those exposed and available mortality rates.

Based on a large body of evidence, mainly from cohort studies, $PM_{2.5}$ (or converted PM_{10} levels) was proposed as an indicator of air pollution to estimate the health effects. The change in the daily inhaled dose of $PM_{2.5}$ related to travelling with a specific mode, for example cycling or walking, compared with not travelling, would be calculated as shown in Table 3.

Although in the current example, "staying at home" was used as the reference scenario, contributions from other activities, such as travelling in a different mode or being at work, would also need to be considered for a HEAT model.

Conversion factors between background concentrations and walking, cycling and in-car concentrations were proposed, based on three studies performed in different cities that estimated $PM_{2.5}$ concentrations in these three different microenvironments *(6)*. Minute ventilation rates according to physical activity level (walking, cycling, car driving, sleeping, etc.) were also proposed based on a method developed by the United States Environmental Protection Agency. For the final risk assessment, it was suggested to use the relative risk from a recently published meta-analysis that includes 11 international cohort studies and calculated a relative risk of 1.06 (CI 1.04–1.08) for all-cause mortality per 10 mg/m^3 increment of $PM_{2.5}$. Based on the calculation of the attributable fraction among the exposed people (Table 3) and the mortality rate, the number of deaths in the population could be derived. The following input data would be required to use the air pollution model:

- annual mean concentration of $PM_{2.5}$ or PM_{10} in the place of interest (two international databases with PM_{10} concentrations in cities available);
- trip duration in minutes or distance travelled in km (already part of the existing HEAT models); and
- all-cause mortality rate among adults in the study population (already part of the existing HEAT models).

Table 3. General formulas to calculate the impact of air pollution for various modes of transport

	Formula
Inhaled dose (mg/day)[a]	Minute ventilation (m^3/h) * Duration (h/day) * Concentration (mg/m^3)
Total dose (mg/day)[a]	Inhaled reference dose[b] + inhaled dose during transport
Equivalent change (mg/m^3)[a]	$\left(\left(\frac{\text{Reference dose}^{b} + \text{transport (mode) dose}}{\text{Reference dose}^{b}\text{ of pollutant}} \right) - 1 \right)$ * mean concentration

Relative risk	$\text{Exp}\left(\text{Ln}(RR_{10}) * \left(\frac{\text{Equivalent change}}{10}\right)\right)$
Attributable fraction among those exposed	$AF_{exp} = \frac{(RR - 1)}{RR}$
Mortality rate among travellers	Mortality rate in the city or region * number of travellers
Mortality due to exposure	Mortality rate in travellers * AF_{exp}

[a]This formula was calculated for each mode of transport.
[b]Reference scenario currently "staying at home", including sleep dose + resting dose. For other scenarios, contributions from other activities may be considered.
RR = relative risk; RR_{10} = relative risk per each increment in 10 mg/m^3 of $PM_{2.5}$; AF_{exp} = attributable fraction among the people exposed.

4.2 Discussion

The participants confirmed that considering air pollution in HEAT is a relevant topic based on experiences with the HEAT target audience, which has expressed on several occasions concerns about negative air pollution health effects when promoting cycling and walking. The participants also recognized that the detrimental effects of air pollution somewhat reduce the positive effects of physical activity from walking on cycling, albeit probably to a relatively low degree compared with the benefits of physical activity. However, it was remarked that this effect is already addressed somewhat through the use of all-cause mortality as the relevant end-point. It was also recognized that injuries are a relevant topic to discuss further in the HEAT context. However, methodological complexities still need to be addressed before a new module to assess injuries can be integrated into HEAT. This fact and the perceived higher demand from the users' viewpoints to address the question of air pollution supports addressing this topic first.

Participants welcomed the proposed method as a good basis for developing a separate, optional air pollution module to calculate air pollution effects among cyclists and walkers. A particularly positive aspect of the proposed approach is that the only additional input it would require from the users would be information on annual mean average of $PM_{2.5}$, which is routinely collected in many cities and readily available from international databases. However, it was concluded that at the current stage, inclusion into the HEAT model is conditional on further insights, in particular on the following points.

