Safety interventions and their contribution to mode shift

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Keywords: behaviour, mode shift, safety, transport

An important note for the reader

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Abbreviations and acronyms

ACC	Accident Compensation Corporation
ADT	average daily traffic
AI	artificial intelligence
CBD	central business district
DSIs	deaths and serious injuries
IRR	incident rate ratio
km/h	kilometres per hour
MBCM	Waka Kotahi Monetised Benefits and Costs Manual
PT	public transport
WSB	walking school bus

Glossary

Innovating Streets for People	The Innovating Streets for People programme was established by Waka Kotahi NZ Transport Agency in 2018 to trial a new way of designing and delivering transportation infrastructure. It helps deliver the Government's goals to create liveable cities and thriving regions and was a flagship programme for Keeping Cities Moving, the national mode shift action plan.
Road to Zero	New Zealand Road Safety Strategy for 2020–2030.
Urban Cycleways Programme	A New Zealand government funded programme launched in 2014, now closed, providing increased investment to accelerate the delivery of cycling networks in main urban centres, and incentivised partners to increase their investment in cycling and walking projects.

Contents

Executive summary

> *We have made high speeds safer for drivers of cars, and that has been the focus. But we were not doing this for other modes. If I step out of my door, I should be safe.* (Interviewee P6)

The strategic direction for transport in New Zealand targets an improvement in whole-of-journey safety and encourages mode shift away from private vehicles towards more sustainable modes of travel. While substantial research is available to support the effect of safety interventions on road safety, a gap in understanding exists on the effect these may have on mode shift, this research examines that gap. For this research, safety interventions are those that result in safer journeys that reduce harm, this includes road crash safety, slips, trips and falls and personal security.

This research comprises a literature review and examination of monitoring indicators, expert interviews and New Zealand case studies. Along with this report, an intervention summary is presented in dashboard format.[1]

The literature review, which summarises international and New Zealand literature, including examples of successful and unsuccessful safety interventions that supported mode shift, identified that infrastructure and complete package interventions have the greatest contribution to mode shift. These are grouped in three areas of safer journeys:

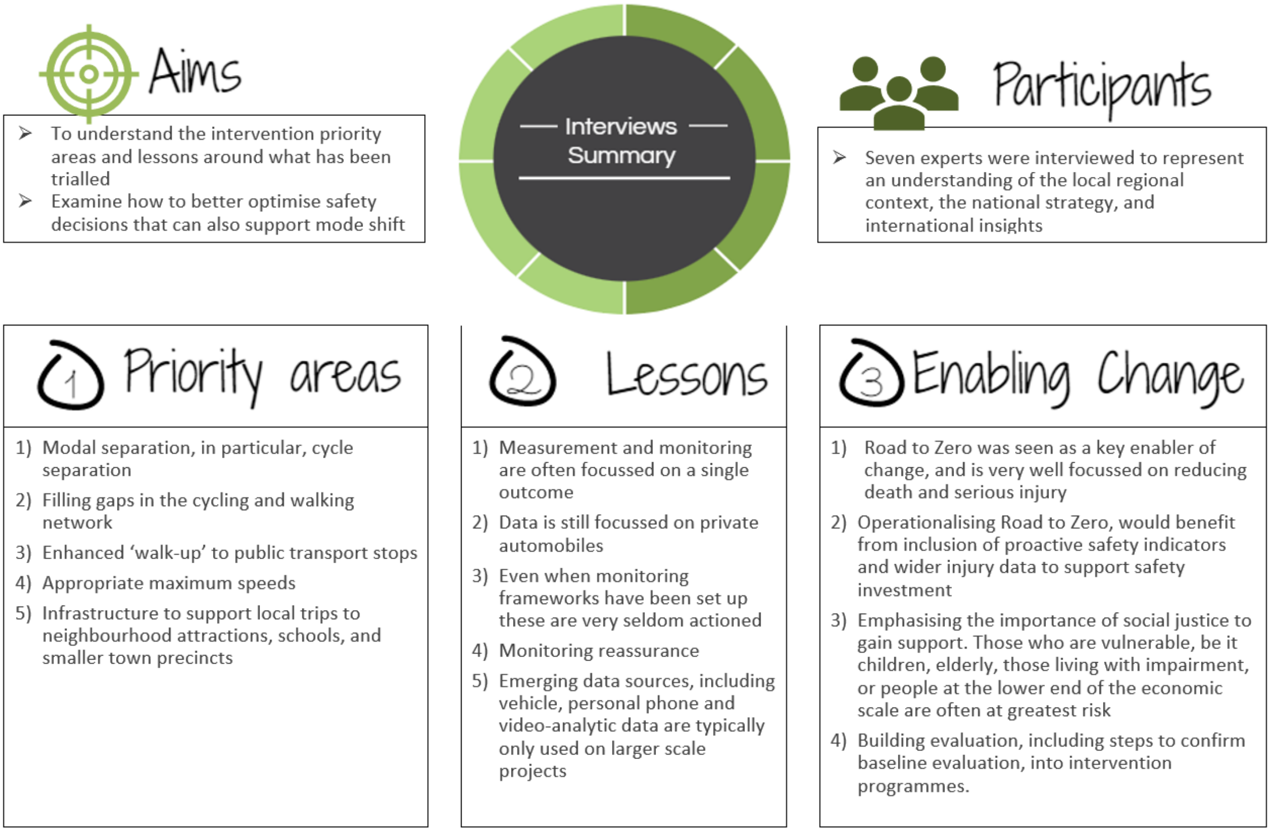
- crash safety interventions:
  - infrastructure that separates modes, especially physical separation of cyclists from motorised vehicles
  - managing speed through lowering speed zones and traffic calming infrastructure
- personal security interventions:
  - real-time public transport information
  - artificial lighting
- slips, trips and falls interventions:
  - where limited evidence was available on the effect of pavement improvements on mode choice.

A combination of personal security, crash safety and smoother path interventions were shown to have more effective increases in the uptake of walking, cycling and public transport. The complete package approach, when applied to complete routes, area-wide treatments or cities, and combining infrastructure change with education, showed the strongest evidence around increasing walking and cycling for education-based trips. A fundamental aspect of the success of safety interventions in achieving mode shift is that they must not be done in isolation. These interventions are about a Safe System approach that looks at the needs and limitations of who is using the space and whole-of-journey safety.

Expert interviews also confirmed the need to focus on filling gaps in disjoined networks and provide complete routes to schools, public transport, local neighbourhood attractions and shops (see Figure ES.1). In addition, the experts identified important lessons around monitoring and enablers of change that have been captured in the recommendations.

[1] Available at www.nzta.govt.nz/resources/research/reports/701

Figure ES.1 Summary of interview priority areas, monitoring lessons and change enablers



Distinct case studies were described in greater depth than studies in the literature review, to capture the work that has been successfully delivered in New Zealand. The case studies show the benefits of the intervention, how this was measured and any significant learnings. The case studies were selected based on safety interventions identified through the literature review and interviews as being most likely to result in mode shift. The case studies focus on changes based on the Urban Cycleways Programme, innovating streets programme and safer speed changes, with much of the available case study evidence focussing on cycle separation as well as traffic calming at major locations.

Lessons from the case studies include:

- It is invaluable to collect robust and thorough data before and after an intervention is installed, not only for assessing the effectiveness of the intervention, but for supporting a business case for future interventions.
- The type of treatment and intervention used at a particular location should reflect the characteristics of the existing road users in that area, and the same intervention may be more or less successful in different areas, depending on other factors (eg schools, proximity to local shops).
- A trial approach provides value because it allows improvements to be made post-implementation, where the changes can be included in conversion to a permanent upgrade.
- It is important that ongoing maintenance costs are included in budgeting.

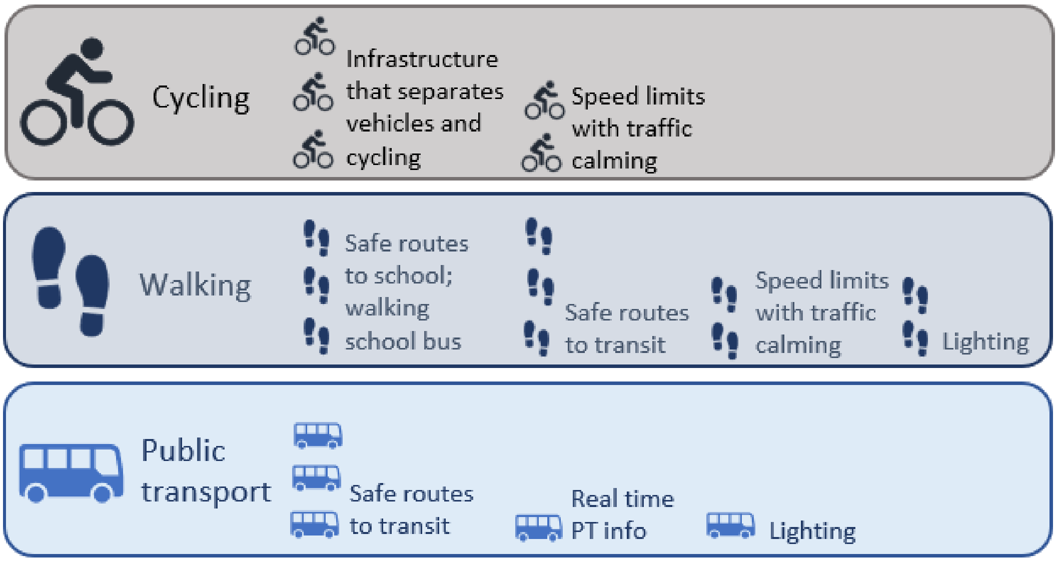
The following recommendations are submitted to Waka Kotahi NZ Transport Agency for consideration.

Recommendations related to key strategy and policy actions are listed here:

1. Future transport strategies for New Zealand, including road safety strategies, to cover a wider range of harms (eg road safety, slips, trips and falls and personal security) and the consequent update of the action steps and funding framework (see also section 5.6).
2. Future transport strategies for New Zealand to consider a funding approach inclusive of whole-of-journey safety (crashes, falls and personal security). This includes consideration of:
   a. Integrated or complete funding opportunities to enable a 'Safe Routes' approach (especially for schools and important public transport hubs, including real-time information)
   b. Walking and micromobility (single party injury) interventions (including traffic calming, but also considering lighting)
   c. Interventions that also work for mode shift on the safety intervention list, to deliver Road to Zero (for example, in updates of the Standard Safety Intervention Toolkit, such as cycle separation)
   d. Linking street and corridor infrastructure rollout with educational initiatives (eg like bikes in schools, walking school buses or individualised travel planning).

   Consequently, it is recommended the safety interventions in Figure ES.2 be considered for implementation to support mode shift (while taking into account contextual factors).
3. Future transport strategies for New Zealand should include minimum requirements for monitoring of the modes affected as criteria for accessing funds (for example, as the Urban Cycleways Programme has done, which has led to more cycle monitoring in New Zealand cities; Pascoe, 2019).
4. Funding documents and national and regional monitoring frameworks should include explicit links to evaluation guidance (to promote greater use of existing evaluation guidance).

Figure ES.2 Intervention effectiveness by mode and mode shift impact



Note: PT = public transport.

Recommendations to support improved decisions based on monitoring:

5. Increasing walking and cycling count data (especially around the central business district, town centres, public transport hubs and lower speed locations).

6. Improving access to monitoring equipment and analytic capability, especially around camera-based data (for more localised treatments or at sample locations), because this provides a rich picture of both safety and mode shift.
7. Consistent monitoring of specific perceived safety indicators, split into road safety, slips, trips and falls, and personal security. Also, consistent monitoring of avoidance during night and day (to understand who is not using an area because they believe it to be unsafe).
8. Continuing provision of case studies showing the benefits of broader monitoring and examples of what good looks like, to encourage better monitoring.
9. Continuing to focus transport safety data integration initiatives on steps to integrate, share and provide training resources, to encourage improved data use. In particular, geospatial requirements need to achieve some level of data integration, such that as the data shifts to having a geospatial code it can be integrated. At a minimum, geospatial location and confirmation are needed that an incident occurred at the street or transport path or public transport hub location.
    a. Provide a mechanism to report safety data, including slips, trips and falls and personal security incidents (ie assaults and verbal abuse) sustained while on public transport, to the police
    b. Integrate public transport safety data and hospital data related to transport into the Crash Analysis System or an appropriate alternative, including defining a zone and/or limit close to public transport stops and hubs.

Abstract

There are journeys that are not made and modes of travel that are avoided because they do not meet the basic need to be safe. This research examines safety interventions that induce mode shift to walk, cycle and ride public transport by making the trip safer, either by reducing harm from road crashes, slips, trips or falls, or threats to personal security. Through a review of literature, examination of monitoring indicators, expert interviews and insights from New Zealand case studies, the research reveals the safety interventions shown to affect mode shift and makes recommendations to improve decision-making to gain benefits beyond safety. Infrastructure that physically separates vehicles and cyclists, speed reductions with traffic calming, lighting and real-time public transport information were identified as effective interventions. However, a fundamental aspect of successful safety interventions in achieving mode shift is that they must not be done in a piecemeal or isolated way. The best evidence supports the Safe System approach, looking at entire routes or areas to develop a complete package, looking at the needs and limitations of who is using and avoiding travel, and ultimately looking at whole-of-journey safety.

1 Introduction

1.1 Overview

New Zealand's land-based travel is traditionally dominated by private motor vehicle travel. Consequently, in the safety space, interventions have focussed on improving motor vehicle travel and safety aimed at reducing fatal and serious injuries involving motor vehicles (eg Safer Journeys 2010–2020 high-priority areas; Woodside, 2010). However, a recent strategic direction is to look at the whole transport system and whole-of-journey safety. For example:

- Government Policy Statement on Land Transport 2021–2031: Intends to achieve a transport system that 'contributes to liveable cities and towns by providing people with good travel options. This requires all parts of the transport system, be it roads, rail, public transport, and walking and cycling routes, to work together' (Te Kāwanatanga o Aotearoa, 2020, p. 13).
- 'Road to Zero' Action Plan for 2020–2022: Road safety actions should support health, well-being and liveable places, with initiatives that include safety infrastructure treatments, safer speeds, and improved safety and access to footpaths, bicycle lanes and cycleways (New Zealand Government, 2019).
- Land Transport Benefits Framework: Examines healthy and safe people, with the inclusion of actual and perceived safety and personal security, as well as inclusive access, with impacts on mode choice and user experience (Waka Kotahi, 2020b).

These strategic priorities can promote interventions that not only meaningfully improve journey safety but encourage a mode shift away from private vehicles towards more sustainable modes (such as walking, cycling and public transport). A gap in our understanding is the effect that safety interventions may also have on mode shift. This research examines that gap by taking a broad view of what makes a safer journey and investigating three components to a safer journey, including: crash safety; slips, trips and falls; and personal security.

1.2 Purpose and research objectives

Waka Kotahi NZ Transport Agency (Waka Kotahi) is seeking to determine which safety interventions provide the best opportunities for supporting mode shift, and how that knowledge can be incorporated in decision-making.

The research objectives are to:

1. Provide a summary of international and New Zealand research on safety interventions to support mode shift from private vehicle trips to public transport, walking and cycling
2. Qualitatively and quantitatively describe examples of where safety interventions have supported mode shift, and how this connection is shown
3. Describe examples of where safety interventions have been unsuccessful in supporting mode shift, and reasons for their failure
4. Describe the strengths and weaknesses of different approaches to measuring connections between safety interventions and mode shift
5. Identify the range of safety interventions that could be used to support mode shift (broken down by mode) in New Zealand conditions
6. Describe and analyse distinct New Zealand case studies that show relationships between safety-focussed interventions and mode shift

7. Describe how to incorporate measures of the benefits of safety interventions supporting mode shift in existing frameworks, to help optimise investment decisions.

1.3 Outside scope

Note that the following items are outside the scope of this work:

- Shifting freight off roads (ie the scope of this work is for personal journeys only)
- Mode shift impacts on safety (ie pure benefit of shift to a safer mode like train)
- Risk profiles of the different transport modes
- Health-based safety interventions (ie including interventions to improve safety around COVID-19)
- Harm as a result of medical conditions or events
- Wider impacts of mode shift, such as public health, economy, environment and access.

1.4 Research approach

The research uses a three-step approach as outlined in Figure 1.1. Steering groups and expert peer review were also involved after Step 1 and Step 3.

Figure 1.1 Three-step research approach

Step 1: Literature review and stocktake: To gain an understanding of the level of effectiveness of potential safety interventions that could influence mode shift from private vehicles to public transport, walking and cycling.

Step 2: Case studies and interviews: Recognising the importance of providing local success, distinct case studies are described in depth to capture the work successfully delivered in New Zealand. Case studies show the benefits of the intervention, how these were measured and any significant learnings. The purpose of the interviews was to capture greater depth around specific case studies (including unreported data) or opportunities to influence strategy. Furthermore, the interviews helped to describe how to incorporate measures of the benefits of safety interventions supporting mode shift in existing frameworks, to help optimise investment decisions.

Step 3: The intervention dashboard aims to:

1. Make the intervention metrics available and openly accessible to a defined audience
2. Promote transfer of associated knowledge and learning from exploring interventions and their different benefits and limitations.

1.5 Definitions of safety interventions, safer journey and mode shift

In the context of this study, the following definitions have been used.

Safety interventions are actions taken that result in safer journeys, as measured by objective safety indicators and changes in perceptions of safety[2] (eg in accordance with the measures presented in Table 2.1).

For this report, when applying the terminology **safer journeys**,[3] we are referring to journeys that reduce harm across the three areas shown in Table 1.1.

Table 1.1 Areas of harm, description and examples of measure to support the definition of safer journeys

Definition	Description	Example of measure in New Zealand
Slips, trips and falls	Slips are the result of too little friction or a lack of traction between the footwear and floor surface that can lead to falls. A trip is the result of a foot striking or colliding with an object, which causes a loss in balance, and usually a fall.	Accident Compensation Corporation slip, trip, fall data
Personal security	The perceived or actual threat of violence, theft or verbal abuse when making a journey.	Assault and theft data
Road safety	The methods and measures used to prevent road users from being killed or seriously injured.	Crash where at least one motor vehicle or cycle is involved (Crash Analysis System)

Mode shift in this report includes:

- mode shift (away from car)
- mode transfer (where it is examined, from one location or route to another)
- trip increases (in bus, train, cycling, walking, micromobility).

[2] Note that, ideally, both objective and perceived safety are measured, or interventions that have been reliably proven to improve objective safety are used in conjunction with perceived safety. This is to avoid any scenario where perceived safety is improved and consequently exposure to safety risk is increased.

[3] Note: This is not referring to the Safer Journeys strategy.

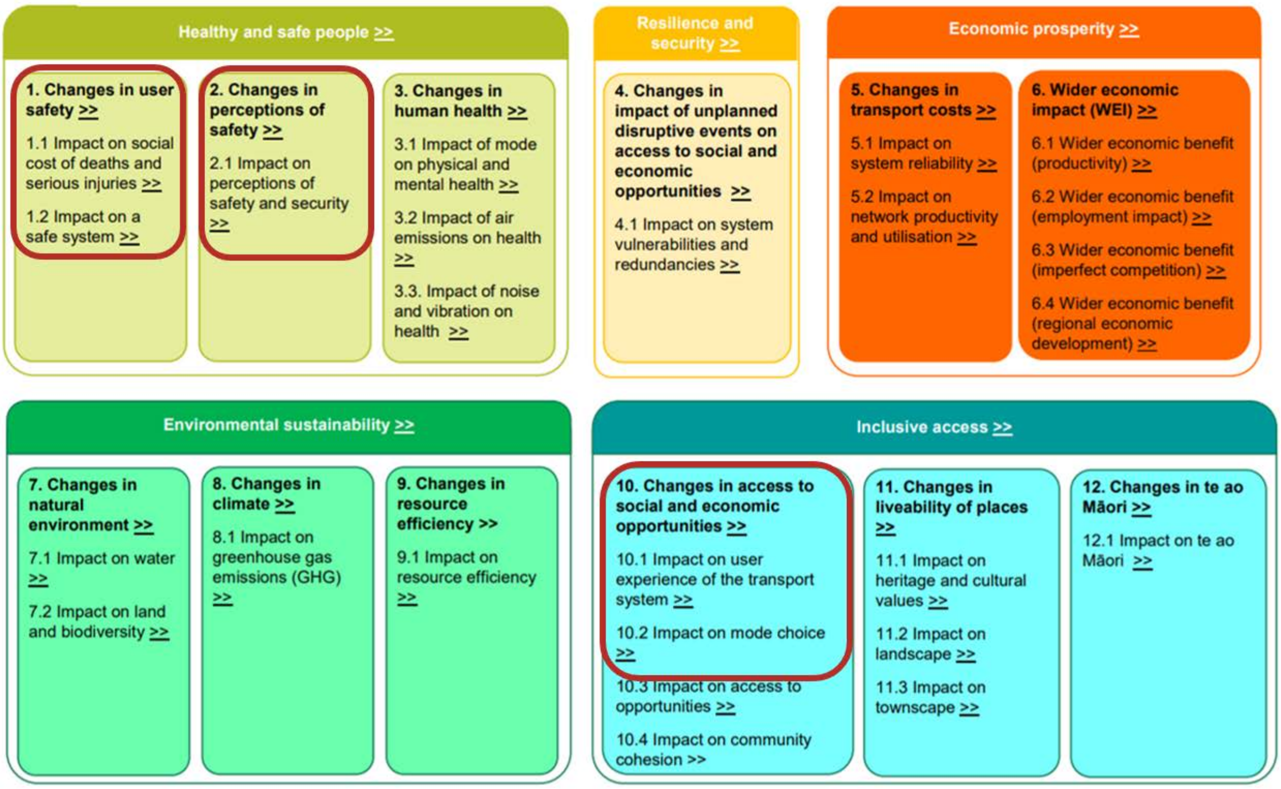
2 Monitoring indicators in New Zealand and other jurisdictions

This section summarises the strategic direction for outcomes and existing metrics within New Zealand and identifies what overseas jurisdictions are measuring that could be applied in New Zealand.

2.1 Strategic outcomes for New Zealand

The New Zealand Land Transport Benefits Framework was developed by Waka Kotahi (2020a) to ensure meaningful investment and tracking and ensure the realisation of benefits following intervention implementation. The Benefits Framework has five broad themes.[4] Of particular relevance to this study are Healthy and Safe People and Inclusive Access. Within the themes are 12 outcome areas, three of which are relevant to this work (see Figure 2.1 and the text highlighted with a red border).

Figure 2.1 Land Transport Benefits Framework indicators of relevance (reprinted from Waka Kotahi, 2020b, p. 16)



Quantitative and qualitative benefit measures are provided in the Land Transport Benefits Framework overview table (Waka Kotahi, 2020b), with extracts relevant to this work shown in Table 2.1.

[4] Note that these themes have been developed in alignment with the Ministry of Transport's Transport Outcomes Framework and the New Zealand Treasury's Living Standards Framework.

Table 2.1 Overview of relevant Land Transport Benefits Framework with measures (adapted from Waka Kotahi, 2020b)

Transport outcome	Benefit cluster	Benefit	Quantitative and qualitative benefit measures (primary associations)			Monetised benefits (included in MBCM)
			No.	Name	Measure	Value proxy and measure of changes in option compared with do-minimum
Healthy and safe people	1. Changes in user safety	1.1 Impact on social cost of deaths and serious injuries	1.1.1	Collective risk (crash density)	Average annual fatal and serious injury crashes per kilometre of road section	$ crash costs by crash type and severity
			1.1.2	Crashes by severity	Number of crashes by severity	
			1.1.3	Deaths and serious injuries	Number of deaths and serious injuries	
			1.1.4	Personal risk (crash rate)	Average annual fatal and serious injury crashes per 100 million vehicle kilometres	
		1.2 Impact on a safe system	1.2.1	Road assessment rating – roads	Infrastructure risk rating	
			1.2.2	Road assessment rating – state highways	KiwiRoad Assessment Programme (KiwiRAP) star rating (for state highways)	
			1.2.3	Travel speed gap	Difference between safe and appropriate speed, and actual speed (under development)	
	2. Changes in perceptions of safety	2.1 Impact on perceptions of safety and security	2.1.1	Access – perception	Perception of safety and ease of walking and cycling	
Inclusive access	10. Changes in access to social and economic opportunities	10.1 Impact on user experience of the transport system	10.1.1	People – throughput of pedestrians, cyclists and public transport boardings	Number of pedestrians, cyclists and public transport boardings	$/vehicle per kilometre of constructed passing lane $/vehicle per kilometre sealed roads $/minutes public transport passengers in-vehicle time in relation to infrastructure
			(Repeat) 2.1.1	Access – perception	Perception of safety and ease of walking and cycling	
			10.1.2	Pedestrian delay	Pedestrian lost time due to intersection delay	

Transport outcome	Benefit cluster	Benefit	Quantitative and qualitative benefit measures (primary associations)			Monetised benefits (included in MBCM)
			No.	Name	Measure	Value proxy and measure of changes in option compared with do-minimum

			10.1.3	Ease of getting on or off public transport services	Percentage of low floor and wheelchair accessible services	and bus and train attributes
						$ per minutes public transport passengers vehicle occupant time for probability of being left and proportion of standing passengers
						$ relative value for different types of cycling facility's quality improvements
						Minutes additional time someone would be willing to spend walking to obtain the improvement of different aspects of the pedestrian realm

			10.1.4	Network condition – cycling	Percentage travel on cycle network classified as complying with defined level of service (facility type)	
			10.1.5	Network condition – road	Percentage travel on road network classified as smooth as per defined level of service	
			10.1.6	People – throughput	Number of pedestrians, cyclists, public transport boardings and motor vehicles (excl. public transport) TIMES average number of people per vehicle	
			10.1.7	People – throughput (Urban Cycleways Programme)	Number of pedestrians and cyclists	
			10.1.8	Traffic – throughput	Number of pedestrians, cyclists and motor vehicles by vehicle type	
			10.1.9	Travel time	Average travel time in minutes	
		10.2 Impact on mode choice	10.2.1	People – mode share	Number of pedestrians, cyclists, public transport boardings and motor vehicles (excl. public transport) TIMES number of people per vehicle, expressed as percentages	
			(Repeat) 8.1.2	Mode shift from single occupancy private vehicle	User to describe	
			10.2.2	Accessibility – public transport facilities	Number of bus or train stops that are fully accessible	

Transport outcome	Benefit cluster	Benefit	Quantitative and qualitative benefit measures (primary associations)			Monetised benefits (included in MBCM)
			No.	Name	Measure	Value proxy and measure of changes in option compared with do-minimum
			10.2.3	Spatial coverage – cycle lanes and paths	Percentage completion of the strategic cycle network	
			10.2.4	Spatial coverage – cycling facilities	Number of people living within 500 metres of a high-quality cycling facility	
			10.2.5	Spatial coverage – public transport – employees	Number of employees within 500 metres of a bus stop or 1 kilometre from a rail or rapid transit station	
			10.2.6	Spatial coverage – public transport – residential population	Number of people within 500 metres of a bus stop or 1 kilometre from a rail or rapid transit station	
			10.2.6a	Spatial coverage – public transport – new residential dwellings	Percentage of recently built residential dwellings with access to public transport services (subset of 10.2.6)	
			10.2.7	Temporal availability – public transport	Public transport frequency per hour weighted by percentage of the population living within 500 metres of a bus stop or 1 kilometre from a rail or rapid transit station	
			10.2.8	Cost of access to key destinations – all modes	User to describe	
			10.2.9	Pricing – more efficient	User to describe	
			10.2.10	Traffic – mode share (number)	Number of transport users by mode pedestrians, cyclists and motor vehicles by vehicle class, expressed as percentages	
			10.2.10b	Traffic – mode share (distance)	Average trip distance per person in urban areas by mode	

Note: MBCM = Waka Kotahi Monetised Benefits and Costs Manual

The Ministry of Transport currently summarises 39 transport indicators, including their status (reported, being developed, require further work), split by transport mode (walking, cycling, road transport, rail transport, maritime, aviation) (Ministry of Transport, 2021). A further 23 potential indicators are identified as recommended initiatives within the Transport Evidence Base Strategy (Ministry of Transport, 2019).

