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Urban Greenways have the Potential to Increase Physical Activity Levels Cost-effectively.

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Abstract

Background: For many, physical activity has been engineered out of daily life, leading to high levels of sedentariness and obesity. Multi-faceted physical activity interventions, combining individual, community and environmental approaches, have the greatest potential to improve public health but few have been evaluated.

Methods: Approximately 100,000 people may benefit from improved opportunities for physical activity through an urban regeneration project in Northern Ireland, the Connswater Community Greenway. Using the macro-simulation PREVENT model, we estimated its potential health impacts and cost-effectiveness. To do so we modelled its potential impact on the burden from cardiovascular disease, namely ischaemic heart disease, type 2 diabetes mellitus and stroke, and colon and breast cancer, by the year 2050, if feasible increases in physical activity were to be achieved.

Results: If 10% of those classified as 'inactive' (perform less than 150 minutes of moderate activity/week) became 'active', 886 incident cases (1.2%) and 75 deaths (0.9%) could be prevented with an incremental cost-effectiveness ratio of £4,469/DALY. For effectiveness estimates as low as 2%, the intervention would remain cost-effective (£18,411 /DALY). Small gains in average life expectancy and disability-adjusted life expectancy could be achieved and the Greenway population would benefit from 46 less years lived with disability.

Conclusion: The Greenway intervention could be cost-effective at improving physical activity levels. Whilst the direct health gains are predicted to be small for any individual,

summed over an entire population they are substantial. In addition, the Greenway is likely to have much wider benefits beyond health.

Keywords: Physical activity; built environment; cost-utility analysis.

Introduction

According to the World Health Organisation (WHO), approximately 3.2 million deaths each year are attributable to insufficient physical activity.[1] Physical inactivity, a modifiable risk factor for numerous chronic diseases, represents a growing global public health problem with attendant increases in healthcare expenditure, loss in economic productivity and for the individual, increased absenteeism from work and reduced quality of life.[2]

To address these issues, there is a need for more research and evaluation of longer-term prevention strategies.[3] Public health interventions are typically complex and often have to span a range of sectors and mechanisms, and adopt a long-term perspective. The role of the built environment in public health, and in particular physical activity, has received increasing attention both in research and policy agendas. Indeed, government policies in both the UK (Foresight report, 2007) and USA (Institute of Medicine and National Research Council of the National Academies, 2009) have recommended improving the built environment to help tackle public health issues.

Multiple studies have consistently identified associations between access to public open spaces, trails, parks and physical activity[4-8] and environmental interventions have been found to be generally more cost-effective than other prevention programmes.[9] This is thought to be due to their potentially large cumulative population effect and whilst they may have substantial initial costs they are usually permanent with lasting effects.

We aimed to estimate the potential health impacts and cost-effectiveness of an urban regeneration project to promote physical activity. We used the PREVENT model, [10] adapted to the Northern Ireland (NI) context, using data from a household survey. We modelled the impact on the burden from cardiovascular disease, colon and breast cancer, given the strong evidence of the association between physical activity and their incidence.[11]

Methods

Intervention

The Connswater Community Greenway, a major urban regeneration project, will take four years to complete. It is funded by a Big Lottery Living Landmarks Award, obtained by a voluntary organisation called the East Belfast Partnership. It will create improved opportunities for physical activity and active transport by constructing 19.4 kilometres of new cycle and walkways and providing accessible and safe green space (www.communitygreenway.co.uk). The UKCRC Centre of Excellence for Public Health (http://coe.qub.ac.uk) obtained grant funding to independently evaluate the Greenway leading to the PARC study: Physical Activity and the Rejuvenation of Connswater.

