Active Travel England

Active Travel Portfolio Research and Evaluation Programme

Evidence assessment: The Impact of Active Travel on Journey Times, Congestion and Resilience

October 2024

Sheffield Hallam University, NatCen and Mosodi Ltd

ACTIVE TRAVEL PORTFOLIO RESEARCH AND EVALUATION PROGRAMME

Title: Evidence assessment: The Impacts of Active Travel on Journey Times, Congestion and Resilience

Date: October 2024

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Contents

Executive Summary

About this Evidence Assessment

Sheffield Hallam University, NatCen, and Mosodi Ltd were commissioned by the Department for Transport (DfT) and Active Travel England (ATE) to carry out an evidence assessment on the impacts of active travel on journey times, congestion, and resilience. Whilst active travel evidence and policy often refers to cycling and walking, a broader and more inclusive definition refers to any travel that is powered, partially or fully, by the sustained physical exertion of the traveller (Cook, et al., 2022). As such the definition also includes wheeling (wheelchair use as well as a variety of other modes such as skateboarding or scooting).

In England, the government has an ambition to make walking, wheeling and cycling the natural choice for shorter journeys or as part of a longer journey. The second cycling and walking investment strategy[1] (CWIS2) aims, by 2025, to increase the percentage of short journeys in towns and cities that are walked or cycled to 46%; increase walking activity to an average of one walking stage per person per day; double cycling activity to 1.6 billion journey stages; and increase the percentage of children aged five to ten who usually walk to school to 55%. Over the longer term, the ambition is that half of all short journeys in towns and cities will be walked or cycled by 2030, and that England will have a 'world-class' cycling and walking network by 2040.

Journey times, congestion and resilience

CWIS2 recognises that increasing active travel represents an alternative, efficient and reliable way of transporting people over short distances, particularly across urban areas. With the right conditions and travel infrastructure in place, walking and cycling have the potential to facilitate favourable journey times and reduce road congestion, particularly during peak hours, whist simultaneously contributing to decarbonisation and health improvement outcomes.

The scope for this theme provides evidence of these potential active travel impacts on: journey times (travel-time savings, route choice, walking-time) and savings by destination and mode; congestion (with specific focus on links with decarbonisation); and the resilience (and reliability) of the travel network. As this theme is focused on outcomes as a result of active travel, any type of active travel intervention, or combination of active travel interventions, was in scope.

Structure of this report

The findings have been split into three chapters: journey times; congestion and resilience, as defined above. These interrelated topics speak to the impact of active travel policy objectives and how positive impacts can be maximised. While the evidence was mixed (and sometimes contradictory), it also points to potential time saving and congestion benefits of walking and cycling and related ways in which perceptions of active travel (and its reliability) influence uptake, sometimes regardless of travel time savings.

1 ATE & Department for Transport (2023). The second cycling and walking investment strategy (CWIS2), 10 March 2023.

Methodology

The report presents findings from 26 studies that were selected following a process of systematic searching, screening, prioritising, and evidence extraction. The evidence reviewed predominantly comprises robust academic studies of the potential impact of active travel on journey times, congestion and resilience of the travel network. Supplementing the academic studies are a small number of relevant reports from non-academic sources.

It is important to note that the scope of the evidence assessment was limited. Therefore, more extensive and systematic research into the evidence base would be required to produce exhaustive findings.

Key Findings

This evidence assessment has attempted to answer the following research question:

- **RQ1:** What impacts does active travel have on journey times, congestion, and resilience of the travel network? Including:
  - Journey times and traffic speeds.
  - Travel time savings by different modes and destination.
  - Levels of congestion and road-space (re)allocation.
  - Resilience and reliability of the travel network.

This section summarises the key findings of this evidence assessment. Key findings were also synthetised in the Key Findings Tables shown at the end of this section.

Journey Times

Modal shift and time savings: Evidence from both UK studies and elsewhere suggests that with the implementation of active travel infrastructure there is significant potential for short car trips to be replaced by walking and cycling (Ma and Jin 2024; Neves and Brand, 2019). This is dependent however on the quality and effectiveness of infrastructure in urban areas.

Active travel and commuting times: There is mixed evidence on whether replacing car journeys with active travel (cycling) to work reduces or increases journey times, although evidence points to time-saving benefits where modal shift is for journeys over shorter distances and across congested urban areas (Both et al., 2022; Plazier et al., 2017). Longer journeys (about twice as long in Plazier et al.'s study) do not always deter a shift to walking or cycling.

Journey times and other factors that influence modal decision making: Not all travellers strive for the shortest possible travel time; positive experiences (e.g., enjoyment of the cycling route; being outdoors; engaging in physical activity; independence from carpooling / public transport schedules) motivate people's choice to walk or cycle (Le at al., 2002; Plazier et al., 2017).

Shared-use roads and travel times: The evidence on the traffic speed impacts of cyclists sharing roads with cars is mixed (The FLOW Project, 2016; Ge & Polhill, 2016; Aldred et al., 2019). Cycling volumes, the design of specific schemes (especially how cyclists may be treated at junctions) and, critically, whether cyclists share the roadway or have segregated lanes, are important determinants of the impact on journey times.

Congestion

Bike-sharing systems: Evidence shows that bike-sharing systems are effective in reducing congestion by replacing car trips and encouraging cycling. Studies in cities such as Seattle, Washington D.C., London, Melbourne, Brisbane and Minneapolis indicate positive impacts on motor vehicle use and congestion levels, with significant substitution rates in cities with high car usage (Fan & Harper, 2022; Fishman et al., 2014).

Electrically powered micro personal mobility vehicles (e-PMVs) and mode substitution: e-PMVs, such as e-cycles and e-scooters,[2] offer alternative transportation modes that substitute car trips and complement public transportation systems. Recent studies show that most new e-cycle users are drivers and pedestrians, rather than pedal cyclists (Bigazzi & Wong, 2020).

Cycle lanes: Evidence suggests that protected or segregated bike lanes significantly increase cycling levels without adversely affecting other transport modes. Goodno et al. (2013) reported substantial increases in cycling volumes along new bike lanes in Washington D.C., while Wardman et al. (2007) forecasted that widespread deployment of segregated bike lanes in the UK could lead to a significant reduction in car usage.

Road space reallocation: Grahn et al. (2021) found that a 'complete streets' retrofit in Pittsburgh led to decreased traffic volumes and increased cycling without affecting traffic speeds on nearby roads. The pedestrianisation of Slovenska Street in Ljubljana also contributed to a decrease in car use and alleviated congestion, highlighting the potential benefits of reallocating road space for pedestrians, cyclists, and public transport (FLOW Project, 2016).

Cycling incentives: Wardman et al. (2007) showed that a modest financial incentive could nearly double the amount of cycling, resulting in a 5.4% reduction in car demand. Similarly, the loaning of free bikes in Bordeaux during a major construction project increased cycling usage from 1-2% to 9% in the city centre, demonstrating the effectiveness of such incentives in promoting cycling and the potential for reducing congestion (FLOW Project, 2016).

Resilience

COVID-19: Studies showed that the reduction in public transport services during the pandemic led to increased use of active travel modes, particularly bike-sharing systems. Qian et al. (2023) reported a rise in bike-sharing in San Francisco following public transport service reductions. An international review by Zarabi et al. (2024) showed a shift from public transport to private cars and active travel during the pandemic, driven by health concerns and reduced services.

Disruptive events: Disruption, such as the withdrawal of public transport services, also affects travel behaviour. Nguyen-Phuoc et al. (2018), in a study of the responses of public transport users in Melbourne to a one-day removal of services, found that over half of respondents would switch to driving, while a smaller proportion would opt for non-motorised modes such as walking and cycling, particularly for shorter trips.

2 Studies on e-cycles are often conflated (i.e. as e-PMVs) with other e-assisted modes such as e-scooters. Whilst this evidence assessment focuses on e-cycles, there are instances where evidence around e-scooters has also been included as a result. However, because the search strategy did not specifically include studies on e-PMVs, including e-scooters, it is not possible to assess the extent to which other relevant evidence has been captured, therefore conclusions in this report on the role of e-PMVs should be considered tentative.

Weather conditions: Weather was shown to play a crucial role in the resilience of active travel infrastructure. Studies from Denmark, the Netherlands, and Sweden show that well-maintained bicycle infrastructure supports winter cycling, while dedicated cycling infrastructure near key destinations in Toronto was found to encourage cycling in all seasons (Nahal & Mitra, 2018).

Response to fuel price fluctuations: Areas with well-developed active travel systems were shown to be more resilient to sudden increases in fuel prices. Bronson and Marshall (2014) found that places with better walking, cycling and wheeling options were more resilient to fuel price shocks. They recommended that policymakers focus on improving access to these alternatives, especially in lower-income areas and those further from city centres, to enhance community resilience.

Limitations and Suggestions for Further Research

All modes of active travel were considered in the evidence searches. However, the searches returned a disproportionate number of reports and articles concerned with the experiences and impacts of cycling / cycling interventions (pedal-cycling, e-bikes, bike sharing schemes, shared-use roads, segregated cycle lanes, cycling infrastructure etc.). The discussion of the evidence in the report reflects this and is therefore focused primarily on the impacts of cycling (on journey times, congestion and transport network resilience).

Although we found significantly more evidence concerned with cycling, the quality and utility of this evidence is varied. Many sources draw on small-scale qualitative approaches, non-representative surveys, modelling of secondary data or (non-systematic) evidence syntheses which lack sufficient detail to assess the quality of data and research claims presented. Sampling and data collection strategies sometimes introduced a bias that may have skewed results. Furthermore, many of the research findings are derived from international case studies and so the findings are often not applicable to a UK context. Studies examining the direct effects of active travel on journey times, congestion and resilience are also limited.

This means that while there is good quality evidence that active travel interventions have a positive impact and show promise, further research is needed to fully understand their impacts on travel times, congestion and the resilience of transportation systems, particularly within a UK context. First and foremost, there is a need for further studies that directly assess the effects of active travel on journey times, congestion and resilience. There are several additional avenues for further research that address methodological shortcomings and gaps in knowledge including:

1. Improving Data Collection:

   – **Experimental studies which adopt high-quality methodologies.** Including pre/post comparisons and control groups, to accurately assess the effectiveness of interventions in reducing travel times and congestion.

   – **Studies should aim for more robust methodologies.** Including larger and more representative sample sizes, and rigorous study designs that minimise biases such as self-selection in participant recruitment.

   – **Robust mixed-methods case studies.** Which focus analytical attention on the context of active travel interventions and implementation processes as well as other factors that influence outcomes and effectiveness.

   – Inclusive sampling strategies. Studies should adopt to capture a broader demographic and spectrum of travel behaviours and choices e.g., among population sub-groups such as women, disabled people and racialised minorities.

2. Filling Research Gaps:

   - **Complex interactions between different transportation modes.** Future research should explore how these interventions interact with one another and with existing transportation infrastructure to maximise their benefits. Understanding the specific role of e-PMVs and other electrically assisted forms of micromobility will be increasingly important.
   - **Research which explores the most effective ways of encouraging active travel.** Amongst those more likely (or pre-disposed) to shift to walking and cycling, and those most likely to benefit from replacing shorter journeys with walking or cycling.
   - **Research in rural communities.** Much of the existing evidence is concerned with active travel within urban areas. Although most of the UK population live in urban settings, it is important that studies consider active travel within rural areas and where journey times are inevitably longer.
   - **Balance across modes of active travel.** Research should strive for greater, moving beyond the current focus on cycling, to include walking, wheeling and other emerging forms.

Key Findings Tables

This section provides summary tables on the key findings from the evidence assessment.

