Micromobility Risk Study

Auckland Transport

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Quality Assurance Information

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Executive Summary

Introduction and Scope

Urban mobility is ever changing, with new technologies constantly emerging. Powered micromobility is placing new demands on Auckland's road infrastructure and the urban environment. New types of mobility devices such as e-scooters (shared or user-owned), e-skateboards, monowheels, and Segways represent both opportunities and threats for Auckland Transport's ability to deliver a transport system that meets the needs of Aucklanders. While unpowered versions of these vehicles have long existed, new vehicle designs are constantly being developed, changing travel behaviours. Public debate has recently emerged around safety, particularly since the large-scale deployment of commercial shared e-scooter and e-bike operations. The novel and constantly evolving nature of micromobility as a travel mode means its safety profile is little understood. Furthermore, the rapidly evolving sector means that data trends are challenging to extract; often micromobility crashes are not recorded at all, while the rapid growth in the sector makes it difficult to evaluate the proportionate scale of safety risk associated with micromobility.

This study is a high-level, broad overview of safety risks and issues. It draws from a wide range of data sources and findings, which can be explored in more depth through further research.

In this context, this study sought to understand the risk to all road users (especially vulnerable road users) associated with new and emerging micromobility and develop a practical approach to assessing risk and accommodating these modes on the network. Micromobility is one of the many transport modes sharing street space with varying and constrained space requirements, travel speeds, and abilities to avoid or withstand collisions. This study has been conducted through a Safe Systems lens, with the four key elements in creating a safe system guiding research – safe roads and roadsides, safe speeds, safe road use and safe vehicles. Regulations are factored into the analysis, however it is not within this study's scope to make regulatory recommendations.

A total of nine research questions were investigated, as follows:

- How significant is skill level in crash results?
- What are the effects of current guidance and operations on safety?
- What are the infrastructure geometry or design requirements for micromobility?
- What is the impact of facility condition and maintenance on risk?
- How does the risk of different micromobility modes compare with other activities?
- What is a safe speed environment for micromobility modes?
- What are the effects on non-user safety?
- How does perception relate to a real safety concern?
- How does hired vs owned micromobility safety relate?

Literature Review

A literature review was undertaken of available information locally in Auckland, nationally and internationally. The review considered research and literature on:

- Who uses micromobility and why
- Perceived safety and preferences
- Epidemiology of micromobility crashes
- Risk factors
- Local regulations

The literature reveals varying approaches to regulating micromobility. Some key findings link speed of micromobility devices with injury severity. It also showed that higher severity injury crashes are more likely to take place on roads, with some studies showing 80% of e-scooter related fatalities involve motor vehicles. Helmet and protective equipment use were also found to be very low (up to 14% amongst injured e-scooter riders), especially amongst shared micromobility users.

Survey

A survey asking respondents to report on any e-micromobility incident was conducted with a total of 810 completed surveys received.

Some key observations from the survey included the following:

- incidents which resulted in collisions are mainly attributed to the behaviour of the e-rider, while falls or crashes with a non-moving object were mainly attributed to road features such as slippery or bumpy surfaces. Overall, 25% of responses were considered to be collisions, 24% were falls or near falls, and 51% were near misses.
- Rental devices were more likely to be involved in e-scooter crashes (than private e-scooters), while e-bike crashes tended to be on private devices. Similarly, 50% of e-scooter incidents occurred within the user's first nine rides, while 60% of e-bike incidents occurred with a rider who had ridden more than 100 times.
- Across all device types, 35% of collision incidents resulted in injury, and 29% of fall incidents resulted in injury. While e-bike incidents tended to happen on road, and e-scooter incidents tended to happen on the footpath, there was a similar profile of injuries resulting from e-bike and e-scooter crashes.

X-Kemm-X Modelling

Analysis of kinetic energy modelling has been undertaken to understand the link between relative speeds of different road users and the potential for a fatal or serious crash to occur. Monash University have developed three risk models for the following crash types:

- Car versus pedestrian
- Car versus two-wheelers
- Two-wheeler versus pedestrian

The models showed that the probability of a serious injury in collision between cars and pedestrians is relatively high at speeds greater than 30km/h. It also notes that for the young, elderly, and in crashes involving larger vehicles the risk of death at all speed limits is much greater.

For collisions with two wheelers, models factor in the speed of the two-wheeled device. The combined impact speed has an effect on risk of fatal and serious injury. For two wheeled devices versus pedestrians, the critical combined impact speed resulting in a concussion is used as the model for serious risk. The model indicates that a combined speed of impact greater than 19km/hr has higher risk of concussion and serious injury to pedestrians. Therefore, combined speeds below 20km/h result in lower risk of collision-related concussions to pedestrians, supporting the speed restrictions of 15km/h proposed in the Accessible Streets Package.

Video Analysis

Video analysis of travel by e-scooters, bicycles, e bikes and other micromobility devices at a number of sites across Auckland was undertaken. It shows that 80% of e-scooters tend to use the footpath, while e-bikes (and other bicycles) favour using the road. Wider footpaths tend to lead to higher uptake of footpath use by e-scooter riders. There was no discernible difference in behaviour and use of infrastructure between e bikes and bicycles.

Crash Statistics

ACC (Accident Compensation Corporation) and CAS (Crash Analysis System) data was analysed to seek key data trends. ACC data was used to compare crash types between different micromobility modes. No significant difference in injury types was found although concussions/head injuries were roughly twice as likely amongst e-bike riders as cyclists.

There are eight times as many e-scooter claims as e-bike claims. Cycle injuries were also compared with e-scooter injuries and it was found that the profile of injuries is comparable. The other key finding is that while e-scooter claims are a recent ACC claim trend, other forms of device, such as skateboards, rollerskates, and scooters represent a higher number of claims overall.

Some key findings from CAS were that the majority of crashes, and all serious crashes investigated occurred with speed limits of 50km/h. Most serious crashes also occurred on road rather than on the footpath or other facilities. The gradient of the location of incidents also affects severity of crashes, with 71% of serious e-scooter crashes occurring on hill roads.

Risk Assessment Framework

Two risk assessment frameworks have been developed, informed by the study findings:

- One relates to types of micromobility devices and will be applicable to new devices.
- The other framework considers infrastructure risk for micromobility users. It looks at the exposure, likelihood and severity of falls, collisions with motor vehicles, and collisions with pedestrians or other micromobility devices.

Speed Analysis

Speed data collection has been undertaken in four locations around Auckland city centre. While device speeds below 16km/h could not be recorded, some key trends were revealed:

- Mean speeds on e-bikes are only 2km/h higher than for bicycles. However, e-bikes are significantly faster uphill.
- Private e-scooters have mean speeds around 4km/h faster than hired e-scooters. It is noted that the hired e-scooters in the survey would have been speed restricted by Auckland low speed zones.
- Helmet use is very low for e-scooters at only 11% of shared devices and 44% for private devices.
- Helmet use is comparable on private e-bikes and bicycles, at around 97%, but much lower on hired e-bikes, at 56%.
- E-scooters were capable of speeds in excess of 50km/hr uphill.
- Overall average speeds across devices were around 25km/h.

Intervention Concepts

Three trials are proposed as intervention concepts, based on the scope and findings of this research which suggest that additional space is required to separate micromobility users from vehicles. The first trial involves further speed and footpath behaviour analysis in sites across Auckland to encompass a wider range of speed environments and areas without speed restrictions on hired e-scooters.

Two physical trials are proposed. One concept involves the creation of a temporary bike/micromobility lane by annexing current on-street car parking on Davis Crescent (requiring a rule change). Another concept involves the creation of a shared path by extending footpath width on Hopetoun Crescent.

Regulatory interventions and rule changes are outside the study scope.

Key learnings

The below list summarises some of the key learnings.

- E-bike riders typically wear helmets, e-scooter riders less so. Riders of hired devices (both e-bikes and e-scooters) have significantly lower rates of helmet use than privately owned devices.
- Skill level is a far more significant factor in e-scooter incidents than e-bike incidents. This is likely because a lot of the skills required to ride an e-bike are transferable from riding traditional cycle.

- Private e-scooter users tend to use the road more than hired e-scooter users. This is likely due to a combination of e-scooter owners having more experience and being more comfortable in higher speed environments and shared-use devices having restricted speeds in low-speed zones.
- The injury profile is similar between e-scooters and e-cyclists, although ACC data revealed slightly higher rates of concussion / brain injuries in e-cyclists.
- Slippery/bumpy or uneven surfaces are the leading cause of solo micromobility crashes.
- Crashes occurring on gradients tend to result in more severe injuries.
- Crashes occurring on the roadway (rather than footpath) tend to be more severe.
- Bike and e-scooter speeds below 20km/h have a lower likelihood of resulting in a concussion if a collision with a pedestrian occurs, hence a lower risk of severe injury to the pedestrian.

Recommendations

The key learnings have led to the following recommendations:

1. E-bikes can be treated as bicycles for planning/policy purposes
2. Allow e-scooters and other forms of micromobility to use on road cycling infrastructure depending on their speed capability and helmet use.
3. Review requirements for helmet use in context of infrastructure use, speed capability of devices, and the forward fall mechanism specific to standing micromobility devices. Where devices are capable of exceeding 20km/h, risk of concussion is higher.
4. Speed restrictions of 15km/h on footpaths are appropriate
5. Where speed limits exceed 30km/h , seek segregation for micromobility or provide wider footpaths to allow more space for micromobility to avoid pedestrians, especially where pedestrian flows are high. Where this is not possible and e-micromobility (excluding e-bike) volume are moderate to high, then the speed limits on the road should be lowered to 30km/h, especially where lane widths are narrow, to facilitate road sharing.
6. Policy makers should give priority to safely getting hired micromobility users past their first few rides (where their chance of an incident is much higher), including through training.
7. Priority for transport policy and design standards should be directed at reducing the likelihood of vehicle vs micromobility crashes.
8. Consideration of low speed zones should be made for roads with higher gradients for shared-use e-micromobility devices.
9. Prioritise designs of downhill facilities that manage conflicts at access and side-roads and between users of the facility.
10. Prioritise designs of downhill facilities to manage e-micromobility rider speeds.
11. Technologies that decrease downhill speed/acceleration should be advocated for and shared-use operators that implement these are recommended.
12. Additional steps are required to increase shared use micromobility helmet use. One option would be to consider helmet check locking systems.

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SECTION 1: SCOPE, BACKGROUND AND METHODOLOGY

1. Introduction

Auckland Transport (AT), in conjunction with ACC (Accident Compensation Corporation), want to better understand the safety risks associated with new and emerging micromobility, and develop a practical approach to assessing risk and accommodating these modes on the network. This in turn is expected to improve both AT's and their partners' ability to deliver better, safer travel options for their customers, by influencing micromobility licensing, design and policy.

Forms of micromobility are some of many transport modes sharing street space with varying space requirements, travel speeds, and abilities to avoid or withstand collisions. Following Auckland Transport's Vision Zero goal, the study will be considered through a Safe Systems lens, looking at all four elements of the safe system: safe roads and roadsides, safe speeds, safe road use and safe vehicles.

This research aims to investigate the risk that micromobility poses both to its riders and other road users, by analysing available and new data. Rather than measuring risk, the research aims to gain better insights into addressing risk factors.

While micromobility user and non-user safety will be the primary focus, the findings from the research will help identify risk factors and consider the severity of crashes/incidents, aligning with the Vision Zero strategy. This will help to develop micromobility risk profiles based on both mode and infrastructure through two Risk Assessment Frameworks.

This report is structured as follows:

Section 1 introduces the study scope, background and methodology, including a description of the process to determine the scope and a literature review.

Section 2 covers the research and data analysis stages, including details of the user survey undertaken, risk analysis, video analysis of micromobility user.

Section 3 details practical outcomes of the earlier research, specifically intervention concepts considered

Section 4 summarises the conclusions of the study and suggests next steps including proposed future trials.

2. Study Scope

2.1 What is Micromobility?

Micromobility for the purposes of this report will be the term used to describe small, *electrically powered* transport devices. Thus, it specifically excludes unpowered bicycles or scooters. This report adopts the same taxonomy of vehicles as defined in the recent Waka Kotahi NZ Transport Agency Research Report 674 (Ensor et al 2021) which in turn references the Accessible Streets Regulatory Package proposal. Six categories of 'vehicles and devices' permitted to be used on paths are defined and reproduced here.

- ***Pedestrians*** *– people on foot, those using wheelchairs (unpowered), and those pushing wheeled items such as prams, trolleys or zimmer frames. Under the proposal, pedestrians would be able to use footpaths or, if a footpath is not available, shared paths, cycle paths, cycle lanes or roads.*

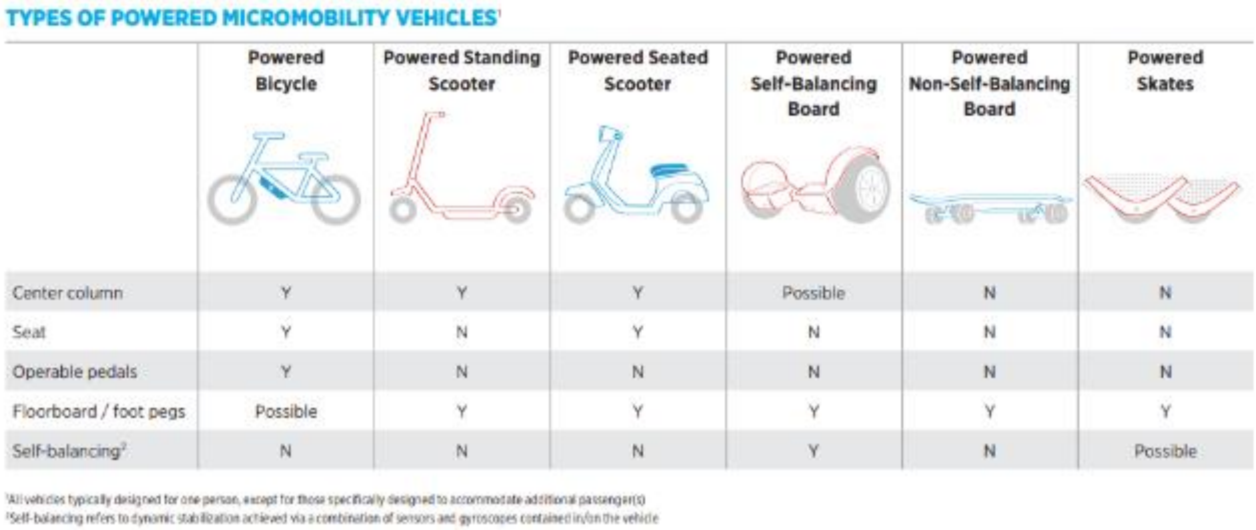
- ***Powered wheelchairs*** *– powered wheelchairs will be treated as pedestrians and hence can also use the footpath. Where no footpath is available, like pedestrians, powered wheelchairs may be used on shared paths, cycle paths, cycle lanes or the road.*

- ***Mobility devices*** *– powered devices for those requiring mobility assistance for medical purposes, up to 150 W. Under the proposal, mobility devices would be able to be used on footpaths as long as they are less than 750 mm in width or have an exemption permit, as well as shared paths, cycle paths, cycle lanes and roads if no footpath is available or permitted by a road controlling authority.*

- ***Unpowered transport devices*** *– small, unpowered devices propelled by human power or gravity, such as skateboards, rollerblades or push scooters; notably, the wheel diameter requirement would be removed under this proposal. Unpowered transport devices would be able to be used on footpaths under certain conditions (including the 750 mm width restriction), cycle paths, shared paths, and cycle lanes (unless a road controlling authority excludes them).*

- ***Powered transport devices*** *– low-powered devices propelled by a motor that have been declared by Waka Kotahi not to be a motor vehicle – currently, this is limited to e-scooters and YikeBikes. Waka Kotahi can declare that a device is not a motor vehicle if its maximum power output is under 600 W. Powered transport devices would be able to be used on footpaths under certain conditions (including the 750 mm width restriction), cycle paths and cycle lanes (unless excluded by a road controlling authority), roads and, if a road controlling authority permits, shared paths. Waka Kotahi may choose to impose further conditions on the use of a powered transport device if the maximum power output is between 300 W and 600 W."*

According to the categories listed above, micromobility vehicles would fit within the category of 'powered transport devices'. SAE International (2019) identifies micromobility sub types as follows in **Figure 2.1,** which describes many of the vehicles considered to be the focus of this study.



TYPES OF POWERED MICROMOBILITY VEHICLES[1]

	Powered Bicycle	Powered Standing Scooter	Powered Seated Scooter	Powered Self-Balancing Board	Powered Non-Self-Balancing Board	Powered Skates
Center column	Y	Y	Y	Possible	N	N
Seat	Y	N	Y	N	N	N
Operable pedals	Y	N	N	N	N	N
Floorboard / foot pegs	Possible	Y	Y	Y	Y	Y
Self-balancing[2]	N	N	N	Y	N	Possible

[1]All vehicles typically designed for one person, except for those specifically designed to accommodate additional passenger(s)
[2]Self-balancing refers to dynamic stabilization achieved via a combination of sensors and gyroscopes contained in/on the vehicle

Figure 2.1 Types of Powered Micromobility Vehicles (SAE International 2019)

New types of micromobility vehicles are emerging constantly, and this study does not seek to classify all of them or set boundaries. Nonetheless it focusses on those powered vehicles which broadly speaking fall within the definitions of Tice 2019, i.e. low weight, small size and low speed:

“Micro-vehicles move down another order of magnitude in scale and speed. Their weight is generally less than 100 kilograms (220 lbs), their footprint is usually 1/2 meter by 2 meters (1.5 ft wide by 6 feet long, 10 square feet), and typically operate at top speeds of 25-30 kph” (Tice, Micromobility and the built environment, 2019).

It should be noted that when communicating externally as part of this study, particularly in undertaking survey work, the term ‘e-micromobility’ has been adopted in order to avoid user confusion with unpowered vehicles. However, this report adopts the term ‘micromobility’ throughout as an umbrella term for small, electrically powered transportation devices. This does not include non-powered skateboards, scooters or bikes.

2.2 Current Legislation

A brief summary of the current legislation as it pertains to micromobility follows. The Accessible Streets proposed legislative changes would result in significant changes to this legislative framework.

Legal use of Vehicles

Currently legislation defines push scooters, skateboards, roller blades and vehicles with a maximum power output of up to 300 watts as wheeled recreational devices for the purposes of legislation. These may use the footpath. A similar device with a power output above 300 watts would be considered a motor vehicle and would not be permitted to use the footpath (unless separately permitted by local authorities).

E bikes have a maximum power output of 300 watts. An e-bike with a greater power output is not considered to be a cycle.

Vehicles above the 300 watt power output include segways which are treated as motor vehicles.

Use of Infrastructure

Currently, e-scooters may use footpaths, the road, or shared paths. They may not use cycle lanes, as these are classified as cycle only facilities. E-skateboards, hoverboards or monowheels (unicycles) are not permitted to use the footpath as they are considered to be motor vehicles.

E-bikes may be used on cycle paths, cycle lanes, shared paths and the road, but not on the footpath. They are legislatively treated the same as bicycles.

The Accessible Streets proposed legislative changes proposes that e-scooters and e-skateboards can use cycle lanes in the future. It also proposes that e-bikes (and bicycles) can use footpaths if they travel no faster than 15kph.

Helmets

Currently helmets must be worn on bicycles and e-bikes. Their use is not required for other forms of micromobility, nor are any changes proposed in the Accessible Streets proposed legislative changes.

Speed

There are currently no speed restrictions legally applicable to the use of micromobility.

The Accessible Streets proposed legislative changes proposes that forms of micromobility (and bicycles) would be permitted to use the footpath if they travel no faster than 15km/h, but no restrictions are proposed for micromobility devices on the road.

Rental vehicle restrictions

In Auckland, various concessions have permitted rental micromobility vehicles to be used since 2018. A summary of the timeline of implementation is provided below in **Figure 2.2**. In Auckland geo-fenced areas of high pedestrian demand have since May 2019 limited the speed of rental e-scooters within them to 15km/h. The geo-fenced areas are:

- Takapuna
- Devonport
- Ponsonby Road
- Jervois Road (College Hill to Curran Street)
- Karangahape Road
- City centre including Queen Street and waterfront area
- Auckland City Hospital precinct
- Parnell (including the Blind Foundation precinct)
- Newmarket
- Mission Bay
- Kohimarama
- St Heliers

2.3 The Safety Question

Micromobility Safety

Micromobility is placing new demands on Auckland's road infrastructure and public spaces. New types of vehicles such as e-scooters (shared or user-owned), powered skateboards, hoverboards, and monowheels represent both threats and opportunities for Auckland Transport's (AT) ability to deliver a transport system that meets the needs of Aucklanders. While unpowered versions of these vehicles have long existed, new vehicle designs are constantly being developed, and travelling behaviours are changing as a result. The public debate has recently crystallised around safety, particularly since the large-scale deployment of commercial shared e-scooter operations. The novel and constantly changing nature of micromobility as a travel mode means its safety profile is currently not understood in detail, and the traditional definitions of vehicles are no longer appropriate for this rapidly evolving group of vehicles.

