METHODOLOGY REPORT

Dec 2018

WALKING AND CYCLING BENEFITS TOOL

BACKGROUND | Novo Nordisk and C40 are committed to support cities to advance their goals of increasing the share mode of active mobility options and become healthier, more liveable and sustainable. Based on the past two years of research they have built an easy to use excel tool for any city to apply in assessing health and climate benefits.

AIM OF THE DOCUMENT | This document aims to summarize the methodology used to develop the tool, in order to inform the process undergone and facilitate future improvements.

WALKING AND CYCLING BENEFITS TOOL

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PART 1 | RESEARCH PROCESS

1.1 Introduction

Issue | Climate change and non-communicable diseases are both increasingly pressing issues faced by cities. Clustering of populations in urban areas is a challenge for health, environment and liveability of cities, but also makes them central for a joint intervention. Broad cross-sector approaches provide opportunities to increase the health of urban populations, while also responding to climate issues.

Research | C40 Cities and Novo Nordisk have established a partnership to support cities in measuring and evaluating urban actions and their impact on health and climate. They are committed to support cities to advance their goals of increasing the share mode of active mobility options and become healthier, more liveable and sustainable.

Process | The programme supported 18 cities worldwide through technical assistance and masterclasses. Based on the past two years of research and an extensive literature review, C40 Cities and Novo Nordisk have built an easy to use tool for any city to assess health and climate benefits of walking and cycling actions. The development of the simple excel-based tool has been led by C40's Measurement and Planning team and reviewed by experts from the University of Cambridge and University of Zürich. The BETA version of the tool was tested at a Masterclass in Copenhagen with six cities to ensure its usability by municipal teams worldwide.

Aim of this report | This methodology report aims to document the process that has been used to develop the tool, in order to facilitate future improvements and extension to other impact assessment areas.

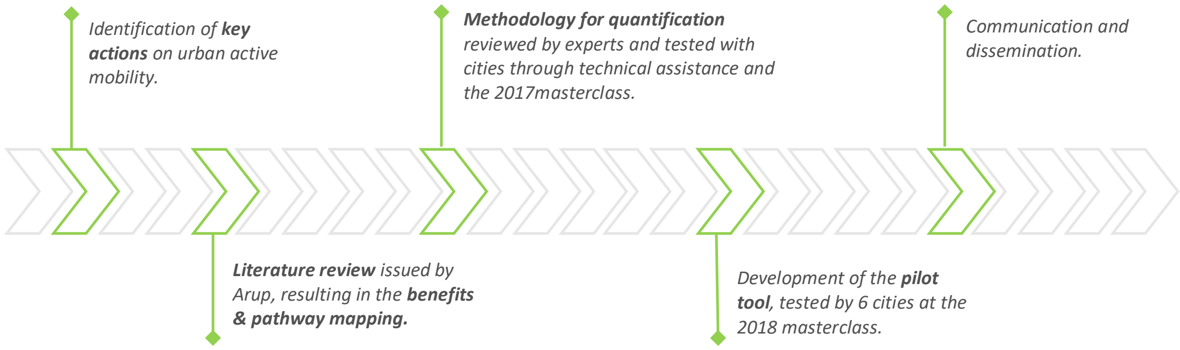

Illustration 1: Simplified view of the Walking and Cycling research process

1.2 An overview of the benefits methodology

Identifying and prioritizing the impacts | Increase of walking and cycling behaviours can entail a broad range of benefits for urban populations who interact with the built environment on a continuous basis. The table below gives an overview of some of the key potential impacts of active mobility, with both positive ("+") and negative ("–") impacts. As this study underlines the links between Health and Environment, the bold impacts were chosen for this version of the tool.

TYPE OF IMPACT	IMPACT
Social benefits (Health and Safety)	+ **Improvement of quality of life and life expectancy** + **Diminution of risk and rate of morbidity for Coronary heart disease, Stroke, Dementia, Depression, Type II Diabetes, Breast cancer, Colon cancer.*** + Reduction in rate of street crime - /+ Change of road accidents
Economic benefits (individual benefits)	+ Change in time spent in leisure or employment, due to less time in traffic jam + Reduction in personal health costs
Economic benefits (wider benefits)	+ **Economic gains from improved public health** + Reduced costs of crime

	+ Increased productivity with less staff sickness + Change in economic activity, enhancement of retail activity near cycling/walking lanes
Environmental benefits	+ Improvement in comfort levels: average street temperature and street noise + Improvement of air quality + **Reduction in GHG emissions**

Table 1: Key potential impacts from urban active mobility.
Source: authors' elaboration based on Opportunity 2030, and the Benefit Pathways mapping of Walking and Cycling, C40 Cities.