- The possible double-counting of effects from air pollution on all-cause mortality needs to be clarified. Further insights on this issue could, for example, come from a more in-depth analysis of the results of a recent international project called TAPAS (Transportation Air Pollution and Physical Activities: an integrated health risk assessment programme of climate change and urban policies). The project looked at the effects of air pollution, road crashes and active transport on health in cities across Europe and could shed light on the extent of the effects of exposure to different levels of air pollution.
- The suitability of the proposed conversion factors and assumptions should be determined. In particular, further work is needed regarding the conversion factors for different modes of transport and the ventilation rates. The proposed conversion factors were derived from the few available studies that examined all three modes of interest simultaneously to reduce methodological diversity, but different approaches could be considered.
- Several scenarios should be simulated to compare the effects of physical activity from cycling and walking versus air pollution.

These issues will be addressed as part of the further work done in the HEAT project. Participants also considered various possibilities to just highlight to users that current research suggested that, in most cases, especially in a western European context, the negative effects to be expected from air pollution would be smaller than the positive effects of physical activity *(26,27)*. However, it was concluded that, given the scope and context of HEAT, providing an actual calculation for the specific analysed scenario would be preferable; whether this would also be costed separately should be decided based on further evidence from the additional work to be done. As an intermediate step, air pollution effects could also be addressed in the frequently asked questions (FAQ) section of HEAT. It should include a recommendation to avoid heavily polluted (such as by vehicular emissions) areas in planning cycling and walking routes.

5 OECD approach for mortality risk valuation in environment, health and transport policies and options for integrating it into HEAT

5.1 Introduction of approach and options

The HEAT tools for walking and cycling use the VSL method to economically quantify the health benefits from reduced mortality through walking or cycling *(2)*. The VSL is derived with a method called willingness to pay: for example, for a policy that would reduce their annual risk of dying in the WHO European Region. In the absence of up-to-date official national VSLs, a single VSL of €1.5 million (in 1998), formalized in the UNITE project but developed with an estimate based on a single country (United Kingdom), was used as a European standard value in the first HEAT for walking and cycling *(2,4)*. In 2011, the value was updated to €1.574 million, adjusting it to the price level of the year 2010.

Nils Axel Braathen, OECD, presented a recent report that proposed a comprehensive, updated European VSL based on a stock of 163 stated preference values (based on the willingness-to-pay approach) from about 80 studies that estimated the VSL for adults in EU27-countries between 1970 and 2008 *(28)*. The studies were selected after careful quality checks. Studies were included if they were based on a representative population sample of at least 200 subjects (or 100 in the case of subsamples of larger studies) and provided information on the size of the risk change in question. The most robust variables explaining variation in VSL were gross domestic product per capita and the magnitude of the risk change that was valuated. Lack of properly explaining the risk to be valuated led to higher VSLs. There was no clear relationship with age. The results were fairly robust given different models, weighting procedures and trimming of the data.

The OECD report calculated 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) *(28)*.

HEAT is a tool developed and disseminated by the WHO Regional Office for Europe and should thus be applicable to all countries of the WHO European Region. Using an average value based on the EU27 countries might therefore not be the first choice for the HEAT tools. In addition, such a value could lead to inflated HEAT results, especially in countries with lower purchasing power than in the EU27. However, the OECD report does not contain VSL studies for all WHO European countries.

5.2 Discussion

Participants welcomed the information provided. It was acknowledged that other recent projects aimed at developing a European VSL: for example, the ExternE (External Costs of Energy) project recently suggested a range of €1.9 to €2.2 million. Nevertheless, participants agreed that the OECD report would represent the best currently available approach to adopt for HEAT.

Although different metrics could also be used, such as the value of a life-year (VOLY), the fact that the main target audience of HEAT is transport planners and advocates still supports the use of VSL. In addition, there are also methodological concerns regarding VOLY: for example, older people are assigned a lower value than younger people, while the OECD meta-analysis did not indicate a clear relationship with age in stated preference studies.

