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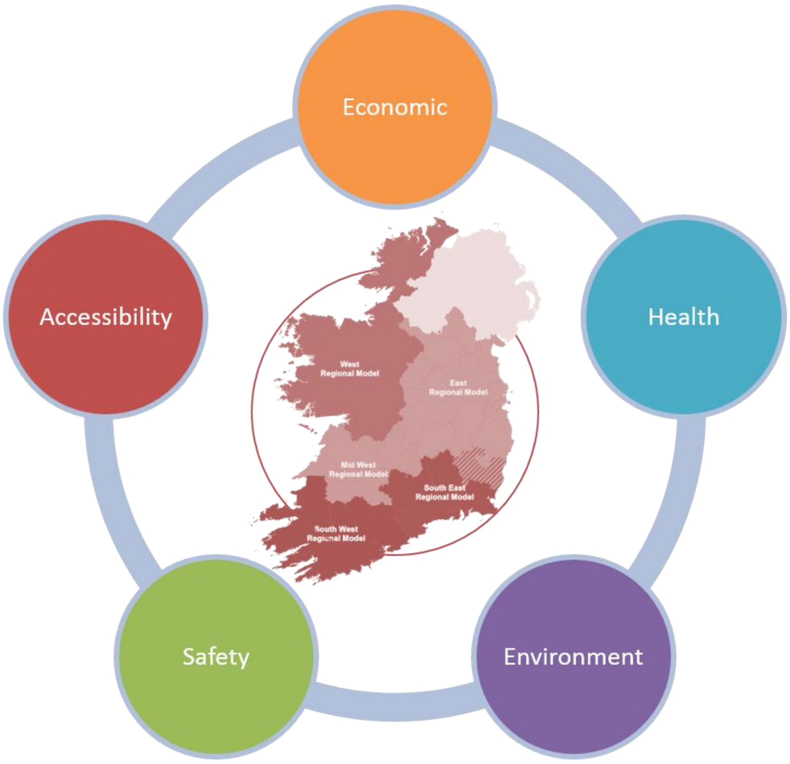

Health Module

Development report

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1 Introduction

1.1 Background

As part of the Modelling Services Framework, Systra/Jacobs were commissioned by the National Transport Authority (NTA) to develop a system of multi-modal transport models for each regional-city in Ireland. As part of this commission, a scoping process was initiated in September 2014 to define the most appropriate suite of appraisal tools to complement the regional models.

A number of separate appraisal processes are being developed:

- Safety
- Economy
- Reliability
- Environment
- **Health**
- Accessibility

This note documents the approach to the appraisal of Health Benefits and the development of the tool itself. It includes a discussion of the health benefit appraisal process, outlines the required datasets and then details the implementation of the approach and tools.

1.2 Overview of Health Appraisal

Active travel modes, i.e. walking and cycling, can bring about significant benefits for our health and environment. Most transport investment is assessed for its value for money using methods which compare costs against benefits over the lifetime of a project. Benefits are now increasingly being assessed in a wider sense – economic, environmental, social, and health. As a result, the consideration of health benefits arising from transport is becoming an integral part of the appraisal process adopted to inform transport policy and investment decisions.

Transport related changes to the following factors can have health impacts:

- **Physical activity** – increased levels of activity can positively impact on reducing the risk of death and occurrence diseases such as heart, diabetes and cancer related illnesses;
- **Absenteeism** – this is expected to decrease when more people walk or cycle. Moderate physical activity can lead to a reduction in the number of sick days and a healthier workforce can, in turn, provide benefit to employers and overall economy;
- **Journey quality** – refers to the quality impacts of schemes on journey experience which is calculated on the basis of ‘safety-insecurity’ and assigning a ‘quality value’ to each trip made by existing and new users;
- **Safety** – a ‘safety in numbers’ effect can result from increasing levels of active travel or conversely a decline in safety where change occurs towards these modes and/or routes with higher accident rates. This is addressed in the Safety note; and
- **Environment** – air quality, greenhouse gas and noise impacts resulting from a decline in road traffic and associated congestion. These factors are considered through damage costs which are discussed further in the Environment note.

1.3 Health Benefit Appraisal Tool Overview

The scope of this Health Appraisal Tool is to provide the basis to calculate benefits associated with changes in levels of physical activity and absenteeism as a result of more walking and cycling taking place. This section provides an introduction to both aspects of the tool.

1.3.1 Physical Activity

The WHO[1] developed the Health and Economic Appraisal Tool (HEAT) to calculate the health benefits associated with changes in physical activity resulting from differences in walking and cycling. The tool is available as an online platform.

Adopting the principles of HEAT, the DfT published *Cycling and Walking: The Economic Case for Action*[2] in March 2015. The 'toolkit' comprises a technical note including an overview of how to demonstrate the economic case for a new cycling and walking proposal accompanied by a spreadsheet based model which provides a basis to replicate calculations for different schemes.