** These diseases were selected for the walking and cycling research as their dose-response function to physical activity are well-documented in epidemiological studies.*

Using pathways as a global approach | The benefits of walking and cycling have been developed following C40 Urban Climate Action Impacts Framework. This method explains a global process to map how a climate action or policy translates into a change for the society, economy, or environment. UCAIF provides a common language and a common approach for cities and researchers who, when monitoring and assessing the effects of climate actions, can contribute to a global evidence base by reporting data in a standardised manner (following the same terminology, taxonomy, methods and tools).

STAGE	DEFINITION	EXAMPLE
Action	Any policy, programme, or investment initiated by urban public officials with the intention to provide some contribution to climate mitigation or adaptation.	*New cycle path.*
Output	What an action produces, such as a provided service, facility, infrastructure, or a financial tool. It should be under the direct control of the project, e.g. if the action is implemented the output will occur.	*Increase in the number of people cycling.*
Outcome	The change generated by the output. It is necessary for the intended impact to occur, and is generally not under direct control of the project/intervention.	*Increase in the number of active people.*
Impact	The medium- or long-term effect of the outcome.	*Reduction in risk of obesity.*

Table 2: Definition of the stages of the Benefits Pathways.
Source: Urban Climate Action Impact Framework, C40 Cities.

Benefits can be mapped into pathways which link four stages of an intervention: actions, outputs, outcomes, and impacts with the above definition. The chart below describes the Pathway for cycling, showing how each impact is related to an improvement of the cycling infrastructure. Both pathways for walking and cycling can be found in the annexes. The causality in the Pathway implies that each stage directly causes or contributes to the occurrence of the next. Therefore, Pathways facilitate a comprehensive mapping of how one action translates into multiple impacts, but also how multiple actions across different sectors may contribute to the same impact. As such, the Pathways can be read from top to bottom or from bottom to top. [1]