Baseline Household Survey

The PARC study involves a quasi-experimental before and after household survey of the Greenway population, in tandem with a parallel (before and after) survey of the rest of NI.[12] The survey took place over a 12 month period (Feb 2010-Jan 2011) using a random sample of addresses from the Postcode Address File stratified by electoral ward. There are 29 wards within the vicinity of the Greenway with a total population ~110,600 and 22 wards (~87,500 residents) with a geographical centroid within a one mile radius. Seven of the wards are within the top 25% most deprived wards in NI. In each household, using the last birthday rule, an adult (16 years or older) was interviewed (*n*=1209). The response rate to the survey was 63%. We compared the age, gender and working status of our sample to the NI population and steps were taken to redress the lower percentage representation of the economically active, men and young people. Subsequently, the survey was weighted to reflect seasonal variations in physical activity and the age and sex distribution of the Greenway population. The survey included the Global Physical Activity Questionnaire.[13] This was used to determine the number of minutes of physical activity performed per week per interviewee. We then calculated, by age and sex, the proportion of those meeting the current physical activity recommendations of 150 minutes per week of moderate physical activity.[14]

Data Sources

A detailed description of data sources and the various derived variables are provided in Appendix A. There were four main categories of input data including (1) population, (2) risk factor, (3) disease and (4) cost inputs.

1. Baseline 2009 population, fertility and mortality estimates were obtained from the Northern Ireland Statistics and Research Agency (NISRA) (www.nisra.gov.uk). For background population disability weights, UK EQ-5D data were used.[15]
2. Baseline Greenway population physical activity levels were obtained from the baseline household survey (Table 2). Participants were categorised as either 'active,' if they met the current UK physical activity recommendations of greater than 150 minutes of moderate intensity physical activity per week[14] or 'inactive,' if they did

not. Relative risks were obtained from the literature for the protective effects of physical activity on disease specific incidence (Appendix B). Since type 2 diabetes is considered a risk factor for Ischaemic heart disease we also included the relative risk of Ischaemic heart disease given diabetes in our model, taken from the literature.[16]

3. The Northern Ireland Cancer Registry (NICR) provided baseline incidence, mortality, and remission rates (www.qub.ac.uk/nicr). By employing these parameters in DISMOD II (a WHO software tool used to check the consistency of disease parameters),[17] we derived the prevalence of colon and breast cancer. For cardiovascular diseases, prevalence was obtained from the 2005/06 NI Health & Social Wellbeing Survey[18] and the 2009 Quality and Outcomes Framework.[19] Furthermore cardiovascular disease mortality was taken from NISRA whereas the incidence of Ischaemic heart disease and stroke was obtained from the General Practice and Research Database (GPRD); and the incidence of type 2 diabetes mellitus was estimated using DISMOD II.[17] Disease weights were taken from the Global Burden of Disease Study (GBD).[20]
4. The estimated construction and maintenance costs of the Greenway, over 41 years, were obtained from the construction company. Annual cardiovascular disease, colon and breast cancer disease costs were taken from the literature (Appendix C).

Statistical Analyses

To model the impact of the intervention, a macro simulation model, PREVENT 3.01 was used.[10, 21, 22] By utilising the epidemiological effect measure ‘potential impact fraction’ (PIF), it estimates the effect of changes in risk factor prevalence, adjusted for population changes, on disease occurrence and mortality. In effect, after specifying a change in risk factor prevalence due to an intervention, PREVENT estimates future disease incidence and mortality by applying the PIF to current disease incidence and mortality rates.

The intervention effectiveness of the Greenway will take four years to be determined. To obtain realistic effect estimates we looked to the evidence for trails, access to public open spaces, 'walkability' and physical activity, which are all major components of the Greenway. The quantified effect of 'walkability' on physical activity was the most consistently measured using accelerometer data.[23-26] Therefore we utilised 'walkability' effect sizes on moderate-to-vigorous physical activity from two European studies (3.1 and 6.8 mins/day).[25, 26] By adding these to our baseline survey physical activity scores, we found the number of 'active' people would increase by 7% and 10%, respectively. Therefore we decided upon three conservative, 'what if' intervention scenarios, A, B and C, which equate to 2%, 5% and 10% of those physically 'inactive' becoming 'active,' respectively. Whilst a drop-off in physical activity levels has been found with short term interventions, the Greenway is a permanent intervention so we assumed no attenuation of effects.[27]

We used PREVENT to compare the projected future disease incidence and mortality with and without the intervention. In addition, we calculated the gains in Life Expectancy (LE) and Disability-adjusted Life Expectancy (DALE) expected for intervention beneficiaries and the Years Lived with Disability (YLD) saved by the Greenway population. The intervention was applied at the baseline year (2009) +1 when baseline physical inactivity levels were recalculated depending on the particular scenario and these new physical activity levels remained until 2050.