Participants achieved consensus on using an updated value of VSL based on the OECD report, thereby replacing the previous UNITE VSL. Calculating a new European average (including to the extent possible also non-EU WHO European Region Member States) based on the new country-specific values was seen as a possible approach, but it remained uncertain to what extent this would influence the value to be used. The main recommendation, however, is to use country-specific values, when possible. The country-specific VSL will be provided.

In addition, participants also supported the possibility to provide a result range, based on a suggested range of ±50% stated in the OECD report); practical implementation will be investigated further.

Final approach for the updated HEAT models

Based on the conclusions of the consensus meeting, experts from Ecoplan developed a slightly amended and updated approach to calculating an average VSL for the WHO-European region based on the EU27-result in the OECD-study (28).

Deriving country-specific VSL from the OECD results

The OECD report gives guidance on how to derive country-specific values (28). The OECD suggests adjustments to account for income level differences across countries and of inflation and income growth over time since these factors are found to have a significant impact on the VSL. Conversion of the currency from USD to local currency, using purchasing power parity-adjusted exchange rates (PPP), is also part of the adjustments to make. The following formula was applied to derive the country-specific values in Euros for the year 2011:

$$VSL_{\text{COUNTRY, 2011 (local currency)}} = VSL_{\text{EU-27, 2005, USD}} * (Y_{\text{COUNTRY, 2005}} / Y_{\text{EU-27, 2005}})^{0.8} * PPP_{2005} * (1 + \%\Delta P_{2005\text{-}2011}) * (1 + \%\Delta Y_{2005\text{-}2011})^{0.8}$$

$VSL_{\text{EU-27, 2005, USD}}$ = base value for EU27 of 3.615 million US$ from OECD-study (±50%)
$Y_{\text{COUNTRY, 2005}}$= real GDP per capita at purchasing power parity in 2005 of the respective country (29)
$Y_{\text{EU-27, 2005}}$ = average real GDP per capita at purchasing power parity in 2005 of EU-27 countries, which equals 26’904 (USD in 2005) (29)
0.8 = income elasticity of VSL according to the OECD-study (28)
PPP_{2005} = Purchasing power parity-adjusted exchange rate in 2005 (local currency / US$) (29)
$(1 + \%\Delta P_{2005\text{-}2011})$ = inflation adjustment with consumer price index of the respective country between 2005 and 2011
$(1 + \%\Delta Y_{2005\text{-}2011})$ = income adjustment with growth in real GDP per capita in the respective country between 2005 and 2011[2]

Average values for EU27, EU28 and WHO European Region

Besides the country-specific values also average values for the EU27, EU28 (including Croatia) and the 53 countries of the WHO European Region were calculated. To do so we use the population weighted average of the country-specific VSL estimates.[3] For 2011 the results are shown in the following table.

[2] For Andorra, Monaco and San Marino not all of the necessary background data is available. For these countries, currently no country-specific value can be calculated. For Turkmenistan and Uzbekistan only values for 2005 (not 2011) can be calculated due to missing data.

[3] Before calculating population weighted averages we transformed all VSL-estimates into € (by applying the exchange rate). As an alternative way we also calculate averages by using the same equation as for the calculation of the country-specific values (see above). For all the necessary input data in the equation we use population weighted averages of the countries considered (EU27, EU28 or WHO European Region). This alternative methodology gives slightly lower results (0.29% for EU27 to 1.76% for WHO European Region), but is more complicated to explain and calculate. Therefore the simpler method was used to derive the values for HEAT.

Table 4: Results for the average VSL in EU27-, EU28- and WHO European Region-countries

	VSL in €, 2011		
	base value	minimum	maximum
average EU27	**3'386'642**	1'693'321	5'079'962
average EU28	**3'370'891**	1'685'446	5'056'337
average WHO European Region (without Andorra, Monaco, San Marino, Turkmenistan and Uzbekistan)	**2'487'283**	1'243'642	3'730'925

6 Conclusions, next steps and closing

The workshop concluded with an outlook on HEAT-related activities foreseen under a new four-year research project on Physical Activity through Sustainable Transport Approaches (PASTA) presented by Regine Gerike. The study will include literature reviews on determinants of cycling and walking and on successful promotion approaches. A longitudinal study to better understand correlates of active mobility and their effects on overall physical activity, injury risk and air pollution will be carried out as well. The results will be used to inform further updates of HEAT: for example, regarding new assumptions, exposure and additional health effects.

