University of the West of England

Review 7

Spatial Planning & Health

The cost-effectiveness of integrating health into the planning process

Decision models of the additional costs and benefits of integrating health into spatial planning appraisal and development

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FINAL REPORT

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Glossary of terms

Term	Definition
Annual Monitoring Report	A statutory requirement (Section 35, Planning & Compulsory Purchase Act 2004) for every local authority. It is considered the main mechanism for assessing the performance of the local development framework.
Appraisal	Formal processes of assessing plans or projects for their potential positive and negative impacts (e.g. EIA, HIA).
Area Action Plan	These are documents contained within the local development framework which are prepared when there is a need to provide the framework for areas where significant change or conservation is needed. They are usually used for the delivery of planned growth areas or area based regeneration initiatives.
Core Strategy	Contains the overall spatial vision for a local planning authority's area, which sets out how the area and places within it should develop.
Development Plan	An aspect of spatial planning in the UK comprising a set of documents, which set out a local authority's policies and proposals for development and use of land in their area. The development plan guides and informs day to day decisions whether planning permission should be granted. In order to ensure that these decisions are rational and consistent, they must be considered against the development plan adopted by the authority, after public consultation and having proper regard to other material factors. All development plans should be prepared within the context of strategic environmental appraisal.

Development Process	Generates actual change to the human environment, and it involves investors, funders, land owners and operators as well as regulatory authorities such as planning. The main link between the development process and planning is the development management (or control) process.
Environmental health issues	As considered in appraisal processes (EIA, SEA etc) including for example, air and water quality, noise, odour or contamination.
Health	A state of complete physical, mental and social well-being and not merely the absence of disease or infirmity.
Local Development Framework	The collection of local development documents produced by a local planning authority which collectively delivers the spatial planning strategy for its area. The core strategy is the key development plan document within the local development framework.
Plan	Spatial plan relating to a whole region, city, town or neighbourhood. It can include topic plans (e.g. for transport, housing and air quality).
Project	Specific development proposals requiring determination through a land use (spatial) planning process.
Spatial planning	A process intended to promote sustainable development and is defined as 'going beyond' traditional land use planning to bring together and integrate policies for the development and use of land with other policies and programmes which influence the nature of places and how they function.

Strategic Environmental Assessment	Strategic environmental assessment is required by European and UK law and has been adopted as an appraisal process in many countries across the world. It is a way of systematically identifying and evaluating the impacts that a plan is likely to have on the environment. The aim is to provide information, in the form of an Environmental Report that can be used to enable decision makers to take account of the environment and minimise the risk of the plan causing significant environmental damage. UK government guidance advises that where a plan requires both strategic environmental assessment and sustainability appraisal, that the former process should be integrated into the latter one.
Sustainability Appraisal	The term sustainability appraisal is normally applied to plans rather than projects, and in the UK is a required part of plan making, including social, economic and environmental criteria, and explicitly including SEA (see above). It is not legally required for project appraisal but many UK local authorities request that some form of sustainability appraisal accompanies major applications.
Sustainable development	Is development that meets the needs of the present generation without compromising the needs of future generations

Glossary – economic terms

Base case analysis	The main analysis which uses the best (most plausible/justified) parameters and assumptions
Benefit to cost ratio (BCR)	The ratio of benefits of investment to the cost of investment expressed in currency or money terms
Concentration-response curve Sometimes known as dose-response curve	This is a graph produced to show the relation between the exposure concentration of a drug (or other chemical) and the degree of response it produces, as measured by the percentage of the exposed population showing a defined effect
Cost-consequences analysis	A type of economic evaluation in which the incremental costs are compared with the incremental effects or benefits expressed in two or more ways. Such studies will present together the costs, health outcomes, intermediate outcomes, process outcomes or any other consequences of perceived relevance
Cost benefit analysis (CBA)	An explicit process to identify, measure and value the incremental costs, benefits and resource savings of a project or investment in monetary terms and to compare the ratio of these elements against each other from a societal perspective
Cost-effectiveness analysis (CEA)	A type of economic evaluation in which incremental benefit is measured in natural units, such as life years or as an index (such as a QALY) derived from natural units
Cost-savings analysis	A cost-savings analysis is a type of economic analysis in which the financial savings due to improved outcomes of the programme (eg. reduced all-cause mortality associated with increased

	physical activity from walking and cycling) are deducted from the additional costs of providing the programme or strategy being evaluated. They are sometimes called cost-benefit analyses, but this is misleading because the changed outcomes are not valued other than in terms of the actual savings realised. Cost-savings analyses are also called cost-offset analyses.
Cost-utility analysis (CUA)	A form of CEA in which benefits are measured in units of quality adjusted life years saved (QALYs)
Cost of illness study	A study which estimates the overall cost or financial burden to a country of a particular disease or condition. These studies do not consider either the costs or effects of alternative possible treatments or policies.
Deterministic analysis	Analysis which uses single values (point estimates) for each numerical assumption (in contrast to probabilistic analysis, which is based on sampling from a defined distribution of possible parameter values)
Discount rate	The annual rate used in model-based economic evaluations by which costs or benefits incurred in the future are reduced to reflect positive time preference (that is the common preference of either individuals or society to prefer to receive benefits earlier rather than later, but to defer negative expenditures later rather than earlier)
Dynamic micro-simulation model	A technique used in applied econometrics to simulate computer models of changes in individual behaviour over time to reflect the range of those changes

Economic evaluation	A comparative evaluation which includes quantification of both costs and effects or benefits of two or more policy or treatment comparative options
Liveability	Quality of living conditions includes perceptions of safety, education, hygiene, healthcare, culture, environment, recreation, public transport and political-economic stability
Net present value	The value of estimates of future streams of benefits less future streams of costs, when both are discounted to their value in the base year (i.e. year of the analysis)
One–way sensitivity analysis	Varying one model or analysis input variable at a time to explore the impact on the main result of interest
Return on investment (ROI)	The rate of resources saved or revenue earned for every £1 invested
Time horizon	The length of time usually years from the time of the policy decision over which and analysis estimates costs and outcomes/effectiveness
WTP	Willingness to pay is the maximum amount an individual, government or agent would be willing to pay to receive a good or service

SUMMARY AND OVERALL CONCLUSIONS

The purpose of Review 7 was to inform the assumptions and evidence needed structure and populate decision models to provide a means of translating 'best available' evidence for the additional costs and health benefits of integrating health into planning appraisal and development under conditions of uncertainty and variability.

It consisted of a review of the economic literature for the additional costs and benefits of degrees of integrating health into the planning appraisal and development and public health systems to produce plans for modifications to the built environment. Decision models are developed to test theories about the additional costs associated with different degrees of integration of health (ranging from none to full integration) into planning appraisal and development and the additional health benefits that might arise through the planning and construction processes as a result of incurring these initial costs. Evidence from studies identified during a systematic literature review was combined with evidence from experts and additional studies to structure and populate the pathways of the decision tree models.

A decision model and its pathways indicate theoretical boundaries of cost-effectiveness under explicit assumptions and conditions for the decision problem of how best to integrate health into spatial planning appraisal and development to maximise health benefits for communities. Viewed comparatively, the range of cost-benefit ratios can act as a useful tool in thinking through alternatives for integrating health into planning and the boundaries of cost-effectiveness. Sensitivity analysis is undertaken to indicate the impact of a great number of assumptions made about the costs, probability of events and benefits on the estimated cost-benefit ratios. Decision models were used to estimate:-

1. The range of cost-benefit ratios connected with three options for integrating health into spatial planning appraisal and development of whole town infrastructure for a cohort of 100,000 people to facilitate active travel (walking and cycling).

2. The range of cost-benefit ratios connected with options for integrating health into spatial planning appraisal and development of retro-fit streetscape and home zones for 408 dwellings across twelve streets for a cohort of 1,600 people.

The five pathways of the decision model that arise from the three options for integrating health into planning are:-

Planning whole-town infrastructure and promotion of active travel

Pathway 1 – Comprehensive health appraisal integrated with other assessments - stakeholder consultation at the outset - good plan with no delays or reapplication required – good quality construction or use of land, well positioned- more active travel by more community members - greater health benefits

Pathway 2 – Comprehensive health appraisal integrated with other assessments - no stakeholder consultation at the outset – bad plan with delays and re-application required – poor quality construction or use of land, poorly located - less active travel by less community members - lower health benefits

Pathway 3 – Rapid health appraisal stand-alone from other assessments - stakeholder consultation at the outset - good plan with no delays or reapplication required – good quality construction or use of land, well positioned- more active travel by more community members - greater health benefits

Pathway 4 – Rapid health appraisal stand-alone from other assessments - no stakeholder consultation at the outset – bad plan with delays and re-application required – poor quality construction or use of land, poorly located - less active travel by less community members - lower health benefits

Pathway 5 – No health appraisal as part of assessment - no stakeholder consultation at the outset – bad plan with delays and re-application required –

poor quality construction or use of land, poorly located - less active travel by less community members - much lower health benefits

Planning retro-fitting 408 homes with insulation as part of a home-zone

Pathway 1 – Comprehensive health appraisal integrated with other assessments - stakeholder consultation at the outset - good plan with no delays or reapplication required – good quality retrofit - greater health benefits

Pathway 2 – Comprehensive health appraisal integrated with other assessments - no stakeholder consultation at the outset – bad plan with delays and re-application required – poor quality retrofit - lower health benefits

Pathway 3 – Rapid health appraisal stand-alone from other assessments - stakeholder consultation at the outset - good plan with no delays or reapplication required – good quality retrofit - greater health benefits

Pathway 4 – Rapid health appraisal stand-alone from other assessments - no stakeholder consultation at the outset – bad plan with delays and re-application required – poor quality retrofit - lower health benefits

Pathway 5 – No health appraisal as part of assessment - no stakeholder consultation at the outset – bad plan with delays and re-application required – poor quality retrofit – much lower health benefits

Questions

The review questions were structured to examine whether planning developments in which health considerations are effectively integrated through the engagement of local authority planners and PCTs are more or less cost effective than the equivalent developments where that integration has not occurred. The specific questions were:-

1. What is the evidence for the level, type and magnitude of additional resources resulting in integrated planning processes that promote health and reduce health inequalities when spatial planning decisions are implemented?

2. What is the evidence for the level, type and magnitude of health benefits that arise from planning developments or implementations in which health considerations have been fully integrated?

3. What is the evidence for the likely distribution of health benefits across the community?

4. What is the likely impact of new housing developments on an existing community when degrees of collaboration between housing developers, the NHS and local authority planners produces healthy sustainable housing and neighbourhoods for community health benefits?

Limitations to the review

It is important to note four major limitations to this review and its decision modelling.

First, the whole of this research programme as set up by NICE has focussed on the planning system. It has not been primarily concerned with the degree to which, or the ways in which, the built environment impacts on health and well-being – though an understanding of this emerging field has been vital. A separate paper prepared by Hugh Barton for the Government Office for Science Foresight Report, entitled *Land use planning and health and well-being* deals succinctly with this huge issue. It was published in *Land Use Policy* last year, and is referenced in this report.

The second limitation concerns the degree to which the planning system is the driver of land use and built environment change. The statutory processes intervene in the on-going market process of land development, and may often have much less influence than the land owners, developers, investors, operators and users who are the other players in the development process game. The plans themselves, in the UK context, can guide but not dictate, and have to operate within what the market, in the broadest sense, can deliver. The key junction of planning system and development is the planning application process ('development control' or 'management'). The decision models have not delved deep into this, except in relation to project appraisal.

Third, decision analytic modelling would be the preferred approach for estimating the costs and benefits of integrating health into spatial planning processes to facilitate good planning of modifications to the built environment that improve health outcomes. The contextual, institutional and market factors connected with development planning and control processes severely limit the range of possibilities for gathering data to structure and populate a Markov-type decision analytic model, so a decision tree approach is applied in R7. In many ways the significance of the actual numbers in the results of these decision trees needs to be downplayed because of the lack of data and the sensitivity of the results to the assumptions of the models. However, the large magnitude of many of the cost-benefit ratios would suggest that there are potentially very large gains to be obtained from effective integration of health and planning that will often far outweigh the cost of incorporating the change.

Fourth, some chalk-and-cheese comparisons are made as a result of fragility and fragmentation in the evidence base for transport and planning, so two types of analysis CBA and CUA co-exist in this report. CBA studies in transport and other planning do not include health benefits such as increases in life expectancy. A view has been taken in this report that where health is not included as a benefit in an economic analysis, the health benefits generated will be positive and large, so the construction or retrofit intervention will dominate (de Hartog et al. 2010). Estimates of QALYs or concern about rules of thumb for scaling up benefit-to-cost ratios, is not necessary in R7 because cost saving in the long run combined with positive health benefits must equal cost effective integration of health into spatial planning.

The evidence base and research methods

Decision models were focussed on economic efficiency expressed in marginal cost-benefit ratios and the sensitivity of these to the wide range of assumptions and estimates. The evidence review to structure and populate the decision models focussed upon cost benefit analyses (CBAs) rather than NICE's preferred cost utility analyses (CUAs). One reason for this decision is that in areas outside of health, such as transport and housing, Quality Adjusted Life Years (QALYs) the outcome measure of CUAs are not used in economic analyses, so it makes more sense to populate the decision trees with benefit measures that meet the usual currency of

transport and other planners (such as green space planners). The other reason is that almost all the studies found during R7 are CBAs rather than CUAs based on QALYs.

One drawback of the CBA approach to economic evaluation is not being as adaptable to the consideration of health inequalities as a CUA approach because individual preferences of value or willingness to pay (WTP) are reflected in a CBA rather than governmental preferences or WTP to implement changes in the allocation of resources. Where the NHS cost per QALY threshold lies has been estimated by trial and error across all NHS interventions. For example, the WTP for a QALY elicited through individual WTP studies is around £60,000-£80,000, but the NHS is funded to pay up to £20,000 to £30,000 per QALY or around one third as much as individuals would be willing to pay. If the same kind of difference between CBA and CUA applies to other areas of public spending, it implies that projects with a benefit to cost ratio less than about 3:1 should not be funded.

A summary of the best available evidence was drawn from relevant, quality-appraised studies from a range of sources to inform the decision analytic base case analysis of the modelling process. The sources were a systematic search of EconLIT, a check of relevant grey literature identified in the research, but not used so far in previous reviews, drawing on experts in the field known to the collaborating centre or advised by the PDG.

In addition, evidence and insights from the Marmot Review and from WSP Environment and Energy on the land developer's perspective was used to populate the decision models and to express implications for the distribution of health benefits in a community of the efficiency of pathways in decision models i.e. cost-benefit ratios for integrating health into spatial planning developments. This was achieved for active travel development and retro-fit of home zones.

The studies which were quality appraised and data extracted were:-

1. Atkinson, P., & Cooke, A. (2005). Developing a framework to assess costs and benefits of Health Impact Assessment. Environmental Impact Assessment Review, 25, 791-798.

2. Chapman, R. Howden-Chapman, P. Viggers, H. O'Dea, D. Kennedy, M. (2009) Retrofitting houses with insulation: A cost-benefit analysis of a randomized community trial. Journal of Epidemiology and Community Health, 63:271-277.