Table 1: Impact of active travel on journey times

Key evidence	Source/Method/Sample/Country
Modal shift and time savings	
There is significant potential for short car trips (under three miles) to be replaced by active modes, including when journey purpose and trip chaining is accounted for. However, time constraint was one of the main reasons participants used the car over short distances.	Neves and Brand (2019) Mixed methods including interviews, cross-sectional survey, and GPS tracking UK
Improving walking and cycling infrastructure (e.g. improving on-road cycle lanes and pavements) is by far the most effective intervention for modal shift from the car and accruing the highest time-saving benefits (compared with Autonomous Metro and demand responsive buses) as modelled for the city of Cambridge.	Ma and Jin (2024) Modelling drawing on real-world data UK
At a 10% micromobility (referring to shared bikes and scooters) uptake, motor vehicle speeds on most roadways increase between 0% and 1%, which can help reduce journey times. Urban arterials tend to benefit more from short car trip replacement than do freeways/expressways because most short vehicle trips occur on urban arterials.	Fan and Harper (2022) Modelling drawing on cross-sectional survey, n=6000 US
Modal shifts to bike-sharing could enable significant economic gains. Reducing travel times and mitigating traffic congestion in turn leads to greater connectivity with and accessibility to workplaces, creating economic efficiencies.	Teixeria et al. (2021) Literature review drawing on 77 papers. Global
The existing evidence on the impact of Low Traffic Neighbourhoods on mode shifts to active travel is mixed and unclear.	Ipsos (2024) Mixed methods including evidence review, local authority and resident surveys, and stakeholder engagement. UK
36% of residents living within four LTN schemes thought the introduction of a LTN had increased journey times to frequently visited places.	Ipsos (2024) Mixed methods including evidence review, local authority and resident surveys, and stakeholder engagement. UK
Not all individuals have the same probability of shifting travel mode choices where sustainable options are feasible. Different 'lifestyle groups' (car oriented, bicycle oriented, walk and public transport oriented, and public transport averse) have specific perceptions of travel time which make them more or less amenable to active travel options.	Prato et al. (2017) Cross-sectional survey, n=7,958 Denmark

Key evidence	Source/Method/Sample/Country
Active travel and commuting times	
While e-bike commutes were shortest in distance, they took longer (M = 46 min) than commutes by car (M = 29.7 min), and about equally long as commutes by bus (M = 46.6 min).	Plazier et al. (2017) Mixed methods including interviews and GPS tracking Netherlands
Positive experiences underpin e-bike commuters mode choice e.g. enjoyment of the cycling route and surroundings; being outdoors and breathing fresh air; engaging in physical activity; and independence from carpooling or public transport schedules.	Plazier et al. (2017) Mixed methods including interviews and GPS tracking Netherlands
Not all travellers strive for the shortest possible travel time. Travellers are willing to spend more time travelling owing to the 'positive utility of travel'.	Le et al. (2020) Longitudinal survey, n=186 US
Shifting to walking or cycling can increase the numbers of commuters able to reach their workplaces within 30 minutes. Drawing on Australian census data, it was shown that an additional 5.8% of workers could reach their jobs within 30 minutes by shifting mode to walking. For mode shift to cycling, this would mean an additional 28.6% of workers could reach their workplaces within 30 minutes.	Both et al. (2022) Modelling drawing on cross-sectional survey Australia
Travel mode is the greatest determinant of how much additional time an individual allocates for their commuting journey, and that holding all else equal, pedestrians, cyclists, and transit users budget less additional time, respectively, as compared with drivers. This suggests that active transport networks have greater travel time reliability and that less time is lost due to travel time unreliability	Loong and El-Geneidy (2016) Cross-sectional survey, n=2,496 Canada

Key evidence	Source/Method/Sample/Country
Shared-use roads and travel times – impacts for cyclists	
After 'the green wave' (which helped to indicate to approaching cyclists if their current speed was appropriate to reach the next green light) was introduced in Copenhagen, cycle trips to the city centre became faster.	FLOW Project (2016) Review drawing on 20 case-studies Global
In Aberdeen, cyclists sharing roads with cars did not lead to longer commute times or larger commute time variability for cars.	Ge and Polhill (2016) Modelling drawing on secondary data UK

Key evidence	Source/Method/Sample/Country
Shared-use roads and travel times – impacts for other road users	
Modelled movements across London Bridge showed that buses are impacted significantly by cyclists at current peak flows, with an 18% median increase in journey time compared to there being no cyclists present. The focus was on the interaction between buses and cyclists in a bus lane with two further general traffic lanes also being in place.	Aldred et al. (2019) Modelling UK
Following the installation of protected bike lanes on a major avenue in Manhattan, there was a 35% decrease in travel time for the average car to go from 96th to 77th streets.	FLOW Project (2016) Review drawing on 20 case-studies Global

Table 2: Impact on congestion by active travel intervention type[3]

Key evidence	Source/Method/Sample/Country
Bike-sharing systems	
More people using micromobility (shared bikes) leads to less congestion, as urban arterial links[4] become less congested. Modelling in Seattle (United States) found that if 10% of people switched to micromobility, there was a 3% decrease in the number of main roads with moderate congestion and a 1.5% decrease in those with severe congestion. Meanwhile, the number of roads without congestion went up by about 0.5%.	Fan and Harper (2022) Modelling drawing on cross-sectional survey, n=6000 US
In a study of bike share programmes in Melbourne, Brisbane, Washington D.C., London and Minneapolis/St. Paul, it was shown that in general the net impact of bikeshare schemes (once the vehicle use required to manage the schemes themselves are accounted for) was a positive one, with between 2-4 km of private car use avoided per km travelled by bike share. An exception to this was London where a car mode substitution rate of 2% and heavy demand for bicycle redistribution across docking stations, meant that there was approximately 2.2km in motor vehicle support service travel for each kilometre of private car use avoided (indicating a net impact at the lower end of the range).	Fishman et al. (2014) Mixed methods including cross-sectional surveys and trip data, n=8,964 across four surveys Australia and US
Bike-sharing can play a prominent role in encouraging and normalising cycling, and as a result reducing congestion through mode shift. Within a systematic review of evidence, it was shown that an increase in overall cycling levels occurred after the implementation of a bike-sharing system. For example, 68% of users of Dublin's bike-share system had not cycled the undertaken trip before and 70% of respondents of users of London's bikeshare scheme reported starting to cycle or cycling more as a result of the scheme. The review found that environment and health concerns were among the main reasons stated by bike-sharing system users for switching.	Teixeria et al. (2021) Literature review drawing on 77 papers. Global
Equity assessments from the UK and North America revealed that the most disadvantaged groups (including low-income, less educated and minority ethnic groups) are systematically under-represented among bike-share scheme users. Much of this is due to a lack of awareness, with it being less likely that friends or family would be using the systems and having less access to the Internet and smart phones.	Teixeria et al. (2021) Literature review drawing on 77 papers. Global

3 Some of the findings outlined in this table relate to evidence reviewed on bike-sharing systems and e-PMVs (such as e-bikes and e-scooters), in terms of how they impact transportation modes through mode substitution (the shift from using one mode of transportation to another). Mode substitution was seen as a proxy to infer a reduction in congestion by reducing the number of vehicles on the road.

4 Arterial links are major roadways that form the primary transportation network within a city or region. They are designed to handle high traffic volumes and provide connections between different areas.

Key evidence	Source/Method/Sample/Country
Electric-powered micro personal mobility vehicles (e-PMVs)	
A meta-analysis of 38 observations (or surveys)[5] of mode substitution patterns in 24 published studies from around the world found that e-bike median mode substitution across all studies was highest for public transport (33%), followed by regular bikes (27%), cars (24%), and walking (10%).	Bigazzi and Wong (2020) Systematic review of reviews, drawing on 24 papers Global
Mode substitution is affected by whether e-bikes are owned or rented. Privately owned e-bikes exhibit a lower probability of replacing walking journeys, indicated by a notably low odds ratio[6] of 0.23. In contrast, rented or loaned e-bikes demonstrate a higher probability of substituting walking trips, suggesting a more frequent usage pattern for shorter, recreational outings or local trips.	Bigazzi and Wong (2020) Systematic review of reviews, drawing on 24 papers Global
The review found that newer studies of e-bike adoption report greater displacement of driving (with an odds ratio of 1.11 per year) and walking (odds ratio of 1.08 per year) and less displacement of conventional bike trips (odds ratio of 0.89 per year). This shift suggests that the majority of new e-bike users are coming from groups like drivers and pedestrians, rather than from people who already cycle a lot.	Bigazzi and Wong (2020) Systematic review of reviews, drawing on 24 papers Global
The adoption of shared e-scooters results in a number of mode substitution patterns. Half of respondents surveyed on shared e-scooter use in Germany (n=605) experienced no change in their public transport use, 45% reported a decrease, and a small fraction (5%) noted an increase. Approximately 43% of trips were substituted from walking, followed by around 19% from public transport. E-scooters replaced bicycles in roughly 12% of cases, similar to the percentage of car trips replaced, which stood at 11%.	Weschke et al. (2022) Cross-sectional survey, n=605 Germany

Key evidence	Source/Method/Sample/Country
Cycle lanes	
The installation of bike lanes in two locations in Washington D.C. led to a notable increase in bicycling levels along the designated corridors. Afternoon peak hour bicycle volumes increased more than 500% at count locations on 15th street and more than 250% on Pennsylvania Avenue (between April 2010 and June 2012). These levels increased at a 'substantially higher rate' than in the rest of Washington D.C. during the same period, highlighting the effectiveness of bike lanes in promoting active travel.	Goodno et al. (2013) Modelling drawing on real world data US
In the most favourable modelled scenario, where all cycle time is spent on a completely segregated cycleway, 9% of commuters are forecast to cycle to work (a 55% increase from the base case), and there would be a 3% reduction in car use. This can perhaps be interpreted as providing an indicative upper limit of the extent to which cycling (specifically, segregated bike lanes) could be expected to reduce motor vehicle traffic.	Wardman et al. (2007) Modelling drawing on real world data UK
If protected bike lanes were available for all short trips (less than three miles) between origin and destination points, the reduction in congestion could be twice as much compared to the baseline scenario.	Fan and Harper (2022) Modelling drawing on cross-sectional survey, n=6000 US

5 An 'observation' refers to a specific data collection point, such as a survey. In this context, the authors are drawing on data from 38 unique studies or surveys.

6 An odds ratio is a measure used in statistics to determine the likelihood of a particular event occurring compared to the likelihood of it not occurring. A low odds ratio, such as 0.23, means that the event—in this case, replacing walking with a privately owned e-bike—is significantly less likely to happen. This low odds ratio suggests that individuals with privately owned e-bikes are less likely to use them for short trips that they would typically walk.

Key evidence	Source/Method/Sample/Country
Road space reallocation	
A 'complete streets' retrofit[7] in a mixed urban corridor in a Pittsburgh university campus led to decreases in traffic and increases in cycling while not affecting traffic speeds nearby. The retrofit included a reduction in road space for cars and the addition of two bike lanes. After the retrofit, weekday vehicle traffic volumes over two three-week periods in spring and autumn decreased by between 11-31% during peak AM and PM hours. Average bicycle counts grew from five to 13 bicycles/hour during the morning peak (+160%) and from ten to 38 bicycles/hour during the evening peak (+280%). Traffic speeds on a nearby parallel corridor were shown to be unaffected.	Grahn et al. (2021) Secondary data US
The introduction and enlargement of pedestrianised zones contributed to a relief in road traffic and in turn congestion in Ljubljana, Slovenia. Data from Ljubljana city administration indicates that the extension of the pedestrianised zone worked as planned and contributed to a reversal of trends of increasing car use and decreasing walking: car traffic decreased from 58% (2003) to 51% (2013) and pedestrians increased from 19% (2003) to 25% (2013).	FLOW Project (2016) Review drawing on 20 case-studies Global
Research by DfT found that 41% of residents living within a Low Traffic Neighbourhood scheme believed that traffic congestion on nearby roads had increased. Yet a review of evidence suggested that impacts of LTNs (positive or negative) on boundary roads are minimal.	Ipsos (2024) Mixed methods including evidence review, local authority and resident surveys, and stakeholder engagement. UK

Key evidence	Source/Method/Sample/Country
Cycling incentives	
Modelling undertaken to examine the impact of financially rewarding commuters for cycling to work showed that a payment of £2 per day almost achieves a doubling of the amount of cycling, yielding a 5.4% reduction in car demand. When a package of measures is considered, including modest financial incentives, cycle facilities for around half the journey to work and good parking and shower facilities at work, cycle emerged as a much more significant mode and has an appreciable impact on car share.	Wardman et al. (2007) Modelling drawing on real world data UK
The loaning of free bikes to alleviate congestion caused by a major city centre construction project in Bordeaux, France helped grow the use of cycling, from 1-2% to 9% in the city centre and to 4% in the periphery of the metropolitan area.	FLOW Project (2016) Review drawing on 20 case-studies Global

7 A 'complete streets' retrofit involves redesigning and updating existing roadways to accommodate all users safely, by incorporating features such as bike lanes, wider pavements, and improved crossings.

Table 3: Active travel resilience by event type

Key evidence	Source/Method/Sample/Country
Changes to access to transport due to COVID-19 lockdowns	
Ridership of the existing bike sharing scheme in San Francisco increased at the onset of the pandemic but prior to the stay-at-home order. When public transport service levels were reduced the proportion grew again. The occurrence of bike sharing trips expanded away from the city centre. In addition, weekend recreational trips also increased at the same time. The flexibility of bikeshare and the resilience it provides in the context of disruptions could help it grow in popularity in areas where transit services are limited or unavailable. The study cannot confirm whether the trends observed are temporal or will be permanent during the post-pandemic period.	Qian et al. (2023) Meta-analysis of ridership data US
Globally, a reduction in public transport services and concerns surrounding COVID-19 led to significant shifts away from public transport towards private car use and active travel among pandemic commuters.	Zarabi et al. (2024) Systematic review of reviews, drawing on 36 papers Global

Key evidence	Source/Method/Sample/Country
Disruptive events	
In the event of a major public transport withdrawal in Melbourne, out of 176 respondents who travelled less than 5 km, 46% would shift to 'non-motorised modes'[8] while only 9.1% would cancel their trips. 'Short distance trips'[9] would be conducted by cycling and walking.	Nguyen-Phuoc et al. (2018) Cross-sectional survey, n=640 Australia

Key evidence	Source/Method/Sample/Country
Reponses to fuel price fluctuations	
The availability of 'environmentally friendly transportation options' such as walking, wheeling and cycling was one of the three factors deemed important for community resilience[10] to sudden fuel price increases (alongside household proximity to the town/city centre and household income).	Bronson and Marshall (2014) Cross-sectional survey, n=12,000 US

Key evidence	Source/Method/Sample/Country
Weather	
Dedicated cycling infrastructure is important for supporting winter cycling. Existing cyclists were more likely to continue to cycle through the winter months where there was a higher amount of dedicated bicycle infrastructure close to their shortest route. As this study was based in Toronto (Canada), it has limited applicability to the UK owing to different winter weather and snow clearing practices.	Nahal and Mitra (2018) Cross-sectional survey, n=278 Canada
Better weather conditions led to a reduction in additional budgeted time for public transport, and active modes to a lesser extent.	Loong and El-Geneidy (2016) Cross-sectional survey, n=2,496 Canada

8 Here, 'non-motorised modes' refers to cycling and walking.
9 In this article, 'short distance trips' are defined as an average travel distance of 5.6km (for cycling) and an average travel distance of 3.7km (for walking).
10 In this context, resiliency refers to the ability of a community to react to a disruptive event.

