transport for quality of life

CWIS Active Travel Investment Models: Model structure and evidence base

Technical appendix 4: Overview of evidence on increasing active travel

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Contents

1. Introduction

This appendix provides an overview of the evidence on the relationship between **cycling and walking investment** and **change in cycling and walking levels**, and the factors that influence this relationship.

It updates and substantially extends the Rapid Evidence Assessment (REA) on this topic that was undertaken for DfT by Brook Lyndhurst in October 2016. While it has a particular focus on recent evidence, older evidence has also been included where relevant and useful[1].

The purpose of the evidence review was to inform the development of the Active Travel Investment Models.

A separate Technical Appendix 5 'Compendium of interventions' provides evidence on the impacts and the range of costs per unit of uplift in cycling and walking for each individual intervention.

This review drew on the following sources:

(a) Local authorities that delivered walking and cycling schemes as part of the Local Sustainable Transport Fund (LSTF), with evidence sought at both an 'intervention' level and area or city-wide level

(b) NGOs that have delivered walking and cycling interventions e.g. Sustrans, Living Streets, Cycling UK, British Cycling, TABS, the Bikeability Trust, Bikeplus, Challenge for Change

(c) Transport consultancies and private organisations

(d) The academic literature, focussing on material published since the 2016 REA. Scopus was used to search on seven specific topics[2] supplemented with studies known to team members

(e) Review of relevant sustainable transport evaluation and research reports produced for DfT (covering LSTF, cycling investment programmes, personal travel planning, school travel planning, revenue /capital balance etc.), reports from Transport for London and other grey literature. For this update this included a number of recent overview studies [223, 224,225], that have provided additional supporting evidence on the efficacy and benefits of interventions. Some of the references from those studies are included in this report.

Evidence at the area or city-wide level necessarily came from evaluations of the larger local authority programmes or academic literature, while most of the evidence at the intervention level came directly from local authorities, NGOs and private companies. Few of the academic studies provided cost/outcome data in a form that enabled walking and cycling uplift per unit of expenditure to be estimated but these studies were useful in corroborating the effectiveness of interventions or providing additional data or context that was helpful for development of the model.

The interventions were categorised by type, as shown in Table 1 at the end of this Appendix. The interventions related to all four of the categories in Fishman's typology, as adopted by the previous REA: (1) physical environment (e.g. bike lanes, storage), (2) socio-cultural (e.g. workplace, community or school based interventions), (3) intra-individual (e.g. travel planning, bike training) and (4) policy/regulation interventions (e.g. salary sacrifice schemes).

[1] Some of the earlier studies were included in the original REA, for example references 81 or 161, or are updated versions of key studies, for example reference 2.

[2] (1) Area-, town- or city-wide development of high quality walking networks; (2) 'Flagship' off-road cycle and pedestrian paths (especially those aimed at leisure trips); (3) Town or city-wide 20mph zones; (4) On-street cycle hire schemes; (5) Schemes to increase availability of e-bikes; (6) Built environment factors e.g. urban intensification / creation of walkable neighbourhoods; (7) Town- or city-wide development of cycle path networks (segregated routes on main roads and signed quiet routes) + supporting measures.

In total over 200 sources of evidence were used to develop summaries of well over 100 individual schemes / interventions, packages of interventions, and national programmes across 30 categories. The interventions included both capital and revenue schemes ranging in costs from a few tens of thousands to tens of millions of pounds. For some categories there were only one or two sources of evidence while for others there were more, allowing greater confidence in the range of costs estimated. The sources of evidence have been given a unique reference number, cited in grey text within the report, for example [1, 2], and fully listed in the references at the end.

2. Issues with the evidence

There were a number of issues with the evidence collected from all sources.

Evidence quality: There was a wide range in quality and clarity in the evidence found, both from academic and non-academic sources. Where possible we tried to clarify questions about the data with the original sources but due to staff changes or time constraints this was not always possible. While the body of evidence from local authorities was generally less robust than the academic studies, this was compensated for by the fact that the former was more recent, UK-specific and more likely to include relevant cost and outcome data.

Cost boundaries: Interpreting the evidence on costs was not straightforward, particularly when part of a larger programme, due to a range of potential hidden costs including officer support time, general promotional support or costs spread over other projects. This may contribute to the variability in costs between interventions in the same category.

Attribution: Most non-academic studies lacked control data, and much of the evidence relied on reported trip data from surveys, rather than measured trips. Even where there was good evidence of an uplift of walking and cycling after an intervention, based on measured counts or participant surveys, it was sometimes difficult to attribute the uplift to the specific intervention. This was particularly the case when many interventions were delivered in tandem such as during the LSTF programme, or for large area-wide schemes. The influence of other background factors such as the general economic situation, petrol prices etc which may have influenced outcomes is also difficult to account for in the absence of control data.