Since the beneficial effects of physical activity on disease incidence and mortality will not emerge instantaneously, PREVENT accommodates this using two time lags: (1) the time that the risk remains unchanged after a decline in risk factor exposure (LAT) and (2) the period during which the changes in risk factor exposure gradually affect the risk of disease, eventually reaching risk levels of the non-exposed (LAG). The time between increasing physical activity and achieving reductions in all-cause mortality, and in particular, cardiovascular disease, is relatively short and so in respect of physical activity and its impact on breast and colon cancer, we used a LAT of 5 years and a LAG of 15 years while for cardiovascular diseases, we used a LAT of 1 year and a LAG of 5 years.[28, 29] These time lags broadly correspond to those observed in the epidemiological studies we used to provide relative risk estimates for the protective effect of physical activity on disease incidence (Appendix B).

Cost-effectiveness Analyses

Our aim was to present the Incremental Cost-effectiveness Ratios (ICERs) of the Greenway intervention by identifying the additional costs associated with the intervention per additional unit of health outcome generated by each scenario, compared to no intervention. We conducted our analysis from a healthcare payer perspective in order to compare its effects with alternative health interventions and discounted both cost and health gains by 3.5% in line with the National Institute for Health and Clinical Excellence (NICE) reference case.[30] All costs were derived in pounds sterling (£).

The Greenway construction and maintenance costs related to physical activity were extracted from the overall costs (Appendix C). To calculate the total cost savings through diseases averted, we first estimated the 'annual cost per prevalent case per disease'. For breast cancer we could obtain this directly from the literature for the period 1995/96 and inflate to 2009. For the other diseases we found the total UK healthcare system expenditure for a particular disease in a given year, inflated it to 2009 and divided by its prevalence in 2009, except for colon cancer where we used the estimated prevalence in 2008 since it was the most recently available estimate. For each scenario, we then multiplied the number of incident cases averted each year, for each disease, by its respective 'cost per prevalent case per disease,' and summed over all diseases to obtain the total disease cost savings (Appendix C). As a result of the intervention, more people may live longer but we did not consider the future costs of an 'aging' population. Health outcomes were derived in Disability-adjusted Life Years (DALYs), recommended by WHO, instead of Quality-adjusted Life Years (QALYs) primarily because the PREVENT model utilises disability rather than utility weights.

NICE recommends a lifetime time horizon for chronic disease interventions but we chose 41 years.[30] This may lead to an underestimation of the long-term benefits of increasing physical activity but a longer time horizon would have involved making larger assumptions about the demographics of our study population, disease incidence, mortality rates and costs.

Sensitivity Analyses

PREVENT's projections are dependent on the data and assumptions that populate the model. To assess the impact of parameter uncertainty, we repeated the main analysis using the following different scenarios:

1. Lower and upper relative risk estimates, taken from their respective 95% confidence intervals (95% CIs);
2. A LAG time of 10 and 20 years for colon and breast cancer and a LAG time of 2 and 8 years for cardiovascular diseases;
3. A discount rate of 0%, 3%, and 5% applied to cost and health benefits.

Results

Baseline Characteristics

Socio-demographic characteristics (age, gender, employment and socio-economic status) are outlined in Table 1. Fewer females were active than males and for both genders, levels of physical inactivity were higher at older ages (Table 2).

Preventable Incident Cases & Deaths

The number of potentially preventable incident cases and deaths, by 2050, increases for each disease on moving from intervention scenario A to C, as expected (Table 3). In absolute terms, it is estimated that the greatest number of incident cases could be prevented for type 2 diabetes with 376 cases prevented in scenario C. However, the greatest relative decline in incident cases could be achieved for ischemic heart disease, approximately 2% in scenario C. In both absolute and relative terms, the greatest number of deaths could be prevented for ischemic heart disease, approximately 1.1% in scenario C. Compared to the cardiovascular diseases, substantially fewer cancer incident cases and deaths might be prevented, but with a comparable relative decrease.

Life Expectancy and Disability-adjusted Life Expectancy Gains and Years Lived with Disability Averted.