[1] *Urban Climate Action Impact Framework, C40 Cities.*

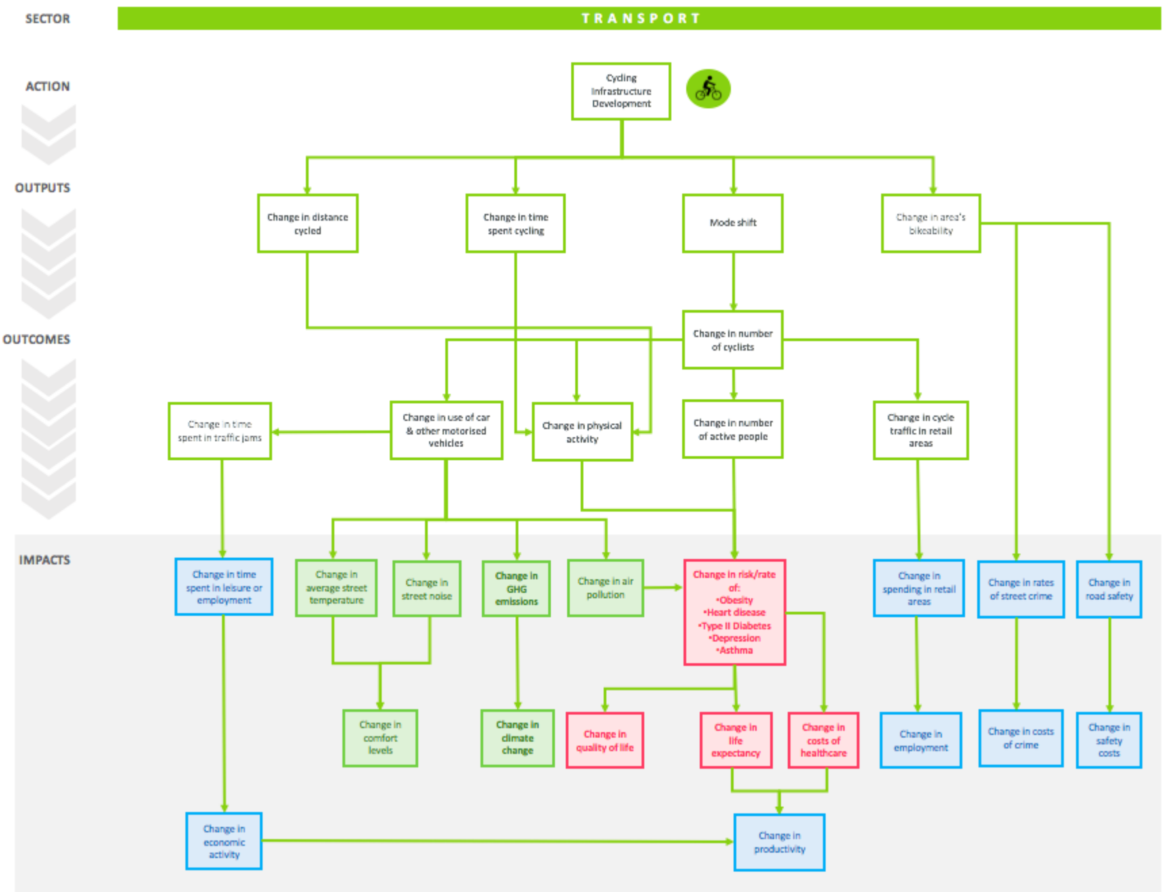

Illustration 2: Causality Pathway of Cycling Benefits
Source: Prepared by Arup for C40 Cities

1.3 Literature review

Review Process | The methodology used in this tool is based on the past two years of research and a number of wider approaches/ methodologies/ tools for measuring the benefits of cities investing in walking and cycling, reviewed by experts in the field from the University of Cambridge and the University of Zürich.

The team from the University of Cambridge analysed existing methodologies and tools for evaluating the health benefits of walking and cycling. Each method had its strengths and limitations listed for comparison in the Review of existing work below. The HEAT 4.0[2] tool and the ITHIM[3] model provided the basis for the mortality and morbidity approach used in the tool. The HEAT guidance has useful details on the links between health, physical activity and air pollution, as well as default general values[4] ; both this methodology and tool will refer to it further. In addition, a detailed review of important methodological considerations around mortality and morbidity, value of statistical life and value of life years, risk factors and disease modelling was also provided.

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[2] *HEAT tool: Health economic assessment tool (HEAT) for walking and for cycling, 2017, WHO*

[3] *Integrated Transport and Health Impact Modelling Tool, 2018*

[4] *The WHO default values are mainly issued from European studies, as very little literature was available from other areas, which is one limitation to the global use of the tool. The user should always question these values, using his local knowledge and provide local data wherever possible .*

Table 3: Comparison of existing methods and tools on walking and cycling benefits.
Source : authors' elaboration based on Cambridge University study

Study	Comments and limitations	Link to website
City of Copenhagen socio-economic model	**Purpose**: Report produced by the Danish consultancy company COWI resulting from a project commissioned by the City of Copenhagen to lead cost benefits analysis of cycling project in Denmark. **Impacts considered**: air pollution, injuries. **Limitations**: It is not a tool, and limited information on methodology are available.	*COWI. Economic evaluation of cycle projects –2009.*
ITDP TEEMP (BRT model)	**Purpose**: A suite of spreadsheet models to evaluate GHG and air pollution impacts of different transport projects. Each model is specific to the project type and only BRT model is available online. The model also includes the reduction in the number of fatalities and injuries as one of the benefits. **Impacts considered:** GHG, air pollution. **Limitations:** The health benefits from the reduction in emissions are not modelled.	*ITP TEMP project*
European Federation of Cyclists	**Purpose**: The report uses HEAT 3 for calculating the cycling benefits, mostly due to physical activity, and partially from congestion. It is a one-off calculation and is not intended to be a tool or used for individual case studies. **Impacts considered:** GHG, air pollution, noise pollution, physical activity. **Limitations:** It is not a tool, and the study is non-replicable.	*ECF Calculating benefits of cycling*
HEAT Version 4	**Purpose**: The World Health Organization Europe Health Economic Appraisal Transport (HEAT) tool originated as a very simple model for calculating premature deaths prevented from cycling and walking. HEAT is governed by an expert group consensus process, led by the WHO. The basic HEAT approach has been used in several other models and is well documented. **Impacts considered:** air pollution, physical activity and injuries. **Limitations:** Currently only recommended for use in WHO European region. Calculation of the deaths only and not the reductions in morbidity.	*WHO - HEAT Guidance*
iSTHAT	**Purpose**: The tool is primarily aimed at city-level long-term changes (>30 years) in the emissions of air pollutants (PM2.5, SO2 and NOx) and GHGs resulting from transport scenarios and comparing those with business-as-usual. To model the health benefits from physical activity, WHO's HEAT model is used. **Impacts considered:** air pollution, physical activity. **Limitations:** Currently only recommended for use in WHO European region. Tool not (yet) open access. Given the model structure and the input parameters it includes, the model seems best suited to evaluate policy changes associated with changes in technology (fuel efficiency) or fuel quality (better emission standards).	*iSTHAT Research Gate*
ITHIM Spreadsheet	**Purpose**: The Integrated Transport and Health Impact Modelling (ITHIM) Tool was originally created by James Woodcock, arising from the Lancet series on climate change mitigation and health in 2009. It has been used in several US states and in several counties within California. It is being developed to a R version. Compared to HEAT, ITHIM provides a higher expertise in the user. A fundamental difference is that HEAT is calculating impacts on new pedestrians and cyclists, while ITHIM is calculating total population impacts of a mode shift to walking and cycling. ITHIM is intended for city wide rather than single project assessments. **Impacts considered:** air pollution, physical activity and injuries. **Limitations:** gradually being phased out. More data input needed than HEAT but also provides more outcomes.	*Science Direct ITHIM*
ITHIM R	**Purpose**: ITHIM- R is under development, led by JW and colleagues. The aim is to bring the best of the different versions of ITHIM together and create a generic model with an online interface. **Impacts considered:** air pollution, physical activity and injuries. **Limitations:** in development.	*CEDAR - ITHIM*
BUCA C40	**Purpose**: A model to estimate air quality and health benefits due to climate actions, considering $PM_{2.5}$ and NO_X levels. **Impacts considered:** air pollution, air quality impact on health **Limitations:** does consider the impacts of car reduction but not physical activity linked to walking and cycling.	*C40- Benefits*

