Should we invest in environmental interventions to encourage physical activity in England? An economic appraisal

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Background: The Department of Health in England asked the National Institute for Health and Clinical Excellence (NICE) to develop guidance on environmental interventions that promote physical activity. The economic appraisals summarized in this study informed the development of that guidance. In view of the difficulties inherent in applying conventional health economic evaluation techniques to public health interventions, the economic appraisal employed a multi-faceted approach. Methods: The analyses comprised of three components. Two cost-utility analyses; the first used a life-time disease progression model which sought to take into account the long-term benefits of physical activity on health outcomes, whereas the second used data from a regression analysis which captured some of the short-term, process benefits of physical activity which might manifest themselves in terms of improved mental health and wellbeing. The third approach was a cost-benefit analysis that took into account benefits beyond healthcare. Results: The cost-utility approaches generated cost-effectiveness estimates ranging between £100 and £10,000 per QALY depending on the level of effectiveness of the intervention and the proportion of the intervention cost that was deemed to be attributable to health. The standardized cost–benefit ratio was 11:1. Conclusion: The findings present a consistent case to support environmental interventions that promote increased physical activity in the sedentary adult population. However, some degree of caution should be taken in interpreting the findings due to the limitations of the evidence upon which they are based. Further consideration should also be given to the relative merits of alternative approaches to assessing the value of changes to the built environment that might also benefit health as a positive externality.
themselves in terms of improved mental health and wellbeing, and, finally, a cost–benefit analysis took into account benefits beyond healthcare.

Methods

Approach 1—standard NICE technology appraisal approach to cost-effectiveness

This approach took an English National Health Service (NHS) perspective and generated quality-adjusted life-years (QALYs) and incremental cost-effectiveness ratios (ICERs). The model followed a cohort of 1000 sedentary adults and estimated the incremental costs and benefits associated with taking up physical activity as a result of an environmental intervention compared with outcomes for those that remain sedentary.

Effectiveness results from the evidence were used in conjunction with the assumption that the resulting increase in physical activity was maintained long enough to obtain the health benefits associated with 120 minutes of moderate intensity activity per week.14–17 Health cost savings and ICER estimates were calculated based on effectiveness results reported by Gordon et al.16 as this was the only study to report results in terms of new users.

The Framingham equations18 were used to generate estimates of the predicted probability of CHD or stroke over a 10-year period and the Diabetes Risk Score, developed by Lindstrom and Tuomilehto19 was used to estimate the risk of developing type 2 diabetes. Relative risks were extracted for CHD, stroke and type 2 diabetes.20–22

Intervention costs were based on information reported by Wang et al.23 Treatment costs for CHD, Stroke and Type 2 diabetes were estimated from available evidence.24–26 These figures were converted to a cost per person per year using Office for National Statistics (ONS) 2007 population estimates.27 All costs were uplifted to 2007 prices. A period of 10 years was considered and costs and benefits were discounted at 3.5%.

Deterministic sensitivity analyses (one-way and two-way) were carried out around intervention effectiveness (1%, 2% and 5%), the intensity of activity (moderate and vigorous), QALY estimates (± 25%, 50% and 75%) and attributable cost (increments of 5% up to 25%, 50% and 100%).

Approach 2—Health Survey for England Regression Analysis

This approach took an NHS perspective and generated QALYs and incremental ICERs. Effectiveness figures used in the model were based on reported data from Gordon et al.16 as this was the only study to report results in terms of new users.

The Health Survey for England (HSE) is a series of comprehensive annual surveys which are designed to measure health and health-related behaviours in adults and children. It has a series of core elements that are included every year and special topics that are included in selected years. The only years for which EQ-5D and measures of physical activity across the whole population were collected were 1999, 2003 and 2004.28–30 As households are surveyed over a 12-month period, seasonality is not an issue. Available data were pooled and interval regression analysis was used to relate individuals’ level of physical activity to their self-assessed health (SAH) (which was aligned with 2004 EQ-5D scores) and other factors (age, sex, ethnicity, employment status, education level, income, marital status, smoking status, alcohol consumption and body mass index). The resultant value for the relationship between physical activity and EQ-5D was then used to measure the long-term QALY gain from a sustained 30 minute increase in physical activity. Four main assumptions were required to generate this QALY estimate.

