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Estimating the Health Economic Benefits of Cycling

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Abstract

This paper examines the health and economic benefits from the construction of a new segregated cycleway in Ireland. The health economic benefits were estimated using the World Health Organisation's (WHO) Health Economic Assessment Tool (HEAT). This tool can be used to calculate the health economic benefits from an intervention (such as construction of a new cycling facility). The HEAT tool also offers research a transparent, coherent and standardized method of evaluating the health economic benefits of cycling investments. The data used for this tool was retrieved from a survey that was undertaken between December 2012 and January 2013 in a study area near Dublin, Ireland. In total, there were 845 responses to this survey. The results show that, if constructed, the cycleway would yield significant health and economic benefits.

1. Introduction and background

Internationally many countries and cities are reporting increases in cycling (Caulfield, 2014; Pucher et al, 2011a; Pucher et al, 2011b). Cycling has many benefits, which have been well documented including reducing emissions and congestion, and ~~the~~ health benefits (Wegman et al, 2012; Börjesson and Eliasson, 2012; Sælensminde, 2004; Jäppinen et al 2013; de Nazelle et al, 2010). Using the HEAT tool and a case study of a cycleway, this paper seeks to examine the health benefits of cycling via a new cycling infrastructure planned in Ireland.The HEAT model was specifically developed to measure the economic health benefits of cycling (WHO, 2011). The purpose of the tool is to create an economic assessment of cycling infrastructure and policies. The HEAT approach is an effective and user-friendly method of valuing and incorporating health benefits into transport appraisals (Rutter et al, 2013).

In many cases, the benefits derived from increased cycling from a new policy or new piece of cycling infrastructure may not have direct tangible economic benefits. The calculation of the return on a potential investment from increased health can be a very difficult aspect to assess (Börjesson and Eliasson (2012)~~)~~, however HEAT provides a methodology to measure these economic benefits. Improving the health of a population as a whole usually leads to several marked improvements in many areas. For instance, if the working population is healthier, then there are less sick days taken annually and therefore the population becomes more productive (WHO, 2011).

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1.1 The cycleway examined

The HEAT analysis conducted in this study was applied to the area surrounding the proposed cycle route. The cycle route that is planned is along a disused towpath of a canal. The cycle route will be fully separated from any vehicular traffic. The proposed route is approximately 60km long and varies greatly in condition. Some sections of the route are presently used as local roads whereas other sections are overgrown and have become flooded by the canal.

A map outlining the study area can be seen in Figure 1. The specific course of the cycle route is displayed in blue. A buffer zone of 5km was placed around the preferred route. The edges of this zone are displayed in red. This zone encompasses most of the major settlements in the area. The population densities of each electoral district in the area can also be seen. Each green dot represents two people. As expected, the population density increases with proximity to Dublin City. It can be observed how there are many settlements along the preferred route that have high densities relative to the surrounding countryside. The road infrastructure is shown in yellow on the map.

FIG 1 HERE

The approach adopted in this paper seeks to apply the model developed by the WHO and show how it can be used to derive the health benefits from a cycling investment. By applying this model one can see some of the limitations of the approach as it currently stands and then focus on areas for future development of the HEAT model. Currently in the field of economic analysis of investment in cycling infrastructure the industry is seeking to demonstrate the benefits of cycling to policymakers and the general public. The findings of the paper add to the research on estimating the benefits of investment of cycling infrastructure and show how including health benefits can demonstrate the positive economic benefits.

2. Examining the economic and health benefits of cycling

2.1 Health Benefits of Cycling

It is well documented that cycling has a very positive impact on both personal and public health (Rojas-Rueda et al, 2013; Unwin, 1995; Wang et al, 2005). Many of these studies conclude that any form of increase in the cycling mode share for commuting and for other purposes would result in a corresponding improvement in the health of an individual who cycles. This also results in an increase in health benefits of the country's population as a whole where there is a reduction in the mortality rate of the cycling population. From the World Health Organisation (2011), it is known that physical inactivity in the world is one of the leading causes of ill health.

Cavill et al (2007) found that physical activity was a fundamental way of improving mental and physical health of individuals. The authors also demonstrate how increased physical activity leads to a reduction in cardiovascular disease, stroke, cancer, and type II diabetes. Increased activity also leads to a reduction in anxiety and depression. Rojas-Rueda et al (2011) and de Hartog et al (2010) both found that the health gains from increased activity from a higher level of cycling far outweigh the potential negatives from the increased risk from a traffic accident and the increased exposure to pollution.