Michal Krzyzanowski thanked all participants for their input and fruitful discussions. Francesca Racioppi outlined the next steps, including:

- comments on the background paper in terms of minor corrections or clarifications, to be made within two weeks after the workshop;
- a brief follow-up meeting of the HEAT core group taking place after the closing of the consensus workshop to review conclusions and to decide on the specific next steps;
- addressing the remaining open questions regarding the dose–response curves and VSL calculations;
- further developing a possible air pollution module for HEAT;
- further exploring possibilities to include in HEAT changes in injury risks depending on the walking and cycling levels;
- further exploring possibilities to include in HEAT the health effects from reduced morbidity related to regular cycling and walking; and
- further assessing various other existing approaches in the scientific community to quantifying the health effects of cycling and walking with regard to possibilities to further develop HEAT.

She closed the workshop expressing appreciation on behalf of the WHO to all participants for the valuable support and inputs provided to the HEAT process.

References

1. Rutter H et al. Economic impact of reduced mortality due to increased cycling. Am J Prev Med. 2013;44:89–92.
2. Health Economic Assessment Tool for cycling and walking. Copenhagen: WHO Regional Office for Europe; 2011 (http://www.euro.who.int/HEAT, accessed 18 March 2014).
3. Kahlmeier S et al. "Health in all policies" in practice: guidance and tools to quantifying the health effects of cycling and walking. J Phys Act Health. 2010;7(Suppl. 1):S120–5.
4. Kahlmeier S et al. Health economic assessment tools (HEAT) for walking and for cycling. Methodology and user guide. Copenhagen: WHO Regional Office for Europe; 2011.
5. Woodcock J et al. Non-vigorous physical activity and all-cause mortality: systematic review and meta-analysis of cohort studies. Int J Epidemiol. 2011;40:121–38.
6. Development of the Health Economic Assessment Tools (HEAT) for walking and cycling: consensus workshop. Meeting background document. Copenhagen: WHO Regional Office for Europe; 2013.
7. Johnsen FN et al. Leisure time physical activity and mortality. Epidemiology. 2013;24:717–25.
8. Wang N et al. Associations of tai chi, walking, and jogging with mortality in Chinese men. Am J Epidemiol. 2013:178:791–6.
9. Sabia S et al. Effect of intensity and type of physical activity on mortality: results from the Whitehall II cohort study. Am J Publ Health. 2012;102:698–704.
10. Nagai M et al. Impact of walking on life expectancy and lifetime medical expenditure: the Ohsaki Cohort Study. BMJ Open. 2011;1:e000240.
11. Stamatakis E, Hamer M, Lawlor DA. Physical activity, mortality, and cardiovascular disease: is domestic physical activity beneficial? The Scottish Health Survey – 1995, 1998, and 2003. Am J Epidemiol. 2009;169:1191–200.
12. Besson H et al. Relationship between subdomains of total physical activity and mortality. Med Sci Sports Exerc. 2008;40:1909–15.
13. Matthews CE et al., Influence of exercise, walking, cycling, and overall nonexercise physical activity on mortality in Chinese women. Am J Epidemiol. 2007;165:1343–50.
14. Schnohr P, Scharling H, Jensen JS. Intensity versus duration of walking, impact on mortality: the Copenhagen City Heart Study. Eur J Cardiovasc Prev Rehabil. 2007;14:72–8.
15. Smith TC et al. Walking decreased risk of cardiovascular disease mortality in older adults with diabetes. J Clin Epidemiol. 2007;60:309–17.
16. Lee IM, Paffenbarger RS Jr. Associations of light, moderate, and vigorous intensity physical activity with longevity. The Harvard Alumni Health Study. Am J Epidemiol. 2000;151:293–9.
17. Bath PA, Morgan K. Customary physical activity and physical health outcomes in later life. Age Ageing. 1998;27(Suppl. 3):29–34.
18. Hakim AA et al. Effects of walking on mortality among nonsmoking retired men. N Engl J Med. 1998;338:94–9.
19. Wannamethee SG, Shaper AG, Walker M. Changes in physical activity, mortality, and incidence of coronary heart disease in older men. Lancet. 1998;351:1603–8.
20. LaCroix AZ, et al. Does walking decrease the risk of cardiovascular disease hospitalizations and death in older adults? J Am Geriatr Soc. 1996;44:113–20.
21. Andersen LB, Cooper AR. Commuter cycling and health. In: Gronau W, Reiter K, Pressl R, eds. Transport and health issues 2011: studies on mobility and transport research. Mannheim: Verlag MetaGISInfosysteme; 2011:9–19.
22. Schnohr P et al. Intensity versus duration of cycling, impact on all-cause and coronary heart disease mortality: the Copenhagen City Heart Study. Eur J Prev Cardiol. 2012;19:73–80.
23. Andersen LB et al. All-cause mortality associated with physical activity during leisure time, work, sports, and cycling to work. Arch Intern Med. 2000;160:1621–8.
24. Bijnen FC et al. Baseline and previous physical activity in relation to mortality in elderly men: the Zutphen Elderly Study. Am J Epidemiol. 1999;150:1289–96.