In this context, this study seeks to understand risk to all road users (especially vulnerable road users (VRUs)). Micromobility is one of many transport modes sharing street space with varying space requirements, travel speeds, and abilities to avoid or withstand collisions. The study has been conducted through a Safe Systems lens, keeping in mind the four key elements in creating a safe system: safe roads and roadsides, safe speeds, safe road use and safe vehicles.

In addition to the risk emphasis in the study wider impacts of micromobility on wellbeing and the ability of the transport system to meet Auckland's needs is also considered.

Actual vs perceived safety

As micromobility is a new and evolving field, the risks that these new modes bring to the transportation system are reasonably unknown. Unfortunately, this means that misperceptions are often formed.

Thus, there are two aspects. The actual safety risk determines the number and severity of injuries that occur, and the perceived safety risk is the subjective experience of risk. It is important to distinguish between the two and make sure that interventions that seek to address injury risk are targeted to reduce actual safety risk. However, there is a role to implement measures that address perceived safety if the objective is to encourage micromobility.

Safe System

AT uses the Safe System approach which targets all elements of road safety for all road users.

The Safe System approach operates on the following guiding principles:

- **People make mistakes**: Road users will continue to make mistakes, and the transport system must accommodate these such that they do not result in deaths and serious injuries.
- **People are vulnerable, and the system should be managed within human biomechanical injury limit**: Our bodies have a limited ability to withstand crash forces without being killed or seriously injured. A Safe System ensures that the forces in collisions do not exceed the limits of human tolerance. Speeds must be managed so that humans are not exposed to impact forces beyond their physical tolerance. System designers and operators need to consider the limits of the human body in designing and maintaining roads, vehicles and speeds.
- **Shared responsibility**: The burden of road safety responsibility no longer rests solely with the individual road user. System managers have a primary responsibility to provide a safe operating environment for road users and ensuring that the system is forgiving when people make mistakes.
- **Strengthening all parts of the system**: All pillars of the road system need to be strengthened so that if one part fails, other parts will protect the people involved from serious harm.

Central to the Safe System approach is human tolerance to crash impacts and the management of kinetic energy transfer so these are within survivable limits. The Safe System approach is based on the following four Safe System pillars:

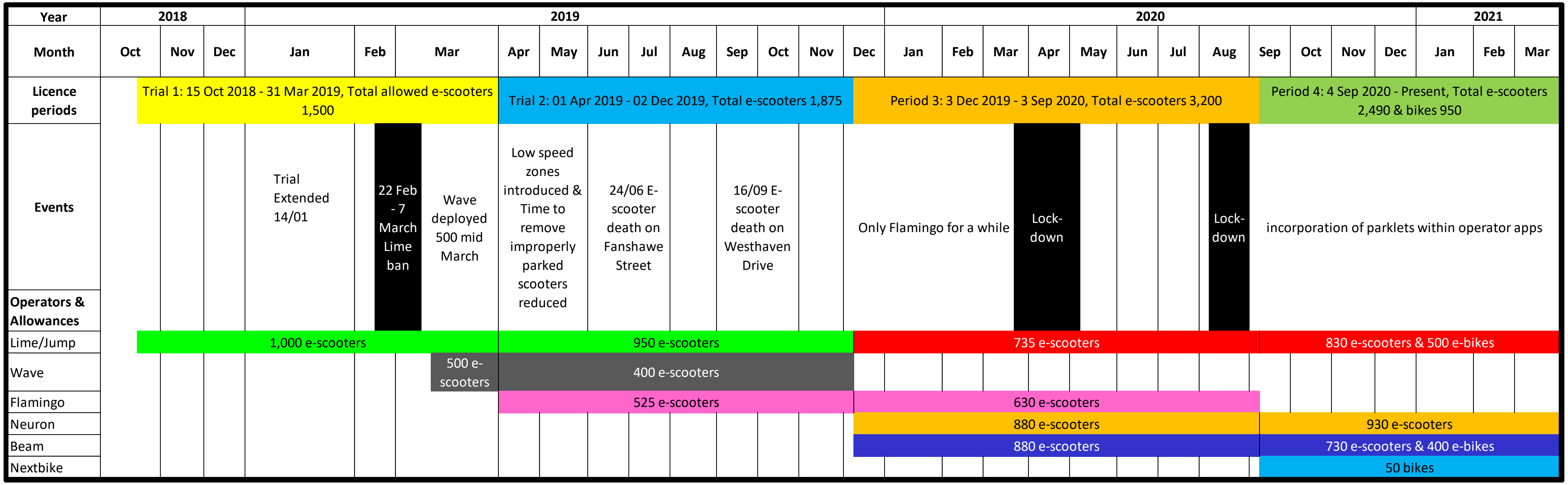
- **Safe Roads** - Roads and roadsides are designed and maintained to reduce the risk of crashes occurring, and to lessen the severity of injury if a crash does occur.
- **Safe Speeds** – speeds are managed to complement the road environment and ensure crash impact forces are within human tolerances.
- **Safe Vehicles** – vehicles lessen the likelihood of a crash and protect occupants and other road users.
- **Safe People** – road users are skilled, competent, alert and unimpaired.

In the context of micromobility, a Safe System means:

- Treating risks of deaths and serious injuries of people in micromobility collisions as preventable incidents that would only occur as a failure in the system rather than an acceptable toll of the road network.
- Acknowledging that some micromobility crashes will occur but that these should not result in either death or serious injury.
- Designing the road network in such a manner that it is forgiving to road user mistakes and there are sufficient redundancies in the system to ensure even if one element fails people are still not killed or seriously injured.
- Focusing on eliminating the possibilities of fatal and serious crashes occurring, instead of on reducing the likelihood of all crashes.
- Designing the road with all road users in mind rather than focusing on just vehicles.
- Utilise evidence-based information to proactively treat risk, rather than simply reactive to crashes that have occurred.

Recent History of Micromobility in Auckland

Figure 2.2 illustrates a timeline of usage of hired micromobility in Auckland which started in October 2018, and key dates and incidents relating to the implementation of micromobility, including fatal incidents, implementation of Lime operator ban due to braking concerns, and dates of COVID lockdowns which affect the usage of rental devices. This timeline helps to give perspective on the severity of incidents over time and their relationships to the rental market environment for micromobility in Auckland.



Year: 2018 (Oct, Nov, Dec) | 2019 (Jan, Feb, Mar, Apr, May, Jun, Jul, Aug, Sep, Oct, Nov, Dec) | 2020 (Jan, Feb, Mar, Apr, May, Jun, Jul, Aug, Sep, Oct, Nov, Dec) | 2021 (Jan, Feb, Mar)

Licence periods
- Trial 1: 15 Oct 2018 - 31 Mar 2019, Total allowed e-scooters 1,500
- Trial 2: 01 Apr 2019 - 02 Dec 2019, Total e-scooters 1,875
- Period 3: 3 Dec 2019 - 3 Sep 2020, Total e-scooters 3,200
- Period 4: 4 Sep 2020 - Present, Total e-scooters 2,490 & bikes 950

Events
- Jan 2019: Trial Extended 14/01
- Feb–Mar 2019: 22 Feb - 7 March Lime ban
- Mar 2019: Wave deployed 500 mid March
- Apr 2019: Low speed zones introduced & Time to remove improperly parked scooters reduced
- Jun 2019: 24/06 E-scooter death on Fanshawe Street
- Sep 2019: 16/09 E-scooter death on Westhaven Drive
- Dec 2019 – Mar 2020: Only Flamingo for a while
- Mar–Apr 2020: Lock-down
- Aug 2020: Lock-down
- Sep 2020 – Mar 2021: incorporation of parklets within operator apps

Operators & Allowances
- Lime/Jump: 1,000 e-scooters (Oct 2018 – Mar 2019); 950 e-scooters (Apr – Dec 2019); 735 e-scooters (Dec 2019 – Sep 2020); 830 e-scooters & 500 e-bikes (Sep 2020 – Mar 2021)
- Wave: 500 e-scooters (Mar 2019); 400 e-scooters (Apr – Dec 2019)
- Flamingo: 525 e-scooters (Apr – Dec 2019); 630 e-scooters (Dec 2019 – Sep 2020)
- Neuron: 880 e-scooters (Dec 2019 – Sep 2020); 930 e-scooters (Sep 2020 – Mar 2021)
- Beam: 880 e-scooters (Dec 2019 – Sep 2020); 730 e-scooters & 400 e-bikes (Sep 2020 – Mar 2021)
- Nextbike: 50 bikes (Sep 2020 – Mar 2021)

Figure 2.2 Recent Timeline of Micromobility in Auckland

2.4 Project Governance

A project steering group was set up comprising representatives from Auckland Transport, Auckland Council, Waka Kotahi, and ACC. The steering group was kept informed throughout the project process through regular steering group meetings with feedback offered as to project scope.

2.5 Research Objectives

This research primarily focuses on the safety of micromobility devices. It focusses on the Auckland region and aims to identify and fill key gaps in existing data through comprehensive research. The research has the following three over-arching objectives which were agreed with the project steering group.

OBJECTIVE 1	OBJECTIVE 2	OBJECTIVE 3
To undertake primary research into the safety of micromobility	To identify treatments suitable for a network application	To confirm an evidence base which will support decisions on accommodating and licensing micromobility

Figure 2.3 Research Objectives

3. Methodology

3.1 Project Process

Figure 3.1 outlines the high level process used throughout this research. While the process steps follow on from one another, some iteration of process and methodology occurred as a result of each stage. This chapter outlines a brief summary of the steps taken throughout the project process including the decision making which led to subsequent steps. Further detail on outputs are provided in subsequent chapters.

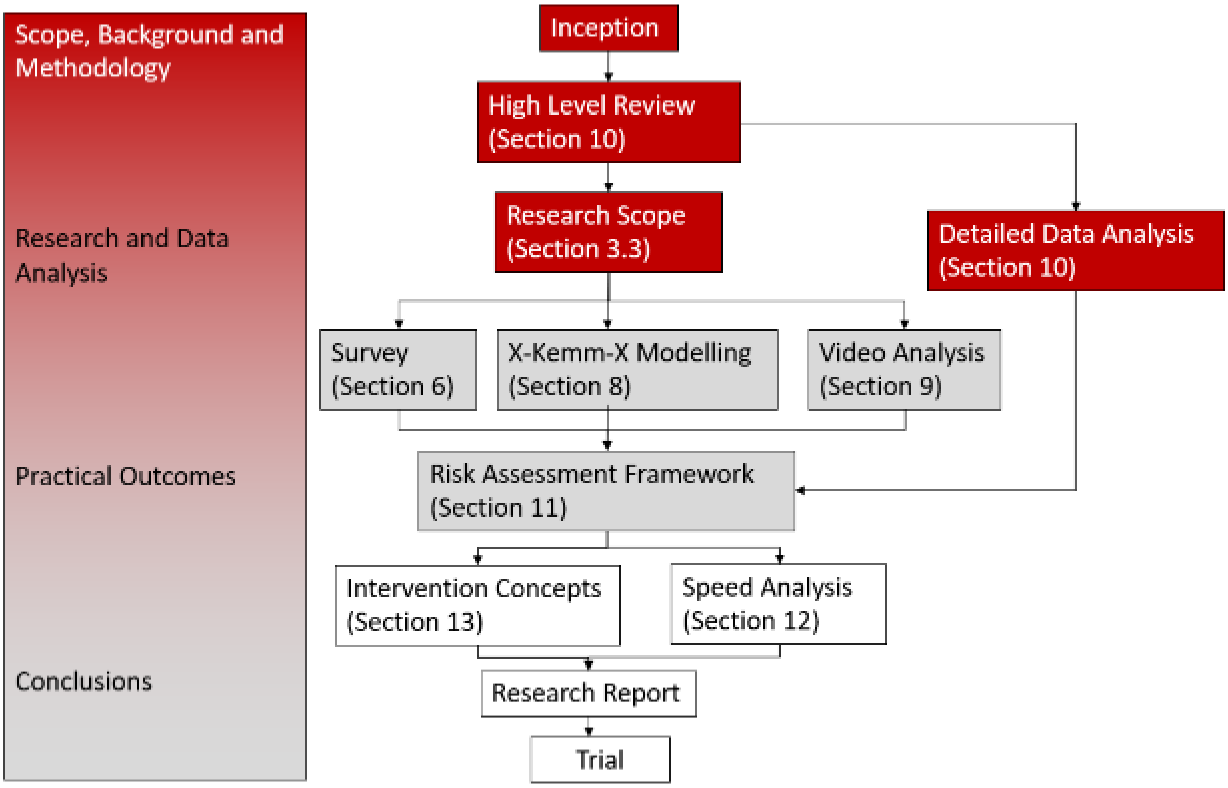


Figure 3.1 Project Process

3.2 High Level Review

The inception involved gathering together the key organisations that were involved with undertaking the study. This involved ACC, Auckland Transport and Auckland Council. In this stage, organisations provided input to direct their areas of interest within the study and indicated material and/or assistance they could provide.

Following the project inception, both a headline data review and literature review were carried out in parallel. This was undertaken to discover what information was already available for the purpose of defining the research scope.

The literature review considered available local, national and international reports and studies around the key areas of:

- Who uses micromobility and why?
- What is the perceived safety of vehicles and infrastructure?
- What are the common injuries that result from micromobility use?
- What are the more severe injuries that can result from micromobility crashes?
- What is the comparison between micromobility crashes and with other modes?

The initial high level data review involved gathering available safety-related data relating to incidents in Auckland and identifying the high level trends which emerged for the initial purpose of defining the scope of this research. The three primary data sources were ACC data, Waka Kotahi CAS data and hospitalisation data. Subsequently more in-depth data was received from ACC and the full data analysis exercise occurred in parallel with the research elements of the study.

The output from the literature review and data review are presented in sections 5 and **Error! Reference source not found.** respectively.

3.3 Research Scoping

An important project stage following the high level review involved determining the scope of the research investigations. **Figure 3.2** shows the research questions development process.

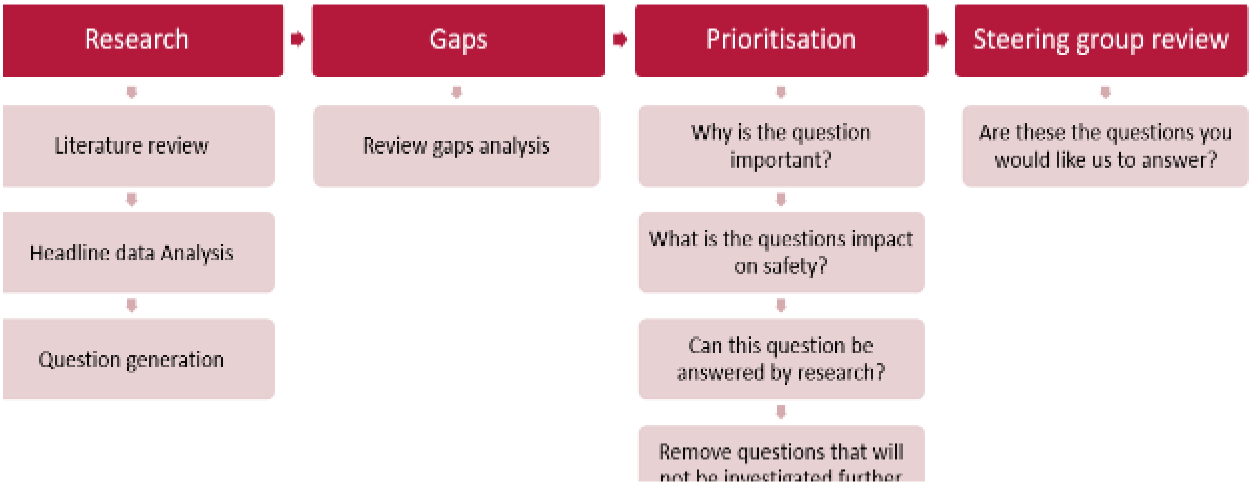
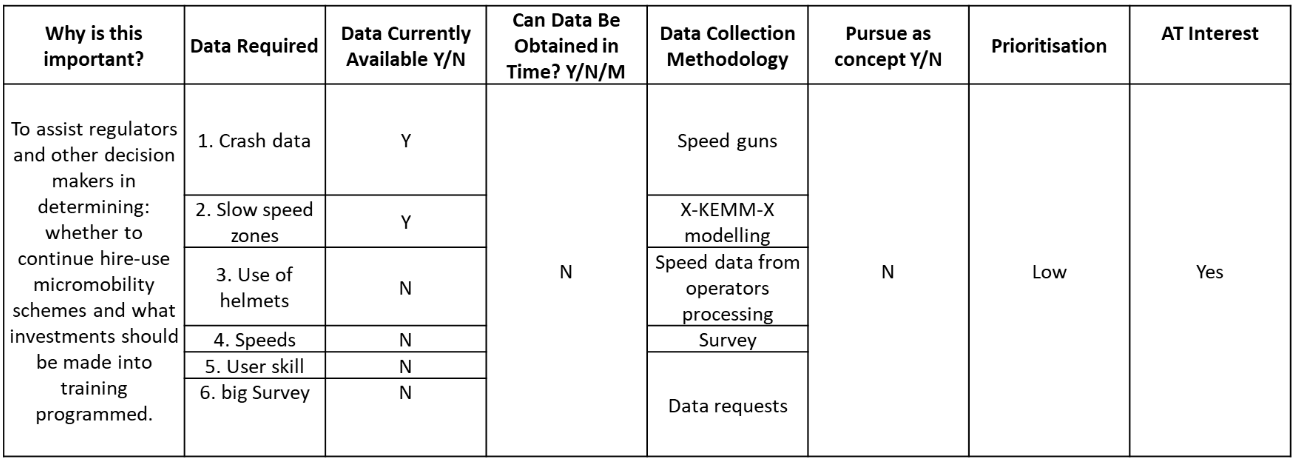


Figure 3.2 Research questions development process

A gap analysis was conducted to determine which areas of micromobility safety had not yet been addressed. Given that micromobility is a relatively new area of research, there are a great deal of potential areas for research. Thus, to ensure that the objectives of the project were achieved, the team iterated down to a number of questions that either were expected to help provide insight into the safety of micromobility modes or target key areas of interest within the field of micromobility.

After the literature review and the headline data analysis were carried out, the research team produced a list of potential research questions. The initial list of possible research questions are provided in Appendix A.

Next, a gap analysis was conducted to determine which of these questions could be answered or partially answered by the existing literature or headline data. This gap analysis can be found in Appendix A. An example of the gap analyses can be seen in **Figure 3.3** below, for the question: “is hired micromobility safer than owned?”. An important part of the gap analysis process included feedback from the project steering group to ensure that the client wished for the research to pursue this focus.



Why is this important?	Data Required	Data Currently Available Y/N	Can Data Be Obtained in Time? Y/N/M	Data Collection Methodology	Pursue as concept Y/N	Prioritisation	AT Interest
To assist regulators and other decision makers in determining: whether to continue hire-use micromobility schemes and what investments should be made into training programmed.	1. Crash data	Y	N	Speed guns	N	Low	Yes
	2. Slow speed zones	Y		X-KEMM-X modelling			
	3. Use of helmets	N		Speed data from operators processing			
	4. Speeds	N		Survey			
	5. User skill	N		Data requests			
	6. big Survey	N					

Figure 3.3 Gap Analysis example: Is hired micromobility safer than owned?

Following the gap analysis stage, a long list of thirteen questions were developed. Some questions were combined to reduce repetition.

These questions then entered the prioritising stage. Each possible question was interrogated with the following sub questions:

- Why is the question important?
- What are the question’s impacts on safety?
- Can this question be answered by research?

Based on answers to these sub-questions the questions were qualitatively analysed and prioritised against each other. The questions that fell to the bottom of the prioritisation were removed. This qualitative analysis can be seen in **Table 3.1**.

