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

1. 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:

3. 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.

2. Methods

2.1.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.

2.2.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.

2.2.1. 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.

2.2.2. 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

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

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

144 *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	-	-

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
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	-	-

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
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	-	-

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
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	-	-

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
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).

2.3.Contextual measures

2.3.1. 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).

2.3.2. 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).

2.4.Outcome measures

2.4.1. 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).

2.4.2. 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%).

2.4.3. 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.

2.4.4. 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.

2.5.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.

2.6.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.

2.7.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.

2.7.1. 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).

3. Results

3.1. Descriptive findings

3.1.1. 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.

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

273 3.1.2. Scheme level route users

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

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

286 *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

Type of user		Pre				Post				Change pre-post		
		Total n	%	Median n	IQR	Total n	%	Median n	IQR	Median %	IQR %	p-value
	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	-	-	-

287 * Sub-group of interest (peak time defined as 7am – 9am and 4pm – 7pm on weekdays; older people classified subjectively by surveyors)
288 [#] 'Other' includes in course of work, education, personal business, holiday base, escort to school, other escort, and other.
289 [$] 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.
290 [&] Type of cyclist was selected by each participant (excluding the option 'women cyclist')
291 Total percentages may not add to 100 due to rounding and missing values.

3.1.3. 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%)

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 (%)
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%)

312

3.2. 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.

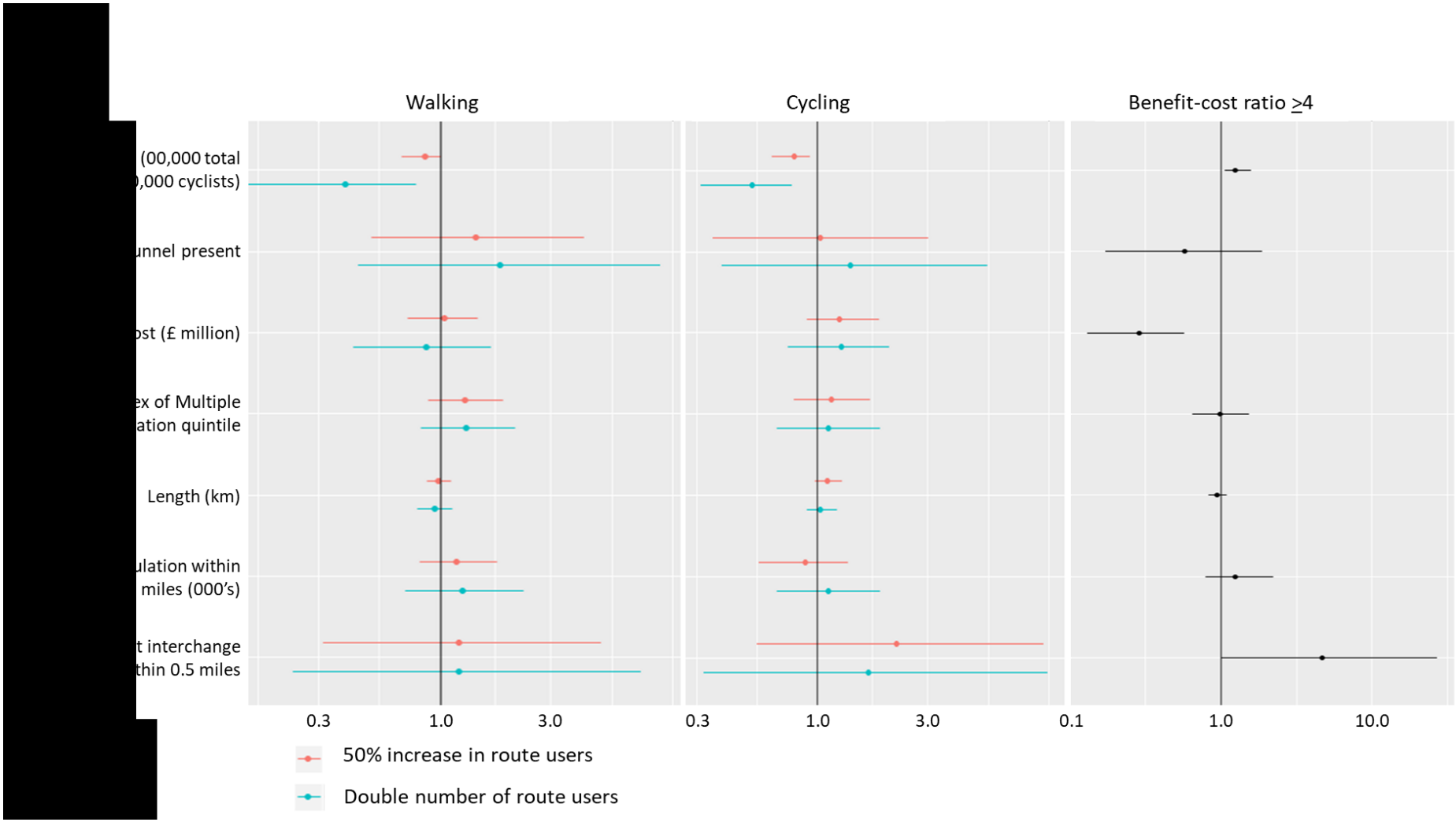


Figure 1: Multivariable binary logistic regression analysis: ORs and 95%CIs for context/ scheme characteristics and either at least a 50% increase or a doubling in the number of route users, and BCR across schemes, maximally adjusted for each independent contextual/scheme characteristic variable (baseline 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)

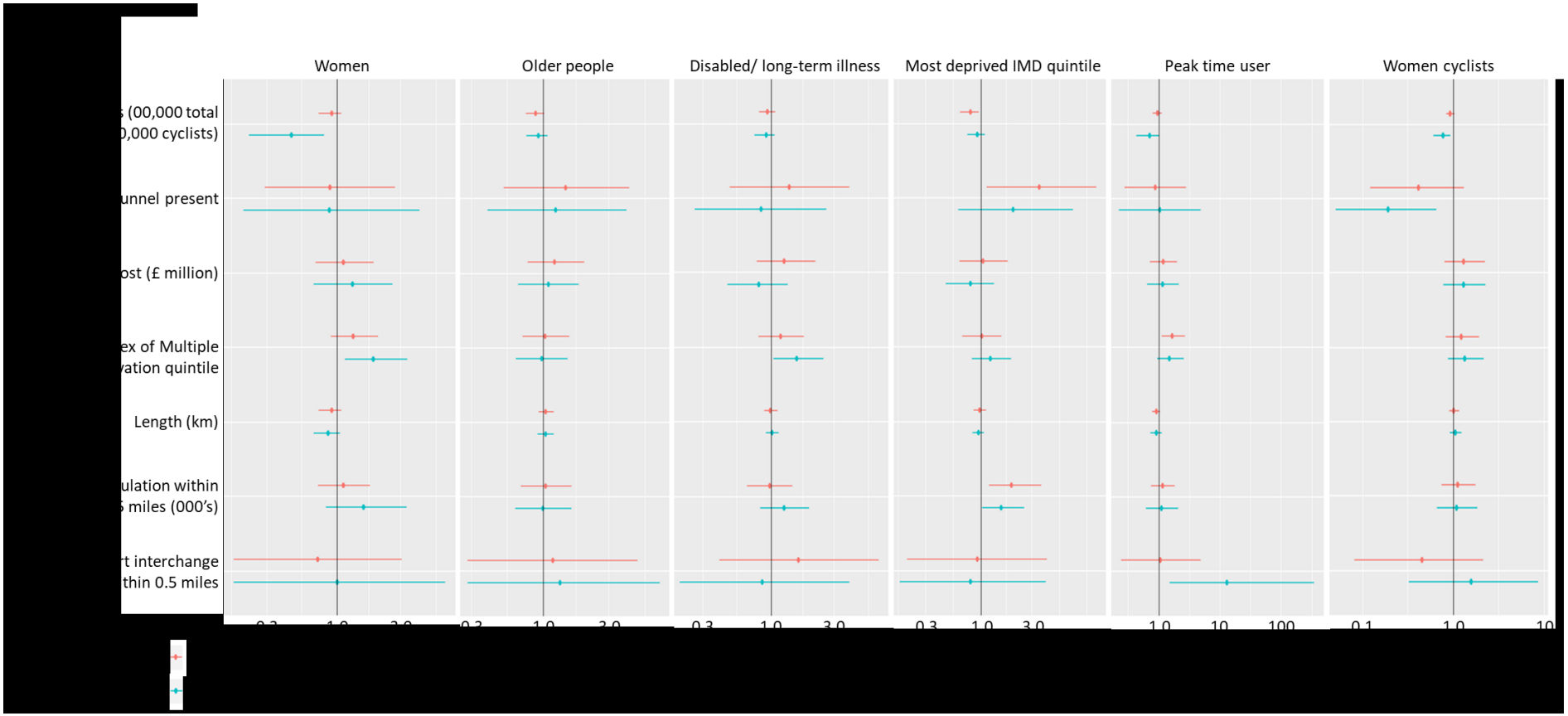
3.3. Users of new walking and cycling infrastructure by local contextual factors and scheme characteristics

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.