Anderson et al (2000) documented 13,375 women and 17,265 men over a 14 and a half-year period cycling. Over this period 2,881 women and 5,668 men died. This research found that those who cycle to and from their places of work and education had 40% reduction in their mortality rate. This reduction in mortality rate was the same for both men and women, with no statistically significant difference between the genders. Mindell et al (2011) looked at how various different transport modes affect human health in an urban environment. It was found that the benefits of transport (access to work, leisure, education, social contacts) were most experienced by the healthy and the affluent. The harmful effects (air pollution, community severance, injuries) of transport are mostly experienced by the poor, young and old in society. It surmised that a modal shift away from cars in favour of walking and cycling would reduce the harmful aspects of transport and improve the health of individuals in society and would also improve the environment and society.

Hendrikson et al (2010) investigated the levels of absenteeism amongst cyclists and non-cyclists. It was discovered that those that cycled to and from their places of work had one day less of absenteeism than non-cyclists. The authors believe that this reduction is due mainly to the better health of those that cycle and results in a financial gain for an employer. Unwin (1995) found that there was a very large potential for improvement in the health of Britain just from increased levels of cycling. It was found in a study of male civil servants that regular cyclists (those who cycled for at least an hour every week) had less than half the coronary attack rates than non-cyclists.

2.2 Health Economic Benefits of Cycling

When trying to monetise the wider benefits from transportation projects several approaches are often taken. Cost Benefit Analysis (CBA) is a common tool used in this field as it provides transport planners and policymakers with a tool that combines a large amount of the impacts and potential impacts of transport projects. Several authors have incorporated health benefits into CBA's of cycling and pedestrian projects. Sælensminde (2004) conducted a CBA on a walking and cycling route in Norway and included health benefits; these benefits were average estimates of reductions in four major diseases. The author in an effort not to over estimate the health economic benefits only applied the benefits to half of the individuals said to walk or cycle in the CBA. Wang et al (2005) provides a good example of how health benefits have been included in CBA by using data on how much less an active person spends on health care, and uses this figure to quantify the economic benefits of investments in pedestrian and cyclist trails. Mulley et al (2013) present another method that estimates the health benefits from cycling by examining the reductions in mortality and morbidity to estimate the economic benefits. The results of this study found a health economic saving of $1.12 (Australian Dollars) per km of cycling conducted.

However, Börjesson and Eliasson (2012) in a review of the literature on including health benefits in CBA, surmise that the evidence that individuals consider health benefits in their mode choice decisions is inconclusive and that health economic impacts shouldn't be fully taken into account in CBA. In an extensive overview of the research estimating health benefits of walking and cycling Cavill et al (2008) concluded that there was a lack of a coherent approach for estimating the health benefits of cycling and walking projects.

3. Research Methodology

This section of the paper details the steps used to conduct the HEAT analysis. Specific information regarding cycling in the area needs to be gathered before the HEAT analysis can commence. The basic process upon which HEAT are divided into five steps.

1. Volume of Cycling Per Person

2. Protective Benefit

Protective benefit requires the calculation of the reduction in mortality which is outlined in Equation 1.

$$\text{Reduction in Mortality} = 1 - (\text{Relative Risk})^{\frac{\text{Volume of Cycling}}{\text{Reference Volume of Cycling}}} \quad \text{Eq (1)}$$

3. Population that Stands to Benefit
4. General Parameters
5. Estimate of Economic Savings

The exact information required for each step is explained in detail in Table 1.

TABLE 1 HERE

The HEAT tool uses estimates of the relative risk of death from any cause among regular cyclists, compared to people who do not cycle regularly. It is based on relative risk data from studies from around the world. The relative risks are applied to the amount of cycling entered by the analyst and a log-linear relationship is assumed between cycling and mortality. In order to prevent inflated values and to keep the analysis accurate, the risk reduction is capped at approximately 50%. The tool uses the mortality rate to calculate the number of people who would normally be expected to die in any given year in the study population. Succeeding this, the reduction in expected deaths in the study population that cycle is calculated from the adjusted relative risk. The tool produces an estimate of economic savings from this calculated reduction in deaths.