The application of this type of data and required local supplementary data were further examined in the steering group session to inform recommendations on high-value monitoring and improved capture of mode shift benefits from safety interventions (see chapter 7).

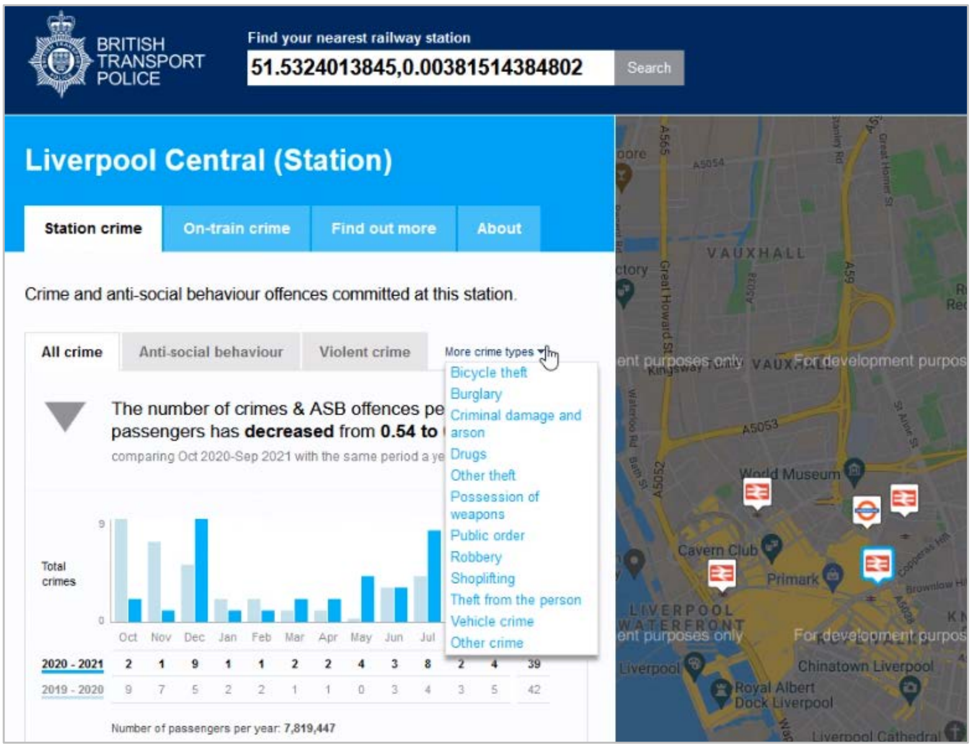
2.2 What are other jurisdictions measuring?

Other jurisdictions measure safety and mode shift in similar ways to what is being done in New Zealand, including road deaths and serious injuries, travel mode surveys, and hospital data collected by the Ministry of Health. However, some locations are using unique approaches that could be considered for a New Zealand context. Examples are outlined below based on the data type.

Personal security data

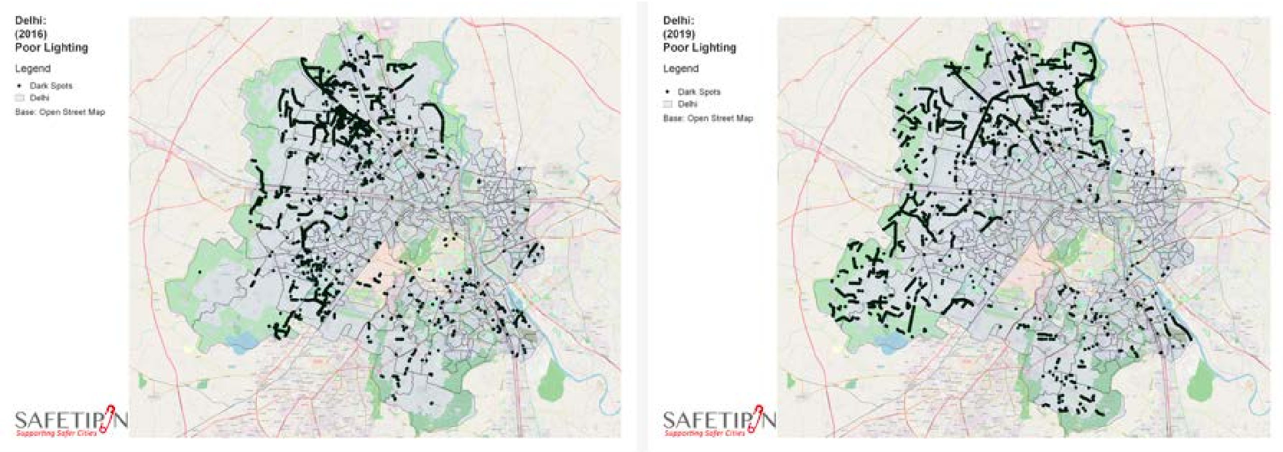
- In New Zealand, personal security measures for transport are typically qualitative and determined through perception of safety and ease of walking and cycling.
- In the United Kingdom, the British Transport Police provide policing services on railways and light-rail systems, intervening in incidents of crime and anti-social behaviour. Members of the public can help by reporting incidents to the Transport Police by calling, texting, or via a form on their website (a mobile app is currently under development).
- Incident data is reported on an ongoing basis on the British Transport Police website, split into incident type (such as violent crime) and location (by station and line; see Figure 2.2).

Figure 2.2 Example screenshot from the British Transport Police public transport crime map (reprinted from British Transport Police, n.d.)



- In Delhi (India) an ongoing partnership between the Delhi Government and mobile app Safetipin has led to the crowdsourcing of personal safety data across the city. More than 75,000 points have been audited, including transport hubs, parks and other public spaces. The safety data collected from the audits has been used by the Delhi Government to address safety concerns, such as areas of poor street lighting, and to inform police patrolling routes (see Figure 2.3; Department of Women and Child Development, 2019).

Figure 2.3 Maps produced by Safetipin showing areas of poor lighting in Delhi in 2016 (left) and 2019 (right) (reprinted from Department of Women and Child Development, 2019, p. 12)



Slip, trip, fall data

- Slip, trip and fall injuries make up about two-thirds of transport-related injuries, compared with one-third from road crash data (Waka Kotahi Crash Analysis System; Frith et al., 2015), and are generally under reported and not integrated (Koorey et al., 2022). Such injuries often relate to multiple factors and these should be considered, whether they are environmental (eg poor surface quality, obstacles, lighting) or medical (eg heart attack) or a combination.
- In Sweden, the Swedish Transport Administration tracks road safety across several indicators that are not commonly looked at, including incidents of slips, trips and falls; safe pedestrian, bicycle and moped passages in urban areas; and helmet use on bicycles and mopeds (Swedish Transport Administration, 2012).
- In Australia, the Australian Institute of Health and Welfare reports on transport injury statistics resulting in hospitalisation across multiple modes, including walking and cycling as well as private vehicles (Australian Institute of Health and Welfare, 2021).

Mode shift data

- The City of Port Phillip in Australia recently introduced video-based artificial intelligence- (AI-) powered traffic sensors at several locations around the city, with more being rolled out over time. The sensors are able to measure pedestrian, bike, car and truck movements, and will soon have the ability to detect other modes (such as e-scooters). This data will be collected on an ongoing basis to identify trends in mode shift, to support the implementation of the city's integrated transport strategy (City of Port Phillip, 2021) (see Figure 2.4). At this stage, however, it does not provide evidence of modal shift linked to a change in transport strategy.

Figure 2.4 Output from a traffic sensor in Port Phillip, Australia, showing the levels of detection for cars, pedestrians, cyclists, motorbikes and buses (reprinted from Bicycle Network, 2021)

- London (United Kingdom) has also begun a rollout of video-based AI-powered traffic sensors throughout the central city. The sensors were initially installed in two locations in 2018 as a trial to replace manual traffic counts. The trial results found the sensors provided more complete data than manual methods, because they run 24 hours a day and can measure walking, cycling and different types of private vehicles. Following this trial, the city has introduced 43 more sensors (Transport for London, 2020).

2.3 Established elements of national New Zealand indicators

In a review of national indicators relevant to safety and mode shift, the following datasets were evaluated by the authors as relevant, accessible, consistent and well used.

- Ministry of Transport (n.d.) New Zealand Household Travel Survey Data is captured robustly following social science best practice, to reduce biases, and reports changes in travel patterns over time.
- The Waka Kotahi (n.d.-a) Crash Analysis System is widely used by practitioners due to ease of online access and supporting guidance and has geolocated data over time with consistent crash coding.
- The Waka Kotahi (2021a) Understanding Attitudes and Perceptions of Cycling and Walking survey has been run since 2016. Of particular relevance are changes in the reported frequency of walking and cycling, and changes in perceptions of safety across different infrastructure environments (eg shared paths, speed zones) and looking at night-time travel (to indicate personal security).
- The Waka Kotahi (2022) Public Attitudes to Road Safety survey shows public attitudes to road safety issues and behaviour, including personal safety, walking and cycling and attitudes towards Road to Zero, and how these are trending over time. This has been run since 2020.

2.4 Areas where other indicators could be strengthened

The following insights were also captured on areas for improvement from a brief review of:

- the Ministry of Transport's (2022) 37 transport indicators
- what other jurisdictions are doing well (see section 2.2)
- against where intervention outcomes could be more easily evaluated (see section 2.5).

2.4.1 Safer journey indicators

- Road policing officer focus on vehicle-based crashes and dangerous driving could be widened to a stronger multi-modal focus, if resourced appropriately (following the example of the British Transport Police in section 2.2). This could support enforcement and improve data, including the ability to look at crash, slips, trips and falls where injury is reported, and personal security aspects of safety.
- Personal security, assaults, and slips, trips and falls data collected at public transport stops (ie at monitored stops) and on-board public transport.
- Accident Compensation Corporation (ACC) injury data on slips, trips and falls related to transport (in the street corridor and away from the street corridor, such as through parks and reserves) at more refined geospatial level, and integration with existing crash data.
- Hospital data related to transport injury, geospatial level (linked to hospital), and integration with existing crash data.

2.4.2 Mode shift indicators

- Increasing walking and cycling count data (especially around the central business district (CBD), town centres, public transport hubs and lower speed locations).
- Increasing availability of public transport patronage data at finer geospatial area (ideally by route or public transport stop through tag-on–tag-off data).
- Accessibility metrics around public transport stops and social infrastructure.

2.5 Summary of what could we measure

Table 2.2 outlines different intervention measurement areas where New Zealand is typically doing well, and proposes recommendations for what should be considered around measurement in New Zealand, based on the literature review, expert interviews and steering group input.[5] Further detail explaining strengths and limitations of different data in relation to the scale of intervention is also outlined below.

Table 2.2 Summary of relevant safer journey and mode shift metrics in New Zealand by scale of intervention type and coded across actual use within evaluations

Key: (shield) Regularly reported on (ruler) Data gap (not typically measured) (tick) Available but not regularly used

Metrics	Safety intervention scale[16]		
	Route	Neighbourhood	City/region
Crash safety			
Crash data	Available but not regularly used	Available but not regularly used	Regularly reported on
Near-miss data (observed or self-report)	Data gap	Data gap	
Self-reported crash safety	Regularly reported on	Regularly reported on	Regularly reported on
Vehicle speed on street (separated modes)	Regularly reported on	Data gap	Data gap
Shared path and shared street user speed	Data gap		

[5] Note this has been coded in relation to the evidence at hand and is only intended to support in identifying opportunities for improved monitoring. This is not intended to be an absolute point of truth on all monitoring or government policy around minimum monitoring requirements.

Metrics	Safety intervention scale		
	Route	Neighbourhood	City/region
Slips, trips and falls			
Injury data (transport falls)	📏	📏	✓
Self-reported slips, trips and falls	📏	📏	
Personal security			
Perceptions of safety at night			✓
Reported use at night	📏	📏	
Reported crime (assault; abuse)	📏	📏	
Crime statistics (assault; abuse)	📏	✓	✓
Mode shift			
Travel survey			✓ 📏
Mobile phone and vehicle journey data	✓	✓	✓
Integrated automated count (eg video-based AI sensors)	📏	📏	
Motor vehicle count data (eg tube counters)	📏	📏	
Bicycle count data	📏	📏	✓
Pedestrian count data	📏	📏	✓
Public transport patronage data	✓	✓	🛡

2.5.1 City and regional scale interventions

National level and regionally collected data: Have the benefit of consistency and ease of access but are limited in ability to link any change to a single intervention. The usefulness of this data is typically realised in larger cities, where enough data is available to be able to examine a region or city (eg injury data, census or household travel survey data national and regionally sampled).

Crash data: Safety intervention monitoring based on crash data is a good safety indicator. However, it needs a reasonable timeline for robust evaluation, especially where the numbers are lower (particularly for walking, cycling and bus crashes). This does not always fit with project evaluation timelines, where the pre-data is often analysed to inform the safety intervention, but the post-data collection period is often limited by the project contract. An opportunity exists to look more closely at crash data for significant interventions over longer timelines. But this would likely need a different funding approach (ie retrospective analyses), because within-project evaluation timelines are often limited (whereas crash data is typically better examined over longer, ie five-year before versus three-year after periods). Also, for wider-area treatments, a challenge can be around other improvements or changes occurring during this time, so comparison location approaches are also recommended. Capture of near-miss data is another approach that provides a safety indicator that has the benefit of a shorter evaluation timeframe (see more in section 2.5.3).

Injury data from slips, trips, falls: Not typically looked at when examining safety interventions, because the focus and ease of access of geolocated data (at least in New Zealand) is crash data. However, slip, trip and fall injuries make up about two-thirds of transport-related injuries, compared with one-third from crash data, so provide a rich dataset (Frith & Thomas, 2010). Transport-related injury data is collected by ACC at the territorial local authority level, which would provide trends that should be monitored. Algorithms to code the open data field around accident causation and geolocation of the data to a street or suburb level would both support ease of data integration and usefulness of the data. This is not currently done to our knowledge.

2.5.2 Neighbourhood and route data – traditional methods

Counting (location based): Whether done via manual counts or automated at spot locations, this is particularly useful for route-based interventions[6] and provides an opportunity to use similar control locations (to account for other changes that may influence travel). Typically, around safety interventions, only one mode is monitored at a time, rather than multi-modal mode data. Lieswyn et al. (2018) provide a good summary of different counting technology and sampling methods, including manual methods and automated count technology. Camera-based data is an area that can overcome some limitations around the traditional counting approach (see section 2.5.3.1).

Speed data: Spot speeds of vehicles by vehicle type using tube counters is the most common data source used. Cycling and walking speed data is typically only examined for research purposes. Understanding compliance with the speed limit as well as speed consistency (homogeneity) supports predictable behaviour around lane changes, turns, and choosing safe gaps between road users at potential conflict points. A limitation in how this is currently measured is that it typically is looking only at a single user type at one time. Low inter-modal speed differentials are also an indicator of safer interactions, for example, for shared on-street spaces for people who ride or drive or for shared off-street paths for people who walk or ride. Multi-modal speed data is rarely captured and used, so understanding how this influences inter-modal interactions, safety and mode shift would be highly useful to determine intervention effectiveness.

Subjective safety metrics: These are typically inconsistent in wording or based on inconsistent definitions of what is meant by safety. Personal safety and crash safety are typically not separated, and usually no mention is made of safety around slips, trips and falls. Also, who is asked and when they are asked is relevant to the quality of the data. For example, most of the data collected for personal security around public transport is collected by routine customer satisfaction surveys, so it is not capturing non-users (including those who have left due to a bad experience, or potential users who perceive trips as unsafe at night or in certain locations). When asked in the correct way, the proportion of people who limit their use of non-car trips is much higher. In a general sample of Aucklanders, Auckland Transport revealed that 27% would not use public transport at night and 24% would avoid using public transport in specific locations (Auckland Transport, 2019a).

The main strength of perceptions around safer journeys is that these are likely to be a better indicator of mode shift than actual safety indicators. Essentially, subjective indicators are critical, because perception leads to behaviour. People use the information readily available to them to make decisions (concept of bounded rationality). They do not look at the crash and injury data before they choose to walk, cycle or ride, but do rely on the previous experience of using those modes in similar conditions, and what their peers think about the safety of that mode (of particular relevance around personal security).

2.5.3 Emerging data opportunities

2.5.3.1 Route-based, neighbourhood and town centre interventions

Camera-based data: Creating a strategy to make better use of this data for crash safety (multi-modal near miss and crash data) and mode choice (counts of modes, speed of mode). This would include priority locations, analysis planning (computer-based analytics processing capability versus small manual samples

[6] A route-based intervention is applied along a specific course from a starting point to destination.

of time). As stated in section 2.2, other jurisdictions are starting to implement video cameras with AI analytics for counts. This has the potential to include count, speed and near-miss data. For the purposes of looking at mode shift and safety at a location, this is an excellent source of data, but analysis costs may be prohibitive at this time.

Camera-based near miss data: Can be captured at targeted locations via video (eg automated conflict analysis or manually coded, eg Thomas et al., 2018), and should be examined more regularly when looking at complex locations like public transport stops, intersections and mid-block crossings. Evidence is available that shows the relationship between near misses (which occur more frequently) is more strongly associated with perceptions of crash risk than actual crashes (which occur less frequently; Sanders, 2015).

2.5.3.2 City or region interventions

Mobile phone and vehicle journey data: Many fleets and applications capture journey data (eg Google maps, TomTom, E-roads, Spark) that can record and monitor safety and flow data of trips. Braking event data, speed data, trip origin and destination data, time of day data can all be captured. This is traditionally used for vehicle-based interventions (eg congestion data). Accessing the data is difficult (eg perceived to be expensive) or has limits around representation (eg not integrated at a large enough level to be representative) and, depending on the data source, is not always reliable at interpreting travel mode. This data does have the advantage of capturing trip-based information (as opposed to spot locations), so is well-placed to understand changes across a neighbourhood or city.

2.5.4 Insights around data

Summary insights from what we could measure
1. Including whole journey injury data in strategy and analysis. Taking opportunities to improve the access to injury data that can be captured and shared at a more refined geospatial level, and greater integration of injury data within a transport corridor. In particular, pedestrian and cycle-only injuries need to be examined equally with those injuries relating to motor vehicle crashes. 2. Placing emphasis on consistent perceived safety indicators. Mode shift is typically more sensitive to perceived safety than actual safety. For the purposes of mode shift, accurate and consistent measurement of perception data is critical. While it is commonly measured, the consistency of measurement makes it difficult to derive comparisons. In addition to consistent language, these should consider separating safety to cover how perceived risk leads to avoidance of travel based on the different sub-risks: crash injury; slip, trip and fall injury; and personal security. 3. Supporting camera-based data capture (for more localised treatments or at sample locations), because this provides a rich picture of both safety and mode shift. 4. Providing mechanisms to promote more complete, multi-modal intervention study evaluations. For example, greater use of evaluation guidance, improved access to monitoring equipment and analytic capability, or requiring monitoring of the modes affected when accessing funds (for example, as the Urban Cycleways Programme has done, which has led to more cycle monitoring in New Zealand cities; Pascoe, 2019).

Case study exemplar to demonstrate the value of combining high-quality metrics – Cairns Cycleway (Munro, 2018)

In Cairns, Australia, the Department of Transport and Main Roads organised a field trial that has an excellent combination of evaluation measures on a route-based intervention. The intervention was a new physically separated 3-metre-wide pedestrian and cyclist path (2.6 kilometres) to connect the western suburbs to the central business district. At intersections, priority was given to path users at nine intersections, which was managed using raised tables, green-coloured surface treatments and give-way signage (see Figure 2.5).

Objective data included:[7]

1. Video-based manual counts of pedestrians and cyclists (including analysis over time of day and week), inclusions of age and gender segmentation analysis (to see if a more diverse riding group was represented)
2. Video-based intersection performance, including compliance around priority, path user hesitancy and interaction severity
3. Cyclist travel time data (from 10 rides using a GPS logging application on mobile phones).

The subjective data, captured using intercept surveys of path users and alternative route users, measured:

1. Safety indicators: perceived safety, reported near misses, reported failure to give way, transfer of trips from less safe route
2. Mode shift indicators: increased walking (by trip purpose), increased cycling (by trip purpose), transfer trips from alternative route (as opposed to due to modal shift)

Figure 2.5 Before (top) and after (bottom) the introduction of a pathway, showing the path and intersection priority path for people who ride and walk (reprinted from Munro, 2018, p. 17)

[7] The purpose of this exemplar is to highlight the value of the combination of high-quality metrics used that can provide a much richer picture of safety and mode shift within a relatively short evaluation timeline. The main limitation to this study was that baseline data was not collected. Some route comparison data was available for an adjacent route.

Case study exemplar to demonstrate the value of combining high-quality metrics – Cairns Cycleway (Munro, 2018)

Observations of intersection performance at a sample intersection (see Figure 2.5) over a seven-day period revealed 169 interactions with motor vehicles at the crossing point, 56% with one or more cyclists and 44% with pedestrians. Compliance around priority, path user hesitation and interaction severity were observed and coded.

Two main points were noted from these observations:

1. Path user hesitancy (even when given intersection priority) could be a sensitive indicator of user comfort at potential conflict points. This is an innovative and thoughtful metric, where cyclists or pedestrians were observed to pause (ie not trust that motorists would give them priority). While many of these interactions are typically safe because people who ride and walk are slowing, waiting and making eye contact, they interrupt flow and could lead to confusion or anxiety in some path users. This showed that hesitancy was worse for pedestrians (40%) but still interrupted several cyclists (14%).
2. Overall, interaction severity was outlined by pedestrian and cyclist modes (see Figure 2.6). While no before video data was captured, and overall numbers of near misses were low, this did enable the pattern of unintended outcome events to be evaluated, for example, the 'screening' of a cyclist behind a waiting vehicle (see Figure 2.7).

Figure 2.6 Proportion of interaction severity by bicycle rider and pedestrian when a motor vehicle was present (reprinted from Munro, 2018, p. 21)

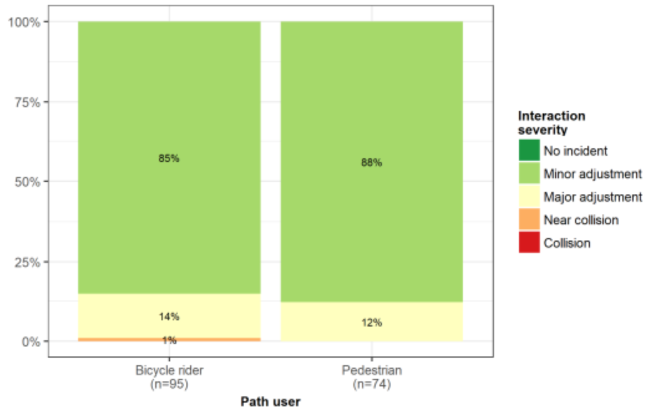


Figure 2.7 Example of an unintended outcome that can be observed via video-based methods, where a waiting vehicle 'screened' or reduced the visibility of a path user (reprinted from Munro, 2018, p. 23)

(a) Motorist slows before entering Mann Street

(b) Motorist accelerates, seemingly oblivious to bicycle rider behind grey vehicle

(c) Motorist initiates braking as soon as they see bicycle rider

(d) Motorist almost stationary ahead of rider

3 Literature review

3.1 Method

3.1.1 Literature sources

The literature was primarily identified from academic databases containing peer-reviewed articles and conference papers, found via key word searches, and supplemented by citations found in initial articles. The key words used included the different modes: ‘walking’, ‘cycling’ and ‘public transport’ in combination with descriptors such as ‘mode shift’ and ‘safety’. When articles on certain topics proved difficult to find, additional descriptor keywords were used that narrowed down the search (eg ‘lighting’). The initial search focussed on articles post-2010, but, when required, searches were expanded to included earlier articles. Abstracts were reviewed to determine whether the article was relevant, and, if so, it was added to the literature review. Where it was an intervention study, details were logged in a spreadsheet to support the intervention dashboard.