Table 3.1 Research Question Decision Making Matrix

Question Theme	Covered by Literature review or Data analysis	Why is this question important?	Does the question have an impact on safety?	Likelihood question can be answered by research?	Rank	Will it be investigated further?	Reason behind ranking and inclusion
How significant is skill level in crash results?	Partially	Influence investment in training	Yes	High	1	Yes	Likely to achieve and will likely lead to safety benefits
What are the effects of current guidance and operations on safety?	Partially	Overarching safety question	Yes	High	2	Yes	Likely to achieve and will likely lead to safety benefits
What are the infrastructure geometry or design requirements for micromobility?	No	Influence funding allocation, future street design and regulations	Yes	Medium	3	Yes	Likely to achieve and will likely lead to safety benefits
What is the impact of facility condition and maintenance on risk?	No	Influence funding allocation, future street design and maintenance	Yes	Medium	4	Yes	Possible to achieve and will likely lead to safety benefits
How does the risk of different micromobility modes compare with other activities?	No	Influence funding allocation, future design and regulations	Yes	Medium	5	Yes	Possible to achieve and will likely lead to safety benefits

What is a safe speed environment for micromobility modes?	No	Influence vehicle speed restrictions	Yes	Medium	6	Yes	Possible to achieve and will likely lead to safety benefits
What are the effects on non-user safety?	No	Influence funding allocation, future street design and regulations	Yes	Medium	7	Yes	Possible to achieve and will likely lead to safety benefits
How does perception relate to a real safety concern?	Partially	Informative for decision makers and public	Partially	Medium	8	Yes	Possible to achieve and will help deepen understanding of micromobility's impact on other modes
How does hired vs owned micromobility safety relate?	Partially	Influence allocation and regulations	Yes	Low	9	Maybe	Limited data: (ACC data not telling us if it is hired or owned: reliant on survey declarations)
Is micromobility replacing short car trips, walking or cycling trips?	Yes	Understanding the benefits/ cost of micromobility	Partially	High	n/a	No	Sufficient research exists at this stage
What is the effect of helmets on safety?	Yes	Influence regulations	Yes	n/a	n/a	No	Covered in literature review
What are the emissions of micromobility?	No	Influence decision made around emission generation	No	Low	n/a	No	No safety benefit – out of scope
What is the impact of pricing mechanisms on safety?	Yes	Influence pricing mechanism and potentially safety	Yes	n/a	n/a	No	Covered in literature review

The final research questions for investigation are therefore as follows:

1) • How significant is skill level in crash results?
2) • What are the effects of current guidance and operations on safety?
3) • What are the infrastructure geometry or design requirements for micromobility?
4) • What is the impact of facility condition and maintenance on risk?
5) • How does the risk of different micromobility modes compare with other activities?
6) • What is a safe speed environment for micromobility modes?
7) • What are the effects on non-user safety?
8) • How does perception relate to a real safety concern?
9) • How does hired vs owned micromobility safety relate?

3.4 Primary Research

Three components made up the primary research. The outputs from the research are discussed in Section 3 of this report.

Survey

A survey was designed aiming to determine revealed data in relation to actual crashes or near misses occurring in the Auckland region involving micromobility. The design process for the survey is described in Chapter 6. Interest groups were also consulted as part of this exercise, and feedback from these groups is provided in Chapter 7.

X-Kemm-X Modelling

Monash University were commissioned to provide advice as to the risk of injury as a result of crashes involving micromobility. Their output is summarised in Chapter 8.

Video Analysis

Auckland Transport have access to fixed traffic cameras which can be used for analysis. A series of locations were selected and the videos analysed over a set time period to determine key underlying statistics. This output is summarised in Chapter 9.

3.5 Detailed Data Analysis

The detailed data analysis looked at ACC data, hospitalisation data and Waka Kotahi Crash Analysis System (CAS) data. To obtain this data the relevant organisations were contacted, informed of the research and the types of data of interest to the study and asked to provide data. Data requests were broad to capture a multitude of transportation modes and activities, both within and outside of micromobility (so comparisons could be made).

ACC data was found to be very useful as it included all crashes related to micromobility modes and could be broken down into a range of different modes. It did not however include the geographical location of where the crashes occurred and held only aggregated information where the exact circumstances around a particular crash could not be determined. Unfortunately, in some cases the data only allowed reporting by year, but not by month, which limited the level of detail of our analysis.

CAS data on the other hand, included the geographical location and allowed for the exact circumstances around a particular crash to be drilled into further. However, the disadvantage of the CAS data was that it only included crashes where a traditional road vehicle (involving: cars, trucks, vans, motorbikes, mopeds, buses and other similar vehicles) have been involved and excludes crashes that do not involve these modes. This means, for example, that crashes involving only a micromobility mode and an inanimate object are excluded, as are crashes between micromobility modes and a pedestrian. Though only including these traditional crashes where a road vehicle is involved eliminates many micromobility crashes, the CAS data is still useful as the literature review indicates that a high percentage of very serious micromobility crashes involve vehicles.

3.6 Risk Assessment Framework

The combined output from the primary research and data analysis allowed for the development of the risk assessment framework which is described fully in Section 11.

3.7 Intervention Concepts

Auckland Transport, Auckland Council, Panuku, Kāinga Ora and local boards are working together on Innovating Streets projects which engage the community with practical implementation of pilot streetscape layouts. An initial concept was that one or more of the projects involved in Tranche 2 of the Innovating Streets programme could be used for a practical analysis of micromobility -focused intervention. The best candidate was Project Wave, a project providing cycling infrastructure close to Auckland Waterfront. The team investigated gathering before and after micromobility data from this project, but it was delayed due to COVID lockdowns in early 2021 and the America's Cup which meant the timing was not ideal.

Following output from the research exercises, and feedback from the steering group, it was determined that speed of micromobility was likely to be a key factor in injuries, but that there is limited information relating to the actual speeds achieved by micromobility devices in different locations. Therefore, as an intervention, practical speed surveys have been undertaken.

The research has also indicated that infrastructure can be an important risk factor. Therefore, two potential locations for a trial intervention, likely to take the form of a tactical urbanism trial have been identified which would facilitate providing additional space for micromobility users and/or pedestrians. High level sketch interventions have been created and are provided in Chapter 3.7.

4. Research Context

4.1 Data Limitations

Accident Data

It is known that crashes, particularly non-injury crashes, are under-reported. All of the data sources investigated in this survey have their limitations. For example, it is generally accepted that 63% of crashes are underreported. In addition, the CAS database has traditionally only reported incidents involving collisions with motor vehicles without the ability to specifically identify micromobility. Recently a check box has been made available for micromobility as a specific mode within CAS which will in future highlight micromobility as a specific mode. For our data, a word search has been undertaken to identify any instances of micromobility being recorded in CAS.

ACC claims are only made if an injury is reported to medical staff, and the data reported to ACC and/or recorded at hospitals is dependent on reporting of the incident. If the correct mode of transport is not named in the ACC or hospitalisation report, then this analysis would not have identified that it was micromobility related.

Micromobility Operator Data

Micromobility Operator Data (the recorded information that Micromobility Operator in Auckland provide to Auckland Transport) could not be used for the research. Due to concerns regarding the sensitivity of Micromobility Operator Data, the data that was provided by Auckland Transport was received too late for the research, and in a format that was not usable.

Micromobility Usage Data

Cordon counts have been taken at 14 locations sites across Auckland during peak times, recording movement into the city. The sites each carry multi-modal transport and the modal split has been calculated as an average across all sites based on November 2020 data showing 1% of vehicles crossing cordons into the city were scooters. The full cordon count data is provided in Appendix B, and an overall summary of the modal split provided below in **Table 4.1**. In total an average of 209 scooters were recorded between 6-9am entering the cordon area.

Table 4.1 Cordon Modal Split

Pedestrians	**10%**
Cyclists	4%
Scooters	1%
HCV	3%
Other Vehicles	83%

This usage excludes travel within the city centre cordon area, and any off-peak travel but indicates a consistent usage of E-scooters as a commuting mode. The breakdown of E-bikes amongst the cyclists is unclear.

4.2 Relationship Between Existing and Research Data

In undertaking this research, the team is cognisant of the relationship between sampled data and the general population. In common with the ACC, CAS and hospitalisation data, research data also samples only a proportion of the micromobility-using population. While our survey focusses on accidents and incidents involving micromobility, the relationship between the total population using micromobility is still unknown. Kantar (2019) indicated that approximately ¼ of Auckland residents had used e-scooters, however, regular users are likely to be significantly lower. This means that while the indicators for accidents can be provided through this survey, surveys do not provide a definitive answer as to how common micromobility crashes are as a proportion of the (unknown) proportion of overall users.

Large surveys do however, provide useful insight into proportions of users involved in incidents. **Figure 4.1** below illustrates the targeted groups in the survey.

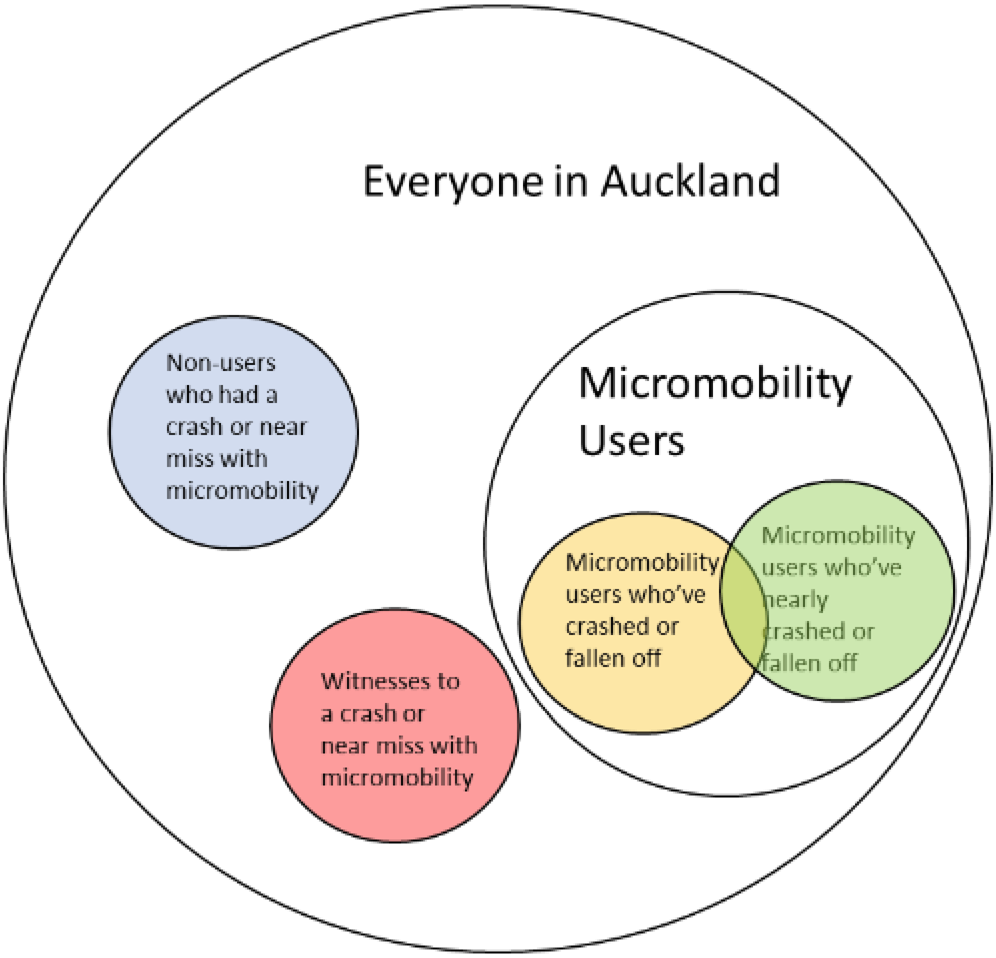


Figure 4.1 Targeted Groups - Survey

SECTION 2: RESEARCH AND DATA ANALYSIS

5. Literature Review

This literature review considers information available locally to Auckland, nationally and internationally. It includes academic publications, reports, and policy documents from city administrations or various institutes. The purpose of the literature review was to take stock of existing micromobility safety research and evidence gaps. Its findings guided the setting of research questions for our study.

The micromobility trend is global, although New Zealand started experiencing it later compared to other countries such as the US and China. Non-powered bicycles and scooters have long been part of the transport mix, and patents for the first e-bikes were registered in the late 19th century. Docked bikesharing systems such as Velib (Paris) or Barclays bikes (London) started appearing from the mid 2000' and paved the way for the dockless operation of shared e-scooter and e-bike schemes which first became mainstream in China and appeared in western cities from 2016/17. Therefore, there is much to learn from the larger and often more mature overseas markets. At the same time, available literature on the experience with micromobility in other NZ urban centres can help shed light on NZ-specific trends and challenges.

Limitations:

- It should be noted that micromobility being a relatively new transportation trend, usage patterns, vehicles, and operational modes are quickly evolving. This means that findings from the early days of mass micromobility (e.g. 2017) may be less relevant in 2021, hence a need for caution in transferring lessons from even the recent past. Local regulatory and transport contexts also vary greatly, however many findings are consistent across the literature, suggesting they may apply in Auckland too.

- Most of the existing literature relates to e-scooters, therefore findings mostly apply to this specific micromobility mode. Specific evidence on other micromobility modes has been researched and was included where available.

To assist with this study's specific scope, the literature review focused on characteristics of observed and studied safety risks. We start with a short summary of findings on rider profiles and attitudes (since it matters in risk), then review the epidemiology (types and frequencies of injuries) and draw out common risk factors identified in the literature.

5.1 Who uses micromobility and why?

While researching users is not strictly within the scope of this study, understanding them can help target safety interventions. This section relies exclusively on surveys of users across various geographical areas (Paris, Portland OR, Tempe AZ, Christchurch NZ, Vienna, Brisbane, Auckland, Germany, France). Methodologies used included online surveys, intercept surveys, and observational surveys (counts). Most focused on e-scooters. For a broader literature review please refer to the recent Waka Kotahi Research Report 674 “Mode Shift to Micromobility” (Ensor et al., 2021).

Typical users

The typical e-scooter rider is male and a young adult (6t, 2019; Christoforou et al., 2020; Haworth and Schramm, 2019; Kantar, 2019; Laa and Leth, 2020; Nunatak, 2020; Sanders et al., 2020, 2020). A survey in five major German cities found that young adults are also the most likely to have tried e-scooters, however older respondents who have tried e-scooters are about as likely to ride regularly as younger respondents who have tried (Nunatak, 2020). There is some level of underage riding despite it being forbidden across all locations with varying age tresholds. A Brisbane study found 11% of observed e-scooter riders to be under 18 years old compared to 2% bikeshare riders (Haworth and Schramm, 2019). Local regulations require adolescents between 12 and 16 to be supervised by an adult when riding an e-scooter.

A majority of riders have higher education qualifications, and students as well as white collar workers in managerial positions with high incomes are overrepresented (6t, 2019; Christoforou et al., 2020; Fitt and Curl, 2019; Laa and Leth, 2020). Evidence from Paris where car ownership is already low suggests that e-scooter riders do not necessarily have lower rates of car ownership than the general population (Christoforou et al., 2020).

Motivations

For first time and occasional users, the main motivation is to have fun and this aspect of playfulness and enjoyment still seems to play a role in the overall ridership, including frequent riders (6t, 2019; Christoforou et al., 2020; Fitt and Curl, 2019; Kantar, 2019). When asking all types of riders, most studies identify speed or travel time savings as a major motivation for riding e-scooters. A range of 57% to over 80% of respondents cite this factor as a motivation (6t, 2019; Christoforou et al., 2020; Fitt and Curl, 2019; Sanders et al., 2020; Smart Mobility Lab, 2020).

Finally, convenience or practical advantages are often cited by users including the fact that using an e-scooter is more comfortable than walking in hot weather (Sanders et al., 2020) or that shared e-scooter can be combined with Public Transport and/or Ridesharing which can cover the return trip for example (Kantar, 2019).

Trip characteristics

Trip length is not covered in the literature review as it varies depending on the location.

The literature suggests that trip destinations and trip purposes vary according to two main factors: whether riders are occasional or frequent and whether they own or hire the vehicle they ride. In many cases owners are likely to be frequent riders and users of shared micromobility more likely to be casual users, however there are regular users of shared e-scooters too so the two factors do not always align. Occasional riders are more likely to use e-scooters to access recreational trips (Kantar, 2019) and in some cases the ride itself is the recreational activity (Sanders et al., 2020). These occasional users are more likely to use shared micromobility than to own the vehicles, and ride more in the afternoon or evening whereas owners ride throughout the day (Smart Mobility Lab, 2020). There can be a social element to riding shared e-scooters as 36% of trips recorded in a French survey of 4,382 respondents involved another rider either on the same vehicle or on another one (6t, 2019). Regular users and owner riders are more likely to use micromobility for accessing work or education (Kantar, 2019; Smart Mobility Lab, 2020).

Trip replacement

Almost all reviewed studies found walking to be the mode most often replaced by e-scooter riding, including in Auckland (6t, 2019; Christoforou et al., 2020; Fitt and Curl, 2019; Kantar, 2019; Laa and Leth, 2020; PBOT, 2019; Sanders et al., 2020). The following Figure (**Figure 5.1**) shows there is a certain amount of consistency in trip replacement patterns between North American cities:

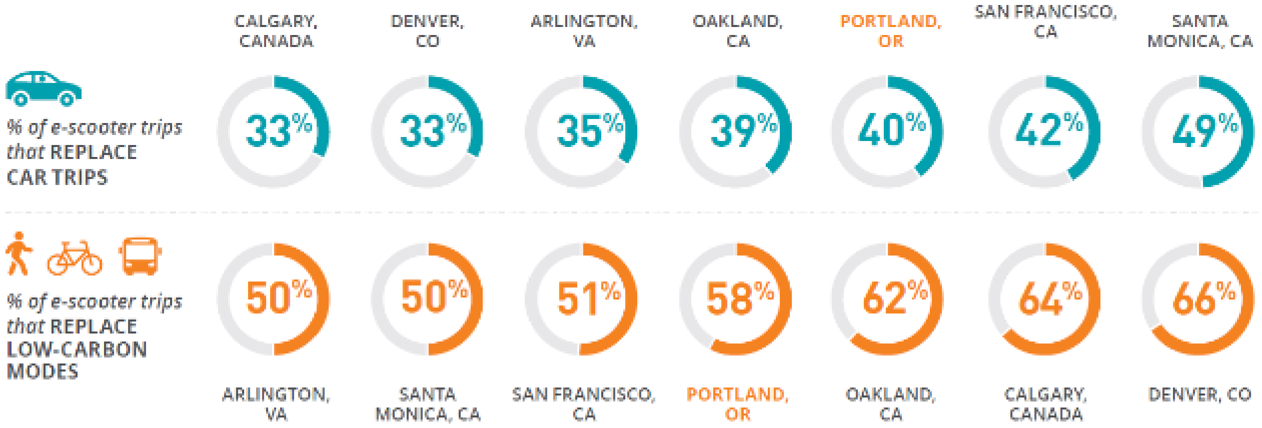


Figure 5.1 Modes replaced by e-scooter trips in North American cities (Source: Portland Bureau of Transportation, 2019)

Comparing North American data to European data reveals differentiated patterns: replacement of private car trips is markedly lower in European cities where public transport is often the second mode most replaced (e.g. Paris and Vienna). In a survey of residents of five major German cities, public transport was the first mode being replaced and walking second (Nunatak, 2020). To the contrary, use or private cars or taxi services is likely to be the second most replaced mode after walking in North American cities, with one case (Arlington, VA next to Washington DC) where using Uber, Lyft, or a taxi was the first mode replaced (James et al., 2019; PBOT, 2018; Sanders et al., 2020). In NZ, a Christchurch survey found 28% of e-scooter trips replaced a car-based (private car, shared car, taxi service) or motorcycle trip, behind active modes (57%) (Fitt and Curl, 2019). In Auckland, the modes being most replaced after walking were also car or motorcycle-based modes (taxi services incl. Uber, driving alone or with a passenger) at 21% of e-scooter trips (Kantar, 2019).

These observed trip replacement patterns in various cities suggest that the second most replaced types of modes after walking may vary with the public transport provision and level of car dominance in the local transport system. This would explain the stark difference between North American and European cities and why patterns in NZ cities are closer to those found in North American cities. There are also differences between users of shared micromobility and owner riders, the latter being more likely to have replaced car driving in Christchurch (Fitt and Curl, 2019).

Multimodality

Trip replacement data seems to hide complex patterns of multimodality. 23% of shared e-scooter users surveyed in France had combined their latest e-scooter ride with another mode (66% of the time they combined with public transport), and 44% of trips were one-way only, suggesting they used another mode to get to their destination or back (6t, 2019). In Vienna, 80% of a small sample of e-scooter owners sometimes of often took their e-scooter on-board public transport (Laa and Leth, 2020). In Christchurch, half of respondents who had ridden an e-scooter only used it for part of their journey, mostly combining with walking (75%) but also car-based modes and public transport (Fitt and Curl, 2019). In Auckland, one in five users said they currently rode shared e-scooters to and from public transport stations (Kantar, 2019).

For further detail on trip characteristics and trip replacement patterns, the recently published Waka Kotahi Research Report 674 “Mode Shift to Micromobility” has an in-depth literature review (Ensor et al., 2021).

