

---

## **A Proposed Methodology for the Incorporation of a Health Benefits' Economic Assessment of Proposed Cycle Infrastructure in Glasgow City Council's Multi Criteria Decision Analysis for Route Prioritisation.**

Giorgia Bow, Sustrans (Partnerships Team) and Glasgow City Council (Neighbourhoods and Sustainability)

### **1 Introduction**

Increasing investments in an expanding cycle network in Scotland calls for a methodology for local authorities to scope and prioritise future cycle infrastructure. It is now well established that increased levels in cycling tackles morbidity, obesity and mental health issues. As a result this has potential to reduce the burden on the public health system. For this reason, other local governments in Europe have attempted to incorporate complex cost-benefit-analyses (CBA) of cycle infrastructure as a standard procedure to plan the expansion of cycle networks.

How can Glasgow follow suit and incorporate a cost benefit analysis based into its decision making process when scoping out future infrastructure?

The aim of this study is to investigate adding the health benefits as a criterion for Glasgow City Council (GCC)'s route prioritisation Multi Criteria Decision Analysis, (MCDA). The intention is to develop a scoring matrix for GCC's MCDA for route prioritisation which reflects the monetary value derived from the following query:

*What is the estimated economic value of the health benefits that occur as a result of the reduction in mortality due to physical activity, per every £100,000 invested by GCC in cycle infrastructure in each neighbourhood?*

Given the city's historic health record with regards to excess mortality, this paper assesses the application of the World Health Organisation (WHO)'s Health and Economic Assessment Tool (HEAT) at a micro level.

This is done via a study of the 56 neighbourhoods in Glasgow to generate a scoring system that can be input to GCC's MCDA formula. This micro level approach is aimed at addressing Glasgow's spatial disparity in excess mortality across the city.

This exercise will generate a monetary value of the benefits of cycling per each neighbourhood as a result of reduction of mortality due to an increment in physical exercise, which can then be translated into a scoring system applicable to the MCDA.

Finally, this study will try to address reliable input data sourcing, data availability and accessibility.

The model deriving from this study is designed for internal use, to include a cost benefit analysis of health benefits in the routes prioritisation process. The final list of prioritised routes will be used to secure funding for future cycle infrastructure in the city and will ensure longevity and continuity of active travel programmes between administrations.

As part of the delivery of its Strategic Plan for Cycling, GCC has been working towards updating its MCDA tool to inform the Council and the public with a list of prioritised cycle routes. One of the criteria to be introduced to the MCDA is the cost to benefits ratio generated by increased levels of cycling as a result of the implementation of new cycle infrastructure.

The aim of this study is to understand which data and which tools are available to carry out a micro level cost/benefit analysis for each neighbourhood in Glasgow based on improvements of mortality rate resulting from proposed cycling infrastructure<sup>1</sup>. It is important to highlight that this exercise does not aspire to estimate the exact cost/benefit ratio of future infrastructure but rather to create a

---

<sup>1</sup> This paper contains preliminary values and parameters which may be subject to change, please do not cite.

---

proportional ranking of possible health benefits to compare the impacts of cycling across all neighbourhoods for an equal proposed amount of investment.

## 2 Background to This Paper

### 2.1 Context

The Scottish Government's long term commitment to creating a more active and healthier population in Scotland is outlined in the Cycling Action Plan for Scotland 2017-2020 (CAP), in which a shared vision of increased levels of active travel is to be achieved through intensive cooperative work by partners, (Transport Scotland, 2017). Accordingly, Glasgow's ambition is to create a sustainable and cycle friendly city, in order to produce a better urban environment for its residents.

A more sustainable Glasgow will offer a liveable environment designed for the people, with fewer cars, and consequently an active, mentally and physically healthier population, with less levels of congestion and air pollution, (Glasgow City Council, 2016).

This is the vision prescribed by the Glasgow Strategic Plan for Cycling 2016-2025, which sets clear objectives, targets and actions to achieve a rapid modal shift to cycling in Glasgow.

Increased levels of investments in active travel are reflected in the growing delivery and improving quality of cycle infrastructure in the city, with Glasgow's cycle network increasing by over 160% in between 2006 and 2016, (Glasgow City Council, 2016). As reported by Bike Life<sup>1</sup> 2018, to date, there are 182 miles of cycle routes including 127 miles of routes physically protected from motorised traffic, (Sustrans and Glasgow City Council, 2018).

Steady increase in government funds to improve levels of active travel are translated in a series of large scale projects in Glasgow which will form the core integrated cycle network. Glasgow's City Ways and the Avenues are the core elements which are set to generate the primary network.

Glasgow's ambitions to become a cycle friendly city has begun through its "City Ways" programme. The "City Ways" will constitute an integrated core network of cycle routes protected from motorised traffic. To date the City Ways include the West City, the South West City Way and the South City Way which is currently under construction. Plans for a North City Way and East City Way are in development. A "City Way" cycle network will provide infrastructure suitable for people of all levels of cycle experience with further links to surrounding routes and destinations provided by "Quiet Ways", (Glasgow City Council, 2019).

Moreover, as part of the Glasgow City Region City Deal funding, Glasgow City Council is investing approximately £115 million within the city centre to deliver on the Enabling Infrastructure - Integrated Public Realm (EIIPR) programme.

More commonly known as the Avenues programme, this project will see streetscape improvements made to the public realm establishing principal Avenues throughout the city centre to form an integrated network of continuous pedestrian and cycle priority routes by 2024, (Glasgow City Council, 2019).

Initially an opportunity and demand approach was used for developing cycle infrastructure but since the adoption of the Strategic Cycle Plan for Glasgow and with active travel becoming a political priority with increased levels of funds, it became clear that a strategic long-term planning for an integrated cycle network was necessary.

Glasgow City Council has recently developed a comprehensive decision tool for routes prioritisation to assist decision-making by using a combination of spatial analysis and MCDA, which includes both supply and demand aspects, (Van Duivenbooden & Little, 2017). The tool presently used in Glasgow does not incorporate monetary aspects of health and construction.

This missing element will be addressed by incorporating in the MCDA for route prioritisation a cost/benefit analysis based on health gains from future cycle infrastructure, particularly due to increasing concerns over the obesity rate of the population in Glasgow, life expectancy, mental health issues and physical inactivity. The 2017 Scottish Health Survey, found that 65% of adults aged 16 and over were overweight, including 29% who were obese, with a steady increase in the population's Body Mass index (BMI), (Scottish Government, 2017).

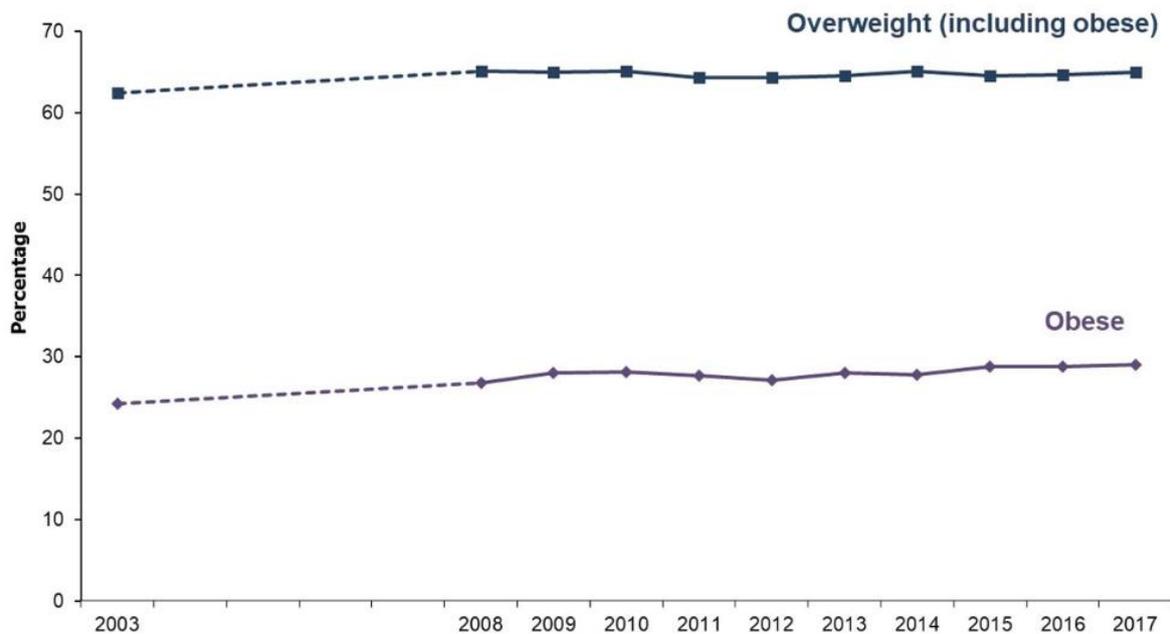


Figure 1: Proportion of adults overweight and obese, 2013-2017 (ages 16+), (Scottish Government, 2017).