In regard to physical actvitity, the basis of the DfT tool is to calculate *'If x people cycle or walk y distance on z days, what is the economic value of the mortality rate improvements?'*

The DfT tool can be applied in many situations, for example:

- To plan a new piece of cycling or walking infrastructure: it models the impact of different levels of cycling or walking and attaches a value to the estimated level when the new infrastructure is in place;
- To value the mortality benefits from current levels of cycling or walking, such as benefits from cycling or walking to a specific workplace, across a city or in a country; and
- To provide input into more comprehensive cost–benefit analyses, or prospective health impact assessments: for instance, to estimate the mortality benefits from achieving national targets to increase cycling or walking, or to illustrate potential cost consequences of a decline in current levels of cycling or walking.

1.3.2 Absenteeism

Benefits associated with a reduction in absenteeism primarily arise through increases in physical activity levels leading to increased productivity as a result of reduction in short-term sick leave. Research undertaken by the WHO in 2003 noted a cycling or walking intervention of 30 minutes per day reduces absenteeism through a reduction in short-term sick leave by between 6% and 32% per annum.

The aforementioned DfT Walking and Cycling Toolkit also includes functionality to calculate health benefits in relation to absenteeism. The monetary value of the total absenteeism benefit is calculated by the total hours per year saved and value of work time per hour.

In summary, the DfT tool:

- Is intended to be part of comprehensive cost–benefit analyses of transport interventions or infrastructure projects;

[1] Health Impact Assessment Tool (HEAT) http://heatwalkingcycling.org/index.php?pg=cycling&cs=q6.1&m=pre

[2] Cycling and Walking: The Economic Case for Action https://www.gov.uk/government/publications/cycling-and-walking-the-economic-case-for-action

- Complements existing tools for economic valuations of transport interventions, for example on emissions or congestion;
- Can also be used to assess the current situation or past investment; and
- Is based on best available evidence, with parameters that can be adapted to fit specific situations. Default parameters are valid for the European context.

The DfT spreadsheet tool includes four modules, the first two use inputs from modal shift which monetise the health benefits of the number of trips being diverted to cycling and walking separately. The third and fourth modules allow for the assessment of health impacts from cycling and walking in separate sheets and independently from the modal shift impact.

1.4 NTA Health Appraisal Tool

Following discussion, it was agreed with the NTA to use the DfT tool as the basis for calculating the health benefits related to changes in physical activity and absenteeism.

Web-TAG recommends that the impact of a proposed scheme on journey distances and also on cycling speeds should be assessed if it is considered that this will be affected significantly. From this, an average journey time may be estimated for new users. Section 11.3.8 of the Design Manual for Roads and Bridges (DMRB) contains further detail on the inference of changes to trip length resulting from a scheme.

Figure 1 summarises the functionality of the Health Appraisal Tool. The inputs and parameters are outlined further in Section 2.2.

