**A natural experimental study of new walking and cycling infrastructure across the United Kingdom: the Connect2 programme**

**Abstract**

Introduction: High quality evaluations of new walking and cycling routes are scarce and understanding contextual mechanisms influencing outcomes is limited. Using different types of data we investigate how context is associated with change in use of new and upgraded walking and cycling infrastructure, and the association between infrastructure use and overall physical activity.

Methods: We conducted repeat cross-sectional pre-post analysis of monitoring data from a variety of walking and cycling routes built in 84 locations across the United Kingdom (the Connect2 programme, 2009-2013), using four-day user counts (pre n=189,250; post n=319,531), next-to-pass surveys of route users (pre n=15,641; post n=20,253), and automatic counter data that generated estimates of total annual users. Using multivariable logistic regression, we identified contextual features associated with 50% increase and doubling of pedestrians, cyclists, and sub-groups of users. We combined insights from monitoring data with longitudinal cohort data (the iConnect study) from residents living near three Connect2 schemes. Residents were surveyed by post at baseline, one-year (n=1853) and two-year follow-up (n=1524) to investigate associations between use of the new infrastructure and meeting physical activity guidelines.

Results: The routes were associated with increased use (median increase in cyclists 52%, pedestrians 38%; p<0.001). Large relative increases were associated with low baseline levels (e.g. odds of doubling cycling were halved for each additional 10,000 annual cyclists at baseline: OR 0.52, 95% CI 0.31, 0.77). Use was associated with meeting physical activity guidelines in both repeat cross-sectional and longitudinal analyses (users vs. non-users after one year, OR 2.07, 95% CI 1.37, 3.21; after two years, OR 2.00, 95% CI 1.37, 2.96).

Conclusions: This examination of use, users, benefit-cost ratios, and physical activity associated with new walking and cycling infrastructure across contexts, using multiple types of data, suggests that building walking and cycling infrastructure could improve population health and reduce inequalities.

**Keywords:** Physical activity, walking, cycling, infrastructure, context, evaluation

# Background

Physical inactivity increases risks of non-communicable diseases including cardiovascular disease, stroke, type 2 diabetes, cancers, and mental health conditions, and premature mortality(Warburton and Bredin, 2017). Walking and cycling is advocated as a way to incorporate physical activity into everyday lifestyles(Norwood et al., 2014; Sahlqvist et al., 2012) and the United Kingdom (UK) government has ambitions to double levels of cycling in England between 2013 and 2025(Department for Transport, 2016). Environmental interventions (those entailing changes to the built environment, such as the construction of new infrastructure) are likely to affect population levels of walking and cycling(Cavill et al., 2019; Goodman et al., 2014). However, evaluating impacts of infrastructure changes can be difficult because research of this nature typically requires natural experimental designs(Craig et al., 2012) with multiple pathways for impact and potentially long timeframes for behaviour change to be seen(Goodman et al., 2014; Ogilvie et al., 2009). Furthermore, infrastructure investment is likely to be provided by transport departments that may not conduct extensive evaluations, despite a stated emphasis on delivering value for money(Department for Transport, 2015). Therefore it is important to understand the utility of monitoring data (e.g. manual counts and surveys of route users) alongside public health research data, which tend to be more scarce(Ogilvie et al., 2005), to demonstrate the outcomes, including economic value, associated with new walking and cycling infrastructure.

We know that elements of physical and social context are important determinants of use of new walking and cycling infrastructure(Götschi et al., 2017; Song et al., 2013) and these contextual issues may be important in influencing decision-makers(Le Gouais et al., 2020). However, there is a lack of published evaluations of use of new and upgraded walking and cycling routes across different contexts and limited understanding of the context-related mechanisms for behaviour change(Panter et al., 2019). Greater understanding about the environmental factors that may influence behaviour change could help explain how features such as bridges, tunnels and transport interchanges impact on facilitating use of new and upgraded walking and cycling routes. This may help to understand heterogeneity of impact of new routes which have been found in other evaluations(Goodman et al., 2013).

User sampling (counts or surveys) conducted as part of monitoring programmes only provide information on users, rather than the general population, but these approaches are cheaper and simpler than longitudinal cohort studies that can compare changes in the behaviour of individuals exposed and unexposed to new infrastructure. In addition, cohort studies tend to have smaller samples than transport monitoring methods which can make the analysis of sub-groups more difficult. Greater understanding of the impact of new infrastructure on sub-groups, including less active groups, would also identify potential impact on inequalities(Aldred, 2019; Macmillan et al., 2018; Panter et al., 2017; Smith et al., 2017), especially since the greatest health gains are expected to arise from increased physical activity by the least physically active(Kelly et al., 2014).

Some studies have suggested that new walking and cycling infrastructure may increase the frequency of journeys for existing users rather than attracting new users(Cavill et al., 2019). Transport sampling methods may not account for displacement of journeys from alternative routes, nor distinguish interventions that encourage existing pedestrians and cyclists to travel further or more frequently from those that encourage new people to walk or cycle, which may produce a greater health gain if they were previously relatively inactive. This may result in an over-estimation of new users and subsequent impact on population health. This can result in associated impacts on calculated benefit-cost ratios (BCRs), which indicate the value for money of a project. It is therefore important to further investigate the association between use of new infrastructure and overall physical activity. Finally, greater availability of cost-benefit analyses of walking and cycling interventions could also be useful to influence investment decisions(Cavill et al., 2019; Smith et al., 2017).

We conducted a repeat cross-sectional, uncontrolled pre-post analysis of data for 84 new and upgraded walking and cycling routes across the UK, built between 2009 and 2013, involving counts and surveys of route users, and estimates of total users (based on a combination of automatic counter data, counts and surveys of users), to answer the following research questions:

1. How do use and estimated BCRs of new walking and cycling infrastructure vary by the nature and local contextual factors of schemes?
2. How does use of new walking and cycling infrastructure by different population sub-groups vary by the nature and local contextual factors of schemes?

Analysis of the survey data was then combined with a longitudinal analysis of repeat postal questionnaire data from a cohort of residents living near three of the routes to answer the research question:

1. What is the association between type of use of new walking and cycling infrastructure and overall physical activity?

The final research question also enables novel investigation of the utility of different methods by combining insights from routine monitoring data alongside public health research data.

# Methods

## Intervention

The Connect2 programme involved the creation or upgrading of 84 walking and cycling routes. Each scheme crossed a physical feature such as a river, railway line or major road, for example via new bridges, rehabilitating disused bridges or improving road crossings, plus networks for local traffic-free journeys. These walking and cycling routes were provided across the four countries of the UK, in England (N=64), Scotland (N=4), Wales (N=11) and Northern Ireland (N=5).

The Connect2 programme was led by the UK walking and cycling charity Sustrans, securing £50 million of investment from the Big Lottery Fund in 2008. Sustrans worked with dozens of stakeholders, including local government, statutory and non-statutory bodies and local community groups, to raise matched funding against the original award and deliver the schemes on the ground. The overall investment in the Connect2 programme was £175 million.

## Measures of use

We used four datasets to understand use, involving pre and post data from Sustrans’ Connect2 programme collected between 2009 and 2013 and the longitudinal iConnect study conducted between 2010 and 2012:

1. Four-day counts of users (71 schemes)
2. Surveys of route users (84 schemes: 78 schemes with pre data, 81 schemes with post data)
3. Estimated total annual scheme users and BCRs (77 schemes)
4. iConnect cohort questionnaires (3 schemes).

The application of each dataset relative to the research questions is described in Table 1. The available data for each Connect2 scheme, alongside contextual features, are described in Table 2.

### Connect2 cross-sectional measures of use and benefit-cost ratios

The counts of users were recorded manually pre and post construction between 7am and 7pm on four days at each scheme. Cross-sectional user surveys were conducted at the same times as the manual counts. Selection was on a next-to-pass basis and informed consent was obtained (see Appendix A for additional details). The user survey asked questions about: frequency of journey on the route; mode of travel; purpose of trip; how long the journey would take; on how many days in the previous week at least 30 minutes of physical activity had been conducted; and demographic information (see Appendix B).

Total annual scheme users were estimated by Sustrans using a combination of automatic counter data, counts of users, user survey data and trip lengths from the UK Government’s National Travel Survey(Department for Transport, 2010). Proxy routes were used for the baseline usage figures for completely new routes. For example, where a new pedestrian and cycling bridge was built, a nearby traffic bridge was used for the baseline measurement.

BCRs were calculated by Sustrans(Sustrans, 2013a) in line with the UK Department for Transport’s web-based transport appraisal guidance (WebTag)(Department for Transport, 2013), involving the Health Economic Assessment Tool (HEAT)(World Health Organization, 2011).

Additional details of the methods for estimating total annual scheme users and BCRs are included in Appendix A.

### Cohort survey of residents living in the vicinity of a Connect2 scheme

The longitudinal iConnect study was conducted with a cohort of adult residents, randomly sampled from the electoral register, living within 5km of three Connect2 schemes in Cardiff, Kenilworth and Southampton. Postal questionnaires were completed at baseline (before scheme construction) and at one-year and two-year follow-up. Further details of the iConnect methods are published elsewhere(Ogilvie et al., 2012). The iConnect questionnaire asked: whether the local Connect2 route had been used; whether on foot or by bike, and for what purpose; time spent doing physical activity in the previous week; and demographic questions (see Appendix C). Participants who reported that they used the relevant route were classified as users at that time point (i.e. at one-year follow-up and/or two-year follow-up), as pedestrians and/or cyclists, and as users for the particular purposes reported. Previously published iConnect research found that overall physical activity was associated with distance from the new routes(Goodman et al., 2014). This study extents earlier findings to evaluate the association between use of the new routes and meeting guideline levels of physical activity.

Table 1 – Research questions, variables and datasets

| **Research question** | **Exposures** | **Outcomes** | **Covariates** | **Level** | **Dataset** |
| --- | --- | --- | --- | --- | --- |
| **1**: How do use and estimated BCRs of new walking and cycling infrastructure vary by the nature and local contextual factors of schemes? | Contextual factors:   * Population living within 0.5 mile * Public transport interchange within 0.5 mile (Yes/No) * Baseline number of users (pedestrians and/or cyclists) * IMD quintile   Nature of scheme:   * Cost * Length * Bridge/ tunnel present (Yes/No) | **Percentage change in use (pre-post):**  At least 50% increase (Yes/No); Double (Yes/No):   * Pedestrians * Cyclists   **Benefit-cost ratio:**  >4 (‘very high’) | Time from scheme completion to post-monitoring | Scheme level | Total annual scheme users |
| **2**: How does use of new walking and cycling infrastructure by different population sub-groups vary by the nature and local contextual factors of schemes? | **Percentage change in user sub-groups:**  At least 50% increase (Yes/No); Double (Y/N):   * Women * Older people * Peak-time users * Women cyclists | Counts of users |
| * Disabled/long term illness * Low SES | Surveys of users |
| **3**: What is the association between type of use of new walking and cycling infrastructure and overall physical activity? | * Frequency of journey * Time * Mode * Trip purpose | **At least five# days with self-reported 30 minutes physical activity in the previous week:**  (Yes/No) | Demographics:   * Gender * Age * Employment status * Ethnicity\* * General health * Disabled/ long term illness * Deprivation quintile * Children in household (Yes/No)   iConnect only:   * Baseline physical activity * Scheme | Trip level | Surveys of users |
| * Use (Yes/No) * Mode * Purpose | **At least 150 minutes of self-reported physical activity in the previous week**:  (Yes/No) | Individual level | iConnect |

IMD = Index of multiple deprivation (UK-adjusted quintiles; see main text)

# Four days for users who were running on the route at the time of the survey (see section 2.4.4)

\*Ethnicity was only a covariate in the user survey analysis because the sample of non-white participants was very small in the iConnect cohort

Table 2 – Features of Connect2 schemes and sample size for each dataset (Number of schemes = 84)