The aim of this study is to provide a first screening tool to identify areas of Glasgow where the investment on new cycle infrastructure could maximise health benefits.

### 3 Route Prioritisation and Glasgow's Public Health

#### 3.1 Glasgow's MCDA for Route Prioritisation

In light of the quick expansion of Glasgow cycle network and the resources available, Glasgow City Council has introduced a more transparent, evidence-based decision making approach. This tool, developed by Twan Van Duivenbooden and Dr Collin Little informs the Council of the proposed routes' relative priority in the form of a prioritisation list.

The process entails scoring a proposed route according to the following criteria:

1. Type of network - This criterion assess whether the route is considered a primary infrastructure instrumental in the expansion of the core network or if it is considered a secondary or leisure route;
2. Links to existing network – This criterion assesses the route links into a good state primary network, if it links into a poor state primary network, a good secondary network or the city centre;
3. Cycling potential – This criterion adds household density to the total of trip generators 10 and origin/destination journeys;

4. Risk/safety – This criterion scores the route in function of the proposed type of infrastructure and the motorised traffic flow along the cycle path with a plan to add accident data to the equation in the near future;
5. Feasibility – This criterion is scored according to officers' knowledge and experience.

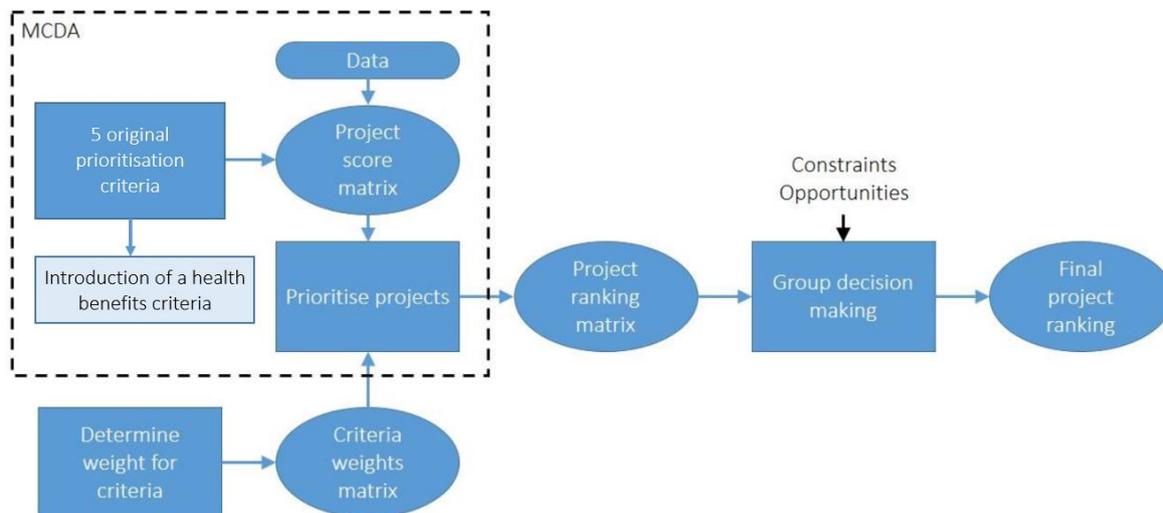


Figure 2: MCDA process, (Van Duivenbooden & Little, 2017)

The 'health benefits' criteria will be added to the current prioritisation criteria and the cumulative score will produce a ranking of prioritised routes. The list will finally be assessed by a group of expert council officers who will discuss feasibility and will finalise the ranking following a knowledge-based approach. A short report of the process and the final list will subsequently be presented to the public and incorporated in the annual review of actions for the Glasgow Strategic Plan for Cycling.

### 3.2 Glasgow Neighbourhoods and Health Demographics

In 2017, Glasgow's population counted 621,020 inhabitants, (Glasgow Centre for Population Health, n.d.). The National Records of Scotland forecast that population in the city will increase by 7% over the next 25 years which translates in a growth of 44,000 people. It is estimated that whilst the population under 50 will reduce by 5%, the overall increase of the population over 50 will increase by 5%. The part of the population aged 65-74 will increase by 34% and the population aged over 75 will increase by 55% over the next 25 years, (Glasgow Centre for Population Health, n.d.),<sup>ii</sup>. Facing the challenges of an aging population, strategic investment in cycle infrastructure could help increase healthy life expectancy in Glasgow and reduce health care costs.

Figure 3 below shows how male/female average life expectancy and healthy life expectancy in Glasgow is compared to male/female average healthy life expectancy in Scotland and the EU, (Public Health information for Scotland, 2013).

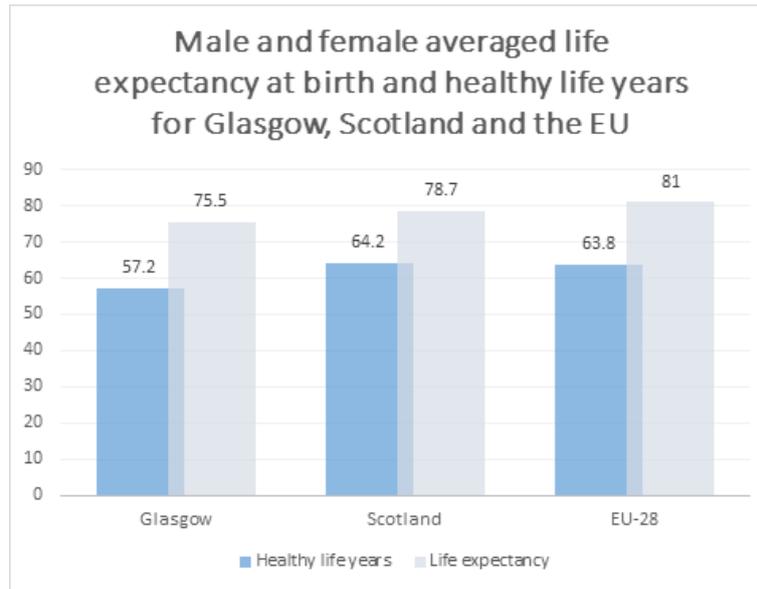
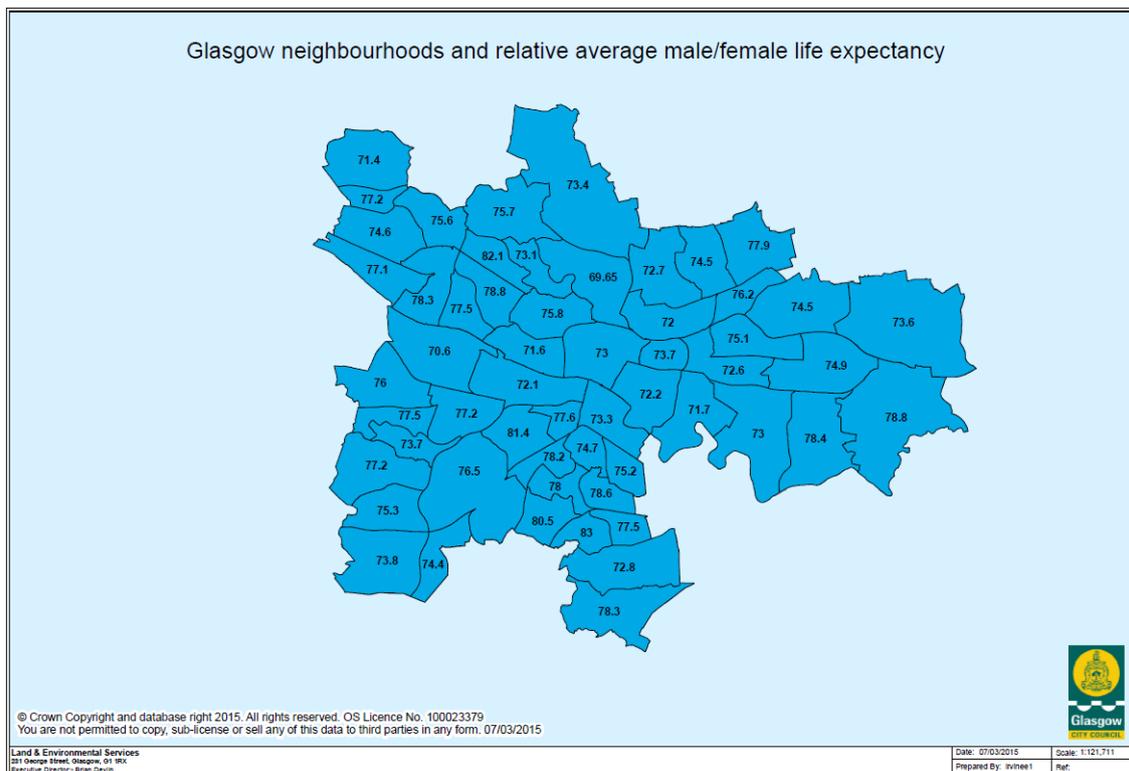