Modelling mortality and morbidity: the choice of a life table approach | Several chronic disease and all-mortality modelling methods exist: simple atemporal comparative risk assessment (CRA); life table models that follow a population over time; or microsimulation models that follow individuals over time. Since economic appraisal evaluates 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 because of 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 following a population over time constitute a method for addressing these issues and thus increasing the precision of assessment. Recent scientific appraisal of the health benefits of cycling or walking has applied such approaches. This life table approach enables to calculate life-year estimates (rather than just prevented deaths and cases). [5]

Relative risk reduction | The relative risk reduction factors determine the percentage of change in chances of having a disease, considering the minutes of physical activity. To avoid inflating values, the results are capped to a maximum level of activity of 447 minutes of cycling and 460 minutes of walking per week, and a maximum reduction of 45% for cycling and 30% for walking. These multipliers have been determined based on the existing tools reviewed:

- **Mortality risk reduction** : the tool follows the HEAT approach based on a meta-epidemiological-analysis, which applies a linear dose–response curve to the mortality rate. It uses a relative risk of 0.90 for cycling (representing 100 minutes of cycling per week as a common exposure level, equivalent to meeting the recommended level of at least 150 minutes of moderate-intensity physical activity per week), and 0.89 for walking (representing 170 minutes of walking per week).[6]
- **Morbidity risk reduction:** the set of relative risk reduction factors for the 7 diseases studied (Coronary heart disease, Stroke, Dementia, Depression, Type II Diabetes, Breast cancer, Colon cancer) is based on an extensive literature review from the Integrated Transport and Health Model (ITHIM). This percentage of risk reduction varies depending on amounts of physical activity in the population using a log-linear formula to indicate the reduction in risk for each disease and is capped. The risk reduction applies to the incidence of getting the disease for Dementia, Type II Diabetes, Colon cancer and Depression, and applies to the combined risk of dying and incidence of getting the disease for the Coronary heart disease, Stroke and Breast cancer.[7]

Age range | Risks for mortality and for most diseases (except e.g. depression) increase rapidly with age. If one assumes average mortality or disease rates for a population but the population taking up walking and cycling are much younger or older (typically they are younger), then benefits would be overestimated. ITHIM uses travel survey or other data to estimate baseline variations and makes assumptions on who is taking up new walking and cycling. HEAT uses age ranges excluding older adults and does allow users to specify assumptions on if the population is older or younger than average (20-64 years for cycling and 20-74 years for walking). The tool follows the HEAT recommendations.

Time needed to reach the full level of walking or cycling | Transport interventions can take various lengths of time to influence a specific type of behaviour. For example, a certain new cycle path might result in immediate uptake, whereas increasing use on another might take a year or more. [8] The uptake in users might also differ by gender and age : for example, a new cycling lane might be used by a majority of young men in a first period and by a wider range of population a few months later. The speed of evolution is not monitored by the tool but can be taken into consideration by the user depending on the socio-economical local context.