3.1 Applying HEAT

This section details the processes that were used to determine the health economic benefits. The information required, how it was attained and the analysis performed on the information is outlined. As seen in the steps outlined previously, before the HEAT analysis could be performed, specific information regarding cycling in the study area needed to be gathered. A survey was distributed in December of 2012 amongst staff at the National University of Ireland, Maynooth, Intel Ireland and Hewlett Packard offices in Leixlip and to the local Business Association. These institutions and groups were located within 1km of a proposed high quality cycle route. Participants for the survey were recruited as they lived or worked close to the proposed cycleway. Extensive analysis was also conducted into the 2011 census statistics of the electoral districts located within the buffer zone of 5km.

For the present day evaluation of cycling benefits, information was required on the number of trips per day, per person, and the number of days on average a person cycles. The average distance of these trips, and the number of people undertaking these trips also needed to be identified. From this, a baseline was established, from which, the benefits of an intervention (new cycling infrastructure) could be determined. Following from the establishment of a baseline, information on the potential and predicted usage from an intervention is necessary. The information required was the same as the pre-intervention data, except that this data is what is predicted and therefore determines the potential benefits.

The questions posed, in the survey, were in relation to the regularity of present day cycling, and commute distance and time. The respondents were presented with “What if” questions in relation to the creation of a high quality cycling facility along the proposed cycle route.

3.2 Data Gathered

There were in total 845 valid responses to the survey. In Table 1, a selection of the responses from the survey undertaken can be viewed. It can be seen that 27% of the respondents cycled to and from their place of work and education. Presently at a national level in Ireland, the percentage of people cycling to and from their place of work and education is 2.2 % (CSO, 2010). In Dublin, the percentage of people commuting to and from their place of education and work is 5%. Therefore, it can be seen how there is a bias in the sample of people surveyed. However, the section containing the means of travel of those who do not cycle to and from work provides a reasonably good representation of the country with the percentages matching approximately with the national figures. The numbers and percentages of those that said they would use a cycle route constructed along the Royal Canal towpath are shown in Table 1. It can be seen that 56% said that they would use the cycle route to commute from their place of work/education and 29% said they wouldn't.

TABLE 2 HERE

The personal information of the respondents and the demographic information from the census data from the study area and the national census statistics can be viewed in Table 2. The census statistics were gathered from the POWSCAR dataset, which is produced by the Central Statistics Office in Ireland (CSO, 2011). The census statistics from the study area in Table 2 compares favourably to the national census statistics in terms of providing a representation of the country. It can then be seen that many of the categories from the survey are comparable to the census statistics from the local study area and the national census statistics.

TABLE 3 HERE

3.4 Limitations of the HEAT approach

As with any models that try to generalise individuals' benefits - be they travel time, economic, health or safety, they can both under or overestimate these benefits (van Wee, 2007; Wang et al, 2005; Sælensminde, 2004). The fear of overestimation of the results from these studies can result in some understating the potential benefits deliberately as not to mislead (Sælensminde, 2004). Several of the main limitations of the HEAT model are documented in the HEAT user manual (WHO, 2011). The main limitations of the approach is that it uses a number of Danish and Swedish figures for the benefits and this may not be a fair reflection on how these benefits would work in an Irish context.

The data collection methods used in this study also needed to be amended to make some of the HEAT results more realistic. It can be seen in Table 3 that cycling is overstated in the survey by a factor of approximately 15. If the results from the survey were extrapolated to the population within the catchment zone, one would infer that there are 38,422 people cycling to and from work and education, whereas the census results state that there are 2,443 people cycling to and from their place of work and education. The results from the survey indicate that approximately 50% of respondents who presently do not cycle, would cycle to and from their place of work and education, if a cycling facility was constructed as proposed. If this figure was used in the HEAT analysis, it would suggest that of the 103,335 people that fall into this category within the catchment area, 51,845 people would start cycling to and from work. This would represent an approximate 2,000% increase in people cycling. This type of increase in modal shift is very unlikely, in the author's opinion, and the results of any analysis conducted based upon this assumption would be unreasonable and inaccurate.

It should be noted that the results of the HEAT analysis conducted in this paper should come with some caveats. As mentioned previously one of the main limitations of the study is that if the survey data were taken at face value, ~~that~~ there would be a large over estimation of the health economic benefits. This may be defined as a weakness of both the HEAT approach and the survey undertaken as respondents in contingent valuation choice (similar to the one in this study) often respond positively and can overstate support for the introduction of a public good (Schläpfer et al, 2004). However, as previously stated conservative values for usage of the cycle lane were used in the study as not to overestimate the health economic benefits.