Figure 3: Male and female averaged life expectancy and healthy life years in Glasgow, Scotland and EU-28, (Public Health information for Scotland, 2013), (Eurostat, 2016).

Whilst men’s and women’s life expectancy in Glasgow is showing signs of improvement, it still rings alarm bells when compared to the average female/male mortality amongst EU member states, which according to recent Eurostat findings sits at 81 years of age, (Eurostat, 2016).

The link between deprivation and health is well established. However, recent research has highlighted the existence of a ‘Glasgow Effect’, a term used to describe the higher levels of mortality and poor health experienced in Glasgow over and above that explained by socio-economic circumstances, (Glasgow Centre for Population Health, 2010). This is true not only for the most deprived areas of the city but it manifests itself across the whole population: all ages (except for the very young), both males and females, in deprived and non-deprived neighbourhoods.



---

It is therefore Glasgow City Council's intent to help address the issue and to maximise the benefits of active travel across the city.

Glasgow is made of 56 neighbourhoods.

The following summary provides some of the key health statistics for Glasgow as published by the Glasgow Centre of Population Health (GCPH) on the Understanding Glasgow webpage, (Glasgow Centre for Population Health, n.d.):

6. For Glaswegian men, life expectancy at birth is 3.7 years less than in Scotland as a whole and Glaswegian women are predicted to live for 2.3 years less on average (in period 2015-17) ;
7. Geographic and socio-economic health inequalities are demonstrated by a 15 year gap in male life expectancy at birth across Glasgow's neighbourhoods and an equivalent 11 year gap in female life expectancy (in the period 2008-12) ;
8. Male life expectancy is approximately 13.7 years lower in the 10% of most deprived areas of Glasgow compared to the 10% of least deprived of the city; the equivalent gap for women has widened over the last two decades to 10.7 years (in the period 2010-12) ;
9. Glaswegian men and women have the lowest health life expectancy in Scotland compared to other local authorities. The predicted period of life spent 'not in good health' is 16.7 years for men and 20 years for women (in the period 2009-2013); and
10. Mental well-being has been consistently lower in Glasgow than in other Scottish cities.

The graph below shows the male and female averaged life expectancy at birth for all neighbourhoods in Glasgow.

### Life Expectancy at birth in Glasgow, by neighbourhood, (2008-2012)

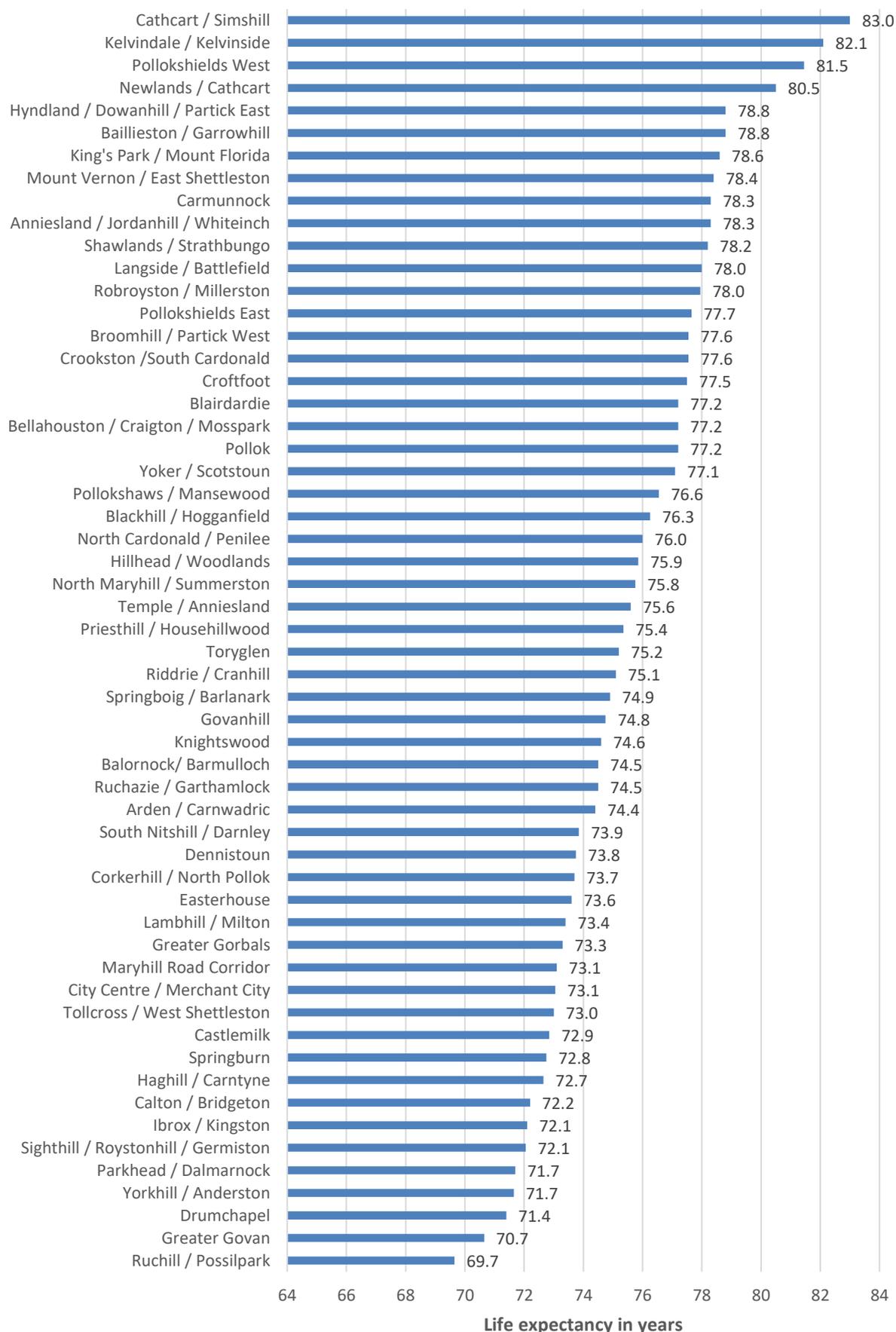


Figure 4: 2008-2012 male and female averaged life expectancy at birth for each Glasgow neighbourhood, (Glasgow Centre for Population Health, n.d.).