In addition, government agency and other websites (eg SafetyCube, n.d.), reports and factsheets from trusted sources (eg research institutes), and handbooks (eg Road Safety Manual (Transportøkonomisk Institutt, n.d.)) were searched for unique metrics on safety and mode shift measures. Interventions are presented as those that achieve a safety benefit for slips, trips and falls, personal security or road safety, with details on the level of safety improvement and mode shift achieved (or not achieved where this is reported on).

3.2 Safer journey interventions

3.2.1 Slip, trip and fall interventions

3.2.1.1 Street surfaces and walking behaviour

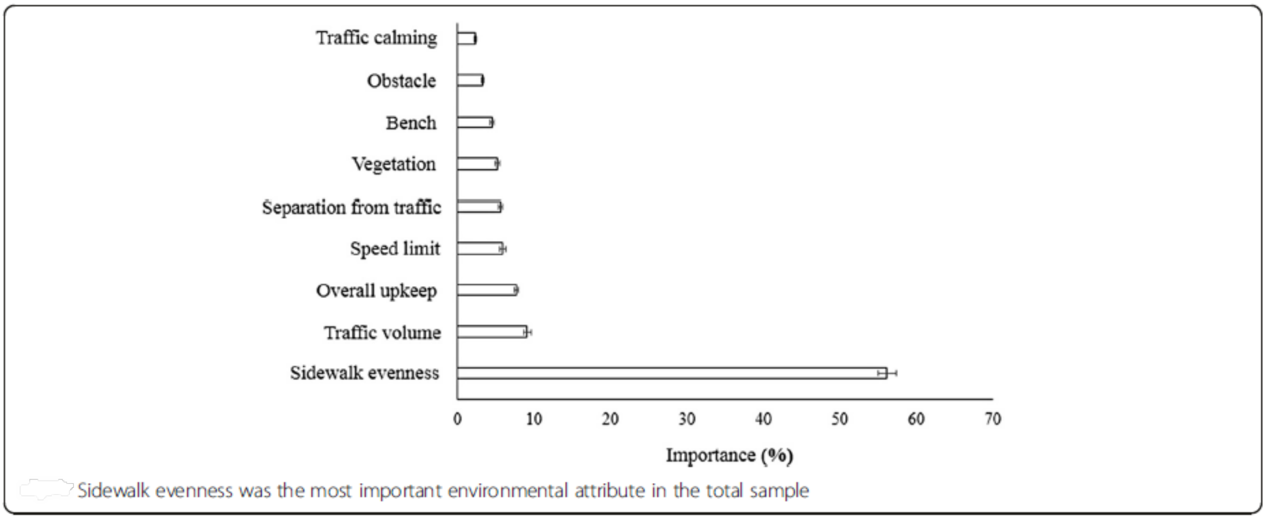
Pedestrians, especially older adults, state that they choose not to walk certain routes due to poor surface conditions. Mitra et al. (2015) investigated barriers and enablers to walking for a group of older adults using in-depth interviews and a photo-voice approach. The authors identified that poor sidewalk quality, absence of streetlights and personal safety concerns were major barriers to walking for those living in suburban residential neighbourhoods.

Brookfield et al. (2017) conducted focus groups and interviews of 22 purposively sampled older adults and identified that physical barriers to movement, such as steps, slippery surfaces, uneven pavement, kerbs, cluttered pavements, inclines and poor street lighting, had a discernible impact on the outdoor mobility of older adults. The participant sample included healthy individuals, stroke survivors and people with dementia. The impact of physical barriers was more pronounced in individuals with mobility limitations, and strategies such as using a mobility scooter, walking on the road to avoid uneven pavements or selection of alternative routes were adopted. Some participants reported falls due to uneven kerbs and pavements, with others reporting a fear of falling.

Good lighting has also been found to improve obstacle detection. Uttley et al. (2015) investigated the effect of illuminance and spectrum on obstacle detection by pedestrians by measuring how changing illuminance and scotopic/photopic luminance ratios affected the ability of older and younger test participants to detect peripheral obstacles. They found that detection performance increased with illuminance, reaching a plateau at 2.0 lux. A higher scotopic/photopic ratio improved obstacle detection but only at the lowest illuminance used (0.2 lux). Older participants showed poorer obstacle detection than younger participants but again only at the lowest illuminance. This is potentially problematic, because older pedestrians are also more focussed on routes with safe crossing locations, as opposed to well-lit routes (see section 3.2.2.1).

Other attributes of the pedestrian environment affect walking experience. In a study with 1,131 Flemish older adults, Van Cauwenberg et al. (2016) asked participants to complete online questionnaires containing modified street photographs that were changed on nine environmental attributes: sidewalk evenness, separation from traffic, obstacles on sidewalk, traffic volume, speed limit, traffic calming device, overall upkeep (tidiness), vegetation and benches. Participants chose which streets they would prefer to walk for transport. Results indicated that sidewalk evenness had the far greatest appeal for transportation walking (56.2%, 95% CI = 55.0, 57.4; see Figure 3.1).

Figure 3.1 Results from an online questionnaire asking about preferred environmental attributes for walking. Sidewalk evenness was identified as the most important environmental attribute (reprinted from Van Cauwenberg et al., 2016, p. 10)



While the barriers and perceived risk of injury while walking are well documented, controlled studies documenting pavement surface improvements on mode shift are lacking. The CIVITAS Eccentric programme provides an example of where multiple features in the environment led to an increase in walking and cycling of 15% (see section 3.2.2.3), but the impact of the pavement improvements alone was not determined (Ilieva, 2020).

Summary insights from slips, trips and fall interventions

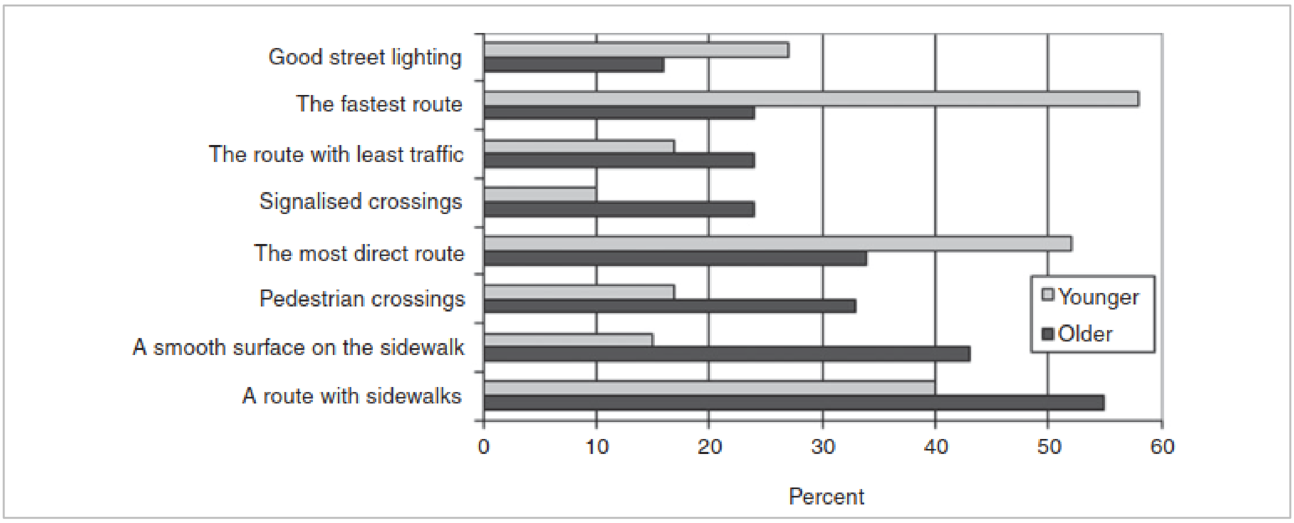
- Poor pavement surface conditions are one of the greatest barriers to using a particular route, particularly for older and mobility impaired users.
- Improved lighting results in better obstacle detection, however, lighting is less important to older walkers than other attributes (see section 2.4.2).
- Controlled studies documenting pavement surface improvements on mode shift are lacking.

3.2.2 Personal security interventions

When personal security interventions involve a combination of factors, evidence can be seen of improved mode shift. The CIVITAS Eccentric programme used LED lighting, surveillance cameras, night buses, and better app-based information, which all contributed to personal security and led to a 20% increase in public transport use (Ilieva, 2020). However, this study also looked at wider safety improvements around slips, trips, falls and safe crossings so the effect on security features alone was not demonstrated (for more detail on the CIVITAS Eccentric programme, see section 3.2.2.3).

When pedestrian route choice is examined, the relative benefit of features like good street lighting appears to be slightly less important to older walkers (70 or more years of age), who value safer crossing points and smooth surfaces more highly than others (see Figure 3.2; Fotios et al., 2015).

Figure 3.2 Important factors when selecting a pedestrian route by age group (reprinted from Fotios et al., 2015, p. 451)



Evidence is limited on the effectiveness of separate personal security interventions and their contribution to mode shift, mostly because various upgrades occur in combination. The literature available points to these types of interventions being at least somewhat useful at supporting mode shift, in particular, around the use of artificial lighting and real-time information on public transport stops, which are covered below.

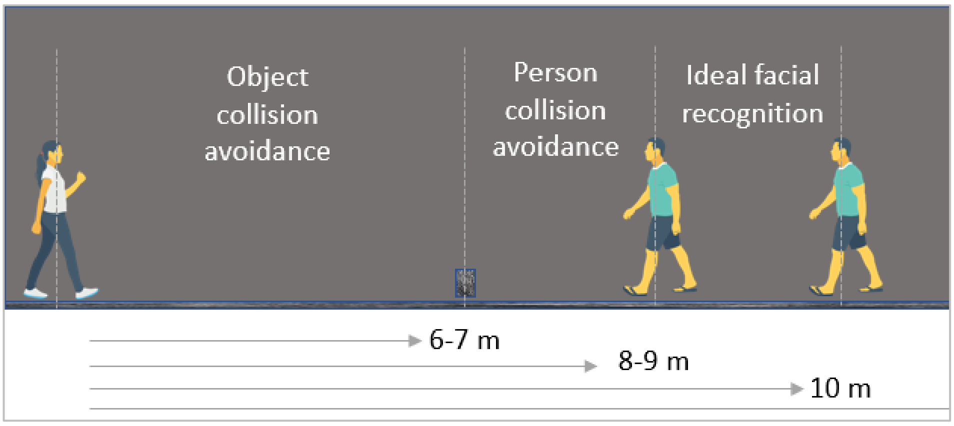
3.2.2.1 Artificial lighting

Lighting aimed at pedestrian safety and at making sure drivers see obstacles on the road are entirely different types of lighting with different objectives and standards. Present pedestrian lighting aims to reduce falls and allow humans to recognise other pedestrians whether animal or human and take action to avoid situations involving possible anti-social behaviour by others. As Schreuder (1998, p. 152) remarks, referring to pedestrian lighting.

> *We should really have a type of general lighting where being able to identify other road users is often more important than being able to detect small obstacles. An example to illustrate this: it is not pleasant to tread in a dog's mess, but it is much worse to be attacked unexpectedly by a robber or a rapist. The emphasis in the example is on the word unexpectedly. The ability to identify other road users from a sufficient distance is essential.*

A Waka Kotahi review of standards and user requirements for public lighting for safe and attractive pedestrian areas provides rich detail (Lester, 2010). This includes locations of interest where lighting could be considered more closely based on usability (implying more useful locations increase walking trips), personal security (implying people are actually safer), as well as minimum visibility requirements (safe negotiation of objects and other users; Lester, 2010). Controlled laboratory studies under 'night lighting conditions' found the minimum visibility field for person avoidance and feelings of personal security at night (ie the comfortable distance for facial recognition) are not too dissimilar (Lester, 2010; see Figure 3.3).

Figure 3.3 Visibility field minimum distances at night for safe obstacle and person avoidance and feeling comfortable around personal security (derived from studies summarised by Lester, 2010)



The review (Lester, 2010) considers pedestrian behaviour or tasks done at particular locations and shows that places of interest for pedestrian lighting include:

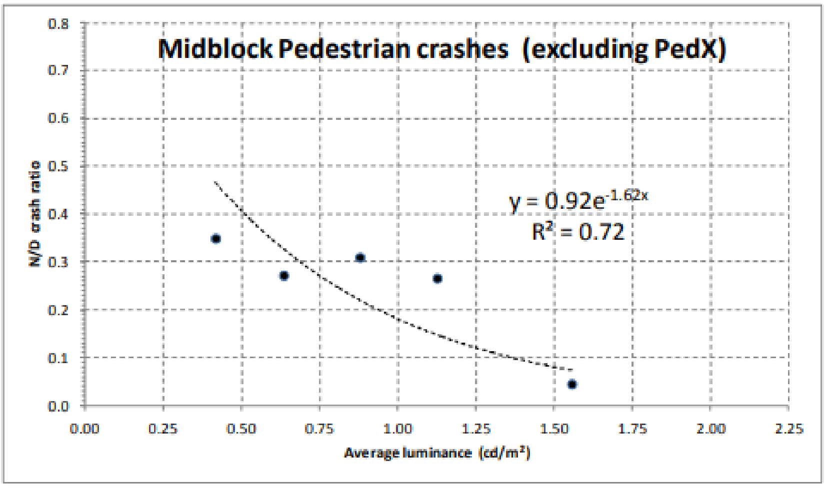
- **Minimising slips, trips and falls:** Locations with obstacles, edges of walkways, changes of grade (kerbs, stairs) or faster moving pedestrians (ie common jogging routes)
- **Where people pause, dwell:** Bus stops, maps and information panels, seating or tables
- **Locations that may involve money:** Payphones, vending machines, money machines/automatic teller machines.

Two studies by Uttley and Fotios (2017a, 2017b) looked at the effect of ambient light conditions on road traffic collisions involving pedestrians and levels of active travel. In the first, researchers compared the rate of road traffic collisions at pedestrian crossings in the United Kingdom before and after a shift to daylight saving time, because this let them compare collisions occurring during daylight and darkness but at the same time of day. This was done using a database of personal injury accidents, filtered to show road traffic collisions involving a pedestrian within the relevant time window either side of the daylight saving shift. Control times were also included.

Uttley and Fotios (2017a) found the odds ratio of a collision involving a pedestrian during the dark versus during the daylight was 1.70, an increase that shows the significant effect ambient light condition has on pedestrian risk. Interestingly, they noted that 98% of the crossings they evaluated did have after-dark street lighting, which raises the question of whether the standard of lighting at crossings is adequate enough to improve the visibility of pedestrians using them.

Road lighting, however, is specifically set up to allow drivers to detect obstacles on the road, including pedestrians, no matter where they cross the road. Only one-in-ten pedestrian crashes with motor vehicles occur on or near a pedestrian crossing (Waka Kotahi, n.d.-b) so if road lighting levels are to be questioned, then all road lighting should be included, not just that at pedestrian crossings. Figure 3.4 from Jackett and Frith (2012) shows the relationship between luminance and the night-to-day ratio for mid-block pedestrian crashes. This indicates the night–day ratio (a reduced ratio indicates greater night-time safety) asymptotes to a low value at around an average luminance of around 1.6 candela per square metres indicating this may be an approximation to an optimal value for pedestrian lighting. Pedestrian crossings were excluded from the figure because they are frequently equipped with supplementary lighting.

Figure 3.4 Relationship between average luminance and the night-to-day ratio for mid-block pedestrian crashes (reprinted from Jackett & Firth, 2012, p. 30)



The second study used automated pedestrian and cyclist counters to count the number of pedestrians and cyclists using various routes in Arlington County during the same hour before and after a shift to daylight saving (during a period between 2011 to 2016). Control times were again included. Uttley and Fotios (2017b) found the calculated odds ratio indicated that the number of pedestrians and cyclists were significantly higher during daylight conditions than after dark, with daylight conditions resulting in a 62% increase in pedestrians and a 38% increase in cyclists.

Farrington and Welsh (2002) ran a meta-analysis of 13 studies from the United States and United Kingdom that revealed a 20% reduction in crime as a consequence of improved lighting alone. The analysis reports large variation in the level of effectiveness, with five of the more recent studies in the United Kingdom (of the 13 investigated) providing a 30% reduction in crime. However, the studies did not reveal that night-time crime decreased more than day time with improved lighting (ie lighting also had a positive impact on crime generally). Consequently, the authors attributed the improved street lighting as part of the solution, and that it was most effective in locations where there was also increased community pride and informal social control, using an example of a Bristol (United Kingdom) case study, where the area was also undergoing gentrification. This may explain why some lighting studies show more positive results, because it may require a combination of infrastructure improvements reinforced by a more stable, active community. Mode shift as a consequence of crime reduction was not the focus of this meta-analysis, but one study that was evaluated did look at mode shift more closely (Painter, 1996).

Painter (1996) examined pedestrian use and crime levels in three different urban streets that had poor lighting and were crime blackspots in London. Sites were selected by a multi-agency team made up of a crime prevention officer, local authority officials, lighting engineers and academics from several areas identified by the police as being ‘poorly lit, fear inducing and potentially hazardous’. The lighting was improved at each location to give an average illuminance of 10 lux and a minimum of 5 lux, and high-pressure sodium lamps replaced the low-pressure sodium (orange) lamps being used that did not meet minimum lighting standards. In relation to crime, drops occurred in frequency of physical assault (from 8 to 0), vehicle theft (17 to 3) and threats (from 16 to 4). Over 90% of pedestrians interviewed (before and after the lighting) felt less fearful of crime in the surrounding area. Overall, monitored evening pedestrian trips increased across the three locations from 11,179 to 16,884 trips (over 10 evenings before and after), an increase of 51% in pedestrian trips. Several important insights were noted from this work:

- Problem or higher crime locations could be targeted for pedestrian lighting as an intervention, which is currently in New Zealand guidance (Lester, 2010).
- People varied in why they thought they felt safer walking on this street, where in one location 83% attributed it to the light, whereas in another location only 30% attributed it to the light. This group still said they felt safer but did not know why. This could indicate that subjective measures asking directly about the quality of lighting may under-represent the benefit.
- An indication of wider benefits was also evident, with two adjacent unlit roads that led to the lit road also reducing in crime (from 17 incidents to 3). The author states that increasing evidence is showing that crime prevention initiatives can have benefit beyond the immediate location.

A summary of lighting insights has been captured with all personal security insights below, because the overall finding is that lighting is complex (in relation to implementation, interaction effects and ease of monitoring) but also undervalued by users.

3.2.2.2 Real-time public transport information

A public transport personal security intervention frequently studied is the use of real-time information systems, providing users with information on how far away the next service is, delays and other relevant information. These systems have the potential to reduce user uncertainty and the time people need to spend waiting (including lowering exposure to waiting alone at a stop).

A real-time transit information system was provided for users of Seattle's bus service in 2008, which gave information through a variety of interfaces, including web, mobile, SMS and voice. Two studies were done of this system by Ferris et al. (2010) and Gooze et al. (2013). The first study involved the development of a survey to evaluate the effects of the system on perceptions of safety and public transport ridership levels. The researchers found that 18% of respondents reported the system had made them feel somewhat safer and 3% reported feeling much safer, increases that were statistically significant. The results also showed the increase was correlated with gender, with greater increases for women. In the second study, the same set of questions was used, but by this time the system had been operating for a while and improvements had been made to make it more user friendly. The results showed an increase of 32% in the proportion of people who stated the system made them feel somewhat or much safer (compared with 21% for the first study).

In terms of public transport ridership, the first study identified an increase in the number of bus trips taken per week by users of the system, with more gains in non-commute trips versus commute trips (Ferris et al., 2010). The second study found a larger percentage of users who stated they took one, two or three more trips because of the real-time transit information (Gooze et al., 2013). Data accuracy was also found to be important, with 9% of users who experienced an error stating they took the bus substantially or slightly less often as a result of the error (Gooze et al., 2013).

The same system was introduced in Tampa, Florida, in 2007. Brakewood et al. (2014) conducted a similar study using a pre- and post-intervention online survey with treatment and control groups. They found that feelings of safety during the daytime significantly increased in the treatment group, but no significant difference was evident in feelings of safety at night. The authors note this may be because the pre-intervention survey was conducted when daylight hours were much longer, resulting in many users likely not having the opportunity to experience a change in feelings of safety at night.

Brakewood et al. also found that 39% of the treatment group rode the buses somewhat or much more often. This result was not statistically significant, however, when compared with the control group. They note this may be because many bus riders in Tampa depend on public transport and so have limited ability to increase their trips. In addition, the study participants were recruited from people who were already in the sphere of influence of the public transport provider, so no opportunity was available to analyse the impact of the real-time information on attracting new riders.

The above studies relate to public perceptions of safety associated with the system and self-reported changes in public transport use associated with the system. It was also mentioned in the studies that data accuracy, which directly relates to the actual waiting time, is important, with self-reported bus use declining with lower accuracy.

Čelan et al. (2017) compared, using 245 observations and interviews at four different bus stops, the following:

- passenger arrival time to the bus stops
- passenger waiting time
- passengers perceived waiting time
- actual bus arrival time.

On average, passengers arrived at bus stops 7 minutes before the scheduled bus arrival time and 7.5 minutes before actual bus arrivals. Where the bus headway was under 20 minutes, the average waiting time was just below 6 minutes, and the perceived waiting time was 23% greater than the actual waiting time. With headway between 20 and 30 minutes, the average waiting time was almost 9 minutes, and the perceived waiting time was 47% higher than the actual waiting time. The authors concluded that the higher the headway the more important the real-time information.

Lu et al. (2018) carried out a stated preference survey in London to assess how real-time bus arrival information affects passenger behaviour and the values they place on waiting time at the bus stop. Live bus arrival information is provided by countdown signs at over 2,500 London bus stops and is also available via smartphone or tablet apps, the internet and SMS.

Multipliers of disutility per minute for expected waiting time in relation to bus in-vehicle time were estimated. The sample was weighted using the London Bus User Survey to reflect the composition of the bus user population in London. Table 3.1 shows the waiting time multipliers for each means of checking information.

Table 3.1 Waiting time multipliers for each means of checking information[8] (adapted from Lu et al., 2018, p. 30)

Sample average values	Sample (%)	Before weighting	After weighting
Have not checked or no access to information	61	2.3	2.2
Checked waiting time using mobile	32	1.8	1.7
Checked waiting time using internet	4	1.0	1.0
Checked waiting time using both mobile and internet	2	0.8	0.8
Overall	100	2.0	

Table 3.1 shows that, on average, London bus users value changes in waiting time two times more than changes in in-vehicle time. This indicates that waiting time is given a sizeable value by bus users in London and so can be expected to be a significant determinant of the likelihood of mode shift.

3.2.2.3 Improved walk-up to public transport (CIVITAS Eccentric)

As part of CIVITAS Eccentric, a European Union programme to get more feet on pavements and increase safety for pedestrians and cyclists in five European cities, Druzhba (a suburb in Ruse, Bulgaria) is highlighted as having poor pavement quality, with citizens, especially those with disabilities, avoiding walking

[8] The countdown timer was not included in the final model because, after bootstrapping, its effect was not found to be significant.

and leading to a higher level of motorised transport than is essential.[9] A high risk of pedestrian road accidents is reported among those with disabilities. As part of the project, the quality of pedestrian crossings in Druzhba was analysed and improvements made. These included use of LED lighting and elevated crossings, with surveillance cameras installed to monitor performance and increase perceptions of safety, and new sidewalks separating walking and cycling from the road. This formed part of the suburb-wide interventions, including provision of a park and ride facility, night buses, a public transport scheme and a mobile app for public transport. Overall, the interventions led to a decrease in car use by 20%, an increase in walking and cycling by 15% and public transport by 20%, but the effect of the pavement improvements alone was not determined (Ilieva, 2020).

3.2.2.4 Neighbourhood accessibility planning

A complete package approach was undertaken in New Zealand as an initiative under the 'Road Safety 2010' strategy by Land Transport NZ that trialled physical and behavioural initiatives around routes to schools and other community locations. Named 'Safer Routes', before being renamed 'Neighbourhood Accessibility Planning', the projects aimed to give safe access to all ages of pedestrians and cyclists in neighbourhood areas and involved a council working with neighbourhoods to identify issues and solutions to be implemented (NZ Transport Agency, 2009). Within the outcome reports, five out of the six case studies presented did not report on mode shift, due to a lack of evaluation or a focus on safety outcomes, however, the Nelson case study reported a positive impact (see Figure 3.5).

The Nelson Neighbourhood Accessibility Plan (2004) included a colourful education campaign and the completion of 23 engineering improvements valued at $1.3 million. This resulted in an increase in pedestrian numbers in the CBD, with a pedestrian volume increase of 22.5% over 2006 and 2007, combined with a 7% overall reduction in reported crime in 2006 (including no change in assaults, 21% reduction in disorder and 33% reduction in wilful damage). A significant crash reduction rate also occurred for cyclists and pedestrians, from a pre-project three-year average of five annual pedestrian crashes and 11 cycle crashes, to a post-project reported crash result for 2007 of one pedestrian crash and no cycle crashes (Johnson, 2008).

This 'complete package' approach generally had better outcomes than single interventions. In addition, it seems to be a consistent trend where larger scale interventions, such as the US Safe Routes to School, have evaluated both safety and mode shift over a longer timeframe that allowed for more robust outcome analysis.

Summary insights from personal security interventions

- Safety interventions to improve artificial pedestrian lighting will positively affect mode shift, especially around walking trips, including walking trips to public transport.
- Lighting will have the best effect in areas perceived to have issues with personal security, and where a stable community is supportive of the improvements.
- Lighting is likely undervalued by the community because people do detect a benefit but may not specifically notice the change in lighting and, consequently, do not attribute the improvement to lighting (or complain about a lack of lighting).
- Auditing and assessing lighting should be based on the users and use of the space.
- An accurate and reliable real-time transit information system will positively affect mode shift, with potential to specifically increase non-commute trips and those made by women.
- The complete package approach in Neighbourhood Accessibility Planning has been shown to be consistent over long timeframes in both safety and mode shift outcomes.