5.2 Perceived Safety and Preferences

Experience of Incidents

Few studies have looked at rider and non-rider experiences of crashes or near-misses. This is why our primary research includes an Auckland wide survey to dig deeper into these experiences (see Section 6). A previous survey in Auckland found that one in two respondents claim to have experienced a safety issue with rental e-scooters (mainly as pedestrians but also as cyclists or motorists). 4% of pedestrians reported having been hit or collided with a rental e-scooter (either moving or non-moving) and 23% had had a near miss. 8% of motorists reported they had had a near miss with an e-scooter (Kantar, 2019).

A 2020 France-wide survey commissioned by the insurance industry looked at all forms of micromobility including e-bikes and gathered 5,014 responses. 23% of owner-riders reported having been involved in a micromobility related fall or crash against 13% of shared micromobility users. Out of crashes respondents had witnessed or experienced, 50% thought that the micromobility rider was responsible for the crash and 68% considered the cause of the accident to be a broken traffic rule by one party, with excessive speed (40%) and footpath riding (30%) being the most frequent reported infringements. In 35% of these crashes, micromobility riders collided with pedestrians, and in 18% of cases they collided with cars (Smart Mobility Lab, 2020).

Feeling of Safety

Safety is the main barrier to trying an e-scooter (Fitt and Curl, 2019; Kantar, 2019) and it remains a concern for many riders including other types of micromobility. 50% of micromobility users (all types of vehicles) responding to the French insurance industry survey agreed that micromobility is a dangerous travel mode (Smart Mobility Lab, 2020). Respondents also were asked to rate their feeling of safety out of 10 when using various transport modes: micromobility was rated the lowest on average (6.3 by owner riders and 6.5 by shared micromobility users) compared to 7.1 for walking or riding a motorcycle. This means respondents felt less safe riding a micromobility vehicle than walking or riding a motorcycle.

In a survey of 1,250 Tempe (Arizona) University staff, not all of whom used micromobility, just under 65% of current and past riders reported feeling ‘somewhat’ or ‘very’ safe while riding an e-scooter. More frequent riders were more likely to feel ‘very’ safe. Safety concerns related to hitting someone while riding or getting hit by riders (Sanders et al., 2020). The same study found differences in reported barriers between men and women: men were more likely to cite barriers related to equipment (e.g. vehicles being in good condition) while women were more likely to cite safety barriers related to worries about hitting or being hit by others, falling, and losing control. Additionally, men were more likely to find scooting “very safe”. These gender characteristics align with past research on barriers to cycling.

The literature confirms the general worry of pedestrians when around e-scooters or other forms of micromobility. In the Auckland survey carried out when the first shared e-scooter operations had just been introduced to the city (late 2018), 69% of pedestrians thought the speed of e-scooters was ‘a bit’ or ‘very’ unsafe[1] and three in five respondents felt at least a bit unsafe when sharing footpaths with e-scooters (Kantar, 2019). Getting hit because of poor rider behaviour (e.g. riding too fast or too close) was the main concern, and the elderly or people with disability felt particularly at risk. **Figure 5.2** illustrates the difference in perceptions between users and non-users.

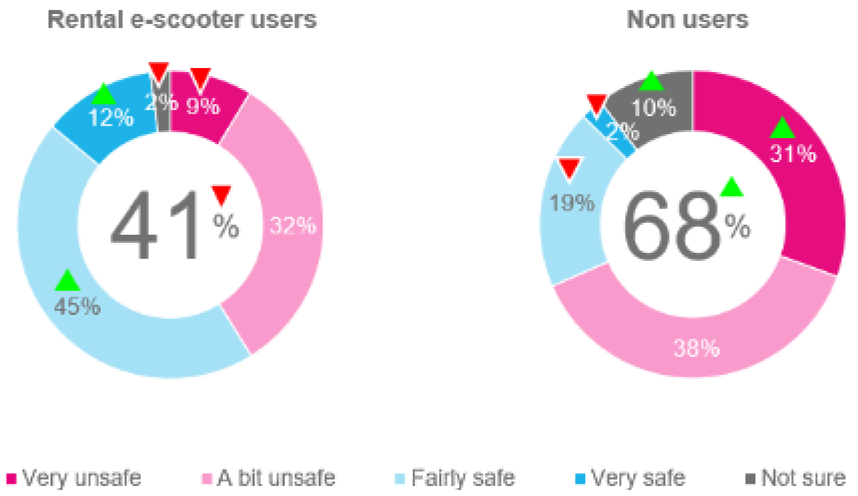


Figure 5.2 Safety perceptions when walking on shared footpaths and other pedestrian areas with e-scooters (% of respondents) (Source: (Kantar, 2019))

2019 evidence from a district in the Washington DC urban area shed light on how perceived safety around dockless e-scooters compares to other forms of micromobility: respondents felt significantly less comfortable around dockless e-scooter riders (56% feeling unsafe or very unsafe around them) than dockless ebikes (29%) or other bikes (docked bikeshare or rider owned, 11%) (James et al., 2019). A similar pattern applied when driving: 67% felt uncomfortable or very uncomfortable driving around dockless e-scooter riders compared to 21% around dockless bike riders. In all situations the study found a clear difference in attitudes between respondents who had ridden an e-scooter before and those who had not. The former group was significantly less concerned than the latter, in line with the Auckland findings.

Parking

Parking of micromobility vehicles, especially shared e-scooters, is another aspect of pedestrian safety. While micromobility riders can collide with pedestrians, pedestrians can also trip on parked micromobility devices and hurt themselves. For VRUs or pedestrians with disability, avoiding parked e-scooters or e-bikes can come with physical challenges (e.g. effort required) and new risks (e.g. stepping onto the road where the footpath is obstructed). One in four respondents to the Auckland 2018 survey claimed to experience poorly parked scooters on a weekly basis. Concerns expressed by pedestrians have led several US transport authorities and researchers to undertake counts and field assessments of parked micromobility vehicles. Methodologies vary but they generally consist of counting infringements to local parking rules (and operator terms of service for dockless shared vehicles), the number of vehicles impeding pedestrian movement, and the number of vehicles found lying on the ground (i.e. not upright). The below table provides an objective view on micromobility parking patterns in a selection of US cities.

Table 5.1 Results of micromobility vehicle parking surveys

	% of devices parked properly (as per local rules or guidelines)	% of devices partially or fully blocking pedestrian movement	% of devices impeding disability access	% of devices not upright
Portland (e-scooters only)	72.8	13.4	2.8	Unavailable

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[1] Note: the low speed zones and speed caps in place in 2021 had not been introduced as of late 2018 yet, so e-scooter riders were able to travel at speeds up to 30km/h on flat ground, with no restrictions in high volume pedestrian areas.

(PBOT, 2018)				
Seattle (dockless bikes only) (SDOT, 2018)	70	4	Unavailable	Unavailable
San Jose, CA (e-scooters only) (Fang et al., 2018)	90	2	Less than 2%	3
Arlington, VA (e-scooters only) (James et al., 2019)	84	6	Unavailable	4.5
Bikes and scooters in 5 US cities: Austin TX; Portland OR; San Francisco CA; Santa Monica CA; Washington DC. (Brown et al., 2020)	99.2	0.9	Unavailable	1.3

While local definitions of what constitutes improper parking vary, the US literature is unanimous on the finding that the vast majority of micromobility devices are parked properly, and only a small proportion of devices are impeding pedestrian access or lying on the ground in a non-upright position (the position in which they would take up the most space and represent an increased trip hazard).

Brown et al. (2020) went further than previous studies and compared parking of micromobility vehicles to parking of motor vehicles as well as footpath objects and furniture (e.g. sandwich boards). They found that footpath objects were more likely to impede pedestrian movement and that rates of motor vehicle infringing on local parking rules were significantly higher than the rates of micromobility vehicles infringing local parking rules in the same surveyed areas. These infringements were also more likely to impede pedestrian movement than micromobility parking violations. Therefore, they “hypothesize that cognitive biases could lead many to overestimate the prevalence of parking violations among micromobility vehicles and underestimate violations among motor vehicles” (Brown et al., 2020). According to their findings, 36.8% of micromobility vehicles were parked at or in dedicated bike/scooter parking, showing that riders do notice and use the provided facilities. This suggests that providing appropriate parking facilities can further reduce rates of non-compliance and footpath obstructions and this theory has empirical backing: rates of dockless bike parking violations dropped sharply in Seattle in 2019 after the city added 1,000 cycle parking spaces.

Infrastructure Preferences

Several studies have looked at the types of infrastructure micromobility riders prefer to use and there is near consensus despite different local regulations (e.g. footpath riding bans overseas and cycle lane bans for e-scooters in NZ). Users surveyed in France and the US overwhelmingly cited cycleways (incl. cycle lanes or protected/off-road cycle paths) as their favourite place to ride (6t, 2019; Bird, 2019; PBOT, 2018). Christchurch users also considered cycleways, shared paths and quiet streets the most suitable environments for e-scooter use (Fitt and Curl, 2019).

Footpath bans for micromobility have been instituted in a number of locations around the world. Gössling (2020) suggests that the availability of infrastructure (eg cycling infrastructure) to accommodate micromobility in some cities could mean there is no need for micromobility to use footpaths which could be the reason for a ban on footpath use.

Footpath riding can be considered dangerous by riders because of conflicts with pedestrians and data suggests it is only used when there is no better option (6t, 2019; PBOT, 2018). Many cities or states have banned micromobility on footpaths. However, even in Christchurch where footpath riding is legal and riding in cycle lanes is forbidden, only 51% of users thought that the footpath is an appropriate environment to ride (Fitt and Curl, 2019). In Portland, where footpath riding is illegal, the practice varied in relation to posted speed limits on roads. Where the speed limit was 20 mph (32km/h), 18 percent of riders used the sidewalk. Where the posted speed limit was 30 mph (48km/h) or higher, more than half of riders rode on the footpath (PBOT, 2018). Auckland is an outlier when it comes to footpath riding as 51% of users prefer to ride on footpaths compared to 38% in separated cycle lanes and 37% on shared paths (Kantar, 2019). Comparing the city's local transport context to its counterparts leads to the hypothesis that both a lack of cycling infrastructure and the car dominance (including high speed and volumes) on Auckland's roads mean footpaths are the only consistently available type of infrastructure where users feel safe. The Kantar survey predates Auckland Transport's city centre speed reduction programme which was announced in October 2019.

Finally, riding on the road seems to be mostly reserved to experienced and confident riders. It is more likely among riders who own their vehicle (80% of them use the roads for part of their trips) than among shared micromobility users (23%) (Smart Mobility Lab, 2020). This finding is intuitive as owner riders are more likely to be frequent riders who have built up confidence in their skills. They may also be using faster micromobility vehicles whereas shared micromobility is almost systematically speed capped around the world.

5.3 Epidemiology of micromobility crashes

Not all micromobility crashes are reported nor recorded and it is likely that some injury crashes are not recorded if victims consider the injuries too minor to warrant medical attention. For injuries that do get recorded through medical institutions, there could be a bias towards higher severity and only limited historical data is available since most micromobility modes have only really been introduced in mass since 2018. The focus has mostly been on e-scooters due to their mass adoption and only limited data is available on injuries from other micromobility modes (apart from cycling). Also, the types of vehicles and people's experience with them are likely evolving quickly, hence the need for more micromobility safety studies.

Colliding mode of injury crashes

The most common type of e-scooter crash identified in the literature consists of riders falling or colliding with a non-moving object on their own (Harmon, US, 2020). This can represent over 90% of crashes (Brownson et al., Auckland, 2019; Trivedi et al., California, 2019). These falls result from skidding, braking, swerving, or hitting a kerb, pothole, or street furniture. A large proportion of crashes happen on the footpath (range of 44-58%) including where footpath riding is prohibited (Badeau et al., Utah, 2019; Cicchino et al., Washington DC, 2021; Harmon, US, 2020). Whether crashes happen on the road or on the footpath, most of them occur at intersections (range of 70-80%) (Cherry et al., Tennessee, 2020; Cicchino et al., Washington DC 2021), and this applies to bicycle as well as e-scooter riders.

Collisions with motor vehicles are likely to be overrepresented in hospital data since their severity is likely higher (80% of the first 24 e-scooter deaths in the US involved motor vehicles (Harmon, 2020)). Conversely, crashes that do not involve motor vehicles may be less severe and may not result in hospital care. 2018 Portland data counted 13.6% of e-scooter injury crashes involving cars or trucks and 1.7% involving pedestrians (PBOT, 2018). An Auckland study found only 2.8% of e-scooter injuries treated at Auckland City Hospital had a car as "mechanism of injury" and 0.6% had "pedestrian" (Brownson et al., 2019). The literature indicates that riders injured riding on the road are mostly male and experienced (Cicchino et al., 2021). This is in line with findings summarised in previous sections suggesting confident riders ride more often on the road and do so faster. As a result, if crashes do occur to them, these are more likely to involve a motor vehicle and result in high speed impacts. The converse to this finding would be that riders who lack experience or confidence (who we know are less likely to ride on the road) are more likely to crash on their own and on the footpath. Available data uses the footpath as a general location (mostly to differentiate from crashes that occur on the road) and does not allow identifying specific areas of the footpath.

Little data is available on pedestrians getting injured by micromobility riders due to small sample sizes, however this in itself may suggest that pedestrians rarely get injuries from micromobility riders that require medical attention. For example, a study of injuries treated at two southern Californian medical centres over the course of a year found that 8.4% of victims of crashes involving e-scooters were non-riders (Trivedi et al., 2019). This data is based on 21 individuals only (11 were hit by an e-scooter, 5 tripped over a parked scooter, and 5 were attempting to lift or carry a scooter not in use).

Common injuries

The proportion of soft tissue injuries varies between studies (range of 27.7% to 65.6%) and likely depends on the categorisation used and areas of focus (Badeau et al., 2019; Brownson et al., 2019; Trivedi et al., 2019). The more remarkable trends are the high proportions of head & face injuries and the proportion of fractures & dislocations found in the medical literature. The following table summarises findings in these two areas.

Table 5.2 Common Injuries from Literature

Location & Study	Head & Face Injuries (% of presenting patients)	Fractures & Dislocations (% of presenting patients)
Austin, TX (APH, 2019) (E-scooters)	48% had head injuries 15% had traumatic brain injuries	35% had bone fractures (excluding nose/fingers/toes)
Auckland (Brownson et al., 2019) (E-scooters)	17.2% had head/neck injuries 10.6% had face injuries	41.7% had fractures
US-wide (DiMaggio et al., 2020) Based on consumer data between 2000 and 2017 (mostly before shared e-scooters). E-scooters and ebikes.	3% of e-scooter injuries involved head injuries 0.5% of e-bike injuries involved head injuries	Unavailable
Southern California (Trivedi et al., 2019) (E-scooters)	40.2% had head injuries	31.7% had fractures
Salt Lake City, UT (Badeau et al., 2019) (E-scooters)	8% had major head injury and 36% minor head injury	36% had major musculoskeletal injury (fractures and disclocations) and 34% minor.
US-wide (Aizpuru et al., 2019) (E-scooters)	27.6% had head injuries	23.9% had fractures or dislocations

As summarised in the table, most studies find that 25% to 50% of presenting patients have injuries to the head, neck, or face. The Di Maggio study which does not fit this range is based on consumer data between 2000 and 2017, so mostly before shared e-scooters became a reality in US cities. Its much lower numbers of head injuries compared to other studies using more recent data suggest there could be something about shared e-scooters and their use that makes head injuries more common than in previous e-scooter uses. Alternatively the low incidence of head injuries could also stem from insufficient data since e-scooters were rare prior to 2017.

Several studies have noted the high rates of head injuries and offered explanations. A study focussed on craniofacial trauma from e-scooter crashes found that injuries to the head, neck and face were concentrated in the midface (Faraji et al., 2020). Combined with a relatively high incidence of arms and hands injuries found in other studies (APH, 2019; Cicchino et al., 2021), this pattern is a strong indication that forward falls are frequent.

The forward fall mechanism has been attributed to the high centre of gravity from the rider’s standing position (Tice, 2019). This effect possibly compounds with the small wheel sizes that make kerbs and potholes more challenging compared to bicycle wheels and mean the front wheel could get stuck causing the rider to tip over the handlebar. Implications for helmet design and helmet use are unclear as typical helmets do not protect the face but can reduce head trauma.

Noticeable differences between e-bike and e-scooter crashes based on the US consumer product safety dataset are that ebike injuries less often involve head injuries but are more likely to involve internal injuries than e-scooter injuries. This could relate to the fragility of older riders as persons injured using e-bikes have become noticeably older over the 2000-2017 time period (DiMaggio et al., 2020).

Severity

In the available medical literature, most (84-94%) patients presenting to emergency department get discharged home without getting admitted to hospital (Badeau et al., 2019; Cicchino et al., 2021; Trivedi et al., 2019). Rates of severe injuries vary, not least because of varying assessments of what constitutes a severe injury from one jurisdiction to another. An Austin study considered that almost half of presenting patients had a severe injury[2] (APH, 2019). A Californian study found only 0.8% qualified as having a severe injury (Trivedi et al., 2019). In an Auckland City Hospital study, 4.4% of e-scooter riders had an Injury Severity Score higher than 6 (the highest category) compared to 15.6% medium severity (ISS 6-12) and 80% low severity (ISS <6) (Brownson et al., 2019).

Characteristics of severe injuries can start to be drawn from existing studies, even though it is possible that they only apply in their local context:

- Severe or fatal injuries are more common at night (Harmon, 2020) - US;
- Many of the severely injured riders hit their head on the ground (Brownson et al., 2019) – Auckland. In this study only 1.7% of riders were recorded as wearing a helmet. Note that helmet use is discussed in section 5.4;
- Injuries occurring on the road are more likely to be severe than on the footpath or other types of infrastructure (Cicchino et al., 2021) – Washington DC;
- Powered micromobility leads to significantly higher rates of severe injuries than non-powered micromobility (Tan et al., 2019) – Singapore.

The last two findings may be related in that riders of micromobility can reach higher speeds than non-powered mobility devices and we have previously established that fast micromobility riders are more likely to ride on the road. Non-powered mobility devices on the other hand is likely to remain on paths and cycle infrastructure. Collisions with motor vehicles may partly explain the higher severity of crashes on the road but only a small proportion of crashes involve motor vehicles and some of these even occur when riders are on the footpath, for example if a motor vehicle is manoeuvring onto or through the footpath (Cicchino et al., 2021). Therefore, motor vehicle collisions with micromobility are not sufficient to explain why powered micromobility had triple the risk of severe injury and double the risk of requiring hospitalisation compared to non-powered mobility devices in Singapore. The contrast was also found in previous Chinese and Swiss studies comparing e-bike with pedal cycle injuries versus pedal cycles (Tan et al., 2019). These studies suggest that speed itself is an important factor in injury severity in addition to the choice of where to ride and whether a motor vehicle is involved.

Rider age is also a variable that likely impacts injury severity data as it does in other modes (Aizpuru et al., 2019). Across most medical studies where data has been provided, patient age ranges are higher than those found in micromobility user surveys (which include people who have not been injured). As noted earlier, the demographics of e-bikes are older than pedal bicycles which could partly explain why e-bikes have higher severe injury rates (Tan et al., 2019).

Injury Rates

Several studies have attempted to quantify injury rates to allow comparison between locations and with other modes. There is consistency between injury rates found across studies. Note that the Brownson et al. study only considered Auckland City Hospital so it may have missed injured riders who presented to other hospitals.

Table 5.3 Injury Rates from Literature

	Injuries by trip number	Injuries by distance	Injuries by population
Portland, OR (PBOT, 2019)	25 injuries per 100,000 e-scooter trips	14 per 100,000 e-scooter km travelled	n/a
Austin, TX (APH, 2019)	20 per 100,000 e-scooter trips	n/a	n/a
US-wide (Harmon, 2020)	n/a	13 per 100,000 e scooter km travelled	n/a

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[2] Severe injuries including fractures (84% of severely injured patients), injuries to nerves, tendons and ligaments (45%), hospital stays longer than 48 hours (8%), severe bleeds (5%), and sustained organ damage (1%).

US-wide (Aizpuru et al., 2019)	n/a	n/a	2.6 cases of electric scooter injury per 100,000 population in a year
Auckland City Hospital (Brownson et al., 2019)	18.3 per 100,000 e-scooter trips[3]	n/a	n/a

5.4 Risk factors identified in the literature

This section picks up on risk factors that have been either suspected, proven or investigated in the literature. It aims to uncover areas where insufficient evidence exists and guide this piece of research.

Rider Behaviour

Rider behaviour impacts on safety outcomes by modulating the likelihood of crashes and the severity of injuries.

Intoxication

The medical literature reports anywhere between 4.8% and 23.3% of patients injured in micromobility crashes having consumed alcohol (Badeau et al., 2019; Brownson et al., 2019; Trivedi et al., 2019). This data often relies on perception by medical staff or patients' self-declared intoxication since blood alcohol level is rarely measured. Importantly, there are higher rates of intoxication among severe injuries and deaths (Harmon, 2020) and specifically higher rates of intoxication in patients with craniofacial trauma (Brownson et al., 2019; Faraji et al., 2020).