3. Cope, A. Kennedy, A. Ledbury, M. Cambery, R. Cavill, N. Parkin, J. Nair, S. (2010) Cycling Demonstration Towns – An Economic Evaluation. London: Department for Transport.

4. de Hartog, J.J., Boogaard, H., Nijland, H., & Hoek, G. (2010). Do the Health Benefits of Cycling Outweigh the Risks? Environmental Health Perspectives, 118, 1109-1116.

5. Mathias, R. & Harris-Roxas, B. (2009) Process and impact evaluation of the Greater Christchurch Urban Development Strategy Health Impact assessment. *BMC Public Health*,9,97:1-12.

6. Rutter, H., Cavill, N., Dinsdale, H., Kahlmeier, S., Racioppi, F., & Oja, P. (2008). Health Economic Assessment Tool for Cycling (HEAT for Cycling) User Guide: Version 2. World Health Organisation: Europe.

7. Yang, L. Sahlqvist, S. McMinn, A. Griffin, S. Ogilvie, D. (2010) Interventions to promote cycling: a systematic review. *BMJ*; 341:c5293 doi:10.1136/bmj.c5293

8. York Health Economics Consortium (2006) Cost benefit analysis of health impact assessment, London: Department of Health.

Findings

For Britain, there is strong evidence, from all the reviews in this programme when the public health authority links closely with the planning authority, that health can be effectively and cost-effectively incorporated in planning processes. The reverse is not always true. Expert evidence in this review suggests that collaboration through section 106 agreements could provide an incentive for developers to prioritise health considerations in partnership with local authorities. Health can be prioritised without intervention by the health authority, as a consequence of the growing awareness of the planners themselves of the potential profits connected with a very small cost outlay.

Critical to success is the political and professional starting point - political commitment to health and well-being - planning and other departments prioritising health when defining the purpose and scope of plans and projects. The appraisal processes are integral to the whole decision-making process, and ensuring health objectives help shape the options that are considered throughout the decision modelling. Every effort has been made to make assumptions explicit and to demonstrate the limitation of estimates derived from the evidence, but these assumptions and estimates are all open to challenge and inaccurate estimation under varying market conditions and price signals that might apply at a particular time. The logic and methods of decision tree analysis do not readily extend to modelling political processes or contextual and institutional factors, so the findings presented in this review should be viewed with those qualifications in mind.

Scale of infrastructure for active travel integrated in planning There is robust evidence from The Netherlands in a study by de Hartog and others, that the scale of infrastructure for active travel has an impact on the additional benefits of integrating health into spatial planning appraisal and development. There the legal system, planning design and infrastructure work together to give priority to walkers and cyclists in the Netherlands, providing traffic-free and ‘safe’ routes for cycling, traffic calming and a legal obligation to observe ‘the rights’ of cyclists when sharing road space. Good spatial planning backed up by law making has created a conducive social-cultural, ‘safety in numbers’ effect for walking and cycling in the Netherlands which means that RTA rates are low, even in traffic dense areas (de Hartog et al.

2010). It would be helpful to consider how far this model could be transferred to Britain given the potential impact of walking and cycling on health inequalities and climate change (Geddes et al. 2010).

Planning whole-town infrastructure and promotion of active travel There is mixed evidence from a range of sources, some of it robust, for comprehensive health appraisal or assessment integrated with other statutory assessments in which stakeholder consultation happens early in the development process results in good plans that maximise the health benefits of walking and cycling through pathway 1 of a decision tree (Atkinson & Cooke, 2005; Mathias & Harris-Roxas, 2009; YHEC, 2006). The additional health benefits in a cohort of 100,000 community members in which walking and cycling has increased by 1.75 per cent and 3.5 per cent per annum respectively, as a result of good planning processes and large scale, whole-town infrastructure, all-cause mortality from additional physical activity expressed through the value of a statistical life outweigh additional costs with a BCR 60:1 for walking and 168:1 for cycling (Rutter et al. 2008; Cope et al. 2010; de Hartog et al. 2010; Sloman et al. 2010; Yang et al. 2010).

In many ways the significance of the BCRs needs to be downplayed because of the lack of data and the sensitivity of the results to the assumptions of the models. However, the large magnitude of many of the BCRs would suggest that there are potentially very large gains to be obtained from effective integration of health and planning for whole-town infrastructure for walking and cycling that will often far outweigh the cost of incorporating health considerations early in the planning process.

Planning retro-fitting 408 homes with insulation as part of a home-zone There is mixed evidence from a minimal range of sources, for comprehensive health appraisal or assessment integrated with other statutory assessments in which stakeholder consultation happens early in the development process results in good plans that maximise the additional benefits of retro-fitting homes in a home-zone with insulation through pathway 1 of a decision tree (Atkinson & Cooke, 2005; Mathias & Harris-Roxas, 2009; YHEC, 2006). This pathway predicts a reduction in GP visits, hospital visits, days off work/school, energy savings and CO_2 emissions in residents

of 408 dwellings across twelve streets in a community cohort of 1,600 people, as a result of good planning processes for home-zones outweigh additional costs from comprehensive health assessment integrated with other assessments with a BCR 50:1. This shows retro-fitting homes in home-zones with insulation is cost-effective from a societal perspective, but the benefits arising from retro-fitting insulation over time form one part of the potential benefits that are realised from home-zones (Chapman et al. 2009).

The decision trees provide a base case that might be further worked upon in the future. It was not possible to find robust evidence for the additional benefits of home-zone neighbourhoods that could populate the decision trees. A dearth of evidence at any level of quality prevents sensitivity analysis that includes estimates of these additional benefits in this report. The health benefits of reduced pollution from creation of home-zones are a major omission as poorer communities, often the subject of home-zoning, on average experiencing higher concentrations of pollution and higher prevalence of cardio-respiratory and other diseases. In Britain 66 per cent of carcinogenic chemicals emitted into the air are released in the 10 per cent most deprived wards (Geddes et al. 2010). Similar findings from a longitudinal study of the socioeconomic position and health status of people who live near busy roads in Rome support these findings (Cesaroni et al. 2010).

Sensitivity of cost-benefit ratios to changes in assumptions

Decision trees are particularly sensitive to assumptions made about the probabilities of events. When assumptions about marginal costs and probabilities are applied equally to all options, Option 2, rapid stand-alone health assessment for infrastructure for walking and cycling and retro-fitting homes with insulation, becomes more cost-effective than Option 1. The findings of sensitivity analysis suggest that threshold analysis for cost-effectiveness of integrating health into spatial planning should be conducted to provide more robust evidence of cost effectiveness than that provided by decision trees in this review.

Mainstreaming health in appraisal: The decision models in R7 derive costs from the literature on HIA. However, application of these costs in the decision models does not imply HIA is the method recommended to integrate health into planning

appraisal most effectively – it reflects instead the availability of data and evidence for estimation in this area. R1, R2 and R3 show that there is no conclusive evidence on whether it is best to integrate health into other forms of assessment or to have separate health assessment. Both approaches can be successful in achieving health benefits, and there are excellent international examples of both. However, experience of HIA (outside statutory processes) is overall mixed, while that of integrated appraisal is good, so the evidence perhaps favours the latter. But the key to positive impact for either IA or HIA is involvement through the whole plan, policy or project process, so that health objectives are integrated into the thinking from the outset. The decision models in R7 set out to reflect evidence on the additional costs and benefits of integrated appraisal in general while using available data on the costs of HIA.

Integrated appraisal: The findings of R7 support conclusions in R3 that integrating health, social and environmental considerations into one statutory, holistic, integrated assessment process could ensure that health is properly considered in plan and project appraisal. This implies legislative change, at least at the project level, because the scope of EIA is limited. At the plan level Sustainability Appraisal (SA) is already supposed to be holistic and revised official guidelines could be sufficient.

The value of the HIA approach: evidence from R3, San Francisco and Christchurch shows the value of drawing on diverse sources of knowledge, including local knowledge, especially where there are ethnic and cultural divides. Three groups of actors are needed in order to build strong outcomes: the community, the experts (including built environment professionals and public health) and the policy-makers. The findings of R7 support the notion that stakeholder engagement early in a development process is vital to the likelihood of success of its planning developments and its marginal cost is low compared with marginal benefit further along the planning chain and the roll out of plans into constructions or refits. The HIA approach contrasts with the much more technical EIA process and the tick-box approach of many SA/SEA studies. The inclusive HIA approach is helpful to set the agenda *ab initio* (scoping) as well as in later stages of evaluation. Neither EIA of projects nor SA/SEA of plans currently involves stakeholders as a matter of course in

this way. The findings of R7 show there is a large opportunity cost arising from failure to engage stakeholders in consultation that plays out later on in planning delays, re-application of plans and poorly conceived plans which incur additional costs and produce lower quality and less appropriate modifications to the built environment which feeds through to lower use and health benefit (Barton, 2009; Geddes et al. 2010).

The likely impact of new housing developments on an existing community when degrees of collaboration between housing developers, the NHS and local authority planners produce healthy sustainable housing and neighbourhoods for community health benefits is difficult to estimate using decision models. The NHS London's Healthy Urban Development Unit (HUDU) planning development tool could be used to structure scenarios for different degrees of developer and local authority collaboration through the planning system that provide incentives and cost-savings that result in land development for low-carbon housing and conducive neighbourhood with green, open spaces to enable active travel, access to shops, services, social spaces, employment and schools (See HUDU website for documents and R5/6 in this programme of reviews.) However, scenarios from application of the HUDU tool are outside the scope of this current review.

Health equity: evidence from the Marmot review team supports prioritising policies and interventions that both reduce health inequalities and mitigate climate change (Geddes et al. 2010). It is suggested interventions to encourage active travel include investing in better walking and cycling routes, reducing car speed to improve road safety, and improving public transport are the priority interventions for reducing health inequalities. The evidence from the decision tree models supports the view that 'better' or high quality cycling infrastructure that is well planned and located appropriately through consultation with stakeholders, often leads to long-term increases in cycling, and much lower numbers of cyclists killed or seriously injured (de Hartog et al. 2010; Yang et al. 2010). There is less evidence for increased physical activity as a result of new infrastructure for walking. However, access to good quality green space has a clear effect on physical and mental health and well-being. Many studies show the positive effect and dose-response of good quality

green space and green physical activity on mental health and mood (Pretty et al. 2005; Barton & Pretty, 2010).

Conclusions of Review 7

There is some evidence demonstrated by decision trees for the cost-effectiveness of comprehensive health assessment integrated into other assessments that leads to effective planning and collaboration. Looking at the totality of the pathways of decision trees in R7 is instructive and indicates that a good spatial plan for modifications to the built environment that integrates health considerations will tend to outshine poor or no spatial planning and no engagement with communities about these modifications. However, "comprehensive" spatial planning for health does not always exceed "rapid" planning for health on every occasion. The take home message is that integrating health into spatial planning is cost-effective and that it needs to happen through consultation with communities and that this can be either through rapid approaches or in a more comprehensive way, preferably the latter.

In many ways the significance of the BCRs of this decision tree needs to be down played because of the lack of data and the sensitivity of the results to the assumptions of the models. However, the large magnitude of many of the cost-benefit ratios would suggest that there are potentially very large gains to be obtained from effective integration of health and planning for whole-town infrastructure for walking and cycling and the retrofit of home zones that will often far outweigh the cost of incorporating health considerations early in the planning process. Other evidence uncovered during this review indicates infrastructure for walking and cycling and retro-fit of homes with insulation could be targeted progressively across the social gradient without widening health inequalities. It is apparent that a pre-condition for integrating economic, social (equity) and environmental objectives at the local level is effective collaboration between state (national and local), market and community interests, together with coherent inter-agency working – particularly planning with transport with housing, regeneration, parks and economic development. This is the ideal of spatial planning, often not realised.

1. Introduction

The last of the suite of reviews of this programme is intended to provide a systematic review and synthesis of the economic evaluation evidence to distil knowledge of cost-effectiveness in policy and intervention to complement previous systematic reviews of effectiveness earlier in the process. Report 1 examined how projects (concerned with land use) are appraised as part of the planning process. It examined how far and in what ways the statutory and non-statutory appraisal of projects account for potential positive and negative impacts on health and the social and environmental determinants of health, and what lessons emerge from current practices. Report 2 examined the same issues, but looked specifically at plan appraisal. Report 3 looked at the UK planning system and assessed the degree to which health and well-being are part of planning processes and as such assessed how well they influenced policy and implementation. In that context the aim was to identify barriers and opportunities to the full integration of health into planning. Review 4 examined design guidance and indicators as devices which can assist rational and effective spatial planning for health. The purpose of review 5/6 was to draw together all the work done so far, together with new evidence from countries overseas, in order to reach conclusions about the best way, or ways, of integrating health into the spatial planning process. The original brief for Review 5 concerned project and plan appraisal, while Review 6 was about spatial planning as a whole. These reviews were amalgamated into one report so that the appraisal process could be seen as a part of the spatial planning process, not separate from it.

Review 5/6 made a number of conclusions which have formed a starting point for review and economic modelling in Review 7. It was concluded in R5/6 that the planning system was originally devised to improve the health and well-being of citizens. Over the last century that perspective has often been overlooked and other priorities given precedence. There is every reason why it should, as a matter of course, become central again, and as we have seen, some places are seeking to achieve this. The co-incidence of interest between health and sustainable development (as exemplified by Brundtland's anthropocentric definition of sustainable development) mean that in principle the centrality of health and well-being should not be controversial. In some instances (e.g. Freiburg) the focus on

sustainable development has led to a very healthy environment. However, in most places a renewed focus on the health and well-being of people would be one way to strengthen the political desire to achieve more sustainable development. Healthy communities result from effectively combining economic, social and environmental objectives, not trade-offs between them.

Strategic environmental assessment is required by European and UK law and has been adopted as an appraisal process in many countries across the world. It is a way of systematically identifying and evaluating the impacts that a spatial plan is likely to have on the environment. However, there is no legal requirement for SEA or other types of statutory assessment to include the health impacts of spatial planning in an assessment which creates a gap in the evidence to for the health aspects of planning developments (YHEC, 2006). Evidence from previous reviews and synthesis to inform model development in this report has suggested the options for integrating health into planning developments through health appraisal of various types.

Health appraisal can take a number of forms and can be described as rapid or comprehensive. This label often depends on the degree that sequential stages are followed through the process and the amount of time and resources devoted to appraisal completion (YHEC, 2006). Health appraisal can be undertaken on its own (stand-alone), or as part of a range of other statutory assessments (integrated). The conduct of an integrated health appraisal process tends to increase the range of contact and frequency of interaction and engagement between different professionals and stakeholders compared with stand-alone health appraisal. All types of health appraisal have the potential to undertake public and stakeholder engagement through their processes, but the nature and quality of consultation will be influenced by the degree of integration of health appraisal with other assessments including SEA.

The evidence review to structure and populate the decision models focussed upon cost benefit analyses (CBAs) rather than cost utility analyses (CUAs) preferred by NICE. One reason for this decision is that in areas outside of health, such as transport and housing, Quality Adjusted Life Years (QALYs) the outcome measure of

CUAs are not used in economic analyses, so it makes more sense to populate the decision trees with benefit measures that meet the usual currency of transport and other planners (such as green space planners). The other reason is that almost all the studies found during R7 are CBAs rather than CUAs based on QALYs.