| Connect2 scheme | Country | New/ Upgraded route\* | Cost  (£ million) | Length (km) | Bridge /tunnel present? | Population within 0.5 mile | Counts of users | | Survey of users | | Estimated annual route users (‘000s) | | Estimated benefit-cost ratio | iConnect cohort | |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| n Pre | n Post | n Pre (% of count) | n Post (% of count) | n Pre | n Post |  | n 1-year | n 2-year |
| Argoed bridge | Wales | New | 0.3 | 0.04 | yes | 700 | 222 | 852 | 65 (29) | 62 (7) | 15 | 35 | 17.2 | - | - |
| Ballymoney railway bridge and links | Northern Ireland | Upgrade | 1.2 | 1.91 | yes | 6,300 | 1,166 | - | 133 (11) | 140 (-) | 93 | 197 | 11.5 | - | - |
| Bath 2 tunnels greenway | England | Upgrade | 5.2 | 6.34 | yes | 33,200 | 1,326 | 4,648 | 268 (20) | 398 (9) | 114 | 264 | 3.4 | - | - |
| Bedlington network | England | Upgrade | 2.0 | 9.48 | no | 26,700 | 1,823 | 2,333 | 150 (8) | 99 (4) | 325 | 552 | 3.3 | - | - |
| Bethnal Green local link | England | Upgrade | 2.2 | 2.90 | yes | 78,100 | 2,985 | 6,628 | 258 (9) | 240 (4) | 267 | 584 | 9.0 | - | - |
| Birmingham links to New Hall Valley | England | Upgrade | 2.1 | 19.15 | no | 61,900 | - | - | 337 (-) | 743 (-) | 351 | 437 | 4.0 | - | - |
| Blandford – Stourpaine Trailway | England | New | 0.7 | 3.67 | no | 3,700 | - | 1,626 | - (-) | 358 (22) | - | 186 | 15.0 | - | - |
| Blyth network | England | Upgrade | 2.5 | 14.45 | no | 36,600 | 2,538 | 3,152 | 192 (8) | 241 (8) | 661 | 769 | 3.5 | - | - |
| Bradford links | England | Upgrade | 3.7 | 1.87 | yes | 34,800 | 2,454 | 3,237 | 87 (4) | 129 (4) | 255 | 403 | 1.4 | - | - |
| Bristol – Nailsea: ‘The Festival Way’ | England | Upgrade | 1.4 | 15.25 | no | 29,300 | 5,676 | 9,176 | 720 (13) | 285 (3) | 481 | 877 | 15.2 | - | - |
| Brompton-on-Swale rural links | England | New | 0.5 | 2.94 | yes | 3,900 | 294 | 161 | 56 (19) | 58 (36) | 42 | 20 | 1.0 | - | - |
| Bury greenway | England | New | 1.0 | 2.58 | yes | 18,100 | 3,112 | 6,240 | 340 (11) | 315 (5) | 265 | 324 | 9.4 | - | - |
| Cardiff - Penarth link | Wales | Upgrade | 4.9 | 4.56 | yes | 17,500 | 2,254 | 15,704 | 614 (27) | 1,099 (7) | 275 | 512 | 3.0 | 589 | 487 |
| Carlton-Le-Moorland – Bassingham link | England | New | 0.5 | 2.05 | no | 1,900 | 377 | 1,118 | 67 (18) | 102 (9) | 46 | 79 | 5.4 | - | - |
| Cheshunt: A10 crossing and links | England | Upgrade | 2.9 | 5.01 | yes | 25,100 | 139 | 2,185 | 29 (21) | 101 (5) | 32 | 259 | 0.8 | - | - |
| Chester greenway extension, links and riverside path | England | Upgrade | 1.7 | 5.86 | yes | 32,100 | 1,438 | 1,206 | 167 (12) | 122 (10) | 1,641 | 2,129 | 21.9 | - | - |
| Clydach links | Wales | Upgrade | 1.1 | 5.38 | yes | 8,300 | 164 | 1,821 | 44 (27) | 236 (13) | 60 | 105 | 3.5 | - | - |
| Conkers path in the National Forest | England | Upgrade | 1.2 | 0.55 | no | 400 | 247 | 219 | 76 (31) | 59 (27) | 20 | 11 | 0.3 | - | - |
| Conwy – Penmaenmawr coastal path | Wales | New | 0.9 | 1.31 | yes | 600 | 155 | 413 | 49 (32) | 96 (23) | 17 | 44 | 3.2 | - | - |
| Croydon parks links | England | Upgrade | 1.9 | 2.34 | no | 31,300 | 3,041 | 17,175 | 149 (5) | 291 (2) | 331 | 1,208 | 16.1 | - | - |
| Dartford: Darent Valley Path | England | Upgrade | 1.9 | 6.40 | yes | 27,200 | 2,621 | 1,436 | 123 (5) | 122 (8) | 164 | 222 | 3.0 | - | - |
| Derry greenway | Northern Ireland | New | 15.7 | 5.80 | yes | 14,800 | 11,462 | 10,644 | 477 (4) | 347 (3) | - | - | - | - | - |
| Dewsbury greenway links | England | Upgrade | 1.2 | 2.80 | yes | 15,100 | 260 | 734 | 90 (35) | 198 (27) | 35 | 106 | 3.2 | - | - |
| Dover greenway to city centre and seafront | England | Upgrade | 0.8 | 2.84 | yes | 20,700 | 5,584 | 7906 | 256 (5) | 328 (4) | 555 | 813 | 22.3 | - | - |
| Dumfries: Connecting two railway paths | Scotland | New | 0.6 | 2.96 | yes | 12,000 | 750 | 1,278 | 161 (21) | 444 (35) | 68 | 108 | 5.8 | - | - |
| Everton Park – Mersey waterfront links | England | Upgrade | 1.2 | 3.72 | no | 24,200 | 2,270 | 1,407 | 164 (7) | 518 (37) | 287 | 235 | 0.8 | - | - |
| Falkirk canal towpath repairs | Scotland | Upgrade | 0.3 | 2.64 | no | 12,000 | 707 | 329 | 35 (5) | 81 (25) | 44 | 45 | 3.1 | - | - |
| Foryd Harbour(Rhyl): Bridge and link | Wales | New | 6.0 | 0.88 | yes | 4,400 | 6,664 | 5,273 | 369 (6) | - (-) | - | 388 | - | - | - |
| Glasgow network | Scotland | Upgrade | 3.3 | 2.50 | yes | 27,000 | 5,451 | 11,343 | 114 (2) | 146 (1) | 681 | 902 | 1.4 | - | - |
| Hamilton – Larkhal link | Scotland | Upgrade | 2.2 | 10.55 | no | 16,900 | 1,008 | 1,327 | 39 (4) | 142 (11) | 305 | 368 | 2.1 | - | - |
| Haringey traffic-free environment | England | Upgrade | 0.4 | 0.50 | no | 30,600 | 9,503 | - | 245 (3) | 149 (-) | 773 | 902 | 10.8 | - | - |
| Harrogate: The Nidderdale Greenway | England | New | 0.7 | 4.48 | yes | 5,000 | 2,879 | 9,405 | 145 (5) | 269 (3) | 166 | 561 | 44.4 | - | - |
| Hastings – Bexhill coastal path | England | Upgrade | 0.5 | 2.27 | no | 6,400 | 968 | 2,172 | 185 (19) | 382 (18) | 104 | 218 | 17.5 | - | - |
| Havering – Ingrebourne Valley links | England | Upgrade | 4.5 | 20.66 | no | 66,800 | 1,272 | 2,897 | 88 (7) | 258 (9) | 627 | 754 | 3.3 | - | - |
| Hereford links | England | Upgrade | 0.5 | 10.57 | yes | 32,600 | - | 496 | - (-) | 49 (10) | 106 | 109 | 2.6 | - | - |
| Huyton local greenway | England | Upgrade | 0.4 | 2.80 | yes | 14,000 | 518 | 715 | 78 (15) | 93 (13) | 63 | 46 | 1.0 | - | - |
| Islington local link | England | Upgrade | 1.5 | 2.67 | no | 79,500 | 5,396 | 5,664 | 219 (4) | 121 (2) | 874 | 1,070 | 8.0 | - | - |
| Kenilworth – Burton Green greenway and link to the University of Warwick | England | New | 1.2 | 9.98 | no | 16,400 | 297 | 2,115 | 96 (32) | 303 (14) | 71 | 255 | 10.9 | 734 | 602 |
| Killamarsh – Halfway Tram Terminus – Rother Valley Country Park | England | New | 2.1 | 3.78 | no | 11,300 | 738 | 1,245 | 120 (16) | 123 (10) | 139 | 179 | 5.2 | - | - |
| Kirkby local links | England | Upgrade | 0.8 | 3.01 | no | 19,600 | 2,704 | 2,482 | 237 (9) | 218 (9) | 272 | 244 | 3.4 | - | - |
| Leeds: The Wyke Way green corridor | England | Upgrade | 0.4 | 2.07 | no | 13,500 | 1,378 | 4,156 | 84 (6) | 142 (3) | 166 | 254 | 12.4 | - | - |
| Leicestershire: Watermead Park links | England | Upgrade | 1.7 | 7.78 | yes | 20,700 | 3,033 | 7,819 | 412 (14) | 175 (2) | 431 | 607 | 8.0 | - | - |
| Luton – Harpenden link | England | Upgrade | 1.0 | 8.38 | yes | 24,700 | 583 | 1,141 | 207 (36) | 216 (19) | 64 | 146 | 6.5 | - | - |
| Merthyr Tydfil local links and to the Taff trail | Wales | New | 0.6 | 6.20 | yes | 14,100 | 404 | 187 | 48 (12) | 54 (29) | 60 | 79 | 4.7 | - | - |
| Monmouth links along the River Monnow | Wales | Upgrade | 0.6 | 1.77 | yes | 7,700 | 536 | 1,906 | 175 (33) | 205 (11) | 207 | 244 | 2.2 | - | - |
| Nantwich – Crewe link | Wales | Upgrade | 1.6 | 6.34 | no | 21,600 | 742 | 2,496 | 155 (21) | 353 (14) | 110 | 169 | 4.0 | - | - |
| Newport – Caerleon link | Wales | Upgrade | 2.5 | 8.97 | yes | 41,300 | 214 | 608 | 52 (24) | 146 (24) | 153 | 405 | 7.9 | - | - |
| Newton Abbot – Kingsteignton links | England | New | 3.0 | 7.77 | yes | 19,100 | 1,741 | 2,670 | 258 (15) | 335 (13) | 298 | 379 | 3.1 | - | - |
| Newtownabbey local links | Northern Ireland | New | 1.3 | 9.35 | yes | 24,500 | 332 | - | 65 (20) | 92 (-) | 82 | 87 | 0.5 | - | - |
| Northampton local links | England | Upgrade | 2.3 | 6.62 | no | 22,900 | 1,090 | 1,981 | 168 (15) | - (-) | 137 | 217 | 2.9 | - | - |
| Northwich network | England | Upgrade | 2.5 | 4.94 | yes | 18,800 | 1,071 | 3,653 | 149 (14) | 291 (8) | 100 | 308 | 7.9 | - | - |
| Norwich network and riverside routes | England | Upgrade | 3.0 | 9.80 | yes | 60,100 | 1,568 | 1,014 | 290 (18) | 145 (14) | 371 | 534 | 7.6 | - | - |
| Omagh riverside path | Northern Ireland | New | 0.8 | 0.46 | yes | 1,900 | 2,537 | 2,536 | 252 (10) | 241 (10) | 38 | 42 | 0.7 | - | - |
| Ottery St Mary local links | England | New | 1.0 | 1.83 | yes | 4,300 | 587 | 1,236 | 115 (20) | 138 (11) | 70 | 103 | 3.7 | - | - |
| Padiham, Burnley and villages: Greenway, linear park and links | England | New | 2.8 | 10.17 | no | 33,000 | 2,861 | 4,423 | 190 (7) | 288 (7) | 332 | 427 | 4.1 | - | - |
| Plymouth network | England | Upgrade | 2.1 | 10.86 | no | 52,200 | 5,674 | 8,266 | 126 (2) | 287 (3) | 783 | 1,231 | 9.2 | - | - |
| Port Talbot –Pontrhydyfen – Afan Forest Park | Wales | Upgrade | 0.7 | 16.70 | yes | 20,000 | 621 | 624 | 262 (42) | 139 (22) | 108 | 170 | 8.8 | - | - |
| Radstock – Midsomer Norton ‘5 Arches’ route | England | New | 0.9 | 2.62 | no | 12,000 | 1,498 | 3,579 | 178 (12) | 347 (10) | 19 | 69 | 2.8 | - | - |
| Rochdale network and greenway | England | Upgrade | 1.5 | 20.74 | no | 75,300 | 1,474 | 1,629 | 399 (27) | 438 (27) | 246 | 291 | 3.1 | - | - |
| Royston subway | England | Upgrade | 3.6 | 2.40 | yes | 13,700 | 638 | 754 | 69 (11) | 85 (11) | 75 | 113 | 1.0 | - | - |
| Rugby links | England | New | 1.2 | 9.29 | yes | 29,600 | 2,526 | 2,244 | 124 (5) | 321 (14) | 306 | 295 | 3.3 | - | - |
| Sale – Stretford network | England | Upgrade | 0.7 | 15.05 | no | 70,700 | 895 | 10,726 | 138 (15) | 193 (2) | 188 | 799 | 31.7 | - | - |
| Scunthorpe Ridgeway and links | England | Upgrade | 4.1 | 12.40 | no | 36,000 | 2,053 | 5,762 | 262 (13) | 342 (6) | 181 | 239 | 0.7 | - | - |
| Shoreham bridge | England | Upgrade | 11.1 | 0.80 | yes | 8,800 | - | - | 75 (-) | - (-) | 757 | 880 | 3.6 | - | - |
| Shrewsbury riverside path and network | England | Upgrade | 2.3 | 5.29 | no | 19,800 | 7,642 | 5,560 | 320 (4) | 414 (7) | 940 | 558 | 1.4 | - | - |
| Sleaford – Leasingham link | England | Upgrade | 0.9 | 2.62 | yes | 8,700 | 349 | 481 | 77 (22) | 102 (21) | 341 | 594 | 3.7 | - | - |
| South Bermondsey (South East London) links | England | Upgrade | 1.1 | 8.12 | yes | 132,300 | - | 6,410 | - (-) | 299 (5) | - | 2,096 | - | - | - |
| Southampton: Itchen Riverside Path and links | England | Upgrade | 4.0 | 8.04 | no | 57,900 | 7,480 | 8,851 | 310 (4) | 341 (4) | 873 | 652 | 1.7 | 529 | 431 |
| St Helens: access to greenspace | England | New | 0.3 | 2.33 | no | 13,100 | - | 936 | - (-) | 90 (10) | - | 92 | - | - | - |
| St Neots network | England | Upgrade | 3.5 | 16.78 | yes | 24,800 | 1,675 | 2,613 | 111 (7) | 114 (4) | 307 | 362 | 2.1 | - | - |
| Stockbridge rural link | England | New | 0.2 | 5.75 | yes | 1,300 | - | 105 | - (-) | 7 (7) | - | 38 | 11.6 | - | - |
| Stockport – Marple through Chadkirk Country Park | England | New | 1.6 | 7.06 | yes | 21,500 | 199 | 162 | 58 (29) | 54 (33) | 34 | 31 | 0.6 | - | - |
| Swindon links to industrial sites | England | New | 0.5 | 2.33 | no | 6,600 | 446 | 1,670 | 109 (24) | 105 (6) | 268 | 247 | 11.2 | - | - |
| Titanic Quarter – Belfast city centre: Comber Greenway extension | Northern Ireland | Upgrade | 0.4 | 5.15 | no | 34,700 | 2,048 | 10,900 | 127 (6) | 822 (8) | 365 | 448 | 32.5 | - | - |
| Topsham bridge | England | New | 0.6 | 0.80 | yes | 3,100 | 1,638 | 9,567 | 160 (10) | 102 (1) | 135 | 146 | 13.2 | - | - |
| Treforest: part of the Valleys Cycle Network | Wales | Upgrade | 1.4 | 4.09 | no | 13,500 | - | 338 | 197 (-) | 106 (31) | 37 | 37 | 0.6 | - | - |
| Tyne Dock safety improvements | England | Upgrade | 0.6 | 1.60 | no | 13,100 | 1,256 | 1,650 | 208 (17) | 241 (15) | 129 | 161 | 7.6 | - | - |
| Watton – Griston links | England | New | 1.1 | 6.30 | no | 9,100 | 715 | 1,543 | 170 (24) | 136 (9) | 97 | 224 | 7.5 | - | - |
| Westminster: Connection across A40 | England | Upgrade | 0.3 | 0.19 | yes | 38,700 | 2,323 | 3,240 | 144 (6) | 219 (7) | 173 | 276 | 14.6 | - | - |
| Weymouth network | England | Upgrade | 2.6 | 14.74 | no | 32,900 | 25,386 | 25,660 | 1,825 (7) | 1,788 (7) | 2,405 | 2,375 | 6.8 | - | - |
| Whitstable: Costal path and links | England | Upgrade | 0.5 | 23.26 | yes | 44,800 | 1,413 | 2,331 | 270 (19) | 172 (7) | 1,199 | 1,260 | 17.0 | - | - |
| Wicken Fen: The Lodes Way and rural links | England | New | 2.0 | 14.50 | yes | 3,400 | - | 325 | 23 (-) | 114 (35) | 6 | 41 | 1.1 | - | - |
| Worcester links and canal towpath | England | Upgrade | 4.4 | 17.10 | yes | 57,800 | 12,161 | 18,734 | 237 (2) | 304 (2) | 2,095 | 3,346 | 30.8 | - | - |
| Workington bridge | England | New | 2.5 | 0.17 | yes | 6,000 | - | 2,283 | - (-) | 285 (12) | - | 206 | - | - | - |
| **TOTAL** |  |  |  |  |  |  | **189,250** | **319,531** | **15641 (8)** | **20253 (6)** | **25,312,896** | **37,799,119** |  | **1,853** | **1,524** |

\*Many Connect2 routes were a combination of new and upgraded sections. The variable in this column refers to the majority of the route (for example, a new bridge was also built as part of the Cardiff - Penarth scheme).

## Contextual measures

### Contextual factors

Local resident population and presence of a transport interchange within 0.5 mile of the routes were determined using mapping software and 2011 UK census data. Baseline numbers of pedestrians and cyclists were taken from the estimated annual route users before each scheme was constructed (see details in Appendix A). Index of Multiple Deprivation (IMD) ranks were used as a proxy for deprivation, applied at local government level rather than the much smaller Lower Super Output Areas (LSOA) level because many of the schemes were very long and crossed multiple LSOAs in different IMD deciles. Separate deprivation indices were available for rankings in England, Scotland, Wales and Northern Ireland. To allow comparison we calculated UK-adjusted IMD quintiles using Abel et al.’s percentage of the population living in areas in each deprivation quintile by country(Abel et al., 2016).

### Scheme level characteristics

Scheme designs provided details of route length, cost and whether a bridge or tunnel was present. Cost per mile was not included as a variable because it was not comparable between schemes which often comprised a mixture of shorter, higher-cost sections (e.g. new bridges) and longer, lower-cost sections (e.g. upgrading an existing path). Instead length and cost were included as these are more relevant to design criteria. They were not strongly correlated (Spearman’s rho 0.42) and were therefore treated as independent variables, as were length and population within 0.5 mile (Spearman’s rho 0.59).

## Outcome measures

### Percentage change in use

The percentage changes in use by pedestrians and cyclists were calculated from the total annual scheme users (pre and post). Most schemes reported some increase in cyclists (N=69 out of 77 schemes (90%)) and pedestrians (N=63 out of 77 schemes (82%)). Doubling, and increases of at least 50%, in the number of users were chosen as outcomes because of the clarity of message that this was thought to provide to decision-makers in demonstrating successful schemes. The former also relates to the UK government’s target of doubling cycling by 2025 in England(Department for Transport, 2016).

### Benefit-cost ratio

The UK’s Department for Transport defines BCRs of at least 4 as ‘very high’ value for money(Department for Transport, 2015). This was therefore chosen as an outcome because it was thought likely to be persuasive to decision-makers. It was achieved in 38 schemes (49%).

### Percentage change in user sub-groups

Older people, people with long-term illness or disability and people living in the most deprived areas (a proxy for low socio-economic status) were chosen as sub-groups of primary interest because their levels of physical activity tend to be lower(NHS Digital, 2017) and increases in these user groups could lead to greatest health benefits and impact on health inequalities(Kelly et al., 2014; Li et al., 2016; Marmot et al., 2020; Sattelmair et al., 2011; Smith et al., 2016). Women’s physical activity is generally lower than men’s(Guthold et al., 2018) and there is an increasing realisation of the importance of understanding gender impacts of interventions(Brown and Smith, 2017; Criado Perez, 2019), therefore women were also included as a sub-group. Peak time users were chosen because these may impact on levels of traffic congestion and therefore be of interest to the transport sector. Women cyclists were included as they were under-represented in the UK.(Department for Transport, 2016).

Separate outcomes of 50% increase or doubling sub-group users were analysed because these are large increases which may be influential to decision-makers.

Percentage changes of women, older people, peak time users and women cyclists were calculated from their proportion of total users, as recorded in the counts of users, multiplied by the total annual users at pre and post time-points. Peak time was classified as between 7am - 9am and 4pm – 7pm on weekdays. Percentage changes of people with disability or long-term illness and those living in the most deprived areas were obtained from their proportion of total users, as recorded in the surveys of users, multiplied by the total annual users at pre and post time-points. Users from the most deprived areas were those with home postcodes in the most deprived UK-adjusted IMD quintile, based on LSOA rank, following Abel et al.’s methodology(Abel et al., 2016) to adjust for differences between countries within the UK.

### Meeting physical activity guidelines

The survey of users asked: “In the past week on how many days have you completed 30 minutes or more physical activity that was enough to raise your breathing rate? (This may include sport, exercise and brisk walking or cycling for recreation)” with response options of 0-7 (see Appendix B). The iConnect questionnaire asked how much time over the last seven days participants walked and cycled for different purposes, as well as time spent doing moderate and vigorous intensity leisure-time physical activity(Adams et al., 2014) (see Appendix C). Since the UK Government’s guidelines recommend at least 150 minutes of physical activity of at least moderate intensity per week (Public Health England, 2016) outcomes of at least 5 days of 30 minutes, or at least 150 minutes in total, of physical activity were used as proxies for meeting the guidelines in the surveys of users and iConnect questionnaires respectively (extreme values of reported minutes of physical activity were truncated at 1260 minutes). Because the guidelines include the option of 75 minutes of vigorous activity per week, or a mixture of vigorous and moderate intensity physical activity(Department of Health and Social Care, 2011), we made an exception in the case of users who were running at the time of the route user survey. We assumed that the average intensity of their physical activity throughout the week would be higher than for other route users,(Ainsworth et al., 2011) and therefore applied a threshold of at least 4 days of 30 minutes’ activity to define the meeting of guidelines in this group.

## Contextual factor covariates

Schemes differed in the time between completion and post monitoring and previous research has found that it can take many months for people to start using new routes(Goodman et al., 2014), therefore this needed accounting for as a potential confounder. Additional details are included in Appendix A.

## Demographic variables

Demographic information that may influence physical activity outcomes were included as covariates: gender, age, employment status, general health, whether respondents had a disability or long-term illness, whether they had children in the household and their UK-adjusted IMD deprivation quintile. The user survey analysis also included ethnicity as a covariate, although this was not used for the iConnect cohort due to low numbers of non-white respondents. Demographic variables for respondents are shown in Table 4.

## Statistical analysis

Analyses were performed using R(R Core Team, 2019).

A Wilcoxon non-parametric test was used to identify significance in median changes and percentage changes in pedestrians, cyclists and sub-groups of users across schemes since data were positively skewed.

Multivariable binary logistic regression analysis was conducted firstly unadjusted and then with models adjusted for each outcome (walking or cycling separately, with 50% increase or doubling in users; meeting guideline levels of physical activity): scheme level analysis models were adjusted for each independent contextual/scheme characteristic variable, and then additionally for the time from completion to post-monitoring; physical activity models were adjusted for demographic variables, and for iConnect analyses also adjusted for baseline physical activity and scheme.

Sensitivity analysis was conducted for 50% increase and doubling in number of users with disability/long-term illness and from the most deprived quintile, because these used data from the surveys of users and some schemes had low numbers of respondents for these sub-groups. Where zero sub-group users were recorded these were reassigned as one, and where the number of survey respondents differed by less than four (equivalent of one sub-group user per monitoring day) then the post-monitoring survey value was reassigned the same value as for baseline. Sensitivity analysis was also conducted for meeting guideline levels of physical activity for runners using five days of thirty minutes physical activity in the previous week, rather than four, since intensity of each bout of activity was unknown.

### Missing data

The surveys of users did not distinguish between zero children in the household and missing data, therefore both were treated as indicating zero children in the household. Where home postcodes were missing for user survey responses, which were used to determine UK-adjusted IMD quintiles, participants were assigned the local government IMD quintile of the scheme they were using since the majority of route users were local (77% of user survey respondents reported travelling 10 km or less to reach the route). Where demographic information was missing at baseline for iConnect but available at follow-up, the value from one-year follow-up was used, or if not available, from two-year follow up (age was adjusted down accordingly). Missing recreational physical activity values in the iConnect data were reassigned as zero where responses for transport physical activity had been completed as zero (this applied to 18 cases at baseline; 5 at one-year follow-up and 14 at two-year follow-up).

# Results

## Descriptive findings

### Scheme level use and benefit-cost ratio

The median increases in cyclists and pedestrians on the 77 Connect2 schemes with pre and post data were 51.8% and 38% respectively (p<0.001). Doubling of cyclists and pedestrians occurred in 22 and 17 schemes respectively, with at least a 50% increase in 39 and 32 schemes respectively. Table D.1 and Table D.2 in Appendix D show overall change and estimated annual users for each scheme.

Table 2 includes each scheme’s estimated BCR. The median BCR was 3.7 (IQR 6.6), a comparatively high value as defined by the UK’s Department for Transport(Department for Transport, 2015).

### Scheme level route users

As shown in Table 3, demographic characteristics of users in the pre and post user surveys were similar overall. However, the proportion of cyclists significantly increased after scheme construction. This was found in both the manual count and survey of users. This was mostly due to increases in working-age men and women cyclists, with larger increases among men and experienced, regular cyclists, although there were also significant increases in new cyclists and those starting to cycle again, and borderline significant increases in occasional cyclists. Overall, most route users were pedestrians, white, without disability/ long-term illness, travelling off-peak for recreational purposes. They were most commonly working-age men, and not from the least deprived areas.

The counts of users found increases in women and older adults in 36 schemes (52%), in peak time users in 42 schemes (61%) and in women cyclists in 47 schemes (68%). The survey of users found increases in people with disability/ long-term illness in 44 schemes (62%) and users from the most deprived areas in 31 schemes (43%).