1. Introduction

1.1 Active travel policy context

Active travel can be defined as travel that is powered – either partially or fully – by the sustained physical exertion of the traveller. Whilst active travel evidence and policy often refers to cycling and walking, a broader and more inclusive definition refers to any travel that is powered, partially or fully, by the sustained physical exertion of the traveller (Cook et al., 2022). As such the definition also includes wheeling (wheelchair use as well as a variety of other modes such as skateboarding or scooting). In recent years, active travel has received increasing recognition for its potential to help facilitate a range of environmental, public health and economic policy outcomes (Hirst, 2020).

In England, the government has an ambition to make walking, wheeling and cycling the natural choice for shorter journeys or as part of a longer journey. The government's original Cycling and Walking Investment Strategy (CWIS) published in 2017 set out specific, measurable aims and provided the financial resource to help achieve them.

The second cycling and walking investment strategy[11] (CWIS2), published in 2022 and updated in March 2023, aims, by 2025, to increase the percentage of short journeys in towns and cities that are walked or cycled to 46%; increase walking activity to an average of one walking stage per person per day; double cycling activity to 1.6 billion journey stages; and increase the percentage of children aged 5 to 10 who usually walk to school to 55%. The latter is set out as a specific target. Over the longer term, the strategy is that half of all short journeys in towns and cities will be walked or cycled by 2030, and that England will have a 'world-class' cycling and walking network by 2040. CWIS2 also introduced a more inclusive definition of active travel to include wheeling.

To support the implementation of projects that deliver its active travel aims, the Government has made an investment projected to be £3.6 billion from 2021 to 2025, and established ATE. ATE's role is to administer the funding whilst working with local authorities to ensure the delivery of high-quality active travel infrastructure for walking, wheeling and cycling, provide tools to deliver ambitious active travel programmes, and support children and other people to cycle.

1.2 Background to the evidence assessment

In 2022, the Department for Transport (DfT) commissioned Sheffield Hallam University in partnership with the National Centre for Social Research (NatCen) and Mosodi Ltd to undertake a portfolio evaluation of active travel. Overall management of this evaluation programme was transferred to ATE in September 2023. The overall aims of the evaluation are to understand how active travel interventions are being delivered; what impact they are having on uptake of active travel; whether they represent value for money; and how they are contributing to the government's walking and cycling objectives.

To support the development of evaluation activities, ATE commissioned a suite of evidence assessments across a range of research and policy priority areas to help assemble evidence of 'key facts' and identify research gaps. The complete list of these evidence assessments is:

11 ATE and Department for Transport (2023). The second cycling and walking investment strategy (CWIS2), 10 March 2023.

1. Enabling adult cycling.
2. Walking and wheeling.
3. Early consideration of active travel via planning and design.
4. Economy.
5. Health and wellbeing.
6. Journey times, congestion, and resilience.
7. Active school travel.

1.3 Journey times, congestion, and resilience

This report presents the results of the journey times, congestion, and resilience evidence assessment. The CWIS2 recognises that increasing active travel represents an alternative, efficient and reliable way of transporting people over short distances, particularly across urban areas. With the right conditions and travel infrastructure in place, walking and cycling have the potential to lead to more favourable journey times across all modes and to reduce road congestion, particularly during peak hours. Broader benefits include the simultaneous contribution to transport decarbonisation and health improvement outcomes.

The scope for this theme was focused on three discrete yet connected areas and capturing evidence on the impacts of AT on them. Firstly, journey times, which relates to how AT impacts on travel-time savings and route choice, as well as savings by destination and mode. Secondly, congestion, and what impacts AT has on this, whether this been by causing congestion through the removal of road-space or the alleviation of through improved traffic flow. Thirdly, the resilience (or reliability) of the transport network as a result of AT, such as the ability to respond to pandemics, extreme weather events, or fuel shocks. As this assessment was focused on outcomes as a result of AT, any type of AT intervention, or combination of AT interventions, was in scope.

1.4 Research questions

This evidence assessment seeks to synthesise available evidence to address the following research question.

RQ1. What impacts does active travel have on journey times, congestion, and resilience of the travel network? Including:

- Journey times and traffic speeds.
- Travel time savings by different modes and destination.
- Levels of congestion and road-space (re)allocation.
- Resilience and reliability of the travel network.

1.5 The structure of this report

The report is structured as follows:

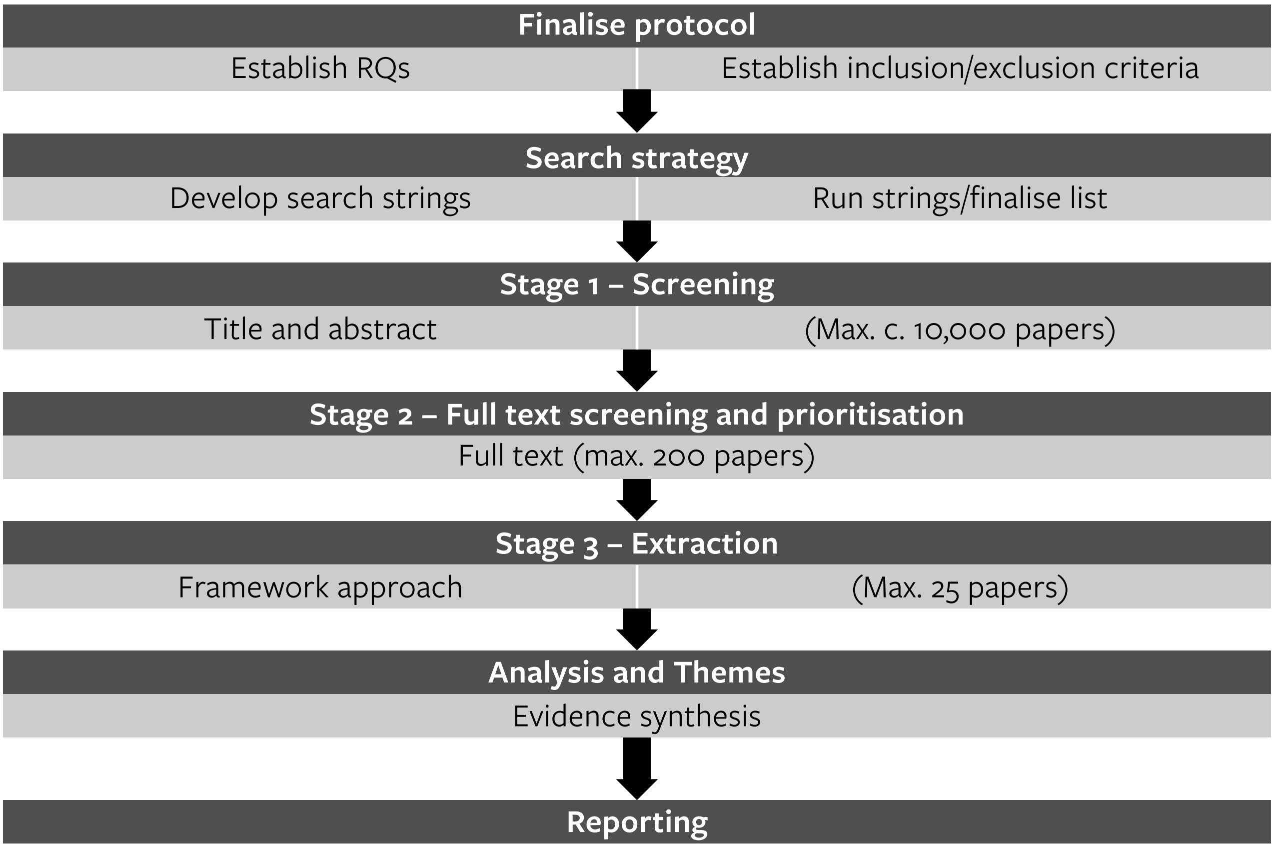
- **Executive summary.** The executive summary provides a high-level summary of the report, as well as a summary of key findings.
- **Introduction.** The first chapter provides background to this evidence assessment.
- **Methodology.** The second chapter provides a summary of the methodology used for identifying and synthesising relevant evidence.
- **Journey times.** The third chapter explores evidence on the impact that active travel has on journey times. It looks at time savings arising from modal shift to active modes; commuting times; the modal decision-making process and link to journey times; and the impact of cycling and sharing road space on journey times.
- **Congestion.** The fourth chapter explores evidence on the impacts of strategies aimed at tackling congestion through active travel and related urban planning interventions. Specifically, it looks at evidence on the impact on congestion of bike sharing systems; electrically powered micro personal mobility vehicles; cycle lanes; road space reallocation schemes; and cycling incentive schemes.
- **Resilience.** Finally, this fifth chapter examines the evidence of the resilience of active travel to shocks such as disruptive events (e.g., strikes) and the COVID-19 pandemic; as well as the transport resilience that active travel provides in the face of shocks to other modes (such as fuel price shocks).
- **Conclusion and next steps.** A final chapter provides a summary conclusion of the evidence against the research questions and sets out implications and recommendations in terms of addressing gaps in the evidence base.

2. Methodology

This section outlines the overall methodology and approach to the evidence assessment. It provides further detail about the development of the assessment protocol, each of the specific stages in the identification, screening and extraction of evidence, as well as identifying the limitations of the research design.

The overall design was organised into three key stages and a set of supporting activities, as summarised in Figure 1.

Figure 1: Evidence assessment stages



2.1 Evidence assessment protocol

A protocol was developed which outlined the process and method to be followed. This helped to ensure consistency across the suite of assessments and to support the identification of relevant, high-quality papers within each assessment within a finite resource.

We determined initial thematic priorities for the evidence assessment with ATE. A stakeholder engagement process was held with key staff within ATE, DfT and other organisations to discuss and agree the thematic scope, agree a set of sub-themes to structure the identification and assessment of evidence, research questions and the concepts and terms that would be used to specify the inclusion criteria. Suggestions were also made by stakeholders for specific non-academic studies and reports for consideration in the evidence assessment. Initial scoping was supported by running a series of test searches using generic search strings on bibliographic databases to provide an initial indication of the likely size of the evidence base. This was used to help further refine the thematic scope of the assessment and its sub-themes and provide initial information on the broad composition of the evidence base (e.g. likely availability of UK-based evidence, types of methods and studies, availability of systematic or meta review studies).

2.2 Search strategy

Academic literature was identified as being potentially relevant to the assessment theme and sub-themes using two database searches: an academic search using the Scopus database and a manual grey literature search across a range of relevant sites (full details of this, including the specific search strings used, can be found in Annex A). In addition to this, evidence identified by experts from ATE and DfT at the stakeholder engagement stage was incorporated into the screening.

2.2.1 Inclusion and exclusion criteria

The inclusion criteria were developed to narrow the search to the papers most relevant to the overall theme. These criteria were applied to both search pathways but not to the third pathway, which was the suggested evidence from ATE and DfT staff.

- **Language:** Only English language papers.
- **Country:** UK, Europe, North America, New Zealand and Australia (those deemed most relevant to the English context).
- **Year:** Papers published from 2013 onwards (to ensure the most recent evidence was prioritised).
- **Publication status:** Published peer-reviewed academic literature in addition to published grey literature (to prioritise peer-reviewed evidence).
- **Type of studies:** Systematic/evidence reviews, meta-analysis, theoretical papers, or studies using primary data collection or secondary data analysis.

2.2.2 Academic database search and search strings

Separate search strings were developed for each of the identified sub-themes within the overall theme. For this assessment, these sub-themes and their broad coverage were as follows:

1. **Journey times,** including travel time savings, route, and mode choice.
2. **Congestion,** including traffic and modal filtering, reallocation of road space, shared space and segregated lanes, active or low traffic neighbourhoods, queues, bus lanes; and
3. **Resilience,** including COVID-19 and pandemics; disruptive events such as mega-events, severe weather, fuel shocks, and transport strikes; bike sharing schemes; propensity to cycle, walk and wheel; access to facilities, education, and employment.

These strings were then used to search the Scopus bibliographic database, which is a large and comprehensive database of peer reviewed academic publications. Annex A provides an outline of the search strategies deployed and breaks down the number of results returned for each search string and in each database. The total number of studies identified as being potentially relevant was as follows:

- Sub-theme 1 (journey times): 2,186.
- Sub-theme 2 (congestion): 1,722.
- Sub-theme 3 (resilience): 214.

2.2.3 Grey literature search

To supplement the academic database search, a search of 'grey' literature was conducted across a range of relevant websites using the Google search engine. This applied a standardised set of search strings for all evidence assessments to identify further sources. The results were then manually screened by each theme to identify relevant evidence for inclusion in the full text screening stage. Theme leads coordinated to avoid including the same piece of evidence in multiple themes. For this theme, one additional report was identified for inclusion in the full text screening. A full list of the websites searched for grey literature is included in Annex A.

2.2.4 Suggested evidence

A final pathway through which evidence was identified was suggested evidence provided by experts at ATE and DfT. The stakeholder engagement stage included inviting suggestions of evidence that might be included in the assessment. For this theme, two papers were identified through this pathway.