351

352 *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*
353 *independent contextual/scheme characteristic variable (baseline users, bridge or tunnel present, cost, index of multiple deprivation quintile, length, population within 0.5 miles, public*
354 *transport interchange with 0.5 miles) and time from completion to post-monitoring*[1]

[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.

3.4.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.

382 [&] Non-commuting transport includes travel for shopping, visiting friends/family, social/entertainment and other purposes.
383 [#] 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
384 (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).
385 [$] Adjusted for baseline demographic variables: gender (male/female), age, employment (employed full time/employed part time/retired/other), general health (excellent/good/fair/poor),
386 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).
387

4. Discussion

4.1. 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.

4.2.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.

4.3.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).

5. 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.

6. 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

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

7. References

Abel, G.A., Barclay, M.E., Payne, R.A., 2016. Adjusted indices of multiple deprivation to enable comparisons within and between constituent countries of the UK including an illustration using mortality rates. BMJ Open 6, e012750. https://doi.org/10.1136/bmjopen-2016-012750

Adams, E.J., Goad, M., Sahlqvist, S., Bull, F.C., Cooper, A.R., Ogilvie, D., Consortium, on behalf of the iConnect, 2014. Reliability and Validity of the Transport and Physical Activity Questionnaire (TPAQ) for Assessing Physical Activity Behaviour. PLoS One 9, e107039. https://doi.org/10.1371/journal.pone.0107039

Adkins, A., Makarewicz, C., Scanze, M., Ingram, M., Luhr, G., 2017. Journal of the American Planning Association Contextualizing Walkability: Do Relationships Between Built Environments and Walking Vary by Socioeconomic Context? https://doi.org/10.1080/01944363.2017.1322527

Ainsworth, B.E., Haskell, W., Herrmann, S.D., Meckes, N., Bassett, D.R., Tudor-Locke, C., J, G., Vezina, J., Whitt-Glover, M., Leon, A.S., 2011. Compendium of Physical Activities: a second update of codes and MET values. Med. Sci. Sports Exerc. 43, 1575–1581.

Aldred, R., 2019. Built Environment Interventions to Increase Active Travel: a Critical Review and Discussion. Curr. Environ. Heal. reports. https://doi.org/10.1007/s40572-019-00254-4

Aldred, R., Woodcock, J., Goodman, A., 2020. Major investment in active travel in Outer London: impacts on travel behaviour, physical activity, and health. https://doi.org/10.31235/OSF.IO/5NY4C

Brand, C., Goodman, A., Ogilvie, D., 2014. Evaluating the impacts of new walking and cycling infrastructure on carbon dioxide emissions from motorized travel: a controlled longitudinal study. Appl. Energy 128, 284–295. https://doi.org/10.1016/j.apenergy.2014.04.072

Branion-Calles, M., Winters, M., Nelson, T., de Nazelle, A., Panis, L.I., Avila-Palencia, I., Anaya-Boig, E., Rojas-Rueda, D., Dons, E., Götschi, T., 2019. Impacts of study design on sample size, participation bias, and outcome measurement: A case study from bicycling research. J. Transp. Heal. 15. https://doi.org/10.1016/j.jth.2019.100651

Brown, B.B., Smith, K.R., 2017. Complex active travel bout motivations: Gender, place, and social context associations. J. Transp. Heal. 6, 335–346. https://doi.org/10.1016/j.jth.2017.01.014

Carse, A., Goodman, A., Mackett, R.L., Panter, J., Ogilvie, D., 2013. The factors influencing car use in a cycle-friendly city: The case of Cambridge. J. Transp. Geogr. 28, 67–74. https://doi.org/10.1016/j.jtrangeo.2012.10.013

595 Cavill, N., Davis, A., Cope, A., Corner, D., 2019. Active travel and physical activity evidence review.
596 Sport England.

597 Craig, P., Cooper, C., Gunnell, D., Haw, S., Lawson, K., Macintyre, S., Ogilvie, D., Petticrew, M.,
598 Reeves, B., Sutton, M., Thompson, S., 2012. Using natural experiments to evaluate population
599 health interventions: New medical research council guidance. J. Epidemiol. Community Health
600 66, 1182–1186. https://doi.org/10.1136/jech-2011-200375

601 Craig, P., Ruggiero, E. Di, Frohlich, K.L., Mykhalovskiy, E., White, M., Campbell, R., Cummins, S.,
602 Edwards, N., Hunt, K., Kee, F., Loppie, C., Moore, L., Ogilvie, D., Petticrew, M., Poland, B., Ridde,
603 V., Shoveller, J., Viehbeck, S., Wight, D., 2018. Taking account of context in population health
604 intervention research: guidance for producers, users and funders of research.
605 https://doi.org/10.3310/CIHR-NIHR-01

606 Criado Perez, C., 2019. Invisible women: exposing data bias in a world designed for men. Chatto &
607 Windus, London.

608 Dahlgren, G., Whitehead, M., 1991. Policies and strategies to promote social equity in health.

609 Department for Transport, 2020. Cycle infrastructure design [WWW Document]. Local Transp. Note
610 1/20. URL
611 https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_dat
612 a/file/906344/cycle-infrastructure-design-ltn-1-20.pdf (accessed 9.14.20).

613 Department for Transport, 2016. Cycling and Walking Investment Strategy.

614 Department for Transport, 2015. Value for money. Framework. Moving Britain ahead.

615 Department for Transport, 2013. Transport analysis guidance: WebTAG [WWW Document]. URL
616 https://www.gov.uk/guidance/transport-analysis-guidance-webtag

617 Department for Transport, 2010. National Travel Survey: 2010 [WWW Document]. URL
618 https://www.gov.uk/government/statistics/national-travel-survey-2013 (accessed 4.14.20).

619 Department of Health and Social Care, 2011. UK physical activity guidelines [WWW Document]. URL
620 https://www.gov.uk/government/publications/uk-physical-activity-guidelines (accessed
621 2.13.19).

622 Dowd, K.P., Szeklicki, R., Minetto, M.A., Murphy, M.H., Polito, A., Ghigo, E., Van Der Ploeg, H.,
623 Ekelund, U., Maciaszek, J., Stemplewski, R., Tomczak, M., Donnelly, A.E., 2018. A systematic
624 literature review of reviews on techniques for physical activity measurement in adults: a
625 DEDIPAC study. Int. J. Behav. Nutr. Phys. Act. 15. https://doi.org/10.1186/s12966-017-0636-2

626 Goodman, A., Panter, J., Sharp, S.J., Ogilvie, D., 2013. Effectiveness and equity impacts of town-wide
627 cycling initiatives in England: A longitudinal, controlled natural experimental study. Soc. Sci.
628 Med. 97, 228–237. https://doi.org/10.1016/j.socscimed.2013.08.030

629 Goodman, A., Sahlqvist, S., Ogilvie, D., 2014. New walking and cycling routes and increased physical
630 activity: One-and 2-Year findings from the UK iConnect study. Am. J. Public Health 104, 38–46.