One drawback of the CBA approach to economic evaluation is not being as adaptable to the consideration of health inequalities as a CUA approach because individual preferences of value or willingness to pay (WTP) are reflected in a CBA rather than governmental preferences or WTP to implement changes in the allocation of resources. Where the NHS cost per QALY threshold lies has been estimated by trial and error across all NHS interventions. For example, the WTP for a QALY elicited through individual WTP studies is around £60,000-£80,000, but the NHS is funded to pay up to £20,000 to £30,000 per QALY or around one third as much as individual would be willing to pay. If the same kind of difference between CBA and CUA applies to other areas of public spending, it implies that projects with a benefit to cost ratio less than about 3:1 should not be funded.

The decision models are predicated on the assumption that where health appraisal has not been undertaken at all (Option 3), in either a stand-alone (Option 2) or integrated form (Option 1), that a 'bad plan' will result from not consulting with stakeholders or the public at the outset of the planning cycle. A 'good plan' produces good quality, safe infrastructure in an appropriate location that will be used by community members for health benefit. Consultation with stakeholders at the outset of planning provides an opportunity for developers to adjust the plan to maximise the use and benefit of the new or refitted infrastructure. The structure of the decision models in R7 indicates the timing of and opportunity for consultation is essential to the development process - consultation at the outset mitigates bad planning. Assumptions such as those above which are built into the structure of the decision models explicitly are open to challenge and criticism, but there is evidence to support some of the logic of these structures for the decision models. (See all studies in Appendix B.)

The overarching research questions are:

1. What is the evidence for the level, type and magnitude of resources utilised in the two stage process of integrating health fully into planning appraisal and planning development processes?

2. What is the evidence for the level, type and magnitude of health benefits that arise from planning developments or implementations in which health considerations have been fully integrated?

3. What is the evidence for the likely distribution of health benefits across the community?

4. What is the evidence for the impact of new housing developments on an existing community when degrees of collaboration between housing developers, the NHS and local authority planners produces healthy sustainable housing and neighbourhoods for community health benefits?

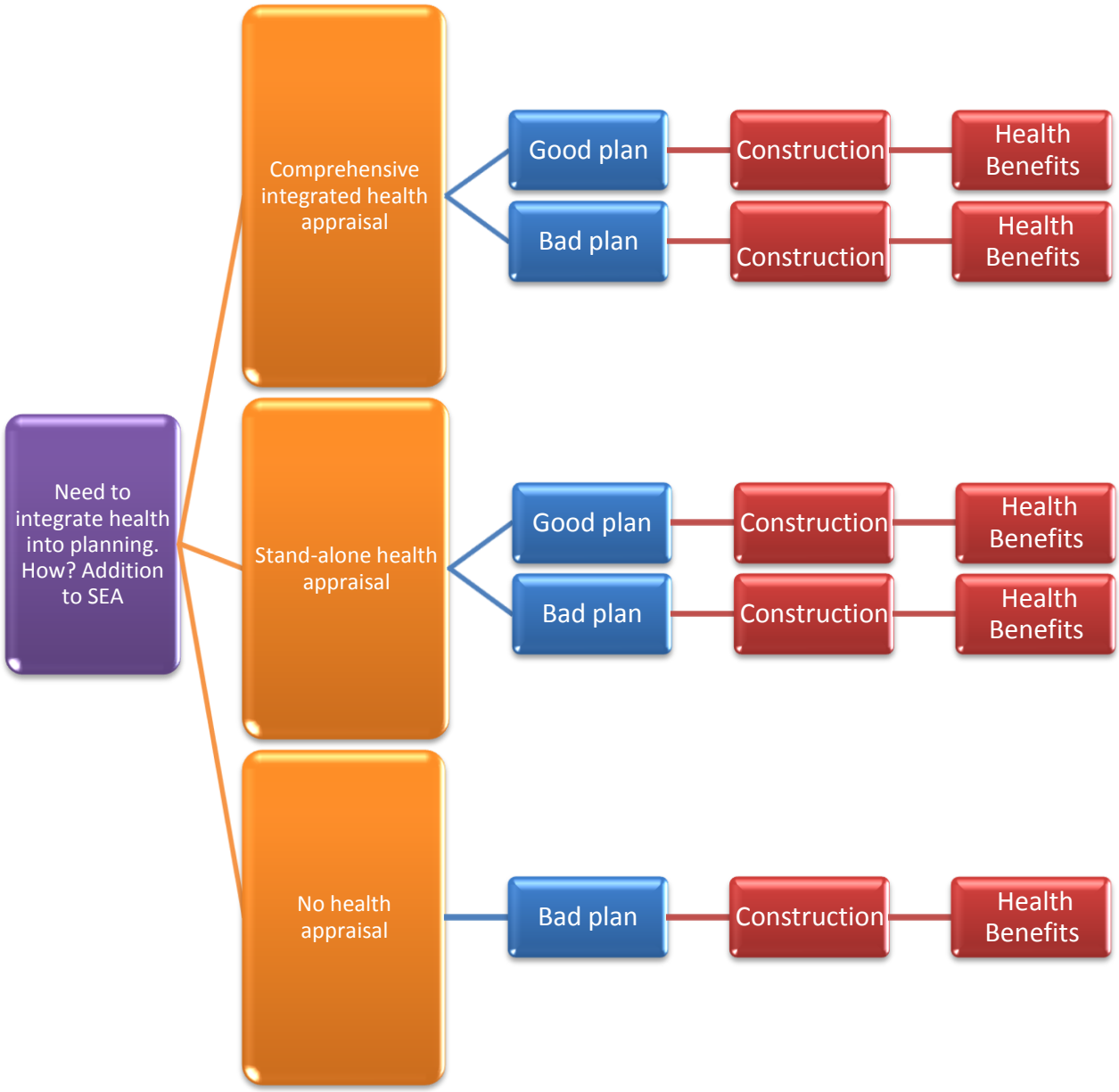
2. Conceptual frameworks

The conceptual framework for the structured pathways of the decision trees draws on that for review 5/6, nesting circles: the appraisal processes sit within the overall planning process, which itself is a part of the development process. It is the latter which generates actual change to the human environment, and it involves investors, funders, land owners and operators, as well as regulatory authorities such as planning.

Decision trees represent the process of individual community members acquiring health benefits, as a result of changes to the built environment engendered by construction of whole town infrastructure for walking and cycling and retro-fit home-zones, through the planning appraisal and development processes. In Figure 1 the *decision node* is represented by the square box at the start of the decision tree column 1 represents the decision problem being addressed by the models – how to integrate health into planning cost-effectively, as an addition to SEA. The *chance nodes* arise from a decision node as a range of possible options to address the decision problem, and the range of possible pathways that characterise the effects of the alternative options for integrating health into spatial planning.

The branches of the decision tree that draw from the chance nodes represent particular events that a cohort may experience at that point of the tree. The likelihood of events is represented in branch probabilities. For all three options for integrating health into planning, the first chance node relates to whether or not the cohort is subject to good or bad spatial planning. Here the probabilities of the events are influenced by stakeholder and community acceptance of plan – in turn influenced by the extent of consultation through health appraisal and the degree of successful integration of health in plan implementation and construction – in turn corresponding with the effect of health benefits in a community cohort. In this model the probability of events is conditional on other events earlier in the decision tree, but the evidence to populate this element of the decision tree is very uncertain for the models under development.

Figure 1. A decision tree for integrating health into spatial planning appraisal and development for active travel and retro-fit home zones



The combination of the different branches in the tree determines a series of five *pathways* in Figure 1 that could apply to each of the community cohorts as they pass along them. In Figure 1, the five pathways of the decision model that arise from the three options for integrating health into planning are:-

Planning whole-town infrastructure and promotion of active travel

Pathway 1 – Comprehensive health appraisal integrated with other assessments - stakeholder consultation at the outset - good plan with no delays or reapplication required – good quality construction or use of land, well positioned- more active travel by more community members - greater health benefits

Pathway 2 – Comprehensive health appraisal integrated with other assessments - no stakeholder consultation at the outset – bad plan with delays and re-application required – poor quality construction or use of land, poorly located - less active travel by less community members - lower health benefits

Pathway 3 – Rapid health appraisal stand-alone from other assessments - stakeholder consultation at the outset - good plan with no delays or reapplication required – good quality construction or use of land, well positioned- more active travel by more community members - greater health benefits

Pathway 4 – Rapid health appraisal stand-alone from other assessments - no stakeholder consultation at the outset – bad plan with delays and re-application required – poor quality construction or use of land, poorly located - less active travel by less community members - lower health benefits

Pathway 5 – No health appraisal as part of assessment - no stakeholder consultation at the outset – bad plan with delays and re-application required – poor quality construction or use of land, poorly located - less active travel by less community members - lower health benefits

Planning retro-fitting 408 homes with insulation as part of a home-zone

Pathway 1 – Comprehensive health appraisal integrated with other assessments - stakeholder consultation at the outset - good plan with no delays or reapplication required – good quality retrofit - greater health benefits

Pathway 2 – Comprehensive health appraisal integrated with other assessments - no stakeholder consultation at the outset – bad plan with delays and re-application required – poor quality retrofit - lower health benefits

Pathway 3 – Rapid health appraisal stand-alone from other assessments - stakeholder consultation at the outset - good plan with no delays or reapplication required – good quality retrofit - greater health benefits

Pathway 4 – Rapid health appraisal stand-alone from other assessments - no stakeholder consultation at the outset – bad plan with delays and re-application required – poor quality retrofit - lower health benefits

Pathway 5 – No health appraisal as part of assessment - no stakeholder consultation at the outset – bad plan with delays and re-application required – poor quality retrofit – much lower health benefits

The pathways of a decision tree are mutually exclusive, the probabilities for each option must sum to 1.

The five pathways in the decision models explore the probability of delays in roll out of plan development and plan approval, the cost of re-engaging stakeholders and public to rework and resell a plan development later on in the development process to achieve planning approval. Other events are an increase in the probability of building delay and policy hiatus leading to sub-optimal development let through on appeal. In theory, the cost of an effective health assessment integrated with SEA for example, is substantially less than those plans that are not properly based in terms of the health and wellbeing of stakeholders and the public. In addition, the health costs and reduction in health benefits of inappropriate development from ‘bad

planning' can impact into the future for generations and this interpretation is reflected in the assumptions drawn on the marginal health benefits (Barton, 2009).

There are resource inputs and costs attached to optional activities, such as health assessment at various types and levels of public engagement and consultation to integrate health considerations into planning. The decision models that are populated from this review are structured to demonstrate the extent to which health and sustainability scoping, as a result of health appraisal of various types (comprehensive and integrated or rapid and stand-alone) early in a plan process, and the extra quality and 'soundness' of the plan then emerging, can result in bigger additional health benefits in the long term. For example, community consultation might reveal that infrastructure located in a particular place and built to a good level of quality for an open space setting might avoid routes shared with traffic and encourage more people to cycle i.e. across boggy land that sometimes floods etc.

The *pathway costs* are undertaking health assessment, the cost of stakeholder engagement, the cost of re-application for planning approval, the cost of planning delay and the cost of quality of construction/retro-fit. This is a simplification of the potential cost categories in these cases. These costs have been estimated using evidence available directly from studies, by combining studies, and making assumptions to work towards an estimate that seems reasonable in the light of a fragmented evidence base. The likelihood of or probability of adverse events connected with total costs for the five pathways of Figure 1 must be equal to 1 across the pathways, so the probability of planning delay - as an adverse event, is multiplied by the probability of poor quality infrastructure/retrofit, to find the overall probability of adverse events for each pathway.

The expected cost of each of the five pathway options of Figure 1 is the product of its additional costs and the compound probability of adverse events connected with the generation of these additional costs. Each branch of the five pathways of Figure 1 requires an estimate of benefit for planning appraisal, planning development and construction i.e. whole town infrastructure for active travel in a cohort of 100,000 people and retro-fit of 408 homes with insulation. There is minimal evidence at this time to construct measures of health benefit in life years gained or QALYs from an

NHS or local authority perspective for the reasons explained in the summary and discussion sections of this report. Therefore benefit estimates for each cohort are derived from the most relevant studies and expressed in £ sterling converted to 2010 prices.

The probability of events connected with the benefit of whole-town infrastructure for walking or cycling and retrofit of home zones for the five pathways of Figure 1 must be equal to 1 across the pathways. The probability of a decrease in the use of infrastructure over time or shift in the dose-response curve for active travel infrastructure is multiplied by the probability of poor quality infrastructure/retrofit, to find the overall probability of events for each pathway. Quality, location (and related safety concerns from shared space with traffic) of cycling infrastructure is very important, as access to poor quality infrastructure doesn't show the same benefits as good quality infrastructure (Saelensminde, 2004; de Hartog et al. 2010).

The following considerations apply to the structure of the decision tree in Figure 1.

The adverse events of interest i.e. the probability of planning delay or the probability of poor quality infrastructure/retrofit, occurs once not on multiple occasions, although the implications of these adverse events might have multiple events connected with them. A series of competing adverse event risks should be assumed i.e the risk of planning delay and local authority cuts, but this has not been possible in the models. There is difficulty in making assumptions about the durability of the benefit effect from cycling, walking and retrofit of a home with insulation that results from good spatial planning. The probabilities of adverse events are likely to change over time, but are assumed static in these analyses. It has not been possible to include all the important adverse events that might occur across the decision trees and the extent of double-counting and omission is not known.

3. Methods

In order to inform the base case for modelling it was necessary to review the case studies consistent with the findings of reviews 1-5/6 to identify useful studies for review 7 already identified in previous reviews (this content has already been assessed for content and quality).

EconLIT was searched with new search terms (see below) for decision models or theory-based studies that attempted to articulate and explain – in context – the relationship between resource inputs to implementation of effective health-integrated spatial plans and associated health benefit outcomes in the community. Where possible, useful probability estimates, contextual influence estimates, resource use, cost, level and type of benefit data from these studies were extracted using a standardised data extraction form (see Appendix A).

The criteria for quality appraisal of the evidence extracted were:

- Where it was possible, useful and relevant data to structure and populate the decision analytic models were extracted from studies and assessed for their quality using a scale (good ++, fair +, weak -).

☐ ++	A well conducted non-RCT, case-control study, cohort study, cost-effectiveness, cost-offset study or correlation study with a low risk – or chance – of bias or confounding
☐ +	A non-RCT, case-control study, cohort study, cost-effectiveness, cost-offset study or correlation study with a moderate risk – or chance - of bias or confounding
☐ -	A non-RCT, case-control study, cohort study, cost-effectiveness, cost-offset study or correlation study with a high risk – or chance – of bias or confounding

The evidence identified for data extraction is:-

- Evidence for measured frequency of event rates or probabilities in a given sample or population or data that allows event rates to be calculated.

- Evidence for parameter inputs, for example, resources used in health appraisal or planning developments and associated costs where health is effectively integrated, and characterisations of uncertainty connected with estimation or the magnitude of contextual influences and stakeholder engagement and consultation.

- Evidence for the costs of spatial plan implementations, costs of built environment adaptations and collaborative working between developers and local authority planners.

- Evidence for the level and magnitude of health benefits that arise from adaptations of the built and natural environments, for example, life years gained, quality adjusted life years gained (QALYs), disability-adjusted life years gained (DALYs), survival benefits.