In 2014 only 63% of adults took part in the recommended 150 minutes of moderate activity each week, with physical inactivity adding about 2,500 deaths in Scotland each year, (NHS Health Scotland, 2014).

Cycling is a relatively cheap mode of transport, it helps improving mental health and physical health. Could the delivery of an integrated cycle network in strategic areas of the city, together with a strong behavioural change campaign and incentivising programmes, help improve excess mortality and therefore life expectancy in Glasgow?

#### 4 Available Datasets

This section explains which sets of data are currently available to the Council, what these data tell us and how they can be used to run an economic assessment of health benefits of proposed cycle routes.

##### 4.1 GCC Automatic Cycle Counters

There are currently 41 automatic counters operational sites, strategically located in the Glasgow area:

11. 22 automatic counters in a cordon ring around the perimeter city centre; and
12. 19 automatic counters outside the city centre cordon.

Each counter detects cycles when they travel over the sensors. A set of cables at each site runs across the carriageway and detects the number of cycles crossing the sensors. These sensors are calibrated to identify cycles only according to the distance between wheels travelling over the device and the weight of the object going over the sensors. All counters detect bidirectional movements and provide information regarding northbound, southbound, eastbound and westbound cycle trip.

The graphic below shows automatic counters by location.

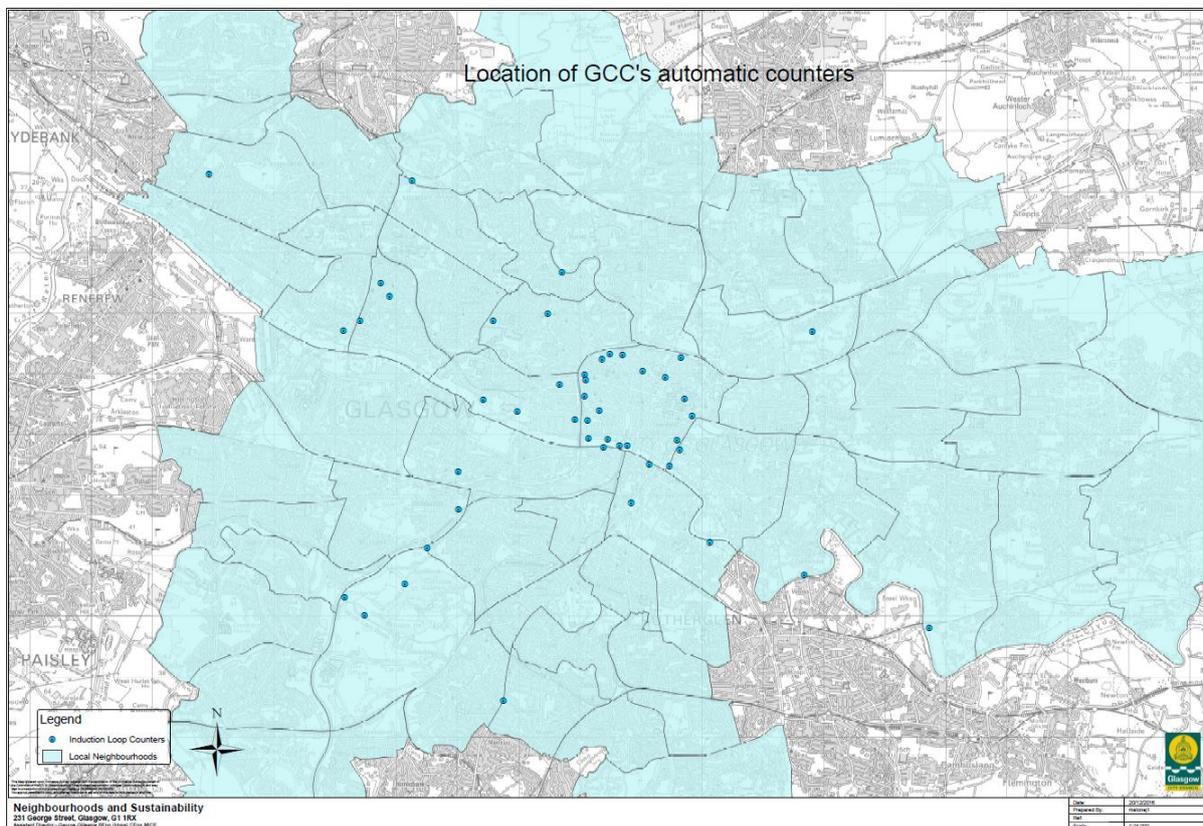


Figure 5: GCC's automatic cordon counters and Glasgow's neighbourhoods.

---

Whilst the counters are efficient in identifying trips in and out of the city centre, they do not determine where cycle trips generate or end.

This study will use automatic cordon counts to investigate the correlation with crowd-sourced origin/destination data sets and to adjust them to reflect the cycle population at large.

#### 4.2 Strava Metro Data

Strava is a popular GPS tracking application for recording physical activity via smart phone or GPS devices. The application's cycle tracking option allows its users to record cycle trips and collect information about distance, speed of travel, trip's origin, trip's destination, time, elevation and route. GPS tracking apps offer the possibility to produce data at a fine spatial and temporal scale for a large number of people. The data collected by such apps are raw GPS trajectories represented as latitude, longitude and timestamps. Strava users' profile is rather defined and specific; it is mainly, but not exclusively composed of athletes who want to record their cycling times and compare them to those of other athletes who cycle the same route. Strava is also widely used by commuters to record distance and timings of their commute and to establish preferred routes. The application is also used by individuals who simply want to track the amount of exercise done daily, weekly or monthly.

Strava Metro is the data science division of Strava which processes the raw data and aggregates and anonymises datasets. Data are then shared with researchers and planners to analyse cycling patterns. One of these processed datasets is an origin and destination (O-D) matrix of the cycling trips set to census output level areas, plus added information about the routes taken by different cyclists. The aggregated information provides GIS compatible data that offer a minute by minute count of users at street level based on Open Map roads network. Glasgow City Council obtained Strava data for the Glasgow area through the Urban Big Data Centre (UBDC) at the University of Glasgow.

Recent studies from Sustrans and the University of Glasgow have found a correlation respectively between Strava data and automatic cycle counters and Strava data and manual cycle counts. Both papers discourage the use of Strava Metro data alone and suggest to use Strava data to complement non crowd-sourced data. Hong et al (Hong, McArthur, & Livingston, 2019), found that in 2014 1 Strava trip represented on average 25 actual cycle trips in Glasgow.

More recently, a study conducted by Sun et al in 2017 compared annual average daily flow data provided by the UK Department of Transport and Strava cycling counts for the Clyde Valley area. Their analysis showed a very high correlation between those two data sources ( $r=0.83$ ), implying that Strava data could be utilised for spatial analysis of cyclists in general, (Hong, McArthur, & Livingston, 2019). A similar study was replicated by Hong et al in 2019 and a strong correlation of 0.816 was found between Strava Metro data and manual cycle counts in Glasgow. The linear relationship increased when data were aggregated at the daily level ( $r=0.908$ ), (Hong, McArthur, & Livingston, 2019)

This project requires origin data points so that the number of trips generated in each neighbourhood can be quantified and so that the result can be inputted in HEAT to calculate the health benefits produced by cycling in each Glasgow neighbourhood.

Once all data are available, the correlation between Strava Metro data and a number of selected GCC's automatic counters and between Glasgow Cycle Challenge data and GCCs' automatic counters will be assessed. All three datasets will then be used to make an estimation of cycle trips generated daily in each of Glasgow neighbourhoods.

---

### 4.3 Glasgow's 'Around the World' Cycle Challenge and Naviki App Data

Glasgow City Council are hosting their second virtual 'Around the World' cycle challenge in May 2019, also known as Glasgow Cycle Challenge. The challenge aims at encouraging new and existing cyclists to use their bikes more for all types of trips; from commuting, to shopping and leisure.

The aim of the challenge is to cycle and surpass the total distance of over 42000 km around the world, (cycling distance only, flights distance not included).