Table 3: Change in types of users across schemes using counts of users (Number of schemes = 69) and user survey (Number of schemes =73)

| Type of user | | Pre | | | | Post | | | | Change pre-post | | |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Total n | % | Median n | IQR | Total n | % | Median n | IQR | Median % | IQR % | p-value |
| **COUNTS OF USERS (69 schemes)** | | | | | | | | | | | | |
| Mode | Pedestrians | 123,448 | 77.1 | 947 | 1,802 | 201,427 | 69.2 | 1,413 | 2,947 | -3.1 | 13 | 0.116 |
| Cyclists | 29,589 | 18.5 | 260 | 324 | 76,899 | 26.4 | 498 | 913 | **3.5** | **12** | **0.048** |
| Wheelchair users | 658 | 0.4 | 4 | 9 | 1,124 | 0.4 | 7 | 12 | 0.1 | 0 | 0.878 |
| Horse riders | 131 | 0.1 | 0 | 2 | 257 | 0.1 | 1 | 4 | 0.0 | 0 | 0.377 |
| Runners | 6,297 | 3.9 | 37 | 56 | 11,388 | 3.9 | 63 | 111 | 0.3 | 3 | 0.346 |
| Age group and gender | Children | 31,121 | 19.4 | 250 | 447 | 51,097 | 17.6 | 476 | 783 | -1.2 | 12 | 0.483 |
| Working-age men | 64,393 | 40.2 | 539 | 766 | 124,331 | 42.7 | 993 | 1,646 | 1.5 | 9 | 0.164 |
| Working-age women | 47,789 | 29.8 | 393 | 582 | 86,747 | 29.8 | 602 | 1,521 | 0.1 | 5 | 0.891 |
| Older men | 9,944 | 6.2 | 73 | 106 | 17,159 | 5.9 | 154 | 222 | 0.2 | 4 | 0.743 |
| Older women | 6,876 | 4.3 | 51 | 73 | 11,761 | 4.0 | 94 | 164 | 0.3 | 3 | 0.729 |
| All women\* | 54,665 | 34.1 | 458 | 654 | 98,508 | 33.8 | 736 | 1,611 | 0.3 | 6 | 0.946 |
| All older people\* | 16,820 | 10.5 | 120 | 175 | 28,920 | 9.9 | 249 | 403 | 0.1 | 6 | 0.604 |
| Time of use | Peak\* | 34,387 | 21.5 | 224 | 469 | 58,799 | 20.2 | 525 | 727 | 1.3 | 6 | 0.498 |
| Off-peak | 125,736 | 78.5 | 1,145 | 1,484 | 232,296 | 79.8 | 1,839 | 3,444 | 3.5 | 8 | 0.498 |
| Type of cyclist | Child cyclists | 6,844 | 4.3 | 60 | 101 | 13,802 | 4.7 | 123 | 509 | 0.1 | 4 | 0.920 |
| Working-age men cyclists | 15,557 | 9.7 | 120 | 211 | 43,114 | 14.8 | 275 | 509 | **3.0** | **7** | **0.019** |
| Working-age women cyclists | 5,157 | 3.2 | 34 | 53 | 15,088 | 5.2 | 80 | 209 | **1.1** | **3** | **0.040** |
| Older men cyclists | 1,483 | 0.9 | 9 | 17 | 3,526 | 1.2 | 19 | 45 | 0.2 | 1 | 0.269 |
| Older women cyclists | 548 | 0.3 | 2 | 7 | 1,369 | 0.5 | 6 | 19 | 0.1 | 0 | 0.172 |
| All women cyclists\* | 5,705 | 3.6 | 37 | 56 | 16,457 | 5.7 | 85 | 229 | **0.9** | **3** | **0.021** |
| Counts of users TOTAL | | 160,123 | - | 1,413 | 1,951 | 291,095 | - | 2,331 | 4,428 | - | - | - |
| **SURVEYS OF USERS (73 schemes$)** | | | | | | | | | | | | |
| Age | 16-24 | 1,158 | 8.0 | 10 | 16 | 1,540 | 8.2 | 15 | 18 | 0.1 | 5.7 | 0.827 |
| 25-34 | 2,149 | 14.9 | 20 | 23 | 2,756 | 14.7 | 29 | 35 | 0.0 | 7.4 | 0.759 |
| 35-44 | 2,876 | 20.0 | 28 | 30 | 3,762 | 20.1 | 38 | 36 | -0.8 | 7.3 | 0.787 |
| 45-54 | 3,091 | 21.5 | 30 | 30 | 4,060 | 21.7 | 38 | 47 | 0.0 | 8.2 | 0.491 |
| 55-64 | 2,547 | 17.7 | 24 | 38 | 3,394 | 18.1 | 31 | 40 | 0.4 | 8.5 | 0.264 |
| 65+\* | 1,968 | 13.7 | 18 | 24 | 2,838 | 15.2 | 26 | 36 | 1.3 | 7.5 | 0.329 |
| Gender | Female\* | 5,948 | 41.3 | 64 | 63 | 7,641 | 40.8 | 70 | 91 | 1.2 | 12.5 | 0.352 |
| Male | 8,305 | 57.7 | 84 | 93 | 11,064 | 59.1 | 110 | 104 | -0.2 | 11.92 | 0.172 |
| Mode | Pedestrian | 11,063 | 76.8 | 114 | 127 | 13,288 | 71.0 | 127 | 151 | **-5.6** | **15.4** | **0.002** |
| Cyclist | 2,858 | 19.8 | 19 | 31 | 4,799 | 25.6 | 40 | 68 | **5.9** | **14.8** | **0.002** |
| Runner | 376 | 2.6 | 3 | 5 | 452 | 2.4 | 3 | 6 | -0.1 | 2.4 | 0.863 |
| Wheelchair | 67 | 0.5 | 0 | 1 | 104 | 0.6 | 1 | 2 | ***0.0*** | ***0.46*** | ***0.052*** |
| Roller skating | 8 | 0.1 | 0 | 0 | 12 | 0.1 | 0 | 0 | 0.0 | 0.0 | 0.412 |
| Horse riding | 6 | 0.04 | 0 | 0 | 17 | 0.09 | 0 | 0 | 0.0 | 0.0 | 0.130 |
| Type of cyclist& | Women cyclists\* | 754 | 5.2 | 4 | 9 | 1,155 | 6.2 | 10 | 16 | **1.4** | **4.0** | **0.030** |
| New to cycling | 48 | 0.3 | 0 | 1 | 73 | 0.4 | 0 | 2 | **0.0** | **0.4** | **0.034** |
| Starting to cycle again | 171 | 1.2 | 1 | 3 | 296 | 1.6 | 2 | 4 | **0.02** | **1.8** | **0.018** |
| Occasional cyclist | 225 | 1.6 | 1 | 4 | 388 | 2.1 | 2 | 5 | ***0.3*** | ***2.1*** | ***0.052*** |
| Experienced, occasional cyclist | 536 | 3.7 | 4 | 6 | 895 | 4.8 | 7 | 11 | 0.7 | 3.6 | 0.142 |
| Experienced, regular cyclist | 1,581 | 11.0 | 10 | 19 | 2,861 | 15.3 | 23 | 37 | **4.3** | **10.0** | **0.001** |
| Journey purpose on route | Commuting | 1,892 | 13.1 | 14 | 25 | 2,679 | 14.3 | 21 | 45 | 0.8 | 7.9 | 0.508 |
| Recreation | 7,757 | 53.9 | 73 | 76 | 10,042 | 53.6 | 99 | 95 | 1.9 | 17.8 | 0.763 |
| Shopping | 1,767 | 12.3 | 16 | 26 | 2,267 | 12.1 | 17 | 41 | -0.8 | 5.1 | 0.851 |
| Visit friends/family | 630 | 4.4 | 6 | 9 | 939 | 5.0 | 10 | 15 | 0.2 | 4.1 | 0.538 |
| Social/entertainment | 819 | 5.7 | 8 | 12 | 988 | 5.6 | 7 | 15 | -0.3 | 4.4 | 0.163 |
| Other# | 1,451 | 10.1 | 13 | 19 | 1,781 | 9.5 | 16 | 22 | -0.04 | 6.0 | 0.784 |
| Ethnicity | White | 12,091 | 84.0 | 138.5 | 123.75 | 17,497 | 93.5 | 170 | 189.5 | 0.04 | 3.5 | 0.930 |
| Non-white | 507 | 3.5 | 2 | 5.5 | 729 | 3.9 | 2 | 5.25 | 0.0 | 2.0 | 0.672 |
| Disabled/ long term illness | Yes\* | 1,807 | 13.4 | 16 | 20.5 | 2,549 | 14.4 | 25 | 31.5 | 1.4 | 8.7 | 0.104 |
| No | 11,708 | 86.6 | 125 | 137.5 | 15,121 | 85.6 | 168 | 159 | -1.1 | 9.2 | 0.364 |
| UK-adjusted IMD quintile (1=most deprived) | 1\* | 3,196 | 22.2 | 14 | 61 | 4,121 | 22.0 | 22 | 70 | -0.01 | 5.6 | 0.703 |
| 2 | 3,328 | 23.1 | 24 | 44 | 4,132 | 22.1 | 33 | 51 | -0.2 | 9.2 | 0.956 |
| 3 | 2,803 | 19.5 | 24 | 42 | 3,756 | 20.1 | 35 | 51 | 1.1 | 7.6 | 0.654 |
| 4 | 2,859 | 19.9 | 22 | 34 | 3,807 | 20.3 | 34 | 52 | -1.4 | 7.1 | 0.669 |
| 5 | 2,216 | 15.4 | 12 | 43 | 2,903 | 15.5 | 23 | 41 | 0.1 | 3.7 | 0.731 |
| User survey TOTAL | | 14,402 | - | 149 | 163 | 18,719 | - | 198 | 192 | - | - | - |

\* Sub-group of interest (peak time defined as 7am – 9am and 4pm – 7pm on weekdays; older people classified subjectively by surveyors)

# ‘Other’ includes in course of work, education, personal business, holiday base, escort to school, other escort, and other.

$ 71 schemes were used in analyses of users from the most deprived quintile and those with a disability/long-term illness due to missing data.

& Type of cyclist was selected by each participant (excluding the option ‘women cyclist’)

Total percentages may not add to 100 due to rounding and missing values.

### Participant descriptive statistics

As seen in Table 4, respondents differed in demographic characteristics between datasets – the user survey respondents were most commonly male, working-age, employed full time, white, in good health, from more deprived areas and without children. The iConnect cohort were most commonly female, older, white, in good health, from the least deprived areas and without children. Users of the new routes were most commonly employed full time, whereas non-users were most commonly retired.

Just over half of the cross-sectional survey sample reported meeting guideline physical activity levels (pre 52.6%; post 53.2%). Higher proportions of the iConnect cohort reported meeting the guidelines: 66.1% of non-users and 86.8% of route users at one-year follow-up; 63.9% of non-users and 83.6% of users at two-year follow-up. The percentage of respondents in the iConnect cohort who reported using the routes increased between one-year and two-year follow-up: from 52% to 53% at Cardiff; from 17% to 23% at Southampton; and from 23% to 37% at Kenilworth.

The percentage of survey respondents reporting that their decision to use the routes was influenced by an aim of achieving exercise rose from 55% at baseline to 61% at post-monitoring. 67% of users of the routes in the post survey reported that they thought that the routes increased their physical activity. (See Table D.3 and Table D.4 in Appendix D for further details about reasons for using the routes and other modes used to access them.)

Table 4: Comparison of participant characteristics in cross-sectional survey of users and iConnect cohort at baseline

| **Variable** | **Survey of users** | | **iConnect** | | | |
| --- | --- | --- | --- | --- | --- | --- |
| **1-year follow-up** | | **2-year follow-up** | |
| **Pre**  **(n=13,343) (%)** | **Post (n=19,544) (%)** | **Non-users of route (n=1,322) (%)** | **Users of route (n=531) (%)** | **Non-users of route (n=945) (%)** | **Users of route (n=579) (%)** |
|  | **n (%)** | **n (%)** | **n (%)** | **n (%)** | **n (%)** | **n (%)** |
| **Sex** |  |  |  |  |  |  |
| Male | 7,696 (57.7%) | 11,479 (58.7%) | 591 (44.7%) | 256 (48.2%) | 405 (42.9%) | 268 (46.3%) |
| Female | 5,647 (42.3%) | 8,065 (41.3%) | 731 (55.3%) | 275 (51.8%) | 540 (57.1%) | 311 (53.7%) |
| **Age** |  |  |  |  |  |  |
| 16-24 | 1,132 (8.5%) | 1,645 (8.4%) | 63 (4.8%) | 9 (1.7%) | 33 (3.5%) | 7 (1.2%) |
| 25-34 | 2,054 (15.4%) | 2,984 (15.3%) | 113 (8.5%) | 72 (13.6%) | 63 (6.7%) | 56 (9.7%) |
| 35-44 | 2,754 (20.6%) | 4,017 (20.6%) | 135 (10.2%) | 82 (15.4%) | 86 (9.1%) | 78 (13.5%) |
| 45-54 | 3,003 (22.5%) | 4,389 (22.5%) | 209 (15.8%) | 117 (22%) | 157 (16.6%) | 130 (22.5%) |
| 55-64 | 2,487 (18.6%) | 3,559 (18.2%) | 334 (25.3%) | 127 (23.9%) | 135 (14.3%) | 160 (27.6%) |
| 65+ | 1,913 (14.3%) | 2,950 (15.1%) | 468 (35.4%) | 124 (23.4%) | 371 (39.3%) | 148 (25.6%) |
| **Employment** |  |  |  |  |  |  |
| Employed full time | 6,321 (47.4%) | 9,973 (51%) | 436 (33%) | 229 (43.1%) | 276 (29.2%) | 235 (40.6%) |
| Employed part time | 1,966 (14.7%) | 2,682 (13.7%) | 197 (14.9%) | 85 (16%) | 143 (15.1%) | 96 (16.6%) |
| Retired | 2,790 (20.9%) | 4,083 (20.9%) | 521 (39.4%) | 169 (31.8%) | 398 (42.1%) | 202 (34.9%) |
| Other | 2,266 (17%) | 2,806 (14.4%) | 168 (12.7%) | 48 (9%) | 128 (13.5%) | 46 (7.9%) |
| **Ethnicity** |  |  |  |  |  |  |
| White | 12,840 (96.2%) | 18,712 (95.7%) | 1,256 (95%) | 467 (87.9%) | 903 (95.6%) | 558 (96.4%) |
| Non-white | 503 (3.8%) | 832 (4.3%) | 56 (4.2%) | 15 (2.8%) | 39 (4.1%) | 19 (3.3%) |
| **General health in last 4 weeks** |  |  |  |  |  |  |
| Excellent | 3,507 (26.3%) | 6,020 (30.8%) | 213 (16.1%) | 182 (34.3%) | 289 (30.6%) | 154 (26.6%) |
| Good | 8,680 (65.1%) | 11,866 (60.7%) | 640 (48.4%) | 316 (59.5%) | 709 (75%) | 307 (53%) |
| Fair | 913 (6.8%) | 1,281 (6.6%) | 193 (14.6%) | 70 (13.2%) | 272 (28.8%) | 64 (11.1%) |
| Poor | 243 (1.8%) | 377 (1.9%) | 52 (3.9%) | 11 (2.1%) | 52 (5.5%) | 6 (1%) |
| **Deprivation quintile** |  |  |  |  |  |  |
| IMD 1 (= most deprived) | 3,471 (26%) | 4,700 (24%) | 125 (9.5%) | 24 (4.5%) | 97 (10.3%) | 23 (4%) |
| IMD 2 | 3,026 (22.7%) | 4,261 (21.8%) | 190 (14.4%) | 55 (10.4%) | 131 (13.9%) | 59 (10.2%) |
| IMD 3 | 2,622 (19.7%) | 3,834 (19.6%) | 191 (14.4%) | 90 (16.9%) | 130 (13.8%) | 90 (15.5%) |
| IMD 4 | 2,309 (17.3%) | 3,793 (19.4%) | 342 (25.9%) | 162 (30.5%) | 238 (25.2%) | 175 (30.2%) |
| IMD 5 | 1,915 (14.4%) | 2,956 (15.1%) | 474 (35.9%) | 200 (37.7%) | 349 (36.9%) | 232 (40.1%) |
| **Long-term illness or disability** |  |  |  |  |  |  |
| Yes | 3,745 (28.1%) | 5,582 (28.6%) | 377 (28.5%) | 85 (16%) | 294 (31.1%) | 105 (18.1%) |
| No | 9,598 (71.9%) | 13,962 (71.4%) | 945 (71.5%) | 446 (84%) | 651 (68.9%) | 474 (81.9%) |
| **Children in household** |  |  |  |  |  |  |
| Yes | 3,772 (28.1%) | 5,593 (28.6%) | 162 (12.3%) | 97 (18.3%) | 103 (10.9%) | 97 (16.8%) |
| No (inc. missing data for user survey) | 9,633 (71.9%) | 13,968 (71.4%) | 1,160 (87.7%) | 434 (81.7%) | 842 (89.1%) | 482 (83.2%) |
| **iConnect scheme** |  |  |  |  |  |  |
| Cardiff | 0 (0%) | 1,049 (5.4%) | 313 (23.7%) | 277 (52.2%) | 231 (24.4%) | 258 (44.6%) |
| Southampton | 306 (2.3%) | 335 (1.7%) | 441 (33.4%) | 88 (16.6%) | 333 (35.2%) | 99 (17.1%) |
| Kenilworth | 88 (0.7%) | 303 (1.6%) | 568 (43%) | 166 (31.3%) | 381 (40.3%) | 222 (38.3%) |

## Use and benefit-cost ratio of new walking and cycling infrastructure by local contextual factors and scheme characteristics

Results for maximally adjusted models, shown in Figure 1 (see Table D.5 in Appendix D for full data table), indicated that higher relative increases in cyclists and pedestrians were associated with lower baseline levels of users. The odds of observing at least a 50% increase in cyclists were reduced by nearly a quarter for each additional 10,000 annual cyclists at baseline (OR=0.79, 95% CI=0.63,0.92), and the odds of observing a doubling in cyclists were halved (OR=0.52, 95% CI=0.31, 0.77). The odds of observing at least 50% increase in pedestrians were reduced by more than a tenth for each additional 100,000 annual users at baseline (OR=0.86, 95% CI=0.68,1.01) and the odds of observing a doubling in pedestrians were reduced by more than three-fifths (OR=0.39, 95% CI=0.14, 0.78).

An estimated BCR of at least 4 was associated with higher baseline levels of users (per additional 100,000 annual users at baseline: OR=1.24, 95% CI=1.05, 1.57), lower cost schemes (per additional £1 million scheme cost: OR=0.29, 95% CI=0.13, 0.57) and the presence of a public transport interchange within 0.5 mile (OR=4.64, 95% CI=1.00, 26.62), although 95% confidence intervals were wide and the association was not significant in the unadjusted model. No other clear significant relationships were found.

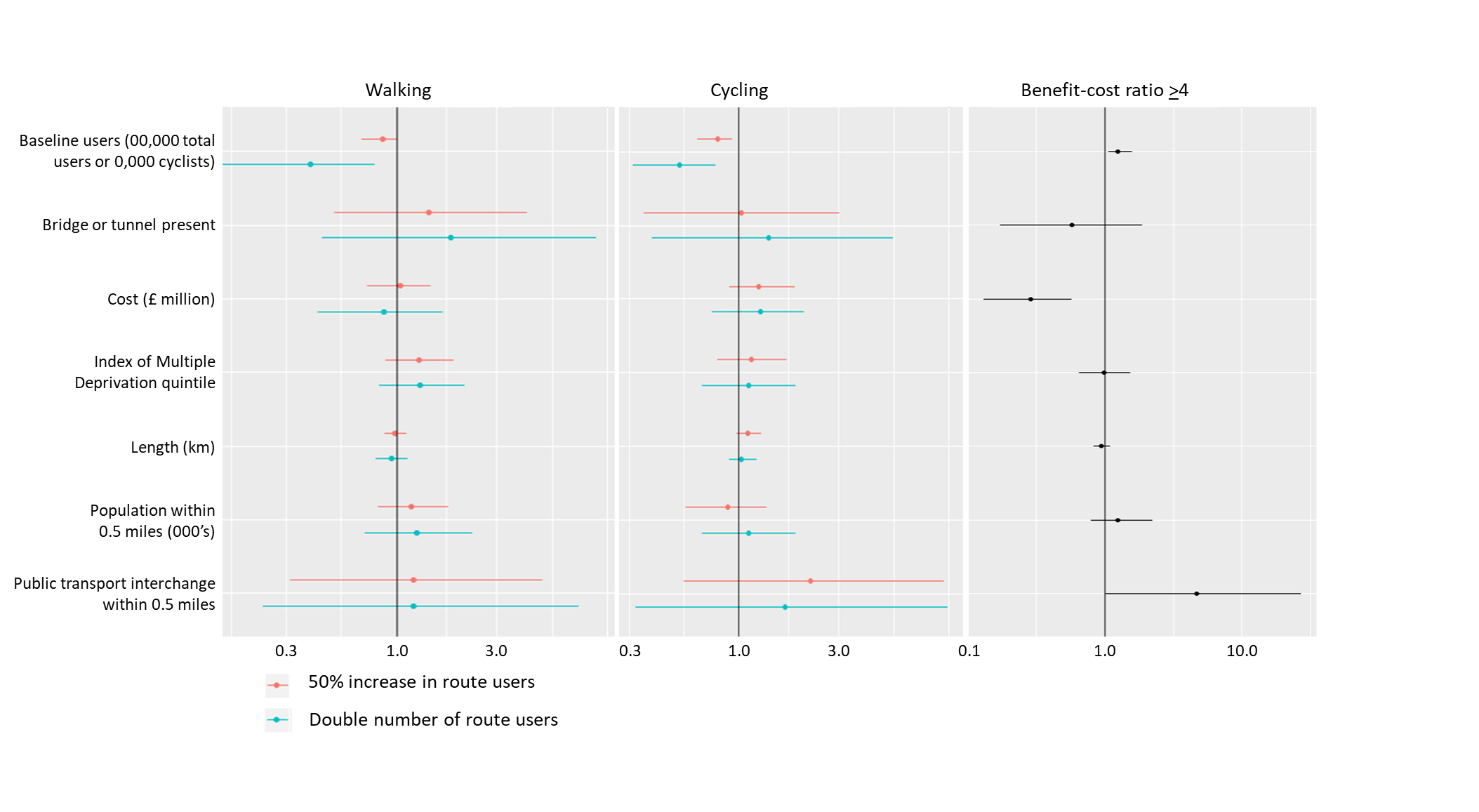


Figure 1: Multivariable binary logistic regression analysis: ORs and 95%CIs for context/ scheme characteristics and either at least a 50% increase or a doubling in the number of route users, and BCR across schemes, maximally adjusted for each independent contextual/scheme characteristic variable (baseline users, bridge or tunnel present, cost, index of multiple deprivation quintile, length, population within 0.5 miles, public transport interchange with 0.5 miles) and time from completion to post-monitoring (Total annual scheme users, Number of schemes = 77)

