

CYCLIST INFRASTRUCTURE CHOICE AND DUAL CHOICE NETWORK

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1 Summary

This paper looks at the question: *what kind of road or path infrastructure encourages cyclists to cycle?* The topic of *cyclist infrastructure choice* is relatively sparsely researched. The question is important in that cycle infrastructure is the most expensive element of any local authority programme to encourage cycling, typically making up around 90% of total funding on cycling. It is also widely believed that the quality of cycle infrastructure is a crucial element in the success or failure of measures to increase cycling. This question has been given added urgency by the Covid 19 emergency and climate emergency, as well as the on-going public health crisis and the need to promote cycling to replace car use and its many negative externalities. Additionally, the findings of the paper have a bearing on the interpretation of LTN 1/20 guidance.

Building on a review of the existing evidence base, this paper examines the findings of a survey of cyclists – ‘the Oxfordshire Cycle Survey 2019’ (OCS19), which was undertaken by Oxfordshire County Council in 2019 in preparation for its Local Cycling and Walking Infrastructure Plans (LCWIPs). The findings of the OCS19 confirmed existing research that an unwillingness to share with car traffic (which we term “comfort”) was a major factor in cyclist infrastructure choice but this was balanced by a desire for *directness*.

The OCS19 found that cyclists’ choice between these two factors was a powerful predictor of more detailed cyclist infrastructure choice, such as between cycle lanes and cycle tracks. In fact, the OCS19 suggested that this choice between comfort and directness was more important in determining infrastructure choice than other factors, such as gender, age and frequency of cycling, which are established in the literature and in conventional wisdom.

The second main finding of the survey was that Oxford cyclists differed in many characteristics compared to the rest of Oxfordshire (ROX). The conclusion was that a cycling culture exists in Oxford which does not exist in ROX. The OCS19 found that Oxford cyclists were much more likely to be direct cyclists and make different infrastructure and general travel choices from ROX cyclists. As a result, the area where cyclists lived was also a major predictor in their choice between comfort and directness.

In the discussion, the paper first briefly looks at the criticism of the underlying approach of the research – that the views of existing cyclist choice will not be the same as those needed to encourage non-cyclists to start cycling. It then looks at the concept of a dual choice network and whether that is compatible with inclusive cycling. With respect to the impact of a cycling culture, it posits a model that different infrastructure is appropriate at different town-wide levels of cycling. Cycling attitudes and

infrastructure choices are different in Oxford due to the emergence of a town-wide cycling culture which alters the balance of journey type and therefore the type of infrastructure that most cyclists choose. In brief, at lower levels of cycling it is important to create comfortable routes but at higher levels of cycling it is more important to provide direct routes. It continues with a discussion of how these findings support or challenge the route infrastructure guidance in LTN 1/20. Finally, it identifies the advantages of providing cycle lanes as a way of expanding cycling, meeting cycling targets and embedding cycling at the heart of urban travel.

2 Research Evidence

An internet trawl of both the academic and grey literature was undertaken on the question of *cyclist infrastructure choice*. The criteria for inclusion were reports of any surveys of cyclists or potential cyclists which asked detailed questions on route infrastructure preference in urban travel environments in the UK or other high-income countries. Considering the importance of the topic, there were relatively few surveys found. It should be noted no continental European survey was found. Figure 1 sets out the surveys examined, including the country, town and number of survey responses. The OCS19 data (split between Oxford and the rest of Oxfordshire ROX) has been included in this list for comparison. Whilst the number of surveys were relatively few, they represent the views of over 20,000 cyclists in total. Whilst most of the surveys were opportunistic, some were based on randomised sampling. The surveys are listed in descending order by the frequency of cycling of respondents because that factor has been shown to be important in cyclist infrastructure choice.

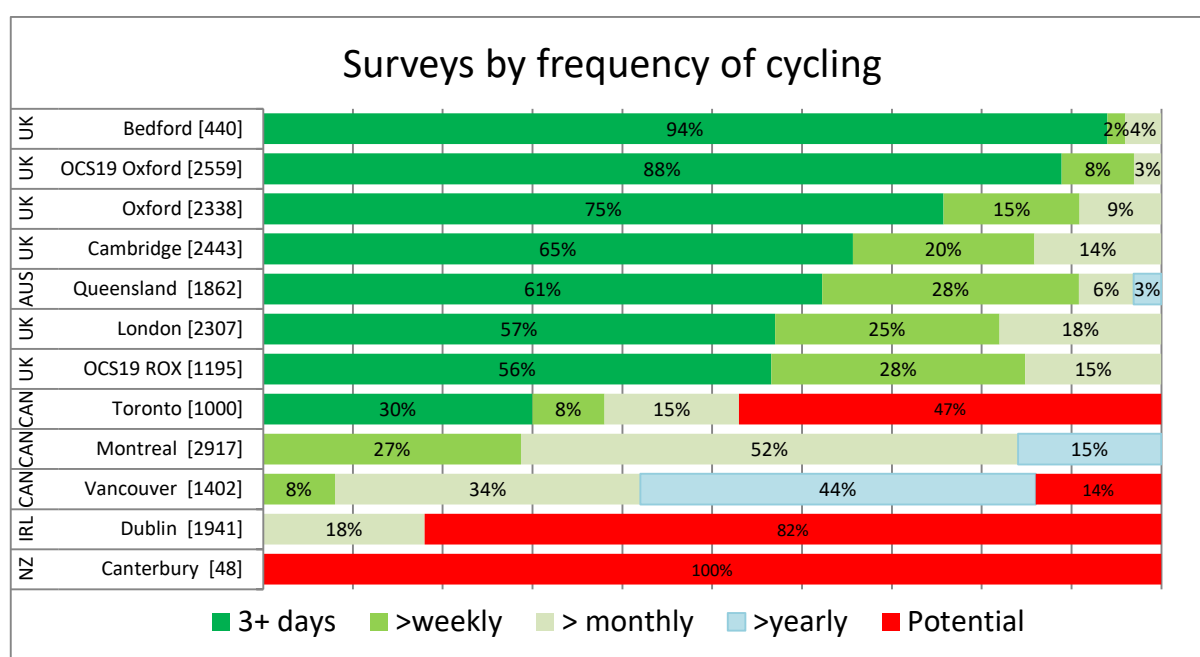


Figure 1 Cycle Surveys analysed, by frequency of cycling (percentages of all respondents (number of respondents in square brackets))

2.1 Evidence – Survey purpose

The Oxfordshire Cycle Survey 2019 (OCS19) was designed to understand the cycle infrastructure priorities of Oxfordshire’s cyclist population. In more detail, the OCS19 was intended primarily to understand

- Cyclists’ main problem locations (*data not used in this paper*)
- Cyclists’ route choice in terms of road types and paths
- Factors (such as gender, age, cyclist experience) that affect cyclists’ route choice

The survey was aimed specifically at cyclists because its focus of interest was to understand cyclists’ choices when making cycle journeys, especially detailed choices about different kinds of infrastructure based on experience. This heuristic knowledge would only be available to someone who cycles.

2.2 Survey methods and response numbers

The OCS19 was an internet-based survey undertaken to support the production of Oxfordshire’s Local Cycling and Walking Infrastructure Plans (LCWIPs). The consultation webpage invited all cyclists living in Oxfordshire to take part, but particularly those living in the three proposed LCWIP towns of Oxford, Didcot and Bicester. The survey was hosted on Oxfordshire County Council’s consultation website from 6th June 2019 to 8th August 2019. Over the 2 months, 3754 surveys were submitted, comprising

- 2559 (68% of total) responses from Oxford City and
- 1195 (32% of total) responses from the Rest of Oxfordshire (ROX).

No surveys were unfinished or rejected. Data below analyses Oxford and ROX separately. The gender ratio of responses was 51% male and 46% female for Oxford, whereas for ROX it was 62% male and 36% female.

2.3 OCS19 representativeness

Figure 2 gives an estimate of percentage response rate as a percentage of 1) the adult population (Oxfordshire CC data) and 2) adult cyclists (Active Lives Survey data). For Oxford around 2% of all adults and 5% of all adult cyclists responded, with lower percentages in the rest of Oxfordshire (0.3% of adults and 1.3% of adult cyclists).

OCS 2019	OCS 2019 responses	% of all responses	All Adults	% response rate	ALS Cyclists	% response rate
Oxford City	2,559	68.2%	131,000	2.0%	53,000	4.8%
ROX	1,195	31.8%	440,000	0.3%	94,000	1.3%

Figure 2: Percentage of population and cyclists responding to OCS19

Figure 3 shows the percentage response rate for Oxford by the age group of survey respondents compared to the population in Oxford. This suggests that age groups 35-44 and 45-54 were most represented and 19<24 and 65+ groups were least represented. However, it is quite likely that this skew in responses more closely represents the age profile of Oxford cyclists rather than all Oxford adults. Note that

the survey was conducted out of term-time, so it is unlikely many responses were from students.

OXFORD only				
Age groups	OCS19 Count	Percentage of responses	2019 Oxford	% response rate
<18	10	0.4%		
19<24	214	8.4%	25,274	0.8%
25<34	749	29.3%	32,316	2.3%
35<44	647	25.3%	18,990	3.4%
45<54	506	19.8%	15,654	3.2%
55<64	268	10.5%	13,489	2.0%
65+	138	5.4%	18,913	0.7%

Figure 3 Comparison of age profile of OCS19 Oxford responses with age profile of Oxford population

As the OCS19 was opportunistic, we cannot know whether it was representative. However, we can compare the OCS 19 to the Active Lives Survey (ALS) which is based on a representative survey. In figure 4, the number of Oxford cyclists according to the ALS is set out and the percentage of OCS19 respondents for that frequency is calculated. By this analysis, frequent (x5 weekly+) cyclists responded to the OCS19 survey (7.5%) more than less frequent cyclists (1.6% for x1 weekly). This indicates a bias towards more frequent cyclists in the OCS19. This is to be expected as more frequent cyclists are more likely to be interested in a cycle survey.