Estimating cost of uplift: Interventions with evidence on both cost and outcome data potentially allowed the cost per uplift to be estimated. However for many interventions the outcomes were reported in terms of a change in modal share or percentage of participants who increased their levels of walking and cycling. Assumptions had to be applied to convert these outcomes into an annual trip number. We have generally used conservative assumptions (e.g. assuming an increase in cycling following an intervention will be lower or not sustained in the winter months). The estimated costs per trip may change over time as new evidence emerges.

Capital vs revenue schemes: For the purposes of the model we have estimated **costs per additional annual trip**, in the year of, or the year after, full implementation of the initiative. However it is important to note that for capital schemes annual trips are likely to increase and then stabilise, probably over a timescale of one to two years, whereas for revenue projects annual trips may peak quickly and then diminish over time. The model does take account of these build-up and decay effects. The cost per additional annual trip should therefore not be taken as a measure of the overall value for money of an intervention (for which the cumulative cost divided by the cumulative additional trips is the more relevant measure).

Scale of intervention: There is typically more outcome data on larger projects due to the disproportionate cost of collecting outcome data for smaller interventions. This may have provided a slight bias towards evidence on larger projects e.g. flagship cycle routes or large scale household PTP, rather than smaller-scale interventions, particularly capital schemes, which may be equally effective in terms of cost per uplift but where outcome data is lacking.

3. Main findings on costs and effectiveness

The following summarises the key findings from the evidence for different categories of intervention.

3.1 Large scale capital schemes – networks and flagship routes

This includes urban-wide cycle/walking networks based on data and analysis from the Sustainable Travel Towns (STTs), Cycling Demonstration Towns / Cycling City and Towns (CDTs/CCTs), LSTF and Cycle City Ambition (CCA) schemes. It also includes evidence from Sustrans Connect2 and Links to Schools projects and outcome data from Transport for London (TfL) Cycle Superhighways and Quietways, plus a number of academic studies.

Evidence from a number of UK schemes and academic studies shows cycling increasing in areas with area-wide cycling programmes by 0.5-6% per year and increases on flagship routes by up to 60% for cycling and around 50% for walking, albeit the latter do not take account of reassignment (relocation from different routes) [1, 2, 3, 5, 7, 10, 11, 13, 14, 16, 17, 210]. However there is a large variation in cost per trip depending on what method is used to estimate trips. For area-wide cycling networks/programmes the costs range from £10 - 70 per additional cycle trip, with higher costs in smaller urban areas, and lower costs in larger urban areas. For flagship routes the costs range from £13 - £21 for additional active travel trips when routes are first introduced, with links to schools at the lower end of the cost range [188]. All of these costs may fall significantly over time if cycling and walking volumes grow.

Evidence from the LSTF Large Projects based on cycle counts and surveys shows an increase in cycling volumes. This is corroborated by analysis of data from the Active People Survey (APS) which shows a statistically significant increase in cycling participation in the Large Project local authorities compared to a control group of local authorities [1]. There was also scheme-specific evidence of increases in walking, but the APS did not show evidence of this at a programme level. LSTF costs per cycle trip were substantially lower than costs estimated from most CDT/CCT schemes [1,2]. This may reflect the fact that most CDT/CCTs were small to medium-sized towns, whereas the LSTF Large Projects were in larger urban areas. One piece of evidence tending to support this inference is the observation that the cost per cycle trip in the largest of the CCTs (Bristol) was comparable to the cost per trip for the LSTF Large Projects.

Some of the estimates for individual routes do not take account of reassignment. Some studies suggest most of the increase is reassignment with a modest 4-6% new trips after two years [16]. Emerging evidence from the CCA Programme suggests a higher figure of 18% new trips after only one year [22]. Other studies have shown that new local routes displace walking/cycling trips in the short term but generate new trips in the long term, with one study estimating an additional 4 minutes/year walking and cycling after the first year [7]. There is no evidence that effects decay over time.

In terms of factors influencing effectiveness, some studies have also shown that proximity of home residence to a bike path is associated with increases in active commuting and likelihood of cycling to work [5, 12]. Segregated cycle paths were found to be more effective at increasing the propensity to cycle to work than unsegregated paths [8, 18]. There is also some evidence that cycle networks with greater route density encourage more cycling trips than linear routes [23].