2.3 Screening and extraction

2.3.1 Title and abstract screening

4,259 titles were initially screened. This process involved assessment of titles and the publication title against the inclusion criteria. Several rounds of refinement were required to exclude irrelevant articles or publications. All papers were considered against a prioritisation tool and checklist to ensure the final list of papers would address the research questions specifically. The criteria used at this stage were:

- Relevance to the theme and sub-themes.
- Geographic focus (aiming to identify UK based studies where possible).
- Paper type[12] (e.g. systematic review paper, primary research paper, literature review, discussion paper).
- Study/data type (aiming to prioritise inclusion of studies which used real-world data as opposed to modelled or synthetic data).
- Coverage across sub-themes (aiming for a pragmatic distribution of studies across the agreed sub-themes).
- Whether the study was specifically recommended at the stakeholder engagement stage for inclusion; and
- Age of the study (aiming to include most recent studies where possible).
- Age of the study (aiming to include most recent studies where possible).
- Following this screening process, 102 studies were accepted for full text review.

12 Systematic review papers were prioritised (where available) as these papers synthesise the available evidence on a topic or the effectiveness of an intervention by drawing on multiple primary research papers. This means that evidence from systematic reviews is more comprehensive and reliable than from individual studies.

2.3.2 Full text screening and prioritisation

100 papers went through full text review from the academic search. The additional source identified from the grey literature search and two from recommendations from ATE and DfT, all three were included meaning that 103 sources were taken to full text review.

A Weight of Evidence (WoE) approach was used to score evidence according to the quality of its research design and presentation of findings. This was assessed using the questions and scoring scheme set out in Table 4 to arrive at a final WoE score out of 14 for each candidate source.

Table 4: Weight of Evidence scoring scheme

Question	Score
Is there a clear statement of the aims/objectives or clear research questions?	1-4
Is the sampling strategy (or data selection strategy if not collecting primary data) clearly described and appropriate for the research questions/aims?	1-4
Is the method of data collection and analysis clearly described, and appropriate to answer the aims/research questions?	1-3
Are there any concerns regarding accuracy (e.g. discrepancies within the report)? (high score means no concerns)	1-3
Total Weight of Evidence (WoE) score	**4-7 (low)** **8-11 (medium)** **12-14 (high)**

2.3.3 Data extraction

Using the WoE scoring to prioritise the most robust studies, 26 papers were identified to extract data and evidence from. The full list of papers is shown in Annex B along with their WoE scores. An extraction framework was developed to organise the evidence extracted. The framework was structured thematically, to ensure a spread of papers across the sub-themes. Once extraction was complete, the evidence was summarised and synthesised for inclusion in this report.

2.4 Limitations of the research design

This was a focused evidence assessment. It drew on a limited number of sources in line with the available resource, using a systematic screening and prioritisation process. To draw more exhaustive conclusions a larger Rapid Evidence Assessment (REA) or systematic review would be required to ensure broader coverage of sources.

3. Journey times

This chapter examines the evidence about how active travel impacts on journey times. Within this broad topic, we summarise evidence relating to three themes that emerged from the literature included in the assessment:

- Modal shift and time savings.
- Active travel and commuting times.
- Shared-use roads and travel times.

Whilst all modes of active travel were considered in the evidence searches, there was a skew towards evidence on cycling (pedal cycling, e-bikes, bike-sharing schemes) reflected in the discussion below.

The evidence reviewed presents a mixed picture on whether active travel (cycling primarily) increases or decreases journey times. The findings from across the sources indicate that the impact of active travel on journey times is dependent on several factors including: the length of the journey being taken, the environment within which the journey is made (e.g. city centre) and travel infrastructure. A key finding is that longer journey times do not always deter people from choosing active travel options. Other factors influence active mode choices and the extent to which a longer journey time is tolerated, including the travel experience, climatic conditions, individual travellers' lifestyles and pre-dispositions.

The evidence for this chapter was identified in 13 sources, including both UK and international evidence. It draws on a range of primary and secondary analysis utilising a range of qualitative, quantitative and mixed-method approaches. The evidence taken forward for inclusion in this assessment was of the highest quality of the available evidence, but there are some acknowledged limitations. For example, some sources draw on small-scale qualitative approaches, non-representative surveys or evidence syntheses, rather than systematic reviews. Many of the research findings are also derived from context-specific case studies, including outside of the UK, and as such may be more limited in how generalisable the findings are to other contexts (such instances are highlighted). A recommendation, therefore, would be to carry out further higher quality mixed-method studies, within a UK context.

3.1 Modal shift and time savings

Several studies sought to identify the actual or potential time savings that can be made through a shift to active travel modes.

Evidence from one UK-based study suggests that there is significant potential for short car trips (under three miles) to be replaced by active modes, including when journey purpose and trip chaining is accounted for. Neves & Brand (2019) drew on in-depth observation of a purposively selected cohort of 50 residents in Cardiff (Wales). Data was collected through journey tracking (using personal GPS devices), seven-day travel diaries, and interviews over two seasonally matching seven-day time periods in 2011 and 2012. Taking account of constraints around trip chains and trip purpose, it was found that walking or cycling could realistically substitute for 41% of short car trips, which is equivalent to 4.5% of all car trips. This had the further potential to mitigate carbon emissions from car travel by 4.5%, or 1.15 kgCO_2e per person per week. Time constraints was however one of the main reasons that participants used their car over these short distances. Neves & Brand's (2019) study concluded that a high-quality walking and cycling infrastructure connecting Penarth and Cardiff

'Connect2' was unlikely (in part because of delays to implementation) to promote a mode shift away from private motorised transport sufficient to lead on its own to a significant reduction in carbon emissions.

An alternative (UK) perspective is provided by Ma & Jin (2024), who also point to the potential of walking and cycling infrastructure to reduce travel time. They used a land use-transport interaction (LUTI) model to compare the impacts of sustainable transport alternatives (metro, buses, and active modes) on time-saving benefits and mode shifts in Cambridge (UK). The modelling indicated that improving walking and cycling infrastructure (e.g. improving on-road cycle lanes and pavements) is by far the most effective for modal shift from the car and accruing the highest time-saving benefits (e.g. in comparison to the scenario where a metro was introduced or bus scenarios including doubling frequencies, introducing demand responsive buses, and the former plus the construction of a tunnel for buses through the city centre). Active travel infrastructure improvements were assumed to lead to a 10% increase in cycling and walking speed in the city. The modelling results suggest that, in the case of the study area of Cambridge at least, policies that promote active modes appear to be the most promising in reducing car trips with the highest time-saving benefits findings that might hold some applicability to other small cities.

Using Seattle (US) as a case study, Fan & Harper (2022) similarly suggest potential positive impacts on journey times if a proportion of short car trips were replaced by micromobility modes (shared bikes). They simulated the 3-4pm peak hour under normal conditions and assessed improvements in link performance as short vehicle trips were replaced with micromobility. The simulation drew on a large-scale household travel survey and showed that at a 10% micromobility uptake, speeds on most roadways increase between 0% and 1%. The modelling also suggested that urban arterials (broadly analogous to British A-roads)[13] tend to benefit more from short car trip replacement than do freeways/expressways (analogous to motorways), in terms of both link travel time and speed (0.6% and 1%, respectively, at the upper bound uptake rate). This is because most short vehicle trips occur on urban arterials and as a result these facilities experience greater benefits as short car trips are removed from the road network and replaced with micromobility modes. Fan & Harper (2022) suggest that greater speed and travel time benefits could be achieved as more dedicated bike lanes are deployed.

An article by Teixeria et al. (2021) synthesising evidence from 77 studies on the impacts of implementing a bike-sharing scheme indicated that modal shifts to bike-sharing could reduce travel times and, in turn, enable significant economic gains (see section below). Evidence from the review includes the following:

- 68.2% of Lyon's bike-sharing trips were shorter than car trips, leading to an average distance reduction of 13%. Users were reaching average speeds of 14.5 km/h in the morning rush, close to the average car speeds in European urban cores (Jensen et al., 2010).
- Woodcock et al. (2014) estimated an average 20% reduction in travel times for journeys shifting to London's docked bike-sharing scheme and using hire bikes.
- Comparing origin-destination pairs and travel times between bike share schemes and taxis in New York City, FaghihImani et al. (2017) discovered bike-sharing to be either faster or competitive with taxis for more than half of the origin-destination pairs within distances less than 3km.

13 'A roads' are major roads intended to provide large-scale transport links within or between areas (Department for Transport, 2012).

- Bullock et al. (2017) estimated that Dublinbikes' (Dublin's docked bike sharing scheme) modal shift from walking provided significant trip time savings leading to connectivity and accessibility improvements between home/public transport stations and workplaces.

A study by Curl (2018) revealed differences between objective and self-reported journey time measures that are likely to have an impact on travel choices. Curl suggests that differences can occur either because objective measures do not reflect the lived experience of different social groups very well or because of misperceptions. Car users perceive walking times for the same journey to be longer than they are. Although modal shifts may come with time saving (as well as other) benefits, uptake may depend on an individual's socio-cultural location, predispositions and (mis)perceptions of travel times.

Reducing travel times is a key rationale for the introduction of Low Traffic Neighbourhood (LTN) schemes. A review of LTN schemes for DfT (Ipsos, 2024) suggests that the impact of LTNs on time spent travelling actively is unclear with the evidence pointing to both increases and minimal change. There is also uncertainty about whether positive evidence of increases in active travel are due to higher numbers of people walking or cycling or an increase in the amount of time spent on active travel among those already engaged. The review which included a survey of residents living within four scheme areas, found that around six in ten residents believed that having an LTN within their area had made no difference to how often they use various modes of transport; 36% thought the LTN had increased journey times to frequently visited places. Over three quarters (77%) of disabled residents reported an increase in journey times due to the introduction of LTN schemes and 46% reported that their journeys had become more difficult.

This evidence suggests that modal shifts or the implementation of AT infrastructure can have significant time-saving benefits in some circumstances, but that this potential is not always realised in practice due to context specific factors such as connectivity and synergies with other transport modes, as well as individual and socio-cultural factors). These assumptions are often based on modelled data or studies drawing on only limited data sources. Further high-quality studies that evaluate the actual impact of modal shift to active travel on journey times are required.

3.2 Active travel and commuting times

Several studies included in the review examined the impact of active travel choices on commuting journeys specifically, and the implications of this on commuting times. The evidence from these studies suggests that active travel has the potential to reduce commuting time (particularly those commutes which involve shorter trips within city centre locations), but that mode shifts from cars to cycling or e-bikes over longer distances are likely to increase commuting time, whilst also increasing satisfaction with the journey and reliability. Evidence also suggests that increases in commute time do not necessarily deter people from choosing active travel options for commuting; and that positive travel experiences also play a key role. Increases in journey times associated with active travel such as e-bikes might therefore be offset (for some, but perhaps not others) by positive travel experiences. A major development in active travel over recent years has been the growth of e-biking. E-bikes makes it possible to cover longer distances at higher speeds with reduced physical effort and have emerged as a realistic active travel alternative for commuting. Plazier et al. (2017) examined the commuting behaviour of a sample of 24 e-bike users in the Netherlands by tracking individual use using GPS for two weeks and following up with in-depth interviews. They found that out of 1,090 trips measured, 305 were commuting trips. Of these commuting trips, 63.3% (n=193) were made by e-bike, followed by car (28.2%) and bus (6.2%). Most work-related journeys with work as the single destination were made by e-bike (72.6%), followed by car (20%), bus (6%) and train (2%). Comparison of average commuting distances showed that e-bike trips to work covered an average of 14.1 km; longer commuting distances were covered by bus, car, train and motorbike in increasing order of distance. While e-bike commutes were shorter in distance, they took longer (M = 46 min) than travel by car (M = 29.7 min), and about as long as travel by bus (M = 46.6 min). Despite this, active travellers were more satisfied with their commute time; equal or longer travel times for commuting did not deter them from using an e-bike instead of car.

Qualitative insights from Plazier et al.'s (2017) study highlighted positive experiences underpinning e-bike commuters' mode choice and toleration of longer journey times. This included: enjoyment of the cycling route and surroundings; being outdoors and breathing fresh air; engaging in physical activity; and independence from carpooling or public transport schedules. These factors associated with the travel experience were valued more highly than travel time and speed. Preferences for car use were driven largely by two factors: participants' daily agendas (e.g., the need to combine activities in limited amounts of time) and the weather (rain was a major influence, heavy showers in particular). This latter finding echoes those from other studies which indicate that cyclists are the most susceptible to commute mode change when weather conditions deteriorate (Nahal and Mitra, 2018; Loong & El-Geneidy; 2016; Liu et al., 2015). The extent to which Plazier at al.'s (2017) findings are applicable to commuters living elsewhere might be limited e.g., high levels of cycling are already in place in the Netherlands, compact urban areas, relatively low travel distances, the quality of cycling infrastructure, the flat topography and an associated cycling culture finding.

Another study also challenges common assumptions that travellers (including commuters) strive for the shortest possible travel time. Drawing on app-based journey tracking (186 users making 4397 trips) in the Washington D.C. and Blacksburg, VA (US), Le et al. (2020) studied the differences between ideal and actual journey times and found that for all travel modes studied (car, bus, walking, bicycle) ideal times were consistently lower than the actual times experienced, which is unsurprising. For commuters, the mean actual commute time was greater than the mean ideal commute time by 11 minutes (28 versus 17 minutes). Notably, they also found that the difference between ideal and actual journey times (termed 'desired travel time saving') was much lower for walkers and cyclists generally (not just for commuting). This suggests a greater travel time satisfaction for those modes as users do not desire substantially lower travel times than the actual times they experience owing to the 'positive utility of travel'. Despite some limitations, Le et al.'s (2020) research suggests that transport appraisal practice may overestimate the value of travel time savings if it does not account for factors beyond travel time and monetary cost.