[9] See CIVITAS citivas.eu/cities/ruse for more information.

Figure 3.5 Neighbourhood accessibility plan summary poster (reprinted from Land Transport NZ, 2009)

Nelson city centre neighbourhood accessibility plan

Safer Routes trial project started in January 2004

Objectives

>> To identify problems and hazards in an area at high risk of road-user casualties.
>> To help Nelson residents to identify their routes into and around the city.
>> To work with Police, engineers and the community to find solutions to problems, thereby improving the major routes into and around the city.

Issues and suggested solutions

Controlled intersections

>> Problem: Vehicles turning onto pedestrian crossings while the pedestrian is crossing. Main examples are the intersections of Hardy and Rutherford streets, and Halifax and Trafalgar streets.

>> Solution: Pedestrian-only crossing phase/'Barnes dance' (a pedestrian-only phase allowing diagonal movement).

Raised crossing

>> Problem: Confusion around who has to give way on raised crossings.

>> Solution: Paint them, differentiate surface and run an education campaign.

Amount of traffic

>> Problem: Concern for mobility disadvantaged and cyclists.

>> Solution: Pedestrian-only streets in some parts of city.

Length of pedestrian crossing phases

>> Problem: Not enough time for people with mobility disadvantages to cross.

>> Solution: More time, audible and tactile warning systems, smooth out rough and steep drop kerbs.

Fear of crime

>> Problems: Drunken and disorderly behaviour at night.
Racial harassment experienced by locals and visitors.
Isolation makes people afraid in some parts of the city.

>> Solution: Close bars at midnight/leave bars open indefinitely, provide a mix of bars targeted at different age groups in the same location.

Cyclists

>> Problems: Car angle parking – cyclists can't be seen when vehicles pull out.
Parallel parking – car doors opening.
Pinch points at narrowed sections of road that have kerb extensions.
Lack of secure cycle-parking facilities .

>> Solutions: Advanced stop boxes.
Cycle racks.
Better-researched infrastructure suitable for cyclists.
Encourage cars to reverse into angle parks.

Location

Engineering implementation

New Maitai River cycleway

Cycle lanes and advance stop boxes at Trafalgar Street/ Halifax Street signals

New covered cycle stands

Educational initiatives

Key outcomes and successes

>> Lighting upgrade.
>> Cycle lane and advanced stop boxes at Halifax and Trafalgar Streets.
>> Cycle path, cycle facilities and cycle storage improvements carried out.
>> Three new speed tables installed to slow traffic.
>> Cycle design course for all design engineers.
>> Educational campaign on shared, slow zones and the use of various facilities within this zone.
>> Education on the need to look for bikes when opening car doors and reversing cars.
>> Awareness of pedestrian issues in the CBD was raised in the community and some drivers changed their behaviour to be more considerate of pedestrian safety.
>> New community contacts were obtained and new relationships with community groups were formed.
>> The project triggered activities such as the development of accessibility maps showing the disabled car parks.
>> The project led to the position of 'Community Liaison Adviser, Safe City' being created in the council.
>> The actions specified in the CBD upgrade were prioritised to address the needs of the community.
>> The lowest ever crash rate for pedestrians in Nelson City was recorded in 2006, after the education campaign and some engineering changes.

Land Transport NZ
Ikiiki Whenua Aotearoa

New Zealand Government

3.2.3 Road safety interventions

3.2.3.1 Speed limit reductions and traffic calming measures

Safer speeds are an important component of the Safe System and a forgiving transport system, with the aim of matching the speed allowed to the level of protection of users in a particular environment (International Transport Forum, 2016). Area-wide traffic calming is the coordinated use of traffic control measures in a large, defined area to improve traffic safety and environmental conditions (Elvik & Vaa, 2004). This can include reducing speed in residential streets through use of lower speed limits or physical measures. Traffic calming measures, including speed limit reductions, reduce the number of crashes by 15% to 20% primarily on local streets but also in the surrounding main streets (Transportøkonomisk Institutt, n.d.).

Reduced speed limits and traffic calming measures with a measured contribution to mode shift have been included as components in several different interventions, often as part of a package of infrastructure changes. These interventions include the US Safe Routes to School programme (discussed in section 3.2.3.4), the Safe Routes to Transit programme (discussed in section 3.2.3.5), and a complete streets project in Trondheim, Norway (discussed in section 3.2.3.2).

An intervention in Belfast (United Kingdom) reduced the speed limit of streets in the city centre to 20 miles per hour (around 32 kilometres per hour (km/h)), covering 76 streets. Before the intervention, none of the streets had a speed limit of less than 30 miles per hour (around 48 km/h). The area covered was predominately commercial with a limited number of student and residential properties (Cleland et al., 2021).

Cleland et al. (2021) studied the effect of the speed limit reduction using focus groups, finding that perceptions of safety amongst cyclists had improved. In addition, it was also perceived that the severity of crashes would decrease due to the lower speed limit. Mode shift perceptions were less clear, but several participants commented the slower traffic speeds would make it more likely that they would feel comfortable walking and cycling in the area, as well as letting their kids out to play on the streets.

A speed-related intervention in Auckland introduced the concept of a self-explaining road to several local and collector roads (Mackie et al., 2013). A self-explaining road is one that reinforces the correct expectations and road user behaviour to create a safe and user-friendly road. To achieve this, the local roads had their speed limit reduced to 30 km/h, which was given effect by traffic calming measures including trees planted in the centre of the road and landscaped islands placed periodically along the curb sides. Road markings were also removed to create a less formal environment. Collector roads had their speed limit reduced to 40 km/h, and cycle lanes, pedestrian crossing points and landscaped medians with pedestrian refuges were added.

Mackie et al. (2013) looked at the effect the intervention had on road user behaviour three months before and four months after construction using cameras positioned at nine locations within the treatment area on nine separate days. Tube counters were used to measure vehicle counts and the video data from the cameras was used to count pedestrians and cyclists. Crash data was also obtained for the five-year pre- and two-year post-intervention period.

The authors found that the crash numbers had reduced by 30% per year of the study period and crash costs had reduced by 86% per year, indicating a reduction in crash severity. On local roads, video data showed that pedestrians were less constrained following the intervention, which the authors stated may reflect a perceptually safer environment. In terms of mode use, pedestrian activity was found to have generally increased across the treatment area, with one road corridor seeing an increase of 81%. Overall, school-aged pedestrians increased by 25%, and adult pedestrians increased by 8%. However, not much change could be seen in the number of cyclists.

Another Auckland speed intervention in 2019 introduced traffic calming measures, such as speed bumps and speed tables, to residential areas in Rosehill (Papakura) and Te Atatu South. Gravitas Research, in partnership with Auckland Transport, was asked to evaluate the effects of these changes (Gravitas Research, 2020). A letter was posted to residents in both treatment areas outlining the research and measures that had been undertaken in the area. A paper survey was included with the letter, as well as instructions on how to take the survey online if preferred. A 13% response rate was achieved.

In Rosehill, the residents who responded felt the measures resulted in a net increase in road safety, with 82% of respondents saying the changes increased safety. The finding was similar in Te Atatu South, with 77% of respondents saying the measures increased safety.

Rosehill saw a reported walking net increase of 37% and a cycling net increase of 12%, with 44% of respondents stating they were participating in at least one active mode activity more often post-intervention. In Te Atatu South, a net increase occurred of +26% for walking and +6% for cycling, with 31% stating they were participating in at least one active mode activity post-intervention. For further investigation on this location, see Case Study 1 in section 6.1.

When looking at travel to school, in an Australian study of children aged 9–13 (N = 1,298) in 25 schools, Trapp et al. (2012) discovered through analysing travel diaries and parent–child questionnaires that boys were almost three-and-a-half times more likely to walk to school in the presence of low traffic volumes and less than half as likely to walk if they had to cross a busy roadway. A review of 33 quantitative studies on physical activity in children determined that, when a neighbourhood has lower traffic speeds and volumes, levels of walking and biking increase and when traffic volumes and speeds rise, levels of walking and biking fall (Davison & Lawson, 2006).

Summary insights from speed limits and traffic calming

- Speed restrictions (reduced to around 30 km/h), when combined with traffic calming and features that provide self-explaining speed environments (ie where the perceived appropriate speed aligns with the speed zone limit), are effective at reducing crashes and show evidence of increased mode shift.
- The strongest evidence from speed restrictions and traffic calming was for an increase in walking trips.

3.2.3.2 Physical separation and active modes

Several physical separation interventions have been reported, including traffic calming measures, removing motor vehicles from residential streets and bike boxes at intersections. Physical separation of vulnerable road users from high-speed traffic is an important component of the Safe System approach (International Transport Forum, 2016). In the literature, the most common separation intervention was removing cyclists from the road onto a dedicated cycleway, physically separated from the road. This sort of intervention requires careful design and maintenance because otherwise cycle-only crashes and cycle–cycle crashes may become a problem (Angus, 2016).

Separation of cyclists and pedestrians from motor vehicles: Interventions where safety perceptions and modal shift were measured

A ‘complete streets’ project in Trondheim (Norway) introduced physical separation to a popular commuter route in the city centre, reducing the number of vehicle lanes from four to two and installing a bidirectional cycleway in their place (Vasilev et al., 2018). Vehicle through-traffic was prohibited, and the speed limit was reduced from 50 km/h to 40 km/h. Concrete traffic barriers were installed along 35% of the route, and the remainder was separated from the road by wide diagonal stripes.

Vasilev et al. (2018) conducted a web-based travel survey after the intervention had been completed, to gather perceptions of the changes, which was intended for people who had used the route both before and after. They found that 87% of respondents agreed the intervention had been positive for the neighbourhood in terms of safety, and the percentage of trips by cycling increased by 28.6%. Walking also increased by 7.7%. Public transport and private vehicle use both decreased, from 21.3% to 13.9% and from 16.2% to 10.1% respectively. About 1.4% of all survey respondents stated they began to use a bicycle as a direct result of the intervention.

A smaller scale intervention in Hounslow (London) applied modal filtering to a residential street. Previously, the street had allowed vehicle traffic, but the modal filtering removed this and allowed only pedestrians and cyclists. Aldred and Croft (2019) investigated the effect of the intervention using an intercept survey, with 80% of respondents indicating it had made the street environment safer. Twenty-eight percent of intercepted pedestrians and 32% of cyclists said they were walking and cycling more frequently than before the change. Of these users, around 30% were making an entirely new trip or a mode shift from a motor vehicle.

In Lisbon (Portugal), a large-scale street improvement project saw the reallocation of road space in favour of pedestrians. Cambra and Moura (2020) captured walking experience and pedestrian numbers before and after the intervention was complete using a survey and pedestrian counters, which was controlled for by using two other locations. Safety outcomes were not specifically included, but the before and after ‘walking experience’ was captured using a Likert scale, which found it had increased following the implementation of the intervention. Pedestrian counters at three locations along the route saw percentage increases of 11%, 30.5% and 8.7% in the number of pedestrians.

McNeil et al. (2015) looked at the influence of cycleway buffer types (in this context, buffer includes physical separation or painted buffers) on the perceived safety and comfort of cyclists and potential cyclists by investigating the outcomes of cycleways with different types of road buffers installed along several streets in cities in the United States (Austin, Texas; Chicago, Illinois; Portland, Oregon; San Francisco, California; and Washington, DC). Data from cyclists using the buffered cycleways was captured using intercept surveys, and data from the wider community was captured via a postal survey sent to residents living near the cycleways.

The findings suggest that striped or painted buffers offer some level of increased comfort, but buffers with physical protection (such as plastic flexposts, concrete blocks or planters) yield significant increases in perceived comfort for potential cyclists with safety concerns. About 52% of this group (‘interested but concerned’) stated the safety of cycling on a cycleway with physical buffers had increased a lot, and 36% stated the safety had increased somewhat. Of the residents living near the recently built cycleways, 71% of all residents and 81% of the ‘interested but concerned’ group indicated they would be more likely to ride a bicycle on a route where some form of physical separation from vehicle traffic was present. This aligns with New Zealand rider perceptions around willingness to ride and mid-block separation (eg Bowie et al., 2019; Kingham et al., 2011).

In 2008, the City of Portland completed installation of 12 bike boxes (a marked area of road that places cyclists in front of motor vehicles at intersections to increase visibility and reduce turn conflict). Dill et al. (2011) ran video cameras at each site before and after the bike box installation, to capture their impact on safety and cycle usage. Analysis of the video recordings revealed that the number of observed cyclists had increased by 94% following the installation of the bike boxes. Conflicts decreased by 31%, despite an increase in the total number of cyclists, along with an increase in the total number of right-turning vehicles.

In London, a ‘mini-Holland’ programme was implemented in several boroughs, which included a range of infrastructure changes such as traffic calming measures and separated cycleways along the main roads. Aldred et al. (2019) captured perceptions of cycling safety and reported travel mode using an online survey sampling both those living within the mini-Holland boroughs and those living outside (as a control). The mini-Holland boroughs sample was then further divided into those in ‘high dose neighbourhoods’ (where substantial changes to the local walking and cycling infrastructure had been implemented) and ‘low dose neighbourhoods’ (where limited changes had been made). Perceptions of cycling safety were found to have improved to a greater degree in the treatment areas, compared with the control areas, and perceptions of the cycling environment as a whole also improved. A year of exposure to the interventions was associated with an increase in active travel amongst those living in ‘high-dose’ mini-Holland neighbourhoods, where residents were 24% more likely to have done any past-week cycling at follow-up, compared with those living in non-mini-Holland areas.

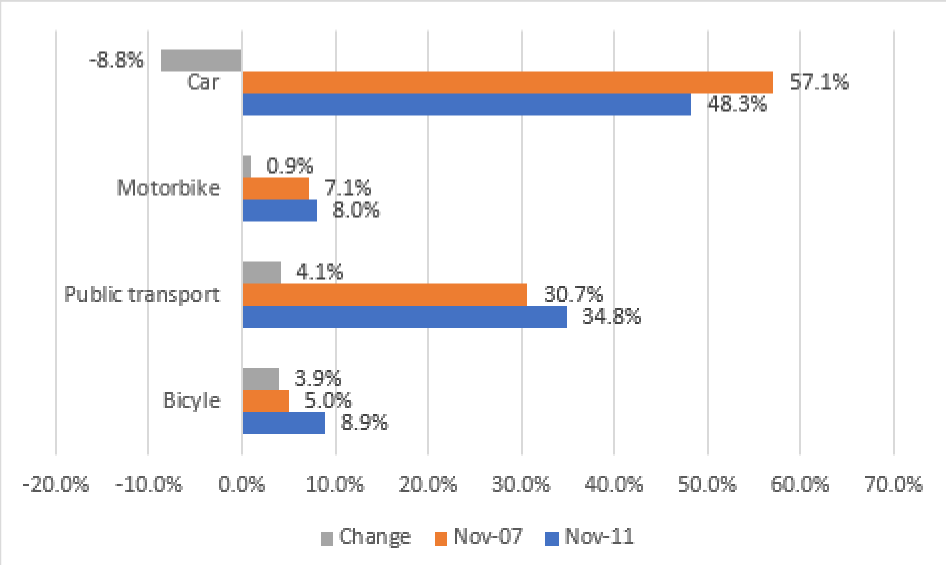
Separation of cyclists from motor vehicles: Interventions where objective safety metrics were also measured

In Seville (Spain), a fully segregated network of bi-directional cycle paths was established over five years (2006–2011; Marqués et al., 2015). This was done mainly by taking away dedicated car spaces (about 8,000 spaces), such as the example given in Figure 3.6. This resulted in both an increase in cycling and a decrease in bicycle traffic injury rates.

The change in mode shift reported shows an increase in cycling of 3.9% (see Figure 3.7; note that walking was not reported in the mode shift data; Marqués et al., 2015). Bicycle traffic injury rates during the same period went from 1.82 per 100,000 trips to 0.55 per 100,000 trips. The data also showed that, in the five years before the programme, cyclist injuries were primarily due to crashes with motor vehicles (94%), and in the five years during the programme this dropped significantly (81%) but was still the leading cause of injury, indicating the intersections of cycling and vehicle traffic were still an area for improvement. During the same periods, deaths and serious injuries for cyclists involved in a crash also moved from 10% to 5.4%. A weakness of this study is it concerns only crashes between motor vehicles and bicycles.

Figure 3.6 Example of before and after replacement of car parks with bi-directional cycleway in Seville, Spain (reprinted from Marqués et al., 2015, p. 35)

Figure 3.7 Summary of travel mode breakdown and mode shift changes between 2007 and 2011 in Seville, Spain (adapted from Marqués et al., 2015, p. 38)

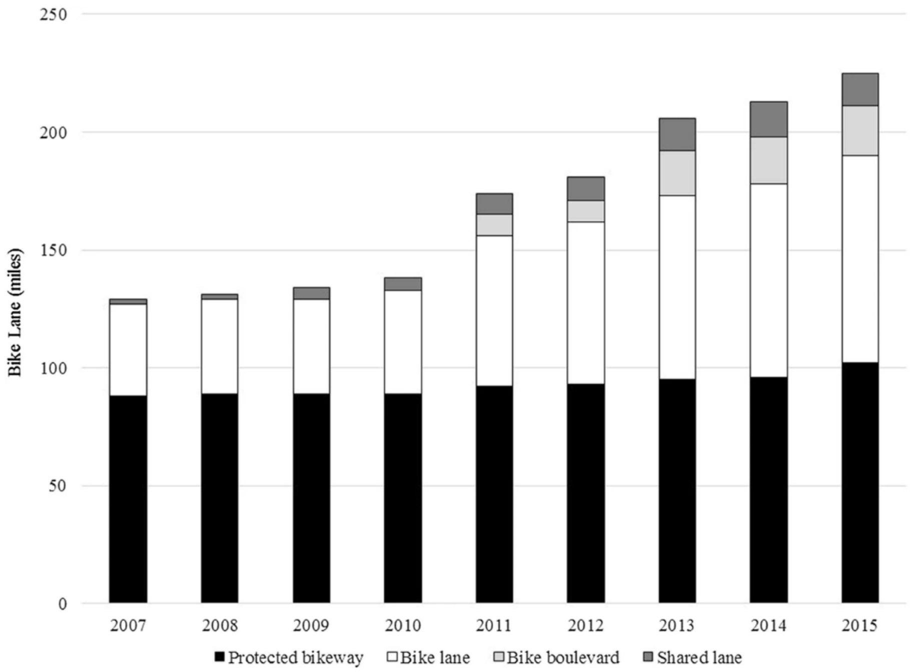


Montreal has a well-established network of physically separated two-way cycle-only facilities along its street network. Lusk et al. (2011) compared cyclist injury rates on six cycle facilities with those occurring on comparable reference streets. The study data included police reported vehicle–bicycle crashes, and their resultant injuries, injuries reported by emergency services and cycle volume counts. This meant injuries from non-motor vehicle incidents on the cycleway that needed emergency service attention were included in the data. The relative risk of cyclist injury on cycle facilities was 0.72 (95% CI 0.60 to 0.85) compared with the reference streets, indicating a 28% reduction.

Cicchino et al. (2020) examined the risk of collisions or falls leading to emergency department visits associated with protected bike lanes, bike lanes demarcated by painted lines, sharrow markings and other roadway characteristics in Washington, DC, New York City and Portland, Oregon. Using a sample of cyclist emergency department patients, the authors compared each fall or collision site with a randomly selected comparison site on the route leading to the incident. The presence of site characteristics that participants described were validated using Google Street View and city GIS inventories of bicycle facilities and other roadway features. More heavily protected bike lanes (tall, continuous barriers or grade and horizontal separation) were associated with lower risk (adjusted OR = 0.10; 95% CI = 0.01, 0.95) while the less separated (eg, parked cars, posts, low curb) had a similar risk to major roads when one way (adjusted OR = 1.19; 95% CI = 0.46, 3.10) and a higher risk when two way (adjusted OR = 11.38; 95% CI = 1.40, 92.57). The main driver of the risk increase was one lane in Washington. Tram or train tracks increased risk (adjusted OR = 26.65; 95% CI = 3.23, 220.17) as did downhill relative to flat grades (adjusted OR = 1.92; 95% CI = 1.38, 2.66), and temporary features, like construction or parked cars blocking the cyclist’s path (adjusted OR = 2.23; 95% CI = 1.46, 3.39). Conclusions were that heavier separation, less frequent intersections with roads and driveways, and less complexity appear to contribute to reduced risk in protected bike lanes. Planners should minimise conflict points when choosing where to place protected bike lanes and should implement countermeasures to increase visibility at these locations when they are unavoidable.

Goerke et al. (2020) examined the impact of cycle infrastructure changes in Minneapolis on the severity of cycle trauma sustained by cyclists admitted to a trauma centre. The technique used was a retrospective cohort study. The total number of miles of bikeway by year was used as a surrogate for cycling infrastructure. The study indicated a significant reduction in cyclist injury severity as a substantial increase in total bicycle lane miles occurred, which was also accompanied by a substantial increase in cycling. A reduction in the number of injuries was not shown. The bikeways included simple designation of thoroughfare residential streets as ‘bike boulevards’, shared lanes, major city arterials with separate bicycle lanes with markers and bollards, and fully separated cycle facilities (see Figure 3.8). The proportion of miles with fully separated facilities declined over time.

Figure 3.8 Minneapolis – increase in cycle facilities over time (reprinted from Goerke et al., 2020, p. 545)



Van Petegem et al. (2021) compared the safety of physically separated cycle tracks with marked or painted cycle lanes and mixed-traffic conditions at distributor roads with a speed limit of 50 km/h in Amsterdam, using ambulance records that reported crashes not involving motor vehicles. Both motor vehicle volumes and cyclist counts were included in the crash analysis. Results show that, controlled for kilometres travelled by bicycle and motor vehicle, 50% to 60% fewer bicycle crashes occur on distributor roads with cycle tracks compared with those with cycle lanes. Curb-side parking and trams are related to an increased likelihood of bicycle crashes, a difference of a factor 2 and 1.7–2 respectively.

Separation of micromobility from other modes

The International Transport Forum (2020, p. 32) suggests micromobility as a connection to public transport to support public transport ridership and thereby avoid private road-vehicle deaths:

> *Public transport is the safest travel mode by far, and cities should promote using micromobility to connect with these services.*

For this report, ‘micromobility’ is defined in accordance with Waka Kotahi research report 674 (Ensor et al., 2021) as an umbrella term for transportation using small, electrically powered transport devices only that can be used on footpaths, shared paths or cycle infrastructure, although most micromobility research has focussed on e-scooters.

While research is available that supports mode shift from vehicles, active modes and public transport to micromobility and new trips generated through micromobility (Ensor et al., 2021), the evidence is limited on mode shift through separation of micromobility from other modes, however, this is a critical factor particularly in terms of separation from road vehicles. Over 80% of e-scooter rider deaths result from crashes with heavier vehicles (International Transport Forum, 2020), and streets and sidewalks have been found to be common locations where collisions occur, suggesting specific infrastructure, such as bicycle lanes, should be considered because e-scooters operate at a similar speed (Toofany et al., 2021).

A survey of e-scooter users by Christchurch City Council (2019) found most were riding on the footpath but would prefer to ride on shared paths (bikes, pedestrians and other users), followed by the footpath and in separated cycle lanes. However, for those who did not ride e-scooters, 55% reported feeling unsafe when sharing footpaths with e-scooters with the main reason being that people felt e-scooter riders were not being safe or considerate due to the speed of operation. Non-rider e-scooter-related injuries have been found to represent between 1% and14% of all e-scooter-related injuries (International Transport Forum, 2020).

Research in Portland and Austin identified that, in both cities, e-scooter riders prefer to ride in bike lanes, compared with car lanes and footpaths (Chang et al., 2019). In a survey of 1,700 e-scooter riders in Portland, 47% of respondents indicated that safer places to ride (eg, bike lanes or paths separated from vehicles) would encourage them to use e-scooters more often (Portland Bureau of Transportation, 2019). Similarly, a survey in Austin, with 7,987 respondents (41% of whom had used dockless mobility e-bikes or e-scooters), identified ‘more infrastructure, such as a connected bicycle facility or shared use pathway’ was the most likely reason to influence their decision to use dockless mobility (City of Austin, 2019).

While this indicates that separation between micromobility and road vehicles has the potential to contribute to mode shift to micromobility, it also highlights the possible reduction in walking when sharing footpaths, and an increase in injury to pedestrians. The limited research suggests that separation of micromobility from both road vehicles and pedestrians (eg on a separated cycleway) is likely to have the greatest contribution to mode shift while minimising rider injury from road traffic and pedestrian injury from shared paths.

Separation between walking and cycling

The evidence of physical separation between active modes and whether this could affect mode shift (ie whether to separate pedestrians and cyclists) is less clear. Factors that may affect use of a shared path (where there is no physical separation) are complex. They include path width, suitability to accommodate the mix of walkers and riders, the volume of users, speeds of users, the type of users (eg commuter cyclists mixing with recreational walkers or walkers with a mobility or visual impairment) and the amount of conflict.[10] In relation to shared paths, Poulos et al. (2015) ran a self-report study surveying adult cyclists in Australia (N = 2,038) and found that higher intensity cyclists (those who liked to travel faster) spent less time cycling on shared paths (about 13% of their travel) than lower intensity cyclists (about 19% of their travel). Self-reported crashes on shared paths represented 11.7% of crashes (relative to reported time spent on these paths of 15.7%) as opposed to cyclists choosing to ride on pedestrian footpaths, where crashes made up 5.4% (relative to reported time spent on footpaths of 4.2%; Poulos et al., 2015). Boufous et al. (2018), in a review of bicycle crash studies (self-report studies), also revealed that only one-in-six crashes on shared paths involves collisions with pedestrians. However, this only reveals where cyclists are riding and the likelihood of crashes, not how pedestrians are influenced, nor how the cyclist choice relates to the type of infrastructure available.