3.2 Built environment factors and neighbourhood traffic calming (20mph schemes)

There is substantial evidence from academic studies that different attributes of the built environment increase the likelihood of walking and cycling: for example in one review 24 out of 28 built environment attributes were found to increase walking/cycling [208]. However, there is very limited information that enables cost per increased trip to be estimated. Several studies point to residential density being a key factor for walkability, with a housing density of over 40 dwellings/ha found to double the likelihood of walking for transport compared to lower density areas [211, 219], and one study suggests an optimal density for walking which, in a UK context, works out at around 48 dwellings/ha [215]. Increased population density also increased the odds for utility cycling [219].

Good walkable neighbourhoods (based on residential density, street connectivity and land use mix, and sometimes retail floor area) double the likelihood of walking for transport [208]. One study found that participants who had 30 or more bus stops within 1,600m of their homes had odds of walking for transportation that were approximately double those of participants who had 0–14 bus stops, and the presence of a train station within 1,600m increased the odds of walking for transport by approximately 50% [217]. A distance to the local shops of <500m instead of over 1km was also found to increase walking by 50% [211]. Other key factors that have been shown to increase the amount of active travel include business density, connectivity and pavement length [212]. One comprehensive review of the literature found that a well maintained footpath without obstructions is the most effective characteristic for increased transport and leisure walking while reducing trail length is most effective for leisure cycling [212]. There are some indications that infrastructure improvements disproportionately benefit socioeconomically advantaged groups [214].

A comprehensive review for DfT on the effectiveness of area-wide 20mph schemes [45] found evidence of a small but significant impact on walking and cycling with 5% (4-6%) residents reporting they are walking more, and 2% (0.5-3.5%) that they are cycling more. There are also reported small but significant increases in cycling amongst children. Although there is evidence from individual local authority schemes that 20mph zone residents reported walking or cycling more [33, 34, 36, 46, 47], there was a lack of information on the increased frequency of walking and cycling by residents. Costs per trip were estimated for these area wide schemes as around <£1 - £3 per additional active travel trip.

3.3 Medium scale capital schemes – cycle parking and on-street cycle and e-bike hire

There were a range of medium scale capital interventions such as cycle parking at stations, cycle hubs with secure parking and on-street cycle hire schemes which were estimated to have costs ranging from £10-£70 per additional cycle trip/stage by the second year, with the higher costs the upper end of cycle parking at stations. These costs may fall over time, if cycling volumes continue to grow beyond two years. The high variability in costs is partly due to the different nature and scale of the schemes. There is evidence that there is high growth in use in the first year of these schemes, followed by continued growth at a slower rate for several years [75, 76, 122, 123] or stability after two years [79]. There is no evidence of decay in the long term. Thus while the costs per additional annual trip are high, the long-term effects mean that these schemes will likely represent value for money.

There was evidence of high suppressed demand for cycle parking at train stations and significant potential to increase cycling trips/stages to/from stations, particularly through smaller (<20 spaces) and larger (>80 spaces) schemes [52]. Studies suggest that unmet demand is satisfied within the first year of cycle parking at stations being provided [53, 54]. Outcome data from one secure bike parking scheme suggests over 50% of users are cycling more as a result of the secure parking, and a high proportion of trips (70-75%) would have been made by other modes in the absence of the scheme [124]. While this was reported to displace some walking trips there is also evidence from the same study that walking to/from cycle parking hubs means there is little or no net reduction in walking trips/stages [124].

Evidence from a large number of local authority on-street cycle hire schemes and academic studies supports the finding that such schemes lead to higher cycling levels, either directly as a result of the scheme or because the schemes prompt some users to buy their own bike, or to cycle more on their own bike [3, 75, 79, 80, 81, 82, 85]. There is evidence cycle hire schemes lead to increased levels of active commuting [83]. While there is evidence that cycle hire displaces both walking and public transport trips [83], one study suggested it had an overall positive impact on active travel time [81]. However while bike hire schemes can increase cycling, studies suggest that such schemes need complementary measures (such as good quality cycle infrastructure) and wider support measures for cycling in order to maximise their effectiveness [82].

There is evidence from a study of 75 schemes worldwide that performance of on-street cycle hire schemes is affected by bike infrastructure, temperature/wind, and whether the operator is a non-profit but not, surprisingly, by the number of stations and bikes [85]. Studies show that those living within 500m of a docking station are more likely to cycle after two years and those exposed to the scheme are more likely to cycle after two years [80], while increasing distance to metro stations increase the odds of cycling versus walking [86]. There is also evidence that on street cycle hire schemes tend to benefit males, younger people and those from more advantaged socio-economic backgrounds [82] and tend to be in areas where a higher proportion of people cycle to work already [84].