Each participant can take part individually or as part of a team by downloading the Naviki application on their smart phones.

Naviki is a GPS tracking app just like Strava which tracks cycle activities. Whilst Strava is advertised as a training app for athletes, (although not only used by athletes), the Naviki app is designed for the average cyclist who wants to find out about best routes from origin x to destination y. It offers world-wide best route planning for bicycles and an extensive documentation of your personal cycling activities. It can be used for every day cycling, leisure, mountain bike and racing bike. Naviki provides specific connections between any start and destination address, it shows desired routes on a map and navigates its users to their target destination by vocal navigation instructions.

Whilst providing participants with a platform for recording their cycle trips and compare them with others, the app also provides the council with valuable origin-destination data.

The challenge runs from the 1<sup>st</sup> until the 31<sup>st</sup> of May 2019.

Previous GCC exercises have validated the suitability of the month of May for cycle data collection.

The month of May was chosen due to the following factors:

- No long school closures;
- Low levels of rainfall, (Met Office, 2019) ;
- Month with most sunshine, due to the greater tendency for anticyclonic conditions often with easterly winds, (Met Office, 2019).

Once the data is made available in June 2019, a correlation to GCC's automatic cycle counters will be investigated to assess whether the dataset can be used to make an estimation of cycle trips originated in each Glasgow neighbourhood.

### 4.4 Life Expectancy Data for Each Glasgow Neighbourhood

The 'Glasgow Indicators' project has been developed by the Glasgow Centre for Population Health (GCPH) with support from a range of partners, including Glasgow City Council, Glasgow's Community Planning Team, Community Safety Glasgow, Glasgow Life, the University of Glasgow, NHS Greater Glasgow and Clyde and the International Futures Forum.

The aim of the project is to create an accessible online resource that informs a wide audience about the wellbeing of Glasgow's population across a range of domains (e.g. health, poverty, education, and environment).

12 domain models were identified to provide a dynamic interlinked view of the city. This paper refers to the 'Health' indicator which provides a health profile for the 56 neighbourhoods in the city.

In 2014, the GCPH published a new set of health and well-being profiles covering all neighbourhoods. Each profile aggregates information from the Scottish Office for National Statistics, Public Health Information for Scotland, National Records for Scotland and Scottish Health Survey.

This project will use life expectancy data provided by the GCPH for each neighbourhood in Glasgow to complement the results obtained through the use of HEAT at a micro level.

The GCPH will be able to share data on mortality by neighbourhood in October 2019. At the end of the year the Council will be able to apply data of mortality rate by neighbourhood to HEAT and get more diversified results which will represent the different health profiles of Glasgow by area.

---

## 5 Tools

Two tools are used throughout this exercise: WHO's HEAT and Sustrans' IIT.

### 5.1 Health Economic Assessment Tool

The HEAT tool was designed by a number of international experts to enable users without specific expertise in impact assessment to conduct economic assessments of the health impacts of walking or cycling. The tool is based on the best available evidence and a number of assumptions which are available on line in HEAT's 'Methodology and Guide', (World Health Organisation, 2017) .

HEAT was designed as a tool relatively simple to use which would enable professionals in the transport and active travel industry to make educated guesses about the economic impacts of the health benefits of active travel.

HEAT estimates the value of reduced mortality that results from specified amounts of walking or cycling, answering the following question:

*If x people regularly walk or cycle an amount of y, what is the economic value of the health benefits that occur as a result of the reduction in mortality due to their physical activity?*

The tool can be used for a number of different assessments, for example:

1. assessment of current (or past) levels of cycling or walking, e.g. showing what cycling or walking are worth in your city or country;
2. assessment of changes over time, e.g. comparisons of "before and after" situations, or "scenarios A vs. scenario B";
3. evaluation of new or existing projects.

This study will assess changes over time of a 'before proposed infrastructure' case and a hypothetical 'after implementation of proposed infrastructure' case.

A separate assessment will be made for each of the 56 neighbourhoods in Glasgow and the cost of infrastructure will be kept constant at £100,000 across all neighbourhood cases. HEAT will therefore estimate the value of reduced mortality per every £100,000 spent on proposed cycle infrastructure in each neighbourhood by answering the following question:

*What is the economic value of the health benefits that occur as a result of the reduction in mortality due to physical activity, per every £100,000 invested by GCC in cycle infrastructure in a specific neighbourhood?*

### 5.2 Infrastructure Impact Tool

The Infrastructure Impact Tool (IIT) is part of a series of tools designed by Sustrans for assessing the impact of cycling. IIT estimates the impact, primarily in terms of increases in the number of cycle trips, of investments in specific types of cycling infrastructure. It uses data from a range of previous interventions to develop a category model for different types of infrastructure, calculating the typical impact of those interventions, (Sustrans, 2017).

This study uses IIT to estimate the number of cycle trips generated in a given neighbourhood in Glasgow for every £100,000 investment in cycle infrastructure.

## 6 The application of HEAT at a Micro Level

It was decided to apply HEAT as this is already widely accepted by an international experts and in order to be able to compare results with other local authorities and organisations using a common methodology.

HEAT is designed to enable users without expertise in impact assessment to conduct economic assessments of the health effects of active travel and it is widely used internationally by local authorities, planning and engineering professionals and campaign groups in order to estimate the value of reduced mortality that results from regular walking and cycling.

HEAT is generally used to assess benefits of cycle infrastructure at a national, regional and city level. The initial challenge was to find the right data to apply HEAT at a micro level to each of the 56 neighbourhoods in Glasgow.

HEAT requires for the following points to be carefully considered in order to ensure that the tool is applicable:

1. Data from local surveys must be ensured to be representative of the population assessed. The studies should be carried out over a sufficient period of time and across sufficient locations to adjust for known seasonal and spatial variation in cycling or walking; otherwise the data have to be adjusted using realistic assumptions to reflect long-term averages as much as possible, (World Health Organisation, 2017);
2. HEAT is to be applied for assessment on a population level and it is designed for habitual behaviour, such as cycling for commuting or regular leisure-time activities;
3. HEAT is designed for adult populations. HEAT calculations are based on mortality rates for the age ranges of 20–64 years for cycling;
4. The tool is not suited for populations with very high average levels of cycling. The tool is therefore not suited for populations with approximately 1.5 hours or more per day of cycling, which exceed the activity levels common in an average adult population;
5. The HEAT air pollution module should not be used for environments with very high levels of air pollution. Most of the studies on the health effects of cycling and of air pollution used for HEAT have been carried out in environments with low or medium and they are therefore unsuited for application to environments representing an exposure for cyclists or pedestrians of particulate matter of considerably more than 50 µg/m<sup>3</sup>. Negative effects from air pollution seem to start to level off at higher concentrations, and the effects of such levels of exposure on cyclists and pedestrians have not yet been well studied.

The table below explains how the points above are deemed valid for the data available to carry out this study.

HEAT requirement	Type of data available	Potential issues	Validity
Data from local surveys must be ensured to be representative of the population assessed	Strava data and Naviki data	Are not a random sample of the population of Glasgow and may over represent cyclists	As soon as all datasets are available the correlation between crowd-sourced data and GCC automatic counters will be assessed. If a strong correlation is found automatic counters data will be used to adjust OD data
HEAT is to be applied for assessment on a population level and it is designed for habitual behaviour	Strava data, Naviki data and population aged 16-64 data at neighbourhoods level	Overestimation of cycle trips per neighbourhood, overestimation of speed of cycles and overestimation of distances cycled. HEAT requires to use data for population aged 20-64 whilst	In order to avoid over estimation discounts will be applied. It was decided to proceed with using population data for people aged 16-64 because they reflect the age range of crowd-sourced data.

		data available cover neighbourhoods' population aged 16-64	Although HEAT calculations are not set for an adolescent population, population data across neighbourhoods will be consistent including 16 to 64 year-olds and for the scope of creating a ranking with results it is deemed valid to proceed with the data available
HEAT is designed for adult populations. HEAT calculations are based on mortality rates for the age ranges of 20–64 years for cycling	Estimates of mortality rate for the population aged 20-64	N/A	Estimates of mortality rate for the population aged 20-64 at neighbourhoods level are available
The tool is not suited for populations with very high average levels of cycling (>1.5 hrs/day)	Strava data and Naviki data	Strava and Naviki data may include trips recorded by people with very high level of cycling.	Because the unit chosen in HEAT to input cycle data is 'trips', the estimated trips per person per neighbourhood even when adjusted to take account of automatic counters data do not suggest high levels of cycling
The HEAT air pollution module should not be used for environments with very high levels of air pollution	HEAT standard value for Average concentration in European urban environment	N/A	Neither the Annual Mean Objective for PM10 nor the Daily Mean Objective was exceeded at any monitoring location during 2016. For PM2.5 the 10µg/m3 objective was not exceeded at any monitoring location during 2016, (Glasgow City Council, 2017).