Oxford only	x5 wk	x3 wk	x1 wk	x1 month	All cyclists
ALS cyclists	23,267	11,148	13,777	4,757	52,949
OCS 2019	1736	520	215	88	2559
% response rate	7.5%	4.7%	1.6%	1.9%	4.8%

Figure 4 Comparison of frequency of cycling for Oxford respondents – Active Lives Survey and OCS19

Obviously, an on-line survey is reliant on self-selected choice and self-selection introduces potential bias. However, the general internet survey had several advantages. Every effort (press releases, emails, twitter feeds, signs at stations etc) was made to publicise the survey as widely as possible, so that cyclists would know about it and have the choice to do the survey. Secondly by making it generally open to all, the overall response rate was sufficiently large that the survey results could be analysed by personal characteristics that are known by other research to alter cyclists' choice, such as age, cyclist experience and gender. Thirdly the data was designed to be consistent with other cyclist infrastructure surveys in the evidence base, so that

the results could inform and be informed by the evidence base. The overall findings were in fact in general accordance with the wider evidence base.

3 OCS 19 Survey findings

3.1 Choice between cycling with traffic and away from traffic

OCS19 asked a series of questions to investigate cyclists' choice in cycle infrastructure. One attitudinal question emerged as very important. Cyclists were forced to answer the following obligatory question: "Generally, when cycling, I choose:

- A direct route sharing with traffic
- A longer or slower route avoiding a main road"

For succinctness, we refer to the former as a 'direct' route and the latter as a 'quiet' route. This question was designed to force the cyclist to prioritise between sharing or not sharing with traffic (i.e. making a choice that would inform the *on-off road debate*). Responses to this question in OCS19 revealed a strong division between Oxford and ROX respondents (*figure 5*). Whereas in Oxford, 58% of respondents chose a direct route, outside Oxford only 26% chose a direct route. Conversely, for ROX, a substantial majority (76%) opted for quiet routes, whereas in Oxford a minority (42%) opted for quiet routes.

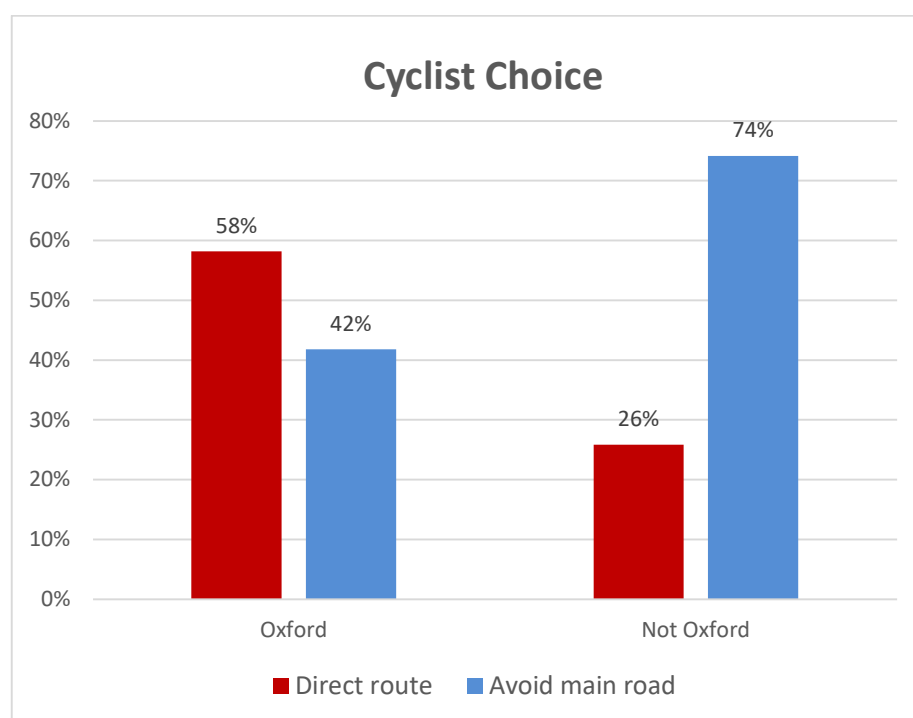


Figure 5 OCS19: percentage of cyclists choosing flow over comfort

3.2 Oxford and Rest of Oxford (ROX)

The difference between Oxford and ROX for the on-off road question was found in the OCS19 for many other factors and pointed to the evidence of a much more embedded cycle culture in Oxford. Some of the key differences are set out below:

- *Reasons for cycling*: whereas 'health/fitness', 'the environment' and 'enjoy cycling' were important for cyclists in both areas, Oxford cyclists put much

greater emphasis on 'quickest time' (51% Oxford vs 14% ROX) along with 'convenience' and 'reliable time'.

- *Car access*: cyclists in Oxford had lower levels of car access and ownership (e.g. 35% sole use compared to 61% in ROX). Additionally, at each level of car ownership, Oxford cyclists cycled more and used their car less than ROX cyclists. For instance, for respondents with sole access to a car, Oxford cyclists used their car for 30% of journeys but ROX cyclists used their car for around 60% of their journeys.
- *Main mode of travel*: cycling was chosen as the main mode by 58% of respondents in Oxford compared to 37% in NOX, whereas car driver was the main mode in Oxford for only 5% of respondents compared to 42% in NOX.
- *Journey purpose*: Oxford respondents cycled for many more purposes compared to ROX respondents (e.g. 84% vs 56% for work, 65% vs 35% for shopping or 59% vs 25% visiting friends). The only exception was recreation (55% Oxford vs 78% ROX)
- *Willingness to cycle*: A higher percentage of respondents in Oxford cycled "all year round" and "when it was raining" and "dark" in Oxford.

All these differences indicated that Oxford has a different cycling culture to areas outside Oxford. In brief, it could be said that Oxford cyclists were much more likely to build their lives around the cycle where outside Oxford, most cyclists were still dependent on the car. For this reason, data for Oxford has been analysed separately from data for ROX in some of the following analysis.

3.3 Gender

In the cycling literature about the on-off road debate, there is a common acceptance that there exist male-female differences. Christmas (DfT 2010) found a strong gender effect on choice of "approach" among focus groups. Most assertive and opportunist cyclists were male and most habitual avoiders were female. Walker (2005) found little difference between male and female cyclist actual *use* of 3 categories of roads in Oxford and Cambridge, but greater confidence or skill among male cyclists rather than female cyclists in certain road manoeuvres. NHF 2013 asked 300 female cyclists where they mainly rode but there was no comparative survey of male cyclists. Heesch et al. (2012) found that male and female cyclists had very similar preferences, though slightly more male cyclists (12%) than female (6%) preferred on road without facilities. Seventy five percent (75%) of both male and female cyclists preferred cycle lanes. Brick E (no date) found females disliked main roads with no facility more than male cyclists and preferred quiet residential streets and off-road cycle tracks more than male cyclists. Aldred R (2017) in a literature review found 23 studies that showed women's preferences for separated infrastructure were stronger and 17 studies that showed no statistical difference.

OCS19 sought to understand the differences in infrastructure choice between male and female cyclists. In line with expectations, the OCS19 found that female cyclists were substantially less likely than male cyclists to choose direct routes i.e. on-road routes. However, as figure 6 shows the *gender* differences were outweighed by the effect of *location* between Oxford and ROX. In numerical terms, there was a difference

of 8% between male and female cyclists within each location, but a 33% difference between Oxford and ROX locations.

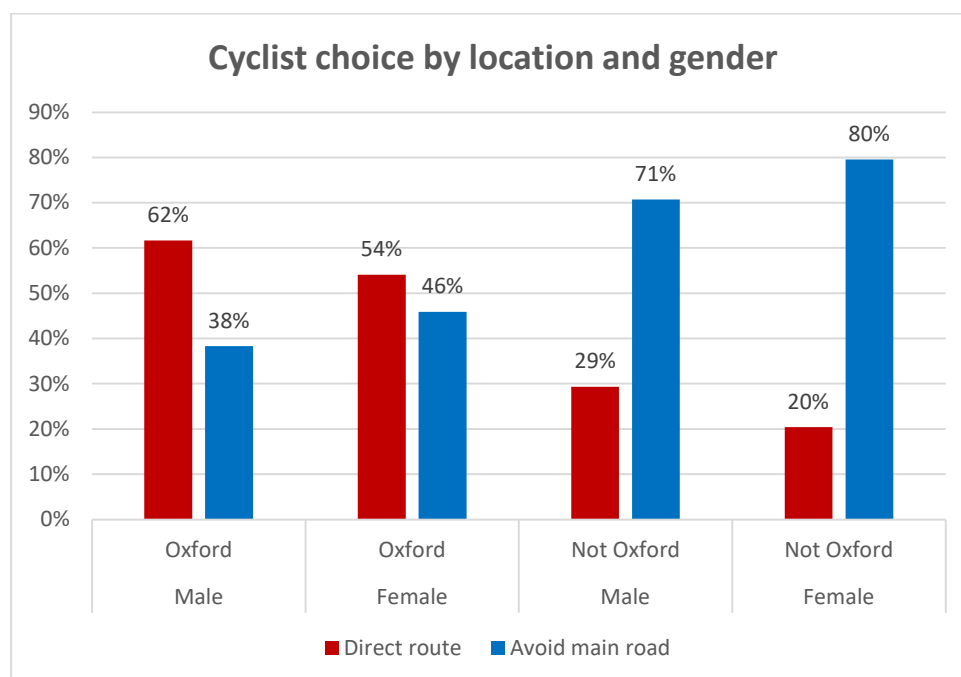


Figure 6 OCS19: percentage choosing direct or quiet routes by gender and location.