631 Götschi, T., de Nazelle, A., Brand, C., Gerike, R., 2017. Towards a Comprehensive Conceptual
632 Framework of Active Travel Behavior: a Review and Synthesis of Published Frameworks. Curr.
633 Environ. Heal. reports. https://doi.org/10.1007/s40572-017-0149-9

634 Guthold, R., Stevens, G.A., Riley, L.M., Bull, F.C., 2018. Worldwide trends in insufficient physical
635 activity from 2001 to 2016: a pooled analysis of 358 population-based surveys with 1·9 million
636 participants. Lancet Glob. Heal. 6, e1077-86. https://doi.org/10.1016/S2214-109X(18)30357-7

637 Kelly, P., Kahlmeier, S., Götschi, T., Orsini, N., Richards, J., Roberts, N., Scarborough, P., Foster, C.,
638 2014. Systematic review and meta-analysis of reduction in all-cause mortality from walking and
639 cycling and shape of dose response relationship. Int. J. Behav. Nutr. Phys. Act. 11, 15.
640 https://doi.org/10.1186/s12966-014-0132-x

641 Le Gouais, A., Foley, L., Ogilvie, D., Guell, C., 2020. Decision-making for active living infrastructure in
642 new communities: a qualitative study in England. J. Public Heal. 42, e249–e258.
643 https://doi.org/10.1093/pubmed/fdz105

644 Li, T., Wei, Shaozhong, Shi, Y., Pang, S., Qin, Q., Yin, J., Deng, Y., Chen, Q., Wei, Sheng, Nie, S., Liu, L.,
645 2016. The dose–response effect of physical activity on cancer mortality: findings from 71
646 prospective cohort studies. Br. J. Sports Med. 50, 339–345. https://doi.org/10.1136/bjsports-
647 2015-094927

648 Macmillan, F., George, E.S., Feng, X., Merom, D., Bennie, A., Cook, A., Sanders, T., Dwyer, G., Pang,
649 B., Guagliano, J.M., Kolt, G.S., Astell-Burt, T., 2018. Do natural experiments of changes in
650 neighborhood built environment impact physical activity and diet? A systematic review. Int. J.
651 Environ. Res. Public Health 15. https://doi.org/10.3390/ijerph15020217

652 Marmot, M., Allen, J., Boyce, T., Goldblatt, P., Morrison, J., 2020. Health equity in England: the
653 Marmot review 10 years on.

654 Mueller, N., Rojas-Rueda, D., Salmon, M., Martinez, D., Ambros, A., Brand, C., de Nazelle, A., Dons,
655 E., Gaupp-Berghausen, M., Gerike, R., Götschi, T., Iacorossi, F., Int Panis, L., Kahlmeier, S.,
656 Raser, E., Nieuwenhuijsen, M., 2018. Health impact assessment of cycling network expansions
657 in European cities. Prev. Med. (Baltim). 109, 62–70.

https://doi.org/10.1016/j.ypmed.2017.12.011

Ng, W.-S., Acker, A., 2018. Understanding urban travel behaviour by gender for efficient and equitable transport policies.

NHS Digital, 2017. Health Survey for England 2016 - Physical activity in adults.

Nomis, 2011. Car or van availability [WWW Document]. Census. URL https://www.nomisweb.co.uk/census/2011/ks404ew (accessed 3.6.20).

Norwood, P., Eberth, B., Farrar, S., Anable, J., Ludbrook, A., 2014. Active travel intervention and physical activity behaviour: An evaluation. Soc. Sci. Med. 113, 50–58. https://doi.org/10.1016/j.socscimed.2014.05.003

Ogilvie, D., Bull, F., Cooper, A., Rutter, H., Adams, E., Brand, C., Ghali, K., Jones, T., Mutrie, N., Powell, J., Preston, J., Sahlqvist, S., 2012. Evaluating the travel, physical activity and carbon impacts of a "natural experiment" in the provision of new walking and cycling infrastructure: methods for the core module of the iConnect study. BMJ Open 2, 13. https://doi.org/10.1136/bmjopen-2011-000694

Ogilvie, D., Bull, F., Powell, J., Cooper, A.R., Brand, C., Mutrie, N., Preston, J., Rutter, H., 2011. An applied ecological framework for evaluating infrastructure to promote walking and cycling: The iConnect study. Am J Public Heal. 101, 473–481. https://doi.org/10.2105/AJPH.2010.198002

Ogilvie, D., Craig, P., Griffin, S., Macintyre, S., Wareham, N.J., 2009. A translational framework for public health research. BMC Public Health 9. https://doi.org/10.1186/1471-2458-9-116

Ogilvie, David, Egan, M., Hamilton, V., Ogilvie, D, 2005. Systematic reviews of health effects of social interventions: 2. Best available evidence: how low should you go? J Epidemiol Community Heal. 59, 886–892. https://doi.org/10.1136/jech.2005.034199

Panter, J., Guell, C., Humphreys, D., Ogilvie, D., 2019. Can changing the physical environment promote walking and cycling? A systematic review of what works and how. Heal. Place 58. https://doi.org/10.1016/j.healthplace.2019.102161

Panter, J., Ogilvie, D., Brand, C., Bull, F., Cooper, A., Day, A., Mutrie, N., Ogilvie, D., Powell, J., Preston, J., Rutter, H., 2017. Can environmental improvement change the population distribution of walking? J. Epidemiol. Community Health 71, 528–535. https://doi.org/10.1136/jech-2016-208417

Patterson, R., Webb, E., Millett, C., Laverty, A.A., 2018. Physical activity accrued as part of public transport use in England. J. Public Health (Bangkok). 41, 222–230.

https://doi.org/10.1093/pubmed/fdy099

PCT Team, 2019. Manual C. PCT methodology: commuting layer.

Prince, S.A., Adamo, K.B., Hamel, M.E., Hardt, J., Gorber, S.C., Tremblay, M., 2008. A comparison of direct versus self-report measures for assessing physical activity in adults: a systematic review. Int. J. Behav. Nutr. Phys. Act. 5. https://doi.org/10.1186/1479-5868-5-56

Public Health England, 2016. Health matters: getting every adult active every day [WWW Document]. URL https://www.gov.uk/government/publications/health-matters-getting-every-adult-active-every-day/health-matters-getting-every-adult-active-every-day (accessed 11.12.18).

R Core Team, 2019. R: A language and environment for statistical computing.

Richiardi, L., Pizzi, C., Pearce, N., 2013. Commentary: Representativeness is usually not necessary and often should be avoided. Int. J. Epidemiol. 1018–1022. https://doi.org/10.1093/ije/dyt103

Sahlqvist, S., Goodman, A., Jones, T., Powell, J., Song, Y., Ogilvie, D., 2015. Mechanisms underpinning use of new walking and cycling infrastructure in different contexts: mixed-method analysis. Int. J. Behav. Nutr. Phys. Act. 12, 15. https://doi.org/10.1186/s12966-015-0185-5

Sahlqvist, S., Song, Y., Ogilvie, D., 2012. Is active travel associated with greater physical activity? The contribution of commuting and non-commuting active travel to total physical activity in adults ☆. Prev. Med. (Baltim). 55, 206–211. https://doi.org/10.1016/j.ypmed.2012.06.028

Sattelmair, J., Pertman, J., Ding, E.L., Kohl, H.W., Haskell, W., Lee, I.M., 2011. Dose response between physical activity and risk of coronary heart disease: A meta-analysis. Circulation 124, 789–795. https://doi.org/10.1161/CIRCULATIONAHA.110.010710

Smith, A.D., Crippa, A., Woodcock, J., Brage, S., 2016. Physical activity and incident type 2 diabetes mellitus: a systematic review and dose–response meta-analysis of prospective cohort studies. Diabetologia 59, 2527–2545. https://doi.org/10.1007/s00125-016-4079-0

Smith, L., Panter, J., Ogilvie, D., 2019. Characteristics of the environment and physical activity in midlife: Findings from UK Biobank. Prev. Med. (Baltim). 118, 150–158. https://doi.org/10.1016/j.ypmed.2018.10.024

Smith, M., Hosking, J., Woodward, A., Witten, K., Macmillan, A., Field, A., Baas, P., Mackie, H., 2017. Systematic literature review of built environment effects on physical activity and active transport – an update and new findings on health equity. Int. J. Behav. Nutr. Phys. Act. 14. https://doi.org/10.1186/s12966-017-0613-9

720 Song, Y., Preston, J., Ogilvie, D., 2017. New walking and cycling infrastructure and modal shift in the
721 UK: A quasi-experimental panel study. Transp. Res. Part A Policy Pract. 95, 320–333.
722 https://doi.org/10.1016/j.tra.2016.11.017

723 Song, Y., Preston, J.M., Brand, C., 2013. What explains active travel behaviour? Evidence from case
724 studies in the UK. Environ. Plan. A 45, 2980–2998. https://doi.org/10.1068/a4669

725 Sustrans, 2013a. Methodology for the estimation of economic benefits.

726 Sustrans, 2013b. Sustrans whole scheme usage estimate: Technical note. Bristol.

727 Transport for London, 2015. Valuing the health benefits of transport schemes: guidance for London.

728 Warburton, D.E.R., Bredin, S.S.D., 2017. Health benefits of physical activity: a systematic review of
729 current systematic reviews. Curr. Opin. Cardiol. 32, 541–556.
730 https://doi.org/10.1097/HCO.0000000000000437

731 World Health Organization, 2011. Health Economic Assessment Tool.

732 Yang, Y., Wu, X., Zhou, P., Gou, Z., Lu, Y., 2019. Towards a cycling-friendly city: An updated review of
733 the associations between built environment and cycling behaviors (2007–2017). J. Transp. Heal.
734 https://doi.org/10.1016/j.jth.2019.100613

735

8. Appendix

8.1.Appendix A. Additional methodological information

8.1.1. 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.