A lack of data from the Census on non-commute trips and distance travelled is another limitation of the research presented. The lack of information on non-work trips may underestimate the total benefits as work trips account for 25% of all trips undertaken in Ireland (CSO, 2009). Also the lack of distance travelled data from the census means that survey data was used as a proxy for distance travelled, while in the authors view this is acceptable. These values may be subject to some bias, the survey is a sample whereas Census data would have provided an average distance for the population in the area.

4. Results from the HEAT evaluation

The HEAT analysis undertaken in this study looks solely at commute trips. As the census statistics do not gather information on non-commuting related trips. As a result this section focuses on work and education related trips. As commuting trips represent typically only 25% of trips in Ireland, the benefits estimated in this section are likely to underestimate the true economic benefits of introducing the new cycling facility (CSO, 2009).

Presently, it can be seen from Table 3 that the population of the area surrounding the preferred cycle route is 141,777 people. Of those, there are 2,443 people who cycle for commuting to and from their place of work and education. This represents a work/education travel modal share of 1.72%, compared to the national average of 2.2%. When the results from the survey are compared to the census statistics, it can be observed how the rate of cycling is overstated in the survey. This is most likely due to people who cycle having an interest in participating in a survey on cycling whereas people who do not cycle might not have an interest in partaking in the survey.

TABLE 4 HERE

As it was felt the survey results overstated the potential cycling population, it was decided to complete a modal shift analysis on the surrounding population. Farrell et al (2010) completed a modal shift study on a rural town. The authors of this paper sought to evaluate the potential environmental benefits of a modal shift of certain percentages from those commuting by unsustainable modes to sustainable modes. The authors used modal shifts in the population of 5% and 10%. It was determined that similar percentages would also be appropriate for the analysis of the population in the study area, given the unrealistic changes in cycling number suggested previously. Table 4 displays the present population and the present cycling percentage rate and the number of people cycling. Table 4 then displays the numbers if this cycling rate were to increase to 2.5%, 5% and 10%. It can be seen that if the cycling rate were to go from 1.72% to 2.5%, the number of people cycling would increase from 2,443 to 3,544, and if the cycling rate increased to 10%, the numbers cycling would be 14,178.

TABLE 5 HERE

Another important factor for the HEAT analysis is travel distance and the days travelled. Presently in Ireland, the Central Statistics Office does not compile information on travel distance. For the HEAT analysis, the average distance commuted by cyclists in the survey was used. The number of days per year cycled is also required for the HEAT analysis. This figure again is not in the Census statistics, and therefore the figure from the survey was used. The number of days that people cycle on average in a year by those sampled is displayed in Table 5. This is accompanied by the potential increase if the cycleway were constructed. It can be seen in Table 5 that if the cycleway were constructed, the number of days cycled could potentially increase from 48 days per year to 78 days per year. This represents an increase of 30 days or approximately 63% from present day figures. This was calculated by firstly establishing the average days commuted by those who presently commute by bicycle only. The average days that would be commuted by those that stated they would commute by bicycle was then calculated. This allowed the potential increase in days cycled to then be estimated. This was repeated for the average distance. The average distance commuted by those who presently cycle was calculated first by omitting the responses of the other modes. The responses of those who said they would cycle if the proposed cycling facility were built were then detached from the overall group. The average distance commuted by this group was then calculated. It can be seen that presently the average distance commuted by those presently cycling is approximately 8km. The average distance commuted by those who presently do not cycle but would if the proposed cycle infrastructure was built is approximately 12km. We can see in Table 5 that this represents a growth in the cycling commute distance of 4km or 50%.

TABLE 6 HERE

The information from Tables 4 and 5 were inputted into the HEAT tool. Presently, the population that cycles has reduced their risk of mortality by 16%. If the facility was built and the predicted increase in cycling was to occur, the reduction in the risk of mortality would be 35%. This represents an average decrease in mortality in the population who cycle of 18%. If the cycle route were constructed, the numbers commuting by bike and the distances commuted would increase substantially and lead to a major increase in health benefits for those presently not cycling (See Table 6). Depending on the modal shift, the increased numbers that would stand to benefit from this would vary from 1,101 for a modal share of 2.5% and up to 11,735 for a modal share of 10%. The results of the cycling summary can be viewed in Table 6.