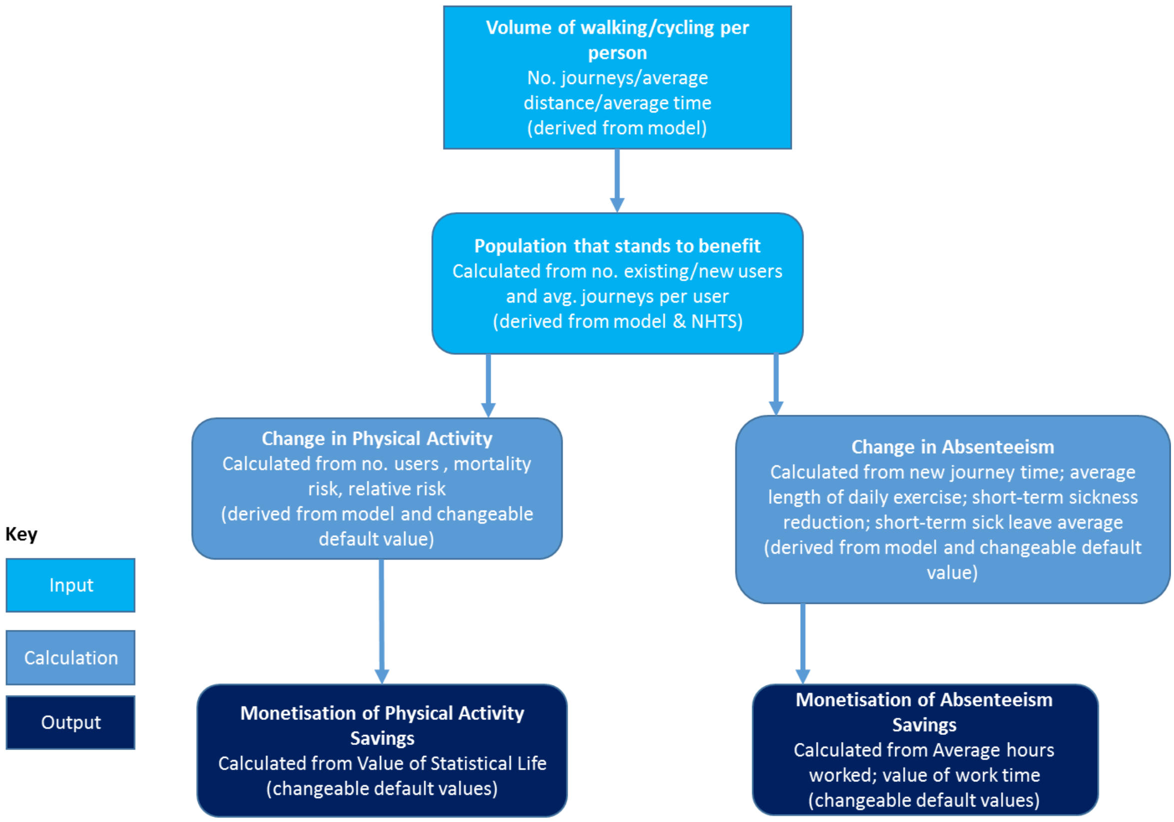

Figure 1 Health Appraisal Tool Overview

2 Implementation of the Health Appraisal Process

2.1 Overview

This section considers the approach to calculating the health benefits associated with physical activity (specifically the reduced risk of mortality based on the time spent walking and cycling) and absenteeism.

Physical fitness benefits are derived through the application of the DfT tool. This was supported by inputs from the emerging DTTAS appraisal guidance, specifically details relating to the calculation of the Relative Risk for cyclists and walkers in Ireland.

Benefits associated with a reduction in absenteeism primarily arise through increases in physical activity levels leading to increased productivity as a result of reduction in short-term sick leave. Research undertaken by the WHO in 2003 noted a cycling or walking intervention of 30 minutes per day reduces absenteeism through a reduction in short-term sick leave by between 6% and 32% per annum.

2.2 Inputs and Parameters

The DTTAS Common Appraisal Framework Guidance and NTA regional model are the primary data source for the different parameters to input to the health benefit appraisal. However, until the DTTAS appraisal guidance is published and formally adopted, it is proposed to work with the following assumptions as defined in HEAT for the calculation of health benefits related to physical activity:

- The build-up of benefits will be accrued over a five year period;
- There is a linear relationship between risk of death and cycling/walking duration (assuming a constant average speed), i.e. each dose of cycling/walking leads to the same absolute risk reduction;
- No thresholds have to be reached to achieve health benefits; and
- Men and women have approximately the same level of relative risk reduction.

Data inputs can take the form of:

- Data from a single point in time – used when assessing the status quo, such as valuing current levels of walking and cycling in a city or if data on the results of an intervention are only available; and
- Before and after data – used when assessing the impact of an actual intervention or hypothetical scenarios. Pre and post measures will be used to calculate health benefits and associated financial savings.

As the appraisal tool is related to the NTA's multi-modal regional model it has been assumed that data input requirements will primarily draw on outputs from scenario testing. As such, the primary sources are before and after data to assess the impact of changes in the levels of walking and cycling resulting from interventions tested.

2.2.1 Demand Model Inputs

Time and distance skims are processed as part of the secondary analysis CUBE Catalog for input to the health appraisal tool. The skims are firstly aggregated to the 24hr level before the calculation of the time and distance weighted averages. This applies to both of the active modes, walking and cycling. For the V3 tool, this has also incorporated the walk component of PT trips.

The factors used for this aggregation are consistent with the factors used in the demand models. The demand is taken as the weighting factor in order to calculate the daily distance travelled and journey duration for each mode.

There are several output print files that display displays the average daily journey duration in minutes and distance in kilometres. These files are named:

- 'Weighted_Ave_Data_PT.PRN''' displays the average daily journey duration in minutes and distance in kilometres for PT trips.
- 'Weighted_Ave_Data.PRN'' displays the average daily journey duration in minutes and distance in kilometres for walk/cycle trips
- 'Weighted_Ave_Data_Comb.PRN' displays the average daily journey duration in minutes and distance in kilometres for all trips.

Inputs drawn from the tool and used by the tool to calculate the health impact of cycling and walking are summarised in Table 1. .