-Evidence for the cost-savings of collaborative working between developers, local authority planners, health professionals and the public.

- Evidence for relative health benefits and health risks, the associations and relationships between benefit and risk, and the pattern of health benefits over time including dose-response and concentration-response functions and relationships.

- Evidence for assessment of the techniques for extrapolation and discounting of health benefits over time and the plausibility of these estimates.

A sensitivity analysis demonstrates the effect of changes in the assumptions and estimates for ratios of marginal benefit to marginal cost for integrating health into spatial planning and development. Assumptions concerning the marginal costs of health assessment, planning development, delay, quality of construction and location have been made for all options and pathways of the decision tree. In addition,

assumptions about planning delay and poor quality development form another part of the models. These assumptions are varied in the following ways for whole town infrastructure for active travel and retro-fitting homes with insulation.

1. Estimation of marginal cost of quality, MC of quality is the same for all options as option 1 with original probabilities constant.
2. Vary balance of existing probabilities connected with planning delay and location of infrastructure by 10 percentage points with original marginal costs constant.
3. Vary 1 and 2 at the same time.

Search strategy

The current search strategy has been devised from an amalgamation of the previous search of EconLIT left out of reviews 1 and 2 and additional search terms below.

ECONLIT (Jan 1987-Sept 2010) Advanced search, Boolean operators, abstracts "economic appraisal" or "economic evaluation" or "economic analysis" or "decision analysis" or "cost benefit" or "cost effectiveness" or "cost analysis" or "cost utility" or "cost minimisation" or "resource*" or "decision model*" or "decision analy*" or "cost* illness" or "probability" or "risk" or "likelihood"

BCR or "benefit-cost ratio" or "cost benefit" or "cost-benefit" or "net benefit" or cost saving or estimate* saving or life years saved or increment* or potential saving* or "QALY*" or "DALY*"

"planner*" or "walk*" or "cycl*" or "run*" or "recreational activit*" or access* or "green space" or "open space"

1 and 2 and 3

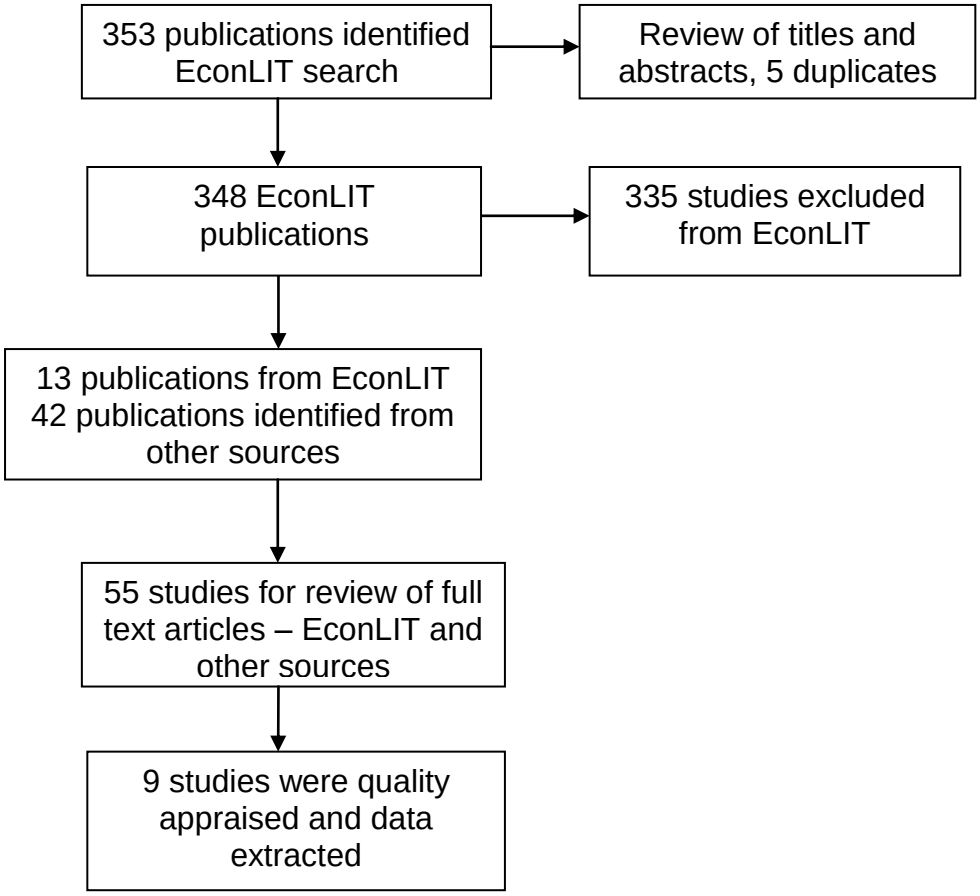
Other terms were subsequently used at a more advanced stage to generate further evidence based on discussions of the PDG. These terms were, "home zone" or "streetscape" or "retro-fit". Sensitivity of searches was important and the search

strategy was designed to pick up as much if not all of the relevant literature as possible in EconLIT.

4. Results

The search of EconLIT revealed 353 hits. A review of abstracts indicated 14 required examination of their full text. Searches of additional records from other sources and reconsideration of literature identified in previous reviews that might be relevant to R7 were undertaken, and a further 42 studies identified. Altogether, fifty-five full text papers from studies were reviewed (see full-text references). Eight studies were put forward for consideration by PDG members and other grey literature was retrieved through contact with one of the authors of PDG recommended studies. An additional piece of grey literature for the retro-fit of home zones was elicited via an email to members of the UWE collaborating centre (Chatterjee, unpublished).

Figure 2. Flow chart of study selection for review



Structure and population of the decision tree models

To recap, the five pathways for integrating health into spatial planning are:-

Planning whole-town infrastructure and promotion of active travel

Pathway 1 – Comprehensive health appraisal integrated with other assessments - stakeholder consultation at the outset - good plan with no delays or reapplication required – good quality construction or use of land, well positioned- more active travel by more community members - greater health benefits

Pathway 2 – Comprehensive health appraisal integrated with other assessments - no stakeholder consultation at the outset – bad plan with delays and re-application required – poor quality construction or use of land, poorly located - less active travel by less community members - lower health benefits

Pathway 3 – Rapid health appraisal stand-alone from other assessments - stakeholder consultation at the outset - good plan with no delays or reapplication required – good quality construction or use of land, well positioned- more active travel by more community members - greater health benefits

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Planning retro-fitting 408 homes with insulation as part of a home-zone

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Pathway 5 – No health appraisal as part of assessment - no stakeholder consultation at the outset – bad plan with delays and re-application required – poor quality retrofit – much lower health benefits

Decision models were focussed on economic efficiency expressed in marginal cost-benefit ratios and the sensitivity of these to the wide range of assumptions and estimates. The evidence review to structure and populate the decision models focussed upon cost benefit analyses (CBAs) rather than NICE's preferred cost utility analyses (CUAs). One reason for this decision is that in areas outside of health, such as transport and housing, Quality Adjusted Life Years (QALYs) the outcome measure of CUAs are not used in economic analyses, so it makes more sense to populate the decision trees with benefit measures that meet the usual currency of transport and other planners (such as green space planners). The other reason is that almost all the studies found during R7 are CBAs rather than CUAs based on QALYs.

One drawback of the CBA approach to economic evaluation is not being as adaptable to the consideration of health inequalities as a CUA approach because individual preferences of value or willingness to pay (WTP) are reflected in a CBA rather than governmental preferences or WTP to implement changes in the allocation of resources. Where the NHS cost per QALY threshold lies has been estimated by trial and error across all NHS interventions. For example, the WTP for a QALY elicited through individual WTP studies is around £60,000-£80,000, but the NHS is funded to pay up to £20,000 to £30,000 per QALY or around one third as much as individual would be willing to pay. If the same kind of difference between CBA and CUA applies to other areas of public spending, it implies that projects with a benefit to cost ratio less than about 3:1 should not be funded.

Input parameters and probability estimates populate the first branches of the decision tree model for the three options for integrating health into planning development leading to all three modifications of the built environment. These were:-

1. Development of whole town infrastructure for active travel: modal shift from cars to walking and cycling and associated health benefits
2. Retro-fit of home zones for health benefits

The following structural issues were considered in drawing up decision trees:-

- A structure for the possible pathway of additional expected health benefits generated by the adaptations to the built environment for active travel, and retro-fit home zones. Synthesis of the evidence for these additional health and wellbeing benefits that might be experienced by those who use the environmental adaptations over time.

- Providing evidence relevant to the research questions that can be used to estimate the input parameters of the model in the knowledge of its structural elements.

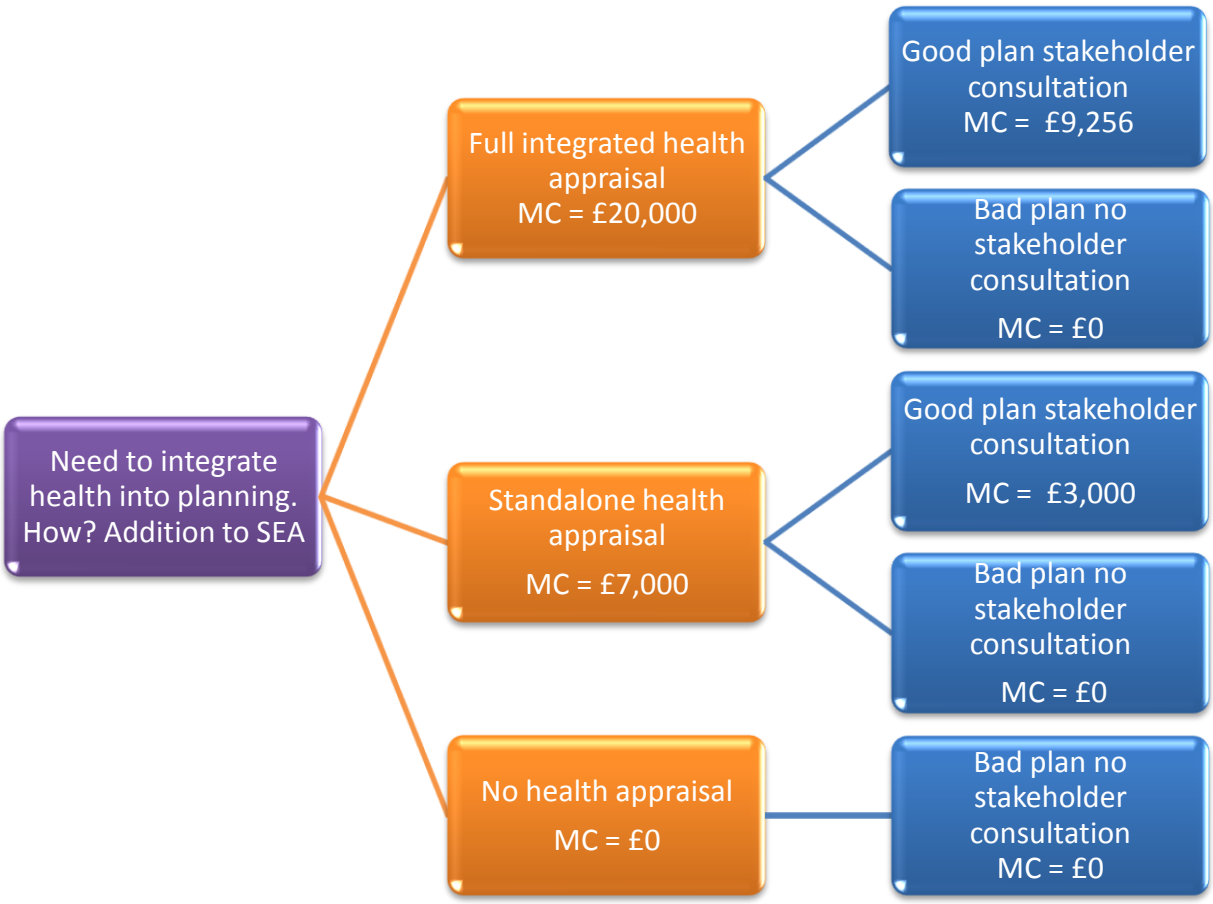
- Providing a way to organise and translate relevant evidence from systematic review into estimates of the expected additional costs and effects of

alternative options compared to integrate health considerations into planning appraisal and development using appropriate decision rules for the various types of economic evaluation study and their funding perspectives.

- Helping to characterise the nature and sources of uncertainty relating to estimation and evaluation, the frailties in the evidence base for estimation of input parameters and the structure of the emerging decision model. Flexibility to characterise heterogeneity of current health states and health outcomes across different sub-groups or individuals in the population and the uncertainty connected with this and expected additional health effects and outcomes.

This structure is illustrated in Figure 3.

Figure 3. Estimates for the first branches of the decision tree



The following assumptions apply to all decision models:-

A. Evidence from studies by Atkinson & Cooke (2005) and Mathias & Harris-Roxas (2009) populates the first part of the decision models. These studies in combination provide 'best available evidence' for the costs of different types of health appraisal across dimensions of scope, conduct and levels of stakeholder engagement and participation providing a source of data to populate the decision trees. Atkinson and Cooke show a breakdown of cost

for resource inputs to comprehensive integrated health appraisal at £25,500 (2005 prices). This is converted to 2010 prices (£29,256) using the retail prices index (RPI) (Rate of inflation[online], 2010). These authors demonstrate stakeholder and community consultation represents 31 per cent of the costs of HIA on average (Atkinson & Cooke, 2005). Estimates of the cost of stand-alone, rapid HIA are taken from averages within a paper from an assessment of its costs and benefits (YHEC, 2006). These costs convert to £10,000 at 2010 prices (Rate of inflation[online], 2010).

B. Modeller assumes planning delay means a plan must be completely reconstructed and re-submitted at least once based on statements put together by the modeller in Barton (2009) and R5/R6 of this suite of reviews and personal communication with travel planners for local councils in Bristol and the Forest of Dean.

C. Modeller assumes stakeholder consultation should take place later if it has not taken place early on in the process once a planning application has been refused. This is based on modeller opinion from personal communication with Sustrans and statements in Barton (2009) and Mathias & Harris-Roxas (2009).

D. Modeller assumes the cost of a development plan increases when health considerations are not integrated through appraisal and development at the outset. This assumption is based on the findings of R5/R6 of this suite of reviews.

E. Assume comprehensive integrated appraisal and stakeholder consultation must feature in some form later and with some cost for resubmitting plans across Options 2 and 3. This assumption follows on from assumption D.

F. Assume stakeholder and community consultation takes around a third of the resources of any health appraisal. This assumption is based on evidence in the study by Atkinson & Cooke (2005).

G. Assume stakeholder consultations undertaken after plan development cost at least the same as stakeholder consultations for full integrated appraisal in pathway one of Figure 3 i.e. £9,256 (2010 prices) (Mathias & Harris-Roxas, 2009).

H. Assume as demonstrated in pathway three of Figure 3 the marginal cost of stakeholder consultation for rapid stand-alone health appraisal is £3,000 at 2010 prices. This evidence comes from the paper by York Health Economics Consortium (YHEC, 2006).

I. Assume the cost of producing an additional planning application for infrastructure for walking and cycling is £20,000 (2010 prices) (Rupert Crosbee, personal communication)

J. The modeller assumes the cost £20,000 under I, is incurred for the delays connected with resubmitting poor quality planning applications that have been rejected for not taking sufficient account of stakeholder and public views.