8.1.2. 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%).

8.1.3. 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.

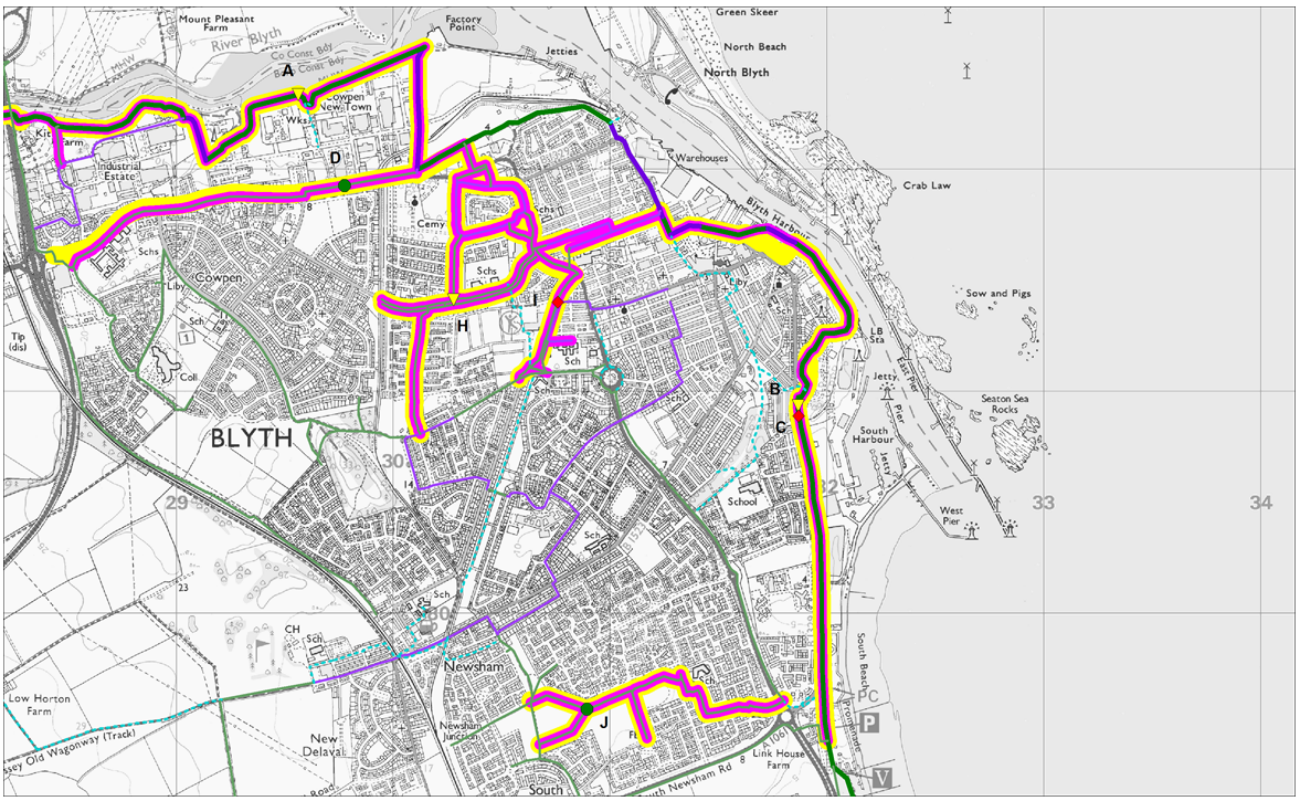


Figure A.1 – Example scheme map and key showing monitoring locations

8.1.3.1. 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	

8.1.3.2. 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:

a) 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.
b) 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):

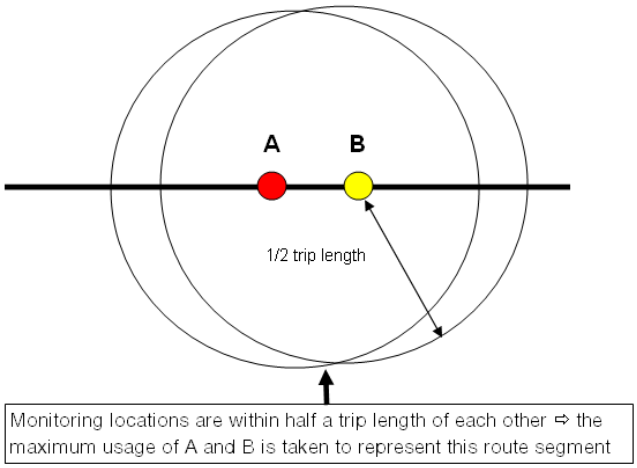


Figure A.2: Rule 1 – Larger value of A or B used

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):

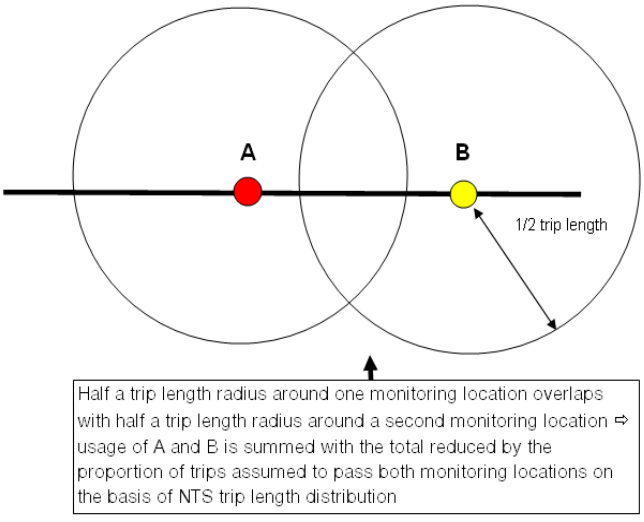


Figure A.3: Rule 2 – Usage at A and B summed, then reduced by amount assumed to pass both points

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):

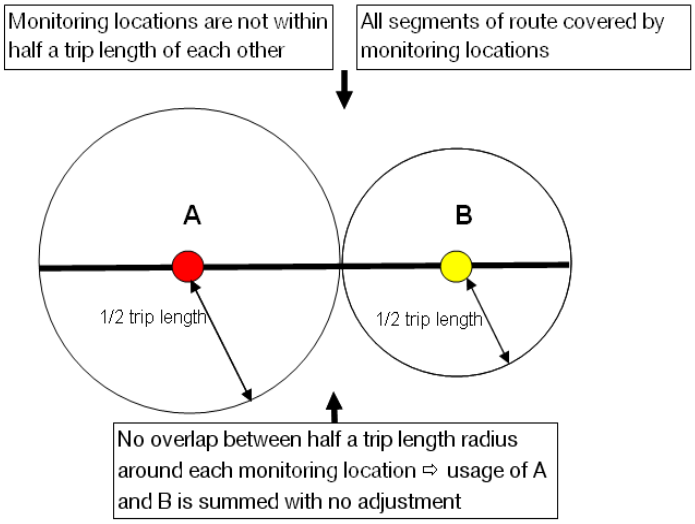


Figure A.4: Rule 3 – Usage at A and B summed

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):

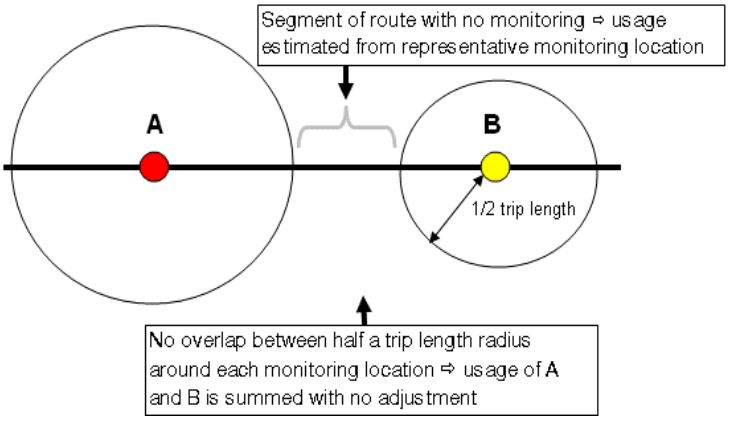


Figure A.5: Rule 4 – 'Block spot' estimated using appropriate monitoring point with a 'per km' usage figure

(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.