4 Other factors by location

The OCS19 sought to understand the impact of other factors which might influence cyclist infrastructure choice, based on the evidence review. Figures 9 shows the differences that were found between cyclists in Oxford and ROX in terms of the six factors. It was found that Oxford and ROX cyclists differed in many aspects according to the percentage opting for direct routes.

Characteristic	OXFORD			Category			ROX		
	% choose Direct route			←————→			% choose Direct route		
Cycle frequency	62	52	31	Daily	Weekly	Monthly	43	22	13
Age	68	56	43	19-34	35-54	55+	38	27	15
Gender	62		54	Male		Female	29		20
Journey purpose	60		54	Work		Recreation	34		24
Car access	60	59	57	No car	Shared	Solo	37	28	23
Years cycling	59	57	55	All life	Adult life	<5 years	25	26	31

Figure 7 Percentage of cyclists living in Oxford or ROX choosing a direct route by various characteristics

Note to understand this chart, the figures equal the percentage for each area (Oxford or ROX) choosing a direct route who have the characteristic which are set out (colour coded) in the 3 middle rows.

Figure 8 illustrates the same data from figure 7. Oxford cyclists for every characteristic and every category choose direct routes by around 30% more than ROX cyclists. For instance, 68% of 19-34 year olds chose direct routes in Oxford, compared to 38% of 19-34 year olds in ROX.

Secondly, it is possible to assess the differences for each characteristic separately for either Oxford or ROX. The most substantial differences are frequency of cycling (daily, weekly, monthly – dashed lines) and age (19-34,35-54,55+ - dotted lines). There are also marked differences in terms of gender (male, female) and journey purpose (work, recreation) for both Oxford and ROX. Car access (no car, shared, solo) has a bigger impact in ROX compared to the marginal impact in Oxford. There is also a trend for years cycling but in opposite directions between Oxford and ROX so that experienced cyclists are more likely to choose direct infrastructure in Oxford but more recent cyclists do so in ROX. This is an interesting difference, but note that the differences in both cases between new and experienced cyclists is relatively small (around 5%).

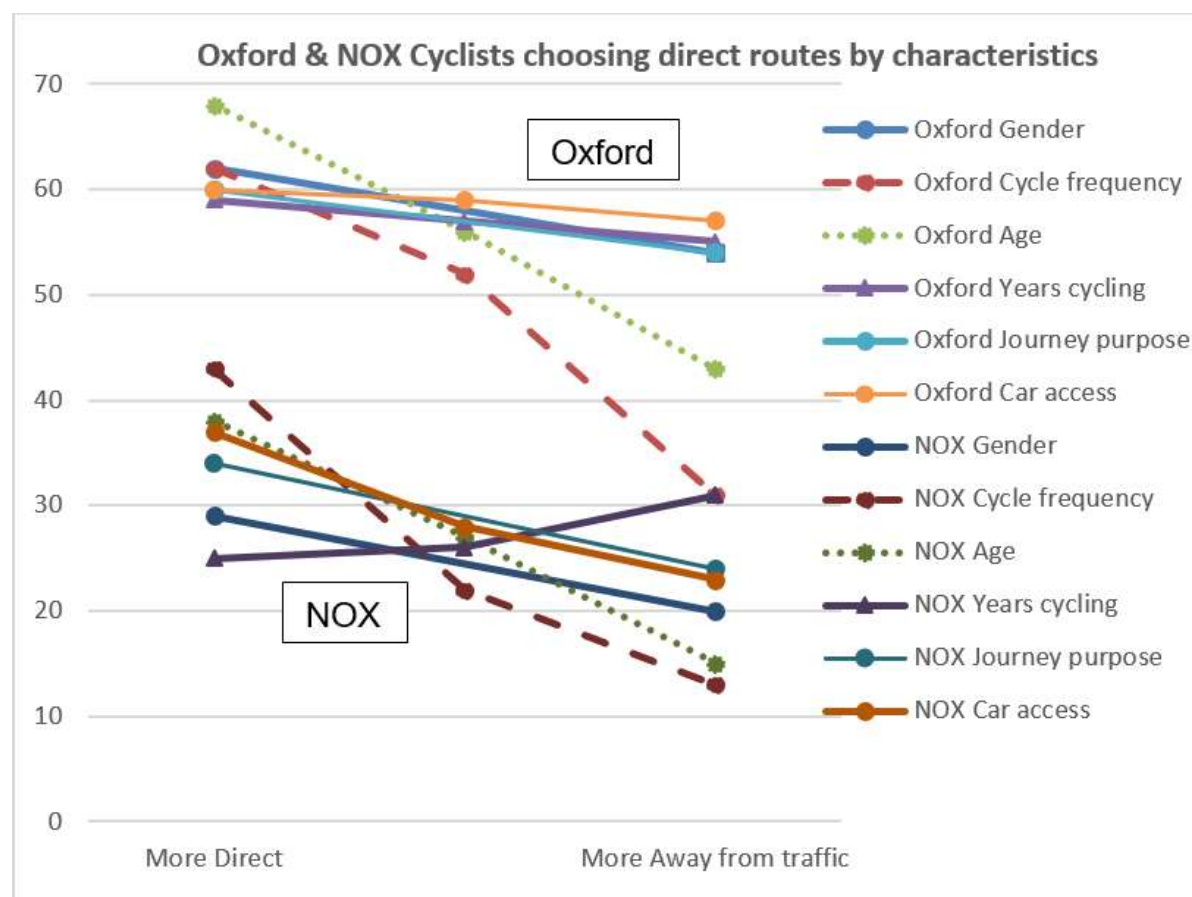


Figure 8 Percentage of cyclists living in Oxford or ROX choosing a direct route by various characteristics

5 Differences in choice of infrastructure

The previous section shows how different characteristics impact on the percentage of cyclists choosing either direct (on road) or segregated infrastructure. In this section we examine in more detail the surveys in the evidence base and OCS19 to understand cyclist respondents' views of different infrastructure types e.g. cycle lanes, cycle tracks etc. This is important because we need to understand what type of infrastructure cyclists find attractive to know whether and what infrastructure we have to change to encourage more cycling.

One of the challenges of reviewing existing surveys was that there was little consistency in survey approach. This applied in several ways:

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- the manner of data collection,
- the range of infrastructure options asked about
- the way that choice of cyclists was measured and
- the way the surveys were then analysed and presented

Figure 9 collates and summarises the evidence available from these surveys. In some cases, the data has had to be converted from a different base. It shows the percentage of cyclist respondents who were either *positive or neutral* (combined percentages) rather than *negative* about each type of infrastructure set out along the x-axis. Where there was a choice of different attitudes, the evidence for regular cyclists has been used. Figure 9 shows that there is considerable agreement between surveys from across the 10 surveys. Note that crosses in red (Canterbury, Toronto, Vancouver, Dublin) contain large numbers of potential cyclists so are likely to represent the views of new cyclists. It is also noticeable that potential cyclists' choices also reflect the views of regular cyclists.

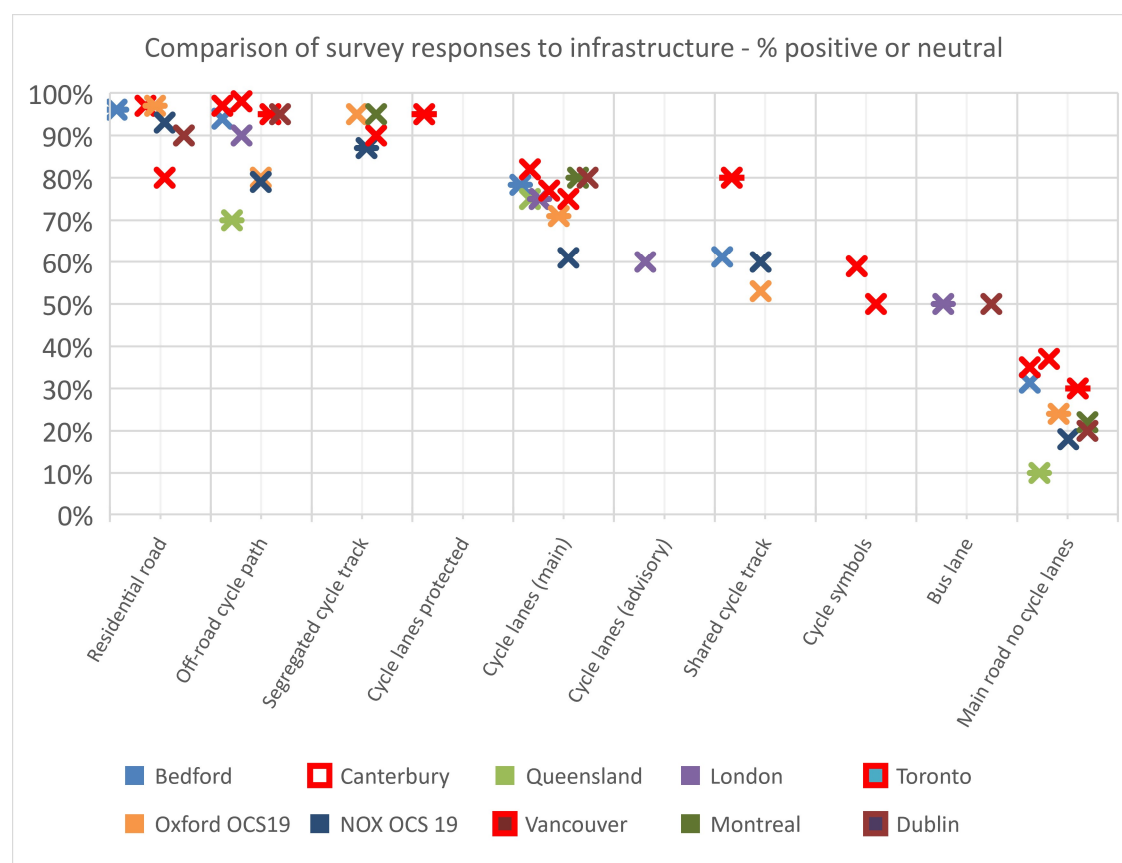


Figure 9 Percentage of cyclists in each survey were positive or neutral about the infrastructure.