TABLE 7 HERE

The proposed cycle route is planned to be of a very high standard and therefore in order to prevent an overestimation of the benefits, a conservative figure of €200,000 per km was used for the estimation of the construction costs of the cycle route. This cost was based on the cost of another cycleway in Ireland (Deenihan et al, 2013). This would lead to a total construction cost of €12,000,000. This was the figure that was used for the estimation of the cost of intervention for the HEAT analysis and was used in the calculation of the benefit to cost ratio. The statistical value of life used in the estimation was €1,574,000 which is the average statistical value of life in the European Union (WHO, 2011). This value is the suggested value from the WHO for the HEAT estimation. The statistical value of life has a very large impact on the HEAT analysis. Any alteration of this value would change the financial benefits to a large extent.

From Table 7, the decreased mortality risks can be seen for the varying modal shifts. The number of deaths reduced per year from the decreased mortality rate varies between 3.39 and 17.93, depending on the modal shift. The HEAT model assumes that once the facility is constructed, that it would take two years for the uptake in cycling to expand and it would take five years before the benefits of this uptake would apply. Therefore, for an assessment over a ten year period, HEAT estimates that the benefits are between €37,080,000 and €196,163,000 or between €3,708,000 and €19,616,000 per year dependent on modal switch. HEAT estimates that the benefits are maximized in year seven when the health benefits have fully accrued and the rate of cycling has been maximized. The HEAT model is able to calculate the maximum financial health benefits from year seven on. After year seven, the annual financial health benefits are between €5,335,000 and €28,225,000, dependent on the modal switch. As this analysis is undertaken over a ten-year period, it is important to take inflation into consideration. The WHO suggested a discounted rate of 5% per annum for HEAT estimation. Therefore, with the discounted rate applied to the benefits over ten years, the benefits vary between €26,695,000 and €141,222,000 or on average between €2,669,000 and €14,122,000 per annum. Therefore, with an initial investment of €12,000,000, this represents benefit cost ratios of between 2.22:1 and 11.77:1. It is important to remember when viewing these results that HEAT does not calculate risk reductions for individual persons, but an average across the population under study. The results should not be misunderstood to represent individual risk reductions.

TABLE 8 HERE

The HEAT analysis was also performed on the predicted group from the survey alone where approximately 50% was to switch commute travel mode. This predicted group led to a benefit cost ratio of over 45:1, and over 10 years, would produce approximately €500,000,000 in health benefits.

5. Conclusions

The results presented in this paper show how the HEAT tool can be applied to new cycling infrastructure. While the approach has many benefits it also has a number of limitations, which have been outlined. While the approaches like the HEAT model have their limitations, specifically in relation to the generlisation of values across the population, the approach does provide more flexibility compared to methods like cost benefit analysis.

The results presented in this paper show that if the cycle route was constructed along the canal towpath, the economic health benefits from present day non cycling commuters switching their travel mode for commuting to cycling, would reduce their mortality rate as a group by 18%. It was investigated how if the modal share of cycling was to increase from 1.72% to 2.5%, 5% and 10% could impact the health of the population in the study area. The increase in cycling rates would reduce the number of deaths per year by between 3.39 and 17.93, depending on the modal switch. Using the European Union's statistical value of life at €1,574,000, it can be inferred that over a 10 year period with a two year uptake of cycling and five years for the buildup of the health benefits, that the benefits accumulated over 10 years would be between €26,695,000 and €141,222,000, dependent on the modal switch. These benefits would result from an initial investment of €12,000,000. This would lead to benefit cost ratios of between 2.22:1 and 11.77:1, dependent on the mode switch. For a transport facility, the ratios are very favourable and indicate that this would be a very worthwhile infrastructure project for the area.

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Conflict of Interest form

\We wish to confirm that there are no known conflicts of interest associated with this publication and there has been no significant financial support for this work that could have influenced its outcome.

We confirm that the manuscript has been read and approved by all named authors and that there are no other persons who satisfied the criteria for authorship but are not listed. We further confirm that the order of authors listed in the manuscript has been approved by all of us.