Had the intervention never occurred and baseline physical activity levels persisted, on average the LE and DALE for men, as predicted by PREVENT, would be 77.5 and 69.1 years, and 81.8 and 71.4 years for a woman. DALE represents life expectancy minus expected years of healthy life lost due to disability. For both men and women, on moving from scenarios A to C, larger gains in LE and DALE can be achieved, though these are marginally greater for women. For scenario C, on average a man can expect to increase his LE and DALE by 0.02 and 0.04 years, respectively, and 0.03 and 0.07 years for a woman. YLD is a measure of the years of healthy life lost due to disability. Again, had no intervention occurred, the baseline YLD would be 12,571 years for the Greenway population. For scenario C, a reduction of 46 YLD could be expected.

Cost-effectiveness Analyses

We found all three scenarios to be cost-effective with ICERs ranging from £4,469/DALY to £18,411/DALY (table 4). These are below the UK cost-effectiveness threshold which is £20,000- £30,000/QALY or DALY.[31]

Sensitivity Analyses

Our results did not substantially change by varying relative risk or disease LAG estimates. When using a 5% discount rate, scenario A breached the cost-effectiveness threshold with an ICER of £32,153/DALY. All other scenarios remained below the threshold.

Discussion

We have described how potentially feasible increases in physical activity levels achieved through an urban regeneration project, could be a cost-effective way to increase physical activity levels. This comes at a time when the potential for environmental modifications to influence health has caught the attention of policy makers since it has become clear that individual, social, and physical environmental factors, all have an interrelated role to play in promoting physical activity.[32] This modelling study therefore provides a timely addition to the evidence base to inform policy and practice in this area.

We have demonstrated that if 10% of those classified as 'inactive' became 'active', a total of 886 incident cases (1.2%) and 75 deaths (0.9%) from ischaemic heart disease, type 2 diabetes, stroke, colon and breast cancer could be prevented by 2050 in the Greenway population. Also, small individual gains in average LE and DALE could be achieved which summed over an entire population are substantial. It is difficult to directly extrapolate our results (for an inner city urban district) to the whole population of NI, a largely rural part of the UK, yet similar increases in physical activity in rural areas have been achieved through walking/cycling trails.[33]

Strengths and Limitations

The strengths and limitations of the PREVENT model have been discussed in detail elsewhere[10] and the limitations of this study pertain to the inputs and assumptions we have made. The relative risk estimates for the association between physical activity and disease occurrence, except for breast cancer, were taken from recent, large meta-analyses (Appendix B). We tested our main results through a series of one-way sensitivity analyses and found the conclusion that increases in physical activity can prevent a substantial proportion of chronic diseases in our population is robust. However, an analysis of extremes would have been a more powerful test of uncertainty. As regards the baseline household survey, only participants aged over 16 years were included and therefore we assumed that all individuals less than 16 met the recommended physical activity levels. As the health outcomes included in our model predominantly affect the elderly and our time horizon is relatively short, 41 years, this assumption should not impact greatly on our results. In order to calculate the YLD saved, we used disease-specific disability weights as reported by the GBD[20] and disability weights for the background population using UK population norm EQ-5D data.[15] However these weights were obtained through different techniques and so to check their compatibility, we compared background population disability weights taken from the Australian Burden of Disease study[34] with UK EQ-5D data and the values were comparable.

We modelled the impact of physical activity on the incidence of the top five physical activity related diseases but physical activity can impact on a number of other diseases and mediating disease risk factors which we did not consider.[35-38] Also, the Greenway may have ‘indirect’ health benefits for the surrounding residents through potentially better income and employment and new residents attracted to the area may also avail of its health benefits.

Therefore, both our health impact and cost-effectiveness estimates could be considered underestimates.

We performed a Cost Utility Analysis with outcomes measured in DALYs, but due to the broad nature of the Greenway intervention, DALYs may not capture its full impact, as it may have extra benefits beyond the health sector. It is possible the Greenway will impact on quality of life through increases in social capital and some of its costs and consequences, including reductions in carbon emissions, improvements in safety and reductions in crime will fall on other sectors of the community such as education and business. Whilst our analysis can provide insight into the health impacts of the Greenway, a cost-benefit analysis, which is routinely used in the environment and transport sectors, may have been better suited to capture its impacts beyond health.