K. Assume an additional change-of-use planning application costs £335 if planning applications have to be re-submitted (Bristol City Council, 2010)[online].

(See data extraction of these studies Appendix B and assessment of the quality of some of this evidence.)

The following additional assumptions apply to the decision models in Table 1 to integrate health into appraisal and development of whole town infrastructure:-

1. Assume town under consideration for whole town infrastructure for walking and cycling has 100,000 community members or cohort of people and resembles one of the first wave of six Cycling Demonstration Towns (CDTs) (Cope et al 2010).

2. The cost of the whole town infrastructure is assumed to be £3m. This total is derived by assuming the cost for one town is one sixth of the £18m cost of the Cycling Demonstration Towns in England (CDTs) (Cope et al 2010).

3. Assume the marginal cost of whole-town infrastructure for cycling in a cohort of 100,000 people is equal to the marginal cost in Cope et al. (2010) - £10 per head or £1m.

4. Assume (following Saelensminde, 2004 and de Hartog et al. 2010) poor quality, inappropriate, badly planned and located infrastructure between cars and bikes/people imposes barrier costs on infrastructure users, including concerns about safety and accidents, that limit the numbers of users and prevent realisation of the full range of benefits from the walking and cycling.

5. Assume construction costs breakdown to management, building and maintenance costs in the same proportion to those in a CBA of cycling infrastructure from Saelensminde (2004).

6. Modeller assumes the additional cost of poor quality infrastructure arising from bad planning development process for Option 3 is 10 per cent of the total construction cost of £3m. In addition assume the additional cost of poor quality infrastructure arising from some bad planning in the development process for Option 2 is 5 per cent of the total £3m construction cost, or £150K. Assume Option 1 has an additional standard infrastructure wear and tear repair cost of 2.5 per cent of £3m construction cost.

7. Cope et al. (2010) demonstrate evidence that total all-cause mortality benefit as a result of new infrastructure and plans for walking and cycling in the six first wave CDTs is £45m. Total reduced all-cause mortality benefit is measured by Cope and others using the HEAT for cycling tool (Rutter et al. 2008).

8. Assume all-cause mortality benefit in the cohort is £7.5m (2010 prices) This total is derived by assuming the mortality benefit for one town is one sixth of the £45m all-cause mortality benefit of the Cycling Demonstration Towns in England (CDTs) (Cope et al 2010).

9. Assume increased prevalence of cycling in the cohort of 100,000 people as a result of whole town infrastructure is 3.5 per cent following evidence in Yang et al. (2010).

10. Assume following Cope et al. (2010) benefits accrue for ten years and there is no change in the number of cyclists over this period.

11. Assume benefits and costs are discounted at 3.5% following Cope et al. (2010).

12. Modeller assumes for a cohort of 100,000 the marginal benefit of pathway five is equal to the marginal cost of £1m following Cope et al. (2010).

13. Modeller assumes marginal benefit in the cohort is doubled for pathways three and four as a result of stand-alone health appraisal leading to a satisfactory planning development process.

14. Assume marginal benefit is tripled for pathways one and two as a result of integrated health appraisal that sets its objectives early and follows a smooth path through the development planning and control process (Barton, 2009; Mathias & Harris-Roxas, 2009).

Mortality benefits from walking more, as a result of whole town infrastructure in the Cycling Demonstration Towns are estimated using a new HEAT tool for walking (unpublished) (Rutter, personal communication). HEAT for walking makes a number of assumptions including average walking speed (5 km/h), weeks per year walked (36) and average walk length (estimated from sample population). Sloman et al. (2010) demonstrate levels of walking in the Sustainable Transport Towns in terms of trips and distance covered is half that of cycling. The following assumptions apply:-

1. Assume the number of new walkers generated through new infrastructure in the Cycling Demonstration Towns is half that of new cyclists at 1.75 percentage points (Sloman et al. 2010).

2. Assume following Yang et al. (2010) - their systematic review demonstrated interventions to promote cycling at a population level were associated with net increases of up to 3.5 percentage points in population prevalence.

3. Assume the effect of infrastructure on walking for all-cause mortality has a lower dose-response relationship than that of cycling because better accessibility for more people requires more green open spaces, following Douglas, (2004); Barton & Pretty (2010); Sloman et al. (2010) and Yang et al. (2010).

4. The decision model assumes that the present value of the mean annual benefit of additional walking generated through whole-town infrastructure is in the region of £9m per year over 10 years (Cope et al., 2010).

One of the main uncertainties is connected with the assumption that the rate of decay of mortality benefits from cycling continue at the same rate for ten years and that the concentration response function is the same over time in walkers. These assumptions are made explicit, but are open to challenge (Powell et al. 2010).

Whole-town infrastructure and promotion of active travel

There is mixed evidence from a range of sources, some of it robust, for comprehensive health appraisal or assessment integrated with other statutory assessments in which stakeholder consultation happens early in the development process - results in good plans that maximise the health benefits of walking and cycling through pathway 1 of a decision tree. Table 1 shows the additional health benefits in a cohort of 100,000 community members in which walking and cycling has increased by 1.75 per cent and 3.5 per cent per annum respectively, as a result of good planning processes and large scale, whole-town infrastructure, all-cause mortality from additional physical activity expressed through the value of a statistical life outweigh additional costs in with BCRs 60:1 for walking and 168:1 for cycling.

Table 2 contains the sensitivity analysis which demonstrates the change in cost-benefit ratios that arise from varying assumptions used in the analysis for:-

1. Estimation of marginal cost of quality, MC of quality is the same for all options as option 1 with original probabilities constant.
2. Vary balance of existing probabilities connected with planning delay and location of infrastructure by 10 percentage points with original marginal costs constant.
3. Vary 1 and 2 at the same time.

The ratios for Options 2 and 3 in Table 2 are particularly sensitive to assumptions made about the probabilities of events. When both assumptions made about marginal costs and probabilities are made, Option 2 (rapid stand-alone health assessment for infrastructure for walking and cycling) becomes more cost-effective than Option 1. The findings of sensitivity analysis suggest that threshold analysis for cost-effectiveness of integrating health into spatial planning should be conducted to provide more robust evidence of cost effectiveness than that provided by decision trees.

Table 1. The BCRs for integrating health into planning of whole-town infrastructure for walking and cycling

	Options for health appraisal as addition to SEA (Cohort of 100,000 people)				
	1.Full Integrated Appraisal		2.Rapid Stand-alone Appraisal		3.No Appraisal
	Pathway 1 Good plan	Pathway 2 Bad plan	Pathway 3 Good plan	Pathway 4 Bad plan	Pathway 5 Bad plan
Marginal cost of appraisal and planning development for whole town infrastructure walking and cycling £s	104,256	104,926	169,256	179,926	359,517
Probability of planning delays and low quality infrastructure from planning process	0.04	0.64	0.09	0.49	1.00
Expected cost of integrating health into planning	4,170	67,153	15,233	88,164	352,363
Marginal benefit from reduction in all-cause mortality due to physical activity from walking £s	500,000	500,000	500,000	500,000	500,000
Probability of no decay in concentration-response function walking	0.5	0.5	0.5	0.5	0.00
Marginal benefit from reduction in all-cause mortality due to physical activity from cycling £s	1,000,000	1,000,000	1,000,000	1,000,000	1,000,000
Probability of no decay in concentration-response function cycling	0.7	0.3	0.7	0.3	0.00
Expected marginal benefit of infrastructure cycling £s	700,000	300,000	700,000	300,000	0
BCR whole town cycling infrastructure	168:1	4:1	46:1	3:1	0:1
Expected marginal benefit of infrastructure walking £s	250,000	250,000	250,000	250,000	250,000
BCR whole town walking infrastructure	60:1	4:1	16:1	3:1	0:1

Table 2. Sensitivity analysis of BCRs for integrating health into planning whole-town infrastructure: walking and cycling

	Options for health appraisal as addition to SEA (Cohort of 100,000 people)				
	1.Full Integrated Appraisal		2.Rapid Stand-alone Appraisal		3.No Appraisal
	Pathway 1 Good plan	Pathway 2 Bad plan	Pathway 3 Good plan	Pathway 4 Bad plan	Pathway 5 Bad plan
BCR cycling	168:1	4:1	46:1	3:1	0:1
Vary MC of planning delay, location and quality of infrastructure so cost is £75,000 same as Option 1 across all options. BCR cycling	168:1	4:1	83:1	6:1	0:1
Vary the product of probabilities of delay and poor quality infrastructure by 10 percentage points so that overall probability of options equals 1. BCR cycling	27:1	11:1	17:1	7:1	0:1
Vary both MC and probabilities. BCR cycling	27:1	11:1	30:1	11:1	0:1
BCR walking	60:1	4:1	16:1	3:1	0:1
Vary MC of planning delay, location and quality of infrastructure so cost is £75,000 same as Option 1 across all options. BCR walking	60:1	4:1	29:1	5:1	0:1
Vary the product of probabilities of delay and poor quality infrastructure by 10 percentage points so that overall probability of options equals 1. BCR walking	10:1	10:1	6:1	6:1	0:1
Vary both MC and probabilities BCR walking	10:1	10:1	11:1	10:1	0:1

Retro-fit streetscape and home zones for health benefits

Housing has an important environmental influence on population health, and there is growing evidence of health effects from indoor environment characteristics such as low indoor temperatures. Chapman et al. (2009) in a randomized control trial of value the health, energy and environmental benefits of retro-fitting insulation demonstrates insulation reduced the number of visits people made to their GPs, hospitalisation episodes, days off school, days off work, energy savings and CO_2 savings. A trial was conducted in 1350 predominantly low-income homes (typical of those often retro-fitted in deprived areas) with at least one member of the household displaying symptoms of respiratory disease. The article demonstrates an improvement in dwelling place will improve health, save energy resources and reduce greenhouse emissions. The findings of this study were used to derive the marginal benefit across the cohort of retro-fitted dwellings. (See data extraction and quality appraisal Appendix B.)

The following assumptions apply to the decision model in Table 3 for retro-fitting home-zones with insulation:-

1. Assume town under consideration for retro-fit of homes with insulation has 1,600 community members in 408 dwellings and resembles Morice Town in Plymouth. Chatterjee (2010) showed that the cost of Morice Town was £5,637 per dwelling (2002 prices) which can be converted to £2.848m at 2010 prices.

2. Modeller assumes planning delay means plan must be completely reconstructed and re-submitted.

3. Modeller assumes cost is increased for a bad plan where health is not integrated and no stakeholder consultation has happened.

4. Modeller assumes comprehensive integrated health appraisal and stakeholder consultation is needed later in order to resubmit a plan.

5. Modeller assumes this is more costly for pathway 5 than for pathways 1 and 2.

6. Modeller assumes there is higher likelihood of objections at plan application stage leading to rejection of plans, plan delay and re-application of plans for pathway 5 than for pathways 1 and 2.

7. Modeller assumes the additional cost of poor quality retrofit arising from a bad planning development process for pathway 5 is 10 per cent of the construction cost at £285K (2010 prices)(Chatterjee, 2010).

8. Modeller assumes the additional cost of poor quality retrofit arising from some bad planning in the development process for pathways 3 and 4 is 5 per cent of the construction cost at £142K (2010 prices).

9. Modeller assumes Pathways 1 and 2 have an additional standard infrastructure wear and tear repair cost of 2.5 per cent of the construction cost at 71K (2010 prices).

10. Assume following Chapman et al. (2009) £1228 per household at 2010 prices represents the benefits of insulation £0.307=$1NZ 2002 prices (X-rates, online) for 30 years at 5 per cent discount rate.

Retro-fitting homes There is mixed evidence from a minimal range of sources, for comprehensive health appraisal or assessment integrated with other statutory assessments in which stakeholder consultation happens early in the development process, results in good plans that maximise the additional benefits of retro-fitting homes in a home-zone with insulation through pathway 1 of a decision tree. This pathway predicts a reduction in GP visits, hospital visits, days off work/school, energy savings and CO2 emissions in residents of 408 dwellings across twelve streets in a community cohort of 1,600 people. Good planning processes for home-zones outweigh additional costs from comprehensive health assessment integrated with other assessments with a BCR of 50:1.

Table 4 contains the one-way and two-way sensitivity analyses which demonstrate the change in cost- benefit ratios that arise from varying assumptions used in the analysis for:-

1. Estimation of marginal cost of quality of infrastructure, MC of quality is the same for all options as option 1 with original probabilities constant.
2. Vary balance of existing probabilities connected with planning delay and location of infrastructure by 10 percentage points with original marginal costs constant.
3. Vary 1 and 2 at the same time.

The ratios for Options 2 and 3 in Table 4 are particularly sensitive to assumptions made about the probabilities of events. When both assumptions made about marginal costs and probabilities are made Option 2, rapid stand-alone health assessment for retro-fitting insulation becomes more cost-effective than Option 1. The findings of sensitivity analysis suggest that threshold analysis for cost-effectiveness of integrating health into spatial planning should be conducted to provide more robust evidence of cost effectiveness than that provided by decision trees.

Table 3. The five decision pathways for integrating health into planning retro-fit of home zones with insulation

Options for health appraisal as addition to SEA (Cohort of 1,600 people 408 dwellings in 12 streets)					
	Full Integrated Appraisal		Rapid Stand-alone Appraisal		No Appraisal
	Pathway 1	Pathway 2	Pathway 3	Pathway 4	Pathway 5
[1]Marginal cost of appraisal and planning development for 1,600 people 408 dwellings in 12 streets £s	100,456	101,126	161,656	172,326	344,317
[2]Probabilty retro-fit leads to planning delays and low quality home-zone retro-fit from planning process	0.06	0.56	0.09	0.49	1.00
[3]Expected cost of integrating health into planning	6,027	56,631	14,549	84,440	344,317
[4]Marginal benefit from reduction in change in GP visits, reduced hospital admissions, reduced days off school/work, energy savings, CO_2 savings £s	501,024	501,024	501,024	501,024	501,024
[5]Probability of no decay in infrastructure benefits	0.6	0.4	0.6	0.4	0.00
[6]Expected marginal benefit of retro-fit £s	300,614	200,410	300,614	200,410	0
[7]BCR retro-fit home-zone	50:1	4:1	21:1	2:1	0:1

1 Sources: Chapman et al. (2010); Chatterjee, (2010)
2 Sources: Barton (2009); Mathias and Harris-Roxas, (2009)
3 Derived from product of rows 1 and 2
4 Source: Chapman et al. (2010)
5 Modeller assumption from logic model of decision trees and interpretation of Geddes et al. (2010) 'Fuel poverty section'
6 Derived from product of rows 4 and 5
7 Derived from quotient of row 6 and row 3

Table 4. Sensitivity analysis for the options and decision pathways of integrating health into planning appraisal and development for retro-fitting homes with insulation

	Options for health appraisal as addition to SEA (Cohort of 100,000 people)				
	1.Full Integrated Appraisal		2.Rapid Stand-alone Appraisal		3.No Appraisal
	Pathway 1 Good plan	Pathway 2 Bad plan	Pathway 3 Good plan	Pathway 4 Bad plan	Pathway 5 Bad plan
BCR cycling	50:1	4:1	21:1	2:1	0:1
Vary MC of planning delay, location and quality of infrastructure so cost is £75,000 same as Option 1 across all options. BCR cycling	50:1	4:1	37:1	4:1	0:1
Vary the product of probabilities of delay and poor quality infrastructure by 10 percentage points so that overall probability of options equals 1. BCR cycling	25:1	5:1	15:1	3:1	0:1
Vary both MC and probabilities. BCR cycling	25:1	5:1	28:1	5:1	0:1

Development of land as green, open space for connectivity, access to shops, services and social spaces, active travel and walk-ability for mental health benefit

There is a high likelihood new housing developments will impact on an existing community (Elton, 2010). When degrees of collaboration between housing developers, the NHS and local authority planners are nurtured, in theory, healthy, well-planned, sustainable housing and neighbourhoods for community health benefits can result. Degrees of developer and local authority collaboration through the planning system rely on incentives and cost-savings that result in land development for low-carbon housing and walk-able, safe neighbourhoods – with green, open spaces to enable active travel, access to shops, services, social spaces, employment and schools. This is an ideal.