Although commuting by e-bike can increase journey to work times, the opposite is also true. Evidence from Both et al. (2022) suggests that shifting to walking or cycling can increase the number of commuters who are able to reach their workplaces within 30 minutes. Drawing on 2016 Australian Census data, Both et al. (2022) explored if people living within an accessible catchment in Australia's largest 21 cities shifted to an alternative mode, what percent could reach their current workplace within 30 minutes by each transportation mode. In these cities, commuting by driving was by far the most popular mode (79.3% overall) and cycling was the least popular mode (only 1.1% of Australian workers commute to work by bicycle). It was shown that, even if all workers were able to switch to an active transport mode, and if nothing else changed, 70.5% of workers would still have workplaces located further than 30 minutes away. However, a mode shift to cycling would, of all modes, enable the largest number of workers (an additional 28.6%) to reach their workplaces within 30 minutes. Only an additional

5.8% of workers could reach their jobs within 30 minutes by shifting mode to walking. These modelled estimates were based on the distance to workplaces and relied on inferred travel speeds across different modes. They did not account for the conditions or built environment and is unlikely to reflect accurately the differences in speeds relating to fitness levels or disabilities.

Another study based on a survey of commuters travelling to a university campus in Montreal (Canada) indicated that travel mode is the greatest determinant of how much additional time an individual allocates for their commuting journey, thereby increasing travel times. It found that drivers budgeted more additional travel time than other travellers to accommodate journey unreliability. Holding other things equal, pedestrians, cyclists, and public transport users budget 66%, 55% and 29% less additional time, respectively, as compared with drivers to accommodate journey unreliability (Loong & El-Geneidy, 2016). This finding suggests that active transport networks have greater travel time reliability than the street network for drivers and that less unnecessary time is lost due to travel time unreliability.

Data also indicated that those who enjoy traveling by a particular mode assign extra time in their commute (the models for pedestrians and cyclists predict increases of 17% and 18%, respectively). Furthermore, pedestrians and cyclists allocate more buffer time to their journeys for every additional ten minutes they add to their journey time. Modelling predicted an increase of 26% (pedestrians), 24% (cyclists), 9% (public transport users) and 15% (car drivers) of buffer for every ten minutes in travel duration. This finding may signify that the design of the street network in Montreal is inefficient for pedestrians and cyclists, more so than for motorised vehicles. For instance, depending on the location, the street network may offer more direct routes for drivers compared with cyclists and pedestrians, who may be required to take a detour. A key limitation of this study is the narrow demographic and geographic specificity.

3.3 Shared-use roads and journey times

High volumes of cyclists can cause delays to buses where road space is shared, and three sources included in the review provided evidence about how the interaction of bikes with other vehicles at peaks times impacts journey times.

It is likely that where cyclist volumes are very high (substantially more than 100 per hour) this causes delays to buses. In London and some other towns and cities in the UK, these cyclist volumes are already observed at peak hours on key bus routes, but associated delays are not fully understood. In countries with higher levels of cycling, such as Denmark and the Netherlands, bus lanes are not generally seen as cycle infrastructure, although cyclists may at times share space with buses, for example in city centres with restricted car access, which suggests that these conflicts are generally avoided. Aldred et al. (2019) modelled movements across London Bridge to examine the interaction between buses and cyclists in a bus lane, with two further general traffic lanes also being in place. Travel time data were collected for all buses, between two (southern and northern) bus stops. The study showed that buses travelling northbound are impacted significantly by cyclists at current peak flows, with an 18% median increase in journey time at peak hour along this route segment, compared to there being no cyclists present. Given this is a short and simple route segment, containing for instance no intersections, it is not possible to extrapolate across the network.

Studies that examine the impact of cycling on shared roads reveal mixed findings. Another study in Aberdeen (Scotland) tested whether cyclists interfere with and slow down traffic, given basic assumptions around the distribution of trip destinations and origins, driver behaviour, road capacities and speeds, and travel demand. Through agent-based modelling, it was shown that cyclists sharing roads with cars did not lead to longer commute times or larger commute time variability for cars (Ge & Polhill, 2016).

The FLOW Project (2016) report on urban measures to tackle congestion examines the impact of an innovative signalling device ("the green wave") which was installed at 13 signalled junctions in Copenhagen in 2004. The measure helped to indicate to approaching cyclists if their current speed was appropriate to reach the next green light rather than being forced to stop at a red light. Measures of travel times, speeds and number of stops in the morning peak hours showed that cycle trips to the city centre became faster: the average speed increased from approximately 15 km/h to almost 21 km/h whilst car traffic towards the city centre was almost unaffected.

A further report included in the review compiled a portfolio of measures to describe the effects of different types of interventions on journey times and congestion (FLOW Project, 2016). One of the studies looked at the impact of a protected bike lane on a major avenue in Manhattan. Data from the New York City Department of Transportation suggested that the average car took about four-and-a-half minutes to go from 96th to 77th streets before the bike lanes were installed in 2010-2011, and three minutes afterward – a 35% decrease in travel time. This was true even as total vehicle volume on the road remained constant. The study suggests that the better traffic flow for cars comes partly as a side benefit from a safety feature added with the bike lanes. Cars turning left now have pockets to wait in to reduce the risk of conflict with a cyclist riding straight, without blocking traffic as they wait.

In summary, whilst the evidence of the impacts of cycle usage on other traffic speeds seems mixed, cycling volumes, the design of specific schemes (especially how cyclists may be treated at junctions) and – critically whether cyclists share the roadway or have segregated lanes, are important determinants of the impact on journey times.

4. Congestion

This chapter reviews evidence of the impact of several key strategies aimed at addressing congestion through active travel modes and urban planning interventions. It focuses specifically on the relationship between active travel and congestion. We summarise evidence relating to five interventions:

- **4.1 Bike-sharing systems.**
- **4.2 Electrically powered micro personal mobility vehicles (e-PMVs).**
- **4.3 Cycle lanes.**
- **4.4 Road space reallocation.**
- **4.5 Cycling incentives.**

The interventions discussed below offer promising strategies for addressing congestion. Bike-sharing systems, through their ability to replace car trips and encourage cycling, have demonstrated effectiveness in reducing congestion levels. Electrically powered micro personal mobility vehicles (e-PMVs), such as e-bikes and e-scooters, contribute to congestion alleviation by offering alternative modes of transportation that can substitute for car trips and complement existing public transit systems. Additionally, interventions like bike lanes, road space reallocation, and cycling incentives play significant roles in promoting active travel, reducing reliance on motor vehicles, and ultimately easing congestion on urban roads.

However, while these interventions show promise, further research is needed to fully understand their impacts on congestion and transportation systems. Studies with high-quality methodologies, including pre/post comparisons and control groups, are necessary to accurately assess the effectiveness of these interventions in reducing congestion. Considering the complex interactions between different transportation modes, future research should explore how these interventions interact with one another and with existing transportation infrastructure to maximise their congestion alleviation benefits.

4.1 Bike-sharing systems

Bike-sharing systems have emerged as a promising solution for urban transportation issues, offering an alternative to more polluting forms of travel and with the potential to reduce congestion on urban roads. These consist of the short-term renting of bicycles distributed across a network of stations (docked systems) or predefined operational areas (dockless systems). Our review included analyses of various cities' bike-sharing initiatives, revealing positive effects on motor vehicle use and congestion levels.

Some studies show that the increased use of shared bikes can alleviate congestion on major urban roads. For instance, in their study in Seattle, Washington (US), Fan & Harper (2022) explored the environmental and congestion benefits of micromobility options like shared bikes. Using a static traffic assignment model and drawing on a large-scale household travel survey (n=6,000), they simulated the 3-4pm peak hour under normal conditions and assessed improvements in link performance as short vehicle trips were replaced with micromobility. They found that more people using micromobility like shared bikes led to less congestion, as a larger portion of urban arterial links became less congested. For instance, if 10% of people were to switch to micromobility, there would be a 3% decrease in the number of main roads with moderate congestion and a 1.5% decrease in those with severe congestion. Meanwhile, the number of roads without congestion would increase by about 0.5%. The study found that with this level of micromobility use, travel speeds would either stay the same or increase slightly by up to 1%.

Bike share is also shown to be effective at replacing car trips. Fishman et al. (2014) explore the relationship between car-based modal share and the effectiveness of bike share programmes. By drawing on Census data, they compare commute transport patterns for Melbourne, Brisbane, Washington D.C., London and Minneapolis/St. Paul and distinguish between high and low car use cities. Brisbane, Melbourne and Minneapolis have between 70% and 76% of residents who travel to work by car (high car use). In comparison, London and Washington D.C. have low car use, with only 36% and 46% of residents respectively travelling to work by car. It is observed that cities with a higher reliance on cars for commuting, such as Brisbane, Melbourne, and Minneapolis, experience greater rates of car mode substitution by bike share users, ranging from 19% to 21%. In contrast, cities with lower car use, like London and Washington D.C., exhibit significantly lower substitution rates, at 2% and 7% respectively. This correlation suggests that bike share systems are more successful in replacing car trips in cities where car use is more prevalent, possibly due to the greater convenience and necessity of alternative modes of transportation. It was shown that in general the net impact of bikeshare schemes (once the vehicle use required to manage the schemes themselves are accounted for) is a positive one, with between 2-4 km of private car use avoided per km travelled by bike share. An exception to this was London where a car mode substitution rate of 2% and heavy demand for bicycle redistribution across docking stations meant that there was approximately 2.2km in motor vehicle support service travel for each kilometre of private car use avoided.

Other studies show that bike sharing can play a prominent role in encouraging and normalising cycling. Within a systematic review of evidence, it was shown that an increase in overall cycling levels can occur after the implementation of a bike sharing system. For example, Molina-García et al. (2015) noted that cycling among university students rose from 7% to 11% within 8 months of a bike-sharing system's introduction in Valencia (Teixeira et al., 2021). However, equity assessments from the UK and North America revealed that the most disadvantaged groups (including low-income, less educated and minority ethnic groups) are systematically under-represented among bike-share scheme users. Much of this is due to a lack of awareness, with it being less likely that friends or family would be using the systems and having less access to the Internet and smart phones (Teixeira et al., 2021).

In summary, the literature reviewed shows that bike sharing systems can be effective in reducing car trips and alleviating congestion. However, their effectiveness was also shown to rely on factors such as local commuting patterns and the operational dynamics of the programmes themselves. There remains a gap in high-quality pre/post studies of the impacts of bike-sharing. A recent review notes that most studies use cross-sectional designs, lack experimental setups with before-and-after comparisons and control groups, and as such, tend to overstate the environmental benefits of bike-sharing on the assumption that all or most bike-sharing trips are replacing car journeys (Teixeira et al., 2021). Future research including regular surveys, combining online and intercept methods, could mitigate these limitations and provide more comprehensive insights on the role of bike sharing in transportation systems.

4.2 Electric micro personal mobility vehicles (e-PMVs) and mode substitution

E-PMVs – including electric scooters (e-scooters), e-bikes and self-balancing vehicles – are gaining popularity as a sustainable transport mode in urban contexts. This review examined evidence on e-bikes and e-scooters respectively, in terms of how they impact transportation modes through mode substitution (the shift from using one mode of transportation to another). Inclusion of this was motivated by the hypothesis that, as with bike-sharing systems (see section 3.1), shifts to e-PMVs may help to alleviate congestion by reducing the number of vehicles on the roads.

E-bikes are mostly used to replace public transport (33%), followed by regular bikes (27%), cars (24%), and walking (10%) according to a review of 24 studies published between 2006-2019 (Bigazzi & Wong, 2020). Using regression models derived from the 24 studies, they found that mode substitution is also affected by whether e-bikes are owned or rented. Privately owned e-bikes exhibit a lower probability of replacing walking journeys, indicated by a notably low odds ratio of 0.23. In contrast, rented or loaned e-bikes demonstrate a higher probability of substituting walking trips, suggesting a more frequent usage pattern for shorter, recreational outings or local trips. In other words, people tend to use their own e-bikes for longer, practical trips like commuting, while rented ones are often used for shorter, leisurely rides (Bigazzi & Wong, 2020).

Bigazzi & Wong (2020) found that in more recent years, more people who drive or walk are choosing to switch to e-bikes, compared to earlier when most e-bike users were regular cyclists. Using regression models, they find that more recent studies of e-bike adoption report greater displacement of driving (with an odds ratio of 1.11 per year) and walking (odds ratio of 1.08 per year) and less displacement of conventional bike trips (odds ratio of 0.89 per year). This shift suggests that most new e-bike users were drivers and pedestrians, rather than people who already cycled a lot. In policy terms, this suggests an opportunity to encourage more drivers and pedestrians to switch to e-bikes rather than conventional cyclists.

Weschke et al. (2022) focus on shared e-scooters and mode substitution. Through a survey of 605 users of shared e-scooters in Germany, they examine the impact of shared e-scooter usage on transportation modes. Half of survey respondents experienced no change in their public transport use, 45% reported a decrease, and a small fraction (5%) noted an increase. This trend suggests a potentially negative impact of shared e-scooter usage on public transport ridership.