8.1.3.3. 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.

8.1.4. 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.

8.1.4.1. 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).

8.1.4.2. 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 dioxide reduction 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].

[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)

8.1.4.3. 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)$_{\text{post survey}}$ - (Number of trips x trip distance)$_{\text{pre survey}}$

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)$_{\text{post survey}}$ – ((Trip distance ÷ default speed) x number of trips)$_{\text{pre survey}}$

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.

8.1.4.4. 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.

8.1.4.5. 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.

8.1.4.6. 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.

8.1.5. 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.

8.2.Appendix B: Sustrans' survey of users questionnaire

Version 1 - 2011 **Sustrans Route User Survey**

Survey Site Number:

Interview Number:

Location:

Date (DD/MM/YY)

Time interviewed started:

Interviewer initials:

Day Type? (Select one choice only)

Weekday ☐ *Weekend* ☐ *Bank Holiday* ☐

School holiday or term time? (Select one choice only)

School Holidays ☐ *Term Time* ☐

Q1 **Activity undertaken?** (Select one choice only)

Walking	☐	*Wheelchair Use*	☐
Cycling	☐	*Roller Skating*	☐
Running/Jogging	☐	*Horse Riding*	☐
Dog Walking	☐	*Other*	☐

Q2 **If you are in a group how many of you are there?** (Please write)

Adults

Children

ABOUT YOUR CURRENT JOURNEY

Q3 **What is the purpose of your current journey?**

	Tick One From	Tick One To
Home	☐	☐
Home - Recreation	☐	☐
Work	☐	☐
In course of work	☐	☐
Education (school/college etc)	☐	☐
Shopping	☐	☐
Personal business	☐	☐
Visiting friends/ family	☐	☐
Social/Entertainment	☐	☐
Holiday base	☐	☐
Escort to school	☐	☐
Other escort	☐	☐
Other	☐	☐

Q4a **Where did you start your journey today? Postcode, location or street name**

Q4b **Where will you finish your journey today? Postcode, location or street name**

Q4c **If you are travelling to a particular destination on your journey please state:**

Q5 **Approximately how long do you estimate your journey today will take?** (Please write)

Hours

Minutes

Q6 **Approximately how far do you estimate you will travel today** (Please only insert in one box)

Miles

Kilometres

Q7 Did you or will you use any other mode of transport for part of this journey today? (Select one choice only - main type)

- *Car / Van* ☐
- *Train* ☐
- *Bus* ☐
- *Taxi* ☐
- *Jogging* ☐
- *Horse riding* ☐
- *None JUST the bike or walking* ☐

Q8 If you did use another mode of transport how far have you travelled by this mode to enable you to make this journey? Please include outward and return distances. (Select one choice only)

- *Under 1 mile* ☐
- *1 - 2 miles* ☐
- *3 - 5 miles* ☐
- *6 - 10 miles* ☐
- *11 - 15 miles* ☐
- *16 - 20 miles* ☐
- *20+ miles* ☐

Q9 How often do you make this journey? (Select one choice only)

- *Daily* ☐
- *2 - 5 times per week* ☐
- *Weekly* ☐
- *Fortnightly* ☐
- *Monthly* ☐
- *Yearly* ☐
- *Less frequently* ☐
- *Other (Write in)* ☐

Q10 If you had been unable to access this route would you still have needed to make this journey to your given destination/ wanted to make a journey for this particular purpose? (For example by another/ alternative route?)

- *Yes* ☐
- *No* ☐
- *Don't Know* ☐

Q11 Which other modes of transport could you have used to make today's journey? (Tick all that apply if not on this route) **See notes for wheelchair users**

- *Car / Van* ☐
- *Taxi* ☐
- *Bus* ☐
- *Rail* ☐
- *Don't know* ☐
- *Wouldn't have made the journey* ☐
- *Other (Write in)* ☐

Q12 Have you heard of Sustrans' routes, programmes, projects or schemes?

- *Yes* ☐
- *No* ☐

Q13 To what extent have the following factors influenced your decision to walk, cycle or use wheelchair today? (Tick the appropriate boxes)

	Strongly Agree	*Agree*	*Neutral*	*Disagree*	*Strongly Disagree*
I can go straight to my destination	☐	☐	☐	☐	☐
It's the best transport option	☐	☐	☐	☐	☐
This is the most convenient route	☐	☐	☐	☐	☐
I save money by using this route	☐	☐	☐	☐	☐
I like the surroundings on this route	☐	☐	☐	☐	☐
This route feels safe	☐	☐	☐	☐	☐
This is the only exercise I get and/or this adds to the exercise I get from other parts of my life	☐	☐	☐	☐	☐
I have environmental concerns	☐	☐	☐	☐	☐

Q14 Do you have any long-term illness, health problem or disability which limits your daily activities or the work you can do? (Include problems due to old age)

- *Yes* ☐
- *No* ☐
- *Prefer not to say* ☐

Q15 Overall how would you rate your general health over the last four weeks? (Select one choice only)

- *Excellent* ☐
- *Very Good* ☐
- *Good* ☐
- *Fair* ☐
- *Poor* ☐
- *Very Poor* ☐

Q16 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)

	0	*1*	*2*	*3*	*4*	*5*	*6*	*7*
Days	☐	☐	☐	☐	☐	☐	☐	☐

Q17 To what extent do you agree or disagree with the following statements? (Tick the appropriate boxes)

	Strongly Agree	*Agree*	*Neutral*	*Disagree*	*Strongly Disagree*
I intend to walk more in the next 12 months	☐	☐	☐	☐	☐
I intend to cycle more in the next 12 months	☐	☐	☐	☐	☐
It is likely I will walk more in the next 12 months	☐	☐	☐	☐	☐
It is likely I will cycle more in the next 12 months	☐	☐	☐	☐	☐

948

ABOUT YOU

Q18 **ASK CYCLISTS ONLY. What sort of cyclist would you say you were? (**Select one choice only**)**

- *New to cycling* ☐
- *Starting to cycle again* ☐
- *Occasional cyclist* ☐
- *Experienced, occasional cyclist* ☐
- *Experienced, regular cyclist* ☐

Q19 **Are you?**

- *Male* ☐
- *Female* ☐

Q20 **Which age group do you fit into? (**Select one choice only**)**

- *16 - 24* ☐
- *25 - 34* ☐
- *35 - 44* ☐
- *45 - 54* ☐
- *55 - 64* ☐
- *65+* ☐

Q21 **Which of the following best describes your working status? (**Select one choice only**)**

- *Employed full-time (30+ hours)* ☐
- *Employed part time* ☐
- *Looking after home/family* ☐
- *Unemployed/sick leave* ☐
- *Retired* ☐
- *Studying* ☐
- *Voluntary worker* ☐
- *Other (write in)* ☐

Q22 **How many other people live in your household? By this we mean people who have your residence as their only or main residence? (**Write in number**)**

- Children under 5 ☐
- Children 5 - 15 ☐
- Adults 16+ (Please do not include yourself) ☐

Q23 **Are you a sole carer for a child/children?**

- *Yes* ☐
- *No* ☐

Q24 **What is your full postcode?** ☐

IF NOT UK WRITE IN THE COUNTRY ☐

Q25 **Is there an ethnic group that you feel you belong to? (**Select one choice only)

- *White* ☐
- *Mixed* ☐
- *Indian* ☐
- *Pakistani* ☐
- *Bangladeshi* ☐
- *Other Asian* ☐
- *Caribbean* ☐
- *African* ☐
- *Other Black* ☐
- *Chinese* ☐
- *Other Ethnic Origin* ☐
- *Prefer Not To Say* ☐

Q26 **Are you a migrant worker? (**Select one choice only**)**

- *No* ☐
- *Yes (EU Country)* ☐
- *Yes (Non EU Country)* ☐
- *Prefer not to say* ☐

Q27 **Has the presence of this route helped you to increase the amount of physical activity that you regularly take? (**Select one choice only**)**

- *Yes, by a large amount* ☐
- *Yes, by a small amount* ☐
- *No* ☐

I hereby consent to the information provided on this questionnaire to be processed by Sustrans for the purpose of monitoring the impact of their projects.