Areas for Future Research

It is likely not everyone living in the intervention area will be affected equally by the project. Several factors may influence whether someone uses the new amenities, including many intrapersonal and environmental factors and/or the distance they live from the nearest path. There is some evidence to suggest that environmental interventions may benefit lower socio-economic groups more and help tackle health inequalities.[39, 40] Future analyses should consider subgroup analyses to assess the impact of these factors on the use of the Greenway and assess whether its effects have been equitable.

Conclusions

By applying traditional techniques of cost-effectiveness analysis to the Connswater Community Greenway intervention, we have demonstrated that it could be cost-effective at improving physical activity levels with wider benefits beyond health, likely.

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Conflicts of Interest:

None of the authors have any financial disclosures.

Key-points

- By applying traditional techniques of cost-effectiveness analysis, we describe how potentially feasible increases in physical activity levels, achieved through an urban regeneration project, could be a cost-effective way to increase physical activity levels.
- This comes at a time when the potential for environmental modifications to influence health has caught the attention of policy makers with research in this area beginning to emerge.
- This modelling study therefore provides a timely addition to the evidence base to inform policy and practice in this area.
- In addition, this study exemplifies how public health interventions typically have benefits beyond health with costs and consequences falling on other sectors of the economy.
- Cost-benefit analyses, which aim to include all costs and consequences resulting from an intervention, may be better suited to capture the broader impacts of public health interventions.

References

1. WHO. Physical Inactivity: A Global Public Health Problem. www.who.int/dietphysicalactivity/factsheet_inactivity/en/index.html. (February 2012, date last accessed)
2. Cadilhac DA, Magnus A, Sheppard L, Cumming TB, Pearce DC, Carter R. The societal benefits of reducing six behavioural risk factors: an economic modelling study from Australia. BMC public health. 2011;11:483.
3. Owen L, Morgan A, Fischer A, Ellis S, Hoy A, Kelly MP. The cost-effectiveness of public health interventions. J Public Health 2011;34(1):37-45.
4. West ST, Shores KA. The Impacts of Building Greenway on Proximate Residents' Physical Activity Journal of Physical Activity and Health 2011;8:1092-7.
5. Starnes HA, Troped PJ, Klenosky DB, Doehring AM. Trails and Physical Activity: A Review. Journal of Physical Activity and Health 2011;8:1160-74.
6. Fitzhugh EC, Bassett DR, Jr., Evans MF. Urban trails and physical activity: a natural experiment. Am J Prev Med. 2010;39(3):259-62.
7. Giles-Corti B, Broomhall MH, Knuiman M, et al. Increasing walking: how important is distance to, attractiveness, and size of public open space? Am J Prev Med. 2005;28(2 Suppl 2):169-76.
8. Lee AC, Maheswaran R. The health benefits of urban green spaces: a review of the evidence. Journal of public health (Oxford, England). 2011;33(2):212-22.
9. Chokshi DA, Farley TA. The cost-effectiveness of environmental approaches to disease prevention. N Engl J Med. 2012;367(4):295-7.
10. Soerjomataram I, de Vries E, Engholm G, et al. Impact of a smoking and alcohol intervention programme on lung and breast cancer incidence in Denmark: An example of dynamic modelling with Prevent. Eur J Cancer. 2010;46(14):2617-24.
11. Bull FC, Armstrong T, Dixon T, Ham S, al. NAe. Physical Inactivity. In: Ezzati M, Lopez A, Rodgers A, Murray CJ, editors. Comparative Quantification of Health Risks: Global and Regional Burden of Disease Attributable to Selected Major Risk Factors. Switzerland: World Health Organisation; 2004. p. 729-881.
12. Department of Culture, Arts and Leisure. Experience of Sport and Physical Activity in Northern Ireland. Findings from the Continuous Household Survey 2010/11. ;Available from: http://www.dcalni.gov.uk/sports_bulletin_201011.pdf (August 2011, date last accessed)
13. Bull FC, Maslin TS, Armstrong T. Global physical activity questionnaire (GPAQ): nine country reliability and validity study. Journal of physical activity & health. 2009;6(6):790-804.
14. Department of Health. UK Physical Activity Guidelines. http://www.dh.gov.uk/en/Publicationsandstatistics/Publications/PublicationsPolicyAndGuidance/DH_127931. (August 2011, date last accessed)
15. Kind P, Hardman G, Macran S. UK Population Norms for EQ-5D. York: Centre of Health Economics, University of York, 1999 172.
16. Yusuf S, Hawken S, Ounpuu S, et al. Effect of potentially modifiable risk factors associated with myocardial infarction in 52 countries (the INTERHEART study): case-control study. Lancet. 2004;364(9438):937-52.
17. Barendregt JJ, Van Oortmarssen GJ, Vos T, Murray CJ. A generic model for the assessment of disease epidemiology: the computational basis of DisMod II. Popul Health Metr. 2003;1(1):4.
18. Northern Ireland Statistics and Research Agency. Northern Ireland Health and Social Wellbeing Survey. http://www.csu.nisra.gov.uk/general%20health.pdf (June 2011, date last accessed)