Boufous et al. (2018), in an observational study of 12 shared paths in Australia (N = 5,421 cyclists), found the median speed of cyclists on shared paths was 16 km/h, that most riders (80%) travelled at 20 km/h or less, but some riders still rode at speeds deemed less safe for this environment, with 7.8% of riders travelling over 30 km/h. They also observed that riders on shared paths did adjust their speed to accommodate pedestrians, with only 4.2% of riders travelling over 30 km/h when pedestrians were present in greater number (over 20 pedestrians per hour). The authors concluded that riders typically adjust to accommodate

[10] See www.nzta.govt.nz/walking-cycling-and-public-transport/cycling/cycling-standards-and-guidance/cycling-network-guidance/designing-a-cycle-facility/between-intersections/shared-paths/, for a summary of factors and considerations.

pedestrians, and characteristics that support visual separation (with visual cues, like centre lines) would allow relatively higher speeds for cyclists (Boufous et al., 2018). While discussion did not focus on outcomes around impacts on trips overall, the authors did indicate that perceptions of risk of injury caused by cyclists, including amongst older walkers, are common.

Summary insights from physical separation

In summary, physical separation that protects users is effective at increasing active travel, especially separation from motor vehicle traffic. The level of evidence of effectiveness indicates:

- Physical separation of cyclists has the greatest effect on mode shift and crash safety. This includes mid-block protected cycle lanes (ie with 'heavier' physical protection for the cyclist), and interventions that reduce the frequency of intersections or create (time) separation at intersections, such as bike boxes, and preventing conflicts between turning motor vehicles and cyclists and pedestrians.
- The success of physical separation depends on the scale of implementation, from specific streets to corridors or full networks (see section 3.2.4 for less effective treatments).
- Important gaps in the evidence are around:
  - Whether pedestrian and cyclist numbers are significantly higher when these modes are separated out, as opposed to on shared paths. The literature supports separation, based on user comfort, conflict and speed differentials, which is problematic for certain pedestrian and cyclist groups (which you could assume would indicate lower numbers, but whether this is significant in relation to mode shift is unclear)
  - Separation for micromobility, such as e-scooters.

3.2.3.3 Complete Streets initiative

A complete streets approach views infrastructure design at street or neighbourhood level to improve safety and accessibility for all modes. The Complete Streets initiative in the United States has resulted in over 1,600 complete streets policies from 2000–2022.[11] Often, this approach encompasses more than one element of safer journeys. In the context of road safety interventions alone some evidence is available showing the effectiveness of the complete streets approach.

A 2014 review of the Complete Streets initiative found that, despite a requirement for evaluation of project outcomes, systematic data collection and evaluation was lacking (Ranahan et al., 2014). A subsequent impact assessment investigated the impact of eight complete streets corridors in Buffalo, New York (Lenker et al., 2016). A variety of complete streets interventions had been used, including dedicated bike lanes, adjusted signal timing, lane reductions for cars, sharrow markings on the pavement and green infrastructure. This assessment combined baseline and post-implementation surveys using comparison corridors, with available mode volume, accident and injury data. Survey respondents indicated that walking (44.6%), biking (79.2%) and driving (84.2%) were more convenient post implementation, and that walking (44.3%), biking (78.8%) and driving (49%) were safer because of the changes. A limited amount of pre- and post-implementation mode count data was available; however, where this was accessible, it indicated the complete streets corridors had higher volumes of vehicles, pedestrians and cyclists with reduced total crashes and injuries (Lenker et al., 2016).

In Pittsburgh (United States), the complete streets approach was applied to an urban corridor where road traffic lanes were reduced from four to three, dedicated bike lanes were added, new traffic signals and

[11] See smartgrowthamerica.org/program/national-complete-streets-coalition/policy-atlas/ for more information.

pedestrian crossings installed, bus turnouts improved, and new pavements and street furniture introduced (Grahn et al., 2020). Traffic counts, speeds, public transport patronage, bicycle counts and crash counts were measured along with environmental air quality. Post-implementation reduced traffic counts were measured in both directions (lower volume direction by 11% to 21% and higher volume direction by 31%), speeds decreased by 2.5 miles per hour and 5.4 miles per hour (15% to 373%), while traffic speeds on parallel streets did not decrease. Bicycle counts increased 280% in the evening peak (160% in morning peak) and public transport patronage also increased. The authors noted, however, this may have been a continuation of an upward trend seen in the preceding years. Grahn et al. (2020) concluded the complete streets approach, combined with a range of measures, indicated some evidence of mode shift among travellers.

Summary insights from complete streets approach

- While extensively implemented, this approach has had limited evaluation.
- When evaluated, the evidence shows the complete streets approach has a positive effect on mode shift and safety.

3.2.3.4 Journeys to school

There appears to be a focus on road safety on the journey to school, where a more captive audience exists for school-based road safety programmes. However, the effect of these studies is difficult to evaluate, and some may be considered mode shift and not safety interventions.

Walking school bus

One behavioural intervention used to target walking to school is the concept of a walking school bus (WSB), which involves parents or other adults escorting a group of children to school on a set route.

In an implementation of WSBs in New Zealand, Kingham and Ussher (2007) looked at the benefits of a WSB system that was established at several Christchurch schools as part of Christchurch City Council's 'Safe Routes to School' programme. They conducted interviews with 33 WSB coordinators, local authority figures responsible for the programme, and principals at schools where WSBs operated.

Several interviewees identified improved safety of the children on their journey to school as a benefit of the WSB programme. In addition, they commented that it allowed children to develop an understanding of road safety skills first-hand. The programme was also seen as beneficial in terms of walking uptake, because it got children into the habit of walking. As a result, many would choose to walk rather than be driven. In some instances, this had also influenced the behaviour of the entire family, because the children wanted to walk to locations other than school. However, while the findings are positive, the evaluation evidence around mode shift and safety in this study is limited to qualitative data.

WSBs have also been identified as a method of overcoming personal security and crime barriers to walking. In a survey of parents as part of the Columbus (United States) Safe Routes to School programme, 74% of respondents expressed a fear of crime and violence as barriers to letting their child walk or bike to school, and further qualitative analysis identified that one-in-four parents thought this could be overcome by a WSB (Columbus Public Health, 2015).

A series of reviews was conducted of WSBs in Auckland cumulating in a longitudinal analysis of five annual surveys to understand changes, successes and challenges in adoption (Collins & Kearns, 2013). The first survey conducted identified that the WSB saved an average 19.5 car journeys per day (Kearns, 2001) and, in 2006, respondents estimated that 63% of children participating would otherwise have been driven. Across all years of the survey, reduction in child pedestrian injury was rated as the fourth highest benefit of WSBs, with preceding benefits including health and exercise, and community and social benefits. The authors suggest that WSBs are not the sole answer to mobility needs, but should be ‘regarded as stepping stones towards two broader developments: increased independent mobility for children for a range of neighbourhood-level journeys; and significantly reduced car use, speeds and density in suburban neighbourhoods’ (Colins & Kearns, 2013, p. 7).

Smith et al. (2015), in a review of 12 studies with 9,169 children and 326 schools, identified safety as both a facilitator and barrier to WSB uptake. While some studies, including Kingham and Usher (2007) detailed above, reported WSBs as providing a safe and supportive environment to get to school, most detail road safety concerns as a common barrier to uptake (Smith et al., 2015). In one study, police walked the route to discuss safety, trained volunteers, and paid crossing guards to stay longer, and the safety concerns were not alleviated (Kong et al., 2009). Three studies specifically measured walking prevalence, all through self-report data, and in all three the results showed that having WSBs increased active commuting (Heelan et al., 2009; Mendoza et al., 2009; Mendoza et al., 2011), while a further two studies reported on a reduction in car journeys (Collins & Kearns, 2005, 2013).

Overall, evidence can be seen of WSBs being positively associated with increased proportions of children walking to school and car journeys being reduced, with initial evidence that they improve perceptions of safety and child road safety awareness.

Bikes in Schools

A Bikes in Schools programme, consisting of a class set of bikes, helmets, cycle skills lessons (both in-classroom and practical), and an on-site bike track, has been introduced in several New Zealand schools over the past decade. Mackie Research (Hawley et al., 2019) evaluated the programme’s effect by selecting a baseline of 16 schools in 2016. Two evaluations were conducted, one after 12 of the participating schools had implemented a bike track (with the remaining four acting as control schools) and another after 13 of the participating schools had implemented a bike track (with the remaining three acting as control schools).

Surveys revealed positive shifts in safety skills amongst both students and teachers. About 87% of students participating in Bikes in Schools reported they could ride a bike ‘quite well’ or ‘really well’, a 9% increase from the baseline, while no increase was found in the control schools. The proportion of students who ‘always’ wear a helmet also increased, from 45% to 58%, while the control schools saw a decrease from 55% to 47%. Most teachers (97%) stated they were confident fitting a helmet properly, an increase from 79%, and 76% stated they were confident conducting a bike safety check, an increase from 34%.

Increases in cycling participation were also found. At the long-term follow up, a 12% increase had occurred in the proportion of students who had ridden a bike in the past seven days in the intervention schools (63% to 75%), compared with a 4% decrease in the control schools. However, change across the intervention schools varied a lot, ranging from –8% to +36%. In addition, the improvements were generally seen within schools, with an overall slight decrease in the rates of cycling outside schools. The researchers note that, when coupled with safer surrounding environments for cycling, the programme’s benefits could be maximised, because one of the main concerns from parents was traffic safety outside of school grounds. This indicates that the concept of education and safety skills, even when supported by a safe training and use location (in school), still needed the wider street infrastructure to translate into cycling uptake, which is the concept of the ‘complete package’.

The complete package approach is supported in a comprehensive review by Larouche et al. (2018) of the effectiveness of active school transport interventions. The authors reviewed 27 articles with 30 interventions, of which 13 reported an increase in active school transport. Greater increases in active transport were reported for those interventions that used multiple strategies, such as Safe Routes to School, and a longer follow-up period. See section 3.2.4.3 for more on education without an on-road practical component.

Safe Routes to School (United States)

Several studies have looked at the effects of infrastructure improvements on safety alone, but few have also examined the effect of education supporting the infrastructure changes. One initiative that has received particular research attention is the US Safe Routes to School programme, which was funded as a standalone nationwide programme between 2005 and 2012. The programme included the installation of several engineering improvements to facilitate safe walking and cycling to schools, including improved pedestrian crossings, pavements, cycle lanes and traffic calming measures. In addition, non-infrastructure improvements were also implemented, such as education programmes. These initiatives are in addition to school buses that are commonly operated in the United States.

Ragland et al. (2014) found that living within 250 feet (around 76 metres) of a Safe Routes to School countermeasure increased the probability that a child walked to school. McDonald et al. (2014) looked at the mode shift implications of the programme in more depth. After controlling for school and neighbourhood characteristics, they found, on average, walking and cycling to school rose by 1.1 percentage points for each year of participation in the programme. In particular, the presence of an engineering improvement was associated with a 3.3 percentage point increase in walking and cycling, which did not depend on how long the improvement had been in place.

Ragland et al. (2014) also mapped the countermeasures (elements) of Safe Routes to School interventions along with collisions that occurred within 250 feet (around 76 metres) of the countermeasure (which were determined to be reasonably likely to be affected by the countermeasure). They used this data to calculate an incident rate ratio for each location. Collisions involving pedestrians and cyclists aged 5 to 18 were found to have an incident rate ratio of 0.47, corresponding to a roughly 50% reduction in collisions in the treatment area (compared with the control area), and collisions involving pedestrians and cyclists of all ages were found to have an incident rate ratio of 0.26, corresponding to a roughly 75% reduction in collisions. DiMaggio and Li (2013) investigated the safety outcomes of the programme in New York City by using geocoded motor vehicle crash data involving pedestrians, captured before and after the Safe Routes to School interventions were implemented. They found the interventions were associated with a 44% reduction in the rate of school-aged pedestrian injury during school travel hours, compared with locations with no interventions where the rate remained virtually unchanged.[12]

Lessons from broader school-based education programmes

Some of the lessons around school-based safety education programmes, including but not limited to road safety, are consistent. Orton et al. (2016) found that education programme effectiveness in injury reduction was inconclusive. However, evidence can be seen of secondary indicators of safety, including improved safety skills, safety behaviour and safety knowledge. The authors’ main lessons were that:

1. The basis of the educational programme and success indicators were often quite disparate (leading to different metrics of success)
2. Reporting was often not clear, with incomplete reporting of important information
3. The evaluation approach was flawed (eg insufficient blinding bias, because the participant knew whether they received the intervention or not).

[12] A later study by Kang et al. (2020) critiqued the Safe Routes to School findings and found no decrease in injury rates. However, C DiMaggio (pers. comm., 21 December 2021) indicated this work did make assumptions that could explain the null finding. Including assumptions around interventions based on the year in which funding was announced (as opposed to when the changes were made, because lags are known between funding, planning, construction and completion).

Stronger evidence can be found around education programmes when they are supporting and reinforcing a more holistic infrastructure package change, what we are referring to as a ‘complete package’.

Summary insights from education, training and behaviour interventions
• Some evidence is available of walking school buses being positively associated with increased proportions of children walking to school and car journeys being reduced, with initial evidence that they improve perceptions of safety and child road safety awareness. • Bike education programmes can increase safety and bike skills in children, but this does not necessarily lead to an increased uptake in cycling to school. This indicates that education alone is not sufficient and should be provided as part of a broader infrastructure package. • Stronger evidence is available around education programmes when they are supporting and reinforcing a more holistic infrastructure package change.

3.2.3.5 Safe routes to public transport stops

Safe Routes to Transit (California)

In California, the Safe Routes to Transit programme in 2004 provided a ‘package’ of enhancements around seven rapid transit stations to encourage people to walk, cycle or catch the bus to the station (rather than driving), comparing two control stations. The interventions implemented included street enhancements, such as construction of pedestrian bridges, cycle lanes and bus shelters, and improvements to right-of-way access for pedestrians and cyclists at intersections. The rapid transit stations themselves also received upgrades, such as the addition of bike lockers.

Weinzimmer et al. (2019) studied the effect of the Safe Routes to Transit programme on perceptions of safety and travel mode using an intercept survey. A small improvement in risk perceptions amongst pedestrians was found, but it was the improvement in risk perceptions amongst cyclists that was the most significant, with levels of concern decreasing 0.8 Likert scale points on average. In terms of travel mode, for the share of respondents who reported travelling more than 5 minutes by a particular mode, increases were noted in difference-in-difference percentage change[13] for walking (3.1%), cycling (0.4%) and bus to the station (2.5%), while driving decreased by 2.5%.

Summary insights from safe routes to public transport stops
• Interventions to encourage mode shift to public transport stops apply a holistic approach to improving the space rather than focusing on a single improvement. • Safety interventions to improve routes to public transport will positively affect mode shift, increasing walking, cycling and bus trips (to train stations), and decreasing trips made by car.

[13] This was calculated by subtracting the mean difference for the control stations from the mean difference for the treatment stations.

3.2.4 Less effective interventions

Some safety interventions identified in the literature review were less effective at shifting modes.

3.2.4.1 Incomplete treatments

In 2013, a 1.5 mile (2.4 kilometre) urban greenway was constructed along arterial streets within a disadvantaged neighbourhood in Philadelphia, Pennsylvania. The greenway work included a complete retrofit of pavements and street segments into a wide, tree-lined paved greenway, along with major intersection improvements, bus stop shelters, and other smaller changes. Auchincloss et al. (2019) conducted systematic observations of the intervention area pre- and post-construction, and an intercept survey was conducted post-construction. Crime rates from the City of Philadelphia Police Department's crime database were also obtained. A comparison site was chosen as a control.

An intercept survey revealed that 92% of survey respondents felt the area was safe to walk or jog alone on the pavement during the day, and 42% at night. About 75% felt it was safe to use the crosswalks. Crime rates at the greenway site were lower than at the control site, but the authors note that, in general, crime trends were similar between the two sites.

While perceptions of the intervention's safety may have been good, observations revealed there had not been much impact on travel mode. The rate of people engaged in moderate or vigorous physical activity (walking, running or cycling) did increase slightly from 16% to 18%, and the rate of people running or cycling rose from 4% to 9%, but these results were virtually the same as the comparison site. Control-adjusted results confirmed there had been no treatment effect.

The authors mention a few possible reasons for why the greenway did not have the intended effect on the levels of active travel. Parts of the greenway still had unsafe intersections that were left untreated, sections of heavy traffic, and industrial and commercial driveways. In addition, the greenway project did not include any improvements to neighbouring streetscapes, and in the context of the wider urban environment it was relatively isolated, only connecting to a few local services but not to Philadelphia's CBD. A person using the greenway to travel somewhere would therefore likely need to travel on untreated, unsafe sections. This highlights the importance of a whole-of-journey approach to improvements, rather than isolated interventions.

3.2.4.2 Appropriate level of physical intervention in relation to risk perception

An intervention in an Auckland neighbourhood introduced various street changes to improve safety, including the relocation of a pedestrian crossing to improve visibility, installation of pram crossings and tactile paving, installation of a pedestrian refuge island, and traffic calming measures such as speed humps.

Two schools were invited to participate in a study by Smith et al. (2020) to investigate the effect of the changes on safety and mode shift. Different data capture methods were used. Children were asked to complete a GIS-based survey that captured behaviour and neighbourhood perceptions. Parents completed a phone interview to measure perceptions and reasons for school travel mode, tube counters were installed to measure traffic speeds and volume, and video cameras were used to count pedestrians and cyclists.

Slower average speeds were detected post-intervention, but an increase in volume of traffic was also observed. Some child and parent safety perceptions improved, including child sense of safety when in the neighbourhood. However, other safety perceptions worsened, such as an increased perception of busy traffic. More parents also reported a lack of safe places to cross post-intervention. Although the intervention did deliver more safe places to cross, the authors note that other literature has found perceived and objective measures of the environment do not always agree, and the intervention may have acted as a stimulus for parents to recognise the value of safe crossing infrastructure. In addition, the increased volume of traffic may have meant more safe crossing spaces were required as mitigation.

Mode shift outcomes reflected the different safety perceptions. The surveys found that the percentage of children who usually walked to school dropped by 15%, while the percentage of children who usually got driven to school increased by 14%. Small changes were detected in the other modes: cycling dropped by 1% and public transport increased by 2%.

From the tube counters (five in total), traffic was found to have increased at all but one site, and the video cameras (four in total) saw a decrease in the number of cyclists at all but one site. However, in contrast to the self-reported decrease in child pedestrians captured via the surveys, the cameras observed an increase in the total number of pedestrians at three of the four sites.

The authors explain that the disparity between the self-reported data and observed data may partly be due to the increased awareness parents had around safety following the intervention. For example, before the intervention, parents may not have been as aware of the safety deficiencies of their local street environment, but after taking part in the pre-construction survey and more closely observing the traffic conditions on their child's route to school, decided to drive them instead. In addition, because traffic volumes increased following the intervention this may have influenced whether parents allowed their child to walk to school (the authors note that previous studies have identified traffic volume as a predictor of child school travel mode). Also, because the cameras were only installed at four sites near the infrastructure changes, they may have observed people transferring to safer routes rather than a neighbourhood-wide increase in pedestrian activity.

This indicates that objective data alone may not be enough to determine the mode shift impact of an infrastructure intervention. Unless counts are done, for example, in such a way as to provide a complete picture of journeys within a neighbourhood, they could overstate the effect of the infrastructure by capturing changes in route choice (transfer of trips to safer routes) rather than an actual increase in walking trips. It also shows how groups may respond to a safety intervention in different ways. For example, while the public may respond well to a particular intervention, it may not be enough to encourage mode uptake among groups more sensitive to safety concerns (such as children and their parents) and, instead, serve to highlight safety problems.

3.2.4.3 Education without an on-road practical component

Within the education space, a programme teaching cycle training skills to children in Flanders (Belgium) was also found to be less effective at creating mode shift. The programme involved four 45-minute in-classroom training sessions held at several participating schools. Children in 4th grade (aged 9 to 10 years) were taught various cycle safety skills, including signalling, braking and steering.

Ducheyne et al. (2014) studied the programme's effectiveness by measuring the level of improvement in cycle skills as well as reported travel mode (captured via a parent survey). Two intervention groups were included; one involving just the child and one involving the child plus a parent who was asked to help their child in completing homework tasks. A control group was also included.

Analysis of variance tests (with time (pre- and post- follow-up) as the within-subjects factor, and condition (the intervention groups and control group) as the between-subjects factor), showed the effect of the cycle training course on the children's total cycling skills had resulted in a statistically significant improvement. In particular, the improvement was found at both a post-intervention period of one week and a follow-up period of five months. The greatest improvement was found with signalling skills, with a statistically significant difference at the post-intervention period and a larger improvement at the follow-up period. The authors state that this was important because a previous study (Lammar, 2005) found that poor signalling strongly correlates to a high accident environment. Statistically significant improvements were also found for other cycling skills, including mounting, dismounting and steering.

However, children's level of cycling to school was not affected by the programme. The authors comment that this lack of effect may be explained by the fact that the cycle training programme was in-classroom only and did not include any real cycling experiences. No exercises on traffic skills, which are necessary to cycle in real traffic situations, were included. They summarise that, if the purpose of a cycle course is to increase both safety and uptake of cycling, the training should focus more on real cycling experiences, because this will allow children to be more prepared to safely deal with traffic. In addition, parental buy-in was limited to supporting children to complete homework tasks. To ensure parents felt comfortable letting their children out cycling, the authors note that including parents in a greater range of activities demonstrating cycling safety skills may be beneficial, such as inviting parents to accompany their child on a cycle journey to school (Ducheyne et al., 2014).

3.3 Which safety interventions contribute to mode shift?

The outcomes of the literature review have been summarised in an interactive dashboard format[14] (see also chapter 4).

[14] Available at www.nzta.govt.nz/resources/research/reports/701

4 Intervention database and dashboard

A database was developed to support the literature review by allowing interventions to be searchable. The benefit of this is different users can more easily access the information that is most meaningful to them.

Searches can include:

1. transport modes affected by the intervention
2. scale of intervention size and intervention typology
3. evidence strength, including strength of research method, and impact on safety and mode shift.

4.1.1 Evidence strength ratings

A star rating was developed to enable searches by evidence strength. The star rating system (0–3 stars) delivered here to evaluate the research strength of the data was simplified and derived from (Turner et al., 2010). Each study was rated independently by two members of the research team. When inconsistencies were identified in ratings these were discussed with a third team member to reach a consensus and, where required, additional context was provided for star rating descriptions. Table 4.1 outlines the star ratings and describes each category for research strength, safety impact and mode shift impact used for this study.

Table 4.1 Evidence strength star rating of each intervention study by research strength, safety impact and mode shift impact

Evidence strength	Research strength	Safety impact	Mode shift impact
0	• No controls, no data	• No impact	• No impact
1	• Self-report, simple descriptive	• Perceived safety eg % of people feeling safe • Anecdotal increases in safety	Increase in mode share < 1% for the location • Walking and cycling counter-based measure ≤ 50% increase (relative increase from baseline)
2	• Quantitative data, simple descriptive • Comparison no statistics • Self-report with statistical analysis • Odds ratio	• Perceived safety eg % of people feeling safe (higher) • Established safety benefits (eg reduced speed zone to 40 km/h or below for walking and cycling)	• Increase in mode share 1% to 3% for the location • Walking and cycling counter-based measure 50% to 100% increase
3	• Quantitative data with statistical analysis – comparison/before–after/matched groups	• Decrease in actual crash and personal injury data • Established safety benefits (eg reduced speed zone to 30 km/h or below for walking and cycling) • Removed risk (eg eliminate vehicles)	• Increase in mode share > 3% for the location • Walking and cycling counter-based measure ≥ 100% increase

4.1.2 Assumptions and limitations

The following assumptions have been applied to the database creation and allocation of star rating:

- Where multiple measures are reported, the star rating represents the strongest impact.
- Interventions, such as speed and physical separation, have known safety benefits, so these have been captured under safety impact.
- Due to the smaller numbers around crash and injury data for non-car modes, any decrease in actual crash and injury data has been provided with a 3-star rating.

The following limitations are recognised:

- Controlled studies looking at impacts on public transport count or patronage data at a localised level were more limited, so ranges for these are presently missing from the mode shift impact column.
- Ranges around the mode share or count data have been derived from the range of plausible increases seen across the interventions reviewed (so are reporting relative impact).

4.1.3 Intervention dashboard

The intervention dashboard is an interactive version of the intervention database described above. Its purpose is to:

1. Make the intervention metrics available and openly accessible to a defined audience
2. Promote transfer of associated knowledge and learning from exploring interventions and their different benefits and limitations
3. Ensure fit-for-purpose interventions are assessable across our network, considering differing functions of movement and place.

The dashboard was developed through consultation and agreement with Waka Kotahi:

1. The Waka Kotahi Technology team was consulted with to ensure the agency's preferred platform for visualisation was used for the dashboard, and that data and information was managed appropriately from an IT perspective.
2. The steering group reviewed and agreed on the type of information and search field criteria at the first steering group.

The dashboard data was populated directly from the literature review database. Power BI was used to deliver the online dashboard format. Example screen captures of the landing page for the dashboard are shown in Figure 4.1 and some of the underlying meta-data are shown in Figure 4.2. This format has been set up for users to easily search and focus on specific interventions based on:

- Geographic location, with a zoomable world map that lets users hover over the intervention, to understand an overview, and the ability to click on the actual intervention title to access the meta-data
- Searchability by intervention type, mode evaluated, mode shift impact, safety impact
- Ability to look through more detailed information around the study details, intervention details and outcomes.

The dashboard is available at www.nzta.govt.nz/resources/research/reports/701.

Figure 4.1 Interactive dashboard screen capture showing an example intervention and the ability to search the content

Figure 4.2 Interactive dashboard screen capture showing example data captured within each intervention

5 Expert interviews

Expert interviews were conducted to gain deeper expert insights. For an overview of the aims, expert interviewees and a summary of insights, see Figure 5.1.

5.1 Semi-structured interview framework

Semi-structured expert interviews were completed with seven participants to capture greater depth of understanding around the following themes:

1. Priority intervention areas to focus on where safety interventions can best support a mode shift away from the car
2. Provide more detail and lessons around specific case studies (including unreported data, which was then fed into the literature review, where appropriate)
3. Identify opportunities to influence strategy, frameworks, guidance and decision-making.