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Figure 1
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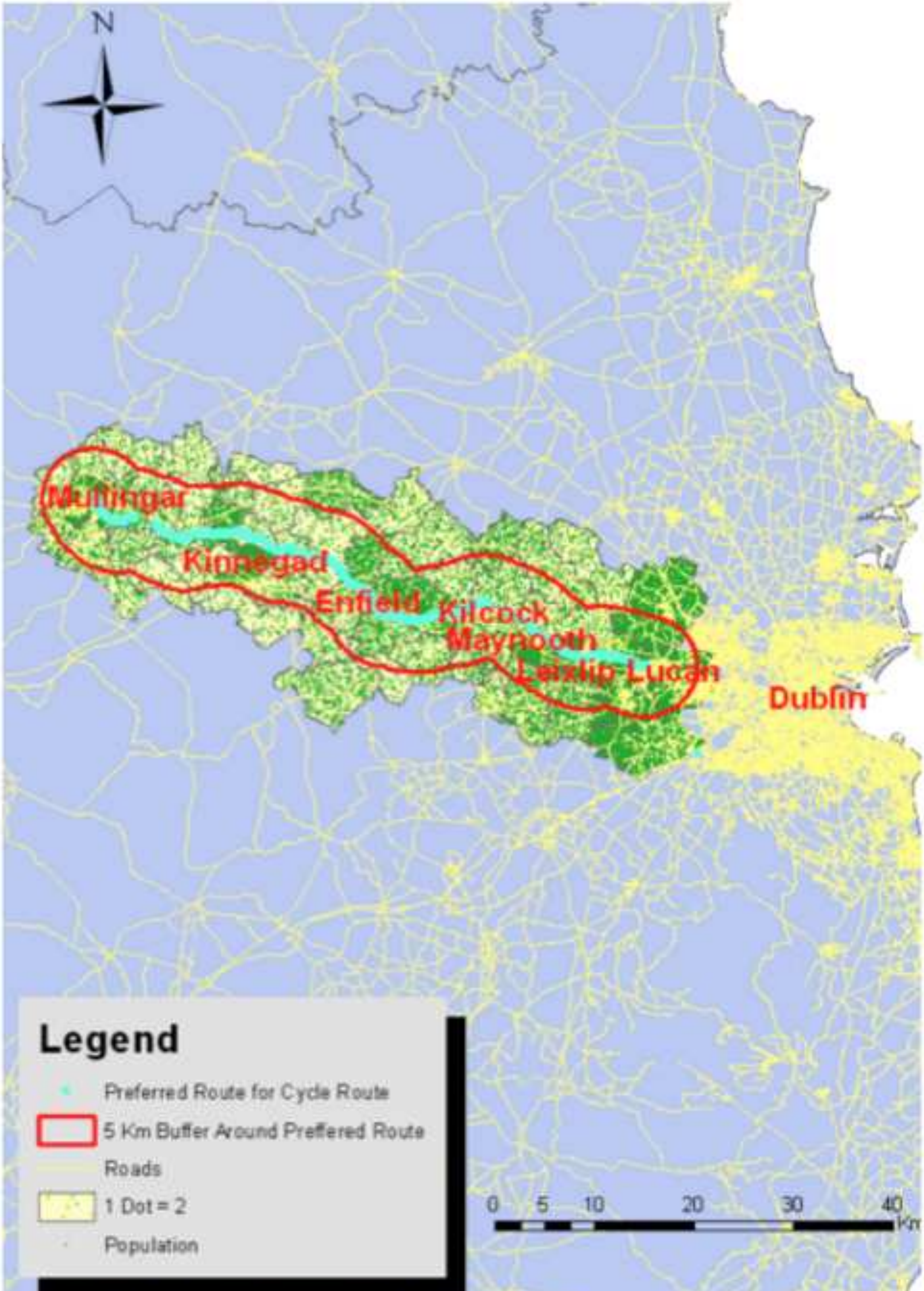

Figure 1 Indicative Map of Preferred Route with Buffer Zone, Population Density, and Roads

Table 1a
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Table 1 Progression of steps and data