Table 1 Summary of Inputs – Physical Activity and Absenteeism

Input	Units	Comment	Source	Values
PHYSICAL ACTIVITY				
Number of cycling/walking journeys per day as a result of the policy/measure.	Number of journeys	These are the journeys resulting from the policy or measure derived from the demand model. Walking and cycling parameters input separately.	Demand Model	Input sourced from demand model
Length of cycling/walking journeys.	Km	Cycle and walking distances derived from the demand model. Walking and cycling parameters input separately.	Demand Model	Input sourced from demand model
Duration of cycling/walking journeys.	Mins	Average cycle and walking times derived from the demand model. Walking and cycling parameters input separately.	Demand Model	Input sourced from demand model
PT Trips				
Number of PT trips per day as a result of the policy/measure.	Number of journeys	These are the journeys resulting from the policy or measure derived from the demand model.	Demand Model	Input sourced from demand model
Length of Walk Leg of PT trips.	Km	Walking distances for the PT trips derived from the demand model.	Demand Model	Input sourced from demand model
Duration Length of Walk Leg of PT trips.	Mins	Walking Times for the PT trips derived from the demand model.	Demand Model	Input sourced from demand model

2.2.2 Tool Parameters

A set of parameters are also built in to the tool as shown in Table 2. Where the source for an input is defined as 'User / Default' this means that default values are already pre-populated in the tool but can be modified with study specific values where appropriate and information is available. The Ireland specific default values for the different parameters are reflected in the tool and also shown in Table 2. These can be amended in the tool by the User where it may be desired, for example, to undertake sensitivity testing around a particular parameter.

Table 2 Summary of Parameters – Physical Activity and Absenteeism

Parameter	Units	Comment	Source[3]	Values
PHYSICAL ACTIVITY				
Percentage of weekday cycled in a year.	Percent	Proportion suggesting the number of days per year cycle trips are made on average.	User / Default	100%
Percentage of weekday walked in a year.	Percent	Proportion suggesting the number of days per year walking trips are made on average.	User / Default	100%
Number of trips per cyclist.		The average number of trips made by a cyclist with data obtained from the National Household Travel Survey (NHTS) Travel Diary .	NHTS Travel Diary	2.79
Number of trips per walker.		Obtained from the NHTS Travel Diary these are the average number of trips made by a walker.	NHTS Travel Diary	3.05
Proportion of 7 days average journey time to 5 days (weekdays) average journey time cycled.		Proportion to convert the weekday average into a 7 day weekly average.	NHTS Travel Diary	1.046
Proportion of 7 days average journey time to 5 days (weekdays) average journey time walked.		Proportion to convert the weekday average into a 7 day weekly average.	NHTS Travel Diary	1.019
Value of life saved.	€ in 2011 prices	The economic value of a life saved based on the willingness to pay of a middle-aged person to avoid a sudden death.	User / Default	€2,310,500
Reference journey time per weekday.	Minutes per week	The average length of active modes journeys in order to achieve a relative risk of death.	User / Default	100 mins (Cycling) 168 mins (Walking)

[3] Spreadsheet: Annualisation_GDA_v4_20150205; DTTAS Common Appraisal Framework Peer Review RfP (2015)

Parameter	Units	Comment	Source[3]	Values
Reduced relative risk index for cycling and walking.	Index	The relative risk of premature death. The relative risk of death as suggested by the HEAT tool. The DTTAS Peer review forecasting advice report notes that for Ireland relative risks are calculated by interpolating between 0 and the maximum reductions of 0.28 and 0.22 for cyclists and walkers respectively on the basis of the average active time per week ..	User / Default	0.90 (Cycling) 0.89 (Walking)
Mortality risk.	Percentage	Mean proportion of population aged 15-64 who die each year from all causes (deaths per 100,000 people per year in the respective age group).	User / Default	0.0019
ABSENTEEISM				
Short-term sickness reduction.	Percentage	The value that is attributed to a decrease in absenteeism due to an increase in the adopting of walking and cycling by an individual.	User / Default	6%
Average length of daily exercise.	Minutes	On a daily basics the average length an individual would typically cycle.	User / Default	30mins
Average hours worked in a weekday.	Hours	The time spend in a workplace by an individual on a daily basics.	User / Default	7.5hrs
Ireland's short-term sick leave average.	Days	This is the annual average sick leave taken by an individual in Ireland.	User / Default	4.9 days per annum
Value of work time per hour.	Euros	The monetarisation of the value each individual would bring spent working. The data is taken from the DTTAS Peer Review report for the base year. To take into account the value in the forecasted year, the forecasted growth in GNP should be used. Table 3 shows the annual percentage factor used in order to grow these statistical values. The growth factor for any year beyond 2025 should adopt the 2025 factor.	User / Default	€34.33

2.3 Calculating Physical Activity Benefits

The health benefits associated with physical activity are derived from a reduction in the relative risk of premature death - the 'Relative Risk of Mortality' is directly linked to the time spent walking and cycling based on the average length, speed and frequency of new trips encouraged by active travel modes. This indicator provides a calculation of the lives saved due to the health benefits of cycling and walking.

The physical activity benefit calculation can be summarised as:

$$Net\ Impact = Impact\ on\ New\ users + Impact\ on\ Existing\ Users$$

Where:

- $Impact\ on\ New\ Users = Expected\ Death\ among\ New\ Users \times Reduction\ in\ relative\ Risk$
- $Impact\ on\ Existing\ Users = Expected\ deaths\ among\ existing\ users \times Reduction\ in\ relative\ Risk$

The calculated reductions in relative risk of death and the number of new walkers and cyclists are used to calculate a figure for the potential number of lives saved based on average mortality rates.