The adoption of shared e-scooters resulted in a notable number of other mode substitution patterns. Approximately 43% of trips were substituted from walking, followed by around 19% from public transport. E-scooters replaced bicycles in roughly 11.5% of cases, nearly equal to the percentage of car trips replaced, which stood at 11.2% (Weschke et al., 2022). The study concludes that the relationship between shared e-scooters and public transport remains ambiguous, with uncertainties regarding whether shared e-scooters compete with or complement public transport. This underscores the complexity of interactions between different transportation modes in urban settings.

While the above studies show that e-PMVs facilitate mode shifts away from more polluting private vehicles in some cases, further research is warranted to fully understand their role in urban transportation systems, including how they interact with public transport and other modes, and their direct effects on congestion.

4.3 Cycle lanes

In urban environments across the world, cycle lanes have been proposed as a solution to various transportation challenges, including congestion.

In an evaluation of cycle lanes in two locations in Washington D.C., Goodno et al. (2013) identify several outcomes associated with their implementation, ultimately finding that the facilities provided greater protection and convenience for cyclists without a negative impact on other modes in the vicinity of the intervention. Their study focuses on two bicycle facilities that were installed in the city in 2010: buffered centre median bicycle lanes on Pennsylvania Avenue, NW; and a two-way cycle track on 15th street, NW. Both facilities included dedicated road space with buffers between cyclists and motor vehicles, signal control and signs and pavement markings.

First, bicycle and motor vehicle volumes were analysed before and after installation of the facilities. This revealed that the installation of the bike lanes led to a notable increase in cycling levels along the intervention corridors. Afternoon peak hour bicycle volumes increased more than 500% at count locations on 15th street and more than 250% on Pennsylvania Avenue (between April 2010 and June 2012). These levels increased at a 'substantially higher rate' than in the rest of Washington D.C. during the same period, highlighting the effectiveness of bike lanes in promoting active travel (Goodno et al., 2013: 144).

Further, the study claimed that the new bike lanes did not adversely affect other transport modes, with motor vehicle volumes remaining relatively constant before and after the facilities were installed. However, whilst trends were compared against city-wide averages, the lack of comparison with counterfactual streets means displacement effects cannot be concluded. Moreover, the nature of the streets - with 8 traffic lanes remaining on Pennsylvania Avenue, and three traffic lanes and two parking lanes remaining on 15th street - mean the relevance of the findings to UK streets, which typically have fewer lanes, may be limited.

In other studies, protected or segregated bike lanes are shown to have positive effects on bicycle use and alleviation of congestion. Drawing on revealed and stated preference data from the UK (including from the representative National Travel Survey), Wardman et al. (2007) develop and apply a hierarchical logit mode[14] to forecast trends in urban commuting over time and to predict the impacts of different measures to encourage cycling. Their forecasts suggest that in the most favourable modelled scenario, where all cycle time is spent on a completely segregated cycleway, 9% of commuters are forecast to cycle to work (a 55% increase from the base case), and there would be a 3% reduction in car use. This can perhaps be interpreted as providing an indicative upper limit of the extent to which cycling (specifically, segregated bike lanes) could be expected to reduce motor vehicle traffic.

A study on protected bike lanes in Seattle, Washington (US), simulated the effects of incorporating micromobility options on congestion (Fan & Harper, 2022). They found that if protected bike lanes were available for all short trips (less than three miles) between origin and destination points, the reduction in congestion could be twice as much compared to the baseline scenario. However, they also note that whilst there are some congestion benefits from replacing short car trips with micromobility, these trips still affect the flow of traffic due to the sparse deployment of dedicated bicycle infrastructure throughout the city, indicating that wide-scale deployment of bike lanes is needed to maximise congestion benefits.

14 A type of regression model that was used here to analyse revealed and stated preference data simultaneously.

In summary, the evidence suggests that bike lanes offer a promising solution to urban congestion by encouraging active travel and reducing reliance on motor vehicles. Studies demonstrate significant increases in cycling levels along designated corridors post-bike lane installation, without adversely affecting other transport modes. Research also suggests that segregated bike lanes could substantially increase cycling commuters, potentially leading to a significant reduction in car usage. Simulations further indicate that widespread deployment of protected bike lanes could effectively double congestion reduction. These findings demonstrate the importance of further developing bike lane networks to maximise congestion alleviation benefits.

4.4 Road space reallocation

Road space reallocation, which involves re-distributing space away from motor vehicles and towards other uses, has been shown to promote shifts to more sustainable travel modes and lead to decreases in traffic congestion.

Grahn et al. (2021) assessed the societal impacts of a 'complete streets'[15] retrofit in a mixed urban corridor in a Pittsburgh university campus to find that it led to decreases in traffic and increases in cycling while not affecting traffic speeds nearby. The retrofit included a reduction in road space for cars and the addition of two bike lanes. After the retrofit, weekday traffic volumes over two 3-week periods in spring and autumn decreased by between 11-31% during peak AM and PM hours. Average bicycle counts grew from 5 to 13 bicycles/hour during the morning peak (+160%) and from 10 to 38 bicycles/hour during the evening peak (+280%). Traffic speeds on a nearby parallel corridor were shown to be unaffected. An inference can be made that users were likely switching modes instead of using alternative routes. While bus ridership was also shown to have increased following the complete streets retrofit, the authors note that it is difficult to attribute the increase to the project itself.

Emerging evidence suggests that the introduction or expansion of pedestrianised zones in urban areas may also alleviate congestion; although with an absence of robust evidence, it is difficult to confirm this assertion. One such example is that of Slovenska Street, a main traffic artery in Ljubljana, Slovenia. In 2013, a core part of Slovenska Street that is usually heavily congested was closed to motorised vehicles and made accessible only for pedestrians, cyclists and public transport (FLOW Project, 2016). Although an absence of methodological detail means that it is impossible to assess its validity, data from Ljubljana city administration indicates that the extension of the pedestrianised zone contributed to a reversal of trends for increasing car use and decreasing walking: car use decreased from 58% (2003) to 51% (2013). It is assumed therefore that the introduction and enlargement of the pedestrianised zones contributed to a relief in road traffic and in turn congestion (FLOW Project, 2016).

Research for DfT (Ipsos, 2024) into the impact of LTN schemes (which included an evidence review and survey of residents living in four LTN areas) found that 41% of residents believed that traffic congestion and queues on nearby roads had increased since the introduction of the existing scheme. Yet a review of existing evidence suggested that seemingly mixed effects of LTNs (whether positive or negative) on boundary roads are minimal, suggesting some discrepancy between measured and perceived impact.

15 A 'complete streets' retrofit involves redesigning and updating existing roadways to accommodate all users safely, by incorporating features such as bike lanes, wider pavements, and improved crossings.

Whilst temporary road space reallocation measures introduced during the COVID-19 pandemic were common in the UK and throughout the world, it is difficult to draw more general conclusions from these given that they were temporary in nature and installed concurrently with other shifts in travel behaviour as a result of stay-at-home mandates and guidance to avoid public transport). The impact of such temporary schemes on traffic congestion or bus journey times cannot be concluded robustly given short-term reductions in those modes during periods of lock-down (and to some extent beyond). The role of the COVID-19 pandemic on transport resilience is covered in more detail in chapter 5.

4.5 Cycling incentives

The promotion of cycling is widely recognised as a valuable strategy for alleviating urban congestion. According to a survey of urban transport practitioners and researchers (n=63), 87% regarded the promotion of cycling as important or very important for relieving congestion (FLOW Project, 2016).

Efforts to promote cycling as a means of reducing urban congestion encompass various strategies, including the implementation of free bike schemes. Modelling undertaken to examine the impact of financially rewarding commuters for cycling to work showed that a payment of £2 per day almost achieves a doubling of the amount of cycling, yielding a 5.4% reduction in car demand (Wardman et al., 2007). When a package of measures is considered, including modest financial incentives, cycle facilities for around half the journey to work and good parking and shower facilities at work, cycle emerged as a much more significant mode and has an appreciable impact on car share. This modelling drew on revealed and stated preference data from the UK (including from the representative National Travel Survey).

The loaning of free bikes to alleviate congestion caused by a major city centre construction project in Bordeaux, France helped grow the use of cycling, from 1-2% to 9% in the city centre and to 4% in the periphery of the metropolitan area (FLOW Project, 2016). However, the source and validity of these findings are not discussed within the report.

5. Resilience

This chapter focuses on active travel and resilience, both in terms of the resilience of active travel systems to certain shocks and disruptions (COVID-19, disruptive events such as public transport withdrawal and adverse weather), and with respect to active travel systems providing resilience in themselves (such as to fuel price shocks).

Studies show that active travel, such as biking and walking, saw increased usage during the COVID-19 pandemic, particularly when public transport services were reduced. Though in response to other disruptive events, such as major public transport withdrawal, studies found that the potential for switching to non-motorised modes (walking and cycling) is highly affected by the distance that would need to be travelled. The chapter discusses how weather conditions impact active travel, with dedicated cycling infrastructure supporting winter cycling and better weather reducing travel time for pedestrians and cyclists. Moreover, the chapter draws on evidence to show that areas with well-developed active travel infrastructure are more resilient to fluctuations in fuel prices, emphasising the importance of investing in non-motorised transportation options.

5.1 Changes to access to transport due to COVID-19 and the lockdown

Two studies within the review provided evidence regarding the resilience of active travel systems in the face of COVID-19.

Qian et al. (2023), using spatial and visual analytics, focus on bike sharing ridership of a bike sharing scheme in San Francisco, US. Ridership of the bike sharing programme increased at the start of the pandemic before the implementation of the stay-at-home order on March 19, 2020. Subsequently, with the reduction in public transport services on April 10, 2020, ridership increased once more, particularly among individuals who previously relied solely on transit.

After transit services were disrupted, the distance between bikeshare stations and transit stops increased notably. This led to a higher number of bikeshare trips shifting from being feeder trips for transit, to replacing transit altogether.

The study also showed that during the COVID-19 pandemic, bike trips expanded away from the city centre, in contrast to pre-pandemic norms. This was seen to reflect the ‘shelter in place’ order that was introduced in response to COVID-19. Weekend recreational trips also increased during this time, as people sought to enhance their emotional well-being during the pandemic.

The second study consists of a systematic review of 36 scientific publications related to commuting during the COVID-19 pandemic (Zarabi et al., 2024). The study found that globally, a reduction in public transport services and concerns surrounding COVID-19 led to significant shifts away from public transport towards private car use and active travel among pandemic commuters. This public transport avoidance was more likely to be pronounced among those with pre-existing car use habits and heightened fear around health risks resulting from proximity to other people.

There is a need for further robust evidence on the adaptability and resilience of active travel systems and practices in response to disruptions such as that caused by the COVID-19 pandemic. While the first study suggests that bike-sharing systems may offer a reliable alternative during periods of disruption, it was limited to a particular bike-sharing scheme in the US.

5.2 Disruptive events

Nguyen-Phuoc et al. (2018) conducted a study into the responses of public transport users to the removal of public transport services for a day using self-reported responses and an online questionnaire (640 respondents). Findings showed that in the event of a major public transport withdrawal in Melbourne, Australia 52% of respondents would switch from public transport to become a car driver, 11% would switch to car as a passenger and 5% would shift to taxi/Uber. More than 13% of public transport trips (with an average travel distance of 17km) would be cancelled. Out of the 176 respondents who travelled less than 5 km, a relatively high proportion (46%) would shift to non-motorised modes (cycling and walking) while only 9.1% would cancel their trips. Short distance trips would be conducted by cycling (average travel distance of 5.6 km) and walking (average travel distance of 3.7 km). The majority of respondents (73.7%) who already access public transport stations by car would switch to a car as a driver while only 4.1% of those would shift to non-motorised modes. This study demonstrates that the potential for switching to non-motorised modes (walking and cycling) in the event of a public transport disruption is highly affected by the distance that would need to be travelled.

5.3 Response to fuel price fluctuations

The availability of active travel systems and infrastructure is an important element in the resilience to fuel price shocks. Areas with better active travel infrastructure are found to be more resilient to fuel price fluctuations. The availability of ‘environmentally friendly transportation options’ such as walking, wheeling and cycling was one of the three factors deemed important for resilience to sudden fuel price increases (alongside household proximity to the town/city centre and household income) in Bronson & Marshall’s (2014) study based on modelled data of Denver, Colorado. Notably, the impact of these alternative transport options was most significant in areas with low-stress environments, where infrastructure is more developed and vehicle volumes and speeds are lower.

Based on these findings, Bronson & Marshall (2014) recommend that to build more resilience into communities and neighbourhoods, policymakers and leaders need to improve accessibility to low-stress alternatives to driving, particularly in areas with lower-income households and those further from the central business district.

5.4 Weather

Evidence about the resilience of the active travel infrastructure in the context of incremental weather conditions emerged in two of the studies reviewed. Through well-organised snow clearance and good quality bicycle infrastructure, winter cycling is better supported in countries such as Denmark, the Netherlands and Sweden; the influence of bicycle infrastructure in mitigating barriers to winter cycling, in other contexts is less well understood (Nahal & Mitra, 2018). In Nahal & Mitra’s (2018) study of commuters to a university campus in Toronto (Canada) and drawing on a university-wide transport survey, they found that dedicated cycling infrastructure is important for supporting winter cycling. Existing cyclists were more likely to continue to cycle through the winter months where there was a higher amount of dedicated bicycle infrastructure close to their shortest route to campus. An odds ratio of 1.57 indicated that there was a higher probability of cycling in all seasons where this was the case. In contrast, dedicated infrastructure along the entire route was found not to be statistically significant, highlighting the importance of some infrastructure provision whilst maintaining a direct route.