Please Tick

I agree with this statement ☐

949

950

8.3.Appendix C: iConnect questionnaire example

(Ogilvie et al., 2012)

SECTION A

About your local area

1. Firstly, we'd like to ask you about the **neighbourhood where you live**. By *neighbourhood* we mean the area that you could walk to in **10–15 minutes from your home**. How much do you agree with the following statements about your neighbourhood? **(Tick one box per row.)**

	STRONGLY AGREE	SOMEWHAT AGREE	NEITHER AGREE NOR DISAGREE	SOMEWHAT DISAGREE	STRONGLY DISAGREE
a. Walking is unsafe because of the traffic.	☐	☐	☐	☐	☐
b. Cycling is unsafe because of the traffic.	☐	☐	☐	☐	☐
c. There are no convenient routes for walking and cycling.	☐	☐	☐	☐	☐
d. There are not enough safe places to cross roads.	☐	☐	☐	☐	☐
e. The area is unsafe because of the level of crime or anti-social behaviour.	☐	☐	☐	☐	☐
f. The area is generally free from litter or graffiti.	☐	☐	☐	☐	☐
g. There are places to walk or cycle to (e.g. shops, restaurants, leisure facilities).	☐	☐	☐	☐	☐
h. There are open spaces (e.g. parks, sports fields or beaches).	☐	☐	☐	☐	☐
i. There are pavements suitable for walking.	☐	☐	☐	☐	☐
j. There are special lanes, routes or paths for cycling.	☐	☐	☐	☐	☐
k. There are many road junctions.	☐	☐	☐	☐	☐
l. There are many different routes for walking and cycling so I don't have to go the same way every time.	☐	☐	☐	☐	☐
m. The area is pleasant for walking or cycling.	☐	☐	☐	☐	☐

2. Now we would like to ask you about **travelling between Penarth and Cardiff Bay**. To what extent do you agree with the following statements? **(Tick one box per row.)**

	STRONGLY AGREE	SOMEWHAT AGREE	NEITHER AGREE NOR DISAGREE	SOMEWHAT DISAGREE	STRONGLY DISAGREE
a. Walking is unsafe because of the traffic.	☐	☐	☐	☐	☐
b. Cycling is unsafe because of the traffic.	☐	☐	☐	☐	☐
c. The level of crime or anti-social behaviour means walking or cycling is unsafe.	☐	☐	☐	☐	☐
d. There are pavements suitable for walking.	☐	☐	☐	☐	☐
e. There are special lanes, routes or paths for cycling.	☐	☐	☐	☐	☐
f. The routes for walking and cycling are generally well lit at night.	☐	☐	☐	☐	☐
g. The routes are pleasant for walking or cycling.	☐	☐	☐	☐	☐

About your travel

SECTION **B**

We are interested in your views about

walking and cycling to travel from place to place.

By *walking and cycling to travel*, we mean any walking and cycling you do to get to places. For example, going to work, going out to get lunch, coming home from work, going shopping, going to the bus or railway station, visiting friends, or escorting someone else (for example, taking a child to school). ⚠**We do not** mean any walking or cycling you do for recreation, health or fitness—we will ask you about this later.

PLEASE COMPLETE THESE QUESTIONS EVEN IF YOU DON'T DO MUCH WALKING OR CYCLING.

3. Think about **walking to travel** from place to place.
How much do you agree with the following statements? **(Tick one box per row.)**

	STRONGLY AGREE	SOMEWHAT AGREE	NEITHER AGREE NOR DISAGREE	SOMEWHAT DISAGREE	STRONGLY DISAGREE
a. Walking to travel from place to place is something I do automatically without really thinking about it.	☐	☐	☐	☐	☐
b. It is beneficial for me to walk for travel.	☐	☐	☐	☐	☐
c. Walking for travel is enjoyable.	☐	☐	☐	☐	☐
d. The people in my life whose opinions I value most would approve of me walking for travel.	☐	☐	☐	☐	☐
e. Most people who are important to me walk for travel.	☐	☐	☐	☐	☐
f. It is possible for me to walk for travel.	☐	☐	☐	☐	☐
g. It is mostly up to me whether I walk for travel.	☐	☐	☐	☐	☐
h. I intend to do more walking for travel over the coming months.	☐	☐	☐	☐	☐
i. I see people in my neighbourhood walking for travel.	☐	☐	☐	☐	☐
j. Over the last 12 months I have done more walking for travel.	☐	☐	☐	☐	☐

954

4. Think about **cycling to travel** from place to place.
How much do you agree with the following statements? **(Tick one box per row.)**

	STRONGLY AGREE	SOMEWHAT AGREE	NEITHER AGREE NOR DISAGREE	SOMEWHAT DISAGREE	STRONGLY DISAGREE
a. Cycling to travel from place to place is something I do automatically without really thinking about it.	☐	☐	☐	☐	☐
b. It is beneficial for me to cycle for travel.	☐	☐	☐	☐	☐
c. Cycling for travel is enjoyable.	☐	☐	☐	☐	☐
d. The people in my life whose opinions I value most would approve of me cycling for travel.	☐	☐	☐	☐	☐
e. Most people who are important to me cycle for travel.	☐	☐	☐	☐	☐
f. It is possible for me to cycle for travel.	☐	☐	☐	☐	☐
g. It is mostly up to me whether I cycle for travel.	☐	☐	☐	☐	☐
h. I intend to do more cycling for travel over the coming months.	☐	☐	☐	☐	☐
i. I see people in my neighbourhood cycling for travel.	☐	☐	☐	☐	☐
j. Over the last 12 months I have done more cycling for travel.	☐	☐	☐	☐	☐

The next set of questions asks about the **vehicles** you have access to and the vehicles you actually use.

5. How many of the following vehicles are kept in your household? (Include all vehicles kept overnight.)

	WRITE IN NUMBER	IF ZERO, TICK HERE		WRITE IN NUMBER	IF ZERO, TICK HERE
Bicycles for adults		☐	Private cars and vans		☐
Bicycles for children		☐	Motorcycles		☐
Company cars and vans		☐			

6. Please tell us about the **cars and vans** you **actually use**. These may be among the cars or vans from the previous question, but they could also include other vehicles owned by friends or family.
If you do not use any cars or vans please tick here ☐ and go to question 8.

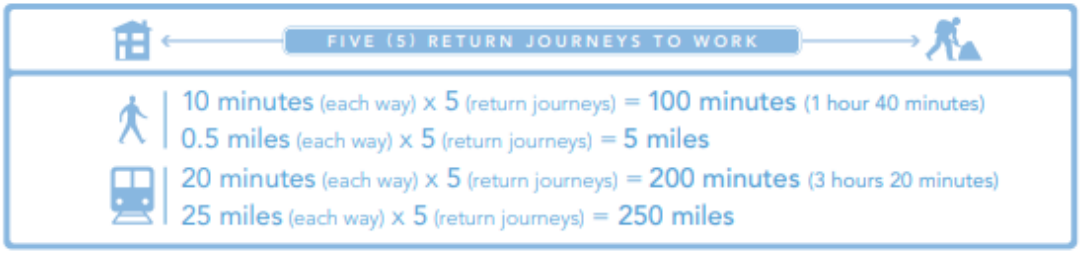
VEHICLE NO.	MAKE AND MODEL	FUEL TYPE	ENGINE SIZE	AGE (IN YEARS)	HOW MUCH HAVE YOU SPENT ON FUEL FOR THIS VEHICLE IN THE LAST seven (7) DAYS?
1		☐ PETROL ☐ DIESEL ☐ OTHER (PLEASE SPECIFY): _____	☐ LESS THAN 1.4 LITRES ☐ 1.4–2.0 LITRES ☐ MORE THAN 2.0 LITRES		£ TICK HERE IF £0 ☐
2		☐ PETROL ☐ DIESEL ☐ OTHER (PLEASE SPECIFY): _____	☐ LESS THAN 1.4 LITRES ☐ 1.4–2.0 LITRES ☐ MORE THAN 2.0 LITRES		£ TICK HERE IF £0 ☐
3		☐ PETROL ☐ DIESEL ☐ OTHER (PLEASE SPECIFY): _____	☐ LESS THAN 1.4 LITRES ☐ 1.4–2.0 LITRES ☐ MORE THAN 2.0 LITRES		£ TICK HERE IF £0 ☐
4		☐ PETROL ☐ DIESEL ☐ OTHER (PLEASE SPECIFY): _____	☐ LESS THAN 1.4 LITRES ☐ 1.4–2.0 LITRES ☐ MORE THAN 2.0 LITRES		£ TICK HERE IF £0 ☐

7. Which of these **vehicles did you use most** over the **last seven (7) days**?
(Please refer to question 6 for the **vehicle number**.)