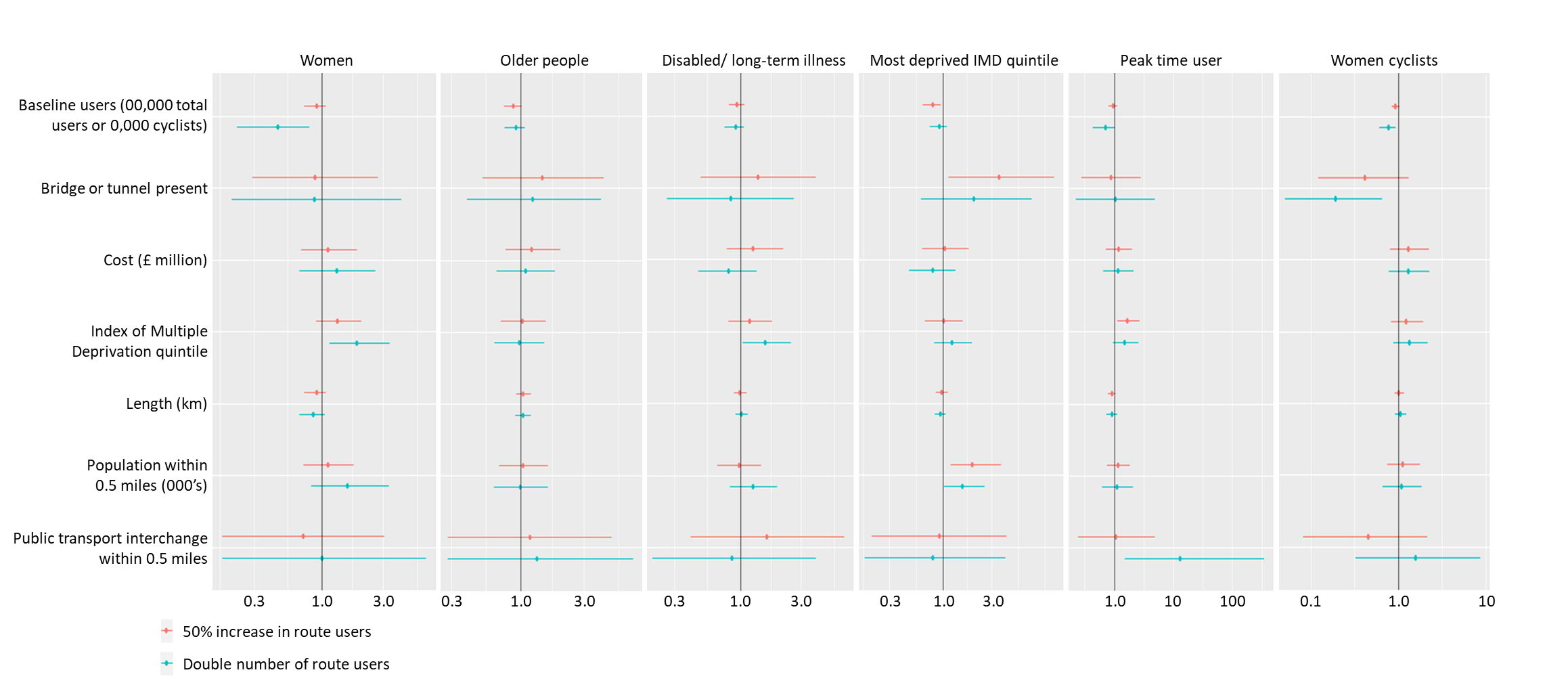
## Users of new walking and cycling infrastructure by local contextual factors and scheme characteristics

The maximally adjusted models, shown in Figure 2 (full data in Table D.6 and sensitivity analysis results in Table D.7 of Appendix D), indicated that higher relative increases in sub-groups were associated with lower baseline levels of users, similar to that found for overall use.

High relative increases of users from the most deprived LSOAs were associated with high population levels within 0.5 miles (odds of observing at least 50% increase almost doubled for each additional 1000 population: OR=1.93, 95% CI=1.18, 3.67; odds of observing a doubling increased by more than half: OR=1.54, 95% CI=1.01, 2.52), and a bridge or tunnel present (at least 50% increase: OR=3.51, 95% CI=1.12, 12.16), although 95% confidence intervals were wide. There were lower odds of doubling women cyclists with a bridge or tunnel present, also with wide 95% confidence intervals (OR=0.19, 95% CI=0.05, 0.64).

Doubling of users of the route with a disability or long-term illness and women users were associated with less deprived IMD local government quintiles (doubling women: OR=1.87, 95% CI=1.14, 3.32; doubling disabled/long-term illness: OR=1.56, 95% CI=1.03, 2.46).

Doubling of peak time users was associated with a public transport interchange present within 0.5 miles (OR=14.12, 95% CI=1.54, 386.86), although the 95% confidence intervals were wide. No other clear significant relationships were found.



*Figure 2: Multivariable binary logistic regression analysis: ORs and 95%CIs for either at least a 50% increase or a doubling the number of users in each sub-group, maximally adjusted for each independent contextual/scheme characteristic variable (baseline users, bridge or tunnel present, cost, index of multiple deprivation quintile, length, population within 0.5 miles, public transport interchange with 0.5 miles) and time from completion to post-monitoring[[1]](#footnote-1)*

## Use and meeting physical activity guidelines

As seen in Table 5, walking and cycling on the Connect2 routes were associated with meeting physical activity guidelines. In the survey of users this was found for regular route users, compared to irregular users (pre: OR=1.80, 95% CI=1.67, 1.94; post: OR=1.93, 95% CI=1.81, 2.05). Non-commuting transport users were less likely to meet the physical activity guidelines, compared to recreational users (pre: OR=0.66, 95% CI=0.61, 0.71; post: OR=0. 77, 95% CI=0.72, 0.83) and runners were more likely than pedestrians to meet the guidelines (pre: OR=1.50, 95% CI=1.19, 1.90; post: OR=1.51, 95% CI=1.24, 1.84). There were no significant differences between pedestrians and cyclists, or recreational and commuting users, on the new routes.

The iConnect cohort analysis found that route users were more likely to meet the physical activity guidelines compared to non-users (at one-year follow-up: users at one-year only OR=2.07, 95% CI=1.37, 3.21 and users at one-year and two-year OR=3.02, 95% CI=2.02, 4.62; at two-year follow-up: users at two-year only OR=2.00, 95% CI=1.37, 2.96 and users at one-year and two-year OR=1.66, 95% CI=1.14, 2.45). As in the survey of users, non-commuting transport users were less likely to achieve the guidelines than recreational users (OR=0.22, 95% CI=0.06, 0.79), although 95% confidence intervals were wide. There was no significant difference at two-year follow-up. There were insufficient data to investigate this outcome for commuters only. Users for both recreational and transport were significantly more likely to meet the guidelines at two-year follow-up, compared to only recreational users (OR=2.07, 95% CI=1.18, 3.75). As in the survey of users there was no significant difference between pedestrians and cyclists in the adjusted models.

Table 5: Logistic regression - Survey of users: odds ratio (95% confidence interval) of meeting guideline levels of physical activity in previous week

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Type of route user** | | **Survey of users: at least 5\* days of 30 min physical activity in previous week** | | | | | | | | **iConnect: at least 150 min physical activity in previous week** | | | | | | | |
| **Pre** | | | | **Post** | | | | **1-year follow-up** | | | | **2-year follow-up** | | | |
| **Sample (n)** | **% of sample achieving 5+ days** | **Unadjusted** | **Adjusted#** | **Sample (n)** | **% of sample achieving 5+ days** | **Unadjusted** | **Adjusted\*** | **Sample (n)** | **% of sample achieving 150 min** | **Unadjusted** | **Adjusted$** | **Sample (n)** | **% of sample achieving 150 min PA** | **Unadjusted** | **Adjusted#** |
| **User time point** | Non-user (reference) | - | - | - | - | - | - | - | - | 1,156 | 65.1% | 1.00 | 1.00 | 893 | 63.3% | 1.00 | 1.00 |
| User at 1-year follow-up only | - | - | - | - | - | - | - | - | 217 | 83.9% | **2.79 (1.93, 4.15)** | **2.07 (1.37, 3.21)** | 58 | 77.6% | **2.00 (1.10, 3.93)** | 1.29 (0.64, 2.74) |
| User at 2-year follow-up only | - | - | - | - | - | - | - | - | 172 | 73.3% | **1.47 (1.04, 2.12)** | 0.96 (0.64, 1.44) | 265 | 83.0% | **2.84 (2.02, 4.06)** | **2.00 (1.37, 2.96)** |
| User at 1-year and 2-year follow-up | - | - | - | - | - | - | - | - | 314 | 88.9% | **4.28 (2.99, 6.31)** | **3.02 (2.02, 4.62)** | 314 | 84.1% | **3.07 (2.22, 4.31)** | **1.66 (1.14, 2.45)** |
| **Frequency of journey on route** | Irregularly (Weekly or less frequently) (reference) | 4,562 | 43.2% | 1.00 | 1.00 | 6,876 | 43.1% | 1.00 | 1.00 | - | - | - | - | - | - | - | - |
| Regularly (Daily/ 2-5 times a week) | 8,781 | 57.9% | **1.78 (1.66, 1.92)** | **1.80 (1.67, 1.94)** | 12,668 | 59.1% | **1.89 (1.79, 2.01)** | **1.93 (1.81, 2.05)** | - | - | - | - | - | - | - | - |
| **Journey purpose on route** | Recreation (reference) | 6,605 | 57.1% | 1.00 | 1.00 | 10,358 | 55.6% | 1.00 | 1.00 | 280 | 87.5% | 1.00 | 1.00 | 316 | 81.3% | 1.00 | 1.00 |
| Commuting | 1,715 | 56.7% | 0.98 (0.88, 1.09) | 1.00 (0.90, 1.12) | 2,751 | 56.5% | 1.04 (0.95, 1.13) | 1.06 (0.97, 1.16) | 5 | 100% | *Insufficient data* | *Insufficient data* | 4 | 50% | *Insufficient data* | *Insufficient data* |
| Non-commuting transport& | 4,997 | 46.2% | **0.64 (0.60, 0.69)** | **0.66 (0. 61, 0.71)** | 6,404 | 49.0% | **0.77 (0.72, 0.82)** | **0.77 (0.72, 0.83)** | 19 | 69.4% | **0.31 (0.11, 0.93)** | **0.22 (0.06, 0.79)** | 31 | 67.8% | 0.48 (0.22, 1.12) | 0.55 (0.21, 1.47) |
| Recreation and transport | - | - | - | - | - | - | - | - | 221 | 89.6% | 1.07 (0.63, 1.86) | 0.95 (0.53, 1.74) | 222 | 90.0% | **1.99 (1.20, 3.39)** | **2.07 (1.18, 3.75)** |
| **Mode on route** | Walking (reference) | 10,441 | 52.0% | 1.00 | 1.00 | 14,046 | 53.6% | 1.00 | 1.00 | 284 | 84.5% | 1.00 | 1.00 | 307 | 79.5% | 1.00 | 1.00 |
| Cycling | 2,485 | 56.7% | **1.21 (1.11, 1.32)** | **1.12 (1.02, 1.23)** | 4,839 | 53.6% | 1.00 (0.94, 1.07) | 0.98 (0.91, 1.05) | 28 | 89.3% | 1.53 (0.51, 6.61) | 1.28 (0.38, 5.89) | 34 | 82.4% | 1.20 (0.51, 3.33) | 0.73 (0.26, 2.26) |
| Walking & cycling | - | - | - | - | - | - | - | - | 213 | 90.7% | **1.77 (1.02, 3.16)** | 1.23 (0.66, 2.37) | 232 | 90.6% | **2.14 (1.31, 3.58)** | 1.46 (0.83, 2.26) |
| Running\* | 324 | 62.7% | **1.55 (1.24, 1.95)** | **1.50 (1.19, 1.90)** | 476 | 63.9% | **1.53 (1.27, 1.85)** | **1.51 (1.24, 1.84)** | - | - | - | - | - | - | - | - |
| Other | 93 | 32.3 | **0.44 (0.28, 0.67)** | **0.44 (0.28, 0.68)** | 183 | 21.9% | **0.24 (0.17, 0.34)** | **0.26 (0.18, 0.38)** | - | - | - | - |  | - | - | - |
| **Journey time on route (hrs)** |  | 13,243 | 53.4% | **1.07 (1.04, 1.10)** | **1.05 (1.01, 1.08)** | 19,406 | 54.0% | 1.00 (0.98, 1.03) | 1.00 (0.97, 1.02) |  | - | - | - |  | - | - | - |

\*At least 4 days of 30 minutes of physical activity for users recorded as running.

& Non-commuting transport includes travel for shopping, visiting friends/family, social/entertainment and other purposes.

# Adjusted for demographic variables: gender (male/female), age (16-24/25-34/35-44/45-54/55-64/65+), employment (employed full time/employed part time/retired/other), ethnicity (white/non-white), general health (excellent/good/fair/poor), disability/long-term illness (yes/no), home IMD quintile, and child under 16 in the household (yes/no).

$ Adjusted for baseline demographic variables: gender (male/female), age, employment (employed full time/employed part time/retired/other), general health (excellent/good/fair/poor), disability/long-term illness (yes/no), home IMD quintile, child under 16 in the household (yes/no), baseline physical activity (minutes) and scheme (Cardiff/Kenilworth/Southampton).

# Discussion

## Route users and context

New and upgraded routes were associated with increases in pedestrians and cyclists with large relative increases associated with low baseline levels of users. This could help to provide political support for investment in areas with existing low levels of active travel. However, places with high baseline users were associated with very high BCRs, which may create tension between investing in areas with the greatest potential for modal change (currently low levels of walking and cycling) and apparent high BCRs where currently walkable and cycleable areas may be more likely to receive investment, perpetuating inequalities in infrastructure availability. This potential tension between relative and absolute change is planned to be investigated further in future qualitative research with decision-makers. Lower cost schemes were also associated with very high BCRs, which may be as a result of relatively minor changes in infrastructure, such as on existing routes that may have improved safety or increased connectivity between key locations, attracting relatively large numbers of users at low cost.

The similarity in demographics of users found in the pre- and post-user surveys suggests that increases were roughly proportional across the whole of the population. However, the user sub-group analysis found that doubling of users who were women or had disabilities or long-term illness was associated with new routes in less deprived areas. This may be explained by people from these groups preferring to walk or cycle in places that are attractive and safe (Table D.4, Appendix D) but if used to justify investment in more affluent areas it could exacerbate health inequalities(NHS Digital, 2017).

High relative increases in route users who lived in the most deprived LSOAs were associated with high population levels within 0.5 miles of the route and with the presence of a bridge or tunnel. Creating convenient routes to access amenities on foot and by bike in high density areas, or overcoming physical barriers, is likely valued by this group (see Table D.4 in Appendix D). Furthermore they are least likely to be able to afford a car and car ownership has previously been shown to be correlated with walking and cycling(Carse et al., 2013; Goodman et al., 2014; PCT Team, 2019). However, the number of women cyclists was less likely to double where a bridge or tunnel was present, an association that was not found for cyclists overall. This may be because these features reduce natural surveillance and therefore reduce perceptions of safety which tend to be highly valued by this group(Yang et al., 2019). If these features lead to employment centres they may appear less convenient for women cyclists who are more likely to conduct shorter, chain trips, such as those related to caring responsibilities(Ng and Acker, 2018). It should be noted, however, that the Connect2 schemes all involved overcoming some sort of physical barrier which is not the case for many walking and cycling routes.

High BCRs and doubling of peak time users were associated with the presence of a public transport interchange within 0.5 miles of the routes. This is consistent with other research that walking and cycling is associated with public transport use(Patterson et al., 2018) and these results could be used to justify investment in walking and cycling infrastructure near to public transport hubs because modal shift may reduce traffic congestion. Previous research from the iConnect study did not detect overall significant modal shift or carbon savings among local residents because most of their reported new use was recreational and did not replace motor vehicle trips(Brand et al., 2014; Song et al., 2017). This may reflect important differences in the ways the samples were recruited.

## Use and physical activity

Results showed that walking and cycling on the new routes was associated with meeting physical activity guidelines, and greater use (in terms of frequency and purpose) was associated with increased likelihood of achieving the guidelines. This builds on findings from previous iConnect research by Goodman et al. which found that living closer to three of the Connect2 routes was associated with greater total physical activity after two years(Goodman et al., 2014). It also supports other research that demonstrates that building walking and cycling infrastructure can increase levels of physical activity to achieve public health benefits(Aldred et al., 2020; Mueller et al., 2018; Smith et al., 2019).

Whilst the baseline user survey found that people who met the guidelines were more likely to be cyclists compared to pedestrians and by those who travelled for longer, there were no significant differences between pedestrians and cyclists or by time travelled by users of the new routes. This suggests that the Connect2 schemes attracted more frequent use by a wider range of people, increasing physical activity across the population, rather than previously only attracting more active people. Runners were more likely than pedestrians to achieve the guideline levels of physical activity, however, this was not seen in the sensitivity analysis with five days of thirty minutes of physical activity, rather than four (see Table D.8 in Appendix D). This points to a limitation in this type of self-report data in that the intensity of activity in general was not captured in the survey, particularly since mode was not recorded for physical activity on other active days in the previous week. Self-reported physical activity is widely used but involves a trade-off between scale and cost(Branion-Calles et al., 2019; Dowd et al., 2018; Prince et al., 2008).

People using the routes for non-commuting transport purposes were less likely to achieve the physical activity guidelines compared to recreational users in the survey of users and at one-year follow-up in the iConnect cohort, whilst by two-year follow-up there was no difference between these purposes, although the confidence intervals were large. This aligns with findings from other iConnect analysis showing that it takes time for behavioural change to occur following construction of the new routes(Goodman et al., 2014). Mechanisms for behaviour change are likely to involve a combination of physical environmental and societal factors(Ogilvie et al., 2011), therefore changes in visibility of people walking or cycling on the new routes can take time to affect cultural norms and encourage physical activity across the population. This may be particularly true for non-employment destinations that were previously inaccessible or unattractive to reach by bike or on foot. Sustrans’ Connect2 post-monitoring data and the iConnect cohort follow-ups were conducted over a relatively short time period and it would be advantageous to repeat measurements to understand longer-term impact.

## Research and monitoring methods: strengths and limitations

This study used monitoring data from 84 new walking and cycling schemes alongside research data from 3 of those schemes to understand how these different methods may be useful in understanding changes in use associated with context, and the association of use with overall physical activity. We demonstrated that both the research and monitoring methods had value - the longitudinal iConnect dataset was able to evaluate individual-level change over time, which was a major strength, whereas this was not possible in the survey of users which was unable to be adjusted for baseline levels of physical activity, nor to determine whether people continued to use the routes and the impact that may have. For example, the survey of users asked about levels of cycling experience and it was unclear whether new or occasional cyclists maintained behaviour to become experienced, regular cyclists, for which there was a significant increase. There may have been some route displacement, attracting pedestrians and cyclists from other places, but it was unclear to what extent this occurred with the questionnaire. This difficulty in understanding displacement is not uncommon(Aldred, 2019). It was not possible to identify to what extent increases in use were due to new people moving into the area, which was also a limitation of the cohort dataset. An additional limitation was that baseline measurements of some of the Connect2 schemes were conducted months or even years before construction started and it is unclear to what extent the assumption of minimal change between pre-monitoring and construction is valid.