Weather conditions also impact on the time people allocate for their journeys. In Loong & El-Geneidy's study (2016), better weather conditions led to a reduction in additional budgeted time for public transport, and active modes to a lesser extent. Modelled estimates using data from commuters to a university campus in Montreal (Canada) showed that good weather in general is shown to reduce additional budgeted time for a commute. Although the models predict a reduction in allocated extra time of 2% for pedestrians and 7% for cyclists, the impact of good weather is most pronounced and only statistically significant for transit users, predicting a decrease in buffer time by 11%. This finding could imply that among the different transportation networks, the stability of the public transportation network is the most affected by weather conditions.

6. Key determinants of and barriers to participation in active travel

In assessing the evidence of the impact of active travel on journey times, congestion and resilience, several key determinants of and barriers to active travel participation were noted. These are summarised as follows:

6.1 Key determinants

- **The active travel environment.** Positive experiences of active travel routes and their surroundings are an enabling factor.
- Active travel may be particularly attractive to commuters who may value **independence** from collective forms of transport (e.g. car sharing or public transport). This may be important for transport users such as disabled people, who may face specific difficulties or have concerns about using vehicles that are poorly adapted to their needs, or who have safety concerns, or concerns about missed timetable connections.

6.2 Key barriers

- **Time constraints** are found to be a key barrier to active travel. These are experienced differently across different population groups, with trip chains involving taking children to childcare or education settings or leisure activities, and food shopping disproportionately being undertaken by women.
- **Accessibility**. Awareness of interventions can vary by demographic e.g. although studies find that an increase in the use of micromobility (e.g. shared bike or scooter schemes) can have an impact on reducing congestion, these modes are not equally accessible to all population groups. Equity assessments from the UK and North America revealed that the most disadvantaged groups (including low-income, less educated and minority ethnic groups) are systematically under-represented among bike-share scheme users.
- Although **shared use** of the roadway by cyclists does not generally impact on vehicle speeds and flows, shared routes are not equally attractive to, or appropriate for, all population groups.

7. Limitations

Walking, wheeling and cycling were all considered in the evidence searches. However, there were several limitations with the present assessment of evidence. A key limitation of many of the studies included in this review is their reliance on context-specific case studies, often conducted outside the UK. This geographic specificity limits the applicability of some of the findings to other contexts, including the UK. The narrow demographic focus of other studies poses a further limitation. Another limitation of the evidence is the skew towards cycling. While all modes of active travel were included in the evidence searches, there was a disproportionate focus on pedal cycling, e-bikes and bike-share schemes in the evidence reviewed. E-assisted modes beyond e-bikes, including e-PMVs such as e-scooters, were also included in some studies despite not being directly searched for, as these don't fit within the standard definition of 'active travel'. Such e-assisted modes are frequently, but imprecisely, conflated with e-bikes in the literature. Whilst they have been included due to the relevance to a focus on congestion, resilience and journey times, conclusions on the contribution of those modes should be considered tentative.

Other forms of active travel, such as walking and wheeling, were underrepresented. Studies examining the direct effects of active travel on journey times, congestion and resilience are also limited. Several of the studies reviewed, for instance, show only how interventions such as bike-sharing schemes or e-PMVs indirectly impact congestion by displacing car journeys or reducing the number of vehicles on the roads.

The robustness of the methods employed by the included studies varied significantly. Some relied on relatively small sample sizes (in the context of survey methods), while others employed self-selection convenience sampling, introducing the risk of response bias. The timing of data collection posed another methodological limitation. Some studies were based on what would now be considered relatively dated datasets, hence the applicability to current active travel landscapes may be limited. Some studies were conducted during specific seasons or times of the year, potentially influencing participant behaviours or perceptions.

The transparency of study methodologies also varied. Some studies provided only limited information on, for instance, inclusion and exclusion criteria, and sampling, making it difficult to assess robustness.

8. Conclusions

This report provides valuable insights into the impact that active travel has on journey times, congestion, and resilience, along with highlighting gaps and limitations in terms of the evidence base.

This evidence assessment has attempted to answer the following research question:

RQ1. What impacts does active travel have on journey times, congestion, and resilience of the travel network? Including:

- Journey times and traffic speeds.
- Travel time savings by different modes and destination.
- Levels of congestion and road-space (re)allocation.
- Resilience and reliability of the travel network.

There is good quality evidence that with the right conditions and travel infrastructure in place, walking and cycling have the potential to facilitate favourable journey times and reduce road congestion, particularly during peak hours, whist simultaneously contributing to decarbonisation and health improvement outcomes. Further research is needed however to fully understand their impacts, particularly within a UK context. To provide an indication of evidence quality, the Weight of Evidence score for each piece of evidence in the review is given in Annex B.

The evidence reviewed presents a mixed picture on whether active travel (cycling primarily) increases or decreases journey times, with the impact being dependent on several factors including: the length of the journey being taken, the environment within which the journey is made (e.g. city centre) and travel infrastructure. A key finding is that longer journey times do not always deter people from choosing active travel options.

Bike-sharing systems, through their ability to replace car trips and encourage cycling, have demonstrated effectiveness in reducing congestion levels. Electrically powered micro personal mobility vehicles (e-PMVs), such as e-bikes and e-scooters, contribute to congestion alleviation by offering alternative modes of transportation that can substitute for car trips and complement existing public transit systems. Additionally, interventions like bike lanes, road space reallocation, and cycling incentives play significant roles in promoting active travel, reducing reliance on motor vehicles, and ultimately easing congestion on urban roads.

Determinants / barriers of participation

The reviewed evidence highlights that active travel modes and micromobility (e.g. shared bike or scooter schemes) are not equally accessible to all population groups. Many barriers to participation such as time constraints are experienced differently across different population groups. One example is that trip chains involving taking children to childcare or education settings or leisure activities and food shopping are disproportionately being undertaken by women, which impacts on mode choice and journey times.

Active travel may be particularly attractive to commuters who may value independence from collective forms of transport (e.g. car sharing or public transport). The extent to which this is a determinant for active travel varies between and within demographic groups.

Resilience

In terms of resilience of active travel systems to disruptions (COVID-19, transport strikes, adverse weather), and with respect to active travel systems providing resilience in themselves (such as to fuel price shocks), studies show that active does support resilience to a degree. For instance, evidence shows that active travel saw increased usage during the COVID-19 pandemic, particularly when public transport services were reduced. However, in response to other disruptive events, such as major public transport withdrawal, studies found that the potential for switching to non-motorised modes is highly affected by the distance that would need to be travelled. Finally, evidence showed that areas with well-developed active travel infrastructure are more resilient to fluctuations in fuel prices, emphasising the importance of investing in non-motorised transportation options.

8.1 Future research

Future research should address these key gaps to advance understanding and inform effective policies on active travel. In particular:

- Experimental studies which adopt high-quality methodologies, including pre/post comparisons and control groups, to accurately assess the effectiveness of interventions in reducing travel times and congestion. Considering the complex interactions between different transportation modes, future research should explore how these interventions interact with one another and with existing transportation infrastructure to maximise their benefits.
- Studies should aim for more robust methodologies, including larger and more representative sample sizes, and rigorous study designs that minimise biases such as self-selection in participant recruitment.
- Studies should adopt more inclusive sampling strategies to capture a broader demographic and spectrum of travel behaviours and choices e.g., among population sub-groups such as women, disabled people and people from minority ethnic groups.
- Research which explores the most effective ways of encouraging active travel amongst those more likely (or pre-disposed) to shift to walking and cycling, and those most likely to benefit from replace shorter journey with walking or cycling.
- Robust mixed-methods case studies which focus analytical attention on the context of active travel interventions and implementation processes as well as other factors that influence outcomes and effectiveness.
- Research in rural communities. Much of the existing evidence is concerned with active travel within urban areas. Although most of the UK population live in urban settings, it is important that studies consider active travel within rural areas and where journey times are inevitably longer.
- Research should strive for greater balance across modes of active travel, moving beyond the current focus on cycling, to include walking, wheeling and other emerging forms.
- There is a need for further studies that directly assess the effects of active travel on journey times, congestion and resilience.

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Annex A – Database searches

Sub-theme: Journey times

- Platform: Scopus.
- Date searched: 15 February 2024.
- Number of results: 2,186.

Table 5: Journey times sub-theme search string

String no.	Search string	No. of results
1	TITLE-ABS-KEY (active OR bicycl* OR cycl* OR bik* W/2 commut* OR journey* OR travel*) OR TITLE-ABS-KEY (walk* OR pedestrian)	452,562
2	TITLE-ABS-KEY ("journey time*" OR "travel time savings" OR "route choice" OR "mode choice" OR "time saving" OR "walking-time")	30,964
3	#1 AND #2	4,173
4	Limit language to English	3,853
5	Limit document type to article, review	3,232
6	Limit publication year to 2013-2024	2,186

Sub-theme: Congestion

- Platform: Scopus.
- Date searched: 15 February 2024.
- Number of results: 1,722.

Table 6: Congestion sub-theme search string

String no	Search string	No of results
1	TITLE-ABS-KEY (active OR bicycl* OR cycl* OR bik* W/2 commut* OR journey* OR travel*) OR TITLE-ABS-KEY (walk* OR pedestrian)	452,562
2	TITLE-ABS-KEY ("congestion pricing" OR "congestion" OR "idling" OR "superhighways" OR "cycle lanes" OR "bi* lanes" OR "segregated lanes" OR "low-traffic neighbourhoods" OR "15 minute neighbourhood*" OR "20 minute neighbourhood*" OR "traffic filtering" OR "modal filtering" OR "road-space reallocation")	154,515
3	#1 AND #2	3,794
4	Limit language to English	3,616
5	Limit document type to article, review	2,299
6	Limit publication year to 2013-2024	1,722

Sub-theme: Resilience

- Platform: Scopus.
- Date searched: 15 February 2024.
- Number of results: 214.

Table 7: Resilience times sub-theme search string

String no	Search string	No. of results
1	TITLE-ABS-KEY (active OR bicycl* OR cycl* OR bik* W/2 commut* OR journey* OR travel*) OR TITLE-ABS-KEY (walk* OR pedestrian)	452,562
2	TITLE-ABS-KEY (″resilience″ OR ″reliability″) AND TITLE-ABS-KEY (covid* OR ″coronavirus″ OR ″pandemic″ OR disrupt* OR ″mega-events″ OR ″severe weather″ OR ″weather″ OR ″fuel shocks″ OR ″energy resilience″ OR ″transport strikes″ OR ″school holidays″ OR ″bike shar*″ OR ″propensity to cycle″ OR ″propensity to walk″ OR ″propensity to wheel″ OR ″access to facilities″ OR ″access to education″ OR ″access to employment″)	48,633
3	#1 AND #2	330
4	Limit language to English	316
5	Limit document type to article, review	228
6	Limit publication year to 2013-2024	214

Grey literature searches

To supplement the academic database search, a search of 'grey' literature was conducted across a range of relevant websites using the Google search engine. This was undertaken on 28 February 2024 using a standardised set of search strings for all evidence assessments to identify further sources. This yielded 136 results, detailed below.

Table 8: Grey literature searches

Organisation	Search string	Valid results
Active Oxfordshire	(INTITLE:research OR study OR analysis) AND (active AROUND(2) (travel OR commute OR journey OR transport)) AND AFTER:2012 AND site:activeoxfordshire.org/	6
Active Travel Academy (University of Westminster)	(INTITLE:research OR study OR analysis) AND (active AROUND(2) (travel OR commute OR journey OR transport)) AND AFTER:2012 AND site:westminster.ac.uk/ata/	5
Age UK	(INTITLE:research OR study OR analysis) AND (active AROUND(2) (travel OR commute OR journey OR transport)) AND AFTER:2012 AND site:ageuk.org.uk/	6
Association of Cycle Traders (ACT)	(INTITLE:research OR study OR analysis) AND (active AROUND(2) (travel OR commute OR journey OR transport)) AND AFTER:2012 AND site:cycleassociation.uk/	1
British Heart Foundation (BHF)	(INTITLE:research OR study OR analysis) AND (active AROUND(2) (travel OR commute OR journey OR transport)) AND AFTER:2012 AND site:bhf.org.uk/	2
Campaign for Better Transport	(INTITLE:research OR study OR analysis) AND (active AROUND(2) (travel OR commute OR journey OR transport)) AND AFTER:2012 AND site:bettertransport.org.uk	10