An average mortality rate of 0.0019[4] is used, the mean proportion of the population aged 15 – 64 who die each year. The number of potentially prevented deaths is then multiplied by the value of a prevented fatality used in accident analysis (see Safety note) to provide a monetary value.

For Ireland the relative risks are calculated by interpolating between 0 and the maximum reductions of 0.28 and 0.22 for cyclists and walkers respectively. This is on the basis of the average active time per week (CSO Census POWSCAR, 2011); for example, for cyclists: 41.8mins [(average active time per day)*5/ 100mins * 0.1 = 0.21]. This is higher than the reference population, but lower than the maximum cap.

Table 3 Relative Risk for Cyclists and Walkers in Ireland[5]

Mode	Cyclists		Walkers	
	Return	Single	Return	Single
Average Active time per workday (mins)[6]	44	22	36	18
Proportion of individuals	0.9	0.1	0.9	0.1
Average Active time per workday (mins)	41.8		38	
Reduction in relative risk	0.21		0.11	

In summary, the physical activity monetary benefits are calculated as follows:

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[4] DTTAS Common Appraisal Framework Peer Review RfP (2015) – Appendix 5 (In 2011 5,895 deaths occurred in the 15 – 64 year old population and there was 3.73m people in the 15 – 64 year old population).

[5] DTTAS Common Appraisal Framework Peer Review RfP (2015) – Appendix 5

[6] DTTAS Common Appraisal Framework Peer Review RfP (2015) – Appendix 5 (Data from POWSCAR 2011 (CSO) commute times for walkers and cyclists main mode up to maximum of 45 mins cycle and 1 hour walk (new users assumed unlikely to make long commuting journeys by active modes).

- The change in all-cause mortality rates as a result in the change in activity;
- The calculated reduction in relative risk of death and the number of new walkers and cyclists are used to calculate the potential number of lives saved based on average mortality rates (evidence suggests this proportion is 0.0019 of people aged 15 – 64 years in Ireland);
- The number of prevented deaths is multiplied by the value of a prevented fatality (€2,258,250 in 2011 prices)[7] to give a monetary benefit for each year. A peer review of the DTTAS CAF noted that the value stated appears to relate to the cost of a fatal motor accident which includes a range of non-casualty costs as well as casualty costs in respect of more than one casualty. It was suggested the Irish Value of Statistical Life in respect of one individual should be used in preference (or alternatively Web-TAG presents the equivalent value for the UK in 2010 prices);
- Calculations are repeated for both cyclists and walkers for each year of the appraisal period, including real growth in value; and
- Each annual value is summed to and discounted to give a total net present benefit.

Future benefits include real growth in the value of a prevented fatality in line with forecast GDP/capita. GNP per person is used to adjust the cost of pedestrian and cycling accidents from one year to another (nominal GNP for years prior to the baseline year and real GNP thereafter).

The Department for Transport's (DfT's) Web-TAG guidance notes that the HEAT methodology estimates the benefit to the population using active modes for any level of activity, not just those achieving a specific threshold. There are these considerations for new and existing users:

- For any new walk and cycle trips (shifting from mechanised modes) there will be some health benefits to each individual; and
- For existing walk and cycle trips, health benefits may change where the duration of travel may change (e.g. removal of severance on a specific route to decrease journey times).

The physical activity calculation process is presented diagrammatically below in Figure 2.

[7] DTTAS Common Appraisal Framework Peer Review RfP (2015) – Appendix 5 & Peer Review & Forecasting Services Report to DTTAS (SYTSRA & DKM, April 2015)