Whilst cohort studies like iConnect have advantages they are rarely conducted. They also have limitations, therefore understanding the value of multi-site cross-sectional evaluations is useful. A strength of Sustrans’ Connect2 datasets (counts, surveys of users and total annual scheme users) was the number of locations that were included, following the same methodology, and their breadth of contexts, allowing assessment of the impact of context on use, which is rarely evaluated and not clearly understood(Adkins et al., 2017; Cavill et al., 2019; Panter et al., 2019). The much larger sample sizes than the cohort study enabled greater disaggregation of sub-groups for the evaluation of use and meeting guideline levels of physical activity. However, understanding impacts by types of user sub-group at a scheme level often resulted in large confidence intervals due to the relatively small number of schemes included in the samples. It is therefore recommended that this type of multi-scheme evaluation is conducted at a greater scale to provide more reliable results about context on user sub-groups. We note that the routes were completed between 2009 and 2013 and evaluation of more recently constructed walking and cycling infrastructure would be valuable, particularly following improved cycle infrastructure design standards(Department for Transport, 2020).

Contextual issues are important to consider in complex public health intervention research(Craig et al., 2018), however, there are relevant contextual factors that were not assessed in this analysis, for example, whether additional investment or behaviour change strategies were being done in parallel that could have influenced outcomes(Sahlqvist et al., 2015). Also, because of the multi-purpose nature of the Connect2 routes, their often extensive lengths with variety of population densities along them, and the lack of information about the quality of the surrounding environment for walking and cycling, it was challenging to understand to what extent these contextual features influenced the impact of the new routes. Smaller scale qualitative or ethnographic approaches to unpacking the complexity of contextual influences may therefore be important alongside large-scale quantitative evaluation. Further qualitative research into what contextual features are important to decision-makers of new walking and cycling routes is planned.

It appeared that the survey of users was broadly representative of route users, as measured by the manual count, however this data was captured over four days for each scheme, without adjustment for weather, as is often the case in transport assessments(Aldred, 2019). The iConnect respondents who reported using the routes appeared to be less representative of route users, more likely being older, female, from less deprived areas and without children. Although representativeness of the general population may not be necessary for cohort studies since confounders can be controlled for in regression analysis(Richiardi et al., 2013) and bias was reduced by inviting a random sample of local residents to complete the questionnaires, the low response rates of the iConnect cohort (15.6% response rate(Song et al., 2017), of which 60% had complete data for inclusion in this analysis) resulted in some sub-groups of users unable to be investigated separately, such as commuters. In contrast, the survey of users found that about 14% of people overall used the routes for commuting (29% of users were recorded as commuters on the three iConnect schemes, including 52% during peak hours). However, the cross-sectional survey of users did not investigate other purposes that people used the routes for, whilst 8% of users in the iConnect cohort reported using the routes for commuting alongside other purposes. Therefore combining findings from both datasets gives a fuller picture of the impact of this infrastructure on commuting behaviour, which may be useful for influencing non-health sectors, such as transport planning, to influence the wider determinants of health(Dahlgren and Whitehead, 1991).

# Conclusion

Evaluations of new walking and cycling infrastructure may involve trade-offs between scale, cost, representativeness of sample and ability to capture within-participant change. Combining pragmatic monitoring methods allowing estimations of users and benefit-cost ratios with longitudinal analysis, we demonstrated that new walking and cycling infrastructure can lead to large relative increases in pedestrians and cyclists and has the potential to increase population levels of physical activity, whilst also providing very high value for money. We were also able to understand more about the role of context in attracting people to use new and improved local networks for walking and cycling, particularly from less active groups such as older people, disabled/with long-term illness and people from the most deprived areas. This study suggests that construction of new and improved walking and cycling infrastructure at scale could improve population health and reduce health inequalities.

# Acknowledgements

The authors thank the iConnect study participants for their cooperation, and the iConnect study team led by Karen Ghali for managing data collection.

The authors are also grateful to all the respondents of the Sustrans Connect2 surveys. Thanks also to staff at Sustrans who planned the collection of the data, and supported collation and management of data.

**Ethical approval statements:**

The iConnect study was approved by the University of Southampton Research Ethics Committee (reference number CEE 200809-15).

The Connect2 study was not conducted for academic purposes and therefore ethical approval was not sought.

**Data sharing statement:**

iConnect data: The data set used in this study is managed by the MRC Epidemiology Unit at the University of Cambridge. The access policy for sharing is based on the MRC Policy and Guidance on Sharing of Research Data from Population and Patient Studies. All data sharing must meet the terms of existing participants’ consent and study ethical approvals. The authors’ Data Access and Sharing Policy defines the principles and processes for accessing and sharing our data. They welcome proposals for projects and aim to make data as widely available as possible while safeguarding the privacy of our participants, protecting confidential data and maintaining the reputations of our studies and participants. All data sharing is dependent on the project being approved by the study team, a data sharing agreement being in place with the University of Cambridge and resources being available to support the request. For further information please refer to the MRC Epidemiology Unit data sharing portal at [http://epi-meta.medschl.cam.ac.uk](http://epi-meta.medschl.cam.ac.uk/)

Connect2 data: The data set used in this study is managed by Sustrans. Please apply to monitoring@sustrans.org.uk.

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# Appendix

## Appendix A. Additional methodological information

### Counts of users

Cross-sectional manual counts of route users were undertaken on behalf of Sustrans by market research companies. The manual counts were conducted pre and post construction at one or more monitoring points for each scheme between 7am and 7pm on four days covering term time, holiday, weekday and weekend. All route users were classified subjectively by surveyors as either child, working-age man, older man, working-age woman or older woman and mode of travel was recorded as either cycling, walking, running, horse riding, wheelchair or other.

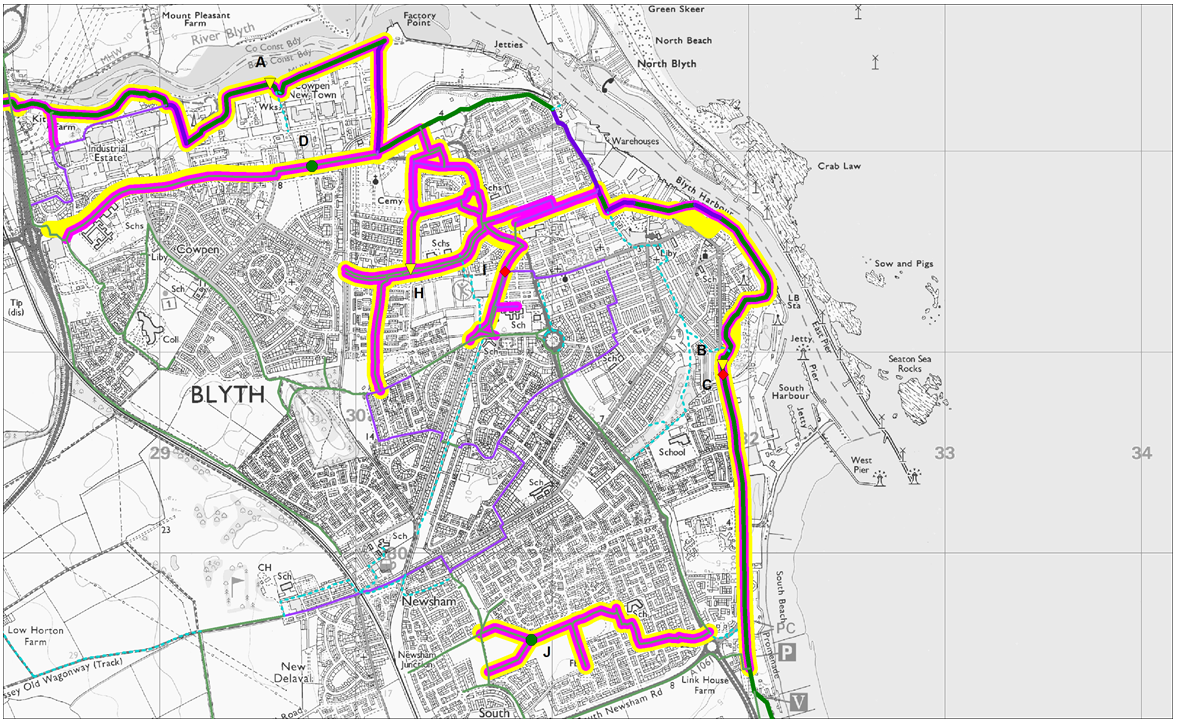
### Surveys of users

Cross-sectional user surveys were undertaken on behalf of Sustrans by market research companies at the same times as the manual count. Selection was on a next-to-pass basis, such that when the surveyor had finished one survey, the next adult (16 years or older) to pass them in either direction was invited to take part in the survey. Informed consent was obtained. The user survey asked questions about: frequency of journey on the route; mode of travel; purpose of trip; how long the journey would take; how many days in the previous week at least 30 minutes of physical activity had been conducted; and demographic information. Extreme values for length of journey greater than 480 minutes were excluded (188 responses, 0.5%).

### Total annual scheme users

Total annual scheme users were estimated by Sustrans using multiple datasets for each Connect2 scheme(Sustrans, 2013b), including automatic counter data, manual counts of users and user survey data. The method for estimating numbers of users on each Connect2 scheme(Sustrans, 2013b) is outlined below:

1. Map obtained of each scheme showing baseline monitoring points. An example is shown in Figure A.1.
2. Using information from the map and survey of users the scheme details were understood, such as journey purpose, type of scheme, connectedness etc.
3. Average trip length calculated for each scheme based on trip lengths in the National Travel Survey (NTS)(Department for Transport, 2010) and the types of journey reported in the survey of users.
4. Schematic maps made for each scheme. Mapping software used to determine distances between monitoring sites and schemes divided into segments.
5. Following a series of rules (see below for details), monitoring sites were identified for inclusion or exclusion in the total annual scheme users.
6. Annual estimates of users at each monitoring site was calculated using seasonal distribution curves where less than 6 months data is available, or directly extrapolated where more than 6 months data was available. The seasonal distribution curves were derived from data on automatic cycle counters on similar schemes.
7. Total annual scheme users calculated for baseline and post-implementation: Usage estimates from monitoring sites chosen for inclusion were summed. Where double counting was identified the total annual scheme users was reduced appropriately. Where black-spots were identified the figure was increased as required.



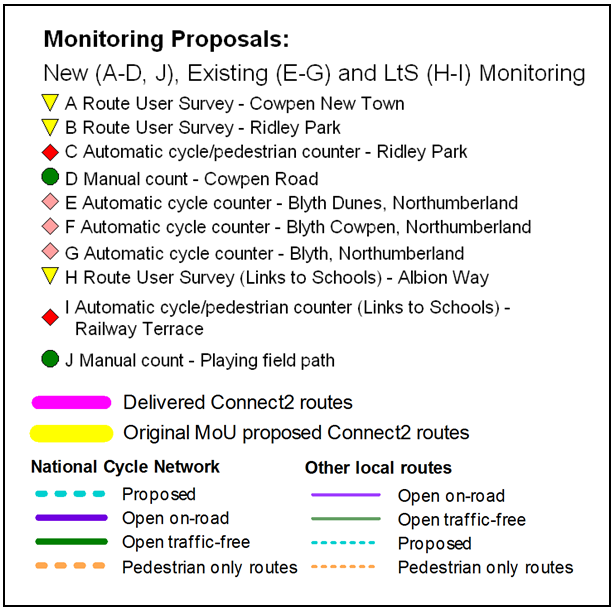


Figure A.1 – Example scheme map and key showing monitoring locations

#### Average trip lengths

The survey of users included questions about journey origin and destination to allow journey distances to be calculated. However, this often led to unreliable responses as people did not know exact addresses for where they were going to, or in the case of leisure routes, how far they were going if it was a circular route. Therefore, it was decided that average distances for each journey type would be taken from the NTS (2002-2010)*(Department for Transport, 2010)*. However, the NTS only records utility trips, not leisure trips (i.e. only recording journeys to a recreation location to undertake an activity rather than considering the journey itself a form of leisure as would be the case for a recreational walk or bike ride). Therefore, survey data from the National Cycle Network in 2011 was used for leisure trips. Categories ‘escort to education’, ‘other escort’, ‘holiday base’ and ‘other’ for cycling were all assigned the average trip length for all purposes (2.5 miles). This is shown in Table A.1.

The survey of users was used to identify the purposes of journeys along each route and together an average route trip length was calculated.

Table A.1 – Walking and cycling trip length by purpose used by Sustrans.

|  |  |  |
| --- | --- | --- |
| Purpose | **Walking trip length (miles)** | **Cycling trip length (miles)** |
| Commute | 0.853 | 2.879 |
| Leisure | 2.000 | 8.000 |
| In course of work | 0.701 | 2.480 |
| Education | 0.698 | 1.638 |
| Shopping | 0.611 | 1.428 |
| Personal business | 0.595 | 1.746 |
| Visit friends/family | 0.684 | 2.016 |
| Social/entertainment | 0.792 | 2.629 |
| Holiday base | 0.900 | 2.500 |
| Escort to school | 0.542 |
| Other escort | 0.644 |
| Other | 0.954 |

#### Rules to identify monitoring sites used

Many schemes had multiple monitoring points. To avoid double counting, a series of rules were followed to determine which monitoring points to be used. Two main methods were used:

1. Using route user data: Where survey data was sufficient, journey origin and destination postcodes were used to determine the percentage of trips which passed both monitoring points. This allowed reduction of monitoring figures from particular monitoring points to avoid double counting.
2. Using trip distances: Using the average trip distances by mode (from NTS survey and the survey of users), and the known distance between monitoring sites, an estimation was made of how many trips were likely to be double counted:

**Rule 1**: Where two monitoring sites were less than half the average trip distance from each other the monitoring point with the larger overall value were used since it was assumed that users counted at one monitoring point would be counted at the other (Figure A.2):

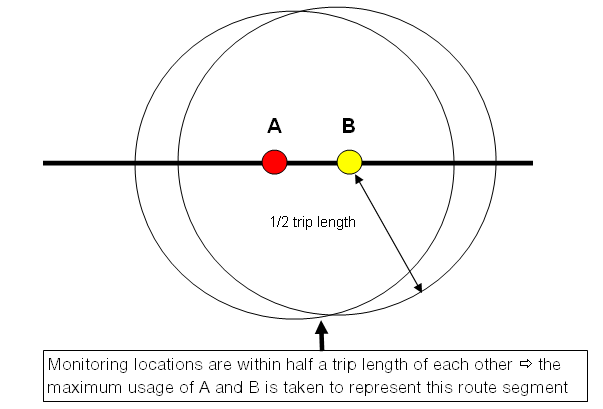


Figure A.2: Rule 1 – Larger value of A or B used

**Rule 2**: Where the half average trip length from two monitoring points overlapped the usage at each monitoring site was summed and the total reduced by the amount assumed to pass both points based on average trip length (Figure A.3):

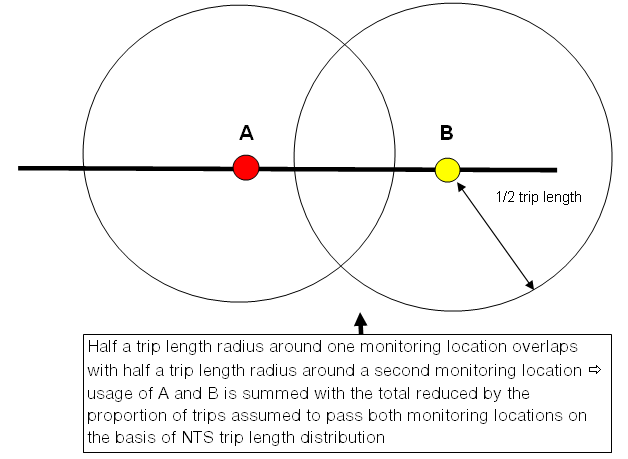


Figure A.3: Rule 2 – Usage at A and B summed, then reduced by amount assumed to pass both points

**Rule 3**: Where the half average trip lengths from two monitoring points did not overlap then the usage from each monitoring point was summed (Figure A.4):

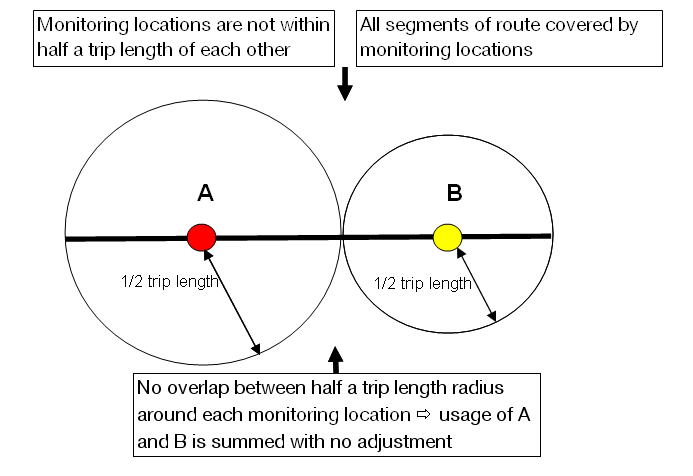


Figure A.4: Rule 3 – Usage at A and B summed

**Rule 4**: Where segments were not covered by estimated usage from monitoring points (‘black-spots’) an estimate was calculated from the closest or most representative monitoring point using an estimated ‘per km’ usage figure (Figure A.5):

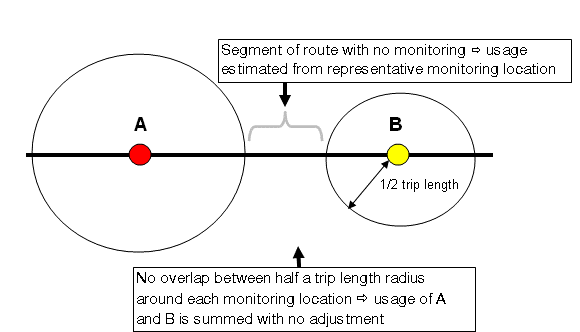


Figure A.5: Rule 4 – ‘Block spot’ estimated using appropriate monitoring point with a ‘per km’ usage figure

(Annual usage on monitored route segment / length of monitored route segment) \* length of unmonitored route segment = use on unmonitored route segment

The broad rules were assessed on a case-by-case basis for each scheme involving local stakeholders as appropriate. If a scheme consisted of disparate sections completely isolated from each other or not linked by continuous existing network these sections were treated separately and usage summed for each segment.

Is it acknowledged that there may be some uncertainty around users accessing routes in multiple locations and who therefore may not be captured by monitoring points.

#### Other adjustments

Common to transport assessments, it was assumed that 90% of journeys were return journeys and 10% were one-way journeys on the route.

As outlined above, seasonal distribution curves were used within the calculation of total annual scheme users. Sustrans assessed the reliability of using the seasonal distribution curves, compared to simply extrapolating where more than 6 months data is available. Although the data did not match exactly, it was believed that this method was the most reliable available. Although it may seem that over or under estimates are likely where the majority of data was in one season, for example if collected mostly in winter, it was found that matching count data to distribution curves where more than 6 months was available was less reliable than simply extrapolating and therefore the latter method was followed in such a scenario. Some schemes only had cycle counters. If local stakeholders believed that the nearest survey of users was not representative of pedestrian usage then a modal split using National Cycle Network data was used to estimate pedestrian usage. Whilst this may be representative of the modal split on the National Cycle Network it may not be representative on the scheme. However, it was viewed as more appropriate than using a non-representative monitoring site. Where a proxy monitoring point was used there may have been some differences between that location and the actual Connect2 sites, although they were judged to be appropriately similar by local stakeholders.

### Benefit-cost ratios

Sustrans followed the WebTAG(Department for Transport, 2013) (now known as Transport Analysis Guidance, see <https://www.gov.uk/guidance/transport-analysis-guidance-webtag>) methodology to estimate the economic benefits of the Connect2 schemes. This uses assumptions about benefits to health, car kilometres replaced and time travelled*,* as outlined below.

#### Health Economic Assessment Tool

Sustrans used the previous version of the Health Economic Assessment Tool (HEAT)(World Health Organization, 2011) to calculate mortality benefits and BCRs, many of the assumptions used HEAT default values:

Assumptions used in HEAT:

* Value of statistical life: £3,229,114 (Transport for London, 2015)
* Mean annual all-cause mortality - walking: 0.004341 (HEAT default value)
* Mean annual all-cause mortality – cycling: 0.002490
* Relative risks for walking based on all-cause mortality data: 0.89 (Kelly et al., 2014)
* Relative risks for cycling based on all-cause mortality data: 0.90 (Kelly et al., 2014)
* Build-up for benefits: 5 years
* Build-up of uptake for walking and cycling: 2 years
* Discount rate for future resource savings: 5% (HEAT default)
* Mean annual benefit: 10 years (HEAT default)
* Assumed walking and cycling attributable to Connect2: 50%
* Respondents in pre-specified age categories (walking >20, <74; cycling >20, <64): 100% (adults only)
* Number of days cycling per year: 124 days (HEAT default)
* Discount rate for BCR: 1.5%
* Assessment period: 30 years
* Total cost of the Connect2 project: £170M

HEAT models for walking and cycling assumed that 50% of the walking and cycling was attributable to Connect2. This estimate was based on previous research suggesting that Connect2 is associated with newly induced walking and cycling and a shift from previous walking and cycling trips (Goodman et al., 2014).