According to a Paris-based study, intoxication is more likely in e-scooter riders aged 17-24 (more than 40% of them stated that they have ridden an e-scooter after having consumed alcohol, while 20% of them have ridden after having consumed drugs). Young and male riders are also the most likely to use their smartphones while riding (Gioldasis et al., 2019).

Helmets and other protective equipment

Use of helmets has been found to be consistently low (ranging from 0 to 14%) among injured shared e-scooter riders (APH, 2019; Badeau et al., 2019; Brownson et al., 2019; Cicchino et al., 2021; Tan et al., 2019; Trivedi et al., 2019).

An observational survey in Brisbane (where helmets are compulsory and helmet wearing rates are higher) found that helmets were not worn or not fastened properly in 39% of shared e-scooter riders, 19% of shared bicycle riders, and 5% of private e-scooter riders (Haworth and Schramm, 2019). The French insurance industry survey (helmets not compulsory) found 86% of private micromobility (all vehicles) riders declared wearing helmets compared to 9% of shared e-scooter users (Smart Mobility Lab, 2020). Additionally, 62% of private micromobility riders reported wearing reflective equipment at night (e.g. high visibility armband or jacket) versus only 15% of shared micromobility users. Overall this study found that users of shared micromobility as well as infrequent rider owners are the ones least likely to wear protective equipment, to be aware of insurance requirements, or to display safe behaviours. Between types of micromobility devices, riders of gyrowheels/monowheels are the most likely to wear a helmet and other types of protective equipment.

Other non-sanctioned behaviours

Estimates of the practice of double riding (i.e. two riders on one micromobility device) range between 2 and 4% of observed micromobility trips and, in the 2019 Brisbane survey, 10.6% of shared e-scooter riders were observed to be underage (Cicchino et al., 2021; Haworth and Schramm, 2019). Combining all types of illegal behaviour, 48% of shared e-scooter and 12% of private e-scooters were found to be ridden illegally, either because of double riding or underage riding, or because of helmet use or riding in the wrong place. The proportion of illegal behaviour was lower among shared bicycle riders than shared e-scooter riders.

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[3] This estimate does not take patients at other hospitals nor private micromobility trips into account.

Skills

Riding experience and skills (or the lack thereof) is another area that requires further investigation. Initial evidence suggests a significant concentration of crashes in riders' early rides. Two studies found a range of 33 to 37% of injuries occurred on the first ride, and one of them added that another 30% of injuries occurred within their ride number 1 to 9 (APH, 2019; Cicchino et al., 2021). The evolution of injury numbers over time seems to confirm a reduction in injury crashes which could partly be attributed to experience: both Auckland and Brisbane have seen the monthly number of e-scooter injuries progressively reduce from an initial peak despite increasing fleets of shared micromobility vehicles being deployed (Auckland Transport, 2019), although ridership levels would need to be controlled for to draw conclusions on injury rates.

Speed & Infrastructure

The lack of data on micromobility speeds before crashes means the literature has to rely on the perception of riding too fast, whether self-assessed by riders or reported by third parties. In the Austin study, 37% of injured riders reported that excessive e-scooter speed contributed to their injury. In a French survey, excessive micromobility rider speed (40%) was the most frequently reported infringement (Smart Mobility Lab, 2020).

Beyond perceptions, there is no consensus as to the determination of appropriate speed for each context. An overview of speed regulations in various jurisdictions in **Figure 5.3** shows the variety of approaches around the world.

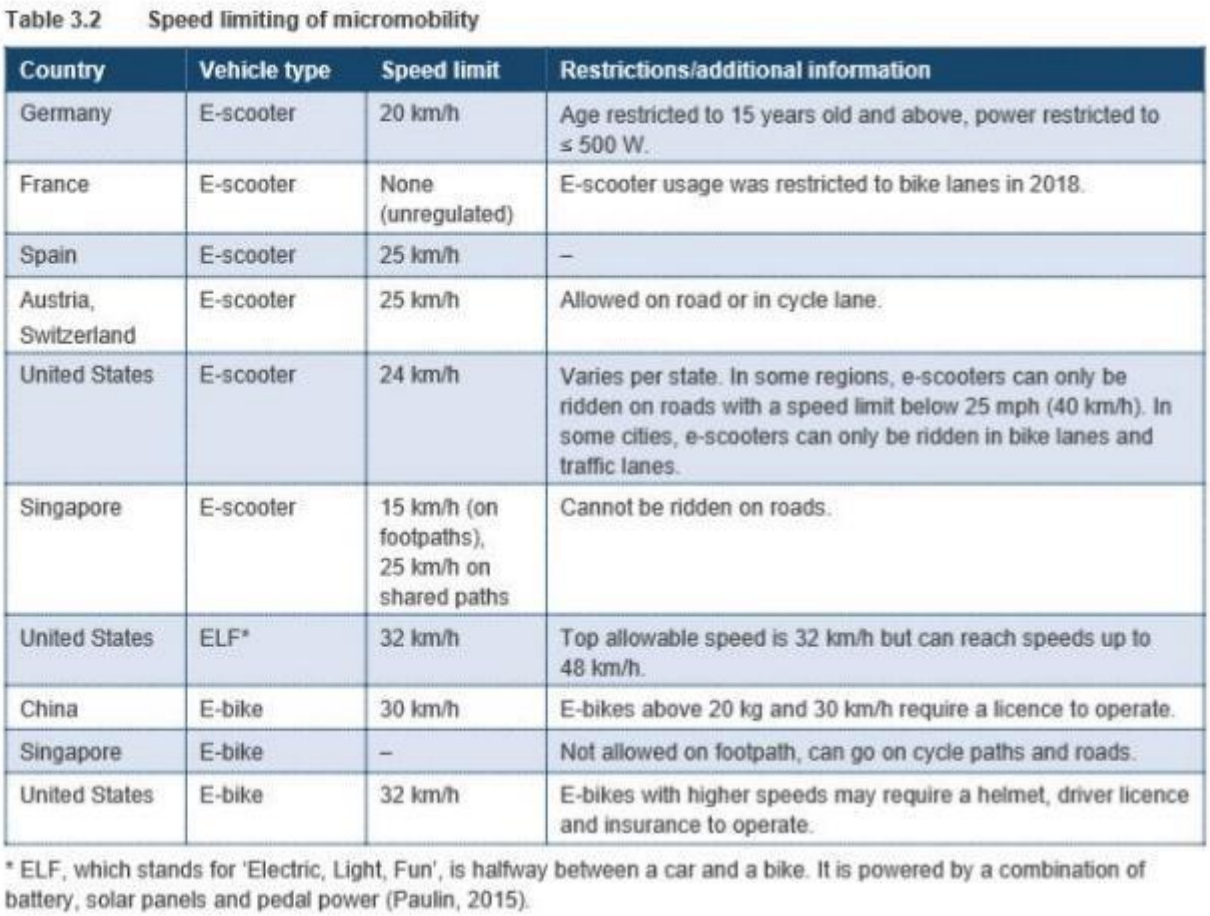


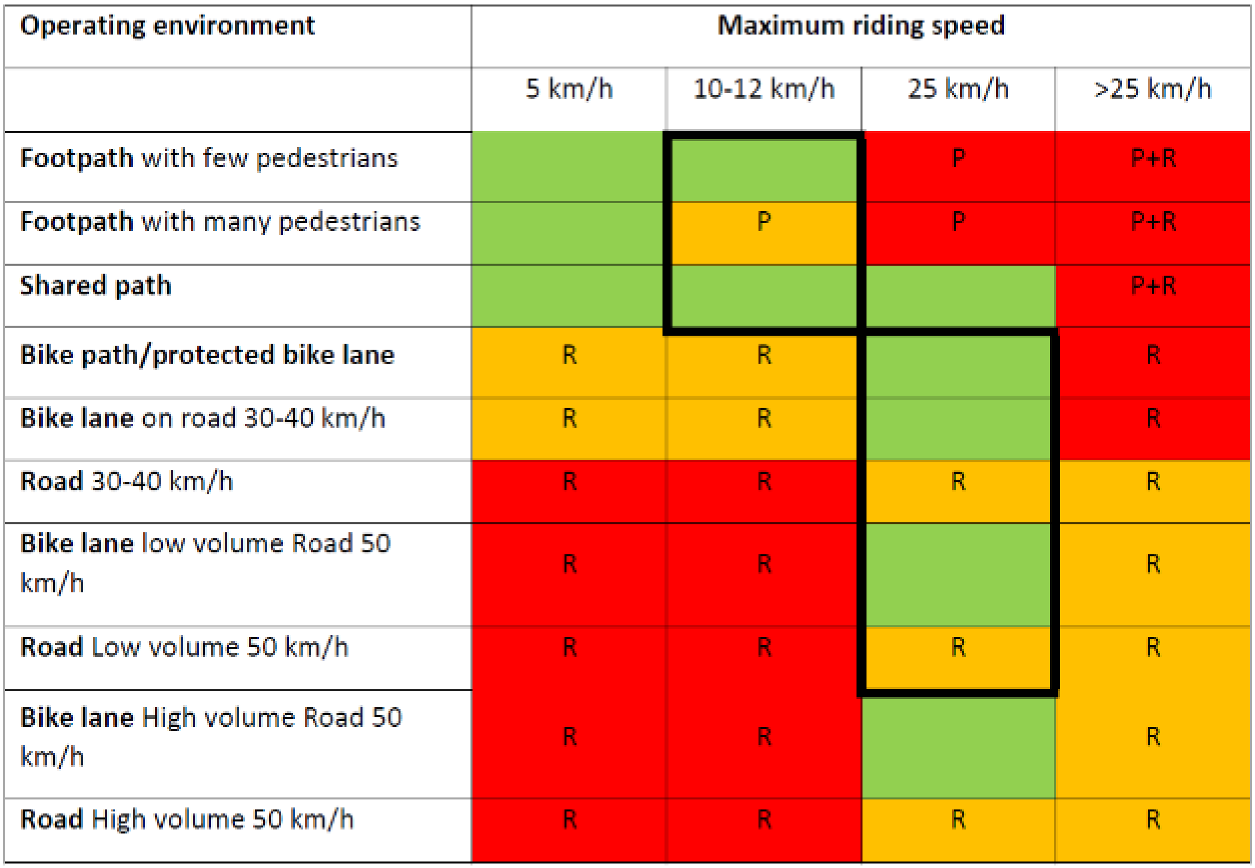
Table 3.2 Speed limiting of micromobility

Country	Vehicle type	Speed limit	Restrictions/additional information
Germany	E-scooter	20 km/h	Age restricted to 15 years old and above, power restricted to ≤ 500 W.
France	E-scooter	None (unregulated)	E-scooter usage was restricted to bike lanes in 2018.
Spain	E-scooter	25 km/h	–
Austria, Switzerland	E-scooter	25 km/h	Allowed on road or in cycle lane.
United States	E-scooter	24 km/h	Varies per state. In some regions, e-scooters can only be ridden on roads with a speed limit below 25 mph (40 km/h). In some cities, e-scooters can only be ridden in bike lanes and traffic lanes.
Singapore	E-scooter	15 km/h (on footpaths), 25 km/h on shared paths	Cannot be ridden on roads.
United States	ELF*	32 km/h	Top allowable speed is 32 km/h but can reach speeds up to 48 km/h.
China	E-bike	30 km/h	E-bikes above 20 kg and 30 km/h require a licence to operate.
Singapore	E-bike	–	Not allowed on footpath, can go on cycle paths and roads.
United States	E-bike	32 km/h	E-bikes with higher speeds may require a helmet, driver licence and insurance to operate.

* ELF, which stands for 'Electric, Light, Fun', is halfway between a car and a bike. It is powered by a combination of battery, solar panels and pedal power (Paulin, 2015).

Figure 5.3 Speed and power restrictions in several jurisdictions (Source: (Ensor et al., 2021))

Studies that link effective speed with injuries remain rare, so a more theoretical approach has been used to define safe speeds for regulatory purposes. As part of a consultation by the Australian National Transport Commission (NTC) on 'Barriers to the safe use of personal mobility devices', the Centre for Accident Research and Road Safety - Queensland (CARRS-Q) submitted a response (Haworth, 2019). It analysed speeds for safe micromobility in various environments based on principles of kinetic energy transfer and separation. This work demonstrates the importance of speed in micromobility safety risk: "the kinetic energy of a 60 kg [Personal Mobility Device (PMD)] travelling at 25 km/h is 43 times that of a person walking and 3 times that of the same PMD travelling at 15 km/h". The CARRS-Q produced a risk matrix (**Figure 5.4** below) highlighting where pedestrians or riders would be at risk.



Operating environment	Maximum riding speed			
	5 km/h	10-12 km/h	25 km/h	>25 km/h
Footpath with few pedestrians	🟩	🟩	🟥 P	🟥 P+R
Footpath with many pedestrians	🟩	🟧 P	🟥 P	🟥 P+R
Shared path	🟩	🟩	🟩	🟥 P+R
Bike path/protected bike lane	🟧 R	🟧 R	🟩	🟥 R
Bike lane on road 30-40 km/h	🟧 R	🟧 R	🟩	🟥 R
Road 30-40 km/h	🟥 R	🟥 R	🟧 R	🟧 R
Bike lane low volume Road 50 km/h	🟥 R	🟥 R	🟩	🟧 R
Road Low volume 50 km/h	🟥 R	🟥 R	🟧 R	🟧 R
Bike lane High volume Road 50 km/h	🟥 R	🟥 R	🟩	🟧 R
Road High volume 50 km/h	🟥 R	🟥 R	🟧 R	🟧 R

Figure 5.4 Risk matrix for micromobility devices as a function of maximum riding speed and operating environment.

In the Figure P=risk to pedestrian, R=risk to rider, P+R=risk to both pedestrians and riders and colours represent low to high risk operation of micromobility devices (green to red). The black borders were used to represent the impact of the proposed regulation. (Source: (Haworth, 2019))

This type of theoretical approach is important evidence to inform regulatory policies, but actual crash data is also useful to confront theoretical models with real-world conditions. This data seems to currently be mostly missing.

As this work shows, speed is intrinsically linked to infrastructure as a rider's speed should at all times be safe and appropriate for the infrastructure they are riding on. Which speed is appropriate depends on which other road users including motor vehicles (and how many of them) are using the same infrastructure simultaneously but it also depends on the quality of such infrastructure. There is intriguing but insufficient evidence that surface features and obstacles can be significant factors of risk. In one study, respondents reported that falls due to adverse surface features (e.g., pothole, uneven pavement) accounted for 25% of injury crashes and infrastructure (e.g. driveway lip) accounted for 16% (Cicchino et al., 2021). This warrants further research to better understand how infrastructure can influence safer micromobility.

Overall, this literature review has revealed the following gaps in available research:

- Speed of private micromobility and impact of speed on risk
- Importance of rider experience and skills in crash risk
- Locations and cause of crashes
- Comparison of risk between micromobility modes
- The role of riding surfaces (e.g. smoothness, gradients) and infrastructure (e.g. separation from other modes)

6. Micromobility Survey

6.1 Survey Methodology

Survey objectives

Overall, the survey's objective was to understand micromobility crashes and near misses. This includes assessing what happened, behavioural or environmental risk factors that may have contributed to the incident, and road user perceptions of the incidents.

The survey is intended to fill data gaps identified in both the literature review and initial data analysis. In particular, Auckland data for the following is missing:

- Location of micromobility crashes and near misses
- Rider behaviour in these incidents (intoxication, helmet use, speed, etc)
- Role of infrastructure in incidents
- Types of micromobility vehicles involved in incidents
- Involvement of other road users (e.g. pedestrians) in micromobility incidents.

Survey results are intended to directly answer part of the research questions.

Survey content and development process

The survey content was developed by Abley based on early findings and geared towards answering research questions agreed by the Steering group. The online survey was built by Kantar and then tested and refined with Abley, combining Kantar's market research expertise and Abley's road safety and micromobility expertise.

Many iterations were required to ensure any respondent's situation would be covered, offering appropriate options for respondents to characterise their incident. This resulted in a complex decision tree differentiating for example:

- Crashes versus near misses
- Riders versus non-riders
- Involved versus witnesses
- Injury versus non-injury

Due to the depth of information gathered through this survey it is recognised as a challenging survey to complete, requiring respondents to focus and dedicate 10-15 minutes of their time. This was a trade-off compared to an easier survey which may have yielded higher participation but less specific insights.

6.2 Survey Respondents

Number of respondents and sources of respondents

Two strategies were used to recruit respondents:

1. Interest groups and third parties were contacted to circulate the survey link and its context. They were chosen for their relationship to the topic of micromobility and their ability to reach audiences likely to take the survey. The following organisations engaged with us although only some of them followed through to publishing the survey information to their audience. Each used the channels they deemed appropriate to circulate the survey.
    - Auckland Transport

- Waka Kotahi
- Blind and Low Vision Foundation
- CCS Disability Action
- Living Streets Aotearoa
- Bike Auckland
- Heart of the City
- Greater Auckland
- The three companies operating shared micromobility in Auckland at the time of the survey: Lime, Beam, Neuron
- University of Auckland
- The survey was also circulated through personal networks of Abley and Kantar staff.

2. Kantar sent the micromobility survey out to one of their established online panels of respondents aged 15+. These respondents are paid to complete surveys so contrary to the interest groups they were not likely to have a self-selection bias based on their interests. They are considered to be representative of the 15+ Auckland population. This method yielded 631 responses.

The survey was launched on 3 February 2021, and closed on 19 March. It was initially sent out to interest groups, and on 9 March was additionally circulated to Kantar's panel.

The initial approach of circulating links to the survey through interest groups allowed collecting views from groups of particular interest (e.g. people with disability, cyclists, students, micromobility users, pedestrians, etc). However, while there were many clicks on the survey, it only yielded around 179 responses, with 1653 incomplete screenings (those who clicked on the survey but abandoned it prior to being screened out). This number was considered insufficient for robust survey results so a second approach was used to gather responses. Kantar sent the survey out to their panel on 9 March 2021.

Differences between Interest Group and Panel Respondents

Responses between the Kantar panel and the respondents obtained through interest groups differed in some areas. Some key differences are listed below. Generally speaking, the Kantar panel data is more representative of the general population, while the interest group data provides greater exposure into specific vehicle types and those with disabilities.

Eligibility/Screen outs

515 people from the panel (45% of those who were sent the survey) were screened out as they did not qualify. Eligibility was assessed through screening questions: anyone who had not seen or experienced a crash or near miss involving micromobility in Auckland in the past 3 years was screened out.

While there are a relatively high number of screenouts, the screenout statistics indicate that a total of around 55% of those sent the survey had had some exposure to micromobility incidents.

For the interest group sample, as noted above a relatively high number of people clicked to complete the survey, but then abandoned it. As the interest group sample were recruited on the basis that they had been involved or were interested in micromobility, as expected, screenouts for this group are lower, with only 49 screenouts (27% of completes) due to not having been involved or witnessing an incident.

Use of Micromobility

The interest group approach saw a higher proportion of respondents who had used e-bikes (49%) as compared with the panel (39%). The interest group also had a lower proportion of respondents who had used e-scooters (53%) than the panel (62%).

Disabilities

The direct approach through interest groups, some of which included disability groups resulted in 11% of respondents indicating that they considered themselves to have a disability, as opposed to around 4% of the panel respondents.

Ethnicity

The interest group sample tended to include higher numbers of European respondents. It included respondents indicating NZ European or Other European representation of 87%. In the panel sample, this was 58%, which is close to the 2018 census results indicating 53.5% of Aucklanders identify as NZ European ethnic groups. The panel sample also saw significantly higher proportions of respondents identifying as Chinese and Indian (14% and 16% respectively) than the interest group sample (4% and 1%). Again the panel sample is close to census statistics for these ethnic groups (28.2% for Asian groups in the 2018 census).

Geography

The interest group sample had high proportions of respondents from the central areas of Auckland (i.e. Point Chevalier, Grey Lynn, Mount Albert, Greenlane) at 31%. The panel sample had 18% from this area. Most other areas saw similar representation from both samples.

Survey Caveats

Survey Representation

- One limitation is that, due to the nature of the data collection being conducted through multiple sources, the sample cannot be considered completely representative of Auckland residents. Fortunately, the majority of the surveys were conducted by Kantar and thus are derived from a representative sample of Auckland. The sample has been weighted to provide indicative representation of Auckland residents in terms of gender and age.

- The Kantar panel is only open to adults 15+; therefore incidents incurred by children have not been sampled, except where the survey is forwarded to other individuals.