Cost applied | Transport analysis often use the VSL (Value of Statistical Life) to measure the willingness to pay to reduce risks of mortality or morbidity. The methods to calculate this value varies depending on countries, however the OECD provides a set of international values which can be adjusted based on international income.

Some sectors also use as a reference the VOLY (Value of a Life Year) to represent the value of a life lost. While VSL is the monetary value assigned to a full life, VOLY is the value for a single year of life. VSL can be seen as how much people are willing to pay to prevent a fatality whereas VOLY as how much people are willing to pay to live for an extra year. VSL will therefore be much greater than VOLY.

In order to be understood by multiple sectors, the tool presents results both VSL and VOLY based.

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[5] *HEAT tool guidance: Health economic assessment tool (HEAT) for walking and for cycling, 2017, WHO*

[6] *HEAT tool guidance.*

[7] *University of Cambridge pending research, Health assessment.*

[8] *HEAT tool guidance.*

1.4 Default values: proxy data collection

The tool provides a set of default values as a substitute where directly measured city data is likely to be not available. These datasets have been drawn from the HEAT, CURB and ITHIM tool, ICCT (International Council on Clean Transportation), GBD (Global Burden Diseases) and C40 datasets. All sources are listed on the database page. These default values provide the best currently available data, however the user should always question these values, using his local knowledge and provide local data wherever possible.

Table 4 : Proxy sources

Data Type	Source	Link to website
Population data		
National Population and Age Structure	IHME; Global Burden of Disease (GDB) National Population; 2016	*IHME GBD - National Population*
Health data		
Mortality rates - national	IHME; Global Burden of Disease (GDB) Deathrate Data; 2016	*IHME GBD - Deathrate*
Years lived with disability (YLDs) - national	IHME; Global Burden of Disease (GDB) Deathrate Data & National YLDs ; 2016	*IHME GBD - National YLDs*
ITHIM physical activity risk reduction factors	University of Cambridge CEDAR ; ITHIM model ; 2018	*CEDAR - ITHIM*
Physical activity benefit parameters	World Health Organization; HEAT tool; 2017	*WHO - HEAT Guidance*
Mobility		
Mode share	C40 ; Climate Action for Urban Sustainabilty Database, Regional Proxy Mode Shares ; 2016	*C40 - CURB*
Age range of cyclists and pedestrians	World Health Organization; HEAT tool; 2017	*WHO - HEAT Guidance*
Default cyclist and pedestrian population composition	C40 Assumption based on the Population and age structure	-
Minutes of Activity per cylist profile	C40 Assumption based on the Houston Green Oak Case Study	-
Default trips distance	World Health Organization; HEAT tool; 2017	*WHO - HEAT Guidance*
Default trips per year per user	World Health Organization; HEAT tool; 2017	*WHO - HEAT Guidance*
Emissions		
Vehicule load factor	C40 ; Climate Action for Urban Sustainabilty Database, Regional Assumptions ; 2016	*C40 - CURB*
Fuel fleet composition	ICCT; 2012	*ICCT website*
Vehicle fuel efficiency per vehicle class	National Transit Database and Sandia National Database ; 2016	*Sandia website*
Per mile fuel emissions	Argonne Lab ; Greet Model ; 2018	*Argonne Lab Greetl*
Economic Assumptions		
Discount rates	No default data is given	
VSL and VOLY	No default data is given	

PART 2 | TOOL ANALYSIS

2.1 Tool general approach

What is the tool made for? | The tool enables cities to measure the wider benefits of walking and cycling, focusing on health benefits from increased physical activity and the associated economic benefits. It aims to support cities increasing the mode share of active mobility options by:

- **making a stronger case for climate action and healthy lifestyles** to unlock more support from stakeholders such as politicians, citizens, business community and possible opposition groups.
- helping cities **identify the most impactful walking and cycling option** they can implement (to improve both climate and health).

The tool assesses the current levels of cycling or walking, the changes of habits due to an action taken and the consequences in terms of health, including calculating benefit–cost ratios; and enables to compare different scenarios of action.

Who can use the tool? | The tool is designed for a wide variety of users without particular expertise in impact assessment. These include primarily transport and urban 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 and health experts. It is designed be user-friendly with minimal data input requirement and a possibility to use default data, adaptable to local context.