25. Wen CP, Wai JP, Tsai MK, Yang YC, Cheng TY, Lee MC et al. Minimum amount of physical activity for reduced mortality and extended life expectancy: a prospective cohort study. Lancet. 2011;378:1244–53.
26. Johan de Hartog J, Boogaard H, Nijland H, Hoek G. Do the health benefits of cycling outweigh the risks? Environ Health Perspect. 2010;118:1109–16.
27. Rojas-Rueda D, de Nazelle A, Tainio M, Nieuwenhuijsen MJ. The health risks and benefits of cycling in urban environments compared with car use: health impact assessment study. BMJ. 2011;343:d4521.
28. Mortality risk valuation in environment, health, and transport policies. Paris: OECD; 2012.
29. World Bank Search (database). Paris, World Bank Group, 2014 (http://search.worldbank.org/data, accessed 18 March 2014).

Annex 1. Workshop programme

Tuesday, 1 October 2013

9:00–9:30	**Registration and coffee**
9:30–9:45	**Welcome, introduction of the core group and election of the chair and rapporteur of the meeting** *Francesca Racioppi, WHO Regional Office for Europe*
9:45–10:00	**Introduction to HEAT for walking and cycling** *Francesca Racioppi and Christian Schweizer, WHO Regional Office for Europe*
10:00–10:30	**Lessons learned from HEAT since 2008: scope of the proposed update** *Nick Cavill*
10:30–10:45	**Methods and proposed way of working for the consensus meeting** *Chair*
10:45–11:15	*Break*
11:15–12:00	**Review of epidemiological literature on the relative risk of all-cause mortality for cycling and walking** *Charlie Foster*
12:00–13:00	*Lunch*
13:30–14:30	**Discussion and consensus on the relative risk of all-cause mortality for cycling and walking in HEAT** *Chair*
14:30–15:15	**Review of epidemiological literature on air pollution and all-cause mortality and suggestions for integration into HEAT** *David Rojas*
15:15–15:45	*Break*
15:45–17:00	**Discussion and consensus on integrating air pollution exposure into HEAT** *Chair*
17:00	**Closing day one** *Francesca Racioppi, WHO Regional Office for Europe*

Wednesday, 2 October 2013

9:00–9:15	**Welcome and summary of day one**
9:45–10:00	**Summary of the OECD approach for mortality risk valuation in environment, health and transport policies and options for integrating it into HEAT** *Nils-Axel Braathen, OECD* *Christian Schweizer, WHO Regional Office for Europe*
10:00–11:00	**Discussion and consensus on the options for integrating the OECD approach for mortality risk valuation in environment, health and transport policies into HEAT** *Chair*
11:00–11:30	**Outlook for the future development of HEAT (PASTA)**
11:30–11:45	**Next steps and other items**
11:45	**Closing** *Francesca Racioppi, WHO Regional Office for Europe*

Annex 2. List of participants

Karim Abu-Omar
FA University Erlangen Nuremberg
Institute for Sport Science and Sport
Erlangen
Germany