Table 1: validity of available data in relation to HEAT requirements.

Carrying out economic appraisal of the health effects of transport behaviour is a complex undertaking and as outlined above, involves several assumptions and expert judgements.

For the scope of this study it is accepted that the data available to GCC meet all the requirements prescribed above and where issues are identified discounts will be applied to avoid over estimations.

It is important to understand that this specific exercise aims at creating a factor number to be input into the MCDA for routes prioritisation in Glasgow to take into account the possible health benefits that proposed cycle routes may bring to the local population in each of Glasgow's neighbourhoods. It is important to highlight that this exercise does not aspire to estimate the exact cost/benefit ratio of future infrastructure but rather to create a proportional ranking of possible health benefits to compare the impacts of cycling across all neighbourhoods for an equal proposed amount of investment. Because key parameters will be applied with consistency and proportionality across all neighbourhood cases, it is deemed acceptable to use the data described above. Expert judgements were therefore made

---

based on the best available information and evidence. The results will represent an approximate assessment of health benefits deriving from investing a certain amount of funds in delivering new cycle infrastructure in certain areas in Glasgow and further improvements will be made as additional knowledge becomes available.

## 7 Proposed Methodology

This section describes the proposed methodology for:

- The economic assessments of the health impacts for each £100,000 invested in proposed cycle infrastructure in each neighbourhood in Glasgow using HEAT;
- importing economic assessment data into the GCC's MCDA for routes prioritisation; and
- assessing improvements in mortality rate from cycling alone across the city.

### 7.1 HEAT: Tool Application and Choice of Variables Explained

HEAT is composed of 5 main steps:

1. defining your assessment;
2. providing input data;
3. providing information for data adjustments;
4. review of calculation parameters; and
5. results.

The geographic scale selected to carry out this exercise is a sub-city level of Glasgow.

A 'two cases' assessment option was selected in order to allow the tool to compare the 'before intervention' reference case and the 'after proposed intervention' comparison case. The 'before intervention' case reflects the status quo and the 'after proposed intervention' case is hypothetical and uses data projections. A default assessment time of 22 years was chosen in order to reflect the population projection data available.

The following impacts are simultaneously taken into account by the tool:

6. physical activity;
7. Air pollution; and
8. Carbon emissions.

Default values for motorised modes will be used for this study as currently no sub-city motorised traffic and public transport data are available at a neighbourhood level.

'Trips' was chosen as the unit for assessing cycle volume data for both the reference and comparison cases. Crowd-sourced data and automatic cordon counts will be used to estimate the number of trips generated in each neighbourhood.

Figure 6 below shows the use of 'active mode data' as explained in paragraphs 5.1.1, 5.1.2 and 5.1.3.

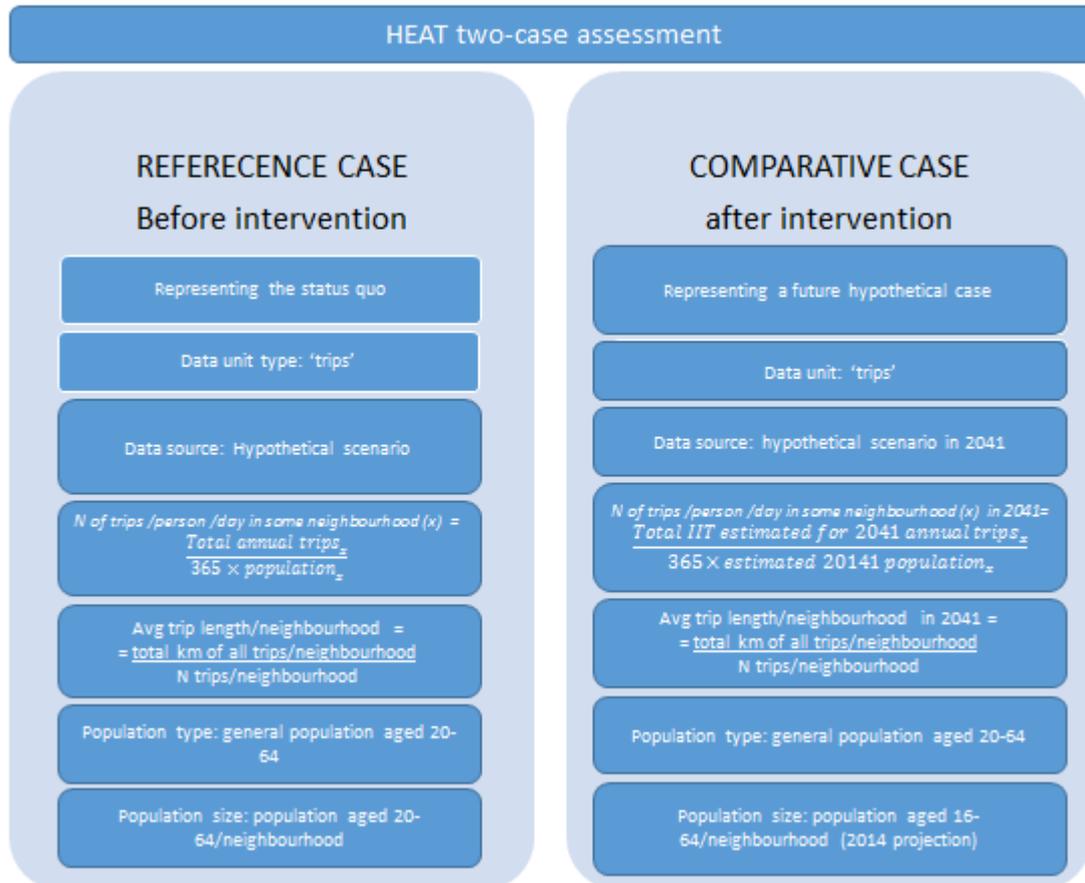


Figure 6: HEAT two-case scenario and use of 'active mode data' for the reference case and the comparative case.

### 7.1.1 Number of Cycle Trips for the Reference Case

Strava data from the month of May 2019 will be used to estimate the number of trips which were generated in each of Glasgow's neighbourhoods. All trips originating within a neighbourhood's polygon will be counted in ArcGIS. Because this study is carried out at a neighbourhood level, it is necessary to estimate the number of trips cycled by each neighbourhood resident only. The number of trips calculated in ArcGIS from crowd-sourced data, will inevitably include trips made by residents and trips made by non-residents. The number of origin points recorded on Strava in each neighbourhood will be compared to Naviki data and subsequently adjusted to proportionally reflect cordon counts.

The population type from which the volume figure of cycle trips was derived was set to 'general population' for both the reference and comparison cases to reflect the nature of population and mortality rate data available.

The unit 'trips' was selected to complete the 'Volume data active modes' section.

The tool requires to input data about the amount of trips made in the selected area per person per day. This value was generated by applying the following formula for each neighbourhood, x:

Number of trips per person per day in some neighbourhood =

$$\frac{\text{Total annual trips}_x}{365 \times \text{population}_x}$$

---

The average distance per cycle trip in each neighbourhood is calculated from the average distance of all annual trips generated in one neighbourhood and recorded on GPS tracking apps. A 20% discount is applied in order to avoid overestimation of distance cycled.