Although the evidence from on-street e-bike hire schemes is limited to one Local Authority scheme [120], the data suggests that this can result in higher annual usage than comparable pedal bike hire schemes due to rapid uptake and more consistent all year usage [120]. This makes schemes potentially more commercially viable following initial set-up costs. However vandalism can be an issue in on-street bike hire schemes [78, 120].

3.4 Medium and small scale capital/revenue schemes – shared e-bikes, bike loans/refurbishment, all-ability cycling

There were a number of medium and smaller scale interventions which involved some revenue support including shared e-bike schemes, bike loans and bike refurbishment schemes. Shared e-bike schemes were estimated to have costs that averaged around £22 per additional cycle trip by the end of the first year, although the range was quite wide between the different schemes. These costs are based only on the direct trips associated with e-bike hire, but there is also evidence of an increase in cycling after the end of the hire period [93, 97, 98]. If these additional trips are factored in the costs are much lower at £2 - £3 per additional cycle trip.

There is significant evidence that e-bikes increase participation in cycling and number of trips [93, 98, 100, 101, 103, 111, 112, 113]. Evidence from 11 UK e-bike schemes showed that e-bikes allowed longer and hillier trips, nearly half of e-bike trips were reported to have replaced car trips and >80% trips were not previously made by bike [93]. The same study found approximately 20% of users had never/rarely cycled, while 26% of users agreed they had previously struggled to use a regular bike for health/fitness [93]. There is also evidence from many studies that usage increased demand and willingness to pay for e-bikes [96, 97, 98, 108, 109, 117]. Evidence from a trial e-bike loan scheme in Brighton found that at the end of the trial, 38% of participants expected to cycle more in the future, and over 70% said that they would like to have an e-bike available for use in the future, and would cycle more if this was the case [98].

Evidence from one Norwegian study of e-bike loans [111] suggests they increase the amount of cycling significantly both in terms of trips and distance cycled compared to a control group of cyclists. The effects on number of trips (but not mileage) were much greater for female cyclists. There is significant evidence that 10-50% people who take part in e-bike trials go on to buy a bike or e-bike (98, 103, 108, 114, 117]. Evidence from an annual Swiss e-bike loan scheme [117] found that even a 2 week trial had lasting effects with participants having weaker habitual association with car use one year on, regardless of whether they had bought an e-bike or not. Seasonal effects are much less pronounced with e-bikes with evidence of users willing to use e-bikes all year round [101, 120]. There is limited evidence that usage increases as people become more experienced with them [100].

While evidence from conventional bike loan and refurbishment schemes was more limited these were estimated to have costs in the range of £1 to £6 per additional bike trip generated by the end of the second year. These lower costs compared to the e-bike schemes are largely due to the generally lower capital costs. There was also evidence of an increase in the proportion of people cycling after the loan [72, 73, 74] and in one survey cycle loan schemes were found to increase the uptake of cycle training [73].

There was limited evidence on all-ability cycling schemes targeted at people with health problems or disabilities, or those unable to ride two-wheel bikes. The costs associated with these schemes were generally higher at around £9 - £50 per additional cycle trip by the end of the second year, due to the high costs of specialised adapted bikes and the level of staff support for users. There was limited evidence from one small scheme that it leads to around 10% of participants cycling independently [131].

3.5 Medium and small-scale capital/revenue school interventions

There are a wide range of medium and small-scale interventions targeting travel to school, including cycle training (Bikeability), active travel promotion programmes, road safety education and small-scale capital projects including road safety improvements around schools (e.g. shared paths, pedestrian crossings). The costs from a number of school travel programmes evaluated at the local authority level are around £1 - £10 per additional annual walk (or active travel) trip with the higher costs for schemes including infrastructure and/or wider scale programmes.

A more recent but very promising intervention, with evidence available from a growing number of local authorities, involves road closures around schools ('school streets') through Road Traffic Orders [199, 200, 201, 202], or the use of Public Space Protection Orders to prevent children being dropped off or picked up by car during prohibited hours. These are usually done in conjunction with complementary behavioural change or small scale infrastructural measures. The costs are at the lower end of the scale for school interventions with most schemes <£1 - £3 per additional walking trip (including park and stride as a 0.5 walk trip). The costs for one local authority appeared higher as they included the higher costs of cameras, excluded any short park and stride trips (<5 mins) and did not include any revenue from the cameras which offsets the costs. The increase in walking trips is often immediate and significant; the impact on cycling is more mixed with some schools seeing large increases in trips and others reductions. Due to the nature of the intervention the impacts are likely to be long lasting though it depends on the size of the restricted area around the school, and methods of enforcement. Schemes which use cameras for enforcement may appear more expensive but may be more effective over the long term, and will also generate revenue to offset the costs of the scheme.