Step	What was Done to Retrieve Data	Data Source
Step 1	This step requires information on duration, distance, and frequency of cycling trips.	For duration, respondents to a survey were asked: "What is your travel time to your place of work/education?" For distance, respondents to a survey were asked: "How far from your place of work/education you live?" For the frequency of cycling trips, respondents to a survey were asked: "How often do you cycle?"
Step 2	This step looks to calculate the present reduction in mortality rate from those cycling. The reduction in mortality rate as a result of cycling is calculated using Equation 1.	Information for Equation 1 is as follows: The "Volume of Cycling" is calculated by HEAT from the information pertaining to the frequency of cycling trips, the travel time, and the distance travelled. Additional information is required in relation to the population that cycle. The numbers of people in the study area commuting by bicycle was retrived from census data (CSO, 2012). As these trips are for commute purposes, it was assumed that there were two trip undertaken on the commute (to work, and then from work). The "Reference Volume of Cycling" is a reference provided by HEAT based on several studies. The "Relative Risk" is figure provided by HEAT based on several studies
Step 3	This step repeats Step 1 and Step 2, except adjusted for the predicted levels of the population that stands to benefit from an intervention.	In order to calculate the predicted levels of usage, respondents to a survey were asked: "If a high quality Greenway/Cycle lane was constructed (along the study route previously outlined), would you use this route for commute purposes". The respondents to a survey were then asked: How often would you use this facility for commute purposes". These two pieces of information are combined with duration, distance and frequency of cycling figures of Step 1, and allow for the predicted "Volume of Cycling" to be calculated.
Step 4	This step requires information on the intervention such as the buildup period, cost, the present mortality rate in the country, the statistical value of a life, and over what time frame the benefits are to be measured.	The build up period was the timeframe over which the infrastructure under investigation would take to become established in the locality. This was assumed to be two years. The cost of the construction of the facility was calculated from the costs of construction of a similar project in Ireland. Cost of construction estimated at €12,000,000. The statistical value of life was taken from the European value from WHO (2012). The moratlity rate of Ireland was also taken from WHO (2012). The timeframe over which the benefits are to be measured was assumed to be 10 years. This value was selected as after 10 years, the facility would need require

Table 1b

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		further large investment for refurbishment due to its location adjacent a canal.
Step 5	This step combines the results of the previous steps and outputs the estimated benefits from an intervention.	Outputs are: A benefit cost ratio based on the input costs of the intervention. Reduction in mortality rate. The value of a reduction in mortality rate. Total value of all benefits from the intervention.

Table 2
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TABLE 2 Selection of Information Gathered from the Survey

Information from Survey	Numbers	Percentage
People who cycle to and from their place of work/education	229	27
People who do not cycle to and from their place of work/education	616	73
Total	845	100
People who to not cycle to and from their place of work/education, what were their means of travel		
Motor Vehicle (Driver)	214	35
Motor Vehicle (Passenger)	29	5
Walk	128	21
Bus	77	12
Train	63	10
Missing (Excluding Cyclists)	105	17
Total	616	100
If a high quality cycling facility was constructed along the Royal Canal Towpath, would you use the facility to commute to and from your place of work/education		
Yes	472	56
No	199	24
Missing	174	21
Total	845	100

Table 3
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TABLE 3 Data from the survey, Census Statistics from the Study Area, and the National Census Statistics

Percentages	Demographics from Survey	Census Statistics From Study Area	Census Statistics for the Entire Country
	%	%	%
Gender			
Male	36	52	52
Female	39	48	48
Missing	25	0	0
Total	100	100	100
Education			
Primary/Secondary	30	31	30
Third Level	44	6	7
Missing	26	63	63
Total	100	100	100
Age			
15-24	25	5	5
25-34	30	20	19
35-44	13	18	17
45-54	15	13	14
55-64	11	6	8
65+	4	1	2
Missing	2	37	35
Total	100	100	100
Relationship Status			
Single	51	22	25
Married	23	41	39
Missing	26	37	36
Total	100	100	100
Commute Mode			
Drive	37	47	46
Drive (Passenger)	4	17	18
Walk	15	15	15
Cycle	27	2	2
Bus	9	11	10
Rail	8	4	3
Other	0	4	3
Missing	0	3	3
Total	100	100	100

Table 4
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TABLE 4 Census Statistics from the Electoral Districts that Lie Within the 5km Buffer Zone around the Preferred Route and the survey results Combined

Census Statistics and the Survey Combined	
Population in 5km buffer	141,777
People who Cycle to and from work (Numbers)	2,443
People who Cycle to and from work (Percentage of Populations)	1.72%
Extrapolating Results from the Survey to Population in Study Area	
Estimated Population who Cycle to Work	38,422
Actual Population who Cycle to Work	2,443
Extrapolating the Number of People who said they would Cycle to the Population	51,845
Survey Predicts People Cycling will increase	2,122%