(Key: off-road means away from the road; cycle track means alongside the road. Segregated means "segregated from pedestrians" and shared means "sharing with pedestrians")

5.1 Analysis of research evidence

In figure 10, the infrastructure types on the X axis in figure 9 have been ordered in the order of favour by the average percentage of each survey. The percentages indicate the total percentages of cyclists who were positive or neutral about that type of infrastructure and provide a rough heuristic to the percentage of cyclists who are

willing to cycle on the type of cycle infrastructure (the percentage includes the views potential cyclists in some surveys). From this it is possible to posit a kind of order of attractiveness of cycling infrastructure.

Infrastructure	Overall	Evidence
Residential road	92%	***
Segregated cycle track	92%	***
Off-road cycle path	89%	***
Cycle lanes protected	95%	*
Cycle lanes (main road)	75%	***
Cycle lanes (advisory)	60%	*
Shared cycle track	64%	**
Cycle symbols	55%	*
Bus lane	50%	*
Main road no cycle lanes	25%	***

Figure 10; Evidence from 10 surveys of the percentage of cyclists willing to use that type of infrastructure in order of preference (cycle lane data has been kept together). Evidence: 1 star: 1-2 surveys; 2 star: 3-4 surveys; 3 star: 5+ surveys.

What does figure 10 show? There is substantial evidence that most cyclists are happy to cycle on residential roads (92%) and off-road cycle paths (89%) (though with some uncertainty in some surveys whether the paths are segregated or shared with pedestrians). For routes along main roads, the potential options relying on 5+ surveys are first a segregated cycle track (92%), i.e. not shared with pedestrians. That is followed by cycle lanes (75%) and then “shared cycle tracks” (64%), i.e. shared with pedestrians. There is evidence from one survey that cycle lanes might be less attractive if they are just advisory (60%) and more attractive if protected (95%). There is also evidence from 2 surveys each that two other alternative treatments - cycle symbols (55%) or bus lanes (50%) are only moderately attractive. The one option that is definitely not liked, and with only a minority of cyclists positive or neutral (25%), is “main roads with no cycle infrastructure”.

5.2 OCS Underlying factor of direct vs comfort choice

OCS19 sought to see if findings of the evidence base on cycle infrastructure choice also applied to Oxfordshire cyclists. For each cycle infrastructure option, respondents were asked to say whether [*shortened forms used in this paper in brackets*]

- I like using it [‘like’]
- I don’t mind using it [‘don’t mind’]
- I use it if I have to [‘tolerate’]
- I avoid it [‘avoid’]

The responses were analysed by the factors, such as age, gender etc, as set out in figure 7. Differences were found in many of the groups. The analysis found however that the general question about choice between direct routes and routes away from traffic was the most powerful predictor of the cyclists’ choice of detailed infrastructure types, with a larger impact than any other characteristic such as age, cycle frequency and location (Oxford or ROX). Figure 11 illustrates how the factor of choice of direct

and quiet are typically at or near the extremes of other factors. In other words, the choice between direct (on-road) vs quiet (segregation) best captured most of the differences in cyclist choice of different infrastructure.

Note particularly the very wide difference in terms of willingness to use main roads without facilities in figure 11. For many groups, “main roads without facilities” represent the biggest differences between cyclists’ willingness to cycle and should be the focus of improving cycle routes.

Some have argued that the cyclist choice question was an artificial construct. However, similar differences would be found if another factor was used such as age or frequency of cycling. What is certain is that cyclists differed in their detailed infrastructure choice by identifiable variables.

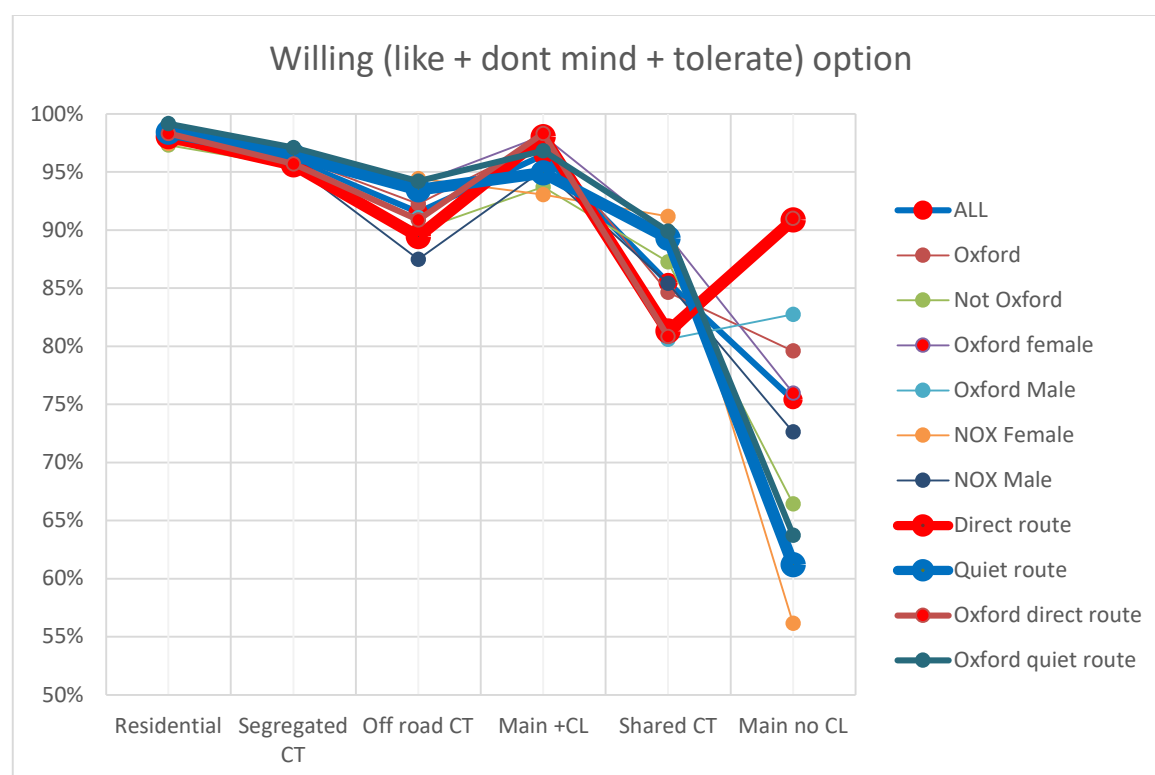


Figure 11 OCS19 Detailed route choice by different factors (combined responses like, don't mind, tolerate)

5.3 Understanding differences in cyclist infrastructure choice

There is a big difference between the choice of Oxford and ROX cyclists in their choice of infrastructure, but what underpins that difference is the different percentages of cyclists choosing a direct route and a route away from traffic. Or put another way, cyclists in Oxford and ROX who chose a direct route in that question chose similar detailed infrastructure types, but there were many more cyclists in Oxford who chose a direct route.

Figures 12 shows for direct cyclists and figure 13 for cyclists choosing routes away from traffic (which we term “quiet cyclists” for convenience) how each group evaluated each infrastructure choice (on the X-axis). Each bar shows the percentage of all respondents who said they “like it”, “don't mind it”, “tolerate it” and “avoid it”.