Studies on child cycle training show a consistent increase in cycling to school following training [64, 65, 66, 67, 68], though there is more variation in outcomes, and hence cost per trip, than is reported from adult cycle training. The costs ranged from around £2 - £7 per additional cycle trip.

An analysis of the impacts of school travel planning in 30 schools found that parking restraint, pupil involvement and safety improvements were associated with greater success in increasing walking, while extensive road safety improvements in the area surrounding the school were associated with higher levels of walking and cycling [183]. Walking levels were not strongly influenced by where pupils lived, in that the proportion of pupils living within one mile of the school was not found to be a significant determinant of the 'end' levels of walking achieved. This evaluation concluded that major increases in walking can be achieved through specific walking initiatives, but that in order to sustain increases in walking in the long term, road safety issues must be addressed [183].

The same evaluation found the combined presence of off-road cycle lanes and cycle parking at school was critical for achieving high levels of cycling at both primary and secondary level, while on-road cycle training was another significant factor for promoting cycling at primary level. Ongoing publicity and information were also critical [183].

Evaluations of school travel interventions found that schools in urban locations achieved higher levels of change (with one large-scale evaluation concluding that urban schools were able to achieve double the level of change, compared to rural schools) [183, 184].

3.6 Medium scale revenue schemes – household and workplace personalised travel planning (PTP), walk promotion programmes, community active travel hubs, mass cycle rides, new bus routes and concessionary fares

A number of revenue schemes, including household and workplace PTP, walk promotion programmes, community active travel hubs and mass cycle rides, are typically carried out at an area-wide level. These are generally estimated to have a range of costs of <£1 - £7 per additional active travel trip, though some workplace PTP schemes and some of the less successful household PTP schemes had much higher costs. In some cases, e.g. workplace PTP or community hubs, there may need to be additional time (and hence cost) factored in for set up and development. Note these schemes often promote sustainable as well as active travel.

The costs above do not include any walking trips/stages associated with increased bus travel, which have been estimated separately [189]. There is evidence that providing new bus services, or increasing the frequency of existing services, can lead to additional walking trips/stages at a cost of around £2 to £5 per additional walk trip/stage. There is also evidence to suggest that concessionary fares schemes have a cost per additional walk trip/stage of about £2 [189].

Evidence from a large number of household PTP studies shows a high variability in costs, though this includes two projects with relatively poor outcomes for walking and cycling and if these are excluded the costs typically average around £1.50 - 2.50 per additional active travel trip. Results from one in-depth study analysing the reasons for different outcomes in two towns suggests areas where there is more support, social acceptance, satisfaction, and share of walking and cycling to begin with are likely to show higher increases in walking and cycling [150]. Generally PTP interventions resulted in increases in both walking and cycling [150, 152, 155, 156, 159] or an increase in cycling and reduction in walking [152, 158].

Evidence from a much smaller number of workplace PTP studies also showed increased levels of cycling and generally lower increased levels of walking [162, 163, 164, 165]. In one study the increase in walking and cycling was only observed in those living <5km from work [164].

There is good evidence from a number of larger scale walking promotion programmes, many aimed at the least active and those in poor health, to suggest that as well as walking more often as a direct result of participation in the schemes, a high proportion of participants increase their walking for other purposes [1, 140, 141, 143, 144, 145]. Costs generally range from <1 - £5 per additional active travel trip.

There is some evidence that mass rides and bike events attract new/occasional cyclists and encourage existing cyclists to start cycling to work [126, 127], and some evidence that spectators of large bike events are encouraged to cycle more [128]. However the large mass cycle rides tend to attract a high proportion of older, male, frequent cyclists [127].

There is evidence from a number of academic studies that concessionary (free) bus passes for older people are associated with greater bus use [191, 192, 193, 194], higher levels of active travel as part of bus journeys, and positive health outcomes [190, 196, 197]. A review of various studies and data sources suggested at least 20% of bus trips are replacing car trips [194]. We estimate the cost per additional walk stage is around £2.

3.7 Small-scale revenue schemes – adult cycle training, led walks and rides, challenges

There are a number of revenue-only interventions which can work at a small scale with both immediate and longer term outcomes. These include adult cycle training and led walks and rides which are often targeted at particular groups of people, for example women, older adults and people with health problems. (Note child cycle training is included in section 3.5 above). These were estimated to have costs in the range of <£1 to £7 per additional active travel trip, though typically <£1 to £2 per additional trip.