Tegan Boehmer
Centers for Disease Control and Prevention
National Center for Environmental Health
Atlanta, Georgia
United States of America

Nils-Axel Braathen
Environment Directorate
Organization for Economic Cooperation and Development (OECD)
Paris
France

Nick Cavill
Cavill Associates
Stockport Cheshire
United Kingdom

Audrey de Nazelle
University College London
Centre for Environmental Policy
London
United Kingdom

Hywell Dinsdale
Consultant
Hyde
United Kingdom

Jonas Finger
Robert Koch Institute
Epidemiology and Health Monitoring
Berlin
Germany

Charlie Foster
University of Oxford
Department of Public Health
Oxford
United Kingdom

Eszter Füzeki
Johann Wolfgang Goethe-Universität
Department of Sports Medicine
Frankfurt am Main
Germany

Regine Gerike
University of Natural Resources
and Life Sciences Vienna
Austria

Thomas Götschi
University of Zurich
Institute of Social and Preventive Medicine
Switzerland

Luc Int Panis
VITO PHARE
Mol
Belgium

Sonja Kahlmeier
University of Zurich
Institute of Social and Preventive Medicine
Switzerland

Paul Kelly
University of Oxford
Department of Population Health
Oxford
United Kingdom

Michal Krzyzanowski
King's College London
Environmental Research Group
London
United Kingdom

Nanette Mutrie
University of Edinburgh
Moray House School of Education
Institute for Sport, Physical Education
and Health Sciences
Edinburgh
United Kingdom

Pekka Oja
UKK Institute for Health Promotion Research
Tampere
Finland

Laura Perez
Swiss Tropical and Public Health Institute
Basel
Switzerland

David Rojas Rueda
Centre for Research in Environmental Epidemiology (CREAL)
Barcelona
Spain

Harry Rutter
London School of Hygiene and Tropical Medicine
London
United Kingdom

Peter Schantz
Swedish School of Sport and Health Sciences
Stockholm
Sweden

Heinrich Sommer
Ecoplan
Altdorf
Switzerland

Sylvia Titze
University of Graz
Austria

James Woodcock
Centre for Diet and Activity Research (CEDAR)
Institute of Public Health
Cambridge
United Kingdom

World Health Organization

Regional Office for Europe

Frank George
Division of Communicable Diseases, Health Security and Environment
WHO European Centre for Environment and Health
Bonn
Germany

Marie-Eve Heroux
Division of Communicable Diseases, Health Security and Environment
WHO European Centre for Environment and Health
Bonn
Germany

Francesca Racioppi
Division of Communicable Diseases, Health Security and Environment
Copenhagen
Denmark

Christian Schweizer
Division of Communicable Diseases, Health Security and Environment
Copenhagen
Denmark

The WHO Regional Office for Europe

The World Health Organization (WHO) is a specialized agency of the United Nations created in 1948 with the primary responsibility for international health matters and public health. The WHO Regional Office for Europe is one of six regional offices throughout the world, each with its own programme geared to the particular health conditions of the countries it serves.

Member States

Albania
Andorra
Armenia
Austria
Azerbaijan
Belarus
Belgium
Bosnia and Herzegovina
Bulgaria
Croatia
Cyprus
Czech Republic
Denmark
Estonia
Finland
France
Georgia
Germany
Greece
Hungary
Iceland
Ireland
Israel
Italy
Kazakhstan
Kyrgyzstan
Latvia
Lithuania
Luxembourg
Malta
Monaco
Montenegro
Netherlands
Norway
Poland
Portugal
Republic of Moldova
Romania
Russian Federation
San Marino
Serbia
Slovakia
Slovenia
Spain
Sweden
Switzerland
Tajikistan
The former Yugoslav Republic of Macedonia
Turkey
Turkmenistan
Ukraine
United Kingdom
Uzbekistan

Original: English

World Health Organization
Regional Office for Europe

UN City, Marmorvej 51, DK-2100 Copenhagen Ø, Denmark
Tel.: +45 45 33 70 00 Fax: +45 45 33 70 01 Email: contact@euro.who.int
Website: www.euro.who.int