See Appendix A for the interview framework and questions.

5.2 Interview context

It is valuable to note that the interviews were conducted between September 2021 and January 2022, within COVID-19 pandemic conditions. This may affect answers, but mostly around theme 1, priority intervention areas, where public transport and travel to main centres may be viewed differently.

5.3 Participants

Interviewees intentionally included:

- Two national transport representatives: To understand wider interventions across the country and decision-making process and drivers at a higher level in the safety and multi-modal teams at Waka Kotahi.
- Two regional transport representatives (New Zealand): To understand regional interventions and decision-making process and opportunities in regions with different levels of densification and transport mode split (Auckland, Tasman).
- Three international representatives: To understand researchers and practitioners representing the best international experience (Australia, United States, United Kingdom).

Figure 5.1 Summary of expert interviews

Interviews Summary

Aims

- To understand the intervention priority areas and lessons around what has been trialled
- Examine how to better optimise safety decisions that can also support mode shift

Participants

- Seven experts were interviewed to represent an understanding of the local regional context, the national strategy, and international insights

1 Priority areas

1) Modal separation, in particular, cycle separation
2) Filling gaps in the cycling and walking network
3) Enhanced 'walk-up' to public transport stops
4) Appropriate maximum speeds
5) Infrastructure to support local trips to neighbourhood attractions, schools, and smaller town precincts

2 Lessons

1) Measurement and monitoring are often focussed on a single outcome
2) Data is still focussed on private automobiles
3) Even when monitoring frameworks have been set up these are very seldom actioned
4) Monitoring reassurance
5) Emerging data sources, including vehicle, personal phone and video-analytic data are typically only used on larger scale projects

3 Enabling Change

1) Road to Zero was seen as a key enabler of change, and is very well focussed on reducing death and serious injury
2) Operationalising Road to Zero, would benefit from inclusion of proactive safety indicators and wider injury data to support safety investment
3) Emphasising the importance of social justice to gain support. Those who are vulnerable, be it children, elderly, those living with impairment, or people at the lower end of the economic scale are often at greatest risk
4) Building evaluation, including steps to confirm baseline evaluation, into intervention programmes.

5.4 Theme 1: Priority intervention area results

Interviewees were asked: Where do you think is the best opportunity for safer journey interventions to support mode shift away from the car?

Overall, the priority intervention area focus was on physical infrastructure changes. The only exceptions were policy-based change around maximum speed zone changes and use of less centralised public transport services (which are both typically supported by some level of infrastructure). A subtler element of this is that physical infrastructure changes that provide a design that serves multiple modes also serve as a constant reminder the environment has been designed for the safety of every journey, regardless of mode. This highlights the importance of choice in relation to perception of safety:

> *People know what is in their best interest. If people feel that they are not safe they are going to drive.* (P6)

Five core areas for priority intervention came up during the interviews, which are outlined below.

5.4.1 Cycle separation

Cycle separation consistently comes through in the literature. Elements where the interviews showed increased nuance were around 1) the principle around the level of separation, and 2) areas where guidance has already been strengthened around known conflict points at intersections with other modes.

Cycle safety interventions are using a wider array of interventions right now, using the concept of 'degrees of separation':

> *The idea behind 'degrees of separation' is that it takes into account the One Network Road Classification framework when considering the appropriate level of intervention. This takes the principle that moving towards greater separation now is better than moving to full separation, but only across very small sections of the cycle network.* (P1)

Cycle separation also needs to consider intersections with other modes, where guidance documents are also constantly improving:

> *Separation needs to consider protected intersection points, including to manage road interactions such as priority at T-intersections, better guidance for driveways, and use of tools like floating bus stops[15] for bus-bike interactions.* (P2)

5.4.2 Filling gaps in the pedestrian and cycle network

To actually shift modes, the breaks in the network between safe paths need to be addressed.

> *Mode shift needs the whole journey to be safe. More complex locations where there are traditionally gaps include bridges and multi-lane arterial roads.* (P2)

Complex locations like multi-lane roads do not align with the common, cost-effective but piecemeal techniques (like the use of pedestrian refuges) to enable mode shift. These require larger changes, like a combination with much slower speeds, or a reallocation of space, like a shift to single-lane roads. The ideal is to provide grade separation or signalised crossings to promote safety and use. It is more difficult to rationalise and build business cases around these larger changes that have a greater impact on the dominant travel mode or have high cost, but this is critical to enable complete and safer routes.

[15] Also known as a 'bus stop bypass', this is an arrangement that involves a cycleway running behind the passenger boarding area at a bus stop, between an island and the footway.

5.4.3 Appropriate maximum speeds (urban areas)

> *The safer speed rollout programme within New Zealand is an opportunity for inner city, town centre, and residential improvements to capture benefits beyond safety, including mode shift impacts*. (P4)

Lowering speed limits from 50 km/h to 30 km/h in urban areas has large benefits to safety that also affect increased walking, cycling, micromobility, and easier walk up to public transport stops. This was seen as especially important in areas with larger speed differentials (ie motorised traffic with cyclists). It was identified that, in some cases:

> *Safer speeds can reduce the need to make more difficult changes around separated cycleways, if speed differentials can be reduced. It also supports walking, with more opportunities for eye contact between pedestrians and drivers.* (P4)

Bringing along the community was a crucial component to the behaviour change required when speeds are changed, including the wider benefits:

> *Speed is very cost-effective to alter and is very scalable as an option. But to bring in support for these changes you need to look at the wider benefits, not just the benefits around road safety.* (P3)

It was commented that physical changes to complement the speed changes were also critical in changing behaviour, by altering the look and feel of the environment. Lessons from the Waka Kotahi Innovating Streets for People Programme (2019–2021)[16] were also referenced, where new methods of designing and delivering transport infrastructure are being trialled throughout New Zealand. These trials allow for activating temporary street designs with community input in locations that could be paired with slower speed rollouts. The aim is to learn, adjust and inform decisions about more permanent infrastructure changes.

5.4.4 Walk up to public transport stops

To attain a big mode shift, the walk up to public transport is critical. This is likely to have a larger uptake in trips previously taken by private cars than other options.

> *We don't recognise and value how important the walking trip is to access public transport.* (P1)

Important elements to this are:

1. Safe, obvious, step-free: This includes safety from collision and threats to security, improved wayfinding cue, and step-free access.
2. Intervention locations: Main locations include bus stops and shelters as well as crossing points to public transport stops (including optimising crossing locations).
3. Intervention types: Identifying what type of intervention will enhance safety and ease of access (for example, raising zebra crossings versus signalised crossing versus underpasses).

Sufficient lighting is an important enabler of the walk up. Sufficient lighting provides reassurance around perceived safety (collisions, falls and personal security) as well as actual safety (reducing collisions and falls). However, from an inclusivity and social equity perspective, where certain groups are more affected, it needs to be valued:

> *Darkness does increase fear of being mugged or threatened. Even if the reality is you are just as safe, perception would still be important.* (P7)

[16] See www.nzta.govt.nz/roads-and-rail/streets-for-people/innovating-streets-for-people-2019-2021/ for more information.

The participant identified that they felt lighting uniformity is essential:

> *We could likely use a lower level of illumination if we could improve uniformity. So we might not need as much light, it is the consistency of light and avoiding 'pools of light' that is important. Then for certain purposes, where you wanted to improve reassurance, you could do more.* (P7)

5.4.5 Local trips as a focus

A trend is evident of more travel within and around the neighbourhood due to the COVID-19 pandemic. It was discussed that people are less focussed on CBD trips and are tending to avoid mass transit.

> *Trips to local social infrastructure and local town centres are now more common.* (P1)

The trend around public transport due to the pandemic is that many are no longer taking public transport into main centres.

> *There are a lot more people are working from home, and some are simply avoiding mass transit. Others are travelling to smaller town centres to meet their needs. Therefore, public transport may need to look across a more varied network base, using more demand-responsive approaches.* (P2)

5.5 Theme 2: Challenges and lessons

For those interviewees who had more direct intervention experience, they were asked about a recent successful example of a project that had a safer journey intervention that also involved mode shift away from cars. They were asked about challenges, lessons, and what would have made this intervention more successful. They were also asked about any evidence around actual case studies, which was then transferred into the literature review, where appropriate. Where the interviewee had been involved in specific projects, challenges and lessons were captured based on their knowledge.

5.5.1 Single outcomes

Based on the case studies discussed in interviews (and literature provided), for road safety the most frequently captured data is vehicle speed, typically via tube counters (that also captured numbers). While the technology is available, few and only larger projects appear to be using GPS-based monitoring (via vehicle or personal phone data). Around travel mode data, the counting technology is typically targeted to measure an individual mode, for example, monitoring of cycling interventions just monitors cycle counts (ie does not examine any effect on vehicle traffic). This limits our ability to look at whether a safety intervention has improved safety for all users and how it has influenced any shift in modes.

5.5.2 Private vehicle focus

A consistent theme was that road safety decision-making and data collection had traditionally focussed on cars (in New Zealand and internationally):

> *We have made high speeds safer for drivers of cars, and that has been the focus. But we were not doing this for other modes. If I step out of my door it should be safe.* (P6)

While the target outcomes are becoming more multi-modal, the monitoring supporting outcomes and the specificity of our outcome targets still need improvement. For example, road safety death and serious injury 40% reduction, what is the personal security or mode shift target equivalent? How will the evidence for this be captured?

5.5.3 Monitoring frameworks

Often when a monitoring framework is well developed it is not useable, because it includes an ideal monitoring regime that has not focussed on the minimum items to monitor. Barriers to monitoring raised across the interviews included:

- Developing but not actioning a monitoring framework
- Monitoring not being embedded in the implementation plan and costing
- Easy access to expertise in monitoring or monitoring equipment
- Ease of access to existing data.

5.5.4 Monitoring reassurance (by day and night)

Perception is reality around safety and mode shift. When a location feels less safe at night, whether it is a perceived threat to collision or personal security, the car often feels safer. Reassurance monitoring examines the overall feel of travelling in a location, and can identify the appropriate intervention for inclusive travel that places value on more diverse times of day at which travel occurs (eg shift workers, those taking night classes, or those making social and entertainment trips). Good reassurance monitoring considers:

- Day versus dark: Monitoring personal security and safety of a location using the day–dark method is one approach examining whether people feel safe travelling in the area in daylight as well as at night.
- Specificity: Also, understanding this broken out by personal security, risk of collision and risk of falls, and whether trips are not being made because of this (ie trip avoidance).
- Use of objective data: Measures of subjective reassurance are best done with insights gained from understanding the objective data.

> *Understand the location first, including how people are using the space as well as the data around slips, collisions and crime.* (P7)

An important benefit of this type of specific monitoring (like the day–dark approach) is it can control for the general fear of crime in an area. This involves whether an infrastructure solution like lighting will activate other travel and use of the area (ie where the location feels safe during daylight hours, but a large reduction in safety occurs at night) or whether this would need support to be effective (ie where personal security is consistently poor across day and night). It also includes other broader initiatives around policing and community support that would be required for activation of improved safety and mode shift outcomes.

5.5.5 Emerging data sources

Technology in larger cities: Video-based analytics with computer vision and individual travel data sources (such as GPS-based vehicle or cell phone data reported at aggregate level so as not to identify individuals) are being used and capability is being improved. Most examples of this are by independent researchers and consultants to trial something new, rather than as part of an ongoing monitoring framework. Similarly, powering monitoring technology is becoming easier, for example, many lighting columns now have the ability to also host other smart sensors on them, such as counters, video, weather monitoring.

Informal visual data (drone footage example): In more regional or less dense areas of New Zealand, an example of visual data is being successfully used and easily captured (P5). Visual data in the form of drone footage has been used to successfully bust myths around barriers to more multi-modal infrastructure changes, especially the perception that changes will cause vehicle congestion. Footage taken over a short timeline at peak commuter time was reported as an agile method that successfully cuts through complaints and media articles around perceived congestion that would otherwise have delayed the intervention and affected the success of similar future interventions. Showing the footage and actual change in movement of vehicles at the most controversial location provided a positive, easily shareable story of success. Using before and after drone footage (or even well-placed fixed camera footage) at targeted locations can be used even in small-scale studies.

Note: Additional data can look at counts by mode, common movement paths and desire lines, any evidence of near misses or avoidance behaviour (although the numbers of these are likely to be low).

5.6 Theme 3: Opportunities for including mode shift in safety intervention decisions

5.6.1 Road to Zero as an enabler

The Road to Zero strategy document was consistently seen as an important enabler to make all trips safer for New Zealand.

> *Every journey should be a safer journey. The real question is, what environment would enable this?* (P1)

The Road to Zero strategy influences changes to the environment through the Road to Zero Speed and Infrastructure Programme Design Framework and tools like the Standard Safety Intervention Toolkit.[17] The focus is on a road system increasingly free of death and serious injuries on New Zealand roads, which means:

> *There is a focus on rural and semi-rural settings and urban intersections.* (P1)

The benefit of this approach is focussed interventions on the worst crashes, a criticism that can always be made is it has a narrow definition of what constitutes a safer journey. To support mode shift or capture, wider benefits with intention would require:

> *A broader definition of safety. As this does not account for slips and falls or personal security.* (P1)

5.6.2 Operationalising the Road to Zero

It was identified that funding mechanisms that come out of the strategy could be improved. Arguably, the Road to Zero strategy is doing well in the focus on reducing deaths and serious injuries. But an element of the funding process is still reactive rather than proactive, with a reliance on vehicle crash data.

> *The Strategy intent is to be proactive. But the evaluation process is actually out of line with this genuinely proactive approach to change, as it relies on prior crashes, with a focus on prior DSI, and on how people have been travelling historically.* (P4)

Benefits would be gained in linking the safety strategy more clearly to land use planning and inclusion of accessibility, as part of the Safe System approach. This approach could look at existing travel mode data, but also latent demand for alternative modes, if the environment were safer to travel by alternative modes. This approach would need to move into the case for funding also:

> *Currently the funding is DSI-specific, so this relies on crash numbers to make changes. It is quite difficult to link to other areas like cycling infrastructure improvements. For example, people may be cycling at low numbers due to a lack of safety, so it does not take that into account.* (P4)

[17] See www.nzta.govt.nz/resources/road-to-zero-speed-and-infrastructure-programme-design-framework/, for further information.

Making it easier to access and incorporate the wider co-benefits of safety interventions into decision-making was seen as beneficial. Currently, the way funding is divided by activity classes makes this difficult.

5.6.3 Emphasising social justice

> *There is a social justice element and a need to emphasise the importance of this. Folks at the lower end of the economic scale are at highest risk. You can see this when you look at a map of pedestrian injury data.* (P6)

An important lesson from several larger-scale projects is the need to support intervention programmes with a social justice element. This helps with the mind-shift required to see genuine change. For example, in the large programme around Safer Routes to School in the United States, a significant shift stemmed from what a safe environment looked like for the most vulnerable:

> *There was a shift in thinking to you can be safe and you can be active. Kids can be allowed to be kids and not have to put their safety at risk. Healthy, active, and safe.* (P6)

This was seen as important in overcoming the traditional backlash around resistance to change, especially when this affected how people used their car:

> *Evidence of public support and political will is critical if the safety intervention is also to achieve some level of mode shift.* (P2)

Proactive consultation with valued groups was discussed as another mechanism for change (which also aligns with the Innovative Streets for People approach in section 5.4.3):

> *It just has to have some level of 'grass roots' community participation. Meeting with the key people and asking what are your concerns and where can we address them.* (P6)

5.6.4 Building evaluation into investment

Building evaluation into the programme at the investment phase is important. This occurs across even large-scale international programmes. For example, this was a critical failing of the US Safe Routes to School programme. The evaluation funding came independently and from disparate sources and research grants, where researchers identified the need and applied for grants to fill this gap, as opposed to being built into the programme.

> *Even if we just place 1% to evaluating and measuring what we are trying to do and build that into it. They are constrained by the programme. Programmes should be based on the 4 E's, engineering, education, enforcement, and evaluation.* (P7)

At a regional level, an example of a monitoring indicator framework and alignment with the Land Transport Benefits Framework can be seen in Table 5.1. The reality is that this data is often quite limited, compared with data from larger cities, and appears to be supplemented with local knowledge, be it from expert visual inspections of sites (eg police, safety engineers), data on complaints from individuals, or agencies with road safety and mode shift interests that have their own data or anecdotal evidence (such as schools and businesses). Funding and improved access for monitoring for cycle and pedestrian count data, and analysis around existing footage collected in regions, is an apparent gap. Monitoring was just as likely to be funded in innovative ways, such as via tourism funding.

Table 5.1 Example monitoring framework for inclusive access and healthy and safe people outcomes from a less dense region of New Zealand (reprinted from Waka Kotahi et al., 2021, p. 67)

OBJECTIVE: INCLUSIVE ACCESS

Measure	Indicator	Desired Trend	Data Sources
1:: Active transport	Mode share of all trips by Walking. & cycling & PT mode share	Increasing	Journey survey/ census
	Number of people living within 500m of a high quality cycling facility	Increasing	GIS
	Cycle and walking counts	Increasing	Count Sites
2: Public Transport Network	Percentage of community living within 500m of a public transport route	Increasing	GIS
3: Public transport	Number of annual boardings	Increasing peak and off peak boardings	Bus ticket data

OUTCOME: HEALTHY AND SAFE PEOPLE

Measure	Indicator	Desired Trend	Data Sources
1: Deaths and serious injuries	Number of deaths and serious injuries	Decrease	CAS Database
2: Deaths and serious injuries	Death and serious injury crashes as a proportion of all crashes	Decreasing	CAS Database
3: Active transport	Cycle and walk counts	Increasing	Count sites

5.7 Summary

Insights from the interviews supported the findings of the literature review in the following areas:

- modal separation, in particular, cycle separation
- enhanced 'walk up' to public transport stops and schools
- appropriate maximum speeds.

An additional priority area was identified through the interviews that is aligned with and expands on the published literature around journeys to school:

- infrastructure to support local trips to neighbourhood attractions, schools and smaller town precincts.

The interviews provided enhanced understanding into areas for improvement when introducing and evaluating initiatives in New Zealand, and how they align with the strategic outcomes for New Zealand, as described in section 2.1. The support for Road to Zero as an important enabler for change was evident, as was inclusion of wider safety indicators, congruent with those discussed in section 2.4.1. A greater emphasis was placed on the importance of social justice to gain support, identifying that those who are living with impairment, or people at the lower end of the economic scale are often at greatest risk. While essential, the wider equity impacts are not a focus of this report (see section 1.3).

6 Case studies

Recognising the importance of providing local success, distinct case studies have been described in this chapter in greater depth to capture the work successfully delivered in New Zealand. The case studies show the benefits of the intervention, how this was measured and any significant learnings.

The New Zealand case studies were informed by the literature review, experts interviewed and the steering group. Criteria for inclusion included having before and after measures (objective or subjective) of safety and mode shift and changes being implemented in the past five years. Case studies were selected based on recent evidence-based intervention programmes across New Zealand including:

1. Urban cycleways programme
2. Innovating streets programme
3. Safer speeds changes (in urban locations, town centres and residential neighbourhoods).

Five case studies are included in this report:

- Case Study 1: Auckland – Residential neighbourhood speed changes
- Case Study 2: Auckland – Willow Park School
- Case Study 3: Christchurch – Cycle route treatments (on- and off-road approaches)
- Case study 4: Wellington – Brooklyn Road Cycleway
- Case study 5: Auckland CBD – Federal Street Contraflow Cycleway.

6.1 Case Study 1: Auckland – Residential neighbourhood speed changes

6.1.1 Description

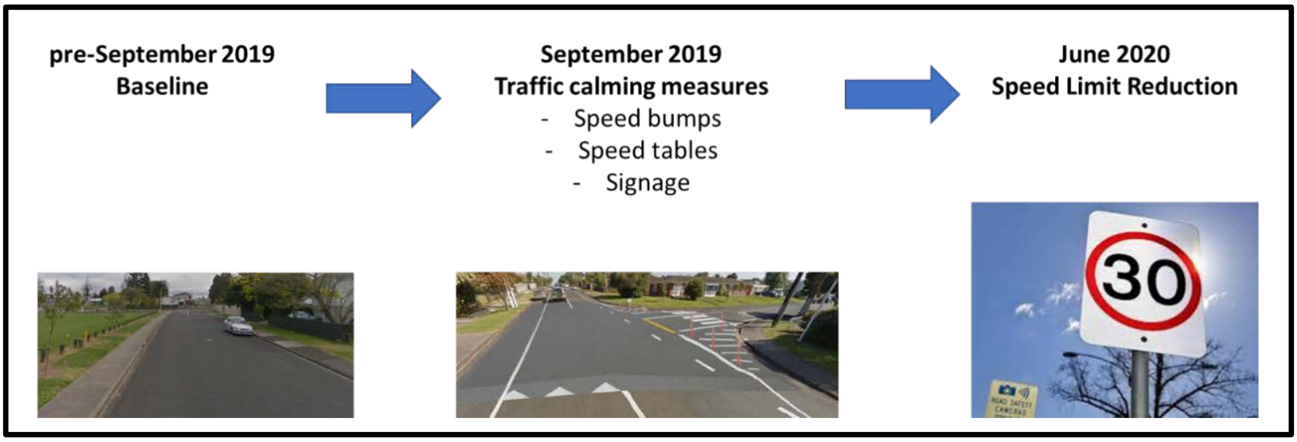
As Phase 1 of the Safe Speeds Programme, Auckland Transport reduced speed limits on around 10% of roads across Tāmaki Makaurau. Two neighbourhoods where residential speed changes were introduced as part of the Phase 1 changes in June 2020 were selected for an in-depth study on the effect of the changes on mode shift (see Figure 6.1). In each site, the speed limit was reduced from 50 km/h to 30 km/h and traffic calming measures were introduced. Comparison sites were identified where no speed changes were applied, to limit the confounding factor of reduced travel due to the COVID-19 pandemic:

1. Speed change site Te Atatu South: Comparison site Te Atatu Road (South)
2. Speed change site Papakura (Rosehill): Comparison site Papakura.

Figure 6.1 Speed change sites (green) and comparison sites (blue) for Te Atatu South (left) and Papakura (right) (adapted from Auckland Transport, n.d.-b)

Before the speed change introductions in September 2019, Auckland Transport introduced speed calming measures to selected residential areas in the Papakura (Rosehill) and Te Atatu South residential areas. Measures included the addition of speed bumps, speed tables and signage, in an attempt to reduce the speed of vehicles on the road and make the streets a safer place for walking, cycling, children, the elderly and differently abled (Gravitas, 2020). A timeline of changes is presented in Figure 6.2.

Figure 6.2 Timeline of changes introduced in Te Atatu and Papakura from 2019 to 2020



6.1.2 Measures

This case study combines data from bus patronage, traffic counts and subjective evaluations, to determine if the introduction of speed reductions resulted in mode shift.

6.1.2.1 Bus patronage

Bus stops within the boundaries of the control and experimental sites were identified, and bus patronage numbers were provided by Auckland Transport. Criteria for inclusion were bus stops within the boundary area and that did not fall on the border between the two zones. Bus stops included are presented in Table 6.1. Bus patronage was compared for the month of May 2019 (pre-COVID baseline) and May 2021 (average Auckland patronage recovery of 70% of pre-COVID).

Table 6.1 Bus stops included in patronage analysis

	Speed change site: Included bus stop ID	Comparison site: Included bus stop ID
Te Atatu	5064, 5066, 5068, 5071, 5073, 5075, 5350, 5351, 5352, 5353, 5355, 5363, 5364, 5366, 5367, 5368, 5369, 5370, 5371	5092, 5094, 5097, 5098, 5100, 5101, 5103, 5105
Papakura	2587, 2615, 2617, 2621, 2623, 2630, 2632, 2634, 2636, 2638, 2640, 2642, 2696, 4413	2514, 2516, 2518, 2519, 2521, 2550, 2551, 2564, 2569, 2705, 2718, 2759

6.1.2.2 Average daily travel count and 85th percentile speed data

Average daily traffic (ADT) count within the experimental and comparison sites was examined, using ADT before the speed change (pre-September 2019) and after (post-June 2020). Data was provided in two forms:

- Speed change sites: Data was provided by Auckland Transport via direct communication for the speed change sites and included pre-, post-construction and post-speed change five-day ADT, seven-day ADT and average speed (85th percentile speed data).
- Comparison sites: five-day ADT and seven-day ADT data was obtained from the Auckland Transport website. ADT data was included if it was collected within the site between January 2018 to September 2019, and at the same location post-June 2020.

6.1.2.3 Subjective evaluation

Existing survey data from the Auckland Transport Road Safety Perceptions Survey (Gravitas, 2020) was used as a subjective evaluation of the traffic calming measures on mode shift. All properties (residents) in both the Papakura and Te Atatu South change areas were posted a letter outlining the research and measures that had been undertaken in the area. No surveys were administered in the control sites. In total, 254 surveys were completed (N = 109 Papakura, N = 145 Te Atatu South, 13% response rate was achieved).

Respondents were questioned on perceptions of safety following the introduction of speed calming measures and the increase in active transport modes. No public transport comparison was made pre- or post-introduction; however, in response to the main mode used for trips to school, work and local shops, public transport was included.

6.1.3 Outcomes

6.1.3.1 Bus patronage

- Bus stop boardings in the Te Atatu South speed change site had a patronage recovery rate of 66.6% (May 2019: 5,294; May 2021: 3,525), which is similar to the rate recorded in the Te Atatu comparison site with 65.2% (May 2019: 5,294; May 2021: 3,525). Compared with the national patronage recovery during this period, this area had a lower rate of recovery.
- Chi-square tests determined no significant difference was evident between the two sites pre- and post-speed change implementation X^2 (2, N = 14,193) = 0.35, p = 0.55.

- The Papakura speed change area had a patronage recovery rate of 78.2% (May 2019: 5,662; May 2021: 4,427), which is notably higher than the patronage recovery rate of the comparison site, at 58.4%.
- Chi-square tests identified a significant difference was evident in patronage between the two sites pre- and post-speed change implementation X^2 (2, N = 11,339) = 22.22, p = < .001.