Many studies show evidence of an increase in cycling following adult cycle training, some of it statistically significant [54, 57, 58, 59, 60, 61]. Demographic data from two interventions showed that 'learn to ride' and confidence training had a higher proportion of women and people from BME backgrounds than the background populations [54, 55]. While some of the new bike trips following training displace walking, one survey also showed an increase in weekly walking [55]. There was also evidence that there was little decay over time once people had changed their cycling behaviour (comparing actual travel at 3 months and 12 months after training) [63].

Evidence from studies of small-scale led walks and cycle rides suggests that these interventions encourage people to continue to walk and cycle independently after participation [136, 174]. Higher costs are associated with targeting harder to reach groups.

Evidence from one workplace cycle challenge showed that 50% of participants were either new or occasional cyclists, 40-50% of whom increased their cycling afterwards [167]. Similar levels of uplift were observed from a national study of workplace cycle challenges [170].

3.8 Policy schemes – salary sacrifice and e-bike grant schemes

There is evidence that the Cycle to Work salary sacrifice scheme increases levels of cycle commuting to work, both amongst new and occasional, as well as regular cyclists [92]. Depending on the assumptions used, the cost (to the Government) was around <£0.5 to £2 per additional bike trip. New guidance, making it clear that bikes worth more than £1,000 are eligible under the scheme, is expected to increase uptake of e-bikes in future[3].

There is also evidence from a number of countries that have operated grant or subsidy schemes for e-bikes [L3GL] including Norway [100], Austria [98, 103, 112], France [101, 102], Jersey [118] and Guernsey [119]. These schemes generally offer a grant of 15-25% or a flat discount towards the cost of the bike. Surveys of recipients show that this increased participation in cycling and the number of

[3] Department for Transport (2019) Cycle to work scheme implementation guidance for employers. Available at: www.gov.uk/government/news/government-ushers-in-new-era-of-green-commutes-with-e-bike-cycle-to-work-scheme

trips and distance cycled [93, 98, 100, 101, 103, 111, 112, 113]. In many cases the distance cycled increased significantly, even doubling [100, 101], enabling users to replace a significant proportion of car trips [110]. A small percentage of e-bike grant recipients (4-7%) sold a car as a result of the scheme [101, 102, 112]. Sweden and Scotland have also launched grant schemes [105] but at the time of writing it was too early for any evidence on outcomes. E-bike grant schemes were estimated to have costs that averaged around £1 - £3 per additional cycle trip by the end of the first year.

3.9 General findings

Continuity of funding: There was evidence from several interventions that the revenue costs associated with delivery of projects tend to decrease over time due to learning from best practice, better targeting or streamlining. Set up time is important for a number of categories of intervention, due to the need to develop relationships and build momentum and a number of projects need a minimum of two years to run. Stop-start funding will therefore significantly impact the cost effectiveness of most revenue-funded interventions.

Walking/cycling displacement: While cycling interventions were more likely to displace walking trips than the other way round there was some evidence that increasing cycling can encourage more active travel overall. There was also evidence from some walking programmes that they encouraged more cycling as well as walking. While there may be some cases where cycling does lead to a reduction in walking trips, it is more likely that there are synergies between activities that encourage walking and cycling and it is not a 'zero sum game'.

Integrated travel improvements: Several local authorities contacted for the study stressed the value of integrating walking and cycling into all travel and infrastructure projects rather than considering them as separate interventions or walking/cycling silos. While this can make it more difficult to identify the specific costs and outcomes for walking and cycling it can also lead to effectively 'free' or serendipitous improvements as part of a package. For example one local authority cited a pedestrian bridge installed as part of a tram project which provided safe and direct pedestrian access from one part of the city to another. An integrated approach also reduces the risk of improvements achieved through a separate walking/cycling intervention being undermined by other infrastructure and travel projects by the same authority.

The effect of supportive policy environments: the evidence was often necessarily based on the most effective projects from proactive authorities and organisations. The outcomes from an intervention will be influenced by the culture of the organisation delivering it and the legacy of earlier projects that it can build on. That success may therefore not be directly replicable in authorities or by organisations with less supportive policy environments or cultures.

4. Local Authority District (LAD) factors influencing effectiveness

The literature review and local authority evidence points to several findings about how LAD characteristics may influence the effectiveness of interventions, and hence the cost per trip, either upwards or downwards:

- Some interventions may be more effective (with lower cost per trip) in **urban** areas, as compared to **rural** areas (e.g. school travel interventions, where evaluation of the Travelling to School Initiative found double the increase in walking at urban schools, compared to rural schools) [183].
- Cycle infrastructure investment may be more cost-effective in **larger** cities, as compared to **smaller** towns (e.g. from comparison of larger vs smaller towns in CDT/CCT programme; supported by evidence from LSTF Large Projects) [1, 2].