Organisation	Search string	Valid results
Campaign for National Parks	(INTITLE:research OR study OR analysis) AND (active AROUND(2) (travel OR commute OR journey OR transport)) AND AFTER:2012 AND site:cnp.org.uk/	4
Centre for Transport & Society (University of the West of England)	(INTITLE:research OR study OR analysis) AND (active AROUND(2) (travel OR commute OR journey OR transport)) AND AFTER:2012 AND site:uwe.ac.uk/research/centres-and-groups/cts	0
Cycle BOOM	(INTITLE:research OR study OR analysis) AND (active AROUND(2) (travel OR commute OR journey OR transport)) AND AFTER:2012 AND site:cycleboom.org/	1
Cycling UK	(INTITLE:research OR study OR analysis) AND (active AROUND(2) (travel OR commute OR journey OR transport)) AND AFTER:2012 AND site:cyclinguk.org/	18
Disability Rights UK	(INTITLE:research OR study OR analysis) AND (active AROUND(2) (travel OR commute OR journey OR transport)) AND AFTER:2012 AND site:disabilityrightsuk.org/	2
Living Streets	(INTITLE:research OR study OR analysis) AND (active AROUND(2) (travel OR commute OR journey OR transport)) AND AFTER:2012 AND site:livingstreets.org.uk/	6
ModeShift	(INTITLE:research OR study OR analysis) AND (active AROUND(2) (travel OR commute OR journey OR transport)) AND AFTER:2012 AND site:modeshift.org.uk	0
National Institute for Health and Care Excellence (NICE)	(INTITLE:research OR study OR analysis) AND (active AROUND(2) (travel OR commute OR journey OR transport)) AND AFTER:2012 AND site:nice.org.uk/	0
Partnership for Active Travel and Health	(INTITLE:research OR study OR analysis) AND (active AROUND(2) (travel OR commute OR journey OR transport)) AND AFTER:2012 AND site:pathforwalkingcycling.com/	0
Paths for All	(INTITLE:research OR study OR analysis) AND (active AROUND(2) (travel OR commute OR journey OR transport)) AND AFTER:2012 AND site:pathsforall.org.uk/	10
Royal National Institute of Blind People (RNIB)	(INTITLE:research OR study OR analysis) AND (active AROUND(2) (travel OR commute OR journey OR transport)) AND AFTER:2012 AND site:rnib.org.uk/	1
Sustrans	(INTITLE:research OR study OR analysis) AND (active AROUND(2) (travel OR commute OR journey OR transport)) AND AFTER:2012 AND site:sustrans.org.uk/	15
The Ramblers	(INTITLE:research OR study OR analysis) AND (active AROUND(2) (travel OR commute OR journey OR transport)) AND AFTER:2012 AND site:ramblers.org.uk/	1
Transport & Health Study Group (THSG)	(INTITLE:research OR study OR analysis) AND (active AROUND(2) (travel OR commute OR journey OR transport)) AND AFTER:2012 AND site:transportandhealth.org.uk/	4
Transport for London (TfL)	(INTITLE:research OR study OR analysis) AND (active AROUND(2) (travel OR commute OR journey OR transport)) AND AFTER:2012 AND site:tfl.gov.uk/	0
Transport Research Laboratory (TRL)	(INTITLE:research OR study OR analysis) AND (active AROUND(2) (travel OR commute OR journey OR transport)) AND AFTER:2012 AND site:trl.co.uk/	8
Transportation Research Group (University of Southampton)	(INTITLE:research OR study OR analysis) AND (active AROUND(2) (travel OR commute OR journey OR transport)) AND AFTER:2012 AND site:southampton.ac.uk/research/groups/transportation-group	0

Organisation	Search string	Valid results
Sport England	(INTITLE:research OR study OR analysis) AND (active AROUND(2) (travel OR commute OR journey OR transport)) AND AFTER:2012 AND site:sportengland.org/	9
Systra	(INTITLE:research OR study OR analysis) AND (active AROUND(2) (travel OR commute OR journey OR transport)) AND AFTER:2012 AND site:systra.com/uk/	1
Transport Scotland	(INTITLE:research OR study OR analysis) AND (active AROUND(2) (travel OR commute OR journey OR transport)) AND AFTER:2012 AND site:transport.gov.scot/	0
Bikeability	(INTITLE:research OR study OR analysis) AND (active AROUND(2) (travel OR commute OR journey OR transport)) AND AFTER:2012 AND site:bikeability.org.uk/	0
Transport for New Homes	(INTITLE:research OR study OR analysis) AND (active AROUND(2) (travel OR commute OR journey OR transport)) AND AFTER:2012 AND site:transportfornewhomes.org.uk/	4
ITS Leeds	(INTITLE:research OR study OR analysis) AND (active AROUND(2) (travel OR commute OR journey OR transport)) AND AFTER:2012 AND site:leeds.ac.uk/transport	0
Centre for Cities	(INTITLE:research OR study OR analysis) AND (active AROUND(2) (travel OR commute OR journey OR transport)) AND AFTER:2012 AND site:centreforcities.org/	7
Chartered Institute of Highways and Transport	(INTITLE:research OR study OR analysis) AND (active AROUND(2) (travel OR commute OR journey OR transport)) AND AFTER:2012 AND site:ciht.org.uk/	14
Chartered Institute of Logistics and Transport	(INTITLE:research OR study OR analysis) AND (active AROUND(2) (travel OR commute OR journey OR transport)) AND AFTER:2012 AND site:ciltuk.org.uk/	1
Total		**136**

Annex B – Details of sources included in the full assessment

Table 9: Source information

Reference and DOI	Method / data	Sample	Geography	Weight of Evidence score	Reason for inclusion where WoE is not high	Journey times	Congestion	Resilience
Aldred, R., Jones, P. and Best, L. (2019) Cyclists in shared bus lanes: could there be unrecognised impacts on bus journey times? *Proceedings of the Institution of Civil Engineers–Transport*, Volume 172(3), pp. 135–151.	Modelling UK	Unknown	UK	13 (high)	N/A			✓
Bigazzi, A. and Wong, K. (2020) Electric bicycle mode substitution for driving, public transit, conventional cycling, and walking, *Transportation Research Part D: Transport and Environment*, Volume 85.	Systematic review of reviews	24 papers	Global	12 (high)	N/A		✓	
Both, A., Gunn, L., Higgs, C., Davern, M., Jafari, A., Boulange, C., and Giles-Corti, B. (2022) Achieving 'Active' 30 Minute Cities: How Feasible Is It to Reach Work within 30 Minutes Using Active Transport Modes? *ISPRS Int. J. Geo-Inf.*, Volume 11(58).	Modelling drawing on cross-sectional survey	-	Australia	14 (high)	N/A	✓		
Bronson, R. and Marshall, W. (2014). Alternative and adaptive transportation: What household factors support recovery from a drastic increase in gas price? *International Journal of Environmental Science and Technology*, Volume 11, pp. 2245-2258.	Cross-sectional survey	n=12,000	US	14 (high)	N/A			✓
Curl, A. (2018) The importance of understanding perceptions of accessibility when addressing transport equity: A case study in Greater Nottingham, UK, *Journal of Transport and Land Use*, Volume 11(1), pp. 1147-1162.	Cross-sectional survey	n=328	UK	13 (high)	N/A	✓		

Reference and DOI	Method / data	Sample	Geography	Weight of Evidence score	Reason for inclusion where WoE is not high	Journey times	Congestion	Resilience
Fan, Z. and Harper, C.D. (2022) Congestion and environmental impacts of short car trip replacement with micromobility modes, *Transportation Research Part D: Transport and Environment*, Volume 103.	Modelling drawing on cross-sectional survey	n=6000	US	14 (high)	N/A		✓	
Fishman, E., Washington, S. and Haworth, N. (2014) Bike share's impact on car use: Evidence from the United States, Great Britain, and Australia, *Transportation Research Part D: Transport and Environment*, Volume 31, pp. 13-20.	Mixed methods including cross-sectional surveys and trip data	n=8,964 across four surveys	Australia and US	10 (medium)	Relevance to two sub-themes	✓	✓	
FLOW Project (2016) The Role of Walking and Cycling in Reducing Congestion: A Portfolio of Measures.	Review	20 case studies	Global	11 (medium)	N/A		✓	
Ge, J. and Polhill, J.G. (2016) Exploring the Combined Effect of Factors Influencing Commuting Patterns and CO2 Emissions in Aberdeen Using an Agent-Based Model, *Journal of Artificial Societies and Social Simulation*, Volume 19(3).	Modelling drawing on secondary data	-	UK	13 (high)	N/A			✓
Goodno, M., McNeil, N., Parks, J., & Dock, S. (2013) Evaluation of Innovative Bicycle Facilities in Washington, D.C.: Pennsylvania Avenue Median Lanes and 15th Street Cycle Track. *Transportation Research Record*, Volume 2387(1), pp. 139-148.	Modelling drawing on real world data	-	US	13 (high)	N/A	✓	✓	
Grahn, R., Hendrickson, C.T., Matthews, S., Qian, S.Z. and Harper, C.D. (2021) Societal Impacts of a Complete Street Project in a Mixed Urban Corridor: Case Study in Pittsburgh, *Journal of Infrastructure Systems*, Volume 27(2).	Secondary data	-	US	13 (high)	N/A		✓	

Reference and DOI	Method / data	Sample	Geography	Weight of Evidence score	Reason for inclusion where WoE is not high	Journey times	Congestion	Resilience
IPSOS (2024), Low Traffic Neighbourhood Research Report, London: IPSOS.	Mixed methods including evidence review, local authority and resident surveys, and stakeholder engagement.	n=1,852 (resident survey), n=6 (interviews)	UK	-	ATE recommended due to relevance	✓	✓	
Le, H.T.K., Buehler, R., Fan, Y. and Hankey, S. (2020) Expanding the positive utility of travel through weeklong tracking: Within-person and multi-environment variability of ideal travel time, *Journal of Transport Geography*, Volume 84.	Longitudinal survey	n=186	US	11 (medium)	Theme coverage	✓		
Liu, C., Susilo, Y.O. and Karlström, A. (2015) The influence of weather characteristics variability on individual's travel mode choice in different seasons and regions in Sweden, *Transport Policy*, Volume 41, pp. 147-158.	Longitudinal survey	n=186	US	13 (high)	N/A			✓
Loong, C., and El-Geneidy, A. (2016) It's a Matter of Time: Assessment of Additional Time Budgeted for Commuting to McGill University Across Modes. *Transportation Research Record*, Volume 2565(1), pp. 94-102.	Cross-sectional survey	n=2,496	Canada	12 (high)	N/A	✓		✓
Ma, M. and Jin, Y. (2024) Estimating time-saving benefits and mode shifts from improvements of sustainable transport modes in Cambridge, UK, *Case Studies on Transport Policy*, Volume 15.	Modelling drawing on real-world data	-	UK	13 (high)	N/A	✓		
Nahal, T. and Mitra, R. (2018) Facilitators and barriers to winter cycling: Case study of a downtown university in Toronto, Canada, *Journal of Transport & Health*, Volume 10.	Cross-sectional survey	n=278	Canada	13 (high)	N/A			✓

Reference and DOI	Method / data	Sample	Geography	Weight of Evidence score	Reason for inclusion where WoE is not high	Journey times	Congestion	Resilience
Neves, A. and Brand, C. (2019) Assessing the potential for carbon emissions savings from replacing short car trips with walking and cycling using a mixed GPS-travel diary approach, *Transportation Research Part A: Policy and Practice*, Volume 123, pp. 130-146.	Mixed methods including interviews, cross-sectional survey, and GPS tracking	-	UK	13 (high)	N/A	✓	✓	
Nguyen-Phuoc, D.Q., Currie, G., De Gruyter, C. and Young, W. (2018) Transit user reactions to major service withdrawal – A behavioural study, *Transport Policy*, Volume 64, pp. 29-37.	Cross-sectional survey	n=640	Australia	13 (high)	N/A			✓
Plazier, P.A., Weitkamp, G., and van den Berg, A.E. (2017) "Cycling was never so easy!" An analysis of e-bike commuters' motives, travel behaviour and experiences using GPS-tracking and interviews, *Journal of Transport Geography*, Volume 65, pp. 25-34.	Mixed methods including interviews and GPS tracking	-	Netherlands	12 (high)	N/A	✓		
Prato, C.G., Halldórsdóttir, K. and Nielsen, O.A. (2017) Latent lifestyle and mode choice decisions when travelling short distances. *Transportation*, Volume 44, pp. 1343–1363.	Cross-sectional survey	n=7,958	Denmark	12 (high)	N/A	✓		
Qian, X., Jaller, M. and Circella, G. (2023) Exploring the potential role of bikeshare to complement public transit: The case of San Francisco amid the coronavirus crisis, *Cities*, Volume 137.	Meta-analysis of ridership data	-	US	11 (medium)	Theme coverage			✓
Teixeira, J.F., Silva, C. and Moura e Sá, F. (2021) Empirical evidence on the impacts of bikesharing: a literature review, *Transport Reviews*, Volume 41(3), pp. 329-351.	Literature review	77 papers	Global	11 (medium)	Theme coverage	✓	✓	

Reference and DOI	Method / data	Sample	Geography	Weight of Evidence score	Reason for inclusion where WoE is not high	Journey times	Congestion	Resilience
Wardman, M., Tight, M. and Page, M. (2007) Factors influencing the propensity to cycle to work, *Transportation Research Part A: Policy and Practice,* Volume 41(4), pp. 339-350.	Modelling drawing on real world data	-	UK	11 (medium)	ATE recommended due to relevance		✓	
Weschke, J., Oostendorp, R. and Hardinghaus, M. (2022) Mode shift, motivational reasons, and impact on emissions of shared e-scooter usage, *Transportation Research Part D: Transport and Environment,* Volume 112.	Cross-sectional survey	n=605	Germany	13 (high)	N/A		✓	
Zarabi, Z., Waygood, E.O.D. and Schwanen, T. (2024) Understanding travel mode choice through the lens of COVID-19: a systematic review of pandemic commuters, *Transport Reviews*, Volume 44(2), pp. 368-404.	Systematic review of reviews	36 papers	Global	14 (high)	N/A			