What are the limitations? | The tool has been developed using the best available research to date and has been simplified to make it easy to use. This results in a few limitations that need to be considered:

- The tool is designed to be used for an **adult population** (20-64 years for cycling and 20-74 years for walking) – it does not include relative risk for children, young adults or older people. The tool is not meant to assess a highly active population as athletes or cycling couriers.
- It assesses **habitual behaviour**, such as cycling or walking for commuting or regular leisure-time activities but not day competitions or single events as open-streets.
- Default values are mainly issued from **US and European studies**, as very little literature was available from other areas. The user should always question these values, using his local knowledge and provide local data wherever possible. The **cyclist profile (age and gender distribution)** is based on US values, as being the best currently available data, but it is strongly recommended that cities conduct simple intercept surveys to inform this data (and other project-related inputs).
- The tool does not integrate calculation of **road accidents**. Some guidance is available in the FAQ.

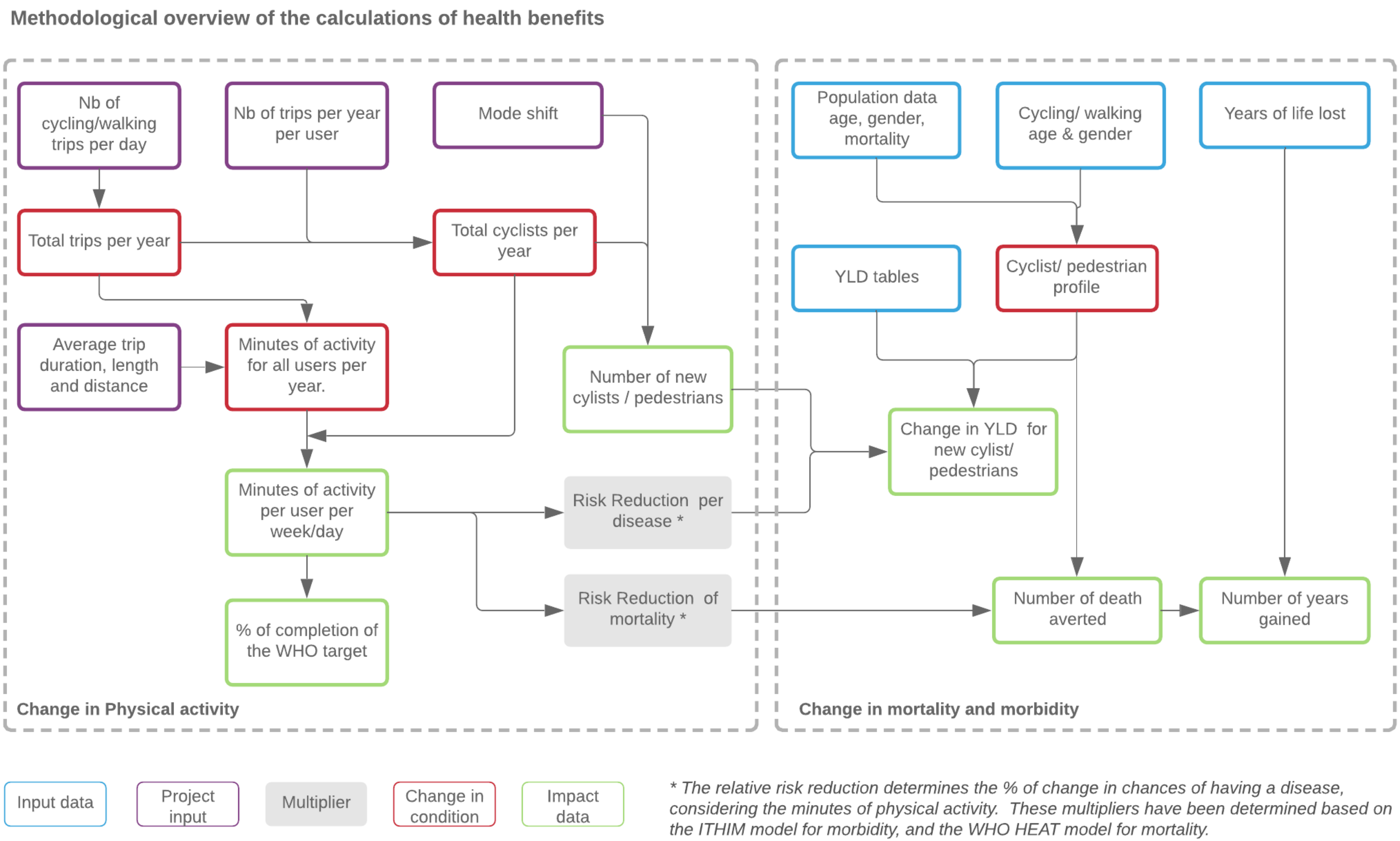
Knowledge of the health effects of walking and cycling is evolving rapidly. Users should bear in mind the approximate nature of the results, much like for many other types of economic assessment of health effects**.**