We'd now like to ask about

your journeys in the last seven days

Please include all the journeys you made however long or short, using any method of transport, not just walking and cycling. **Four points to note** ① A return journey counts as one journey. For example, if you travelled to work and back five (5) times, this counts as five (5) journeys. ② Where a return journey involves a number of purposes, please give the **main** purpose. ③ Include all methods of travel you used as part of a journey (e.g. walking to a bus stop and then catching the bus). ④ If you spent time waiting for public transport please include this within the public transport journey time. Here is an example:



PLEASE COMPLETE THESE QUESTIONS EVEN IF YOU DON'T TRAVEL AROUND VERY MUCH IN GENERAL OR YOU DO NOT DO VERY MUCH WALKING OR CYCLING.

8. Think about your **journeys to and from work**.
(e.g. travel to and from your place of work, accompanying your spouse to and from their work).

a. How often did you make such a journey over the **last seven (7) days**? ☐ TIMES ☐ IF ZERO TIMES, TICK HERE AND GO TO QUESTION 9.

b. How much time in total over the last seven (7) days did you spend travelling **to and from work** by:

	HOURS	MINUTES
Walking		
Cycle		
Bus		
Train		
Car, as a driver		
Car, as a passenger		
Other (please specify): _____		

c. How far did you travel in total over the last seven (7) days **to and from work** by:

	MILES
Walking	
Cycle	
Bus	
Train	
Car, as a driver	
Car, as a passenger	
Other (please specify): _____	

956

9. Think about your **business journeys**, by which we mean any journeys in the course of your work or on employer's business (e.g. travel to and from meetings, making deliveries, etc.)

a. How often did you make such a journey over the **last seven (7) days**? ☐ TIMES ☐ IF ZERO TIMES, TICK HERE AND GO TO QUESTION 10.

b. How much time in total over the last seven (7) days did you spend travelling **on business journeys** by:

	HOURS	MINUTES
Walking		
Cycle		
Bus		
Train		
Car, as a driver		
Car, as a passenger		
Other (please specify): _____		

c. How far did you travel in total over the last seven (7) days **on business journeys** by:

	MILES
Walking	
Cycle	
Bus	
Train	
Car, as a driver	
Car, as a passenger	
Other (please specify): _____	

10. Think about your **journeys to and from a place of study** (e.g. travel to and from your university or college) or **to and from school** (e.g. if you accompany a child to and from school).

a. How often did you make such a journey over the **last seven (7) days**? ☐ TIMES ☐ IF ZERO TIMES, TICK HERE AND GO TO QUESTION 11.

b. How much time in total over the last seven (7) days did you spend travelling **to and from a place of study** or **school** by:

	HOURS	MINUTES
Walking		
Cycle		
Bus		
Train		
Car, as a driver		
Car, as a passenger		
Other (please specify): _____		

c. How far did you travel in total over the last seven (7) days **to and from a place of study** or **school** by:

	MILES
Walking	
Cycle	
Bus	
Train	
Car, as a driver	
Car, as a passenger	
Other (please specify): _____	

957

11. Think about your **journeys for shopping and personal business**
(e.g. food shopping, non-food shopping, window-shopping, visiting a doctor, bank, solicitor or estate agents,visiting a relative in hospital, or accompanying someone else to a doctor, hospital etc.).

a. How often did you make such a journey over the **last seven (7) days**? ☐ TIMES ☐ IF ZERO TIMES, TICK HERE AND GO TO QUESTION 12.

b. How much time in total over the last seven (7) days did you spend travelling for **shopping and personal business** by:

	HOURS	MINUTES
Walking		
Cycle		
Bus		
Train		
Car, as a driver		
Car, as a passenger		
Other (please specify): _____		

c. How far did yo travel in total over the last seven (7) days for **shopping and personal business** by:

	MILES
Walking	
Cycle	
Bus	
Train	
Car, as a driver	
Car, as a passenger	
Other (please specify): _____	

12. Think about your **journeys to visit friends and relatives** and for **other social activities**.
(e.g. a journey to and from the cinema or other entertainment facilities).

a. How often did you make such a journey over the **last seven (7) days**? ☐ TIMES ☐ IF ZERO TIMES, TICK HERE AND GO TO QUESTION 13.

b. How much time in total over the last seven (7) days did you spend travelling to **visit friends or relatives** or for **other social activities** by:

	HOURS	MINUTES
Walking		
Cycle		
Bus		
Train		
Car, as a driver		
Car, as a passenger		
Other (please specify): _____		

c. How far did you travel in total over the last seven (7) days to **visit friends or relatives** or for **other social activities** by:

	MILES
Walking	
Cycle	
Bus	
Train	
Car, as a driver	
Car, as a passenger	
Other (please specify): _____	

958

SECTION C

About your recreation and leisure-time activities

We are interested in your views about

walking and cycling for recreation.

By *walking and cycling for recreation*, we mean any walking and cycling you have done for leisure, health or fitness including, for example, walking or cycling in parks or along trails or walking the dog. ⚠**We do not** mean walking or cycling you may do for the primary purpose of travel to get from place to place.

PLEASE COMPLETE THESE QUESTIONS EVEN IF YOU DON'T DO MUCH WALKING OR CYCLING.

13. Think about **walking for recreation**. How much do you agree with the following statements? **(Tick one box per row.)**

	STRONGLY AGREE	SOMEWHAT AGREE	NEITHER AGREE NOR DISAGREE	SOMEWHAT DISAGREE	STRONGLY DISAGREE
a. Walking for recreation is something I do automatically without really thinking about it.	☐	☐	☐	☐	☐
b. It is beneficial for me to walk for recreation.	☐	☐	☐	☐	☐
c. Walking for recreation is enjoyable.	☐	☐	☐	☐	☐
d. The people in my life whose opinions I value most would approve of me walking for recreation.	☐	☐	☐	☐	☐
e. Most people who are important to me walk for recreation.	☐	☐	☐	☐	☐
f. It is possible for me to walk for recreation.	☐	☐	☐	☐	☐
g. It is mostly up to me whether I walk for recreation.	☐	☐	☐	☐	☐
h. I intend to do more recreational walking over the coming months.	☐	☐	☐	☐	☐
i. I see people in my neighbourhood walking for recreation.	☐	☐	☐	☐	☐
j. Over the last 12 months I have done more walking for recreation.	☐	☐	☐	☐	☐

14. In the **last seven (7) days**, did you do any **walking** for recreation, health or fitness? ☐ YES ☐ NO (IF NO GO TO Q15.)

a. In the **last seven (7) days**, how many times did you **walk** for recreation, health or fitness (including walking your dog)? ☐ TIMES

b. Please estimate the total time you spent **walking** for recreation, health or fitness in the **last seven (7) days** (e.g. 2 times x 20 minutes = 40 minutes). HOURS ☐ MINUTES ☐

15. Think about **cycling for recreation**. How much do you agree with the following statements? **(Tick one box per row.)**

	STRONGLY AGREE	SOMEWHAT AGREE	NEITHER AGREE NOR DISAGREE	SOMEWHAT DISAGREE	STRONGLY DISAGREE
a. Cycling for recreation is something I do automatically without really thinking about it.	☐	☐	☐	☐	☐
b. It is beneficial for me to cycle for recreation.	☐	☐	☐	☐	☐
c. Cycling for recreation is enjoyable.	☐	☐	☐	☐	☐
d. The people in my life whose opinions I value most would approve of me cycling for recreation.	☐	☐	☐	☐	☐
e. Most people who are important to me cycle for recreation.	☐	☐	☐	☐	☐
f. It is possible for me to cycle for recreation.	☐	☐	☐	☐	☐
g. It is mostly up to me whether I cycle for recreation.	☐	☐	☐	☐	☐
h. I intend to do more recreational cycling over the coming months.	☐	☐	☐	☐	☐
i. I see people in my neighbourhood cycling for recreation.	☐	☐	☐	☐	☐
j. Over the last 12 months I have done more cycling for recreation.	☐	☐	☐	☐	☐

16. In the **last seven (7) days**, did you do any **cycling** for recreation, health or fitness? ☐ YES ☐ NO (IF NO GO TO Q17.)

a. In the **last seven (7) days**, how many times did you **cycle** for recreation, health or fitness? ☐ TIMES

b. Please estimate the total time you spent **cycling** for recreation, health or fitness in the **last seven (7) days**. (e.g. 2 times x 20 minutes = 40 minutes). HOURS ☐ MINUTES ☐

The next set of questions is about **other leisure-time physical activities** that you have done in the **last seven (7) days**, besides what you have already mentioned. ⚠ Please do not include any walking or cycling in answering the questions below.