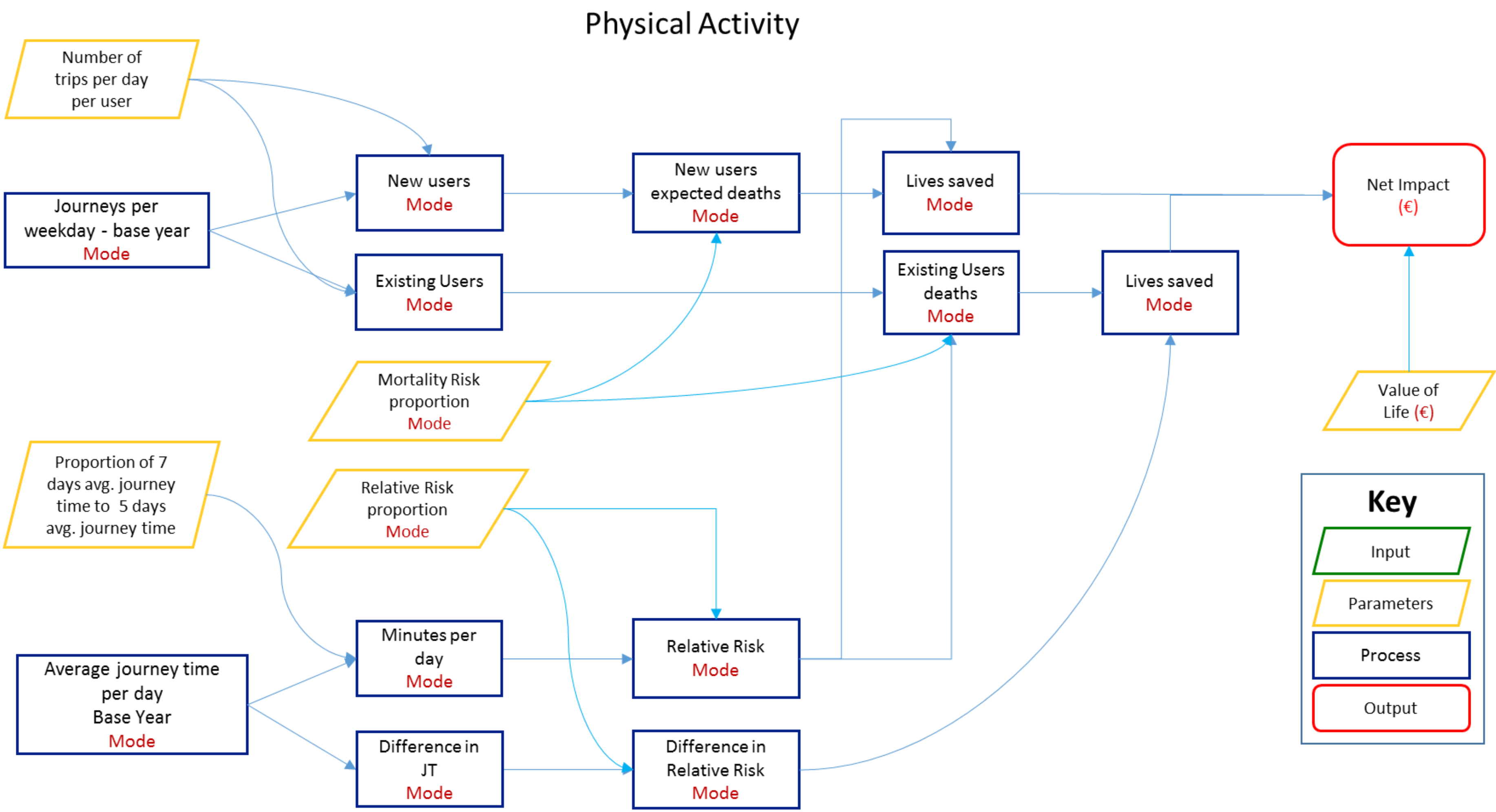

Figure 2 Physical Activity Process Overview

2.4 Calculating Absenteeism Benefits

In order to quantify the impact of a change in walking and cycling on workplace absenteeism, the impact on the reduction of sick days due to an increase in physical activity can be evaluated alongside the value of work time per hour. The absenteeism calculation can be summarised as:

$$Net\ Impact\ = Total\ reduction\ in\ Absenteesim$$

Where:

- $Total\ Reduction\ in\ Absenteeism\ = New\ Demand\ \times Average\ Reduction$
- $Average\ Reduction\ = Average\ Sick\ leave\ in\ Ireland\ \times$ $Reduction\ in\ Sickness\ from\ new\ journey\ time$

The monetary value of the total absenteeism benefit is calculated by the total hours per year saved and value of work time per hour.

The Peer Review undertaken of the draft Department for Transport, Tourism and Sport (DTTAS) appraisal guidance noted that the value of time in calculating absenteeism benefits excluded the uplift to reflect higher wages among travellers. This was not considered appropriate and that value of time should be uplifted in line with standard methodology.

Again, the approach described in this note is as consistent as possible with forthcoming appraisal guidance to be released by the DTTAS.

The absenteeism calculation process is presented diagrammatically below in Figure 3.