### 7.1.2 Number of Cycle Trips for the Comparison Case

Sustrans' ITT is used to estimate the increase of cycle trips derived by investments for the implementation of proposed cycle interventions in each neighbourhood.

The tool requires to input the following parameters:

1. Pre-intervention annual usage, which is calculated by adjusting Strava data with 'All Glasgow Cycle Challenge' data to automatic cycle counters data;
2. Intervention type, which is set to 'cycle and pedestrian tracks' for each neighbourhood in Glasgow;
3. Urban classification of location, which is set to 'urban conurbation' for each neighbourhood;
4. Proportion of leisure users, which is set to 30%, (Sustrans and Glasgow City Council, 2018).

The estimated amount of trips made in the selected area per person per day in 2041 is generated using crowd-sourced data for 2041 and the projected number of people residing in a given neighbourhood  $x$ , in 2041 according to National Records of Scotland data, as follows: :

*Number of trips /person /day in some neighbourhood (x) post intervention in 2041=*

$$\frac{\text{Total IIT estimation for 2041 annual trips}_x}{365 \times \text{estimated 2041 population}_x}$$

### 7.1.3 Population Type

HEAT subsequently requires specific information about the population examined.

There is a discrepancy between the specifications for adult population required by the tool and adult population data available from the National Records of Scotland for the 2011 Census.

HEAT requires the total number of adults between the age of 20 and 64 in a given neighbourhood whilst the National Records of Scotland can either provide the total number of the population in between the age of 16 and 64 or the total number of the population in between the age of 25 and 64.

It was here decided to use the total number of the population aged 16 to 64 in order to cover the age range prescribed by HEAT and it is deemed as a reasonable estimation of age range of people using the GPS tracking apps mentioned in this paper.

### 7.1.4 General Adjustments

For two case assessments, HEAT requires to make the following adjustments to the data to inform calculations.

Where raw values are used as summarised below raw data or extrapolated data are available, HEAT parameters are adjusted accordingly, where data is not available HEAT default values are used as summarised below:

1. Estimated proportion of cycle trips to be excluded because not all cycling observed may be attributable to the intervention. This was set at 30% and applied to all neighbourhoods cases in Glasgow. According to HEAT guide manual the choice of a value that ranges from 30%-80% for this parameter applies to cases where it is believed that other factors than the evaluated intervention have contributed towards the observed changes in cycling;

2. Estimated adjustments to level discrepancy in cycle counts due location of counters and the time of the year counts were carried out. No spatial or temporal adjustment is required as automatic cordon counters data and crowd-sourced data provide continuous counts. Spatially, the demographically skewed GPS data will counterbalance the static nature of automatic counters which in turn better represent the cycling population;
3. Estimating the take-up time for a proposed intervention to generate its maximum volume of active travel. This is set to 10 years;
4. Estimated proportion of new trips which would have otherwise not being made prior to the intervention. This information is unknown and the parameter will be set to 0% as default value;
5. Estimate the percentage of reassigned trips to exclude cycling trips that previously used a different route. This information is unknown and the parameter will be set to 0% as default value;
6. Estimated proportion of trips that are made for transport instead of recreation. This parameter is set to 70% for all neighbourhoods cases according to findings reported by Bike Life 2018, (Sustrans and Glasgow City Council, 2018);
7. Proportion of trips that before the intervention would have been made by car. This is a variable calculated with Sustrans' IIAT;
8. Proportion of trips that before the intervention would have been made by public transport. This information is unknown and the parameter will be set to 0% as default value;
9. Estimated proportion of cycle trip which are made in traffic as opposed to being made away from major roads, parks etc. This parameter is set at 50% as default value.
10. Estimated levels traffic conditions. This parameter is set at the European average in urban areas across all neighbourhoods' cases.

The table below schematically summarises the points explained above.

Type of data	Adjustment value	Adjustment explained
Estimated proportion of cycle trips to be excluded	40%	The HEAT guide manual suggests that a range from 30%-80% applies to cases where it is believed that other factors than the evaluated intervention have contributed towards the observed changes in cycling
Discrepancy in cycle counts due location of counters and the time of the year counts were carried out	No temporal adjustment and no spatial adjustment	Automatic cordon counts and Strava Metro provide continuous data. 'All Glasgow Cycle Challenge' challenge data provide continuous counts for the month of May, (month which best represent average cycle usage in Glasgow). Spatially automatic counters and crowd-sourced data complement each other
take-up time for a proposed intervention to generate its maximum volume of active travel	10 years	This is the maximum value selectable in the HEAT tool.
Proportion of new trips which would have otherwise not being made prior the intervention	0%	HEAT default value
Percentage of reassigned trips to exclude cycling trips that previously used a different route	0%	HEAT default value
Proportion of trips that is made for transport instead of recreation	70%	To reflect findings reported on Bike Life 2018
Proportion of trips that before the intervention would have	Result from IIAT	Variable calculated per each neighbourhood with Sustrans' IIAT

been made by car.		
Proportion of trips that before the intervention would have been made by public transport	0%	HEAT default value
Traffic levels	European average in urban areas	GCC's automatic cordon counters for motorised vehicles do not generate data for each neighbourhood in Glasgow due to their location therefore a HEAT average value for European urban areas is used

Table 2: General adjustment explained.

## 7.2 Adjustment of Calculation Parameters

HEAT provides users with an overview table of all default and background values and data entries to review and to change as appropriate according to the best information currently available.

The following adjustments are made to the following values:

1. Average Cycling Speed per neighbourhood, calculated from the average speed of all trips generated in one neighbourhood and recorded on GPS tracking apps. A 20% discount is applied in order to avoid overestimation of speed;
2. All case mortality rate in Glasgow for the population aged 20-64 in reference case is 375.7541 (National Records of Scotland, 2017), expressed as number of deaths per 100 000 people per year in the respective age group). The Glasgow 2017 mortality rate is used for each neighbourhood case.
3. All case mortality rate in Glasgow age 20-64 in counterfactual case. Due to data unavailability this parameter is equal to the all case mortality rate in Glasgow for the population aged 20-64 in the reference case, (375.7541). The GCPH will share this information broken down by neighbourhood in October 2019 when this parameter will be updated;
4. Average road traffic speed in Glasgow is set at HEAT's default value of 32 km/h as the European average road traffic speed in urban areas.

The table below shows HEAT's calculation parameters. Default parameters are suggested by HEAT when specific data is not available. Defaults parameters were adjusted, (see blue sections I the table below) where area specific data is available.

Parameter	Default value	Edited value	Source of edited value	Unit
Default carbon value by country and year	104.7	104.7	HEAT default value, (value for United Kingdom in 2020)	USD2014/tCO2e
Default carbon value by country and year (value for United Kingdom in 2039)	223.83	223.83	HEAT default value, (value for United Kingdom in 2039)	USD2014/tCO2e
Discount rate	5	5	HEAT default value	%
Average cycling speed	14	Average cycling speed per each neighbourhood	Avg. speed of all trips generated in one neighbourhood and recorded on GPS tracking apps minus 20% discount in order to avoid overestimation of speed	Km/h
Value of	4036471.5254	4036471.5254	HEAT default value,	Euro/death

statistical life in euro by country			(value for United Kingdom in 2015)	
PM2.5 concentration	8	8	HEAT default value for Glasgow	ug/m3
All-cause mortality rate in reference case	238.2573 (value for United Kingdom and age group 20-64)	375.7541	All case mortality rate in Glasgow for the population aged 20-64 in the reference case, (National Records of Scotland, 2017)	Deaths/inhabitants
All-cause mortality rate in counterfactual case	238.2573 (value for United Kingdom and age group 20-64)	375.7541	All case mortality rate in Glasgow for the population aged 20-64 in the reference case, (National Records of Scotland, 2017)	Deaths/inhabitants
Average road traffic speed for	32	32	HEAT default value for European average standards in urban areas for bike	Km/h
Time needed to obtain full health impacts in two cases assessment	5	5	HEAT default build up time for two case assessment	years

Table 3: adjustment of calculation parameters.