- Uplift in cycling per £ spent may be higher in **places that start with higher levels of cycling at baseline** – tentatively reflecting a 'social norm' effect (as evidenced by analysis of the CDT/CCT programme) [2, 189]. Similarly, **household PTP may be more successful** for increasing walking and cycling in areas where there is more support, social acceptance and **higher share of walking and cycling** to begin with [150].
- Proximity to **good quality cycle routes** increases the likelihood of active travel; finer-grained cycle path networks increase cycling rates [5, 12, 23].
- **Segregated cycle path**s are more effective at increasing the propensity to cycle to work than unsegregated paths [8, 18].
- Existence of **'walkable' neighbourhoods** (determined by residential density, street connectivity, land use mix and shorter distances to public transport) increases the likelihood of walking for transport, and of walking to school [218].
- **Higher density housing increases walking**: e.g. areas with housing density >40dph have double the likelihood of walking, compared to areas with housing density <10dph. People moving from areas of lower to higher housing density tend to show increases in walking, and vice versa [211, 215, 219].
- **Good public transport increases walking**: e.g. people with 30+ bus stops within 1.6km of home had odds of walking for transport that were approximately double those for people with 0-14 bus stops [217].
- **Proximity to shops increases walking**: if the distance to the closest shop is less than 500m, instead of over 1 km, this increases walking by 50% [211].
- **A well maintained footpath** without obstructions was found to be one of the most effective built environment characteristics to **increase transport and leisure walking** based on a comprehensive international review [210].
- **Walking levels to school** are not automatically determined by where pupils live. The proportion of pupils living within 1 mile of the school was not a significant determinant of the 'end' levels of walking achieved [183].
- **Usage of e-bikes** has been shown to increase the distance cycled significantly, even doubling [100, 101], and allow for longer and hillier trips and replacement of car trips. They may therefore be of particular value in LADs which are hilly, or where journey distances are longer (i.e. more rural areas) [93, 116].
- **Road closures outside schools (school streets)** can be very effective, but the restrictions on use of cameras for enforcement outside of London may affect the long term impacts of the scheme.
- **Parking restraint and road safety improvements** were associated with **higher levels of walking and cycling to school,** suggesting that school interventions (and, probably, walking and cycling interventions generally) may be more effective if implemented in the context of wider traffic restraint policies [183].
- There is **high suppressed demand for additional cycle parking at some stations,** perhaps suggesting that cycle parking at stations may offer a 'quick win' in some areas [52, 53].
- **Workplace PTP** will be more effective for walking and cycling if targeted at employees living shorter distances from work [164].

- **Higher bus service levels, higher congestion and higher central parking charges** all increase demand for concessionary bus travel amongst older people, and hence associated walking trip stages [192].

5. Other factors influencing effectiveness

There are also findings from the literature and local authority evidence about the existence of synergies or interdependencies between different types of scheme. In particular:

- Cycle hire schemes need **complementary pro-cycling measures and wider support of sustainable urban mobility** in order to thrive [82].
- Performance of **on-street cycle hire schemes is affected by bike infrastructure**, but not by the number of stations and bikes [85].
- Bike loan schemes can **significantly improve the uptake of cycle training** [73].
- The combined presence of **off-road cycle lanes and cycle parking at school** is critical for achieving high levels of cycling at both primary and secondary level, while on-road cycle training is significant for promoting cycling at primary level [183].

These suggest that it is preferable to focus on the potential of 'packages' of schemes to increase walking and cycling, rather than to treat each scheme type (bike lanes, cycle training, bike loans etc.) as independent of all others.

6. Factors affecting population segments

There are findings that suggest that some types of scheme are of particular benefit to certain population segments. This may provide some pointers about how investment scenarios that aimed, for example, to increase health, or to widen gender participation in cycling, might allocate funding. Specifically:

- **Adult cycle training** can particularly benefit women and people from BME backgrounds [54, 55].
- Led walks and led cycle rides can **encourage people to walk and cycle independently** after participation. They can benefit older people and people who are less active or in poorer health [82, 136].
- **Bike hire schemes** may disproportionately benefit males, younger people and those from more advantaged socio-economic backgrounds [84].
- **Refurbished bike schemes** can benefit job-seekers and those on low incomes [90, 91].
- **E-bikes** can particularly benefit the uptake of cycling amongst women [102, 119] and older people [102, 104, 115]. One study also demonstrated that women users of e-bikes increased their cycle trips much more significantly than men [111]. There is evidence that e-bikes are attractive to those who are not regular cyclists [97] or those who are less active or with higher BMIs [114, 115] as well as increasing cycling trips and distance amongst regular cyclists [100, 113]. There is evidence that e-bike participants perceive feeling safer as they can move away from junctions quicker and avoid wobbling up hills [104, 106] which can help overcome a key barrier to cycling for many people.
- Concessionary fares can particularly benefit older people, women and people from BME backgrounds [190, 196, 197] with the possibility that other population groups would also benefit.