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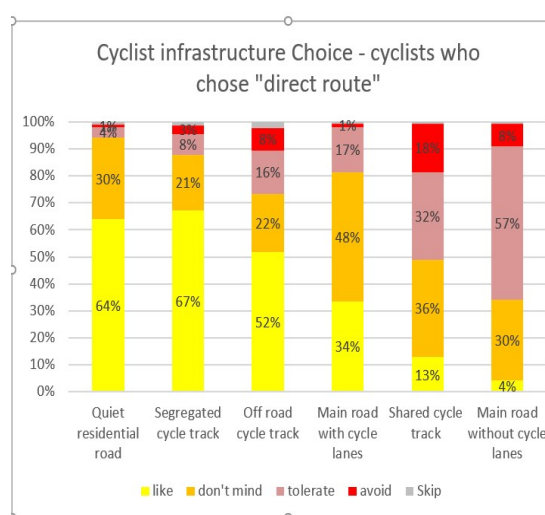


Figure 12 Percentage of cyclists choosing direct routes (Quick cyclists) assessments of different infrastructure types

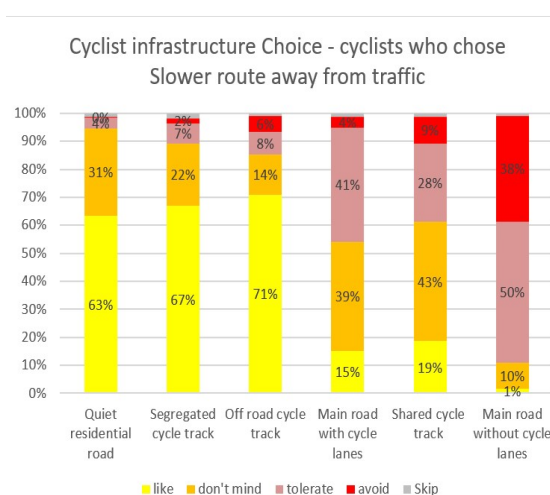


Figure 13 Percentage of cyclists choosing routes away from traffic (Quiet cyclists) assessments of different infrastructure types

Comparing figures 12 and 13, both groups are similarly positive about quiet residential roads and segregated cycle tracks. Differences appear for the other infrastructure types: 'off-road cycle path', 'main roads with cycle lanes', 'shared cycle tracks' and 'main roads without cycle lanes'. For instance, for main roads without cycle lanes, only 8% of *direct* cyclists avoided them compared to 38% of *quiet* cyclists avoiding them.

5.4 Creating a method of evaluating route infrastructure - OxCRAM

A method was needed to capture these differences in a more succinct way. It would be useful if one numerical value could be assigned to different types of cycle infrastructure, depending on whether they are liked or disliked by direct or quiet cyclists. A numerical value was therefore assigned to the 6 different types of cycle infrastructure, depending on whether they were attractive or not to direct or quiet cyclists. This was done by weighting the cyclists' responses, namely +3 to "like", +1 to "don't mind", minus 1 to "tolerate" and minus 3 to "avoid" separately for "quick" and "quiet" cyclists. This was then converted by a simple numerical multiplication to a score from +5 to minus 5, and then for more convenience, the scale was then changed to 0 to 10 by adding 5 to each number.

The results are set out in figure 14. This scoring system has been named the Oxfordshire Cycle Route Assessment Matrix (OxCRAM). The advantage of OxCRAM for Oxfordshire County Council is that it is directly based on Oxfordshire cyclists' actual preferences. It was used to assess and develop the "dual choice network" of Quickways and Quietways in Oxford (for further information see Oxford LCWIP 25.1.2)

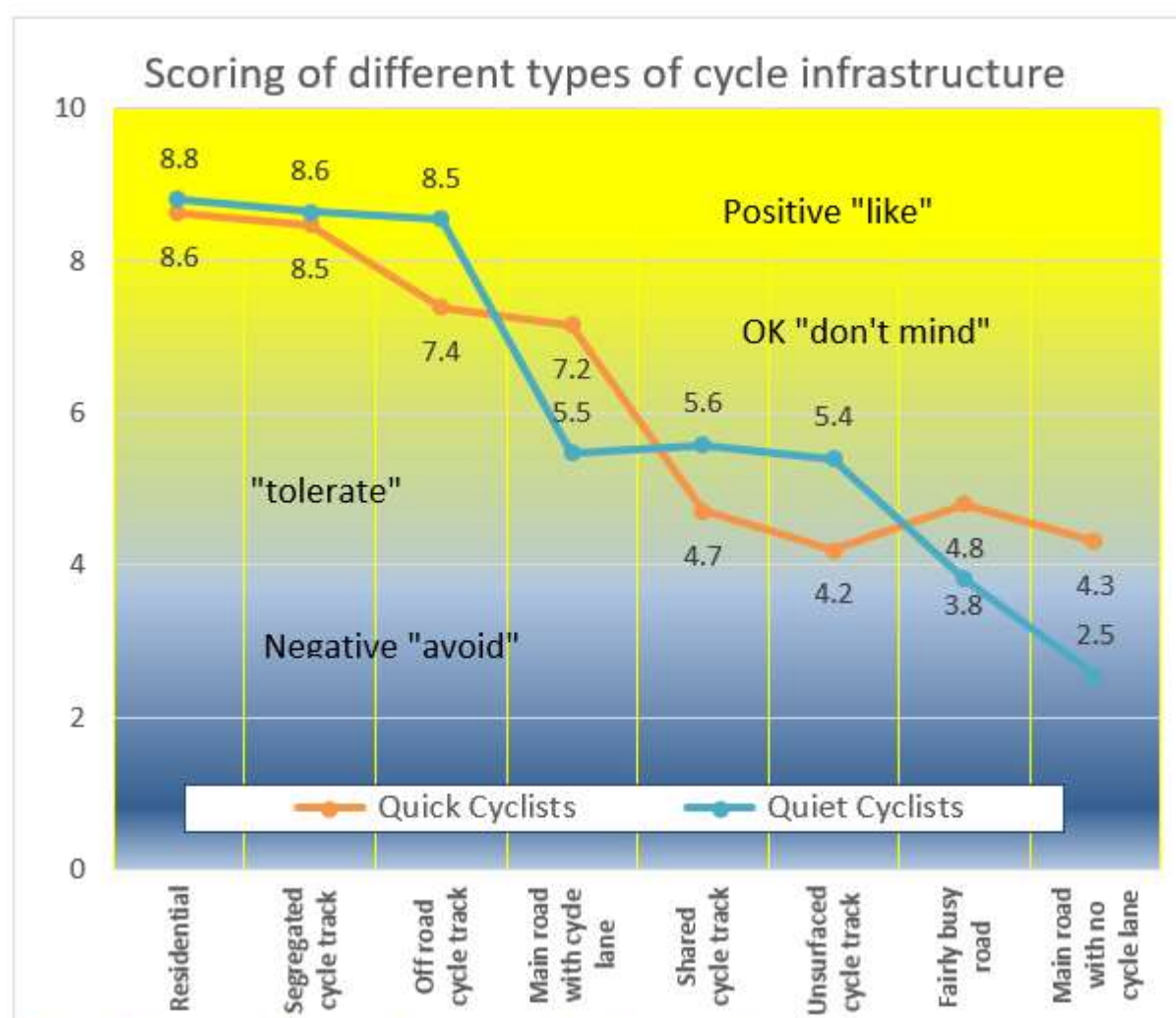


Figure 14 Chart showing OxCRAM rating of different infrastructure for direct (quick) cyclists and quiet cyclists

Note that Bedford data which used the same methodology have been used to add 2 infrastructure types – fairly busy and unsurfaced. Unfortunately, we have no data on bus lanes.

5.5 Evaluating Oxford's cycle network

On the basis of OCS19 and the wider evidence base which shows that cyclists differ in infrastructure choice, Oxford's cycle network in the LCWIP has been developed as a 'dual choice network' catering for both groups. Routes along main roads have been assigned as "Quickways" particularly aimed at direct cyclists and routes along residential roads and cycle paths have been assigned as "Quietways" particularly aimed at quiet cyclists.

The OxCRAM evaluation has been used to evaluate each cycle route (both Quickways and Quietways) from the point of view of *both* quick and quiet cyclists. For clarity, that means we assessed whether the Quietways will be attractive to quick and quiet cyclists and whether the Quickways will be attractive to quiet and quick cyclists. The score is based on calculating the different segments of each route within Oxford's ring road.

Figure 14 shows the evaluation of Oxford’s cycle network from the point of view of quick cyclists and figure 15 from the point of view of quiet cyclists. The cycle routes on the x-axis are numbered with QK denoting a Quickway and coloured red and QT a Quietway and coloured blue.

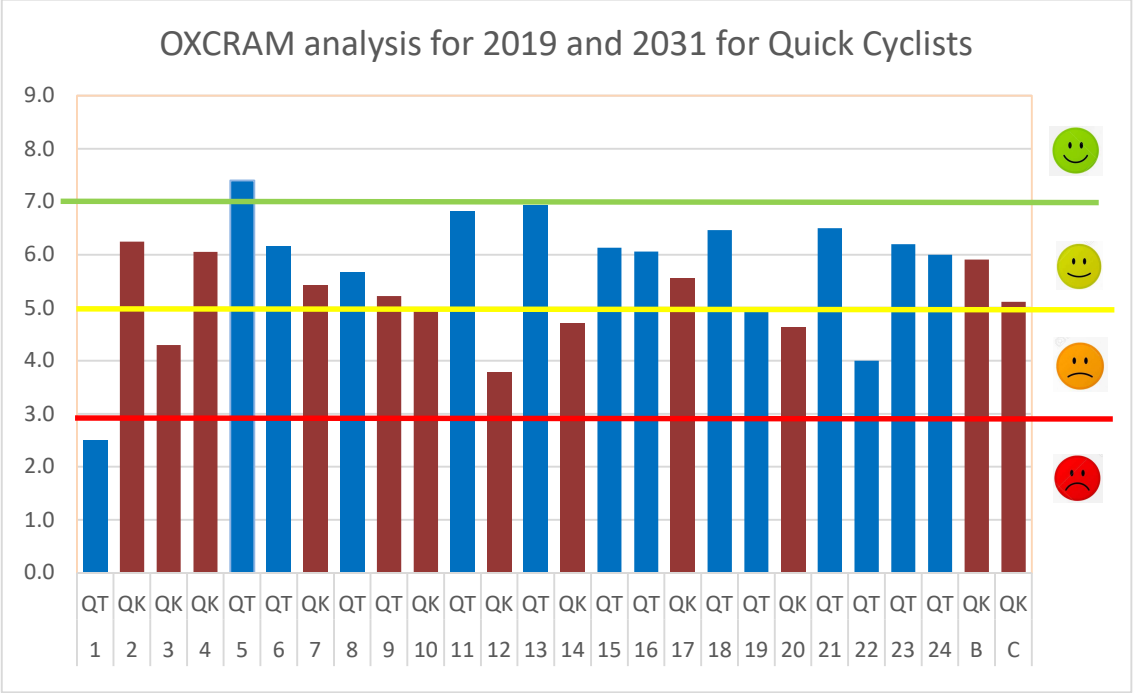


Figure 15 Evaluation of Oxford cycle network routes using OxCRAM from the point of view of quick cyclists