- The additional QALY gains are assumed to be linear over time. This means that for every additional exercise session the incremental increase in QALYs will be constant. However, in reality, additional sessions of physical activity may result in an increase in QALYs but at a decreasing rate (diminishing returns to exercise).

- The questionnaire for the HSE required respondents to state how much physical activity they undertook in one month (short term). The health utility values were estimated holding all other individual characteristics constant (ceteris paribus). The estimated health utility values for a number of additional sessions were calculated by multiplying the health utility value of one session by the increase in additional sessions. The QALY benefits were calculated by taking the health utility estimates and applying these to the additional sessions of activity over the intervention duration;

- Individuals are assumed to be 100% compliant to the additional physical activity for the time period of the intervention;

- The intervention achieves at least one unit (of 30 minutes) increase in physical activity per month;

Capital and maintenance costs were based on information reported by Wang et al.23 and uplifted to GBE2006. It was assumed that the lifetime of the trail, i.e. the period over which it will be maintained sufficiently to be operational, was 30 years. Maintenance costs and benefits were discounted at 3.5%.

Further analyses were carried out to test the robustness of the regression estimates. These included:

- The regressions were estimated separately for each year of data to test for structural differences between years;

- An intercept term was added to test the appropriateness of pooling data from three years;

- Variation in the assumption relating to number of sessions of physical activity undertaken.

Approach 3—combined cost–benefit estimate

The reviewed cost-effectiveness literature considered environmental interventions aimed at promoting cycling or both walking and cycling.31 Six of the reviewed papers reported cost-effectiveness using cost–benefit ratios, as is standard practice in relation to the economic evaluation of transport interventions. The range of reported ratios in these studies was extremely wide (range: 1.35–32.5) given that the interventions share many similarities. Comparisons were further complicated by the fact that studies considered different benefits.

This approach, which took a societal perspective, involved standardizing reported component costs and benefits and necessitated making three major assumptions:

- The average cycle trip was 3.9 km.32

- The total number of trips of a new user was 50 (i.e. approximately one per person per week).

- Capital costs had a life-time of 30 years.

Standardized costs and benefits were uplifted to UK £2006 prices and then transformed into a per user per kilometer (ranges provided):

- Health benefit (£0.46–2.99 per user per km);

- Travel time benefit (£0.03–£0.07 per user per km);

- Capital cost (£0.55–£0.62 per user per km);

- Maintenance cost (£0.50–£0.53 per user per km);

A time period of one year was considered and therefore discounting was not necessary.

Results

Tables 1 and 2 show the key results from Approaches 1 and 2, respectively. Table 1 shows that, using four different values for effectiveness and four different infrastructures (a multi-use trail and three different cycling infrastructures) incremental QALYs range from 0.042 to 0.227. Figures in table 2 show how QALYs are affected by the weekly number of sessions of physical activity (ranging from 0.078 for one session to 0.390 for five sessions). Environmental interventions are introduced for a number of reasons, including promoting physical activity. The attributable cost is the proportion of the cost of the infrastructure that is considered to be
directly related to promoting physical activity. Figures in table 2 also show how the cost per QALY varies with attributable cost, with cost per QALY figures ranging from £9439 (one session of physical activity per week and 100% attributable cost) to £94 (five sessions of physical activity per week and 5% attributable cost). Figure 1 compares results from Approaches 1 and 2 based on the effectiveness reported in Gordon et al. and an average cycle trail cost per user per year of £680 (average of the cost of trail 1 and trail 2). The figure shows that the results from Approach 1 are most similar to those for Approach 2 when Approach 2 estimates are generated based on two sessions of physical activity each week. Table 3 shows that standardized cost–benefit ratio, generated from Approach 3, is 1:11 (that is, for every £1 spent, society accrues £11 in benefits), with the largest benefit (65.92% of the total) being attributed to health.