Future developments | Some future considerations are listed below:

- Additional **benefits**: traffic congestion, safety, air quality and job creation.
- Additional **visuals** that can be directly used by the city.
- Projection of **benefits toward time**.

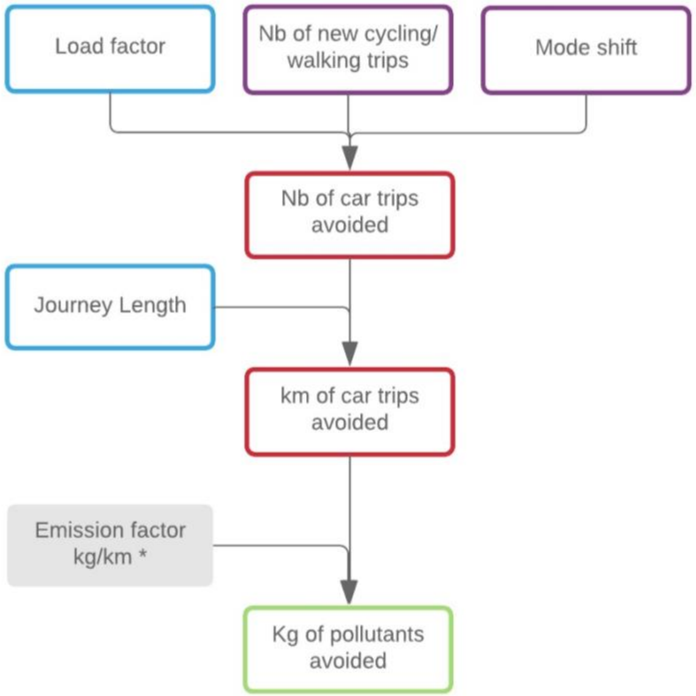
2.2 Calculation methodology chart

The table below provides a conceptual outline of the methodology of health, environmental and economic benefits calculations. It describes the user inputs in terms of baseline (blue), project (purple), factors (relative risk reduction, emission factor and discount rate), and the results in terms of benefits (green).



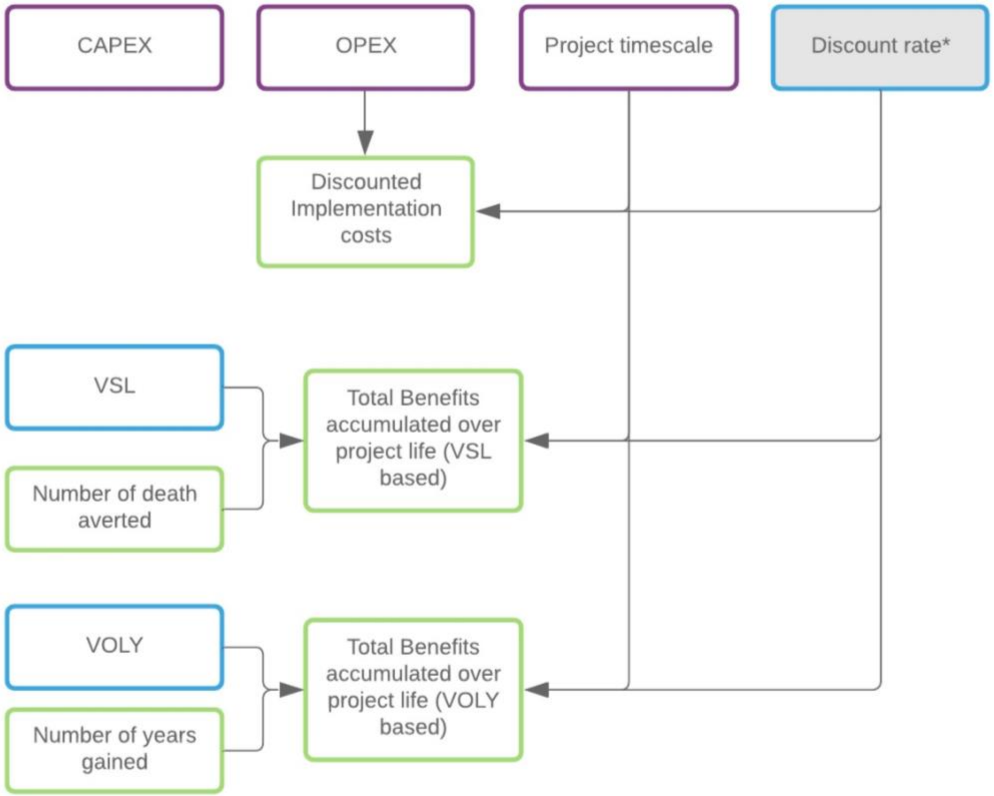
** The relative risk reduction determines the % of change in chances of having a disease, considering the minutes of physical activity. These multipliers have been determined based on the ITHIM model for morbidity, and the WHO HEAT model for mortality.*