7. Areas for future research

There were a number of interventions which appear promising but where there was insufficient evidence on effectiveness or costs, which would be worthy of further research. These include:

- **20mph schemes:** The study team independently observed that there appeared to be unusually high levels of walking and cycling to school in three cities with large scale 20mph schemes, though further research is needed to ascertain whether this is associated with the schemes.
- **E-bike loan schemes**. Several studies show that these are potentially an effective intervention for engaging people who would not otherwise think of using or buying a bike, but there was no accompanying cost data. Studies have suggested that getting people on an e-bike in the first place is an effective hook [108, 109, 98]. Such interventions have been used to target older or sedentary people that do not usually cycle [104, 114] or as a way of breaking the habits of car drivers [117].
- **E-bikes as part of Wheels to Work**. An increasing number of Wheels to Work schemes are offering e-bikes in addition to scooters/mopeds/bikes. However there is currently insufficient evidence on the cost and numbers of additional trips.
- **Innovative personal transport modes**. We have not considered the potential for mode shift from electrically-assisted scooters, hoverboards, trikes, quadricycles, cargo bikes for personal use or various other rapidly evolving forms of low-emission personal transport. This is both because the evidence is very limited, and because many of these new forms of electrically-assisted mobility are not currently legal on UK roads or pavements at this time. However, future iterations of this work might usefully revisit this topic, including an assessment of whether it is appropriate that they are considered in conjunction with walking and cycling.
- **Improvements to walking routes to encourage leisure walking**. There is some evidence that improving the quality of footpaths (e.g. path surfacing, signage or removal of barriers) can result in more people using the routes and that while improved signage is more cost effective, surfacing resulted in higher user numbers[4]. Tourism statistics also show that short walks and long hikes are amongst the most popular activity for tourists (local and overseas) on holiday in Britain[5]. The considerable synergy between public health, tourism and walking for leisure would seem to warrant further research on the extent to which improvements to leisure walking routes increase walking trips.
- **Impact of leisure cycling on utility cycling.** Early work by Cycling England investigated whether casual leisure cycling can lead to more regular utility cycling and a review by TfL suggested that initiatives to encourage cycling for leisure, health and fitness should result in longer term increases in utility and commuter cycling[6]. There is ongoing work by the Isle of Wight Council to gather evidence to quantify this but results are still inconclusive.

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[5] See Table 2.1 on activities undertaken on the trip. Unfortunately this question was removed in 2016. The GB Tourist Statistics 2015. www.visitbritain.org/archive-great-britain-tourism-survey-overnight-data

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Table 1: Categories of interventions

	Intervention category
Cycling	A: Area-wide cycle networks (with supportive promotion) E: Cycle parking at stations F: Adult cycle training G: Child cycle training H: *Conventional bike loans / subsidies* I: On-street cycle hire (of conventional bikes) J: *Bike refurbishment* K: Bike purchase via salary sacrifice L: Electrically-assisted bikes (grants to individuals) M: Secure cycle parking (with additional facilities) N: Mass cycle rides / festivals / events O: *Cycle inclusion schemes* S: Workplace personalised travel planning T: Workplace travel challenges AD: Shared e-bike schemes
Walking	B: Town centre walking infrastructure schemes D: Neighbourhood traffic calming schemes (20mph zones) P: Led walks Q: Walking promotion schemes (including Beat the Street, Walkboost, Change4Life, Walk to Work etc) Y: Bus route enhancements (encouraging modal shift from car to walk-bus-walk) Z: Concessionary fares (as above) AB: Built environment factors affecting walkability (density, land use mix etc)
Cycling and walking	C: Flagship cycling and walking links R: Household personalised travel planning U: Community based initiatives (multi-stranded approaches) V: *Workplace travel initiatives*
School interventions	W: School travel initiatives (walking/cycling promotion) X: Infrastructure (e.g. Links to Schools programme) AA: School streets closures/parking restraint AC: School travel plans

Interventions in italics are those with limited evidence

References

This is a combined list of studies and documents that were reviewed in the course of our evidence gathering for Appendices 4 and 5. Note that some of the references contain a combination of sources which were used to verify information that has been cited in Appendix 4 and 5, or used to develop the model. Many of the Personal Communication sources cited relate to unpublished evaluation reports/surveys of individual interventions.

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