Sometimes housing developers will construct a land deal with the landowner/s and secure planning permission (usually just in 'outline') and then parcel up the development area and sell parcels off to individual developers who will then get the detailed planning permission (i.e. 'reserved matters' approval) for their parcel. It is very rare for developers to buy a site outright before getting planning permission- developers tend to enter into an option agreement with landowners. There are many types of option agreement, but usually they are on the basis that the developer pays an annual 'retainer' and then has to make best endeavours to secure planning permission, but at all times trying to minimise additional costs (which come off the land price and so are effectively paid by the landowner). The actual price paid for the land is not usually negotiated until after the permission is achieved and all the costs to development are known. Housing and land development are driven by market and price signals and wider demand conditions dictated by the current state of the economy and confidence in any future upturn.

The current model of developer and LPA planning contributions is governed by Section 106 agreements as part of planning process. Section 106 of the Town and Country Planning Act 1990, as amended, provides the legal basis for agreement of planning obligations between local planning authorities and anyone with an interest

in a piece of land. Section 106 planning obligations are intended to make "acceptable" development which would otherwise be unacceptable in planning terms.

Planning obligations may:

- restrict the development or use of land;
- require operations or activities to be carried with regard to the land;
- require the land to be used in a specified way; and
- require payments to be made to the local authority.

As such, Section 106 planning obligations are a key tool in securing, from land and housing developers, provision of, and appropriate contributions towards, infrastructure and services to support development (NHS London HUDU website, 2011). The HUDU tool was developed by the Healthy Urban Development Unit and Tower Hamlets PCT, following legal advice on the seeking of planning obligations for revenue and capital funding for health services. The HUDU model includes an assumption of the number of people moving into a new development that are new to the PCT area. Contributions are not sought for that proportion of people assumed to be moving within the PCT area, as it is assumed that this move will not have an adverse impact upon NHS services.

This completely new approach could be vital to engage developers with respect to maximising health benefits of new developments and collaboration with voluntary and NHS / health care professionals. There is work being undertaken at the moment to put a value on ecology and biodiversity, as well as on renewables and CO_2 reduction. In time this could be used to populate a "son of HUDU" model that might be used to maximise health benefits from a development.

5. Discussion of evidence and limitations

In many ways the significance of the BCRs in R7 needs to be downplayed because of the lack of data and the sensitivity of the results to the assumptions of the models. However, the large magnitude of many of the BCRs would suggest that there are potentially very large gains to be obtained from effective integration of health and planning for whole-town infrastructure for walking and cycling that will often far outweigh the cost of incorporating health considerations early in the planning process. These sentiments also apply to the retrofit of home zones with insulation.

Limitations to the review

It is important to note four major limitations to this review and its decision modelling.

First, the whole of this research programme as set up by NICE has focussed on the planning system. It has not been primarily concerned with the degree to which, or the ways in which, the built environment impacts on health and well-being – though an understanding of this emerging field has been vital. A separate paper prepared by Hugh Barton for the Government Office for Science Foresight Report, entitled *Land use planning and health and well-being* deals succinctly with this huge issue. It was published in *Land Use Policy* last year, and is referenced in this report.

The second limitation concerns the degree to which the planning system is the driver of land use and built environment change. The statutory processes intervene in the on-going market process of land development, and may often have much less influence than the land owners, developers, investors, operators and users who are the other players in the development process game. The plans themselves, in the UK context, can guide but not dictate, and have to operate within what the market, in the broadest sense, can deliver. The key junction of planning system and development is the planning application process ('development control' or 'management'). The decision models have not delved deep into this, except in relation to project appraisal.

Third, decision analytic modelling would be the preferred approach for estimating the costs and benefits of integrating health into spatial planning processes to facilitate

good planning of modifications to the built environment that improve health outcomes. The contextual, institutional and market factors connected with development planning and control processes severely limit the range of possibilities for gathering data to structure and populate a Markov-type decision analytic model, so a decision tree approach is applied in R7. In many ways the significance of the actual numbers in the results of these decision trees needs to be downplayed because of the lack of data and the sensitivity of the results to the assumptions of the models. However, the large magnitude of many of the cost-benefit ratios would suggest that there are potentially very large gains to be obtained from effective integration of health and planning that will often far outweigh the cost of incorporating the change.

Fourth, some chalk-and-cheese comparisons are made as a result of fragility and fragmentation in the evidence base for transport and planning, so two types of analysis CBA and CUA co-exist in this report. CBA studies in transport and other planning do not include health benefits such as increases in life expectancy. A view has been taken in this report that where health is not included as a benefit in an economic analysis, the health benefits generated will be positive and large, so the construction or retrofit intervention will dominate (de Hartog et al. 2010). Estimates of QALYs or concern about rules of thumb for scaling up benefit-to-cost ratios, is not necessary in R7 because cost saving in the long run combined with positive health benefits must equal cost effective integration of health into spatial planning.

The questions in this review were structured to examine whether planning developments in which health considerations are effectively integrated through the engagement of local authority planners and PCTs more or less cost effective than the equivalent developments where that integration has not occurred.

Evidence for the level, type and magnitude of additional resources utilised

There is good evidence to support integrating health fully into planning appraisal and planning development processes in terms of additional cost, but it is worth considering the conclusions of a paper by Mathias & Harris-Roxas (2009) for a HIA of an Urban Development Scheme (UDS) conducted in Christchurch, New Zealand, which summarised the collective findings of five other papers on the resources used

in the conduct of HIA (Fleeman, 1998; Ardern, 2004; Atkinson & Cooke, 2005; YHEC, 2006; Wismar et al. 2007).

These authors concluded the costs of HIA are linked to :-

A. Whether the health and wellbeing dimensions of the HIA require rapid or comprehensive assessment.
B. The scale and size of the spatial planning developments being evaluated.
C. The use of external consultants
D. The extent of community consultation and participation.

Therefore it is very difficult to make robust assumptions to model the costs of integrating health into spatial planning as a number of differences in context can radically alter assumptions that could be made and it is difficult therefore to generalise.

They also summarised the activities and resources generally connected with comprehensive, integrated HIA are:-

1. Screening for UDS to assess suitability for HIA
2. Scoping the areas of UDS for HIA
3. Conduct of eight appraisal workshops in technical areas
4. Desk work - Literature reviews and summaries
5. Report back to workshop participants via internet and summary meetings
6. Circulate draft HIA report
7. Conduct concurrent process evaluation

Again it is very difficult to generalise costs that might apply to comprehensive health assessment integrated with other assessments and the stand-alone variety of health assessment or to make assumptions about the cost of stakeholder engagement.

Evidence for the level, type and magnitude of health benefits

Studies tend to approach the economic evaluation of health benefits using a cost-saving approach drawing on data for the numbers of route users observed at two

time points. In this context, cost-saving estimation relies upon skills in drawing together a range of evidence and assumptions concerning the short- and long-term effects of a lack of physical activity in a population, or on the use of tools to estimate its effect on all-cause mortality as a standard part of the approach, but this is not full economic evaluation in any sense.

Studies by Cavill and colleagues and Cope and colleagues for the DfT in Britain are good examples of evidence for how this approach can be used (Cavill et al., 2009; Cope et al. 2010). In these studies the number of additional people cycling regularly between 2006 and 2009 in the original Cycling Demonstration Towns in England was estimated from two surveys commissioned by Cycling England in those years. Estimates of time spent cycling per week and weeks of cycling per year from these surveys were applied as input data to the Health Economic Assessment Tool (HEAT) for cycling (Rutter et al., 2007). HEAT estimates the life years saved or mortality benefits that arise from the physical activity associated with cycling.

The estimates in the study by Cavill and colleagues require certain assumptions, including the assumption that people would continue cycling at the present rate for the next ten years. Although predictive assumptions of this kind are admittedly not easy to make (Petticrew et al., 2006), they are open to challenge. The limitations of the data used in this study typify those of the field in general, and include issues of reliance on self-reported behavioural data, potential recall bias, and estimates of the association between increased physical activity and all-cause mortality based on two epidemiological studies (Andersen et al., 2000; Khaw et al., 2006). These issues are unavoidable within the constraints of currently available data and are acknowledged by the authors (Cavill et al., 2009; Cope et al. 2010).

The study by Chapman et al. (2009) points to the need to consider as wide a range of benefits as possible, including health and environmental benefits, when assessing the value for money of an intervention to improve housing quality. From an environmental, energy and health perspective, the value for money of improving housing quality by retro-fitting insulation in the deprived communities is strong. However, this must be qualified by the cohort in the study as those with respiratory problems had insulation retro-fitted.

The health benefits of reduced pollution from creation of home-zones are a major omission in the decision tree, as poorer communities, often the subject of home-zoning, on average experience higher concentrations of pollution and higher prevalence of cardio-respiratory and other diseases; in Britain 66 per cent of carcinogenic chemicals emitted into the air are released in the 10 per cent most deprived wards (Geddes et al. 2010). Similar findings from Italy support these findings, from a longitudinal study of the socioeconomic position and health status of people who live near busy roads in Rome (Cesaroni et al. 2010).

Evidence for the likely distribution of health benefits across the community

The evidence for health equity was informed by the paper accompanying the Marmot review, outlined in a presentation to the PDG, for the health equity implications of modifications to the built environment for active travel, open space/green infrastructure (Geddes et al. 2010).

Evidence from the Department for Transport on the first wave CDTs emanates from the same dataset and source Cope et al (2010) used to estimate health benefits in this review. Figure 3 in the paper by Geddes and others, demonstrates the proportion of people cycling (and therefore likely to be benefiting from the associated health improvements) in six first wave CDTs follows a clear social gradient across social classes A-E (i.e. prevalence is highest in social classes A and B and lowest in class E) (Geddes et al. 2010). The lower the social grade of a person, the less likely they are to cycle. The whole-town interventions in the cycling demonstration towns provide a coordinated programme of infrastructure, initiatives and facilities. Cycling has increased in all six CDTs where interventions have been implemented from 2006 to 2009 and evidence demonstrates increased prevalence of cycling has happened across the social gradient in similar proportions and has therefore not altered the slope of the social gradient. Approximately equal increases in take-up of cycling across classes suggests there is no basis, a priori, that good quality, appropriately located whole-town infrastructure for cycling will lead to more inequality in the distribution of health benefits in those who choose to take-up cycling (Geddes et al. 2010).

Geddes et al. (2010) suggest improving good quality open and green spaces that are well designed, and close to people's homes would be a second priority. In deprived neighbourhoods, good quality green space can increase levels of social contact and integration which should be borne in mind when creating home-zones and streetscapes. Proximity to good quality green space for green exercise, such as, walking will provide clear health benefits for a local community, prevalence rates for diabetes, cancer, migraine/severe headaches and depression are lower in areas with more green space within a one kilometre radius (Pretty et al. 2010).

There is good evidence in this review for improving the energy efficiency of housing by retro-fitting insulation (Chapman et al. 2009). This would go some way to decreasing the fuel poverty of households in deprived areas and decreasing CO_2 emissions which helps to tackle climate change and has positive health impacts.
Geddes et al. (2010) show cold housing is a clear health risk. It is believed to be the main explanation for the excess winter deaths that occur each year, where 33% of the poorest fifth of households are in fuel poverty, compared to less than 1% of the richest fifth of houses.

Conclusions

There is some evidence demonstrated by decision trees for the cost-effectiveness of comprehensive health assessment integrated into other assessments that leads to effective planning and collaboration. However, the analysis produced here is very sensitive to assumptions made about the probability of events that increase costs in the models. Other evidence uncovered during this review indicates infrastructure for walking and cycling and retro-fit of homes with insulation could be targeted progressively across the social gradient without widening health inequalities. It is apparent that a pre-condition for integrating economic, social (equity) and environmental objectives at the local level is effective collaboration between state (national and local), market and community interests, together with coherent inter-agency working – particularly planning with transport with housing, regeneration, parks and economic development. This is the ideal of spatial planning, often not realised.

APPENDIX A: DATA EXTRACTION TOOL

Study reference:		
Checklist completed by:		
Date checklist completed:		
1. Type and level of resource use – unit costings and prices		
2. Input parameters – where main uncertainty lies		
3. Relative health benefits and risks		
4. Likely pattern or extrapolation of health benefit and/or risk over time		
5. Type level and magnitude of life years saved (one-off) or continuous survival benefits or QALYs or health states		
6. Probabilities - event rates or measured frequency of an event in a population		
7. Reviewer's comments		
Overall assessment of quality for the evidence presented in the study:	**Rating**	**Comment**
Are the findings generalisable to the source population (i.e. externally valid)? **This reflects the extent to which the findings of the study are generalisable beyond the confines of the evidence to the source population.**	☐ ++ ☐ + ☐ -	

APPENDIX B: STUDY REPORTS

Comprising:

- **Completed Study Data Extraction Forms; and**
- **Evidence for modelling statements**

Study reference: Atkinson, P. Cooke, A. (2005) Developing a framework to assess costs and benefits of Health Impact Assessment. Environmental Impact Assessment Review, 25:791-798.

Checklist completed by: Jane Powell

Date checklist completed: 2nd November 2010

Summary: This paper presents some early thinking about how the costs and benefits of HIA might be assessed using a Healthy Living Centre in Dulwich, SE London as a case study to highlight the possibilities and difficulties of collecting the necessary data on the costs and benefits of providing an integrated range of medical and other community services as part of a plan to redevelop Dulwich Community Hospital in SE London. It summarises the findings from other studies on this subject. It considers how evidence on the costs and benefits of HIA might make a difference to application of HIA in the decision making for planning.

1. Type and level of resource use – unit costings and prices

A small number of studies have attempted to evaluate HIA in the UK. These include Alconbury Airport HIA (Close, 2001), Finningley Airport HIA (Abdel Aziz, 2003), the review of four Mayoral strategies (London Health Commission, 2003). Other papers in this edition add further examples (Elliott and Francis, 2005; Bekker et al., 2005). Very few of these studies attempted to quantify the cost of each study and in many instances cost was not even mentioned. The Alconbury evaluation (Close, 2001) estimated the time devoted to the project, a total of 684 hours, but did not convert this into a monetary value, and worked out that the additional expenses (printing, conferences, expenses) were £6000. The Finningley Airport evaluation (Abdel Aziz et al., 2004) took 348 person-days, equivalent to £52,200–69,600 assuming an average cost of £150–200 per day (including overheads). They spent £14,846 on outside consultants and around £2500 printing reports, so

the total cost of the HIA was between £69,200–86,600. Fleeman (1998) costed three projects within the Merseyside HIA programme some years ago at an average at £12,650 each, and Ardern (2004) calculated the costs of a local transport plan HIA study as £11,000, in addition to current work objectives.