Methodological overview of the calculations of environmental benefits



** The emission factor is determined based on fuel type (gasoline, diesel, CNG, CPG, electricity, hydrogen) and fuel efficiency per vehicule type.*

Methodological overview of the calculations of economic benefits through avoided healthcare costs



** Since economic benefits occurring in the future are generally considered less valuable than those occurring in the present, economists apply a discount rate to future benefits.*

2.3 Step-by-step guidance: workflow diagram

Select Analysis | This page allows the user to select the sector type and action they wish to analyse: in this case, the user will select Transportation and then choose Cycling or Walking, depending which action is studied. Over time, additional sectors and actions will be added.

Visualize the Causal Chain Diagram | Once the action is selected, the user can review **the** Pathway diagram, which demonstrates how the action, through a series of system changes, results in outputs, outcomes, and how the impacts are calculated within the tool. The user can explore this page to understand better what the wider benefits of the project to be assessed are.

Collect the city context in the General Parameters | This page allows users to start informing the background (non-project) context. These parameters include information on project location, national population and health data, mobility metrics and economic factors. For most parameters, the tool provides default values when city-specific values are not available to facilitate its use. The user should review all parameters and is encouraged to provide city specific values whenever feasible.

Customize the Project Parameters and visualize the Results | The user can then enter the project-specific parameters and assumptions on the left part. Optional pre-project conditions can be added, describing know how many people are walking or cycling before the action has been implemented. If no pre-project conditions are documented, the tool will consider that no user are walking or cycling before the action implementation.

Once these parameters and assumptions are entered the page shows a variety of the project's anticipated benefits on the right side of the page. Two different kind of visualizations can be chosen, either number or infographic-oriented.

Save & Modify the project versions | Once project assumptions are defined, the user can save the current project input and results as a project alternative. This feature allows the user to review and compare up to five different project alternatives and modify assumptions. This page also allows to delete previously saved alternatives.

Assess the Project Comparisons | This section allows to compare different versions of the project saved. In the Alternative Selection page, the user selects the project alternative they wish to compare to each other, by selecting the alternatives listed with a check mark. The Alternative Comparison Page compares the performance of different project alternatives through charts and detailed metrics.

Contributors to the tool

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2018 Masterclass Cities
Mexico City
Moscow
Nanjing
Rome
Rotterdam
Tel Aviv

Further resources on the tool

Online Resources
Walking and Cycling Tool
Walking and Cycling Tool Methodology
Walking and Cycling Tool FAQ & Terminology
Walking and Cycling Case Studies

Internal Resources
Walking and Cycling Tool Presentation
Summary Report of activities with Novo Nordisk

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Illustration 5: Methodological overview of the calculations of economic benefits through avoided healthcare costs

Table 1: Key potential impacts from urban active mobility. Source: authors' elaboration based on Opportunity 2030, and the Benefit Pathways mapping of Walking and Cycling, C40 Cities.
Table 2: Definition of the stages of the Benefits Pathways. Source: Urban Climate Action Impact Framework, C40 Cities.
Table 3: Comparison of existing methods and tools on walking and cycling benefits. Source : authors' elaboration based on Cambridge University study
Table 4 : Proxy sources

References

HEAT tool: Health economic assessment tool for walking and for cycling, 2017, WHO
HEAT tool guidance: Health economic assessment tool for walking and for cycling, 2017, WHO.

Integrated Transport and Health Impact Modelling Tool, 2018.

Opportunity 2030, C40, 2018.

Urban Climate Action Impact Framework, C40 Cities, 2017.