Incident Self-Selection

- When surveyed, respondents were asked to choose an incident from the past three years that was both one of the most serious incidents they had been involved in and one they could remember in detail. Therefore, if a respondent had been involved in multiple incidents only one would be recorded. Thus, the output is likely underreporting the total number of incidents per respondent and the recorded incidents might be weighted to be more serious.

- The reason that this decision was made, despite its disadvantages, was due to the length of the survey. It was likely that if a respondent had to go through the entire of the survey several times, they would not be willing to enter all of the incidents and thus, the outputs would be less reliable.

- Users were also asked to record ‘near misses’. The definition of a near miss was left open to the interpretation of the individual and is therefore subjective. We may therefore expect over-representation of near-misses.

- An amount of recall/recency bias is likely in the results as respondents are likely to have forgotten less serious incidents occurring some time before. It is also noted that the reporting dates of incidents are dependent on memory and will be inaccurate.

Sample Size

- Unfortunately, due to the limited number of responses, there was limited information around incidents that resulted in high severity injuries. Severity was measured by the number of days required off work and the medical attention sought after the incident had occurred. This meant that some of the questions regarding injury severity could not be answered. One example of this is the severity of e-scooter incidents compared to e-bike incidents. The survey was not able to compare the severity of these two rider categories to a high level of statistical confidence. Thus, these were omitted from the results.

Self-reporting

- Speed is self-reported in the Kantar survey; it is therefore difficult to confidently assess to what degree speed is a factor in accident outcomes.

- Intoxication, double-riding and helmet wearing at time of incident, were self-reported and may inherently be underreported due to participant reluctance to admit to these behaviours.

6.3 Results

All of the following information is derived from the Micromobility report in Appendix C.

In all Kantar images a green triangle indicates a result significantly higher than other groups, and a red triangle a result significantly lower than other groups.

In total, 810 surveys were completed. Out of these, 179 surveys were completed through interest groups. The remaining 631 surveys were completed using the Kantar online consumer panels.

Context

To provide some context around micromobility, respondents were asked before screen out whether they had used a micromobility device before. **Figure 6.1** shows the results from 1146 respondents (638 males, 503 females and the others unknown). Around half of Aucklanders have tried an micromobility vehicle, with e-scooters being the most popular and a significant usage skew towards males.

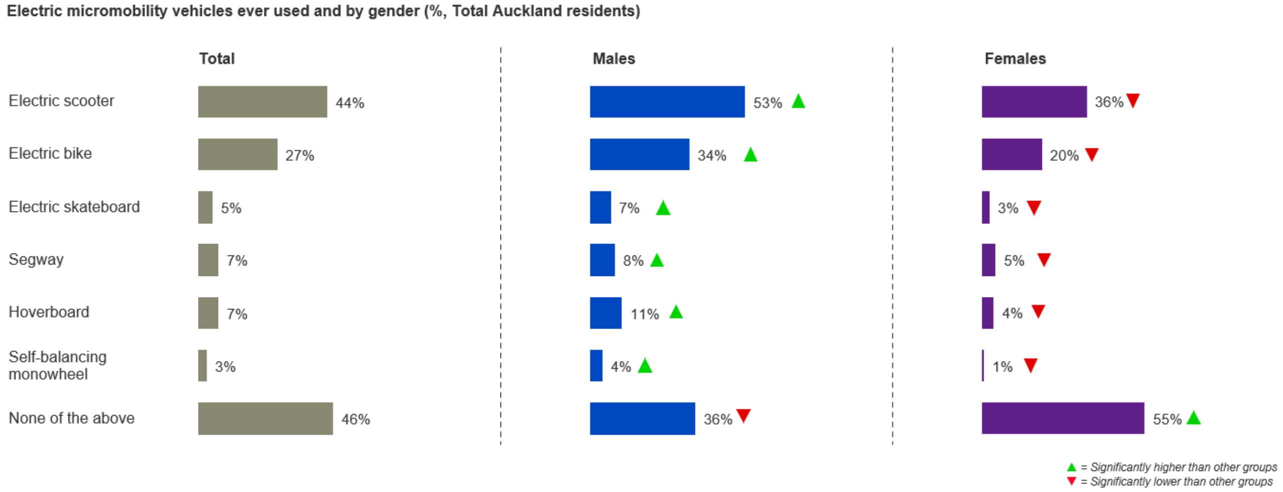


Figure 6.1 **Electric micromobility vehicles used by gender (%, Total Auckland residents)**

It is also important to understand what age demographic is riding micromobility devices. The reason for this is both to understand how micromobility affects transport equity and because different age groups, as shown in the X-KEMM-X model output, have different impact tolerances.

The results showed that having tried micromobility is linked to age, with almost 4 in 5 riders between 15 to 29 having tried at least one type (285 surveyed), compared to 3 in 5 among 30 to 44 year olds (407 surveyed) and 2 in 5 among 45 to 64 year olds (311 surveyed).

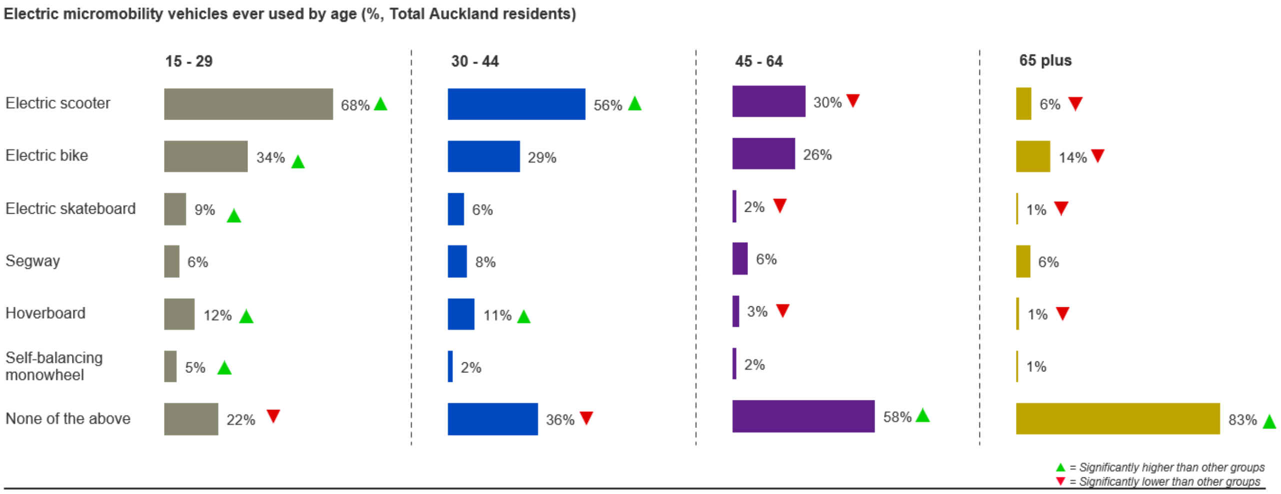


Figure 6.2 Electric micromobility vehicles ever used by age (%, Total Auckland residents)

When it came to the use of different micromobility devices, **Figure 6.3** below shows the frequency of rides in Auckland. E-scooters are ridden weekly by 11% of Auckland residents and e-bikes by 8% (1146 surveyed).

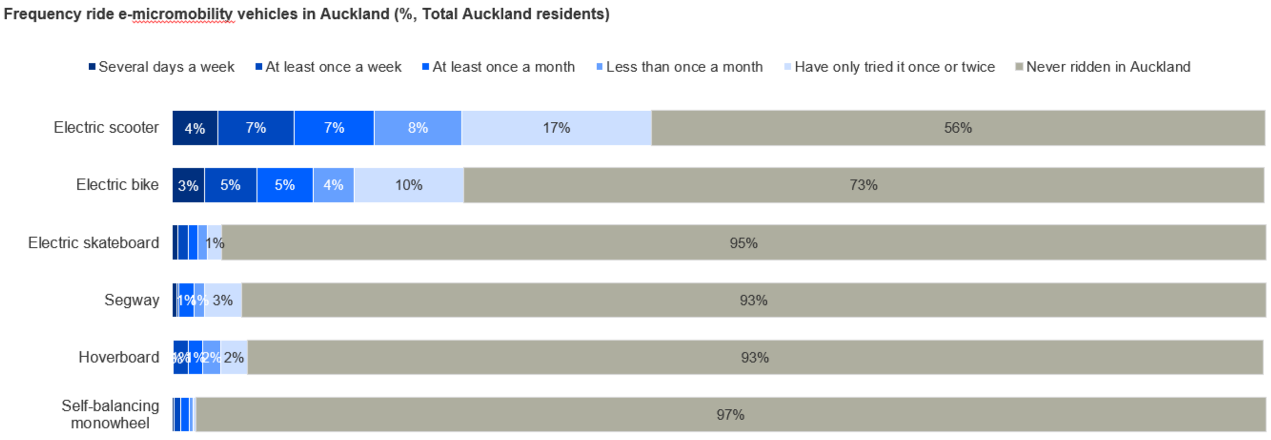


Figure 6.3 Frequency of micromobility usage in Auckland

Findings

Overall just over half of incidents involved witnesses and just under half were directly involved, as illustrated in **Figure 6.4**. Survey results, particularly in the case of witnessed incidents or perceived near misses, can be influenced by emotional reactions (e.g. irritation towards e-scooter riders). They therefore need to be analysed with caution.

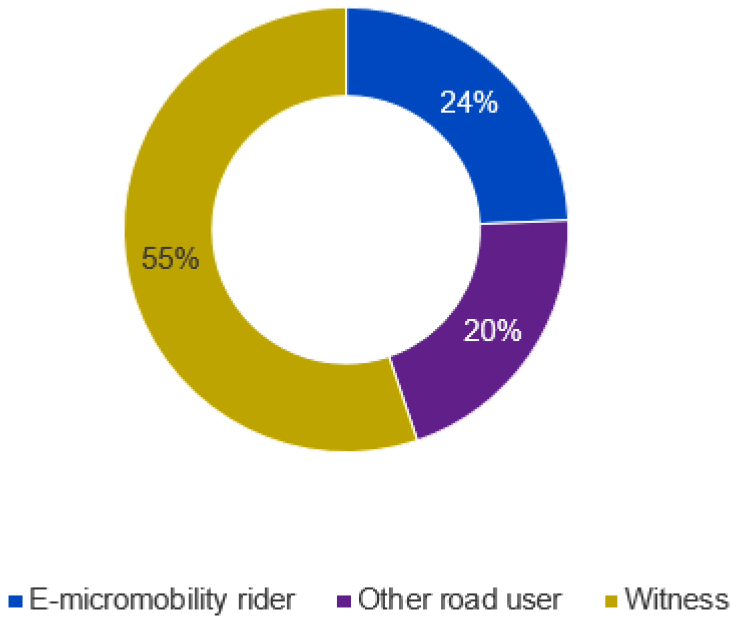


Figure 6.4 Personal involvement in the incident as percentage of total incidents reported

Environmental factors, such as road surface, are the leading cause of e-rider collisions with non-moving objects, while collisions with others are often believed to be the result of rider behaviour. This can be seen in **Figure 6.5**.

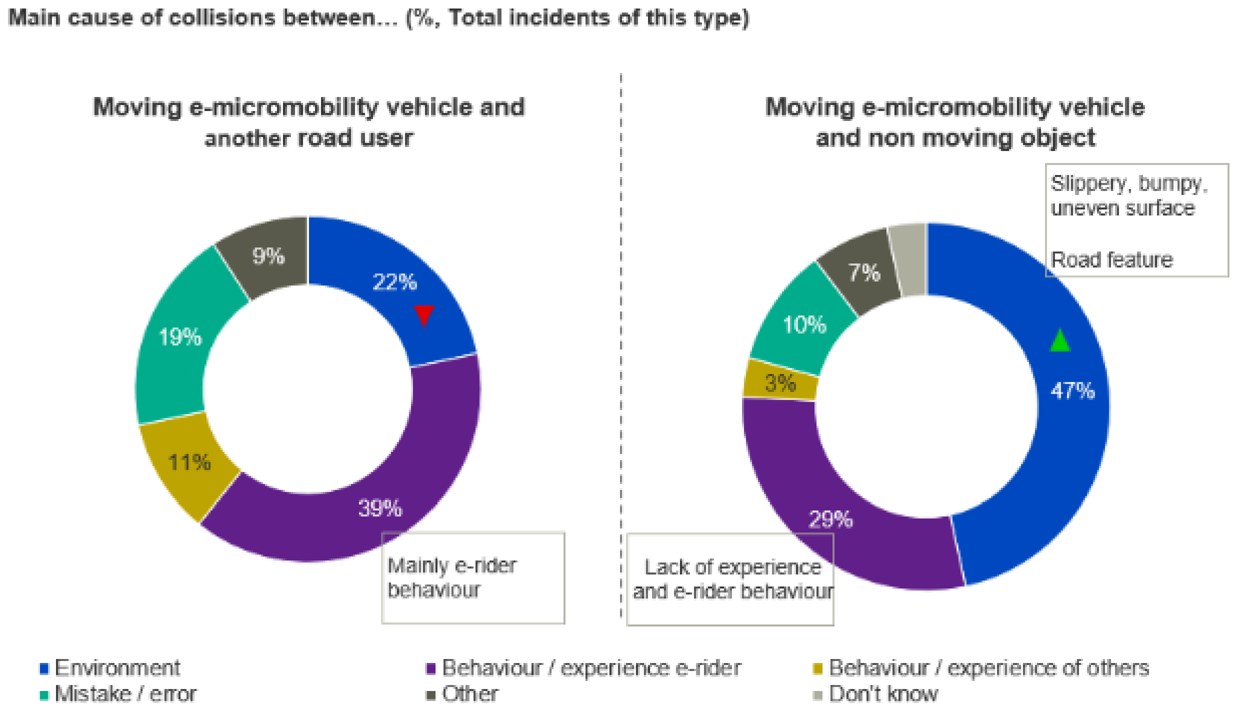


Figure 6.5 Main cause of incidents

Regarding micromobility incidents, one in two micromobility riders have experienced an incident in the past 3 years, most commonly near misses or falling off with only 2% having collided with another road user.

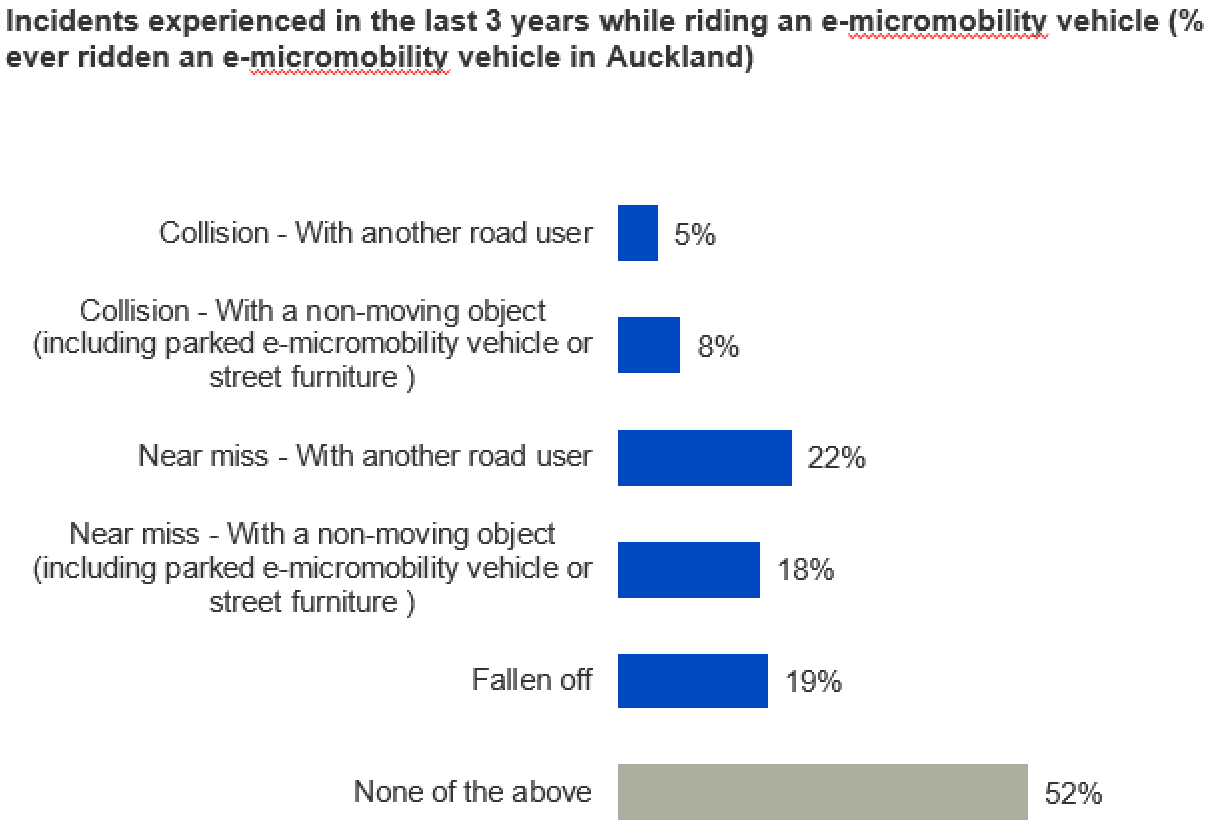


Figure 6.6 Incidents experienced in the last 3 years while riding an micromobility vehicle

Incident overview

Out of the 810 incidents that were reported, half the reported incidents were near misses, one in four were collisions and one in four were rider falls or near falls; just under half were reported by someone personally involved in the incident. In regard to **Figure 6.6** (incidents while riding an micromobility vehicle), if the near misses are excluded, the falls and collisions represent roughly half of the incidents each, although collisions with other road users are only around 15% of all falls or collisions. The relatively high percentage of falls suggests that surface condition, environment or behaviour, rather than other users, are significant factors in the incident occurrences.

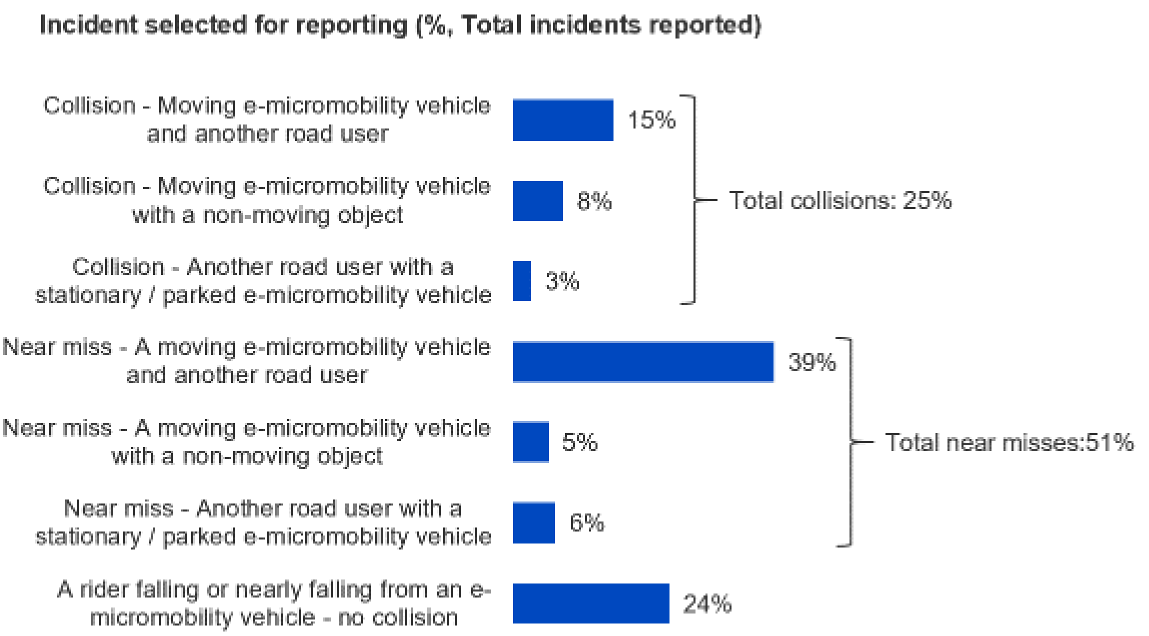


Figure 6.7 Incident type breakdown

The research also examined the relationship between near misses and incidents. **Figure 6.8** shows the breakdown of near misses compared to the total number of crashes. Near misses represent around half of all incidents and accordingly reflect similar trends to total incidents. However, near miss incidents were slightly more likely to involve pedestrians and occur on sunny days. This indicates that near miss data could be used as a good indication of actual risk, for micromobility (810 surveyed, 414 near misses and 368 near misses that involved another road user).