**Discussion**

Our cost-utility analyses generate estimates of cost-effectiveness of a multi-use trail which ranged from less than £100 per QALY to just under £10 000 per QALY. These compare well with the NICE threshold range for cost-effectiveness and are broadly comparable with other types of public health interventions, such as smoking cessation interventions delivered in the workplace (maximum cost per QALY of £1080). The cost–benefit analysis generated a ratio of 1:11. That is, for every £1 spent, society accrues £11 in benefits, thus supporting the economic case for investing in cycling infrastructure. This estimate lies approximately in the middle of the range of cost–benefit ratios presented in the reviewed literature (between 1:1.35 in Denmark and 1:32.5 in the UK), although most of the published cost–benefit estimates were less than

<table>
<thead>
<tr>
<th>Study</th>
<th>Intervention</th>
<th>Reported effectiveness</th>
<th>Incremental QALY (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gordon et al.16</td>
<td>Multi-use trail</td>
<td>22.5% of trail users were classified as new exercisers.</td>
<td>0.125 (0.00005–0.189)</td>
</tr>
<tr>
<td>Mamoli,17</td>
<td>Cycle infrastructure</td>
<td>Cycling increased from 10.5% to 18% of all trips between 1991 and 2000.</td>
<td>0.042 (0.00006–0.063)</td>
</tr>
<tr>
<td>Cope et al.14</td>
<td>Cycle infrastructure</td>
<td>43% increase in users at Elswick Riverside, 50.1% at Tarka Trail, Fremington and 29.7% at Rishton.</td>
<td>0.227 (0.002–0.343)</td>
</tr>
<tr>
<td>Cyclists Touring Cyclists,15</td>
<td>Cycle infrastructure</td>
<td>20% increase in cycle use in 7 years.</td>
<td>0.111 (0.00004–0.168)</td>
</tr>
</tbody>
</table>

**Table 1 Approach 1: ICER results (10 years)**

<table>
<thead>
<tr>
<th>Session(s) per week</th>
<th>Incremental QALYs</th>
<th>Incremental Costs</th>
<th>Cost per QALY</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>100% attributable</td>
<td>5% attributable</td>
</tr>
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<td>1 session</td>
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<td>£680</td>
<td>£34</td>
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<tr>
<td>2 sessions</td>
<td>0.156389</td>
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<tr>
<td>3 sessions</td>
<td>0.234584</td>
<td>£680</td>
<td>£34</td>
</tr>
<tr>
<td>4 sessions</td>
<td>0.312779</td>
<td>£680</td>
<td>£34</td>
</tr>
<tr>
<td>5 sessions</td>
<td>0.390974</td>
<td>£680</td>
<td>£34</td>
</tr>
</tbody>
</table>

**Table 2 Approach 2: ICER results (30 years)**

<table>
<thead>
<tr>
<th>Session(s) per week</th>
<th>Incremental QALYs</th>
<th>Incremental Costs</th>
<th>Cost per QALY</th>
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</thead>
<tbody>
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**Figure 1 Approaches 1 and 2: ICERs**

[Diagram showing the ICER generated from Gordon 2004 for Approach 1 and Approach 2]
It should, however, be noted that published figures may be optimistic. Further, the standardized figure is sensitive to changes in the assumption related to the number of new trips per user. Additionally, converting costs and benefits to GB£ and inflating historic cost data introduces further sources of uncertainty into the analyses. Nevertheless, on balance, cautious support could be given to an economic case related to increasing cycling levels in the general population.

All three analyses conducted as part of this research are subject to some degree of uncertainty as well as methodological limitations. The main limitation of the analyses relates to the availability and quality of evidence on the effectiveness of the interventions under consideration. The majority of the effectiveness evidence on environmental interventions reports an increase in the number of users but fails to report the extent to which the users make use of the new facility and the level of activity the users had undertaken prior to the new facility being available, i.e. whether they were moving from sedentary to active or whether they were previously active and the new facility provides substitute activity. This absence of information on intensity of activity means that it has not been possible to extrapolate findings to areas of physical activity beyond cycling and the use of a multi-use trail. Other weaknesses of the evidence include the reliance on self-reported measures of activity and uncertainty around whether any reported changes of physical activity will be maintained in the medium to long-term. Further, data analyses are based on an assumption of causality, whereas, at best, only correlate data are available and no account is taken of the possibility of reverse causation or correlation. However, although in many respects the paucity of evidence is considered a limitation, the fact the modelling has been based mainly on European evidence means that the key findings may be considered to be highly relevant to other developed European countries.