19. Department of Health. Northern Ireland Quality and Outcomes Framework. http://www.dhsspsni.gov.uk/qof_statistics_for_ni_09_10.pdf. . (June 2011, date last accessed)
20. WHO. The Global Burden of Disease: 2004 Update. www.who.int/healthinfo/global_burden_disease/GBD2004_DisabilityWeights.pdf (June 2011, date last accessed)
21. Soerjomataram I, Oomen D, Lemmens V, et al. Increased consumption of fruit and vegetables and future cancer incidence in selected European countries. Eur J Cancer. 2010;46(14):2563-80.
22. Menvielle G, Soerjomataram I, de Vries E, et al. Scenarios of future lung cancer incidence by educational level: Modelling study in Denmark. Eur J Cancer. 2010;46(14):2625-32.
23. Sallis JF, Saelens BE, Frank LD, et al. Neighborhood built environment and income: examining multiple health outcomes. Soc Sci Med. 2009;68(7):1285-93.
24. Saelens BE, Sallis JF, Black JB, Chen D. Neighborhood-based differences in physical activity: an environment scale evaluation. Am J Public Health. 2003;93(9):1552-8.
25. Van Dyck D, Cardon G, Deforche B, Sallis JF, Owen N, De Bourdeaudhuij I. Neighborhood SES and walkability are related to physical activity behavior in Belgian adults. Prev Med. 2010;50 Suppl 1:S74-9.
26. Sundquist K, Eriksson U, Kawakami N, Skog L, Ohlsson H, Arvidsson D. Neighborhood walkability, physical activity, and walking behavior: the Swedish Neighborhood and Physical Activity (SNAP) study. Soc Sci Med. 2011;72(8):1266-73.
27. Marcus BH, Williams DM, Dubbert PM, et al. Physical activity intervention studies: what we know and what we need to know: a scientific statement from the American Heart Association Council on Nutrition, Physical Activity, and Metabolism (Subcommittee on Physical Activity); Council on Cardiovascular Disease in the Young; and the Interdisciplinary Working Group on Quality of Care and Outcomes Research. Circulation. 2006;114(24):2739-52.
28. Blair SN, Kohl HW, 3rd, Barlow CE, Paffenbarger RS, Jr., Gibbons LW, Macera CA. Changes in physical fitness and all-cause mortality. A prospective study of healthy and unhealthy men. JAMA. 1995;273(14):1093-8.
29. Paffenbarger RS, Jr., Hyde RT, Wing AL, Lee IM, Jung DL, Kampert JB. The association of changes in physical-activity level and other lifestyle characteristics with mortality among men. N Engl J Med. 1993;328(8):538-45.
30. NICE. Guide to the Methods of Technology Appraisal. London: NICE, 2008.
31. McCabe C, Claxton K, Culyer AJ. The NICE cost-effectiveness threshold: what it is and what that means. Pharmacoeconomics. 2008;26(9):733-44.
32. Gebel K, Bauman A, Bull F. Built environment: walkability of neighbourhoods. In: Killoran A, Kelly MP, editors. Evidence-based Public Health effectiveness and efficiency. 1st ed. New York: Oxford University Press; 2010. p. 289-312.
33. Brownson RC, Housemann RA, Brown DR, et al. Promoting physical activity in rural communities: walking trail access, use, and effects. Am J Prev Med. 2000;18(3):235-41.
34. Mathers C, Vos T, Stevenson C. The burden of disease and injury in Australia. Canberra: Australian Institute of Health and Welfare, 1999.
35. Resnick B, Ory M, Rogers M, et al. Screening for and Prescribing Exercise for Older Adults. Geriatrics and Aging. 2006;9(3):174-82.
36. Cauza E, Hanusch-Enserer U, Strasser B, et al. The relative benefits of endurance and strength training on the metabolic factors and muscle function of people with type 2 diabetes mellitus. Arch Phys Med Rehabil. 2005;86(8):1527-33.