Table 1 Main costs of the HIA of Dulwich Healthy Living Centre

Steering group and other meetings £2154

Rapid workshop with steering group £2964

Community profile £3800

Literature review £4537

Stakeholder consultation £2800

Community consultation £5209

Recommendations £3188

Total cost £25,000 approx (2005 prices)

2. Input parameters – where main uncertainty lies

Initially it was assumed that assessing the cost of the HIA would present no real problem, as detailed records were kept regarding expenditure and staff time devoted to the different stages of the HIA, but the task proved more difficult than expected. A decision was taken to include the cost of all staff time, irrespective of the organisation they worked for, to give a total cost rather than cost to the health service. This was the cost that should be used to make comparisons with other public health interventions. However, for some partner organisations staff salaries were not known and the individuals were not willing to share this information. In these cases salary had to be estimated. Staff overheads were not considered in these estimates, but in retrospect, should have been included. Total staff costs were then calculated from the time that individual had devoted to the HIA and their estimated hourly rate.

There were questions as to what contributions should be included, ie. the cost

of the time of someone who simply attended one 2 hour meeting, costs of community participants. Over 200 people attended a number of rapid HIA workshops, and were given no payment, but the value of their time might have been included in the total cost of the project. Other costs were largely fees paid to external HIA consultants and a small amount to support meetings and publish the various reports. These were relatively easy to quantify.

3. Relative health benefits and risks

The benefits of HIA were:-

1. Influencing decision makers – measured with survey of opinion on whether the HIA made a difference to decision making- indicated by the cost of the HIA
2. Improved interdisciplinary and interagency working – measured by attendance at meetings, minutes of meetings and evidence of joint working after HIA complete – indicated by costs of time for attending meetings
3. Promoting health – measured by pre-and post HIA survey to steering group members exploring understanding and practice – indicated by part of the cost of time devoted to HIA
4. Enhancing individual skills, knowledge and experience – surveys and interviews to assess skills before and after HIA, how these were used and what difference they made – indicated by part of cost of time devoted to the HIA
5. Encouraging community involvement – Post HIA workshop survey, numbers coming to later workshops – indicated by cost of time of participants coming to workshops.
6. Informing and assisting future HIAs – measured by numbers asking for copies of HIA – indicated by costs of printing and distributing report

4. Likely pattern or extrapolation of health benefit and/or risk over time

5. Type level and magnitude of life years saved (one-off) or continuous survival benefits or QALYs or health states

6. Probabilities - event rates or measured frequency of an event in a population		
7. Reviewer's comments		
Overall assessment of quality for the evidence presented in the study:	**Rating**	**Comment**
Are the findings generalisable to the source population (i.e. externally valid)? **This reflects the extent to which the findings of the study are generalisable beyond the confines of the evidence to the source population.**	☐ ++ x☐ + ☐ -	

Study reference: York Health Economics Consortium (2006) Cost benefit analysis of health impact assessment, London: Department of Health.

Checklist completed by: Jane Powell

Date checklist completed: 11th October 2010

Summary: This report sets out the findings of a cost benefit evaluation of Health Impact Assessment (HIA). York Health Economics Consortium followed 16 HIAs looking at the process impact outcomes and costs and benefits of HIA at the level of Local Strategic Partnerships (National and regional HIAs are also included). The findings show the benefits of HIA at local levels of planning development (LSPs) outweigh the costs, although the study uses a small sample. Eight of the sixteen HIAs are completed during the time period considered, so impact assessment is partial and the outcome evaluation of these HIAs is not possible.

1. Type and level of resource use – unit costings and prices

The final directly incurred costs (employees pay) in conduct of the local regional and national, stand-alone/integrated and rapid/comprehensive HIAs are captured on timesheets circulated to participating members of the HIA teams and their steering groups on a weekly basis. The breakdown of time allocations across activities are not given, so the type of resource use inputs to each type of HIA are not known. The time input from stakeholders was estimated on the basis of the number attending steering group meetings and the duration of these events.

Data extracted from Tables 3.2, 3.3 and 3.4 in the paper are:-

The average cost of eight complete and incomplete local, rapid, stand-alone HIAs is approximately £11,713 (2006 prices).

The average cost of two local, comprehensive, stand-alone HIAs (1 complete and 1 incomplete) is £5,533 (2006 prices).

The cost of one incomplete (scoping stage finished), local, rapid, integrated HIA is £2,790 (2006 prices).

The average cost of a local, comprehensive, integrated HIA is not given and cannot be estimated from those data presented.

2. Input parameters – where main uncertainty lies
The sample of HIAs in this study is not representative across the levels of planning, degree of integration of health into spatial planning and method of review
3. Relative health benefits and risks
Decision makers and stakeholders were asked to rank the value of the benefits from HIA relative to a number of hypothetical costed alternatives. Data extracted from table
4. Likely pattern or extrapolation of health benefit and/or risk over time
Of those HIAs completed during the course of the study, the benefits outweighed the costs, suggesting local, rapid, stand-alone HIAs are a cost-effective use of resources in general. The benefit to cost ratio (BCR) was in the range (1.2 – 2). Other data in the study suggests
5. Type level and magnitude of life years saved (one-off) or continuous survival benefits or QALYs or health states
6. Probabilities - event rates or measured frequency of an event in a population
7. Reviewer's comments
This process evaluation in this study revealed the difficulties and practical challenges encountered by organisations planning and undertaking HIA at local, regional and national levels. The study is able to say something quite robust, but is descriptive about the process of undertaking HIA through key informant interviews with decision makers and stakeholders. However, there is no firm evidence for the range of resource use inputs to different types of HIA (rapid versus comprehensive or stand-alone on health impacts versus comprehensive integration of health into other strategic spatial plans) versus evaluate the costs and benefits of HIA

Overall assessment of quality for the evidence presented in the study:	Rating	Comment
Are the findings generalisable to the source population (i.e. externally valid)? **This reflects the extent to which the findings of the study are generalisable beyond the confines of the evidence to the source population.**	☐ ++ x☐ + ☐ -	

Study reference: Mathias, R. & Harris-Roxas, B. (2009) Process and impact evaluation of the Greater Christchurch Urban Development Strategy Health Impact assessment. *BMC Public Health*,9,97:1-12.

Checklist completed by: Jane Powell

Date checklist completed: 10.10.10

Summary: Using key informant interviews, focus groups and questionnaires, this study conducts process and impact evaluations of the Christchurch HIA including evaluation of costs and resource use. The evaluation found that local HIA that consulted communities and stakeholders and integrated comprehensive health and wellbeing considerations had demonstrable direct impacts on planning and implementation of the final Urban Development Strategy as well as indirect impacts on understandings and ways of working in collaboration between public health and local government authorities. It summarises the 'modest' resource use connected with HIA and its important role in urban planning with intersectoral collaboration and enhanced relationships as both catalysts and outcomes of the HIA process.

1. Type and level of resource use – unit costings and prices

Data extracted from the base inputs are:-

Types of resource inputs to HIA estimated in NZ$/£-equivalents April 2005 prices, where 1NZ$=£0.38 are:-

1. Employment costs across:
   formal meetings NZ$9100, £3458
   steering group meetings NZ$2160, £821
   HIA dedicated employed hours NZ$31,850, £12103
   Total employment costs NZ$44,210 (2005 prices), £16,800
   with 50% uplift for overhead costs NZ$66,315 (2005 prices), £25,200.

   Hours of formal meetings for HIA 364 hrs
   (Cost per hour NZ$25, 2005 prices), £9.50 per hour

   Hours of steering group meetings 36 hrs

(Cost per hour NZ$60, 2005 prices), £22.80 per hour

Hours of desk and other work 950 hrs
(Cost per hour NZ$33.50, 2005 prices), £12.73 per hour

Total hours of activity for HIA 1350 hrs

2. Direct costs across the categories in 2005 prices are:
   Contractors = NZ$3840, £1459
   Literature reviewers NZ$1,700, £646
   Flights/travel = NZ$770, £293
   Conferences attended = NZ$1500, £570
   Other (catering) = NZ$200, £76
   Total = NZ$8010, £3044
3. The total costs of this HIA NZ$74,325, £28,244 (2005 prices) are borne by Canterbury District Health Board (CDHB) and Christchurch City Council (CCC) from existing employee and budget lines in both organisations. Direct costs are 11% of the total costs of HIA and employment costs 89% of the total costs of HIA.

2. Input parameters – where main uncertainty lies

3. Relative health benefits and risks

HIA considered the following health and wellbeing aspects:-

- air quality
- water quality
- social connectedness
- housing
- transport
- engagement with Maori

Table 2 of the paper summarises HIA recommendations included in the UDS approaches and top twenty priorities for action in the development plans

	No. of HIA recommendations included in UDS approaches	No. of UDS actions addressing HIA recommendations	No. of top twenty actions linked to HIA recommendations
summary	1 of 4	1	0
air quality	4 of 6	2	0
water quality	4 of 5	2	1
social connectedness	6 of 6	5	2
housing	3 of 4	2	1
transport	5 of 7	4	0
engagement with Maori	1 of 1	1	0
Total	24 of 33	17	4

Cross-sectoral collaboration was felt to be key to integrated health and wellbeing considerations being included in the UDS

4. Likely pattern or extrapolation of health benefit and/or risk over time

The process of assessing and incorporating HIA recommendations in the UDS was described by key informants as informal. Responsibility for decision-making rested with planning and policy making staff at CCC responsible for the UDS. They described having read and considered the HIA report while preparing the policy document. HIA recommendations were translated into plan actions to some extent, but CCC also used these recommendations to inform their policy approaches or philosophies that will

continue to direct urban developments through later revisions to planning deliveries. This particular HIA seemed to have impact in terms of the social connectedness aspects of the UDS where 5 of the six recommendations made in the HIA were transferred to UDS action plans
5. Type level and magnitude of life years saved (one-off) or continuous survival benefits or QALYs or health states
Outcome evaluation of HIA not possible in the timeframe.
6. Probabilities - event rates or measured frequency of an event in a population
7. Reviewer's comments
There is more support in this study for the conclusion that HIAs are ill-suited to formal cost-benefit analysis as many of the benefits are long term and indirect in forms that cannot be easily measured.

Overall assessment of quality for the evidence presented in the study:	**Rating**	**Comment**
Are the findings generalisable to the source population (i.e. externally valid)? **This reflects the extent to which the findings of the study are generalisable beyond the confines of the evidence to the source population.**	x☐ ++ ☐ + ☐ -	

Study reference: Cope et al. (2010) Cycling Demonstration Towns – An Economic Evaluation. London: Department for Transport

Checklist completed by: Emma Bird

Date checklist completed: 3rd November 2010

Summary: This paper sets out the findings of an economic evaluation of the first phase of the English Cycling Demonstration Town investment program. The economic evaluation used monitoring data and applied both the WebTAG framework and the World Health Organisation's HEAT for cycling tool in novel contexts.

Using previous literature and report findings, the paper assumes that the program will lead to:

- Reduced absenteeism
- Road decongestion
- Incidence of accidents
- User amenity, or journey ambience
- Changes in levels of physical activity.

The study reveals that the benefits of the program outweigh the costs despite the limited age of the sample and possible lack of control upon external cycle scheme influences.

The study reveals a benefit to cost ratio in the range of 2.6 – 3.5.

Suggestions for future development and improvements are made.

1. Type and level of resource use – unit costings and prices

- The six towns received funding of £500,000 per year (approximately £5 per head of population per year), starting in October 2005, and matched by the respective local authorities so that the total level of investment in cycling was at least £10 per head per year.
- One of the towns, Aylesbury, had a smaller population (65,000 people), and hence received a lower absolute level of funding (approximately £300,000 per year).
- Two of the towns, Derby and Brighton and Hove, had larger populations of approximately 250,000 people. These towns did not receive higher levels of funding, but instead targeted their efforts on a portion of their population. In Derby this was achieved by focusing on children and young people; while in Brighton and Hove the effort was focused on the western half of the city.
- The total investment through the program amounted to around £18 million.

2. Input parameters – where main uncertainty lies

- It is possible that changes in cycling activity may have been influenced by schemes not funded under the Cycling Demonstration Towns program. For example, Darlington was receiving additional funding during this period as part of the Sustainable Travel Towns program.

- Benefits have been calculated based on changes in the number of over-16s cycling only. A number of the Cycling Demonstration Towns targeted schools and there is some evidence that cycling rates amongst school-aged children did increase as a result.
- Many of the impacts valued in this analysis have not been directly observed but estimated using the change in the level of cycling in the Cycling Demonstration Towns.
- The costing model differed from that of previous studies in that the assumed economic life of the infrastructure was much lower (10 years) and no maintenance costs were included. The three-year Cycling Demonstration Towns programme cost GBP£18.7m giving a net present value (NPV) of £17.45 m (2005 prices).
- Adult mortality impacts were estimated from usage data, which were collected using self report surveys of the number of additional adults cycling regularly between 2006 and 2009. These data were factored up using weekly and annual cycling frequencies and projected into the short term future assuming that people would continue to cycle at 2009 levels of participation for the next ten years.

3. Relative health benefits and risks

Estimate of benefits and costs over a 10 year period claimed that:

- Reduced mortality – benefit of £45 million – the single most significant benefit of the program accounting for between 70% and 96% of net benefits.
- The largest negative impact is the dis-benefit of increased accidents amongst cyclists which is estimated to cost up to £15 million although there is uncertainty about whether the program increased the total number of cycling casualties.
-

4. Likely pattern or extrapolation of health benefit and/or risk over time

- Over 10 years, the benefits outweigh the costs suggesting that the program is a cost-effective use of resources in general.
- The total benefits were predicted to total £47-64 million, and costs placed at £18 million.
- The benefit to cost ratio (BCR) was predicted to be 2.6 – 3.5.

Impact	Estimate of benefits and costs over 10 year period (2007 Prices)
Reduced Mortality	Benefit of £45 million
Decongestion	Benefit of £7 million
Reduced Absenteeism	Benefit of £1-3 million
Amenity	Benefit of £9 million
Accidents	Dis-benefit of £0-15 million
Total Benefits	**£47-64 million**
Costs	£18 million
Benefit to Cost Ratio	**2.6-3.5**

5. Type level and magnitude of life years saved (one-off) or continuous survival benefits or QALYs or health states

6. Probabilities - event rates or measured frequency of an event in a population

- Data from automatic cycle counters showed an increase in cycling levels across all six towns (27%) measured from 2005 to 2009.
- Using figures from Active People Survey, the proportion of adult residents cycling for at least 30 minutes once or more per month increased from 11.8% in 2006 to 15.1% in 2008.