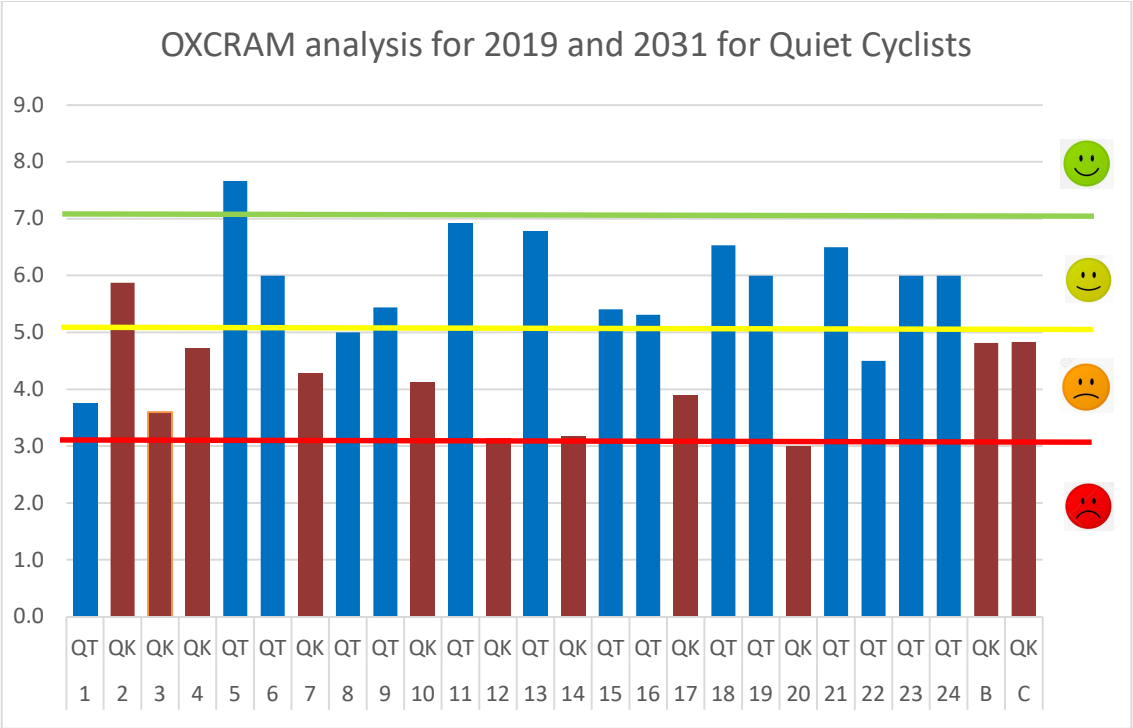


Figure 16 Evaluation of Oxford cycle network routes using OxCRAM from the point of view of quiet cyclists

Note that the same OxCRAM scoring system applies to both quick and quiet cyclists but from their own perspective. In terms of the evaluation, 5.0 is considered the minimum acceptable and 7.0 the point of “ambition”. For quick cyclists, there are 6 routes that currently fall below the minimum standard – 4 quick routes and 2 quiet routes. For quiet cyclists, there are 10 routes below the minimum standard – 8 quick routes and 2 quiet routes. Only one route (route 5) meets the ambition standard for both groups.

Discussion

6 Limitations of research

In academic terms there are many weaknesses in the research. The use of a web survey means that it was not possible to test its representativeness nor undertake more complex statistical analysis. Comparison with ALS data suggests that the results are more representative of frequent cyclists so the results might bias towards these types of cyclists. It should be noted, however, that frequent cyclists (over 3 times a week) make the large majority of cycle journeys, around 80% in total, and in terms of cycle journeys rather than cyclists, their views are in fact under-represented in the responses.

The OCS19 was also based on stated preference rather than revealed preference for infrastructure choice, so it may not reflect the actual journeys that cyclists choose to take. Kazemzadeh, K. et al. (2020) however found agreement between on-line cyclists' responses and in-situ responses to questions about cyclist comfort and concluded that internet surveys were a valid method of understanding cyclists' perceptions. Although Walker (2005) showed that most (around 80%) Oxford and Cambridge cyclists use main roads, this may not mean that they like using them. In fact, the Vancouver survey showed that there is a big discrepancy in what cyclists like and what route types they actually use.

Another criticism is that it is based on choosing between verbal descriptions (e.g. main road) and that may mean something different to a cyclist in Oxford than in ROX. Whilst most of the cyclists' responses in ROX were in urban areas, for some cyclists in rural areas, a main road might mean a 60mph limit rather than 30 mph limit. The Vancouver and Dublin surveys overcome this by illustrating each infrastructure type. Another weakness is that the OCS19 only asked about routes rather than junctions which may also influence cyclist route choice. Cyclists' perceptions of junctions will form a future study to inform junction designs.

6.1 Potential cyclists' choice

Another criticism of the study is that it concentrates on existing cyclists and that the policy focus is on creating new cyclists. Examining non-cyclists' choice of infrastructure was outside the research focus of the OCS19, but the wider evidence base provides some evidence of the preferences of potential future cyclists. Several surveys asked the opinions of non-cyclists or potential cyclists (Toronto, Montreal, Vancouver, Dublin and Canterbury – see figure 1). The attitudes from these surveys to different infrastructure are plotted on figure 9 as red crosses. What is apparent is that potential cyclists differ little from regular cyclists in their order of preference for different infrastructure types.

The most detailed data on the difference between existing and potential cyclists is found in the Vancouver survey where data for regular, occasional and potential cyclists are plotted for many different infrastructure types. What the Vancouver survey showed was that potential cyclists consistently found *all* cycle infrastructure types less attractive (including off-road options) but in the same order of preference as occasional and regular cyclists. The report suggests “the opinions of [regular cyclists] may reflect the future opinions of others as they cycle more often” (Vancouver 2006). However, only off-road paths were considered positive by most potential cyclists in that survey.

The other survey of interest (Canterbury 2011) shown in figure 17 reported detailed data from a small focus group of potential cyclists where the topic of infrastructure choice was examined in detail. This reported a much higher willingness among potential cyclists to use different infrastructure types, but the same general pattern of preference emerges as for Quiet cyclists in the OCS19 data, with sharing carriageway least attractive, segregated cycle track most attractive, with cycle lanes and shared paths roughly equal.

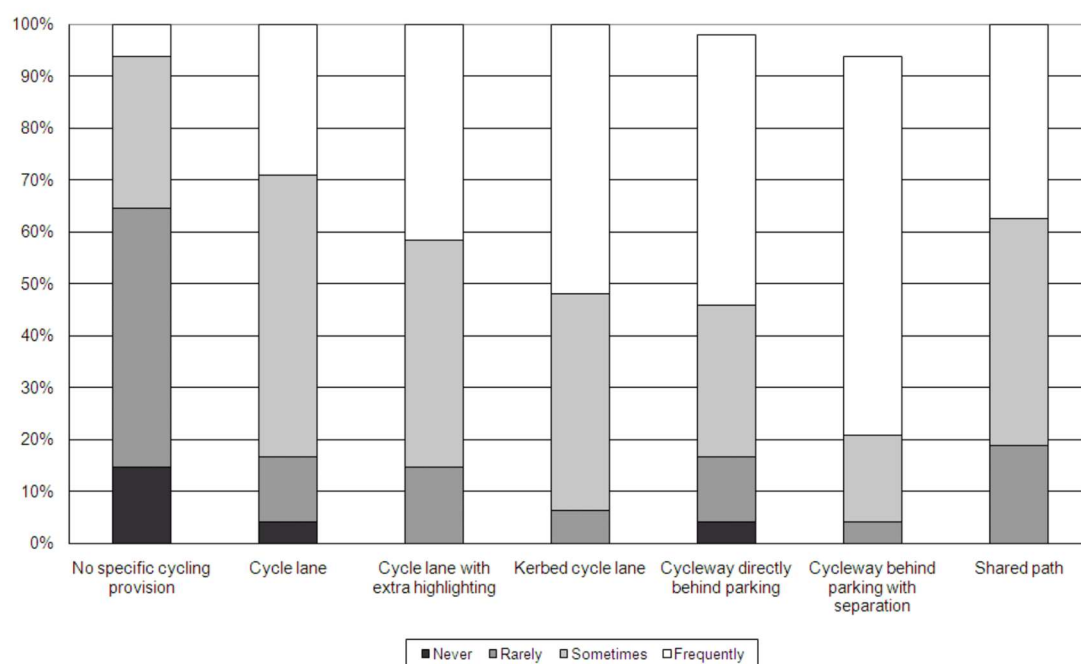


Figure 17 NZTA (2011) “Assessment of the type of cycling infrastructure required to attract new cyclists”

Whilst it is interesting to understand potential cyclists’ stated preferences for cycle infrastructure, it is an open and much bigger research question whether cycle infrastructure alone is necessary or sufficient to encourage potential cyclists to start cycling. Generally, the evidence suggests that cycle infrastructure alone (without “sticks” such as traffic restrictions and parking charges) has only marginal impact on encouraging new cyclists.