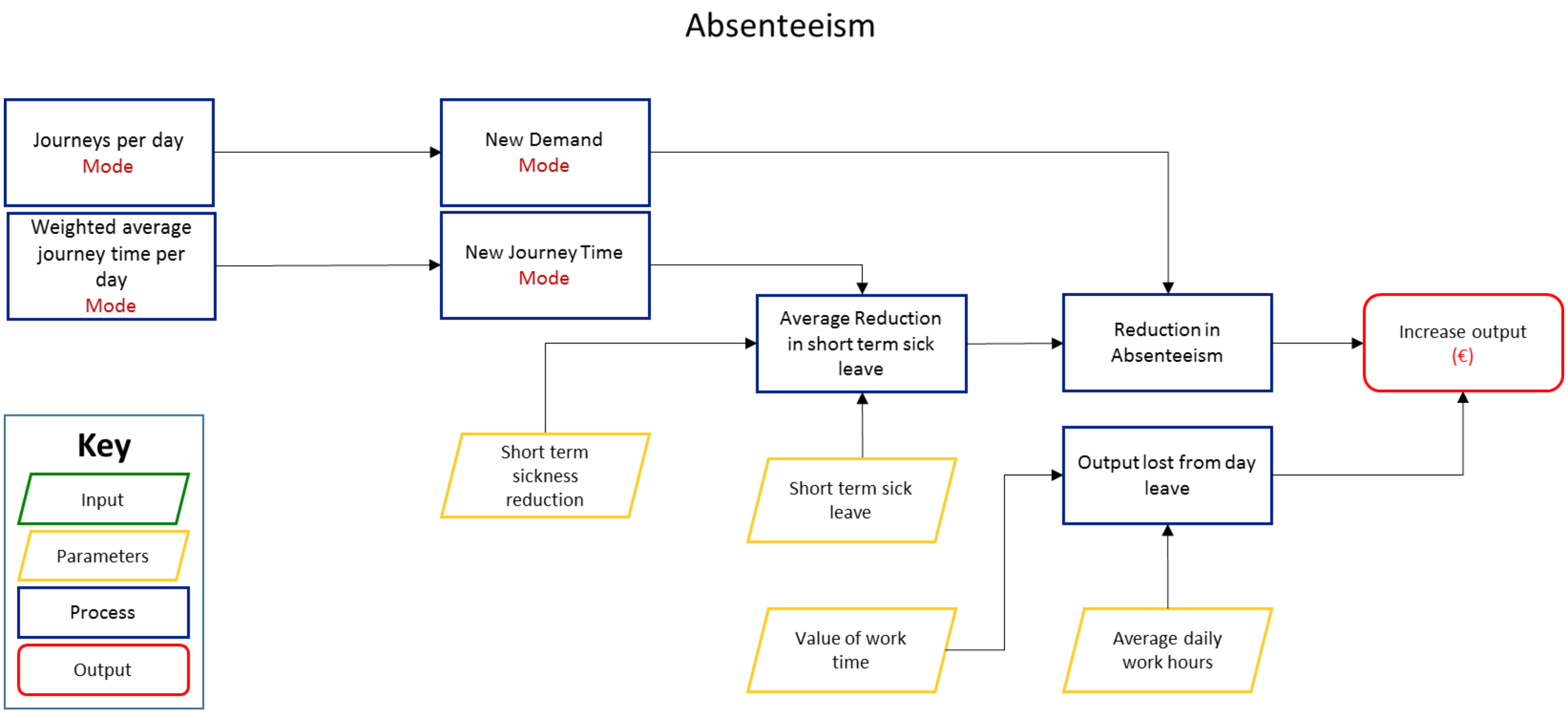

Figure 3 Absenteeism Process Overview

3 Testing

The Health Module has been tested using an ERM sample scenario. The purpose of these tests is to assess the functionality and compatibility of the Health Module for the ERM and therefore the overall functionality of the tool. Tests were undertaken successfully on NTA machines as well as consultant computers.

3.1 ERM

3.1.1 Cube Extraction Process

The Cube process successfully extracted walk and cycle demand, outputting the results to a text file in the correct output folder.

3.1.2 Health Spreadsheet Operation

The health spreadsheet successfully launched upon completion of the Cube process, importing the walk and cycle totals into the calculations.

3.1.3 Test Results

The ERM Health Run yielded major benefits for walking, with some slight dis-benefits for cycling. These dis-benefits were incurred in all three areas covered by the health module; cyclists, walkers and absenteeism. These levels of dis-benefits in cyclists were incurred as a result of the improved public transport network available in the strategy which caused a large shift from active mode to public transport. This reasoning is also why there was a large benefit attributed to walkers, as the walking part of the PT trip was included.

3.2 Parameter updates

Using the same run as mentioned above, updates were made to two parameters between the V2 and the V3 models. The value of life was updated from € 2,258,250 to € 2,310,500. The V2 model came from the DTTAS common appraisal framework peer review RfP 2015, and the V3 model came from the DTTAS common appraisal framework peer review RfP 2020. The other variable that was updated was the value of work time per hour, from € 25.83 to € 34.33. The source for the V2 value was not listed, but then updated V3 value came from the “Project Appraisal Guidelines for National Roads Unit 13.0 - Pedestrian and Cyclist Facilities (October 2016)”. The table below shows the comparison of the PA Calculations and Absenteeism results using the same input data for the V2 and V3 models.