An estimate of the number of days spent cycling per year among adult users of Connect2 was based on the HEAT default value of 124 days per year, the observed number of days spent cycling per year in Stockholm (Schantz & Stigell, 2008).

#### Car kilometres replaced

The estimated number of car kilometres replaced was found from the survey of users: the number of respondents stating that they did not use a car for any part of their journey and the percentage stating that they could have used a car instead of walking or cycling. This was applied to the average trip distance for that scheme and the difference in car kilometres replaced for the pre and post surveys gave the total car kilometres abstracted. This figure was also used to estimate carbon dioxidereduction and collision benefits. Carbon savings as a result of reduced car kilometres were valued using DECC values (£53 per tonne carbon dioxide equivalent).

The values of the marginal benefits associated with the abstraction of car km benefit was calculated using the WebTAG rate for the appropriate road type using the Marginal External Costs spreadsheet[[2]](#footnote-2).

#### Amenity benefits

The amenity benefit of the schemes was calculated using the distance travelled for pedestrians and the time spent on the route for cyclists:

Pedestrians: Additional distance travelled by new users = (Number of trips x trip distance)post survey - (Number of trips x trip distance)pre survey

Amenity benefit to new pedestrians was valued at 7.6 p/km (the sum value for amenity benefit to pedestrians from street lighting, kerb level and pavement evenness, directional signage and new benches).

Cyclists: Additional time spent on intervention by new users = ((Trip distance ÷ default speed) x number of trips)post survey – ((Trip distance ÷ default speed) x number of trips)pre survey

Amenity benefit to existing cyclists was valued at:

4.73 p/min for an off-road segregated cycle path (WebTAG value), or

2.01 p/min for an on-road segregated cycle path (WebTAG value).

Amenity benefit to new users was valued at half that to existing users.

#### Absenteeism and collision benefits

Absenteeism benefits were valued based on average daily salary for each region. Collision benefits were valued based on the car collision rate and the costs per casualty from WebTAG.

#### Growth rates

Calculations assumed that the build-up in demand equalled the time between pre and post survey, followed by 5% growth rate for 10 years. This was in line with the annual average levels of growth observed by Sustrans on the National Cycle Network. For appraisal periods of longer than 10 years, no growth was assumed after the initial two years.

#### Appraisal period and scheme costs

Future impacts, beyond the monitoring period, were captured using a 30-year appraisal period. This differed from the DfT guidance which suggests an appraisal periods of 10 years for footpaths because it was anticipated that the quality of the schemes would enable them to be used for much longer than 10 years. Large infrastructure elements, such as bridges, were considered to have a functional life of 60 years. Therefore, their costs were amortised to the length of the appraisal period. This does not follow standard WebTAG guidance, for which only road or rail is considered to have a usable life of 60 years, but it was used since it was believed that this gives a fairer valuation of the infrastructure.

Scheme costs were converted to market price at baseline. Following WebTAG guidance, 3.5% discount rate was applied.

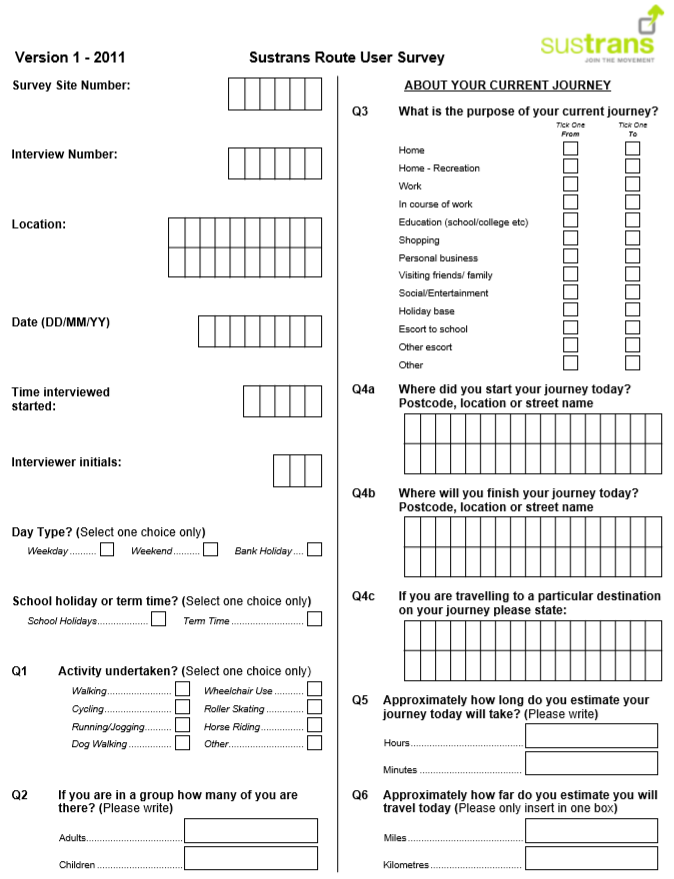
A maintenance cost of £500 per km per annum was included for all schemes. This was based on Sustrans’ experience.

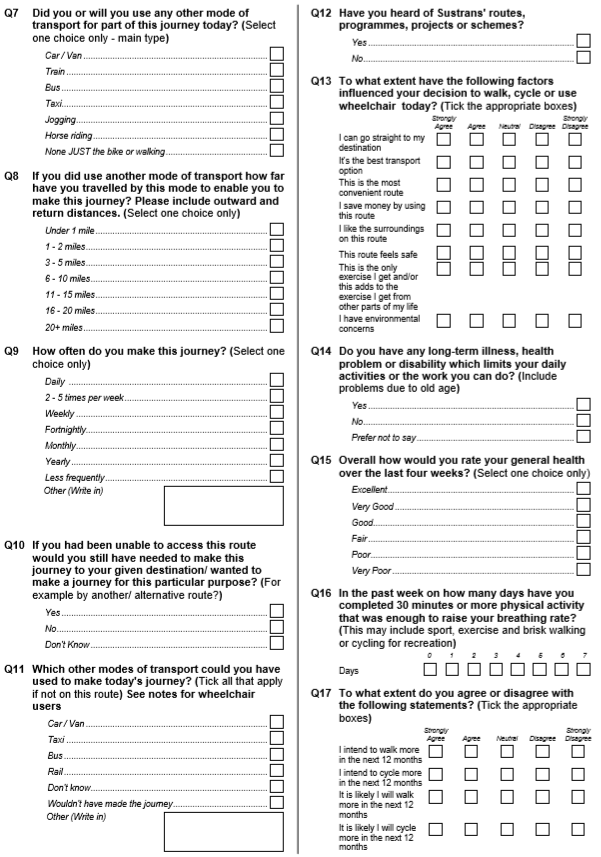
### Contextual factor covariates

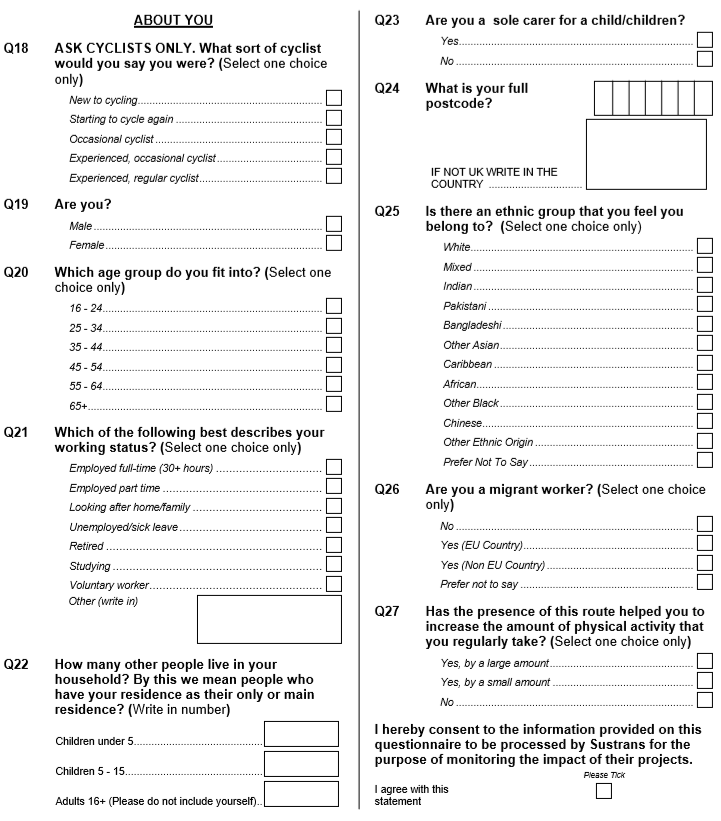
Schemes differed in the time between completion and post monitoring. Where month of completion was not stated, only the year, a conservative estimate was taken of 1 month between completion and post-monitoring. Where monitoring dates were stated as the same month as scheme completion 0.5 months was used since we assumed that some time passed between completion and monitoring. The time between completion and post-monitoring was calculated between end of the first phase of construction, where applicable (assumed to include the ‘core’ component of the scheme, such as a bridge, which may have attracted the most users), and the latest post-monitoring date. Some schemes had pre-monitoring completed years before construction began. It was assumed that minimal change in use occurred between pre-monitoring and start of construction.

Since car ownership has been found to be associated with levels of cycling(Carse et al., 2013) this was considered as a covariate. However, local government level percentage car ownership, from the UK’s 2011 Census(Nomis, 2011), was tested for correlation with deprivation quintile and found it to be strongly correlated (Spearman’s rho 0.81; p-value <0.005), therefore local government level car ownership was not included as a covariate.

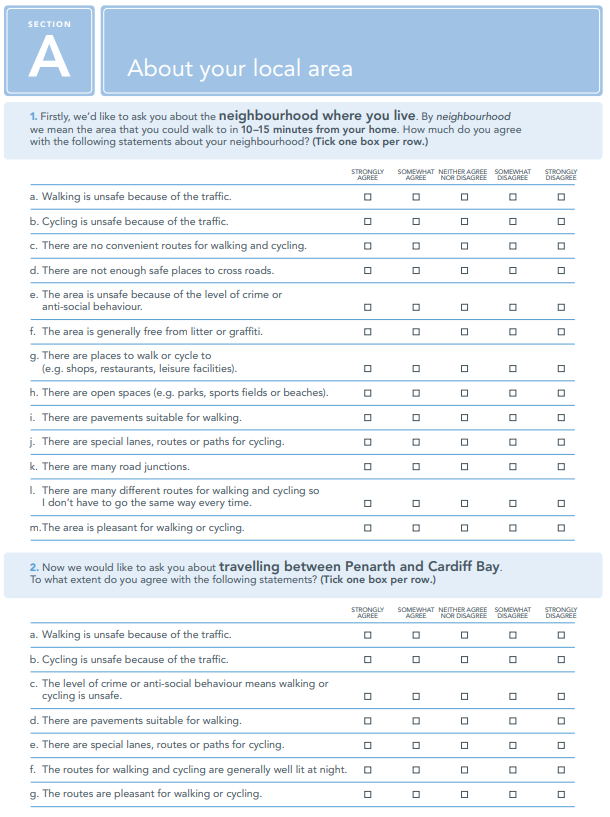
## Appendix B: Sustrans’ survey of users questionnaire



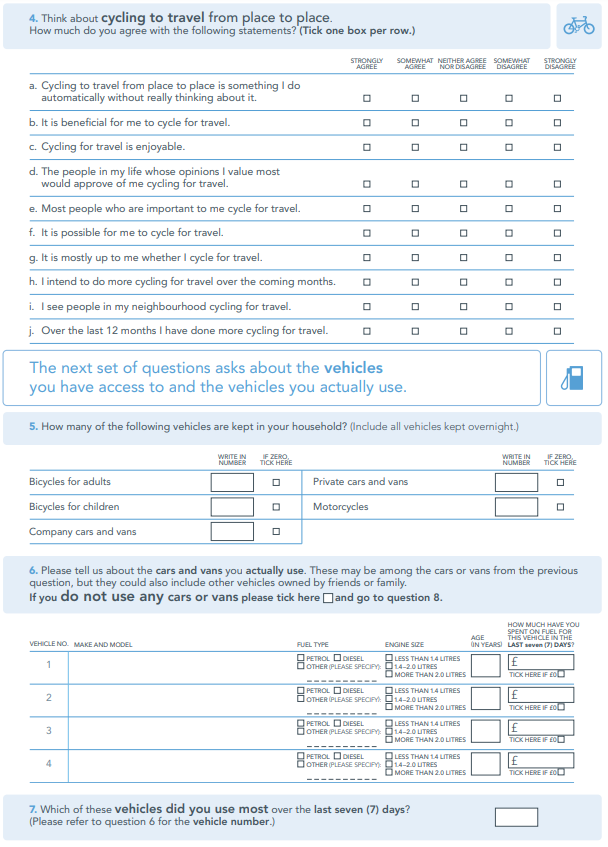


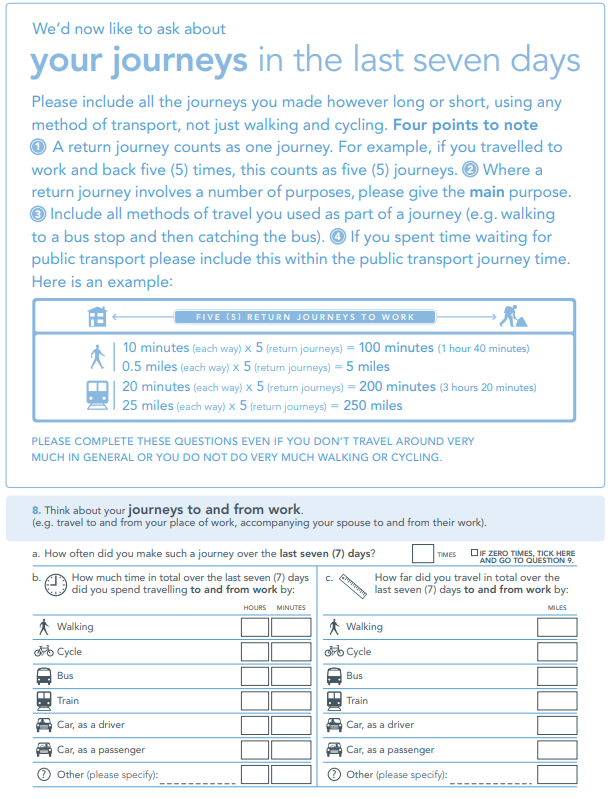


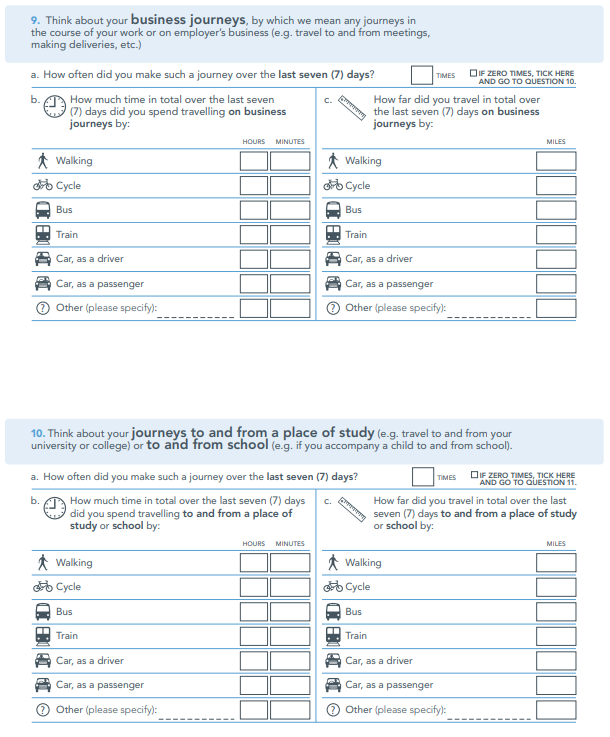
## Appendix C: iConnect questionnaire example

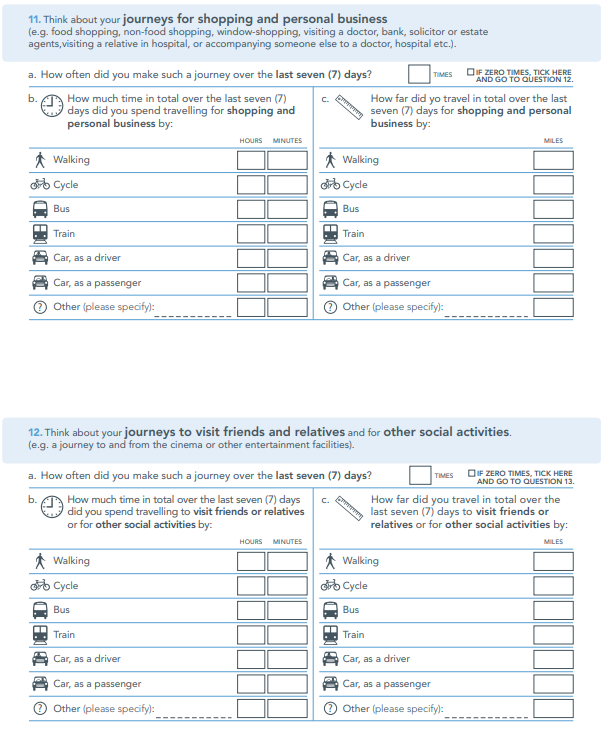
(Ogilvie et al., 2012)