Another important factor is *churn* which is considerable (TfL 2011). An increase in cycling is made up of the balance of cyclists starting or increasing cycle trips being greater than those stopping or reducing their cycle trips. Another question is whether most new cycle trips are the result of new people starting cycling for the first time or

existing cyclists cycling more. The research suggests that a lot of the increase in cycling in London was the result of existing cyclists cycling more rather than new cyclists, pointing to the importance of understanding existing cyclists' views and focusing on people who already do a little cycling. This would fit in with more general models of behaviour change in terms of the various stages of readiness to change behaviour.

6.2 Concept of dual choice network

The concept of the dual choice network has been criticised as conflicting with the concept of inclusive cycling. Evidence from The Netherlands (Delft) concluded that a cycle network is much more effective in promoting cycling than individual routes. The need for a comprehensive cycle network has been generally accepted in all subsequent town policies to promote cycling. The dual choice network approach is practical in that it focuses on creating a town-wide cycle network in as short a time as possible based on the following realities

- Sharing a main road without any cyclist facilities is the least attractive option for all cyclists (and potential cyclists) and therefore the biggest impact would be to provide some (any) kind of quality cycle facility
- Main roads are will always make up the main element of a cycle network as they are generally the quickest and most direct routes into the town centre, which is typically the main focus of existing and future urban cycle journeys
- Main urban roads are always likely to have high levels of motor traffic. Few authorities will be willing or able to introduce modal filters to reduce traffic to levels where cyclists will feel comfortable sharing with motor traffic
- Considering road widths, the needs of freight and buses along main roads, available funding, street trees and other such factors, very few main urban roads in Oxfordshire towns have adequate width to provide continuous off-road segregated cycle tracks of sufficient priority and width to attract Quick cyclists.
- Given that most existing and future urban cycle journeys will be made by Quick cyclists, catering for their needs in the assessment of main roads is essential in order to achieve an increase in cycling.

However, the dual choice network also emphasises that the network needs to be comprehensive for both Quick and Quiet cyclists. For instance, the Oxford LCWIP network has been designed that every resident will have an easy choice of a quick (Quickway) or quiet (Quietway) route from every neighbourhood into the city centre.

For Quietways, the perceptions of Quiet cyclists are the priority. The emphasis is therefore on removing traffic, thereby creating connected direct routes with little or no traffic. This is often (an even greater challenge, as it depends on finding cycle paths and quiet residential roads, that are not used as rat runs, that connect together to provide a complete network of routes. Traffic filters, Low Traffic Neighbourhoods, and Cycle Streets are all essential in creating the Quiet network.

6.3 What does the dual choice network mean in practice?

Generally, dual choice network means that main roads are for the most part supplied with cycle lanes rather than (non-LTN 1/20 compliant) shared (with pedestrians) cycle tracks or non-deliverable (LTN 1/20 compliant) segregated (from pedestrians) cycle tracks. For Quick cyclists, cycle lanes have a much higher attractiveness, whilst for

Quiet cyclists, cycle lanes are equally attractive as shared cycle tracks. Neither group loses out.

So why designate as Quickways and Quietways? The importance of designating it as a Quickway or Quietway is to ensure that this kind of evaluation is undertaken, specifically meeting the needs of each type of cyclist. For Quickways, it is to ensure that the needs of direct cyclists, in terms of design speeds is factored in the design. For Quietways it ensures that traffic levels must be reduced to low levels, so that, for instance, residential roads which are actually used as rat runs need filters and Low Traffic Neighbourhoods. The designation of a dual choice network is to ensure that both groups are fully considered in cycle planning, rather than the needs of either Quick or Quiet cyclists being ignored on a network scale. The purpose and priority of the dual choice network is to be inclusive of and cater for both groups.

6.4 Impact of cycling culture

The main new finding of the OCS19 is that the cycling culture in Oxford has a big impact on cyclist infrastructure choice. One key element of the cycling culture in Oxford is that cycling becomes central to utility journeys, such as shopping, work, visiting friends etc rather than just recreational cycling journeys. With utility journeys, the priority changes from choosing quiet routes to direct routes, because time (quickness) becomes a major factor.

Most of the wider evidence on cyclist route choice has been collected in surveys in low cycling towns and low cycling countries, such as Australasia and Canada, whereas policy aspirations are to have high cycling levels. The lack of data from high cycling towns is a major gap. If we imagine that there is a progress from low to high cycling, there is more research on the starting point rather than the finishing point.

The Bicester LCWIP sets out a model of key stages towards a cycling culture – the CAT (Commitment to Active Travel) scale. The model is that at lower cycling levels where most journeys are by car, it is politically difficult to introduce the changes needed to reduce car use and that good quality off-road cycle routes may be essential first to grow the cycling population so that more controversial traffic management measures in support of cycling have political and public support. At a certain point, the focus must change to “reclaim the road” as the key concept. At this stage, cycle numbers are so high and directness and cycle priority so difficult to achieve in off-road provision, the cycle network can only be delivered by enhancing the quality of the main road network to become attractive to the majority of cyclists who value directness.

6.5 Evaluation of LTN 1/20 - difficult choices in terms of width

The research is also important in critiquing the LTN 1/20 guidance, based as it is on the wide adherence to one perspective of acceptable cycle infrastructure for main roads (namely based on comfort and segregation in terms of off-road or protected cycle lanes).

Surveys in the evidence base (figure 10) based on the views of 20,000 cyclists, highlight the substantial 28% difference between the option of a *segregated* (92%) and *shared* cycle track (68%) and the ranking that a shared cycle track is less attractive than a cycle lane (75%). OxCRAM (figure 14) adds to this evidence by showing how quick cyclists rate cycle lanes (7.2) substantially higher than shared cycle tracks (4.7) whereas quiet

cyclists rate them roughly equally (5.5/5.6). This indicates that cycle tracks need to be segregated from pedestrians to be attractive to all types of cyclists but that the default next best is cycle lanes, in that they are much more attractive to quick cyclists and equally attractive to quiet cyclists compared to shared cycle tracks

However, LTN 1/20 figure 4.1 states that provision of cycle lanes on a main road (over 6000 motor vehicles per day) as “suitable for few people and will exclude most potential users”. LTN 1/20 guidance is contradicted by the evidence base and OCS 19 data. Nor do LTN 1/20 standards in figure 4.1 emphasise the key differences between segregated and shared cycle tracks which this evidence shows has a fundamental impact on cyclist route choice, though the guidance in LTN 1/20 does state repeatedly that shared cycle tracks are unsuitable in urban areas.

It is also of note that the surveys in the evidence base show good evidence that introducing cycle lanes on main roads very substantially improves (by 50% from 25% to 75%) the number of all cyclists willing to use an existing main road without any cycle infrastructure. Likewise, the OxCRAM shows that introducing cycle lanes to a main road substantially raises the attractiveness for quick cyclists from 4.3 to 7.2 and for quiet cyclists from 2.5 to 5.5 (figure 14). Considering that delivering cycle lanes may be typically around 10% the cost of delivering cycle tracks suggests that cycle lanes have a much higher benefit cost ratio than shared or segregated cycle tracks. This finding seems important in national policy terms in ensuring that Changing Gear funding is effective and value for money.

6.6 Safety of cycle lanes and cycle tracks.

It may seem obvious that cycle tracks should be safer than cycle lanes, but for urban areas with 20mph or 30pm speed limits, there is little evidence to support that contention. It very much depends on the number of side roads and driveways that are crossed. A comparison of all STATS 19 reported cyclist casualties in Oxford, over 5 years from 2014 to 2019 across all main road cycle routes, including sections of cycle lanes and cycle tracks, was undertaken in preparing the Oxford LCWIP (OCC 2021). Altogether there are just under 40 km of cycle lanes and just over 20 km of cycle track in Oxford (counting lanes or track on each side of the road separately) compared to around 140 km of vehicle lanes (also counting vehicles lanes in each direction separately) along the main roads.

Figure 18 shows that for cyclists over the whole main road cycle network – the cycle lane casualty rate was 1.6 and the cycle track casualty rate was 1.5 cyclist casualties per 1000 metres compared to 4.3 cyclist casualties per 1000 metres over the same whole routes. For the city centre routes, the cyclist casualty rate was higher – 5.3 in cycle lanes and 15.4 over the same whole routes, though cycle lanes are similarly 3 times as safe as the whole city centre network. There were no cycle tracks in the city centre to compare casualty rates. The higher casualty rate in the city centre is almost certainly an impact of more cyclists. The conclusion is that for Oxford cyclists, the casualty rate per 1000 m is thus almost the same for cycle lanes and cycle tracks and both cycle lanes and cycle tracks are around 3 times safer than the whole route.