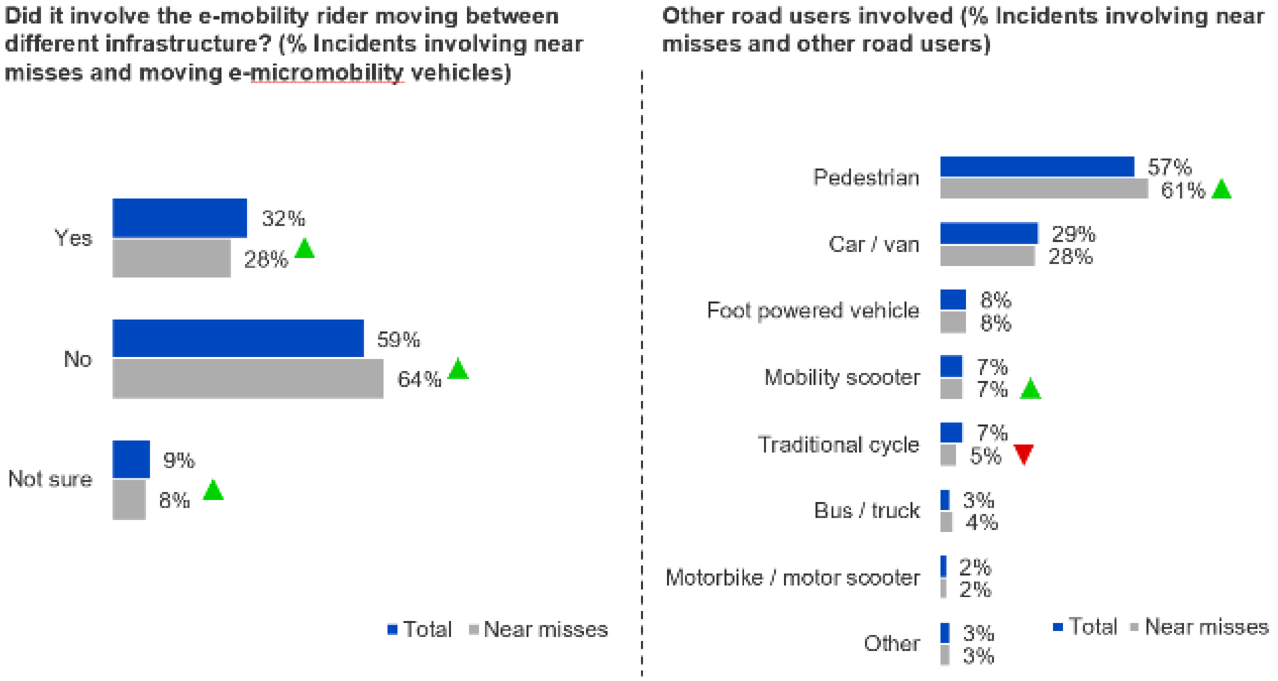


Figure 6.8 Near misses compared to all incidents

To get an understanding of what micromobility devices were involved in incidents, the survey asked the respondents what mode they were using, or witnessed using at the time of the incident. Of the 736 respondents that reported their mode of transport, the majority reported incidents involving e-scooters with 16% involving e-bikes and 8% involving other types of micromobility vehicles.

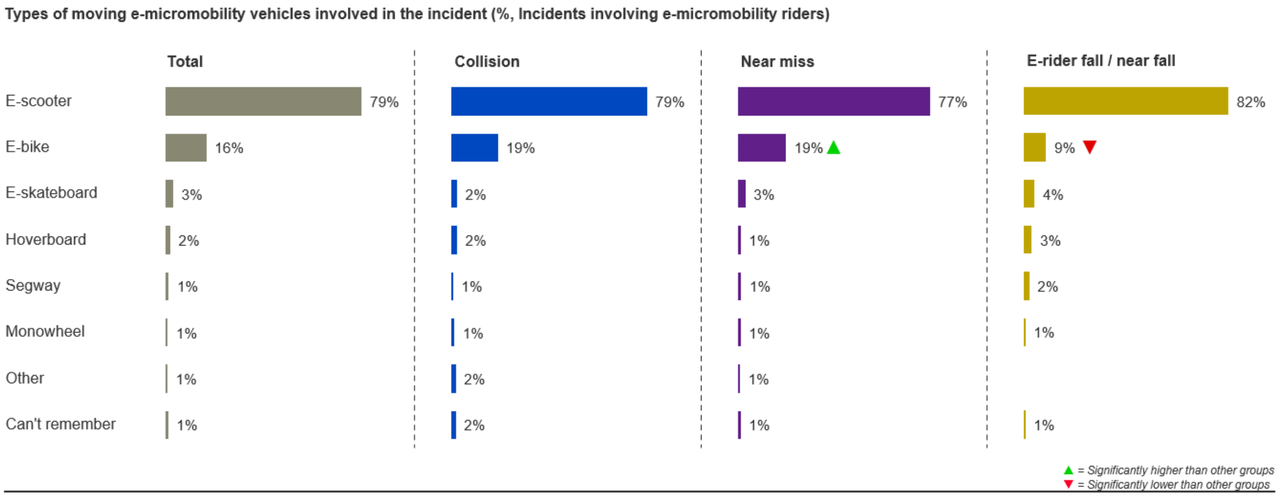


Figure 6.9 Reported incidents between micromobility riders and other road users

One of research questions involves understanding the difference between rental micromobility risk vs private micromobility risk. **Figure 6.10** shows, out of the 688 reported, two in three (68%) incidents with e-scooter riders involved rental or shared e-scooters compared to only 20% of incidents involving e-bikes.

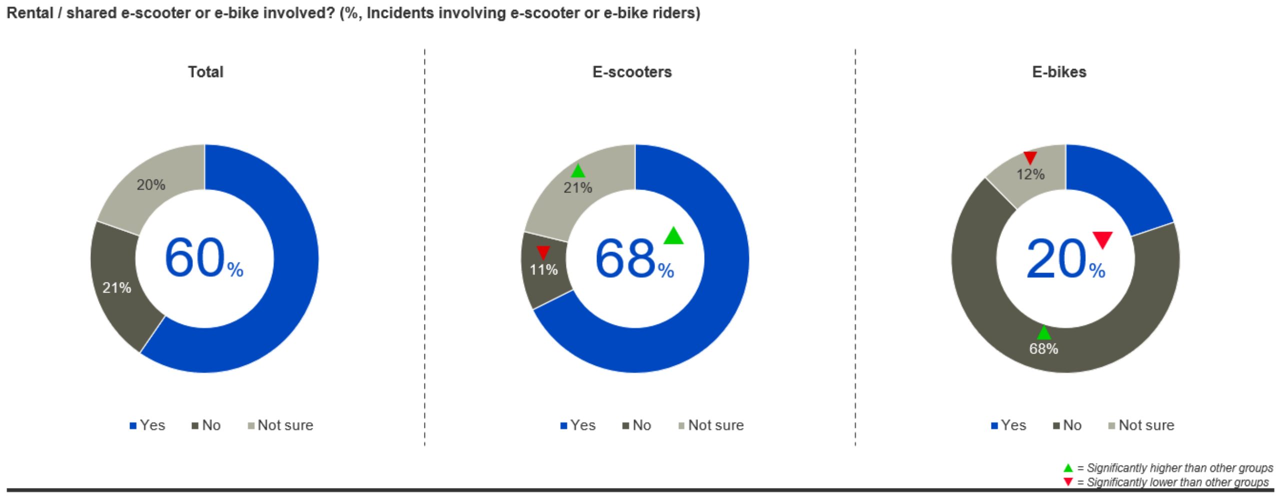


Figure 6.10 Rental vs shared use micromobility

Pedestrian safety is also a key aspect of the study. Reported incidents between micromobility riders and other road users mostly involved pedestrians. **Figure 6.11** shows the breakdown of the 425 incidents that involved another road user. The Figure shows that one third involved a car or van. This is significant as traditional crashes between VRUs and vehicles have a relatively high chance of resulting in serious or fatal injuries.

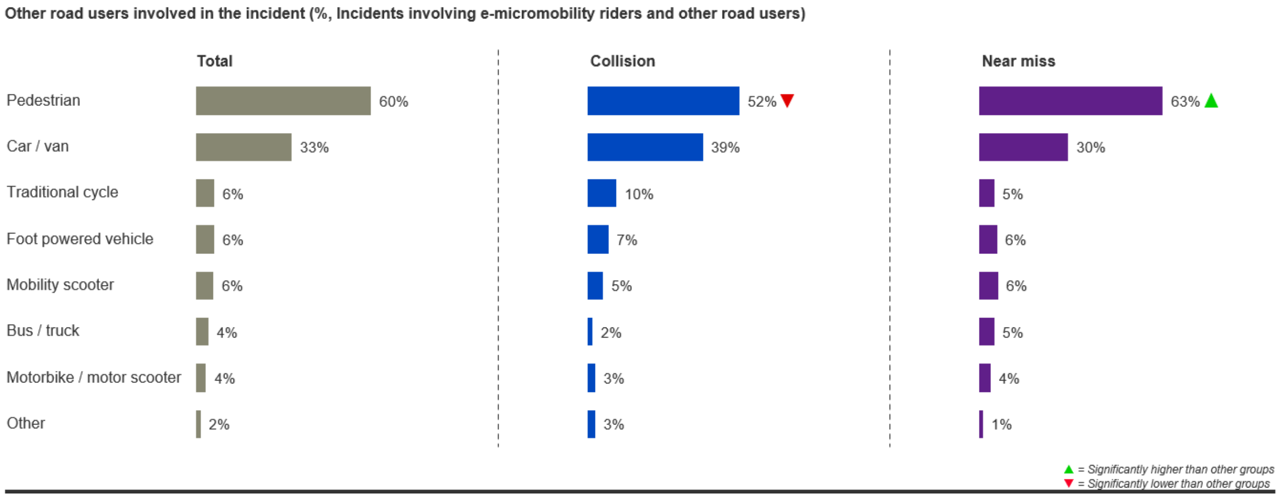


Figure 6.11 Reported incidents between micromobility riders and other road users

When it comes to the infrastructure the micromobility vehicle were using at the time of the crash, almost 2 in 3 (65%) reported incidents occurred on a footpath, including shared paths, however, around 1 in 4 incidents between micromobility riders and other road users occurred on the road.

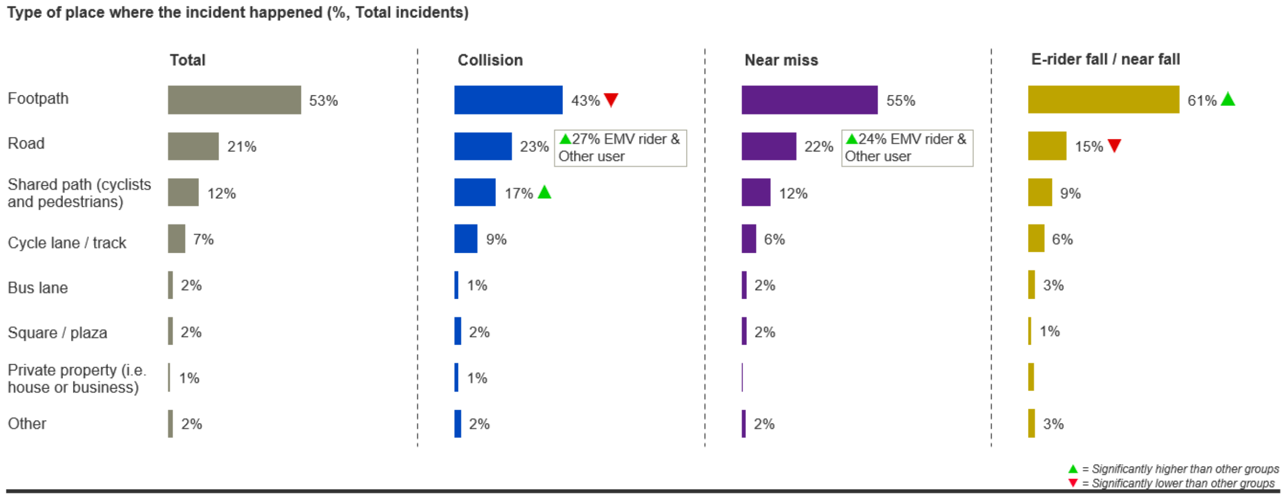


Figure 6.12 Infrastructure where the incident occurred -incident type breakdown

The type of place does however differ between the types of micromobility vehicle involved. E-scooter incidents typically occurring on a footpath and e-bike incidents are mixed between the road, footpaths, cycle lanes and bus lanes. This indicates that there is a substantial difference in incident location between e-scooter and e-bike users, which may reflect infrastructure usage.

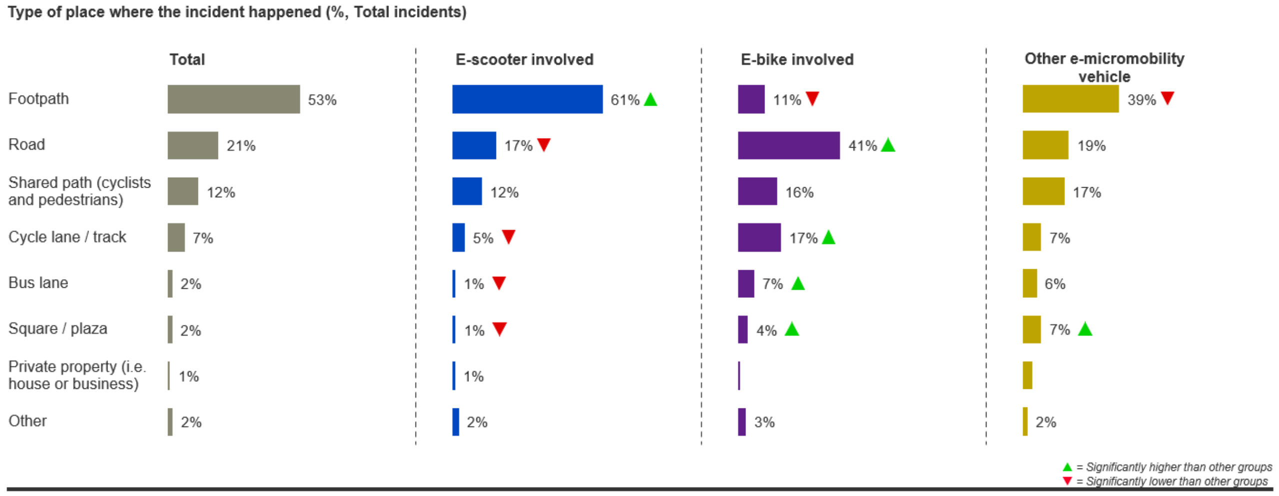


Figure 6.13 Infrastructure where the incident occurred -micromobility mode breakdown

Focusing on the micromobility rider

Considering the behaviour of the micromobility rider, out of the 736 respondents, the majority reported e-bike riders were wearing a helmet but only one in five e-scooter riders were reported to be wearing a helmet.

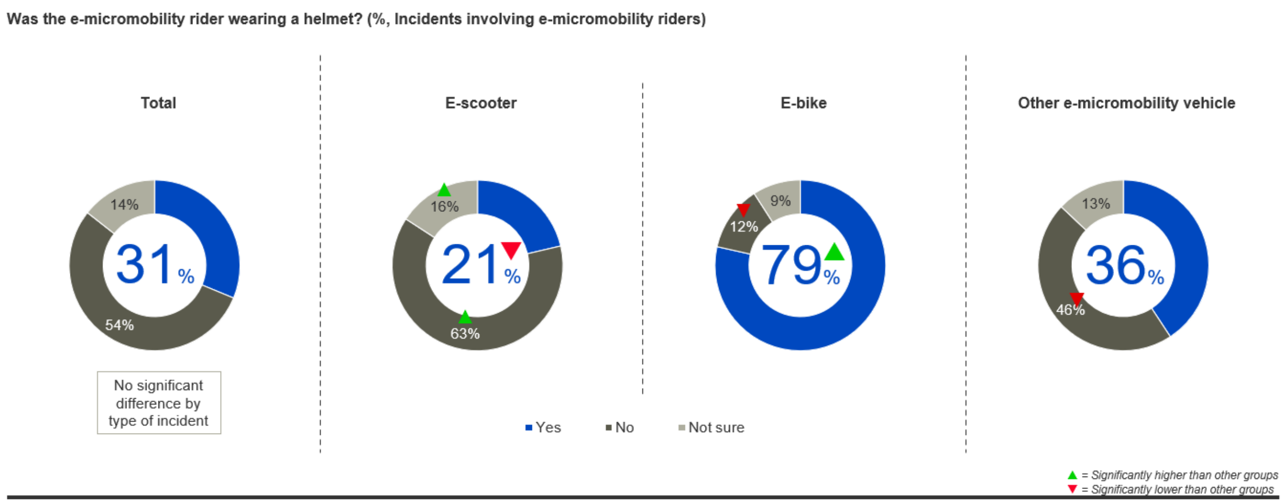


Figure 6.14 Helmet use

Another difference between e-scooter riders and e-bike riders is around the experience level at time of incident. Most e-bike riders involved in incidents are experienced riders however half the e-scooter riders had ridden fewer than 10 times with 31% of e-scooter riders having an incident on one of their first four rides. While this data may also reflect a higher propensity for irregular use amongst the newer e-scooter mode riders as compared with e-bike riders (and should be treated with caution), the data in **Figure 6.15** suggests that there may exist a risk differential between skilled and experienced riders.

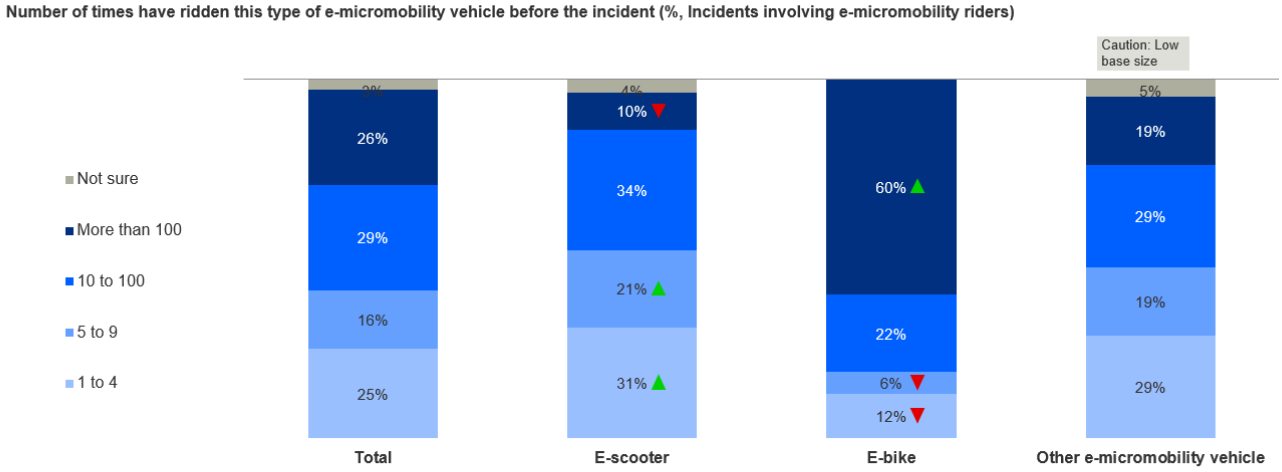


Figure 6.15 Previous e-micromobility vehicle use

Injuries

Out of the 810 incidents, around 19% of incidents resulted in an injury, with roughly a third of collisions and falls off micromobility vehicles causing some harm.

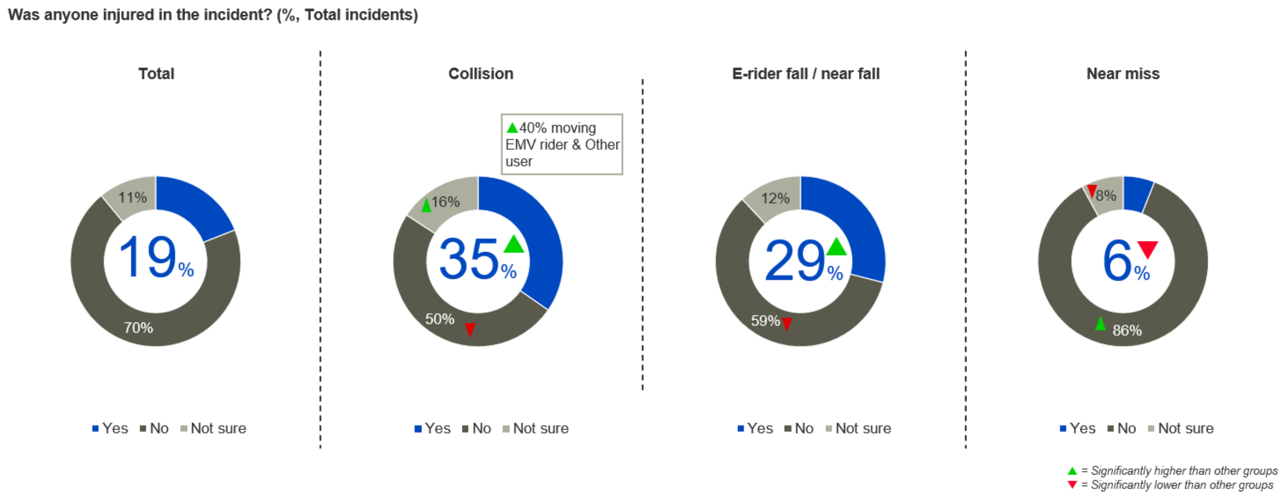


Figure 6.16 Injury overview

Another finding from the survey was that the type of micromobility vehicle involved doesn't have a large impact on the rate of injury, although incidents involving other road users (most commonly pedestrians) were less likely to result in an injury. From the sample of 121 incidents involving e-bike riders compared with 581 on e-scooters, e-bike riders were slightly more likely to receive an injury than an e-scooterist, even though cyclists are more likely to be wearing helmets. As noted above in **Figure 6.13** the location where incidents occur also differs between mode which may reflect this discrepancy.