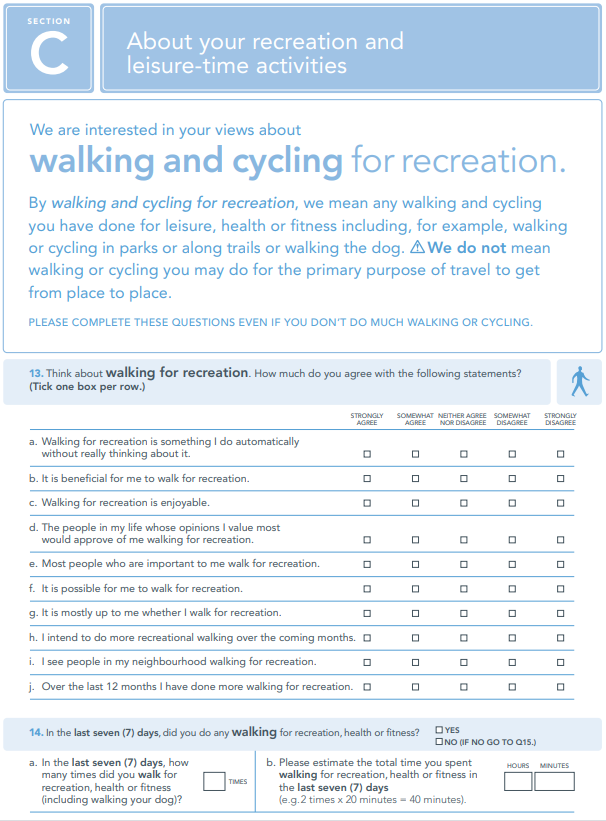


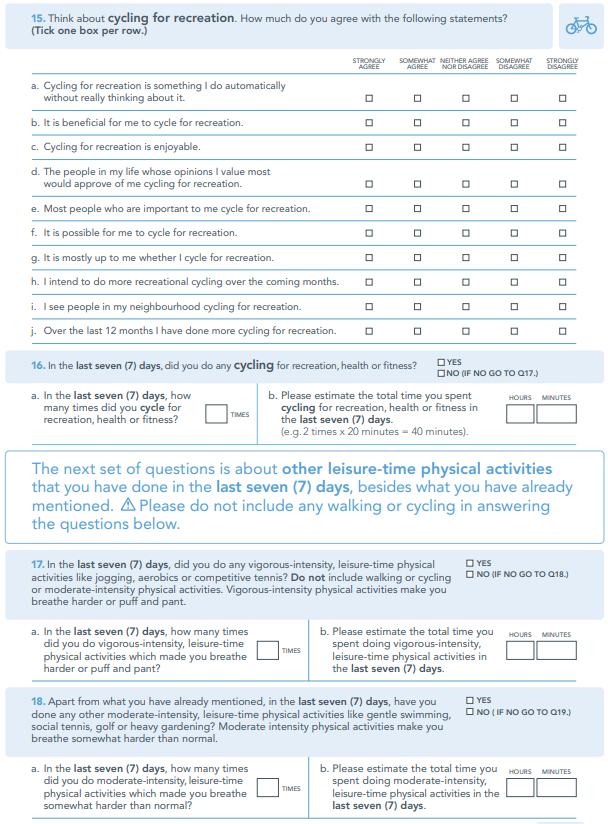


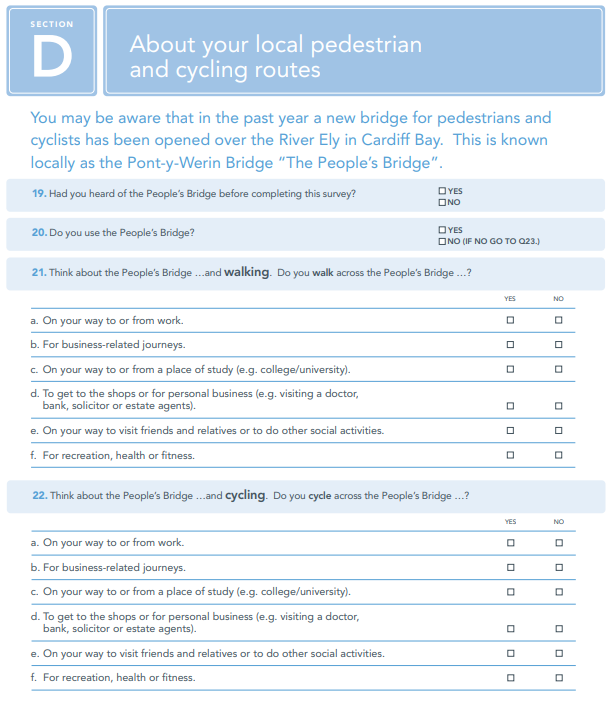


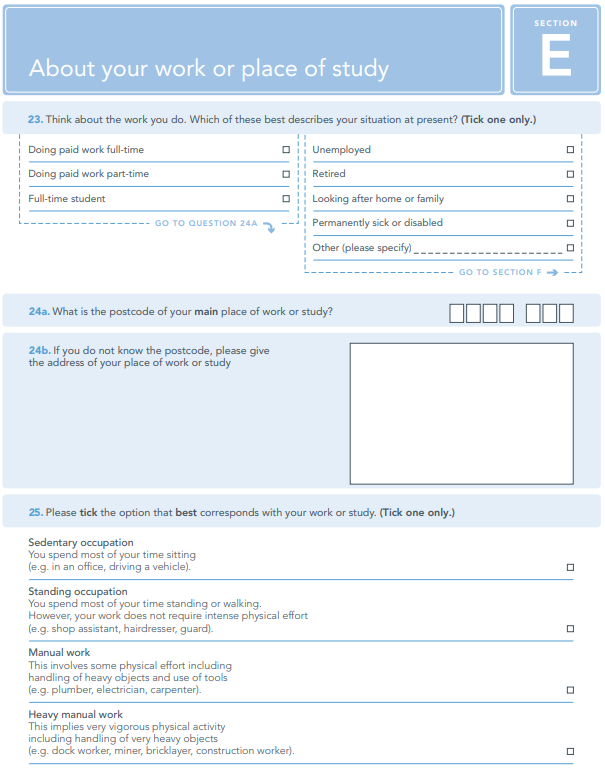


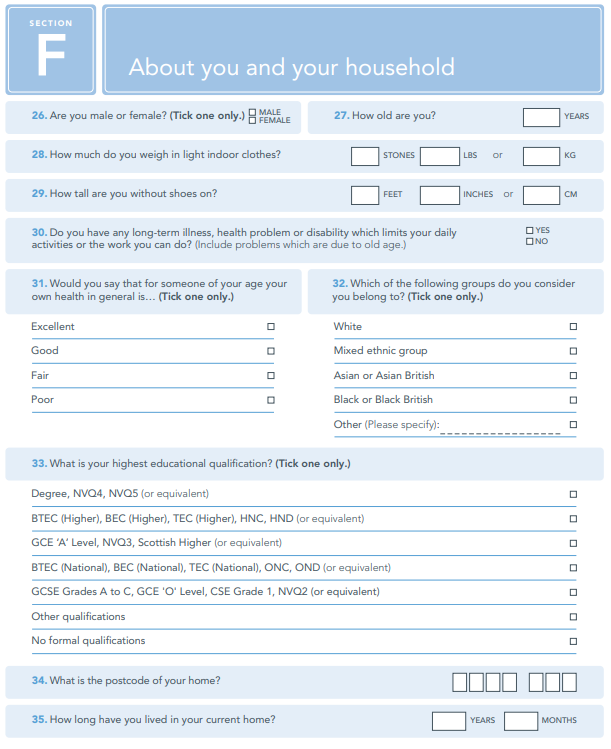


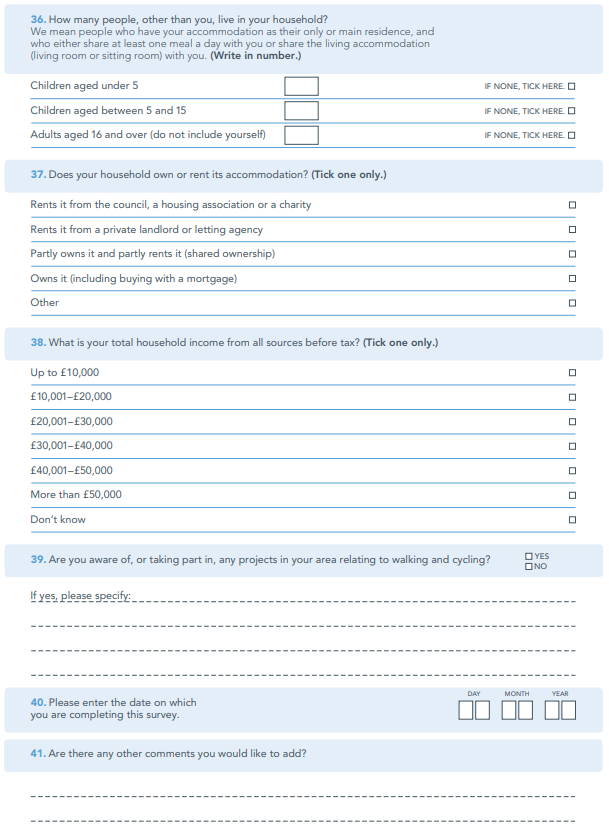












## Appendix D: Additional tables

Table D.1: Estimated total annual scheme users (from Sustrans)

| Scheme | Pre Cycling | Post Cycling | % Change Cycling | Pre Walking | Post Walking | % Change Walking | Pre Total | Post Total | Total Change | % Total Change | BCR |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Argoed | 5,683 | 5,583 | -2% | 9,722 | 29,462 | 203% | 15,405 | 35,045 | 19,640 | 127% | 17.2 |
| Ballymoney | 9,716 | 13,058 | 34% | 83,510 | 184,112 | 120% | 93,226 | 197,169 | 103,944 | 111% | 11.5 |
| Bath | 29,238 | 136,347 | 366% | 85,042 | 127,851 | 50% | 114,280 | 264,198 | 149,918 | 131% | 3.4 |
| Bedlington | 34,557 | 49,297 | 43% | 290,548 | 502,571 | 73% | 325,105 | 551,868 | 226,763 | 70% | 3.3 |
| Bethnal Green | 32,917 | 49,275 | 50% | 234,513 | 534,883 | 128% | 267,430 | 584,158 | 316,728 | 118% | 9.0 |
| Birmingham | 20,284 | 38,460 | 90% | 330,717 | 398,060 | 20% | 351,000 | 436,520 | 85,520 | 24% | 4.0 |
| Blandford | - | 44,692 | N/A | - | 141,226 | N/A | - | 185,918 | 185,918 | N/A | 15.0 |
| Blyth | 51,224 | 86,111 | 68% | 609,925 | 682,700 | 12% | 606,056 | 736,403 | 130,347 | 22% | 3.5 |
| Bradford | 2,003 | 9,608 | 380% | 252,993 | 393,169 | 55% | 254,996 | 402,777 | 147,781 | 58% | 1.4 |
| Bristol | 196,292 | 352,239 | 79% | 284,382 | 524,998 | 85% | 480,674 | 877,238 | 396,563 | 83% | 15.2 |
| Brompton | 14,614 | 9,935 | -32% | 27,034 | 10,240 | -62% | 41,648 | 20,175 | -21,473 | -52% | 1.0 |
| Bury | 37,406 | 42,955 | 15% | 227,688 | 281,181 | 23% | 265,094 | 324,136 | 59,042 | 22% | 9.4 |
| Cardiff | 60,330 | 129,722 | 115% | 214,904 | 382,738 | 78% | 275,234 | 512,460 | 237,226 | 86% | 3.0 |
| Carlton | 10,019 | 23,667 | 136% | 35,910 | 55,225 | 54% | 45,929 | 78,891 | 32,962 | 72% | 5.4 |
| Cheshunt | 2,818 | 24,637 | 774% | 29,518 | 234,445 | 694% | 32,336 | 259,082 | 226,746 | 701% | 0.8 |
| Chester | 30,884 | 35,591 | 15% | 1,610,512 | 2,093,566 | 30% | 1,641,396 | 2,129,157 | 487,761 | 30% | 21.9 |
| Clydach | 29,998 | 31,610 | 5% | 30,196 | 73,520 | 143% | 60,194 | 105,130 | 44,936 | 75% | 3.5 |
| Conkers | 10,811 | 4,162 | -61% | 9,259 | 7,079 | -24% | 20,070 | 11,241 | -8,829 | -44% | 0.3 |
| Conwy | 15,189 | 37,461 | 147% | 1,768 | 6,417 | 263% | 16,957 | 43,878 | 26,920 | 159% | 3.2 |
| Croydon | 15,140 | 29,527 | 95% | 315,421 | 1,178,256 | 274% | 330,561 | 1,207,783 | 877,221 | 265% | 16.1 |
| Dartford | 19,993 | 10,870 | -46% | 143,816 | 211,186 | 47% | 163,809 | 222,056 | 58,248 | 36% | 3.0 |
| Derry | - | - | - | - | - | - | - | - | - | - | - |
| Dewsbury | 11,315 | 25,705 | 127% | 24,090 | 79,817 | 231% | 35,405 | 105,522 | 70,117 | 198% | 3.2 |
| Dover | 11,368 | 22,269 | 96% | 543,678 | 791,084 | 46% | 555,046 | 813,353 | 258,307 | 47% | 22.3 |
| Dumfries | 19,333 | 37,276 | 93% | 48,191 | 70,552 | 46% | 67,524 | 107,828 | 40,304 | 60% | 5.8 |
| Everton Park | 2,040 | 8,073 | 296% | 285,395 | 227,302 | -20% | 287,435 | 235,375 | -52,060 | -18% | 0.8 |
| Falkirk | 7,677 | 10,809 | 41% | 35,989 | 34,194 | -5% | 43,666 | 45,003 | 1,338 | 3% | 3.1 |
| Foryd Harbour (Rhyl) | - | 49,472 | N/A | - | 338,494 | N/A | - | 387,966 | N/A | N/A | - |
| Glasgow | 64,524 | 100,978 | 56% | 616,896 | 800,629 | 30% | 681,420 | 901,607 | 220,187 | 32% | 1.4 |
| Hamilton | 19,408 | 31,030 | 60% | 285,885 | 336,907 | 18% | 305,294 | 367,937 | 62,643 | 21% | 2.1 |
| Haringey | 66,314 | 71,905 | 8% | 707,056 | 829,869 | 17% | 773,370 | 901,774 | 128,404 | 17% | 10.8 |
| Harrogate | 11,428 | 188,421 | 1549% | 154,875 | 372,402 | 140% | 166,303 | 560,823 | 394,519 | 237% | 44.4 |
| Hastings | 23,360 | 85,699 | 267% | 80,273 | 132,194 | 65% | 103,633 | 217,893 | 114,260 | 110% | 17.5 |
| Havering | 53,741 | 58,912 | 10% | 572,838 | 694,594 | 21% | 626,580 | 753,506 | 126,926 | 20% | 3.3 |
| Hereford | 56,397 | 58,456 | 4% | 49,549 | 50,720 | 2% | 105,946 | 109,176 | 3,230 | 3% | 2.6 |
| Huyton | 3,198 | 6,488 | 103% | 60,257 | 39,400 | -35% | 63,455 | 45,888 | -17,566 | -28% | 1.0 |
| Islington | 266,410 | 235,962 | -11% | 607,834 | 834,312 | 37% | 874,244 | 1,070,274 | 196,029 | 22% | 8.0 |
| Kenilworth | 8,159 | 70,755 | 767% | 62,475 | 184,606 | 195% | 70,634 | 255,360 | 184,726 | 262% | 10.9 |
| Killamarsh | 69,715 | 83,220 | 19% | 69,244 | 95,586 | 38% | 138,959 | 178,806 | 39,847 | 29% | 5.2 |
| Kirkby | 26,282 | 30,877 | 17% | 246,108 | 213,617 | -13% | 272,390 | 244,494 | -27,896 | -10% | 3.4 |
| Leeds | 18,083 | 35,108 | 94% | 148,322 | 218,482 | 47% | 166,405 | 253,590 | 87,185 | 52% | 12.4 |
| Leicestershire | 67,285 | 95,815 | 42% | 363,671 | 511,205 | 41% | 430,956 | 607,020 | 176,064 | 41% | 8.0 |
| Luton | 18,902 | 49,163 | 160% | 44,823 | 96,788 | 116% | 63,725 | 145,951 | 82,226 | 129% | 6.5 |
| Merthyr | 4,084 | 4,745 | 16% | 55,742 | 73,786 | 32% | 59,825 | 78,531 | 18,705 | 31% | 4.7 |
| Monmouth | 9,904 | 11,293 | 14% | 196,630 | 232,649 | 18% | 206,534 | 243,942 | 37,408 | 18% | 2.2 |
| Nantwich | 42,626 | 61,162 | 43% | 67,396 | 107,931 | 60% | 110,022 | 169,093 | 59,071 | 54% | 4.0 |
| Newport | 20,692 | 77,745 | 276% | 131,929 | 327,020 | 148% | 152,622 | 404,765 | 252,143 | 165% | 7.9 |
| Newton Abbot | 65,893 | 62,196 | -6% | 231,929 | 316,509 | 36% | 297,822 | 378,705 | 80,883 | 27% | 3.1 |
| Newtownabbey | 38,325 | 37,090 | -3% | 43,621 | 50,193 | 15% | 81,946 | 87,283 | 5,337 | 7% | 0.5 |
| Northampton | 58,880 | 85,925 | 46% | 78,437 | 130,968 | 67% | 137,317 | 216,893 | 79,576 | 58% | 2.9 |
| Northwich | 14,969 | 53,696 | 259% | 85,472 | 254,401 | 198% | 100,441 | 308,097 | 207,656 | 207% | 7.9 |
| Norwich | 161,772 | 186,910 | 16% | 209,408 | 347,101 | 66% | 371,180 | 534,011 | 162,832 | 44% | 7.6 |
| Omagh | 5,853 | 8,067 | 38% | 31,671 | 33,899 | 7% | 37,525 | 41,966 | 4,441 | 12% | 0.7 |
| Ottery | 14,031 | 20,766 | 48% | 55,498 | 82,136 | 48% | 69,529 | 102,902 | 33,373 | 48% | 3.7 |
| Padiham | 19,967 | 33,669 | 69% | 311,995 | 393,587 | 26% | 331,962 | 427,256 | 95,294 | 29% | 4.1 |
| Plymouth | 110,247 | 135,701 | 23% | 672,637 | 1,095,750 | 63% | 782,884 | 1,231,451 | 448,567 | 57% | 9.2 |
| Port Talbot | 25,426 | 40,255 | 58% | 82,227 | 130,035 | 58% | 107,653 | 170,290 | 62,637 | 58% | 8.8 |
| Radstock | 638 | 18,836 | 2852% | 18,030 | 49,704 | 176% | 18,668 | 68,540 | 49,872 | 267% | 2.8 |
| Rochdale | 55,853 | 63,989 | 15% | 190,204 | 227,233 | 19% | 246,056 | 291,222 | 45,165 | 18% | 3.1 |
| Royston | 8,959 | 34,128 | 281% | 66,525 | 79,175 | 19% | 75,484 | 113,302 | 37,818 | 50% | 1.0 |
| Rugby | 32,968 | 65,708 | 99% | 272,672 | 229,452 | -16% | 305,640 | 295,160 | -10,481 | -3% | 3.3 |
| Sale | 42,821 | 225,998 | 428% | 144,731 | 573,289 | 296% | 187,552 | 799,287 | 611,735 | 326% | 31.7 |
| Scunthorpe | 50,045 | 59,155 | 18% | 130,674 | 179,721 | 38% | 180,719 | 238,876 | 58,156 | 32% | 0.7 |
| Shoreham | 83,865 | 137,968 | 65% | 673,147 | 742,128 | 10% | 757,013 | 880,097 | 123,084 | 16% | 3.6 |
| Shrewsbury | 45,330 | 43,452 | -4% | 894,522 | 514,172 | -43% | 939,852 | 557,624 | -382,228 | -41% | 1.4 |
| Sleaford | 34,597 | 53,880 | 56% | 306,832 | 540,129 | 76% | 341,428 | 594,008 | 252,580 | 74% | 3.7 |
| South Bermondsey | - | 116,226 | N/A | - | 1,979,371 | N/A | - | 2,095,597 | N/A | N/A | - |
| Southampton | 87,607 | 99,048 | 13% | 785,651 | 552,804 | -30% | 873,257 | 651,852 | -221,405 | -25% | 1.7 |
| St Helens | - | 10,673 | N/A | - | 81,447 | N/A | - | 92,120 | N/A | N/A | - |
| St Neots | 48,766 | 74,024 | 52% | 257,891 | 287,965 | 12% | 306,657 | 361,988 | 55,332 | 18% | 2.1 |
| Stockbridge | - | 6,935 | N/A | - | 30,744 | N/A | - | 37,679 | 37,679 | N/A | 11.6 |
| Stockport (Marple) | 6,898 | 12,479 | 81% | 26,889 | 18,522 | -31% | 33,786 | 31,001 | -2,786 | -8% | 0.6 |
| Swindon | 172,865 | 189,566 | 10% | 95,266 | 57,792 | -39% | 268,131 | 247,358 | -20,773 | -8% | 11.2 |
| Titanic Quarter | 74,740 | 137,614 | 84% | 290,692 | 310,703 | 7% | 365,432 | 448,317 | 82,885 | 23% | 32.5 |
| Topsham | 107,719 | 109,749 | 2% | 27,722 | 35,781 | 29% | 135,441 | 145,530 | 10,089 | 7% | 13.2 |
| Treforest | 14,916 | 15,220 | 2% | 21,738 | 22,182 | 2% | 36,654 | 37,402 | 748 | 2% | 0.6 |
| Tyne Dock | 68,441 | 99,645 | 46% | 61,002 | 60,955 | 0% | 129,443 | 160,600 | 31,157 | 24% | 7.6 |
| Watton | 12,361 | 38,308 | 210% | 84,960 | 185,717 | 119% | 97,321 | 224,025 | 126,704 | 130% | 7.5 |
| Westminster | 19,767 | 43,266 | 119% | 153,030 | 233,071 | 52% | 172,797 | 276,336 | 103,539 | 60% | 14.6 |
| Weymouth | 332,506 | 374,807 | 13% | 2,072,786 | 2,000,593 | -3% | 2,405,292 | 2,375,400 | -29,892 | -1% | 6.8 |
| Whitstable | 66,103 | 140,091 | 112% | 1,132,798 | 1,119,768 | -1% | 1,198,901 | 1,259,859 | 60,958 | 5% | 17.0 |
| Wicken Fen | 2,316 | 19,157 | 727% | 4,084 | 22,335 | 447% | 6,400 | 41,492 | 35,092 | 548% | 1.1 |
| Worcester | 168,629 | 208,459 | 24% | 1,926,199 | 3,137,672 | 63% | 2,094,828 | 3,346,131 | 1,251,303 | 60% | 30.8 |
| Workington | - | 27,151 | N/A | - | 179,144 | N/A | - | 206,295 | N/A | N/A | - |