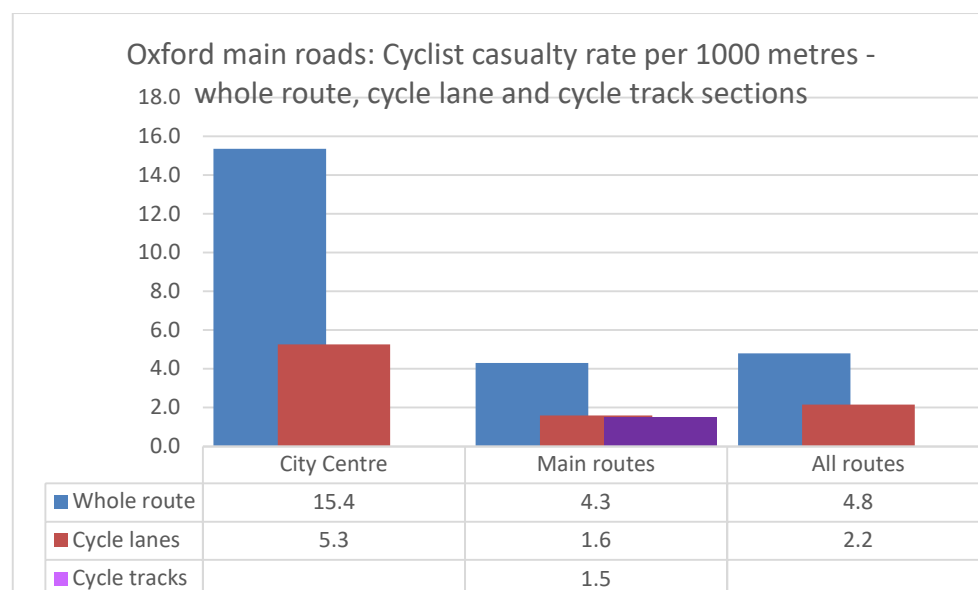


Figure 18 Cyclist casualty rate per 1000 m in city centre, main route network and all routes

6.7 Advantages of cycle lanes over off-road cycle tracks

In fact, on a wider perspective, cycle lanes have many advantages over cycle tracks. These can be summarised as

- Cycle lanes best meet the needs of everyday quick cyclists, who make most cycle journeys (around 80%) and thereby sustain the cycling culture.
- Cycle lanes are as safe as cycle tracks and safer than the rest of the route.
- Cycle lanes use valuable road space more efficiently by a more intensive use of road widths. By cyclists and motor vehicles partially sharing space, it is possible to have wider cycle lanes and narrower vehicle lanes, for instance, when a cyclist overtakes another cyclist and temporarily moves out of the cycle lane, or when a large vehicle meets another large vehicle and temporarily moves into the cycle lane space. With cycle lanes, vehicle lane widths can be reduced to 5.5 m or even 4.5 m, whereas with off road cycle tracks, vehicle lanes cannot be reduced below 6 metres.
- High quality cycle lanes can therefore be delivered on a much wider range of road widths (from as narrow as 7.5 m carriageway width (13.5 m highway width) than can cycle tracks (which need around highway 18 metres width), without the need for instance to cut down trees or reduce pedestrian footway space. They are also generally easier to design and to connect with other routes.
- Cycle lanes are easier, quicker and cheaper to install. Cycle lanes cost approximately £1 million per 5 km compared to around £10 million per 5 km for cycle tracks. They are also quicker to install, within a time frame of about 2 years for a large cycle lane project compared to 4 years for a large cycle track project.
- A comprehensive cycle network can therefore be delivered much more quickly. Even in Oxford only around 40% of the main road network has a cycle lane or cycle track. With around 50 km of route without cycle facilities, it would take around £100 million and perhaps 20 years to complete the cycle network by cycle tracks (if it was physically possible), compared to around £10 million and 5 years by cycle lanes (assuming new major projects starting each financial year). For most other Oxfordshire towns, there is even less existing cyclist infrastructure. This timescale compares to the AHTS and LCWIP priorities to increase cycling in Oxford by 50% and double cycling in Oxfordshire towns outside Oxford by 2030 within 10 years. Without much faster progress, there is little hope of achieving these targets.

- The funding saved from delivering high quality cycle lanes can allow more funding to be diverted to improving junctions in terms of cyclist safety and priority. Junctions are where most cyclist casualties occur so there are potential casualty savings from diverting funding from links to junctions.
- What really makes a difference in terms of encouraging cycling is town-wide traffic management projects, such as Connecting Oxford. A strategy to increase cycling would concentrate funding on rolling out similar projects to other Oxfordshire towns, but this is where the CAT scale identifies the challenges of gaining political and public support and acceptance.
- LTNs are also high value low-cost measures which reduce car use and transform local neighbourhoods into areas where it is safe and comfortable for everyone to cycle and LTNs are shown to increase cycling. They are also essential for creating Quietways. They also help reduce cyclist casualties along main roads away from junctions by reducing car turning movements into and out of side roads.
- Cycle lanes more easily allow a visual narrowing of the carriageway, reducing traffic speed and habituating drivers to be aware of and considerate of cyclist behaviour, such as when cyclists overtake other cyclists or need to turn right across traffic to enter a side street. Motor speed reduction is identified as the major way of reducing cyclist casualties (DfT 2011) and lower speeds also improve cyclists' feelings of safety.
- Cycle lanes also give greater weight to policies of removing car parking along main roads, for instance the Oxford Tranche 2 Quickways will remove around 600 car parking spaces, thereby acting as a catalyst to behavioural change.
- More fundamentally, cycle lanes are a first stage in a longer-term transition of urban main roads to more cycle friendly streets, whereby cyclists become the main users in primary position, whereas removing all cyclists from the road to cycle tracks gives more space and more ownership of the road to car users. One frequent complaint by cyclists in OCS19 was that they were intimidated by car drivers when cycling on road particularly when there existed parallel, but inadequate, off-road cycle tracks.

7 Bibliography [Survey locations in brackets]

Aldred, R. et al. (2017) Cycling provision separated from motor traffic: a systematic review exploring whether stated preferences vary by gender and age, *Transport Reviews*, 37:1, 29-55.

Brick, E., Caulfield B. (nd) *Investigating cycle route preferences in the Greater Dublin Area*, AECOM [Dublin]

Bedford Borough Council (2013 and 2017) *Bedford Station Surveys*, (internal documents) [Bedford]

Cycling Promotion Fund (CPF) and Heart Foundation (2013) *Women and Cycling Survey 2013* at <https://heartfoundation.org.au/images/uploads/publications/Cycling-Survey-2013-Women-and-Cycling.pdf> (accessed 11/05/16)

CTC (2012) *Attitudes to roads and cycle infrastructure*

Cycling in Cities Research Program webpage "Motivating cycling" at <http://cyclingincities.spgh.ubc.ca/motivating-cycling/opinion-survey/> (accessed 11/05/16) [Vancouver]

Davis et al. (1997) *Attitudes to cycling, a qualitative study and conceptual framework*, Transport Research Laboratory, Crowthorne

DfT (2010) *Cycling, Safety and Sharing the Road: Qualitative Research with Cyclists and Other Road Users*, Road Safety Web Publication No.17

DfT (2011) Infrastructure and Cyclist Safety (TRL Report PPR 580), available at <http://assets.dft.gov.uk/publications/infrastructure-and-cyclist-safety/infrastructure-and-cyclist-safety.pdf>

DfT (2020a) *LTN 1/20 Cycle Infrastructure Design*

DfT (2020b) *Gear Change – A bold vision for cycling and walking*

Heesch, K.C., Sahlqvist, S. and Garrard, J. (2012) Gender differences in recreational and transport cycling, *International Journal of Behavioral Nutrition and Physical Activity*, 2012, 9:106 <http://www.ijbnpa.org/content/9/1/106> [Queensland]

Ipsos Reid (2010) *City of Toronto Cycling Study* [Toronto]

Kazemzadeh, K. et al. (2020) Same questions, different answers? A hierarchical comparison of cyclists' perceptions of comfort: in-traffic vs. online approach

Larsen, J. (2010) Beyond the Bike Lane: An Analysis of Cyclists' Travel Behavior in Montreal & A Methodology for Locating New Routes, *Masters in Urban Planning* [Montreal]

NZTA (2011) Assessment of the type of cycling infrastructure required to attract new cyclists, October 2011, *NZ Transport Agency research report 449* [Canterbury]

OCC (2019) Oxfordshire Cycle Survey 2019, summary available at <https://www.oxfordshire.gov.uk/sites/default/files/file/roads-and-transport-connecting-oxfordshire/OxfordshireCycleSurvey2019SummaryReport.pdf>

OCC (2019) Oxford LCWIP, available at <https://www.oxfordshire.gov.uk/residents/roads-and-transport/connecting-oxfordshire/active-and-healthy-travel>

OCC (2020) Bicester LCWIP, available at <https://www.oxfordshire.gov.uk/residents/roads-and-transport/connecting-oxfordshire/active-and-healthy-travel>

OCC (2021) Oxford Cyclist Casualty Report 2014-2019, document available on request

Pooley, C.G. et al. (2011) Understanding Walking and Cycling, Lancaster University, <http://www.roadsafetyknowledgecentre.org.uk/issues/cycling/knowledge/631.html>

SDG (2012) Cycle Route Choice – final survey and model report, Steer Davis Gleave for TfL [London]

TfL (2011) Attitudes towards cycling

University of British Columbia (nd) Cycling in Cities – opinion survey, UBC School of Population and Public Health [Vancouver]

Walker, I. (2005) *Oxford & Cambridge Cycling Survey*, (information supplied by author) [Oxford and Cambridge]