Insight: In one residential speed change site (Papakura), bus patronage was higher relative to the comparison site after the speed change was introduced.

6.1.3.2 Average daily travel count

- Significant differences were evident in five-day average daily traffic between the comparison and speed change sites pre- and post-speed changes, for both Papakura (X^2 (2, N = 66,800) = 785, p = < .001) and Te Atatu South (X^2 (2, N = 313,047) = 321, p = < .001) (see Table 6.2).
- The weighted average speed (based on 85th percentile operating speed) was calculated for the two speed changes sites.
  - Te Atatu had a weighted average speed reduction post-change of 13.2 km/h (from 51.7 km/h to 38.6 km/h).
  - Papakura had a weighted average speed reduction post-change of 12.0 km/h (from 52.8 km/h to 40.7 km/h).

Insight: While the comparison sites had an increase in traffic, the speed reduction sites had a decrease in traffic volume post-implementation.

Table 6.2 Vehicle counts (five-day average daily traffic (5ADT)) for speed change and comparison sites

<table>
<tr><th>Road section</th><th>Baseline (5ADT)</th><th>Post-speed limit reduction (5ADT)</th><th>Difference in 5ADT (from baseline)</th><th>Total difference between comparison and speed change sites</th></tr>
<tr><td>Te Atatu Rd comparison</td><td>125,247</td><td>143,370</td><td>14.47%</td><td rowspan="2">19%</td></tr>
<tr><td>Te Atatu South speed change</td><td>22,752</td><td>21,678</td><td>–4.72%</td></tr>
<tr><td>Papakura comparison</td><td>18,277</td><td>23,718</td><td>29.77%</td><td rowspan="2">47%</td></tr>
<tr><td>Papakura (Rosehill) speed change</td><td>13,576</td><td>11,228</td><td>–17.30%</td></tr>
</table>

6.1.3.3 Subjective evaluation

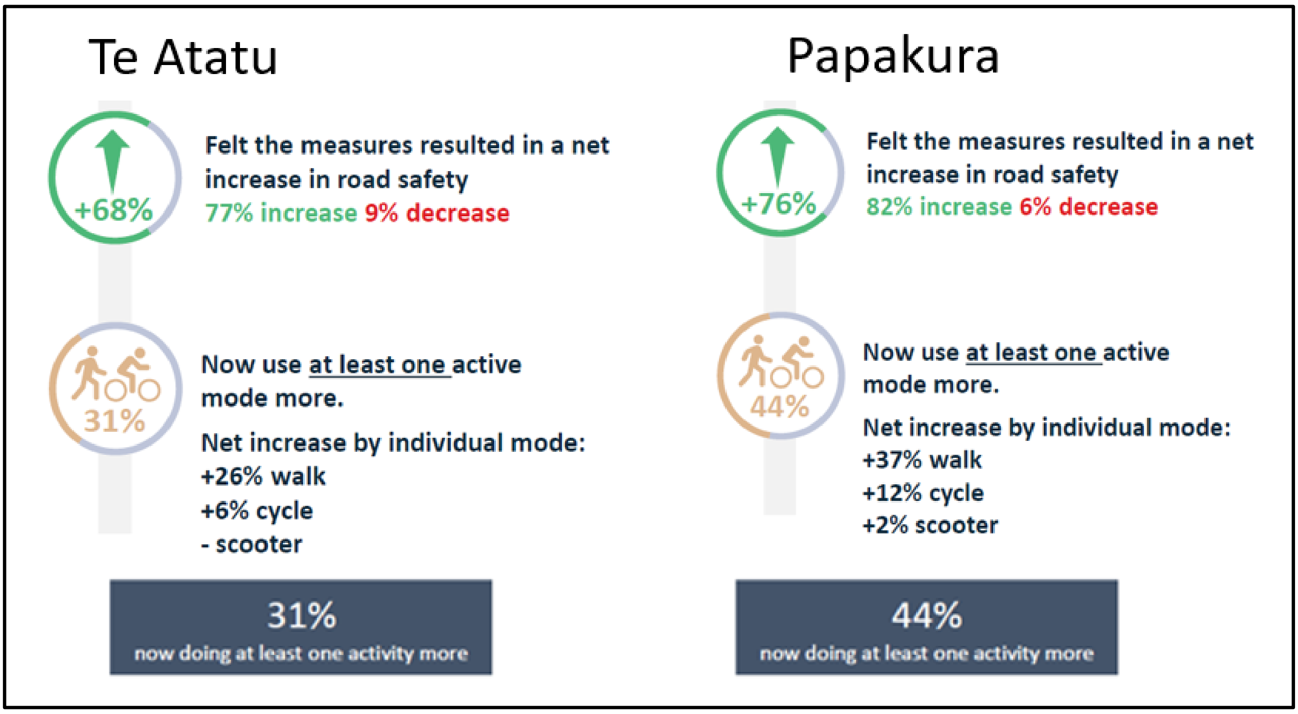
Subjective evaluations of the traffic calming measures were reported by residents of Te Atatu South and Papakura (Gravitas, 2020) (see Figure 6.3).

- Te Atatu South:
  - Residents felt that the measures had resulted in a 68% net increase in safety.
  - Overall, the speed calming measures have had the biggest impact on how often people are walking in their local area, with a net increase of +26%.
  - Cycling has seen a net increase of +6%.
  - Scootering levels are unchanged.
  - Thirty-one percent of respondents state they are participating in at least one active mode activity more often, now that the measures have been installed.

- Papakura (Rosehill):
  – Residents felt that the measures had resulted in a 76% net increase in safety.
  – Overall, the speed calming measures have had the biggest impact on how often people are walking in their local area, with a net increase of +37%.
  – Cycling has seen a net increase of +12%.
  – Overall scootering levels have seen a slight increase (+2%).
  – Forty-four percent of respondents state they are participating in at least one active mode activity more often, now that the measures have been installed.

Insight: Survey data indicates a higher perception of net road safety and a higher percentage of respondents engaged in more active modes in Papakura and Te Atatu South than previously, though both were higher in Papakura. This may be due to the large number of schools in Papakura (5) and proximity to the town centre when compared with Te Atatu.

Figure 6.3 Summary of survey results for Te Atatu and Rosehill traffic calming sites (adapted from Gravitas, 2020, pp. 8 and 14)



6.1.4 Limitations

This case study combined data from three sources and two residential zones, and had several limitations:

- Bus stop distribution in the speed change and comparison sites was varied. While the speed change zones had bus stops throughout, the comparison sites lacked bus stops in the centres of the areas and only had bus stops on the outer roads of the zones (see Figure 6.1).
- Traffic count data was not equally spread across comparison and speed change sites, with the speed change sites having a larger number of counters in place. For the Te Atatu comparison site four traffic counts were in place, with before and after data available, three of these were on Te Atatu Road. The speed change site had 12 count locations. For the Papakura control section, two traffic sites had pre- and post-count data available, compared with seven count locations for the speed change sites.

- The Gravitas (2020) research recognises that changes relating to the COVID-19 pandemic may have affected active travel modes post-traffic calming introductions.
- Overall, opportunities exist to improve the evaluation programme through collecting baseline measures before the introduction of any traffic calming and speed reductions.

6.1.5 Lessons

- This case study provides valuable insights. Traffic calming measures combined with a reduced speed limit were shown to correlate with mode shift away from vehicles in the zone, and an increase in active modes.
- While similar measures were implemented in both sites, it appears they were more effective in one site, so it is important to recognise all factors that will affect outcomes (eg schools; proximity to local shops) when evaluating appropriate locations for speed reduction measures.
- Opportunities exist to improve the evaluation programme through collecting baseline objective walking and cycling measures and conduct an initial resident survey before the introduction of any traffic calming and speed reductions.

6.2 Case Study 2: Auckland – Willow Park School

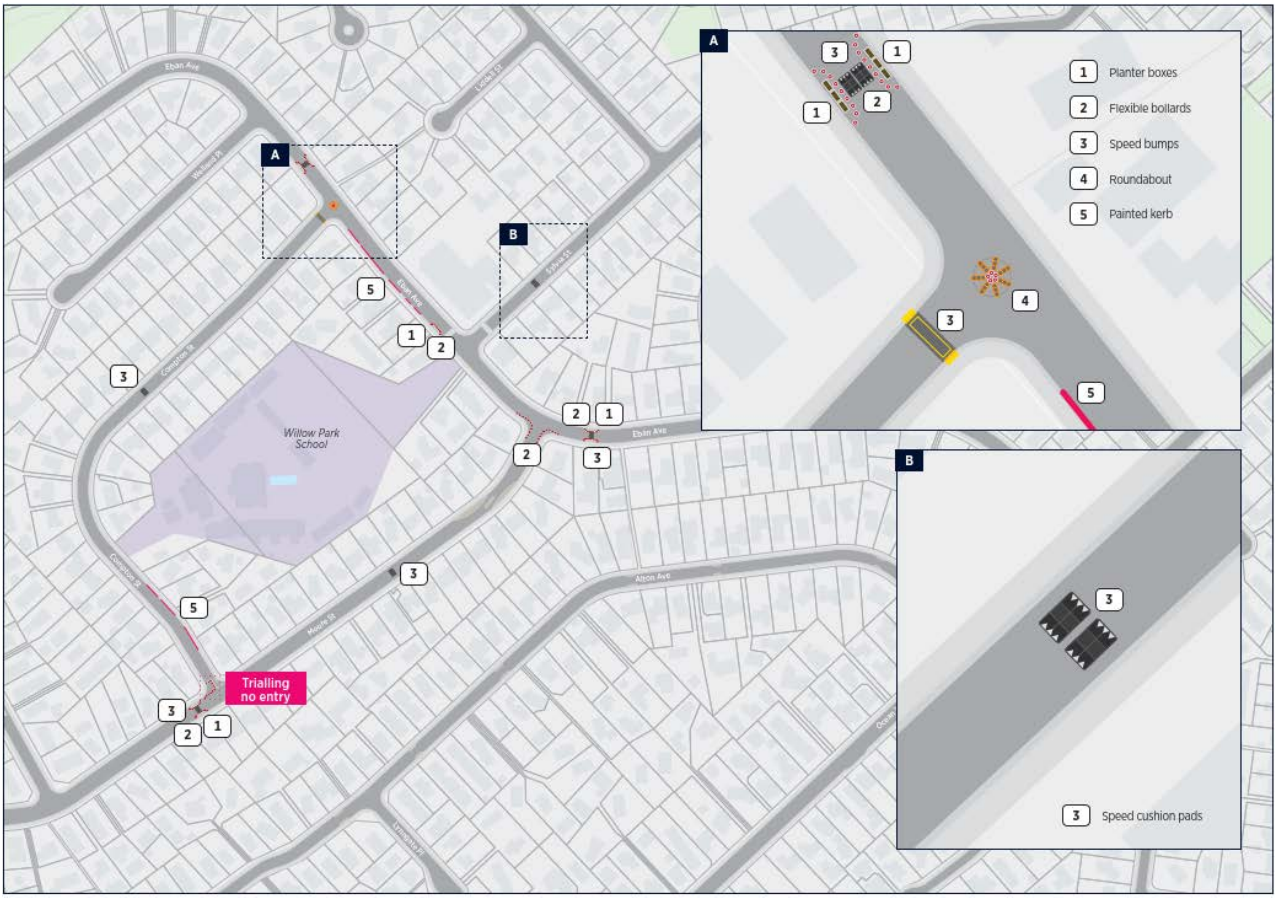
6.2.1 Description

Auckland Transport ran a pilot programme named ‘Safe School Streets’ in 2021 with several schools around Auckland. This programme introduced temporary measures to increase safety outside schools, reduce the number of vehicles during peak times and encourage more students and their families to walk and cycle to school.[18] Willow Park School introduced several changes (see Figure 6.4), which included:

- drop-off and pick-up only vehicle areas (indicated by a painted purple kerb and signage)
- flexible bollards and planter boxes narrowing the road to slow vehicle traffic
- a temporary mini roundabout
- speed cushions
- a no-entry zone street
- narrowing of intersections
- temporary signage placed along the safest route to school.

[18] See https://at.govt.nz/projects-roadworks/safe-school-streets/ for more information.

Figure 6.4 Temporary changes installed around Willow Park School (Auckland Transport, n.d.-a)



6.2.2 Measures

A survey was administered by Mackie Research (A. Raja, pers. comm., 25 March 2022) to residents, to collect baseline data and follow-up feedback on:

- How does your child (or children) usually get to and from Willow Park School?
- The mode of travel used most often for the greatest part of their trip.
- Perceived safety: how safe or unsafe is it for students to walk, bike or scooter near the school entrance (scooter follow-up only)?
- Have the changes to Eban Avenue and Compton Street had any impact on the frequency your child (or children) use any mode to get to/from school?

School staff and student interviews were conducted in two focus groups, to gain feedback:

- Willow Park School staff focus group
- Willow Park School Year 5 and Year 6 students focus group.

6.2.3 Outcomes

In response to the mode travelled to school, respondents were able to select one or more options (see Table 6.3). No significant difference was evident between the number of people travelling by mode in the baseline and follow up (X^2 (4, N = 272) = 23.68, p = 0.72).

Table 6.3 How does your child (or children) usually get to and from Willow Park School?

	Baseline (%)	Follow-up (%)
Dropped off/picked up in car	61	66
Walk	51	56
Bike	4	10
Scooter	7	9
Public transport	0	1
Motorbike (eg pillion passenger)	0	0
Other	4	3

When asked if the changes around Willow Park school had any impact on the frequency their child (or children) used any mode to get to school, 17% of respondents stated 'yes'.

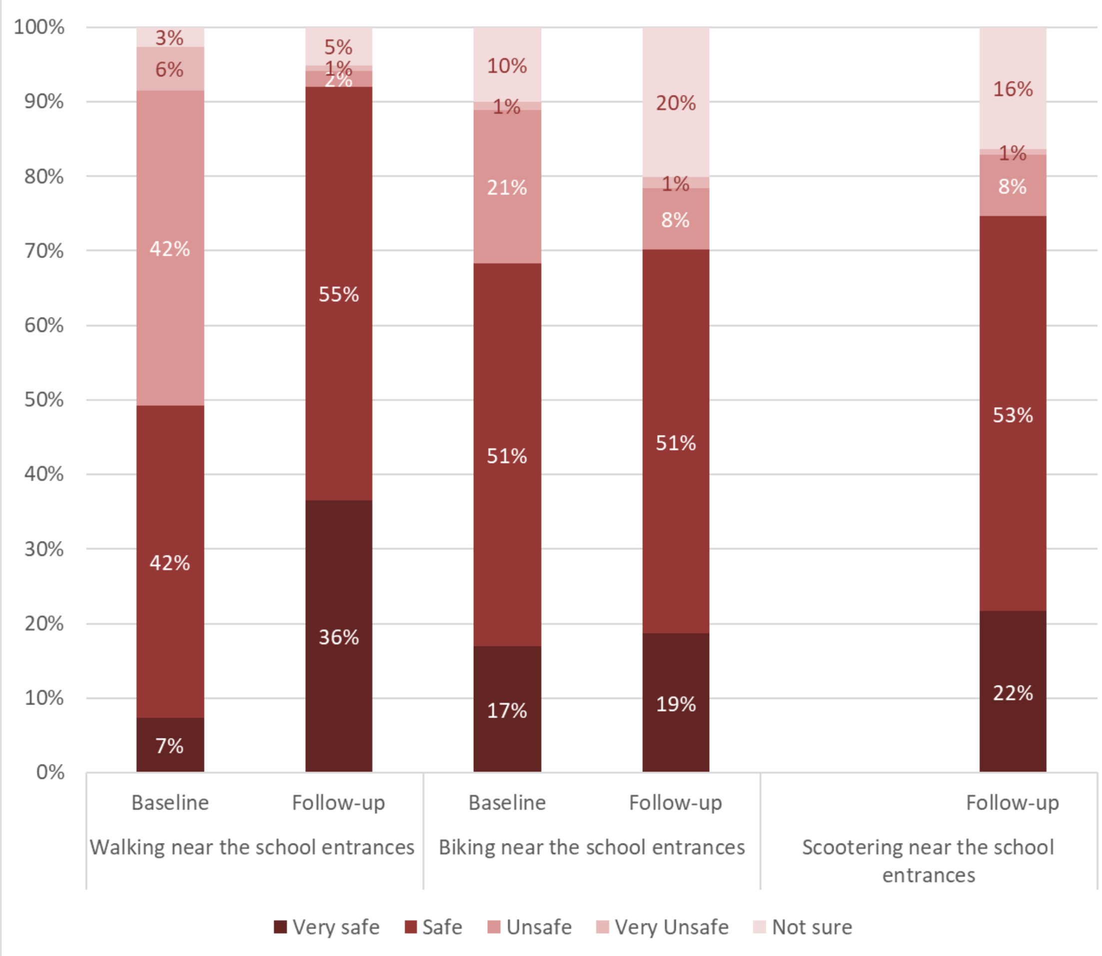
Thirty-three respondents provided reasons for their answers. Of these respondents, 21% reported that the changes had made the surrounding streets safer:

- Nine percent reported the changes to safety had resulted in their child starting to walk or bike to school. One respondent specifically mentioned that the speed cushions reducing vehicle speed had contributed to their child's mode change.
- Twelve percent reported that their child had already been walking to school, but the changes had made either them or their child feel much safer about their journey to and from school.

An additional 9% of respondents reported that their child had begun to walk or bike to school but did not mention if this was due to their perceived safety of the area. Of this group, one respondent mentioned that they had stopped driving their child because the street changes had made it too difficult to drop them off close to the school.

In terms of safety, participants responded that they felt it was significantly safer to walk near school entrances during school pick-up and drop-off times (X^2 (4, N = 326) = 87.0, p < .001) but not significantly safer to bike (X^2 (4, N = 325) = 137.98, p = 0.41) (see Figure 6.5).

Figure 6.5 **How safe or unsafe overall is it for students to walk, bike or scooter near the school entrances during school pick-up and drop-off times? (A. Raja, pers. comm., 25 March 2022)**



Focus groups supported the survey responses, with staff feeling that the road environment was safer for children, infrastructure changes signalling that people are entering a school zone and the one-way street implementation reduced speed and improved driver behaviour. However, they recognised that vehicle traffic may have moved to outside the implementation zone making that area less safe than before.

6.2.4 Lessons

- Subjective evidence is limited in this case study to demonstrate that safety interventions contributed to mode shift.
- Objective data (walking, cycling and vehicle counts) would provide further data.
- Through looking at the whole of journey, the opportunity exists to improve not only interventions within the immediate vicinity of the school but also in the surrounding streets.

6.3 Case Study 3: Christchurch – Cycle route treatments (on- and off-road approaches)

6.3.1 Description

Christchurch City Council's Major Cycleway Routes programme has involved the construction of several cycleways throughout the city over the past several years, including the Rapanui–Shag Rock Cycleway and the Quarryman's Trail Cycleway (see Figure 6.6 for images and outcomes).

The Rapanui–Shag Rock Cycleway was constructed in two parts, with the first being a neighbourhood greenway,[19] from Fitzgerald Ave to Linwood Park, and the second a shared path from Linwood Park to, and along, Linwood Ave. The greenway portion includes various interventions designed to alert road users to the presence of cyclists and slow down and divert vehicle traffic, such as surface markings, speed humps, kerb islands and planting. In addition, the speed limit was reduced to 30 km/h, and buses that previously used the route were diverted. The shared path portion is 3 metres wide and includes surface markings and signalised cycle crossings.

The Quarryman's Trail, from the CBD to Halswell, is first a one-way separated cycleway on each side, with a neighbourhood greenway section followed by a two-way separated cycleway, which includes additional traffic signals and signage.

Figure 6.6 Post-intervention images and outcomes from the Rapanui–Shag Rock Cycleway (Stage 1) (reprinted from Waka Kotahi, n.d.-c) and Quarryman's Trail (reprinted from LennyBoy, 2020)

Rapanui–Shag Rock Cycleway (Stage 1) (Fitzgerald Ave to Linwood Park; 2017)

Route intervention: 30 km/h slow speed interventions/ heavy vehicle diversions/shared path markings

Before–after average annual daily flow: 27 before; 159 after (489% increase route cycling)

Before–after motorised vehicle count (annual daily traffic): 2,351 before; 846 after (64% decrease)

Quarryman's Trail (Haswell to Christchurch CBD; 2018)

Route intervention: Two-way separated cycleway

Before–after average annual daily flow: 119 before; 233 after (95% increase route cycling)

Before–after motorised vehicle count (annual daily traffic): Not reported

[19] Neighbourhood greenways, also known as 'quiet streets', 'slow streets' and 'bicycle boulevards', are streets with low volumes of motor traffic travelling at low speeds; this creates a pleasant cycling environment, without requiring specific cycle facilities.

6.3.2 Measures

An intercept survey was conducted in 2020 to better understand cycleway use, experiences and perceptions of safety (n = 303). Surveyors were stationed at three locations: one on each section of the Rapanui–Shag Rock Cycleway and one on the Quarryman's Trail Cycleway. A residents' survey was also conducted (n = 324), which targeted people resident in the streets where neighbourhood greenway changes had been made (including the two aforementioned cycleways as well as two others).

Cyclist counts were carried out before and after each cycleway was constructed, using a combination of manual and automatic counts. A traffic count was done on Worcester Street (a greenway portion of the Rapanui–Shag Rock Cycleway).

6.3.3 Outcomes

- Ninety-two percent of intercept survey respondents either agreed or strongly agreed that the cycleway had improved their safety when travelling by bicycle.
- Seventy-nine percent of intercept survey respondents either agreed or strongly agreed that the cycleway had encouraged them to make more trips by bicycle.
- Nineteen percent of intercept survey respondents stated that, if the cycleway had not been in place, they would have made that trip by motor vehicle.
- Fifty-six percent of the residents' survey respondents felt that the motor vehicle speed had slowed on their street since the greenway changes were made.
- Seventy-six percent of the residents' survey respondents who cycled felt safer to do so on their street because of the cycleway, and 65% said it had encouraged them to take more trips by bicycle.
- Along the Rapanui–Shag Rock Cycleway (Stage 1), the average annual daily flow of cyclists increased from 27 before the changes to 159 after, a percentage increase of 489%.
- Along the Rapanui–Shag Rock Cycleway (Stage 2), the average annual daily flow of cyclists increased from 83 before to 153 after, a percentage increase of 85%.
- Along the Quarryman's Trail Cycleway, the average annual daily flow of cyclists increased from 119 before to 233 after, a percentage increase of 95%.
- The traffic count on Worcester Street (part of the Rapanui–Shag Rock Cycleway) found a decrease in the ADT from 2,351 before to 846 after, a percentage decrease of 64%.

6.3.4 Lessons

- The type of treatment and/or intervention used at a particular location should reflect the characteristics of the existing road users in that area. For example, Stage 1 of the Rapanui–Shag Rock Cycleway is mostly through a quiet residential area with limited through-traffic, and the chosen urban greenway intervention allowed both motor vehicle users and cyclists to use the same space safely. This is in contrast to Stage 2, which runs down a busy road, where a fully separated cycleway was installed.
- Robust and thorough data collection before and after an intervention is installed is invaluable not only for assessing the effectiveness of the current intervention but for supporting a business case for future interventions.

6.4 Case study 4: Wellington – Brooklyn Road Cycleway

6.4.1 Description

As part of the Innovating Streets for People programme, Wellington City Council reallocated road space on Brooklyn Road to cycling, creating 1.3 kilometres of temporary separated cycleway in the uphill direction (see before and after treatments in Figure 6.7) on a busy 50 km/h road. A unique aspect of this was the treatment of the uphill direction (where the speed differential between people who ride and people who drive would be accentuated) and that the route had use by a high number of heavy vehicles (9.4% of all vehicles).

Figure 6.7 Before and after the Brooklyn Road cycleway (Waka Kotahi, 2021b, p. 2)

6.4.2 Measures

Wellington City Council captured mode counts of cyclists and motor vehicles (before and after), motor vehicle speeds (before and after), and the perceived safety impact of the intervention (via a post-construction survey).

6.4.3 Outcomes

- An increase occurred in the number of people who cycle, by 6% on weekdays and 10% on weekends. A slight drop also occurred in vehicles counted (but the number was not reported).
- Car parks were reduced by 35% within the trial boundary.
- Safer speeds: 85th percentile speeds dropped by 8% (from 56 km/h to 51.7 km/h).
- Perceived safety impact: 64% of people reported that the trial made travel between Brooklyn and the city safer for all users.
- Councillors voted unanimously to make the cycleway treatment permanent (including improved connections at each end).

6.4.4 Lessons

- The council noted that, although some aspects of the project were not great, the changes were still better than what was there previously, and they enabled the project to move forward.
- Due to the time constraints on the project, scope was limited to look at place-making and aesthetics. However, in the end, the functional nature of the finished cycleway suited the location and helped communicate the trial nature of the project.

- Setting a clear path forward through communicating commitment to the project and setting metrics of success helped keep the project focussed on the goals. Connecting to a longer-term and wider plan was helpful to improve understanding of how this project linked into a larger agreed plan.
- Wide engagement (from people who regularly cycle the route as well as motor vehicle users) helped demonstrate the positive appeal of the project.

6.5 Case study 5: Auckland CBD – Federal Street Contraflow Cycleway

6.5.1 Description

Auckland Transport ran a temporary trial of a contraflow cycle lane, using a ‘consultation by trial’ approach to test changes before they were made permanent. The treatments used included narrowing of the street (especially at intersections), colourful paint at intersections, planter boxes and ‘armadillos’ along the bike lane as a buffer, and a new pedestrian crossing (see Figure 6.8).