37. Grant S, Todd K, Aitchison TC, Kelly P, Stoddart D. The effects of a 12-week group exercise programme on physiological and psychological variables and function in overweight women. Public Health. 2004;118(1):31-42.
38. Strohle A, Hofler M, Pfister H, et al. Physical activity and prevalence and incidence of mental disorders in adolescents and young adults. Psychol Med. 2007;37(11):1657-66.
39. Mitchell R, Popham F. Effect of exposure to natural environment on health inequalities: an observational population study. Lancet. 2008;372(9650):1655-60.
40. Gordon-Larsen P, Nelson MC, Page P, Popkin BM. Inequality in the built environment underlies key health disparities in physical activity and obesity. Pediatrics. 2006;117(2):417-24.

Table 1: Socio-demographic characteristics of the Connswater Community Greenway population.

Characteristic		Proportion (%)
Gender	Male	41
	Female	59
Age	16 to 24 years	7
	25 to 44 years	36
	45 to 64 years	30
	65+ years	27
Working Status	Economically active	51
	Economically inactive	49
Socio-economic status[a]	Most deprived	18
	2	18
	3	8
	4	19
	Least deprived	37

[a]According to NIMDM ranking, Northern Ireland Multiple Deprivation Measures.

Table 2: The percentages of the Connswater Community Greenway population not meeting the recommended physical activity guidelines at baseline.

Age group	Males (%)	Females (%)
16 to 34 years	14.2	25.1
35 to 44 years	21.2	36.6
45 to 54 years	38.9	55.6
55 to 64 years	49.3	58.3
65 to 74 years	51.7	75.7
75+ years	68.5	82.7
Total	35.3	52.6

Table 3: The absolute number (and relative percentage decrease) of prevented incident cases and deaths for the Connswater Community Greenway population by 2050.

Incident Cases Prevented	A[a]	B[b]	C[c]
Colon cancer	6 (0.2%)	11 (0.4%)	19 (0.7%)
Breast cancer	12 (0.3%)	20 (0.6%)	37 (1.0%)
Ischaemic heart disease	50 (0.4%)	125 (1.0%)	254 (2.0%)
Type 2 Diabetes	76 (0.2%)	188 (0.5%)	376 (0.9%)
Stroke	40 (0.3%)	97 (0.8%)	200 (1.6%)
Deaths Prevented	**A**[a]	**B**[b]	**C**[c]
Colon cancer	2 (0.2%)	5 (0.4%)	7 (0.6%)
Breast cancer	0 (0.0%)	2 (0.2%)	3 (0.3%)
Ischaemic heart disease	5 (0.2%)	14 (0.6%)	27 (1.1%)
Type 2 Diabetes	0 (0.0%)	1 (0.1%)	2 (0.2%)
Stroke	10 (0.4%)	18 (0.7%)	36 (1.3%)

[a]Scenario A: 2% of those classified as ‘inactive’ become ‘active’.

[b]Scenario B: 5% of those classified as ‘inactive’ become ‘active’.

[c]Scenario C: 10% of those classified as ‘inactive’ become ‘active’.

Table 4: Incremental cost-effectiveness ratio calculations for scenarios A, B and C.

Scenario (estimate of effect)	Discounted Construction & Maintenance Costs	Discounted Disease Cost Savings	Incremental costs	Total DALYs saved	Total Discounted DALYs saved	£/DALY
A (2%)	£6,857,811	£211,811	£6,646,000	1479.25	361	£18,410.82
B (5%)	£6,857,811	£481,179	£6,376,633	2959.24	722	£8,830.10
C (10%)	£6,857,811	£946,088	£5,911,723	5420.19	1323	£4,469.45

DALY, Disability-adjusted Life Year