17. In the **last seven (7) days**, did you do any vigorous-intensity, leisure-time physical activities like jogging, aerobics or competitive tennis? **Do not** include walking or cycling or moderate-intensity physical activities. Vigorous-intensity physical activities make you breathe harder or puff and pant. ☐ YES ☐ NO (IF NO GO TO Q18.)

a. In the **last seven (7) days**, how many times did you do vigorous-intensity, leisure-time physical activities which made you breathe harder or puff and pant? ☐ TIMES

b. Please estimate the total time you spent doing vigorous-intensity, leisure-time physical activities in the **last seven (7) days**. HOURS ☐ MINUTES ☐

18. Apart from what you have already mentioned, in the **last seven (7) days**, have you done any other moderate-intensity, leisure-time physical activities like gentle swimming, social tennis, golf or heavy gardening? Moderate intensity physical activities make you breathe somewhat harder than normal. ☐ YES ☐ NO (IF NO GO TO Q19.)

a. In the **last seven (7) days**, how many times did you do moderate-intensity, leisure-time physical activities which made you breathe somewhat harder than normal? ☐ TIMES

b. Please estimate the total time you spent doing moderate-intensity, leisure-time physical activities in the **last seven (7) days**. HOURS ☐ MINUTES ☐

960

SECTION

D

About your local pedestrian and cycling routes

You may be aware that in the past year a new bridge for pedestrians and cyclists has been opened over the River Ely in Cardiff Bay. This is known locally as the Pont-y-Werin Bridge "The People's Bridge".

19. Had you heard of the People's Bridge before completing this survey?
☐ YES
☐ NO

20. Do you use the People's Bridge?
☐ YES
☐ NO (IF NO GO TO Q23.)

21. Think about the People's Bridge ...and **walking**. Do you **walk** across the People's Bridge ...?

	YES	NO
a. On your way to or from work.	☐	☐
b. For business-related journeys.	☐	☐
c. On your way to or from a place of study (e.g. college/university).	☐	☐
d. To get to the shops or for personal business (e.g. visiting a doctor, bank, solicitor or estate agents).	☐	☐
e. On your way to visit friends and relatives or to do other social activities.	☐	☐
f. For recreation, health or fitness.	☐	☐

22. Think about the People's Bridge ...and **cycling**. Do you **cycle** across the People's Bridge ...?

	YES	NO
a. On your way to or from work.	☐	☐
b. For business-related journeys.	☐	☐
c. On your way to or from a place of study (e.g. college/university).	☐	☐
d. To get to the shops or for personal business (e.g. visiting a doctor, bank, solicitor or estate agents).	☐	☐
e. On your way to visit friends and relatives or to do other social activities.	☐	☐
f. For recreation, health or fitness.	☐	☐

961

About your work or place of study

SECTION E

23. Think about the work you do. Which of these best describes your situation at present? **(Tick one only.)**

- Doing paid work full-time ☐
- Doing paid work part-time ☐
- Full-time student ☐

GO TO QUESTION 24A

- Unemployed ☐
- Retired ☐
- Looking after home or family ☐
- Permanently sick or disabled ☐
- Other (please specify) _____ ☐

GO TO SECTION F

24a. What is the postcode of your **main** place of work or study? ☐☐☐☐ ☐☐☐

24b. If you do not know the postcode, please give the address of your place of work or study

25. Please **tick** the option that **best** corresponds with your work or study. **(Tick one only.)**

Sedentary occupation
You spend most of your time sitting
(e.g. in an office, driving a vehicle). ☐

Standing occupation
You spend most of your time standing or walking.
However, your work does not require intense physical effort
(e.g. shop assistant, hairdresser, guard). ☐

Manual work
This involves some physical effort including
handling of heavy objects and use of tools
(e.g. plumber, electrician, carpenter). ☐

Heavy manual work
This implies very vigorous physical activity
including handling of very heavy objects
(e.g. dock worker, miner, bricklayer, construction worker). ☐

962

SECTION **F**

About you and your household

26. Are you male or female? **(Tick one only.)** ☐ MALE ☐ FEMALE

27. How old are you? ☐ YEARS

28. How much do you weigh in light indoor clothes? ☐ STONES ☐ LBS or ☐ KG

29. How tall are you without shoes on? ☐ FEET ☐ INCHES or ☐ CM

30. Do you have any long-term illness, health problem or disability which limits your daily activities or the work you can do? (Include problems which are due to old age.) ☐ YES ☐ NO

31. Would you say that for someone of your age your own health in general is... **(Tick one only.)**

- Excellent ☐
- Good ☐
- Fair ☐
- Poor ☐

32. Which of the following groups do you consider you belong to? **(Tick one only.)**

- White ☐
- Mixed ethnic group ☐
- Asian or Asian British ☐
- Black or Black British ☐
- Other (Please specify): _____ ☐

33. What is your highest educational qualification? **(Tick one only.)**

- Degree, NVQ4, NVQ5 (or equivalent) ☐
- BTEC (Higher), BEC (Higher), TEC (Higher), HNC, HND (or equivalent) ☐
- GCE 'A' Level, NVQ3, Scottish Higher (or equivalent) ☐
- BTEC (National), BEC (National), TEC (National), ONC, OND (or equivalent) ☐
- GCSE Grades A to C, GCE 'O' Level, CSE Grade 1, NVQ2 (or equivalent) ☐
- Other qualifications ☐
- No formal qualifications ☐

34. What is the postcode of your home? ☐☐☐☐ ☐☐☐

35. How long have you lived in your current home? ☐ YEARS ☐ MONTHS

963

36. How many people, other than you, live in your household?
We mean people who have your accommodation as their only or main residence, and who either share at least one meal a day with you or share the living accommodation (living room or sitting room) with you. **(Write in number.)**

Children aged under 5	☐	IF NONE, TICK HERE. ☐
Children aged between 5 and 15	☐	IF NONE, TICK HERE. ☐
Adults aged 16 and over (do not include yourself)	☐	IF NONE, TICK HERE. ☐

37. Does your household own or rent its accommodation? **(Tick one only.)**

- Rents it from the council, a housing association or a charity ☐
- Rents it from a private landlord or letting agency ☐
- Partly owns it and partly rents it (shared ownership) ☐
- Owns it (including buying with a mortgage) ☐
- Other ☐

38. What is your total household income from all sources before tax? **(Tick one only.)**

- Up to £10,000 ☐
- £10,001–£20,000 ☐
- £20,001–£30,000 ☐
- £30,001–£40,000 ☐
- £40,001–£50,000 ☐
- More than £50,000 ☐
- Don't know ☐

39. Are you aware of, or taking part in, any projects in your area relating to walking and cycling? ☐YES ☐NO

If yes, please specify: _____

_____

_____

_____

40. Please enter the date on which you are completing this survey. DAY ☐☐ MONTH ☐☐ YEAR ☐☐

41. Are there any other comments you would like to add?

_____

_____

964

965 ## 8.4.Appendix D: Additional tables

966 *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

Scheme	Pre Cycling	Post Cycling	% Change Cycling	Pre Walking	Post Walking	% Change Walking	Pre Total	Post Total	Total Change	% Total Change	BCR
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

Scheme	Pre Cycling	Post Cycling	% Change Cycling	Pre Walking	Post Walking	% Change Walking	Pre Total	Post Total	Total Change	% Total Change	BCR
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)

	Pre		Post		Change			% increase		
Mode	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

971 *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

972

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).