Another area of uncertainty is the estimation of the costs of the interventions. Evidence on costs reported in the literature is often poorly defined and lacks detail. For example, costs of injuries resulting from uptake of physical activity by the sedentary population were not reported, nor were any costs reported on the impact on the active population of pollution in cities. A related issue is the attribution of costs. As the cost of environmental interventions is generally funded by non-health public funds, the cost to the health service is zero. Therefore, from an NHS perspective, any environmental intervention which accrues health benefits will result in a favourable cost-effectiveness ratio. If such interventions are funded on a multi-agency basis, recognising that there may be multiple beneficiaries, then this opens a debate about how much of the cost should be set against the health benefits compared with other societal benefits. This issue was supported by results from the sensitivity analyses which show that above an attributable cost of 5% the intervention (establishment of a trail) becomes cost-ineffective at a threshold of £30,000 per QALY. In a research paper, Claxton et al.\textsuperscript{37} introduce an intersectoral compensation test approach, whereby an evaluation of the benefits net of costs which fall on different sectors of the economy is suggested. Employing such a test, which is still at a theoretical stage of development, would mean that the need for budgetary transfers (which would themselves incur a transaction cost) could be assessed.

The equity implications of these findings also need to be considered. As is the case with many public health or health promotion interventions, there is a danger that those accessing the service are actually the least in need and that such interventions could even exacerbate inequalities. This could be particularly relevant to interventions such as cycle trails, which may be positioned in countryside settings and only accessible to those with a car and, inevitably, a bicycle. This issue could be mitigated to some extent through the design and delivery of the interventions as well as subsidising or even incentivising access.

It is important to consider the relative merits of the alternative approaches to economic evaluation. The cost-utility analysis is becoming the dominant form of economic evaluation for assessing health care interventions and as such would be recognizable to stakeholders within this field. However, as previously noted, the interventions under consideration are unlikely to be planned, funded or commissioned by the health sector given that their primary aim is to produce environmental benefits rather than health benefits. In this context, a societal cost–benefit analysis, assuming that there is sufficient evidence to allow the full costs and benefits to be valued, might be a more useful and recognizable approach to planners in transport and environmental sectors, where such an approach is routinely applied. This view is not universally held over all public health interventions. Following a review of the literature on the economic evaluation of public health interventions Drummond et al.\textsuperscript{38} recommend that the impacts of interventions (e.g. in terms of effectiveness and need for incentives) should be quantified in a cost-consequences analysis, which includes the impact on the voluntary sector and private individuals by beneficiary group (i.e. as defined by health status, socio-economic status, etc.). However, a recent study by Phillips et al.\textsuperscript{39} asked a panel of potential users of economic evaluations to prioritise public health interventions to identify their preferences. This study found that cost-benefit analyses and cost-utility analysis were the preferred approaches of participants.

The findings of the three approaches to assessing the costs and benefits present a consistent case to support environmental interventions that promote increased cycling in the sedentary adult population. However, some degree of caution should be taken in interpreting the findings due to the limitations of the evidence upon which they are based. Further consideration should also be given to the relative merits of alternative approaches to assessing the value of changes to the built environment that might also benefit health as a positive externality.

### Acknowledgements

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### Conflicts of interest

B.N. is an associate member of the National Heart Forum. S.B., M.B. and P.T. have no conflicts of interest to declare.

### Key points

- Environmental interventions aimed at increasing activity levels will contribute to the prevention and management of over 20 conditions and diseases including CHD, diabetes, cancer and obesity.
- There is limited evidence of the cost-effectiveness of such interventions.
- The cost–benefit ratio for environmental interventions was 1:11 and cost-utility analyses generate estimates of cost-effectiveness
ranging from less than £100 per QALY to just under £10 000 per QALY;

- The findings of the three approaches to assessing the costs and benefits present a consistent case to support environmental interventions that promote increased cycling in the sedentary adult population.

References