Table 5 Comparison of the PA Calculations results for the V2 and V3 model parameters

V2 Model results

Net Impact per annum	
Cyclists	**-€ 373,265.77**
Walkers	**€ 2,579,803.83**

Parameters	Cyclists	Walkers
BY distance	3.97	1.56
FY distance	3.94	1.59
BY minutes per day	14.51	18.54
FY minutes per day	14	19
FY minutes per weekday	6.65	7.48
New Users	-1946	7195
Existing Users	81,716	1,168,420

% of weekdays cycled	84%
% of 7 days walked	72%

Impact on New users	Cyclists	Walkers
Expected deaths among new users	-3.6973	13.6712
Relative Risk FY	0.0334	0.0216
Lives saved FY	-0.1235	0.2959
Value (€ per year)	**-€ 278,871.54**	**€ 668,166.43**

Impact on existing users (if route Journey Time changes)	Cyclists	Walkers
difference in minutes	-0.055	0.135
difference relative risk	0.000	0.000
Deaths amongst existing users	150.075	2,171.952
Lives saved FY	-0.042	0.847
Value (€ per year)	**-€ 94,394.23**	**€ 1,911,637.40**

V3 Model results

Net Impact per annum	
Cyclists	**-€ 381,902.17**
Walkers	**€ 2,639,493.75**

Parameters	Cyclists	Walkers
BY distance	3.97	1.56
FY distance	3.94	1.59
BY minutes per day	14.51	18.54
FY minutes per day	14	19
FY minutes per weekday	6.65	7.48
New Users	-1946	7195
Existing Users	81,716	1,168,420

% of weekdays cycled	84%
% of 7 days walked	72%

Impact on New users	Cyclists	Walkers
Expected deaths among new users	-3.6973	13.6712
Relative Risk FY	0.0334	0.0216
Lives saved FY	-0.1235	0.2959
Value (€ per year)	**-€ 285,323.90**	**€ 683,626.06**

Impact on existing users (if route Journey Time changes)	Cyclists	Walkers
difference in minutes	-0.055	0.135
difference relative risk	0.000	0.000
Deaths amongst existing users	150.075	2,171.952
Lives saved FY	-0.042	0.847
Value (€ per year)	**-€ 96,578.27**	**€ 1,955,867.69**

Table 6 Comparison of the Absenteeism results for the V2 and V3 model parameters

V2 Model results

Absenteeism

Change in Demand		
Cyclist	-1946	person
Walkers	7195	person
Change in Journey Time		
Cyclist	14.39	minutes per weekday
Walkers	18.88	minutes per weekday

Average reduction in short-term sick leave per cyclist	0.141022
Average reduction in short-term sick leave per walker	0.185024
Change in absenteeism (days)	1056.892563
Output lost from day leave	€ 193.73
Increased output from reduction in absenteeism per year	€ 204,746.51

V3 Model results

Absenteeism

Change in Demand		
Cyclist	-1946	person
Walkers	7195	person
Change in Journey Time		
Cyclist	14.39	minutes per weekday
Walkers	18.88	minutes per weekday

Average reduction in short-term sick leave per cyclist	0.141022
Average reduction in short-term sick leave per walker	0.185024
Change in absenteeism (days)	1056.892563
Output lost from day leave	€ 257.48
Increased output from reduction in absenteeism per year	€ 272,123.41

4 Conclusion and Recommendations

4.1 Conclusion

This report has presented the development of the initial health appraisal module for the NTA. The tool was developed based on pre-existing tools developed by the UK DfT, which were in turn based on HEAT. The tool developed is fully consistent in approach as the HEAT and DfT tools, but it is implemented in a spreadsheet for transparency and ease of adaptation.

In applying the tool within the NTA regional model context, the following factors have been identified for further consideration by the NTA and discussion:

- Treatment of weekend walking and cycling trips which are not included in the regional model;
- Values for parameters specific to Ireland, in particular the basis of the value of statistical life;
- Elasticity of cycling and walking demand, particularly where a scheme may shortening journeys and in turn the time spent undertaking physical activity;
- Position on the treatment of other health benefits, such as those relating to accidents, in other appraisal notes; and
- Limitations of the HEAT based approach and potential/desire for any refinements prior to application of the DfT tool.

4.2 Recommendations

Appraisal of transport related health benefits and their monetisation is an evolving area. HEAT provides a means to assess benefits referencing to impacts on all-mortality (reflecting the number of preventable deaths because of increased physical activity). Areas of potential development and refinement the NTA may wish to consider and incorporate into their own bespoke tool surround the current scope and parameter definitions applied by HEAT, including:

- It applies only to working age adults carrying out exercise at average intensity and therefore not applicable to the population with high physical activity levels. It does not take into consideration differences in the intensity of cycling/walking or the possibility that less well-trained individuals may benefit more from the same amount of activity and therefore potentially underestimate the effect in very sedentary population groups;
- It assumes direct linear relationship between cycling and risk of all-cause mortality (but a more complex non-linear relationship can be applied);
- It does not take account of men and women separately (but it could if different relative risks were introduced);
- It does not take account of the different relative risks for different age groups (but uses a relative risk which is adjusted for age). The age group usually evaluated are adults;
- It does not take account of morbidity and is therefore likely to produce more conservative estimates as it does not account for disease-related benefits;
- It assumes a standard cycling speed (but can be adjusted to allow for different speeds); and
- It assumes that the relative risks found in one study population can be applied to different populations and settings.