Table 5
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TABLE 5 Population and Cycling Rates

Cycling Rate	Percentage	Numbers
Presently Cycling in Study Area at 1.72%	2	2,443
If the cycle rate was to increase to 2.5%	3	3,544
If the cycle rate was to increase to 5%	5	7,089
If the cycle rate was to increase to 10%	10	14,178

Table 6
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TABLE 6 Days and Distances Presently Cycled and Predicted

Number of Days Cycled on Average Per Year	48 Days/year	
If the Greenway were built, Number of Days Cycled on Average Per Year	78 days/year	
Increase in Days Cycled on Average Per Year	30	63%
Average Distance Commuted by those who Cycle	8km	
Average Distance Commuted by those who Don't Cycle and Would Cycle	12km	
Increase in Distance Cycled on average per year	4km	50%

Table 7
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TABLE 7 Cyclist Summary from HEAT

Summary of cycling data	2.5% Modal Shift	5% Modal Shift	10% Modal Shift
Pre-intervention cycling data			
Average number of cycling trips per person per year:	96	96	96
Average distance cycled per cycling trip (km):	8	8	8
Average distance cycled per person per year (km):	803	803	803
This level of cycling is likely to lead to a reduction in the risk of mortality of:	16%	16%	16%
Total number of individuals regularly doing this amount of cycling:	2,443	2,443	2,443
Note: Reduction in risk of mortality calculated from number of cycling trips per year and distance cycled			
Post-intervention cycling data			
Average number of cycling trips **per person** per year:	156	156	156
Average distance cycled **per cycling trip** (km):	12	12	12
Average distance cycled **per person** per year (km):	1,933	1,933	1,933
This level of cycling is likely to lead to a reduction in the risk of mortality of:	34%	34%	34%
Total number of individuals regularly doing this amount of cycling:	**3,544**	**7,089**	**14,178**
Note: Reduction in risk of mortality calculated from number of cycling trips per year and distance cycled			
Average amount of cycling per person per year increased between pre and post data.			
This change results in a decrease in the average mortality risk for your population of cyclists of:	18%	18%	18%
Number of individuals cycling increased between pre and post data.			
Additional individuals regularly cycling, compared to the baseline	1,101	4,646	11,735

Note: Mortality rate taken as the WHO's average European value (431.05 deaths per 100,000 persons per year

Table 8
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Table 8 HEAT Estimate

HEAT estimate	**2.5% Modal Shift**	**5% Modal Shift**	**10% Modal Shift**
This change results in an decreased in the average mortality risk for your population of cyclists of:	18%	18%	18%
Note: Decreased average risk of mortality calculated from subtracting the pre-intervention mortality risk from the post-intervention mortality risk			
The number of individuals cycling has increased between your pre and post data.			
Additional individuals regularly cycling compared to the baseline.	1,101	4,646	11,735
Taking this into account, the number of deaths per year that are prevented by this change in cycling is:	3.39	8.19	17.93
Financial savings as a result of cycling			
The value of statistical life applied is:	€1,574,000	€1,574,000	€1,574,000
Note: Value of statistical value of life is the default value suggested by the WHO for use in the HEAT models			
Based on a 5 year build up for benefits, a 2 year build up for uptake of cycling, and an assessment period of 10 years:			
Average annual benefit over 10 years is:	€3,708,000	€8,964,000	€19,616,000
Total benefits over 10 years are:	€37,080,000	€89,640,000	€196,163,000
The maximum annual benefit reached by this level of cycling, per year, is:	€5,335,000	€12,898,000	€28,225,000
This level of benefit is realised in year 7 when both health benefits and uptake of cycling have reached the maximum levels.			
When future benefits are discounted by 5 % per year:			
Current value of the average annual benefit, averaged across 10 years is:	€2,669,000	€6,453,000	€14,122,000
The current value of the total benefits accumulated over 10 years is:	€26,695,000	€64,534,000	€141,222,000
Benefit–Cost Ratio			
The total costs of:	€12,000,000	€12,000,000	€12,000,000
Total savings over 10 years of:	€26,695,000	€64,534,000	€141,222,000
Assuming 5 year build up of benefits, 2 years build up of uptake, discounting 5 % per year			
The benefit to cost ratio is therefore:	**2.22:1**	**5.38:1**	**11.77:1**