Table D.2: Change in estimated total annual users across all schemes (Number of schemes = 77, using total annual scheme users)

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Mode | Pre | | Post | | Change | | | % increase | | |
| Median | IQR | Median | IQR | Median | IQR | p-value | Median | IQR | p-value |
| Walking | 144,731 | 235,194 | 227,302 | 437,419 | 51,022 | 129,634 | 1.051e-08 | **38** | **64.3** | **1.074e-09** |
| Cycling | 26,282 | 47,452 | 49,163 | 61,474 | 14,829 | 23,823 | 7.411e-12 | **51.8** | **100.2** | **3.826e-12** |
| Walking & cycling combined | 172,797 | 270,794 | 259,082 | 447,521 | 62,643 | 135,912 | 2.127e-10 | **35.6** | **66.2** | **1.111e-10** |

Table D.3: Additional modes and distances to reach routes (Number of schemes = 84)

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  | **Pre** | | | | | | | **Post** | | | | | | |
|  |  | **Total** | **Women** | **Cyclists** | **Female cyclists** | **65+** | **Disabled** | **1st IMD** | **Total** | **Women** | **Cyclists** | **Female cyclists** | **65+** | **Disabled** | **1st IMD** |
| Did you or will you use any other mode of transport for part of this journey today? (%) | Car/Van | **14** | 15 | 6 | 7 | 18 | 15 | 11 | **13** | 14 | 6 | 7 | 16 | 13 | 8 |
| Bus/Train | **7** | 7 | 3 | 3 | 7 | 6 | 8 | **8** | 8 | 2 | 2 | 8 | 8 | 10 |
| Only walking/cycling | **71** | 70 | 85 | 83 | 71 | 76 | 75 | **75** | 73 | 85 | 83 | 73 | 76 | 79 |
| How far did you travel by another mode of transport to enable you to make this journey? (%) | 0-2 miles | **7** | 9 | 2 | 3 | 10 | 9 | 8 | **7** | 9 | 1 | 2 | 10 | 9 | 7 |
| 3-5 miles | **5** | 6 | 2 | 3 | 6 | 5 | 6 | **5** | 6 | 2 | 3 | 6 | 5 | 4 |
| 6-15 miles | **4** | 5 | 2 | 2 | 5 | 4 | 3 | **5** | 5 | 3 | 3 | 5 | 4 | 5 |
| >15 miles | **4** | 3 | 3 | 2 | 4 | 3 | 2 | **3** | 3 | 2 | 2 | 3 | 2 | 2 |

Table D.4: Reasons for choosing to use routes and additional travel modes & distances across all schemes (Number of schemes = 84), except where scheme is specified

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | | **Pre** | | | | | | | | | | **Post** | | | | | | | | | |
| **Total** | **Women** | **Cyclists** | **Female cyclists** | **65+** | **Disabled** | **1st IMD** | **Cardiff** | **Southampton** | **Kenilworth** | **Total** | **Women** | **Cyclists** | **Female cyclists** | **65+** | **Disabled** | **1st IMD** | **Cardiff** | **Southampton** | **Kenilworth** |
| To what extent have the following factors influenced your decision to walk, cycle or use wheelchair today? (Agree/strongly agree (%)) | I like the surroundings on this route | **80** | 80 | 84 | 85 | 88 | 86 | 76 | 92 | 79 | 93 | **85** | 86 | 88 | 88 | 89 | 86 | 90 | 90 | 76 | 99 |
| This is the most convenient route | **75** | 76 | 75 | 75 | 77 | 80 | 78 | 54 | 89 | 56 | **82** | 83 | 81 | 80 | 82 | 82 | 80 | 80 | 82 | 98 |
| This route feels safe | **72** | 71 | 76 | 76 | 78 | 77 | 70 | 79 | 78 | 77 | **81** | 80 | 85 | 85 | 83 | 79 | 92 | 92 | 73 | 91 |
| I can go straight to my destination | **65** | 67 | 66 | 65 | 61 | 68 | 70 | 45 | 86 | 39 | **67** | 69 | 66 | 66 | 61 | 65 | 67 | 67 | 69 | 33 |
| It’s the best transport option | **62** | 63 | 71 | 70 | 62 | 67 | 63 | 43 | 86 | 39 | **66** | 66 | 74 | 73 | 64 | 65 | 66 | 66 | 76 | 54 |
| This is the only exercise I get and/or this adds to the exercise I get from other parts of my life | **55** | 58 | 61 | 62 | 63 | 62 | 53 | 57 | 41 | 81 | **61** | 62 | 65 | 66 | 64 | 65 | 62 | 62 | 75 | 92 |
| I save money by using this route | **50** | 51 | 58 | 60 | 40 | 51 | 56 | 34 | 62 | 7 | **52** | 52 | 59 | 58 | 40 | 49 | 62 | 62 | 57 | 29 |
| I have environmental concerns | **54** | 56 | 63 | 67 | 56 | 57 | 50 | 43 | 74 | 64 | **51** | 51 | 58 | 60 | 51 | 51 | 61 | 61 | 53 | 22 |
| Belief that new route increases physical activity (%) | Yes (a little/ a lot) |  |  |  |  |  |  |  |  |  |  | **67** | 69 | 71 | 76 | 65 | 31 | 67 | 67 | 80 | 32 |

Table D.5: Multivariable binary logistic regression analysis showing relationship between contextual factors/ scheme characteristics and at least 50% increase and double the number of route users across all schemes (Number of schemes = 77, using total annual scheme users)

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Independent variable** | **Cyclists odds ratio (95% CI)** | | | | **Pedestrians odds ratio (95% CI)** | | | | **BCR >4 odds ratio (95% CI)** | |
| **At least 50% increase in cyclists** | | **Double cyclists** | | **At least 50% increase in pedestrians** | | **Double pedestrians** | |
| **Unadjusted** | **Adjusted\*** | **Unadjusted** | **Adjusted\*** | **Unadjusted** | **Adjusted\*** | **Unadjusted** | **Adjusted\*** | **Unadjusted** | **Adjusted\*** |
| Public transport interchange within 0.5 mile | 1.71 (0.55, 5.64) | 2.20 (0.54, 9.48) | 1.13 (0.33, 4.48) | 1.65 (0.32, 9.81) | 1.08 (0.35, 3.58) | 1.20 (0.31, 4.91) | 0.73 (0.21, 2.97) | 1.21 (0.23, 7.21) | 2.28 (0.72, 8.03) | **4.64 (1.00, 26.62)** |
| Population within 0.5 miles (0,000s) | 0.90 (0.71, 1.14) | 0.88 (0.55, 1.34) | 0.87 (0.64, 1.13) | 1.11 (0.66, 1.85) | 1.00 (0.79, 1.26) | 1.18 (0.81, 1.75) | 0.88 (0.63, 1.17) | 1.24 (0.70, 2.27) | 1.20 (0.95, 1.55) | 1.24 (0.78, 2.20) |
| Bridge or tunnel present | 1.6 (0.65, 4.01) | 1.03 (0.35, 3.00) | 2.07 (0.75, 6.15) | 1.39 (0.38, 5.38) | 1.59 (0.64, 4.09) | 1.42 (0.50, 4.12) | 2.25 (0.73, 7.78) | 1.80 (0.44, 8.77) | 0.63 (0.25, 1.54) | 0.58 (0.17, 1.86) |
| Deprivation quintile (1 = most deprived) | 1.23 (0.90, 1.73) | 1.14 (0.78, 1.67) | 1.42 (1.00, 2.05) | 1.11 (0.66, 1.85) | 1.24 (0.90, 1.73) | 1.27 (0.88, 1.86) | 1.31 (0.90, 1.95) | 1.29 (0.82, 2.09) | 0.81 (0.58, 1.11) | 0.99 (0.64, 1.52) |
| Scheme cost (£ million) | 1.12 (0.84, 1.55) | 1.24 (0.89, 1.84) | 0.97 (0.67, 1.31) | 1.27 (0.74, 2.02) | 1.00 (0.74, 1.34) | 1.04 (0.72, 1.44) | 0.78 (0.45, 1.15) | 0.87 (0.42, 1.65) | **0.59 (0.37, 0.87)** | **0.29 (0.13, 0.57)** |
| Length (km) | 1.03 (0.95, 1.11) | 1.10 (0.97, 1.26) | 0.97 (0.88, 1.06) | 1.03 (0.89, 1.20) | 0.99 (0.91, 1.08) | 0.98 (0.87, 1.10) | 0.96 (0.85, 1.06) | 0.95 (0.79, 1.12) | 1.01 (0.93, 1.10) | 0.95 (0.82, 1.09) |
| Baseline (0,000s for cyclists; 00,000s for pedestrians) | **0.85 (0.72, 0.95)** | **0.79 (0.63, 0.92)** | **0.63 (0.44, 0.83)** | **0.52 (0.31, 0.77)** | ***0.88 (0.73, 1.01)*** | ***0.86 (0.68, 1.01)*** | **0.48 (0.24, 0.79)** | **0.39 (0.14, 0.78)** | **1.12 (1.00, 1.32)** | **1.24 (1.05, 1.57)** |
| Time from completion to post-monitoring (months) | 1.01 (0.95, 1.06) | 0.99 (0.92, 1.05) | 1.04 (0.98, 1.10) | 1.02 (0.95, 1.10) | 1.04 (0.99, 1.10) | 1.03 (0.97, 1.11) | 1.07 (1.01, 1.14) | 1.08 (1.00, 1.17) | 1.03 (0.90, 1.10) | 1.06 (0.99, 1.15) |

\* Maximally adjusted model adjusted for other independent variables.

Table D.6: Binary logistic regression for changes in user sub-groups (data sets: counts of users, user survey and total annual scheme users)

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Independent variable** | **Odds ratio of increasing by at least 50% (95% CI) (maximally adjusted)\*** | | | | | | **Odds ratio of doubling (95% CI) (maximally adjusted)\*** | | | | | |
| **Women (N=69)** | **Older people (N=69)** | **Disabled/ long-term illness (N=71)** | **1st IMD quintile (N=73)** | **Peak time users (N=69)** | **Women cyclists (N=69)** | **Women (N=69)** | **Older people (N=69)** | **Disabled/ long-term illness# (N=71)** | **1st IMD quintile (N=73)** | **Peak time users (N=69)** | **Women cyclists (N=69)** |
| Transport interchange present | 0.72 (0.17, 3.01) | 1.17 (0.28, 4.84) | 1.60 (0.40, 6.49) | 0.92 (0.20, 4.13) | 1.05 (0.24, 4.73) | 0.45 (0.08, 2.12) | 1.00 (0.17, 6.34) | 1.32 (0.28, 7.00) | 0.85 (0.20, 3.87) | 0.79 (0.17, 4.02) | **13.00 (1.47, 340.87)** | 1.58 (0.32, 8.54) |
| Population within 0.5 miles (000’s) | 1.12 (0.72, 1.75) | 1.04 (0.68, 1.60) | 0.97 (0.65, 1.43) | **1.93 (1.18, 3.67)** | 1.14 (0.73, 1.78) | 1.12 (0.73, 1.74) | 1.58 (0.82, 3.28) | 0.99 (0.62, 1.59) | 1.25 (0.82, 1.92) | **1.54 (1.01, 2.52)** | 1.11 (0.61, 2.02) | 1.08 (0.65, 1.82) |
| Bridge or tunnel present | 0.89 (0.29, 2.69) | 1.45 (0.51, 4.19) | 1.37 (0.48, 3.89) | **3.51 (1.12, 12.16)** | 0.87 (0.27, 2.75) | 0.41 (0.12, 1.29) | 0.88 (0.20, 4.10) | 1.23 (0.39, 4.02) | 0.83 (0.26, 2.60) | 2.00 (0.60, 7.27) | 1.02 (0.22, 4.74) | **0.19 (0.05, 0.64)** |
| IMD quintile 1 = most deprived | 1.32 (0.90, 2.01) | 1.03 (0.70, 1.53) | 1.17 (0.79, 1.76) | 1.01 (0.66, 1.54) | 1.66 (1.11, 2.62) | 1.22 (0.81, 1.91) | **1.87 (1.14, 3.32)** | 0.97 (0.63, 1.49) | **1.56 (1.03, 2.46)** | 1.22 (0.81, 1.90) | 1.47 (0.92, 2.49) | 1.33 (0.87, 2.16) |
| Scheme cost (£00,000’s) | 1.12 (0.69, 1.86) | 1.20 (0.76, 1.97) | 1.25 (0.77, 2.14) | 1.04 (0.62, 1.77) | 1.16 (0.70, 1.97) | 1.29 (0.79, 2.22) | 1.31 (0.67, 2.57) | 1.09 (0.65, 1.80) | 0.80 (0.46, 1.32) | 0.79 (0.46, 1.31) | 1.15 (0.63, 2.09) | 1.30 (0.77, 2.23) |
| Length (km) | 0.91 (0.73, 1.07) | 1.04 (0.92, 1.18) | 0.98 (0.88, 1.10) | 0.96 (0.84, 1.10) | 0.90 (0.76, 1.03) | 1.00 (0.89, 1.14) | 0.86 (0.67, 1.05) | 1.04 (0.90, 1.18) | 1.01 (0.90, 1.13) | 0.94 (0.82, 1.05) | 0.91 (0.72, 1.10) | 1.05 (0.91, 1.21) |
| Baseline (00,000 total users or 0,000 cyclists) | 0.91 (0.73, 1.07) | 0.88 (0.74, 1.01) | 0.93 (0.80, 1.06) | **0.79 (0.63, 0.94)** | 0.94 (0.78, 1.09) | 0.92 (0.83, 1.02) | **0.46 (0.22, 0.80)** | 0.92 (0.75, 1.07) | 0.91 (0.74, 1.05) | 0.92 (0.74, 1.08) | **0.71 (0.42, 0.98** | **0.77 (0.60, 0.92)** |
| Time from completion to post-monitoring (months) | 1.05 (0.99, 1.13) | 1.03 (0.97, 1.11) | 1.00 (0.94, 1.07) | 1.03 (0.95, 1.12) | 1.04 (0.97, 1.11) | 1.01 (0.94, 1.08) | 1.05 (0.96, 1.15) | 1.08 (1.01, 1.16) | 1.02 (0.96, 1.10) | 1.04 (0.97, 1.12) | 1.07 (0.99, 1.17) | 1.03 (0.96, 1.11) |

\* Maximally adjusted model adjusted for other independent variables and time from completion to post-monitoring.

Note N = Number of schemes

Table D.7: Sensitivity analysis for people living in most deprived LSOA UK-adjusted IMD quintile

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Independent variable** | **Odds ratio of increasing by at least 50% (95% CI) (maximally adjusted)** | | **Odds ratio of doubling (95% CI) (maximally adjusted)** | |
| **Disabled/ long-term illness (N=71)** | **1st IMD quintile (N=73)** | **Disabled/ long-term illness# (N=71)** | **1st IMD quintile (N=73)** |
| Transport interchange present | 1.56 (0.39, 6.34) | 0.97 (0.19, 5.07) | 0.85 (0.20, 3.87) | 0.61 (0.11, 3.96) |
| Population within 0.5 miles (000’s) | 0.97 (0.65, 1.43) | **1.59 (1.03, 2.69)** | 1.25 (0.82, 1.92) | **1.60 (1.02, 2.76)** |
| Bridge or tunnel present | 1.24 (0.44, 3.50) | **4.44 (1.32, 16.72)** | 0.83 (0.26, 2.60) | 1.53 (0.39, 6.33) |
| IMD quintile 1 = most deprived | 1.17 (0.79, 1.75) | 1.07 (0.69, 1.63) | **1.56 (1.03, 2.46)** | 1.01 (0.63, 1.61) |
| Scheme cost (£00,000’s) | 1.14 (0.71, 1.90) | 1.63 (0.93, 3.23) | 0.80 (0.46, 1.32) | 1.12 (0.65, 1.92) |
| Length (km) | 1.00 (0.90, 1.12) | 0.92 (0.80, 1.03) | 1.01 (0.90, 1.13) | 0.88 (0.75, 1.00) |
| Baseline (00,000 total users or 0,000 cyclists) | 0.92 (0.79, 1.05) | 0.89 (0.75, 1.04) | 0.91 (0.74, 1.05) | 0.97 (0.78, 1.12) |
| Time from completion to post-monitoring (months) | 1.01 (0.94, 1.08) | 0.93 (0.85, 1.00 | 1.02 (0.96, 1.10) | 0.96 (0.88, 1.04) |

# Sensitivity analysis for doubling disabled/long-term illness resulted in no difference in results

Note N = Number of schemes

Table D.8: Sensitivity analysis for 30 minutes physical activity on at least 5 days in the previous week for all types of route users, including runners

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Type of route user** | | **Survey of users: at least 5 days of 30 min physical activity in previous week for all types of user, including runners** | | | | | | | |
| **Pre** | | | | **Post** | | | |
| **Sample (n)** | **% of sample achieving 5+ days** | **Unadjusted** | **Adjusted\*** | **Sample (n)** | **% of sample achieving 5+ days** | **Unadjusted** | **Adjusted\*** |
| **Frequency of journey on route** | Irregularly (Weekly or less frequently) (reference) | 4,562 | 43.5% | 1.00 | 1.00 | 6,876 | 43.3% | 1.00 | 1.00 |
| Regularly (Daily/ 2-5 times a week) | 8,781 | 57.5% | **1.78 (1.65, 1.91)** | **1.79 (1.67, 1.93)** | 12,668 | 58.6% | **1.87 (1.77, 1.99)** | **1.90 (1.79, 2.02)** |
| **Journey purpose on route** | Recreation (reference) | 6,605 | 56.6% | 1.00 | 1.00 | 10,358 | 55.0% | 1.00 | 1.00 |
| Commuting | 1,715 | 56.6% | 1.00 (0.90, 1.11) | 1.03 (0.92, 1.15) | 2,751 | 56.4% | 1.06 (0.97, 1.15) | *1.09 (0.99, 1.19)* |
| Non-commuting transport | 4,997 | 46.0% | **0.65 (0.61, 0.70)** | **0.67 (0.62, 0.72)** | 6,404 | 48.8% | **0.78 (0.73, 0.83)** | **0.79 (0.74, 0.84)** |
| Recreation and transport | - | - | - | - | - | - | - | - |
| **Mode on route** | Walking (reference) | 10,441 | 52.0% | 1.00 | 1.00 | 14,046 | 53.6% |  |  |
| Cycling | 2,485 | 56.7% | **1.21 (1.11, 1.32)** | **1.12 (1.02, 1.23)** | 4,839 | 53.6% | 1.00 (0.94, 1.07) | 0.98 (0.92, 1.05) |
| Running | 324 | 48.5% | 0.87 (0.70, 1.08) | 0.83 (0.66, 1.04) | 476 | 47.3% | **0.78 (0.65, 0.93)** | **0.76 (0.63, 0.92)** |
| Other | 93 | 32.3 | **0.44 (0.28, 0.67)** | **0.44 (0.28, 0.68)** | 183 | 21.9% | **0.24 (0.17, 0.34)** | **0.27 (0.18, 0.38)** |
| **Journey time on route (hrs)** |  | 13,243 | 52.6% | **1.07 (1.04, 1.11)** | **1.05 (1.02, 1.08)** | 19,406 | 53.1% | 1.00 (0.98, 1.03) | 1.00 (0.97, 1.02) |

\* Adjusted for demographic variables: gender (male/female), age (16-24/25-34/35-44/45-54/55-64/65+), employment (employed full time/employed part time/retired/other), ethnicity (white/non-white), general health (excellent/good/fair/poor), disability/long-term illness (yes/no), home IMD quintile, and child under 16 in the household (yes/no).

1. Women, Older people, Peak time users, Women cyclists, Number of schemes = 69, data sets = counts of users and total annual scheme users; Disabled/long-term ill, Number of schemes = 71, Most deprived IMD quintile, Number of schemes = 73, data sets = survey of users and total annual scheme users. [↑](#footnote-ref-1)
2. Updated version available at https://www.gov.uk/government/uploads/system/uploads/attachment\_data/file/625402/TAG\_unit\_a5.4\_marginal\_external\_costs\_jul17-2.pdf) [↑](#footnote-ref-2)