Figure 6.8 Federal Street contraflow cycleway (photo supplied by Glen Koorey, 2018)

6.5.2 Measures

Monitoring included reporting by an independent research provider (Thorne et al., 2018) with a thorough range of before and after measurements:

- Vehicle tube counters: With before and after data for four locations measuring vehicle speed and volume data.
- Cycle tube counters at one location: Cycle count data.
- Analysis of crash data: No crashes were reported since 2015.
- Video observations at one location: Multi-modal movement categories and interactions between modes (across 11 hours before and after), including avoidance and near-miss behaviour.
- Attitudes to road safety, usability and comfort: Convenience sampling of pedestrians, people on bikes, and business owners and employees.

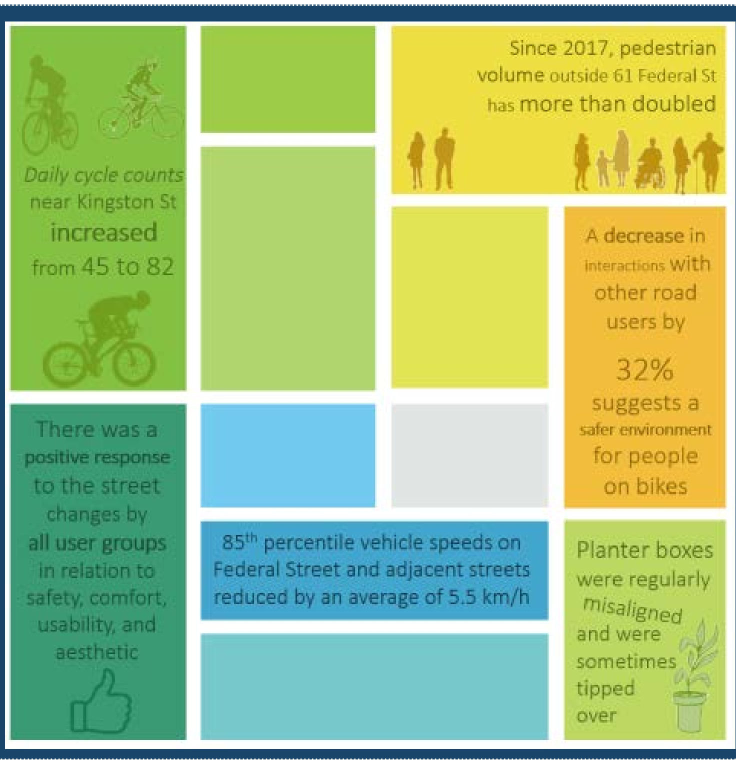
- Expert rides: Using head mounted cameras and Sensibel[20] (good/bad) geo-located ratings that could be described by the expert rider post-ride.

Additionally, a public consultation report was published by Auckland Transport (2019b) that included the results of a structured survey that had 247 submissions, including specific feedback on significant attributes post-implementation. This targeted feedback approach allowed for more refined changes to this intervention.

6.5.3 Outcomes

The outcomes of both evaluation reports are summarised in Table 6.4.

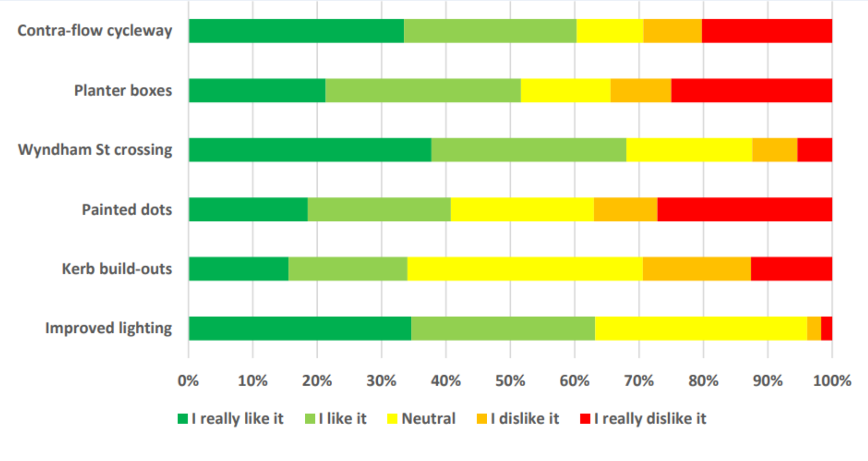
Table 6.4 Summary of outcomes from the Federal Street contraflow cycleway programme (Thorne et al., 2018, p. ii; Auckland Transport, 2019b, pp. 2 and 7)

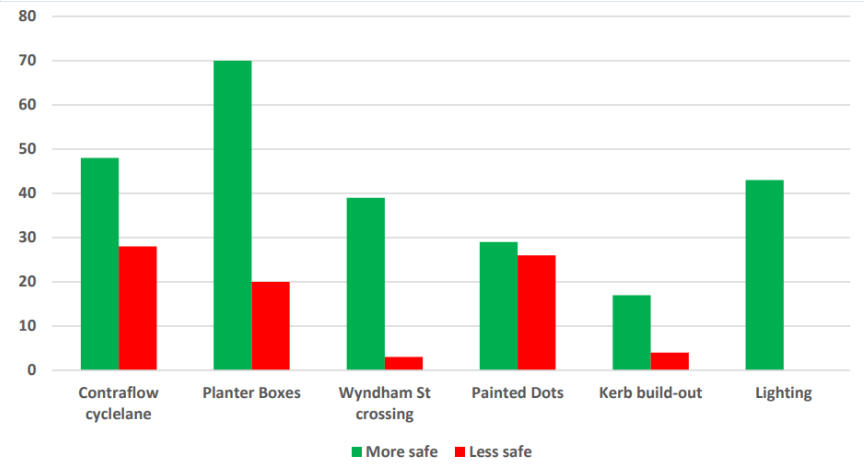
Outcomes from independent evaluation (Thorne et al., 2018): • Walking increased by 100% and cycling increased by 82% (*n* = 45 to *n* = 82). • Car volumes decreased by between 44% and 75%. • People on bikes have 32% fewer interactions (avoidance and near miss behaviour) with other street users. • The 85th percentile speeds on Federal Street and adjacent streets reduced by an average of 19.8% (22.7 km/h to 22.2 km/h).	

[20] Sensibel is a participatory platform that lets citizens share their cycle commute stories by quickly placing a positive or negative 'experience point' along their journey. Later, each cyclist can annotate their experience points with text and images (https://smartchristchurch.org.nz/project/sensibel/).

Outcomes from internal consultation process (Auckland Transport, 2019b):

- The public feedback process highlighted positive community perceptions and perceived safety of the various intervention features. More people rated the features as more safe than less safe, with the planter boxes, Wyndham Street crossing and lighting receiving a particularly large number of 'more safe' responses compared with 'less safe' responses.
- Feedback has led to several enhancements being planned, including the addition of a disability parking space and reflective markings to planter boxes for improved visibility.





6.5.4 Lessons

- The trial approach provides value because it allows improvements to be made post-implementation, where they can be included in conversion to a permanent upgrade.
- Several areas were identified for improvement, including ongoing maintenance of the plants in the planter boxes, susceptibility of the planter boxes to being moved when nudged by vehicles, pedestrian concerns around the armadillos being a potential trip hazard, and fading of the painted road markings over time.
- It is important that ongoing maintenance costs are included in budgeting, although for a temporary installation such as this they are likely to be less than the costs upfront of a more permanent installation.

6.6 Summary

When looking at the intervention types covered in the case studies, the following positive contribution to mode shift was shown, supporting the successful interventions identified in the published literature:

- Traffic calming measures, combined with reduced speed limit, correlate with mode shift away from vehicles in the treatment areas and an increase in active modes.
- Route-specific cycleways, appropriate for the type of road, can increase cycling on the route.
- Creation of a shared space for transport modes, with a dedicated cycle lane, correlates with an increase in cycle count and walking and a decrease in vehicle traffic.

The case studies also highlighted specific areas of importance for application:

- Understanding what is required for an implementation to be practical and successful:
  - Context is important, a one-size-fits-all solution for interventions does not exist.
  - Progressive change is still an improvement over no change, having a solution that can be built upon over time or shifted from temporary to permanent helps to get a project started.
  - Community consultation unlocks commitment to project goals and longer-term plans.
- Identifying specific opportunities for improvement in evaluation that were consistent across most case studies.

7 Discussion and conclusions

7.1.1 Which interventions should be considered for implementation?

It is evident that some safety interventions can contribute to mode shift. When looking at the split by mode, the following is concluded:

- Cycling: Cycling infrastructure that separates cycling from other vehicles has the strongest contribution to mode shift, followed by speed limits with traffic calming.
- Walking: Providing safe routes to specific destinations (eg schools, transit points) contributes to mode shift, with speed limits, traffic calming and lighting improvements also contributing.
- Public transport: Providing safe routes to transit points also supported a mode shift towards public transport use, with evidence showing that real-time public transport information and lighting improvements also result in mode shift.
- E-scooter: Limited evidence is available in this emerging area, however, separation of e-scooters from motor vehicles, for example, into a dedicated cycle lane has the greatest safety benefits. Sharing with pedestrians is not recommended because it may have a negative effect on walking.

At an individual level, infrastructure interventions that had the best evidence in contributing to mode shift included road-safety focussed and personal security interventions. Consistent evidence was also found around larger scale programmes, which we refer to as 'complete package' interventions, having the best outcomes. More detail on this is outlined below.

7.1.1.1 Infrastructure interventions

Infrastructure interventions are themed by the three areas of safer journeys and are outlined below (see also section 3.2 and section 5.4).

1. Road safety interventions

The road safety interventions with the strongest evidence-base in successfully increasing mode shift to walking and cycling are as follows:

- **Infrastructure that separates modes:** This involves physical separation of modes, especially cyclists and micromobility from motorised vehicles. Even in locations where conflict points and residual risk remain (ie where separated modes intersect), this separation is still effective at shifting modes.
- **Managing speed:** Lowering speed zones and traffic calming infrastructure are effective at increasing the number of people who walk and cycle, with the strongest evidence of increases in walking trips.

2. Personal security interventions

The personal security interventions with the strongest evidence base in successfully increasing mode shift are as follows:

- **Real-time public transport information:** This increases public transport trips and enables improved personal security through reduced wait times at stops. However, the real-time information must be accurate to be effective.
- **Artificial lighting**: This is effective at improving walking trips, including walking to public transport, but the literature around cycling trips is less clear. Lighting, in particular, appears to be undervalued as an

intervention due to its complexity rather than its effectiveness (see summary insights in section 3.2.2.1).[21]

- **Combination of interventions**: The more effective increases in walking, cycling and public transport were also more complex. Greater increases were seen in urban environments where a combination of personal security, crash safety and smoother path interventions were combined.

3. Slips, trips and falls interventions

While it was evident that uneven surfaces prevented some groups of people from walking and cycling, a gap exists in the literature on the effect of pavement improvements on mode choice.

7.1.1.2 Complete package interventions

Infrastructure to complete routes and city-wide interventions: This relates to filling important gaps in existing networks (such as motorways, bridges, multi-lane urban roads). These are often at complex locations, so the safety benefit alone may be difficult to rationalise without additional benefits like mode shift.

Complete package approach (infrastructure + education): While the evidence on education alone is weak (often due to lack of effective methods or reporting) there is strong support for a complete package approach. This is where education reinforces infrastructure changes, and the evidence is strongest around increasing walking and cycling for education-based trips.

The complete package approach is based on the principle that supportive transport systems that include safer infrastructure across a route or neighbourhood are more successful when reinforced with initiatives aimed at improving perceptions of safer routes. Improved perceptions are best evidenced in education initiatives where a captive audience exists in an integrated schools programme, with education and real-world skills training. For the adult audience, an opportunity is available around travel planning initiatives for workplaces that could also follow a safer infrastructure rollout for walking, cycling and public transport (especially around safe routes to transit).

An important lesson to consider is that if perceptions of safety are not attended to appropriately, the addition of safer infrastructure alone may not be enough to see mode shift and use (see section 3.2.4.2). This could be improved by linking street and corridor infrastructure rollout with educational initiatives (eg like bikes in schools, walking school buses or individualised travel planning).

In addition to the literature review, a summary of safety interventions that also affect mode shift has been delivered as an interactive dashboard (see chapter 4).

7.1.2 What are the underlying factors around why safety interventions lead to mode shift?

Two underlying success factors for safety interventions to affect mode shift were that they: 1) affect perceptions of safety and 2) have community buy-in.

7.1.2.1 Perceptions of road safety and personal security

> *People know what is in their best interest. If people feel that they are <u>not safe</u> they are going to drive.* (P6)

Perception of safety includes both road safety and personal security. For example, physical separation of modes affects perceptions of road safety, and interventions that improve lighting affect perceptions of personal security. This addresses the concept that only ‘captive’ public transport users, that is, those who do

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[21] At the time of publication, specific national guidance for lighting of walking and cycling was not available.

not have a reasonable alternative transport choice, will continue to walk and ride if they do not feel safe. Actual safety comes into it as well, but more in relation to the fact that if people are involved in or made aware of a crash or assault then this becomes a trigger to reassess their perceptions of safety.

Factors like perceived control may interrupt a safety perception leading to mode shift (eg Bamberg et al., 2003). Take, for example, pedestrian slips, trips and falls. Where a person believes they are in control of their behaviour (eg walking speed, crossing location or path taken) and they feel it is easy to walk without falling, the walking surface may have less impact on the choice to walk, at least when compared with a crash or assault where another individual can influence the outcome. Similarly, people are boundedly rational and use the information readily available to them to inform decisions, rather than make the perfect decision (eg Kahneman, 2003). Therefore, where an intervention has provided a safety benefit this may go unnoticed or not be translated to a significant reassessment of risk.

For perception changes to really activate mode shift, community support or buy-in also appears to be a significant driver.

7.1.2.2 Community buy-in and support

Another factor that activates mode shift is community perceptions and achieving social licence by working with the community. When the community cares, the political support follows. An important element to this is that we should be safe in our own neighbourhoods, regardless of how we travel:

> *We have made high speeds safer for drivers of cars, and that has been the focus. But we were not doing this for other modes. If I step out of my door I should be safe.* (P6)

It is easy to gain support for the concept that every child needs a safe route to school and play.[22] Safer routes to significant social infrastructure within a community, like libraries, sports facilities, parks and public transport hubs is, therefore, a great starting point for gaining support and achieving mode shift.

7.1.3 How can mode shift and safety measures be operationalised from the Waka Kotahi Land Transport Benefit Framework?

The measures in the Waka Kotahi Land Transport Benefit Framework are typically with best practice around what should be monitored. The detail of how these measures are operationalised across different regions (eg in different transport plans and business cases) and then the detail of what data is readily available and what is actually monitored across different street types (ie across the One Network Framework) is where difficulties lie.

As outlined in section 2.5, most of the data currently captured is around crash data involving motor vehicles or self-reported safety data that is only regularly captured at a city-wide scale. A whole-of-journey approach would see multi-modal data around use and safety at a geospatial level useful to inform intervention success and improve investment decisions. See Table 2.2 in section 2.5 for more detail on specific opportunities around better monitoring and where data gaps lie.

1. Including whole journey injury data in strategy and analysis

   This would integrate hospital, ACC and Crash Analysis System data (and wider police data relevant to personal security) at a street segment geospatial level. It would also involve taking opportunities to improve access to injury data that can be captured and shared at a more refined geospatial level, including greater integration of injury data within a transport corridor. In particular, pedestrian, cycle-only and public transport fall injuries need to be examined equitably with those injuries relating to motor vehicle crashes (eg Koorey et al., 2022).

[22] See www.saferoutespartnership.org/healthy-communities/101/every-child-needs for more information.

2. Gaining agreement on consistent perceived safety indicators within the framework

   Mode shift is typically more sensitive to perceived than actual safety. For the purposes of mode shift, accurate and consistent measurement of perception data is critical. While it is commonly measured, the consistency of measurement makes it difficult to derive comparisons. In addition to consistent language, these should consider separating safety to cover how perceived risk leads to avoidance of travel based on the different sub-risks: crash injury; slip, trip and fall injury; and personal security. Avoidance at night and day are other important indicators that should be considered for consistent measurement.

7.1.4 Recommendations: What needs to be done to achieve this?

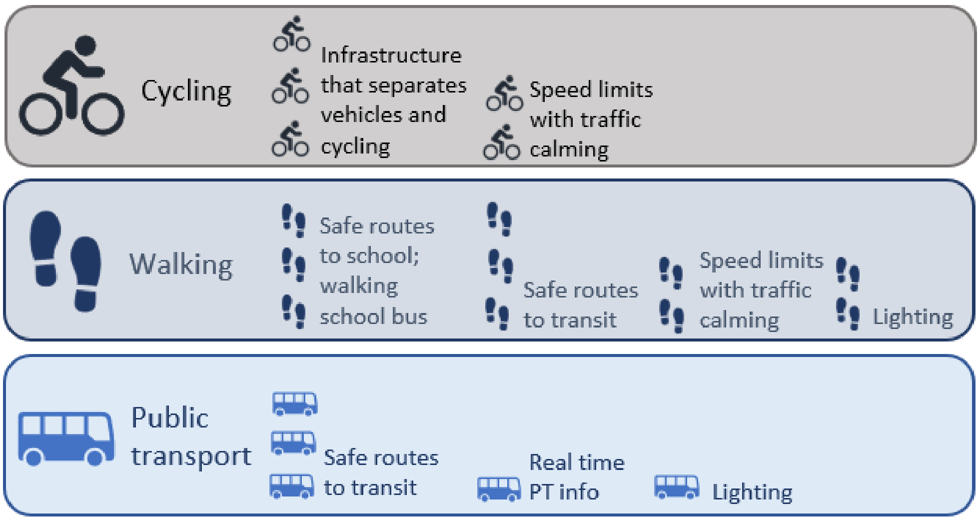
The following recommendations are submitted to Waka Kotahi for consideration.

Recommendations related to key strategy and policy actions are listed here:

1. Future transport strategies for New Zealand, including road safety strategies, to cover a wider range of harms (eg road safety, slips, trips and falls and personal security) and the consequent update of the action steps and funding framework (see also section 5.6).
2. Future transport strategies for New Zealand to consider a funding approach inclusive of whole-of-journey safety (crashes, falls and personal security). This includes consideration of:
   a. Integrated or complete funding opportunities to enable a 'Safe Routes' approach (especially for schools and important public transport hubs, including real-time information)
   b. Walking and micromobility (single party injury) interventions (including traffic calming, but also considering lighting)
   c. Interventions that also work for mode shift on the safety intervention list, to deliver Road to Zero (for example, in updates of the Standard Safety Intervention Toolkit, such as cycle separation)
   d. Linking street and corridor infrastructure rollout with educational initiatives (eg like bikes in schools, walking school buses or individualised travel planning).

   Consequently, it is recommended the safety interventions in Figure 7.1 be considered for implementation to support mode shift (while taking into account contextual factors).

Figure 7.1 Intervention effectiveness by mode and mode shift impact



Note: PT = public transport.

3. Future transport strategies for New Zealand should include minimum requirements for monitoring of the modes affected as criteria for accessing funds (for example, as the Urban Cycleways Programme has done, which has led to more cycle monitoring in New Zealand cities; Pascoe, 2019).
4. Funding documents and national and regional monitoring frameworks should include explicit links to evaluation guidance (to promote greater use of existing evaluation guidance).

Recommendations to support improved decisions based on monitoring:

5. Increasing walking and cycling count data (especially around the CBD, town centres, public transport hubs and lower speed locations).
6. Improving access to monitoring equipment and analytic capability, especially around camera-based data (for more localised treatments or at sample locations), because this provides a rich picture of both safety and mode shift.
7. Consistent monitoring of specific perceived safety indicators, split into road safety, slips, trips and falls, and personal security. Also, consistent monitoring of avoidance during night and day (to understand who is not using an area because they believe it to be unsafe).
8. Continuing provision of case studies showing the benefits of broader monitoring and examples of what good looks like, to encourage better monitoring.
9. Continuing to focus transport safety data integration initiatives on steps to integrate, share and provide training resources, to encourage improved data use. In particular, geospatial requirements need to achieve some level of data integration, such that as the data shifts to having a geospatial code it can be integrated. At a minimum, geospatial location and confirmation are needed that an incident occurred at the street or transport path or public transport hub location.
    a. Provide a mechanism to report safety data, including slips, trips and falls and personal security incidents (ie assaults and verbal abuse) sustained while on public transport, to the police
    b. Integrate public transport safety data and hospital data related to transport into the Crash Analysis System or an appropriate alternative, including defining a zone and/or limit close to public transport stops and hubs.

7.1.5 Limitations

Elements not examined in this report relating to safe journeys increasingly free of harm, and that also affect mode shift, include health-based safety interventions (eg in response to pandemics, or more active travel consequently leading to reduced likelihood or severity of injury).

Because some case studies were conducted during COVID-19 lockdown recovery periods, mode shift may have occurred due to other changes, which is recognised within the relevant case studies. However, this is primarily included in subjective feedback for Case Study 1 and has been overcome by using comparison groups for the same periods, so insights from this work are still viewed as applicable. It is also worth noting that the interviews were conducted between September 2021 and January 2022, within pandemic conditions (COVID-19). This may affect answers, but mostly around Theme 1, priority intervention areas, where public transport and travel to main centres may be viewed differently, and was recognised in some interviewee responses.

The applicability of research conducted in jurisdictions outside of New Zealand is varied because it is often highly dependent on the region of implementation. For example, in some European countries, a historical culture exists of cycling and infrastructure being integrated into transport planning. Therefore, this should be considered when understanding this research in the New Zealand context. The recommendations within this report were formed from the international and New Zealand evidence base and supported by interviews and case studies from within New Zealand, which highlighted specific areas of importance for application. The relevance of the recommendations for New Zealand was discussed in a workshop with the steering group to ensure implementation context was considered and appropriate.

Within this research we have applied a star rating system to enable searches by evidence strength, safety impact and mode shift impact. It should be recognised that these ratings encompass a variety of metrics and are intended to be used only within the scope of this research and are not necessarily transferrable.

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Appendix A: Semi-structured interview questions

The benefit of the semi-structured interview approach is it allows consistent topic areas to be covered (ie general question areas) and expert interviewers to ask different 'probing' questions based on the interviewee responses and knowledge area and gaps in existing knowledge (for example, cycle safety interventions had a stronger evidence base than walking or public transport interventions, based on the literature review).

The semi-structured interview covered the following:

- Themes: Three themes were developed to cover priority intervention opportunities, specific intervention case studies, and opportunities to include mode shift in safety intervention decision-making.
- General questions: Numbered questions were asked of interviewees (numbered).
- Example 'probe' questions: To tease out further information, as required (items with arrow symbols). Note these were used as prompts and would vary during the interview to gain the most insight from the interviewee.

Your background

1. What is your role and background?
2. Around safety and mode shift interventions what level of experience do you have around intervention decision-making / knowledge of intervention effectiveness / intervention evaluation?

Theme 1: Priority intervention opportunities

3. Where do you think is the best opportunity for safer journey interventions to support mode shift away from the car?

   [Note: Safer journey interventions for the purposes of this study include: a) road safety interventions; b) slip, trip and fall interventions; and c) personal security interventions.]

   a. Any specific modes to focus on? Why?
   b. Any future considerations / trends to take into account?
   c. Still thinking about the above: What are the intervention types to focus on? Infrastructure / training / education / operational changes (eg expert staff roles or resource allocation) / organisational (eg links to police / ACC / Health agencies)?

Theme 2: Specific case studies

4. Can you think of a recent successful example of a project that had a safer journey intervention, that also evaluated the impact on mode shift away from car (ie to public transport, cycling, walking, micro-mobility modes)?
   a. What level of involvement did you have with this study?
   b. Is this study very easily accessed online, ie published articles related to this? Can you send through or point me to these?
   c. Any you can think of that did not have all of the evaluation findings published, where it would be good to delve deeper?
5. Overall, how successful was this intervention?
   a. What modes of travel were targeted? Any mode shift improvement?
   b. Any safety improvement?
   c. What is the ONE THING that would have made this more successful?
   d. Any other lessons?
6. What was the evaluation approach?

   a. What type of study, ie before–after, comparison group?
   b. What was the geographic area, ie local route, city, region, country level?
   c. What was measured?
   d. Were there any desired metrics / other data that you wanted to use but didn't? Why (ie cost, technology, timing, political, staff knowledge etc)?
   e. Any published materials related to this? Can you send through or point me to these?
   f. Was there any other unpublished data / other evidence around mode shift?
   g. Any other data we could collect OR analyses we could run now that would be of value to understanding the success of the intervention?
   h. If you could do the evaluation again would you do anything different?

7. How were mode shift metrics / benefits incorporated?
   a. Used up front (eg to inform business case or to help select appropriate intervention or scale of intervention) vs used post-implementation (story-telling, post-impact assessment).
8. Now can you think about [INSERT either a) an unsuccessful or less successful example; OR b) probe for a case study that fills a knowledge gap area]?

   [Repeat above questions and prompts.]

Theme 3a: Opportunities for changing how we make decisions?

9. Thinking about the successful study we discussed earlier, what was the process to get this implemented? *[OR if no specific example – then what should be the process?]*
10. What was key in enabling you to look at mode shift benefits?
11. Where is the best opportunity to influence decision-making to include mode shift benefits in safety intervention decision-making (eg frameworks or key decision points, strategy level, investment level, intervention guidance, impact evaluation)?
    a. What level of support is there for safety interventions to capture mode shift benefits at the following levels? [Broadly code strong / moderate / little / none.]
       i. Strategic safety level: Road to Zero / Vision Zero framework – Which are relevant / critical? Opportunity to add in mode shift? (especially, beyond reduced exposure)
       ii. Investment allocation of funding: Funding allocations available? Criteria used? Funding agencies? (NLTP / local funds)
       iii. Allocation prioritisation: ie evidence-gathering methods / business case / investment logic mapping etc
       iv. Safety guidance / evaluation level – safety guidance documents / post-impact assessment evidence
    b. Thinking about the above, where is the best level to have real impact? Why?
    c. What actionable steps could be done to achieve this in your opinion?
12. [NZ ONLY] Any real New Zealand case study success stories you would like to see promoted further to encourage improved decision-making?
    a. Especially around: Public transport / walking? Cycling / micromobility?
    b. Any other people we should be connecting with around case studies?