7. Reviewer's comments

Overall assessment of quality for the evidence presented in the study:	**Rating**	**Comment**
Are the findings generalisable to the source population (i.e. externally valid)? **This reflects the extent to which the findings of the study are generalisable beyond the confines of the evidence to the source population.**	☐ ++ x☐ + ☐ -	

Study reference: Rutter, H. Cavill, N. Dinsdale, H. Kahlmeier, S. Racioppi, F. Oja, P.(2008) Health Economic assessment Tool for Cycling (HEAT for cycling). Methodological guidance on the economic appraisal of health effects related to walking and cycling.

Checklist completed by: Jane Powell

Date checklist completed: 09.10.10

Summary: This paper presents guidance for use of the WHO Health Economic Assessment Tool for Cycling (HEAT for cycling). The HEAT tool is available to download as an Excel spreadsheet to assist anyone who wishes to conduct an economic appraisal of the health effects related to increased cycling. HEAT should complement existing tools for economic appraisals of transport interventions which have traditionally focussed on emissions or congestion. HEAT can be used to estimate the reduced mortality benefits connected with changes in levels of cycling, such as those that might be induced by land use, engineering infrastructure and neighbourhood design development plans. HEAT helps to answer the question if x people cycle y distance on most days, what is the value of the increased health benefits that occur as a result of the reduction in mortality due to their increased physical activity?

1. **Type and level of resource use – unit costings and prices**

2. **Input parameters – where main uncertainty lies**

The risk reduction associated with data on three variables.

1. Distance cycled
2. Total number of days cycled per year
3. Average speed of cycling

Or changes in these are required as input parameters to run the HEAT tool and estimate the life years saved as a result of increased physical activity from cycling.

If 50% of an extra x% cyclists on top of the baseline number of cyclists are created through implementation of a development plan based on integrated HIA. The net mortality benefit from life years saved are ?? minus the life years lost ??? multiplied by the value of a statistical life £1.25m.

The main uncertainty arises from variations in setting and context for the development planning.

3. Relative health benefits and risks

The formula for estimating the RR of death among cyclists in any community sample is a function of (the distance cycled as a result of implementation of a development policy/ distance cycled in the Copenhagen study) and the RR of death in the Copenhagen study (Anderson et al. 2000).

HEAT formula is:-

$$1 - \frac{\text{[Distance cycled]}}{\text{[Distance cycled in Copenhagen study]}} \times [1\text{-RR*}]$$

4. Likely pattern or extrapolation of health benefit and/or risk over time

The HEAT model assumes a linear dose-response relationship for the relationship between time spent cycling and reduction in relative risk of death from all-causes of disease with no thresholds for the amount of physical activity needed to incur health benefits. HEAT uses a discount rate of 5% for future health benefits.

There is also a safety in numbers effect created by the number and density of cyclists on routes shared between traffic and cyclists which lowers the risk of the killed and seriously injured (KSI) category of RTAs.

5. Type level and magnitude of life years saved (one-off) or continuous survival benefits or QALYs or health states

The relationship between the amount of cycling and the mortality benefits generated is related to spatial design, context and setting for cycling. Traffic free routes for cyclists facilitate lower health risks from exposure to pollution and likelihood of road traffic accidents.

6. Probabilities - event rates or measured frequency of an event in a population		
The relative risk (RR) of death in the Copenhagen study 0.72 is used as the benchmark value for estimating the RR of death from another population sample. HEAT model assumes 50 per cent of all cyclists incur health benefits from regular cycling which is probably a conservative assumption.		
7. Reviewer's comments		
Overall assessment of quality for the evidence presented in the study:	**Rating**	**Comment**
Are the findings generalisable to the source population (i.e. externally valid)? **This reflects the extent to which the findings of the study are generalisable beyond the confines of the evidence to the source population.**	x☐ ++ ☐ + ☐ -	

Study reference: Johan de Hartog, J. Boogaard, H. Nijland, H. Hoek, G. (2010) Do the health benefits of cycling outweigh the risks? *Environmental Health Perspectives,* 118, 8:1109:1116.

Checklist completed by: Jane Powell

Date checklist completed: 20.10.10

Summary: This paper quantifies the impact on all-cause mortality when 500,000 people in a cohort, age 18-64 years, distributed in age categories equivalent to the Dutch population in 2008, make a transition from car to bicycle for short trips on a daily basis in the Netherlands. The paper summarises the literature for health benefits and health risks of air pollution, traffic accidents and physical activity associated with a modal shift from car use to cycling using systematic reviews supplemented with recent key studies. The paper makes international comparisons of net life years saved from the health benefits and risks associated with cycling demonstrating how the net health benefits are substantial and positive compared with the health risks, but vary to some extent between the Netherlands and other countries including the UK. The authors explain that lower differential net benefits in other countries might be related to less conducive physical and social environments for cyclists in other countries compared with the Netherlands. The paper states that urban planning might contribute to health benefits by separating cycle lanes from heavily trafficked roads.

1. Type and level of resource use – unit costings and prices

2. Input parameters – where main uncertainty lies

A scenario based on statistics from the Netherlands was used to derive the relative risks comparing car driving and cycling. The scenario assumes a transition from car driving to cycling for 500,000 people 18-64 years of age for short trips on a daily basis in the Netherlands. Calculations were made for daily travelled distances of 7.5km and 15km – for example , people commuting to and from work for 3.75km (the average short trip) or 7.5km (the maximum short trip). The scenario implies a modal shift of about 12.5% of the 7.95 million short car trips, described as an ambitious, but not unrealistic

percentage. In the Netherlands, 40.8% of people aged 18 years or more own both a car and a bicycle and therefore may be able to shift modes on a daily basis. The scenario is mostly used to calculate air pollution, physical activity, and accident impacts, combined with more generic concentration-response functions.

Uncertainty is introduced through the difficulties in estimating these input parameters accurately. The following assumptions and parameters introduce uncertainty in the estimates presented:-

1. Accuracy of the measurement and calculation of risk exposures connected with the modal shift
2. The age profile of benefits from physical activity and risk of air pollution and RTAs
3. Shape of concentration-response functions in general and across age profiles of the population
4. The substantial influence of contextual factors, planning developments, location and use of space, 'perceptions of safety' for infrastructure used to walk and cycle compared with location of traffic on net health benefits
5. Scenarios and findings applicable to developed countries
6. The assumptions made about 'safety in numbers effects' and 'physical activity substitution' associated with modal shift.

3. Relative health benefits and risks

For the Dutch cohort the health benefit exposure effects estimated and associated with modal shift from car use to cycling are:-

- Increased levels of physical activity – no physical activity substitution assumed
- Decreased air pollution emissions
- Decreased green house gas emissions

The health risk exposures estimated and associated with modal shift from car use to cycling are:-

- Individual adverse health effects associated with higher exposure to air pollution on a bike

- Increased risk of road traffic accidents (RTAs)

A health risk identified, but not included is:-

- Adverse individual and/or age-related health effects associated with increased physical activity (musculoskeletal injury and fatal and non-fatal cardiac events)

4. Likely pattern or extrapolation of health benefit and/or risk over time

Concentration(of exposure/)-response functions are used, but no indication is given of the shape of the functions

5. Type level and magnitude of life years saved (one-off) or continuous survival benefits or QALYs or health states

Mortality impacts are expressed in life years gained or lost using life table calculations. On average, the estimated health benefits of cycling were substantially larger than the risks relative to car driving for individuals shifting their mode of transport. For individuals who shift from car to bicycle, the beneficial effects of increased physical activity are substantially larger (3-14 months gained) than the potential mortality effect of increased inhaled air pollution doses (0.8-40 days lost) and the increase in traffic accidents (5-9 days lost). Societal benefits are even larger because of a modest reduction in air pollution, greenhouse gas emissions and traffic accidents.

For people who shift from using car to bikes the systematic review evidence in this paper demonstrates:-

On average across whole population, the increased health benefits due to physical activity (RR= 0.50-0.90)

The potential mortality effect of increased inhaled air pollution doses (RR= 1.001-1.053)

The potential mortality effect of road traffic accidents (age-specific RR, 0.993-1.020)

6. Probabilities - event rates or measured frequency of an event in a population

7. Reviewer's comments		
Overall assessment of quality for the evidence presented in the study:	**Rating**	**Comment**
Are the findings generalisable to the source population (i.e. externally valid)? **This reflects the extent to which the findings of the study are generalisable beyond the confines of the evidence to the source population.**	x☐ ++ ☐ + ☐ -	

Study reference: Chapman, R. Howden-Chapman, P. Viggers, H. O'Dea, D. Kennedy, M. (2009) Retro-fitting houses with insulation: A cost-benefit analysis of a randomized community trial. *Journal of Epidemiology and Community Health*, 63:271-277.

Checklist completed by: Emma Bird

Date checklist completed: 16 November 2010

Summary:

- Housing is an important environmental influence on population health, and there is growing evidence of health effects from indoor environment characteristics such as low indoor temperatures.
- The purpose of this study was to value the health, energy and environmental benefits of retro-fitting insulation, through assessing a number of forms of possible benefit: a reduced number of visits to GPs, hospitalisations, days off school, days off work, energy savings and CO_2 savings.
- A randomized control trial was conducted in 1350 predominantly low-income homes with at least one member of the household displaying symptoms of respiratory disease.
- The article assumes that an improvement in dwelling place will improve health, save energy resources and reduce greenhouse emissions.
- The study reveals that the benefits of the program outweigh the costs with a benefit–cost ratio of 1.87:1.
- It points to the need to consider as wide a range of benefits as possible, including health and environmental benefits, when assessing the value for money of an intervention to improve housing quality. From an environmental, energy and health perspective, the value for money of improving housing quality by retro-fitting insulation is compelling.
-

1. Type and level of resource use – unit costings and prices

- The overall cost per household in 2001 was NZ$1800 (excluding value added tax).

2. Input parameters – where main uncertainty lies

A number of factors should be considered in drawing broader conclusions about potential benefits of retro-fitting insulation for a wider population:

- The full benefits will only accrue in initially un-insulated houses, but some benefits will accrue even where houses are only partially insulated.
- The households in the sample were a mix of tenure types, although with a smaller proportion renting than the general population.
- The households were also distributed across a mix of areas, including small semi-rural areas, towns and cities, in both the North and South

Islands of New Zealand. These areas are not atypical; they tend to be lower socioeconomic status areas, but not markedly so.

- There are also a limited number of house construction types in New Zealand and the sample was indicative of the range.

3.Relative health benefits and risks

- The health effects quantified and valued were changes in the number of visits to GPs, the number of hospitalisations, and the number of days off school and off work.
- Potential health gains not assigned a value include the everyday enhancement of physical and emotional wellbeing arising from a warmer and/or more comfortable dwelling, and avoidable premature mortality.

4. Likely pattern or extrapolation of health benefit and/or risk over time

- Total savings amount to NZ$3374 (2002 prices) per household, with total costs of $1800. Thus, net benefits (or to be more precise, the NPV of net benefits) are $1574 per household. About two-thirds of the benefits are due to reductions in hospital admissions.
- The benefit–cost ratio is 1.87:1, a comfortable margin above 1.0. At a higher discount rate of 7%, the ratio is 1.59.
- The benefits accruing over time, in terms of health gains and energy savings, are a comfortable margin in excess of the costs of installing insulation in the houses in the study.
- The estimated benefits are resource savings in the health sector and energy sector, and the value of avoided days off school and work, together with wider community benefits of emission reductions.
- The total benefits exclude certain aspects of benefit noted above, in particular, significant enhancement of physical and emotional wellbeing arising from a warmer and/or more comfortable dwelling, possible reductions in mortality, and long-term health benefits as a result of reduced childhood illness.

5. Type level and magnitude of life years saved (one-off) or continuous survival benefits or QALYs or health states

NA

6. Probabilities - event rates or measured frequency of an event in a population

- There was a reduction of 100 inpatient (overnight) hospital stays for older people, which constituted the greatest area of health cost saving.
- Days off school and days off work were significantly reduced by 1828 and 102 respectively.
- However, there was a small increase (additional 45 visits) in the number of GP visits over the 3 months of winter. The estimated total cost increase is

around NZ$165 per household.
7. Reviewer's comments

Overall assessment of quality for the evidence presented in the study:	**Rating**	**Comment**
Are the findings generalisable to the source population (i.e. externally valid)? This reflects the extent to which the findings of the study are generalisable beyond the confines of the evidence to the source population.	x☐ ++ ☐ + ☐ -	

Study reference: Yang, L. Sahlqvist, S. McMinn, A. Griffin, S. Ogilvie, D. (2010) Interventions to promote cycling: a systematic review. *BMJ*; 341:c5293 doi:10.1136/bmj.c5293

Checklist completed by: Emma Bird

Date checklist completed: 28.11.10

Summary:

The paper aimed to determine the effectiveness of cycling interventions in terms of changes to:

- Cycling rates
- Travel behaviour
- The effects of individual marketing on environmentally friendly modes of transport.

In all, twenty five studies were reviewed with approaches ranging from intensive support for individuals, to improving physical infrastructure.

Community-wide projects and improvements to infrastructure were found to display some, if limited, potential to increase cycling behaviour. Future research incorporating more robust, scientific methodology is however required to reduce the problem of self-reported data.

Similarly, individualised marketing techniques reported positive effects; however methodological problems again must be addressed.

The interventions designed to change travel behaviour found only slight or no evidence of an increase in cycling (0.17 trips per week).

Overall, the review demonstrates that it remains unclear whether increases in cycling could be achieved at a lower cost by addressing attitudes and perceptions relating to cycling behaviour.

1.Type and level of resource use – unit costings and prices

2.Input parameters – where main uncertainty lies

- Many of the studies included in the review relied heavily upon self-reported measures of cycling, resulting in unknown reliability and validity.
- There was limited information provided regarding how and why control group participants were categorized into the control group – more robust study design required.
- It was often unclear whether increases in cycling rates demonstrated increasing rates of new cyclists, or whether regular cyclists were simply cycling more frequently.

3.Relative health benefits and risks

Although the review did not set out to directly examine the evidence for the health benefits of cycling, the authors note the complementary body of evidence to support the assertion:

- Cooper et al (2008) and De Geus et al (2009) – at an individual level, cycling to work or school is associated with greater cardio-respiratory fitness.

4.Likely pattern or extrapolation of health benefit and/or risk over time

A small number of studies found that interventions designed specifically to promote cycling were associated with positive effects, with results maintained at follow-up.

This is supported by the Department of Health and Department of Transport (2010) and De Hartog et al (2010), who claim that the health benefits attributable to greater use of physically active modes of transport substantially outweigh adverse effects related to risk of injury or exposure to inhaled pollutants.

5.Type level and magnitude of life years saved (one-off) or continuous survival benefits or QALYs or health states

6.Probabilities - event rates or measured frequency of an event in a population

- Interventions to promote cycling at population level were associated with net increases of up to 3.4% in the proportion of trips made by bicycle or in the population prevalence.
- The interventions designed to change travel behaviour found only slight or no evidence of an increase in cycling (0.17 trips per week).
- The studies investigating the effects of individualised marketing of environmentally friendly modes of transport reported an average net effect of eight additional cycling trips per person, per year in the local population targeted.

7.Reviewer's comments

Overall assessment of quality for the evidence presented in the study:	**Rating**	**Comment**
Is the evidence internally valid (i.e. unbiased)? How well does the evidence minimise sources of bias? Were	x☐ ++ ☐ + ☐ -	

there significant flaws in the design of the evidence?		

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