## 8 Results

The results provided by the HEAT tool when comparing the two scenarios generate the following values:

- Number of premature deaths prevented per year;
- Number of premature deaths prevented per year over the full assessment period;
- Carbon emission per year;
- Amount of carbon emissions over the full assessment period;
- Economic value of impacts per year; and
- Economic value over the full assessment period including a 5% annual discount rate.

## 9 Conclusions

GCC expects to have access to full Strava and Naviki data at the beginning of June 2019. This will allow the assessment of the correlation between crowd-sourced data and GCC's automatic cordon counts using selected counters.

The number of trips estimated per neighbourhood will be used to run 56 HEAT calculations for each neighbourhood in Glasgow in order to understand the amount of benefits derived from improved population's health as a result of every £100,000 spent by GCC on cycle infrastructure.

The 56 values generated as a result of HEAT calculations will be translated into a scoring system compatible with the MCDA for routes prioritisation.

This micro level approach is aimed at addressing Glasgow's spatial disparity in excess mortality across the city.

The results deriving from this study is designed for internal use, to include a cost benefit analysis of health benefits in the routes prioritisation process. The final list of prioritised routes will be used to

---

secure funding for future cycle infrastructure in the city and will ensure longevity and continuity of active travel programmes between administrations.

It is important to highlight that this exercise does not aspire at estimating the exact cost/benefit ratio of future infrastructure but rather to create a proportional ranking of possible health benefits to compare the impacts of cycling across all neighbourhoods for an equal proposed amount of investment.

It is important to remember that many of the variables used within HEAT as well as many of the Glasgow neighbourhoods specific variables input in the tool are estimates and therefore liable to some degree of uncertainty. Providing that the same datasets and assumptions are used across all 56 neighbourhood cases, the approximation of the order of magnitude of the impacts of proposed infrastructure is valid and acceptable for the scope of developing a ranking of investment prioritisation based on health benefits. The accuracy of the results of this study should be understood as estimates of the order of magnitude of the expected effect rather than as precise estimates.

## 10 References

- European Commission. (2013). *Attitudes of Europeans towards Urban Mobility*. Retrieved from ec.europa.eu: [http://ec.europa.eu/commfrontoffice/publicopinion/archives/ebs/ebs\\_406\\_en.pdf](http://ec.europa.eu/commfrontoffice/publicopinion/archives/ebs/ebs_406_en.pdf)
- Eurostat. (2016). *Mortality and life expectancy statistics*. Retrieved from Eurostat: [https://ec.europa.eu/eurostat/statistics-explained/index.php/Mortality\\_and\\_life\\_expectancy\\_statistics](https://ec.europa.eu/eurostat/statistics-explained/index.php/Mortality_and_life_expectancy_statistics)
- Glasgow Centre for Population Health. (2010). *Investigating a Glasgow effect*. Glasgow: Glasgow Centre for Population Health. Retrieved from GCPH: [https://www.gcph.co.uk/assets/0000/0087/Investigating\\_a\\_Glasgow\\_Effect\\_for\\_web.pdf](https://www.gcph.co.uk/assets/0000/0087/Investigating_a_Glasgow_Effect_for_web.pdf)
- Glasgow Centre for Population Health. (n.d.). *Understanding Glasgow*. Retrieved from <https://www.understandingglasgow.com/indicators/population/overview>
- Glasgow City Council. (2016). *Glasgow Strategic Plan for Cycling 2016-2025*. Retrieved from glasgow.gov.uk: <https://www.glasgow.gov.uk/httphandler.ashx?id=33403&p=0>
- Glasgow City Council. (2017). *2017 Air Quality Annual Progress Report*. Retrieved May 16, 2019, from Glasgow City Council: <https://www.glasgow.gov.uk/CHttpHandler.ashx?id=39358&p=0>
- Glasgow City Council. (2019). *Glasgow City Council - South City Way*. Retrieved from Glasgow City Council: <https://www.glasgow.gov.uk/scw>
- Glasgow City Council. (2019). *Glasgow City Council - Avenues*. Retrieved from Glasgow City Council: <https://www.glasgow.gov.uk/index.aspx?articleid=22752>
- Hong, J., McArthur, D. P., & Livingston, M. (2019, March 14). The evaluation of large cycling investments in Glasgow using crowdsourced cycle data. Glasgow, Scotland.
- Met Office. (2019, 03 27). *Metoffice - Climate*. Retrieved from metoffice.gov.uk: <https://www.metoffice.gov.uk/climate/uk/regional-climates/ws#sunshine>
- National Records of Scotland. (2017). *Vital events reference tables 2017*. Retrieved from National Records of Scotland: <https://www.nrscotland.gov.uk/statistics-and-data/statistics/statistics-by-theme/vital-events/general-publications/vital-events-reference-tables/2017/section-5-deaths>
- National Records of Scotland. (2018). *National Life Tables for Scotland 2015-2017*. Retrieved from nrscotland.gov.uk: <https://www.nrscotland.gov.uk/files//statistics/life-expectancy-15-17/nat-life-tabs-15-17-pub.pdf>
- NHS Health Scotland. (2014). *Physical activity*. Retrieved from NHS Health Scotland: <http://www.healthscotland.scot/health-topics/physical-activity/physical-activity-overview>
- Public Health information for Scotland. (2013). *Health life expectancy: local authorities*. Retrieved from ScotPHO: <https://www.scotpho.org.uk/population-dynamics/healthy-life-expectancy/data/local-authorities>
- Scottish Government. (2017). *Health of Scotland's Population - Obesity*. Retrieved from Scottish Government: <https://www2.gov.scot/Topics/Statistics/Browse/Health/TrendObesity>
- Sustrans. (2017). *Active Travel Tool Box*. Retrieved May 16, 2019, from Sustrans: [https://www.sustrans.org.uk/sites/default/files/activetraveltoolbox\\_economiccase\\_infimptool\\_guidev4.pdf](https://www.sustrans.org.uk/sites/default/files/activetraveltoolbox_economiccase_infimptool_guidev4.pdf)
- Sustrans and Glasgow City Council. (2018). *Bike life*. Sustrans.
- Transport Scotland. (2017). *Cycling Action Plan for Scotland 2017-2020*. Retrieved from transport.gov.scot: <https://www.transport.gov.scot/media/10311/transport-scotland-policy-cycling-action-plan-for-scotland-january-2017.pdf>
- Van Duivenbooden, T., & Little, C. (2017). Retrieved from Scottish Transport Applications & Research: <http://starconference.org.uk/star/2017/Little.pdf>
- World Health Organisation. (2017). *Health economic assessment tool (HEAT) for walking and cycling*. Retrieved from Euro WHO: [http://www.euro.who.int/\\_\\_data/assets/pdf\\_file/0010/352963/Heat.pdf?ua=1](http://www.euro.who.int/__data/assets/pdf_file/0010/352963/Heat.pdf?ua=1)
- World Health Organisation. (2017). *Health Topics*. Retrieved May 16, 2019, from World Health Organisation Europe Regional Office: [http://www.euro.who.int/\\_\\_data/assets/pdf\\_file/0010/352963/Heat.pdf?ua=1](http://www.euro.who.int/__data/assets/pdf_file/0010/352963/Heat.pdf?ua=1)

## Acknowledgements

I would like to thank Andy Cope, Director of Insight Research at Sustrans for his support, advice and patience. I would also like to thank my colleagues Lee Muir, Janis Boyd for their feedback, ideas and recommendations, Dr Collin Little for his help and guidance and Bruce Whyte from the Glasgow Centre of Population Health for his invaluable advice and input.

---

<sup>i</sup> Bike Life is produced by Sustrans in collaboration with 15 local authorities taking part in the programme. Bike Life is an assessment of city cycling development including infrastructure, travel behaviour, satisfaction, the impact of cycling, and new initiatives.

<sup>ii</sup> These projections are principal projections rather than the variant projections that NRS also produces, based on several assumptions about underlying demographics and therefore should be interpreted with caution.