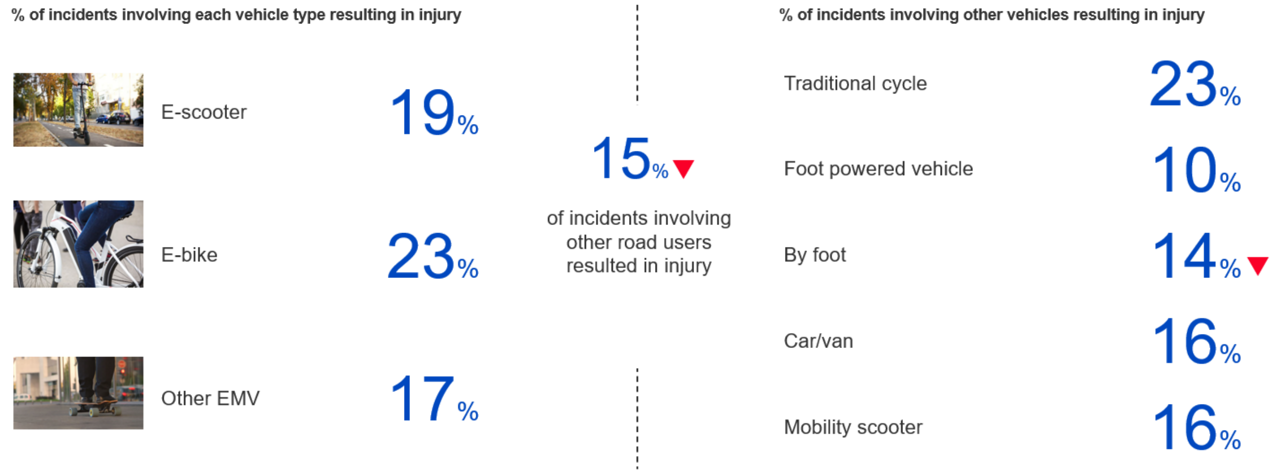
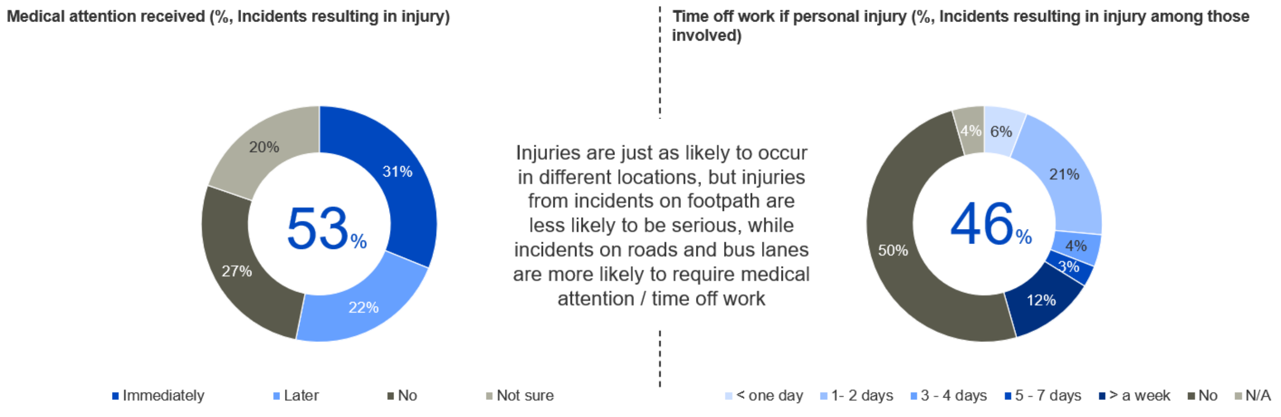


Figure 6.17 Micromobility injury breakdown by vehicle

Out of the 152 people injured, around half required medical attention, and a similar proportion required time off work. **Figure 6.18** shows this breakdown. Interestingly, 12% of people injured required over a week off work in order to recover from their injury. It is perhaps not surprising that injuries on footpaths are less likely to result in higher severity than those that occur on the road. This indicates that though there may be a high number of incidents occurring on the footpath, it should perhaps be the on-road incidents that are designed for, in order to create a system free from deaths and serious injuries.



Injuries are just as likely to occur in different locations, but injuries from incidents on footpath are less likely to be serious, while incidents on roads and bus lanes are more likely to require medical attention / time off work

Figure 6.18 Micromobility incidents requiring medical attention

Pedestrian Injury Incidents

When exploring reported pedestrian injury incidents the data reveals an overall total of 363 incidents reported incurred by either the e-rider or another road user (witnessed incidents have been excluded since it is unknown whether an injury was incurred to pedestrian or e-rider).

- Of the 363 injury incidents reported by riders or road users directly involved, a total of 138 incidents were reported involving pedestrians (38%).
    - Of these, 22 (6% pedestrian incidents) were collisions and the remainder near misses.
    - 5 involved a collision with a stationary e-vehicle.
    - 17 resulted from a collision with a moving micromobility vehicle.
- Of the 5 collisions with a stationary e-vehicle, one resulted in an injury and four were non-injury.
- Of the 17 collisions, there were 9 injury accidents and 8 non-injury collisions.
    - Of the 9 injury accidents, 4 would have been to the e-rider and 5 to the pedestrian).

In general, where a pedestrian is involved, half of the time one party or another was injured, and around half required time off work. Although the sample size for this group is small it does indicate that the consequences of an incident involving a pedestrian can be significant, since both they and the micromobility rider are VRUs.

Incidents of collisions with stationary e-vehicles are small, although it should be noted that since the survey requested users to report on their most serious incident, minor trips may have gone unreported.

Incidents Reported by those with Physical Impairments

The survey asked whether the respondent considered themselves to have a physical impairment. Twenty-five people involved in an incident noted they had an impairment, and of these, seven were categorised as collisions.

The descriptions of the collision incidents do not reveal any overarching trends relating to physical impairments. There are two incidents reported as collisions with parked micromobility devices by those with visual impairments. However, in both cases it appears these were near misses rather than actual collisions. There are also two near misses where a visually impaired pedestrian did not see an e-scooter rider on the footpath until the last moment.

It is clear from the descriptions of the incidents that near misses to those with physical impairments can cause psychological distress even if no physical contact is made.

6.4 Geospatial Analysis

All incidents

Alongside the data analysis conducted by Kantar, the research team also plotted the survey data. This was done on several different maps to determine what geospatial insights could be gained from the data.

Figure 6.19 below shows a plot of all the incidents that have been recorded in the survey across Auckland. It is clear that the main bulk of recorded incidents occurred within Auckland City.

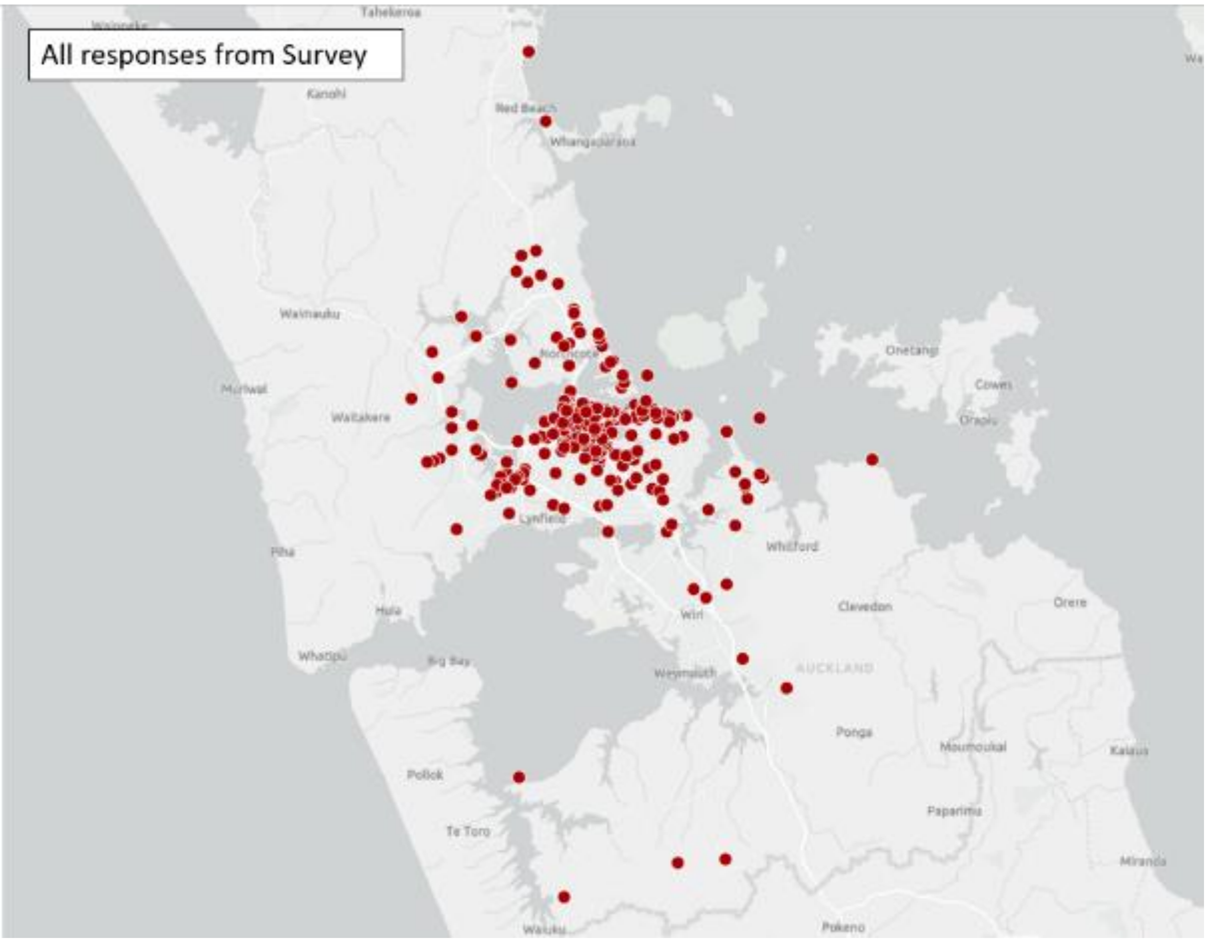


Figure 6.19 Map of all incidents reported through the survey

Incidents broken down into types of micromobility modes

Figure 6.20 shows the reported survey incidents broken down into types of micromobility modes. **Figure 6.21** shows the same information zoomed into the city centre. Comparing these two images it is clear that while e-bike crashes are inside and outside Auckland city centre, the vast majority of recorded e-scooter incidents are recorded within Auckland city centre. Where no micromobility device was identified in the survey, the response is recorded as 'null'.

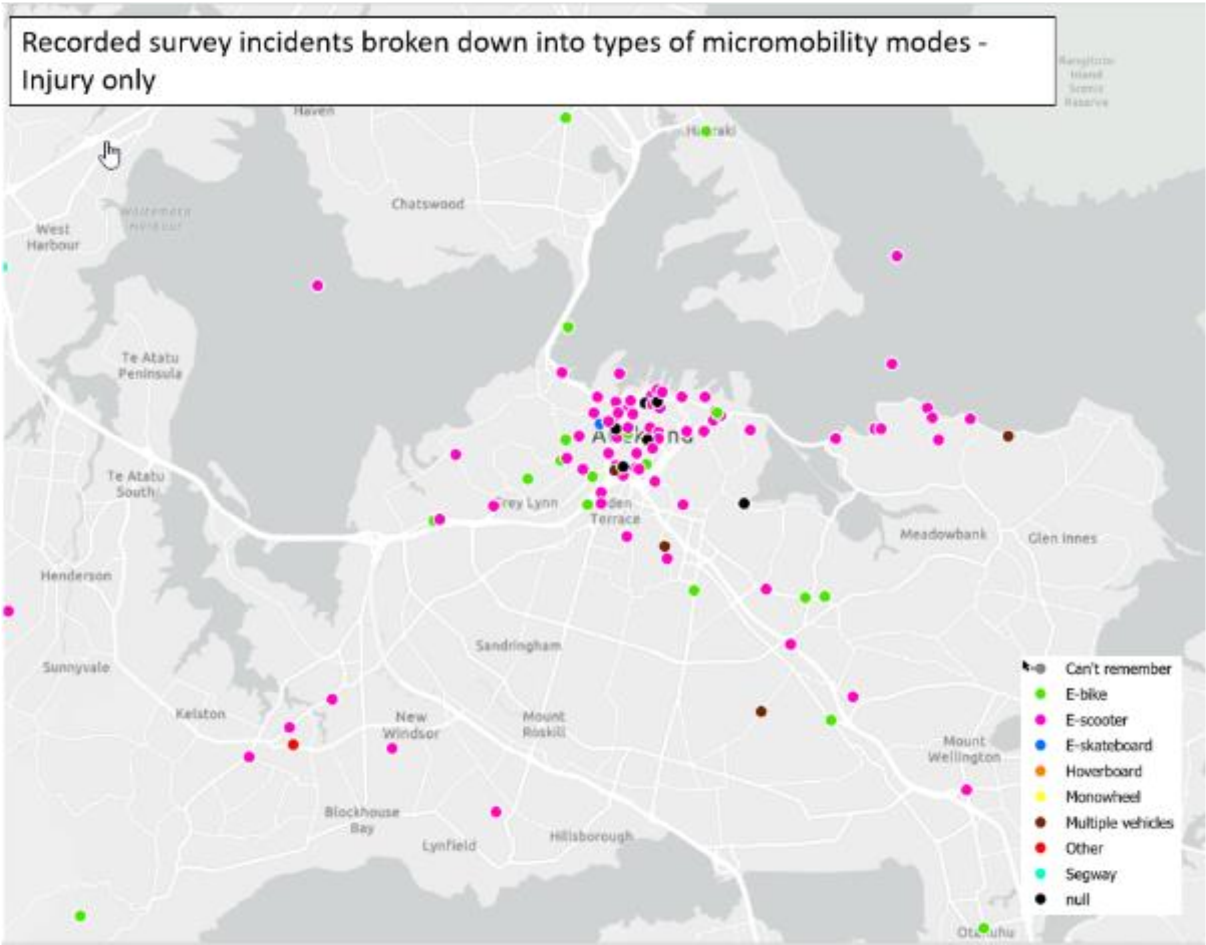


Figure 6.20 Map of survey incidents broken down into types of micromobility modes (Auckland city) - Injury only

Looking at the city centre, it is also interesting to see that there is a cluster of crashes within a relatively large radius around Britomart. This is likely due to a combination of factors such as the high volume of vehicle movements, high pedestrian movements and multiple roadside objects. When considering geographically smaller clusters, there is also one at the intersection of Nelson street and Fanshawe street. There is another at the intersection of Albert Street and Customs Street West. More investigation could be undertaken to better understand why these specific locations have relatively more injury incidents.

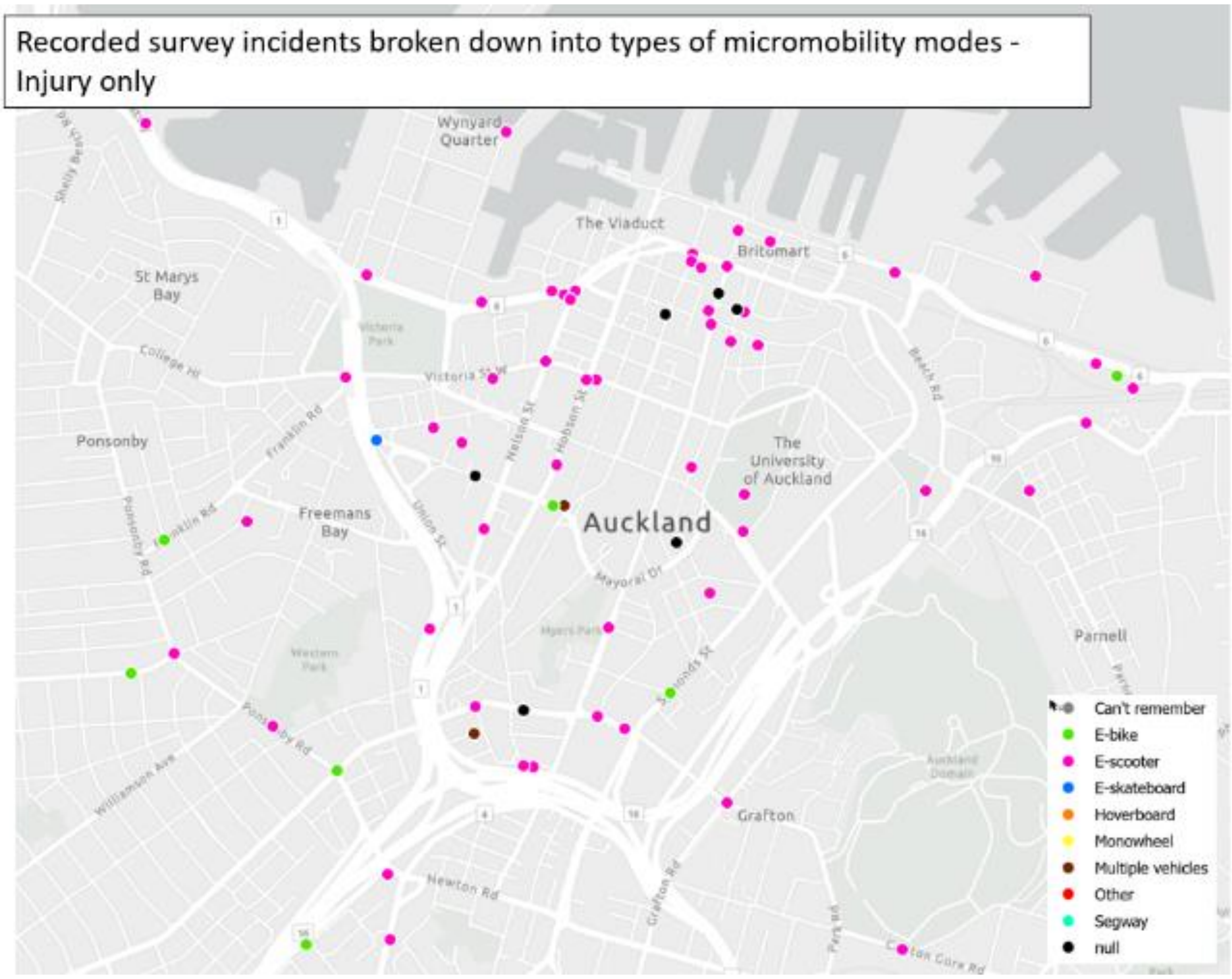


Figure 6.21 Map of survey incidents broken down into types of micromobility modes (Auckland city centre) - Injury only

Incidents broken down into main causes

Figure 6.22 shows the main causes recorded in the survey. These have been grouped into:

- behavioural mistakes of the e-rider,
- behaviour of the other road user,
- environmental factors (eg weather, surfacing, construction),
- general mistakes made (where it was unclear who was at fault), and
- specific e-vehicle related issues, such as braking failures or acceleration problems.

This time the map is zoomed in to show the majority of crashes in more detail. A large number of incidents occurred on Queen Street, involving different causes.

Behaviour of either e-riders and other road users seems to be a perceived cause in many incidents, with only a few incidents considered as general mistakes. Streets such as Anzac Avenue and Symonds Street where there are wide footpaths and relatively lower pedestrian volumes, have more incidents reported as general mistakes, whereas lower Queen Street has a higher number of behaviour related incidents. This could be due to perceptions regarding where e-scooters are integrating with high pedestrian traffic, with higher behaviour concerns where pedestrian volumes are high. Alternatively, the gradients on Anzac Avenue and Symonds Street may allow e-riders to travel at higher speeds and lead to higher consequences in case of mistakes.

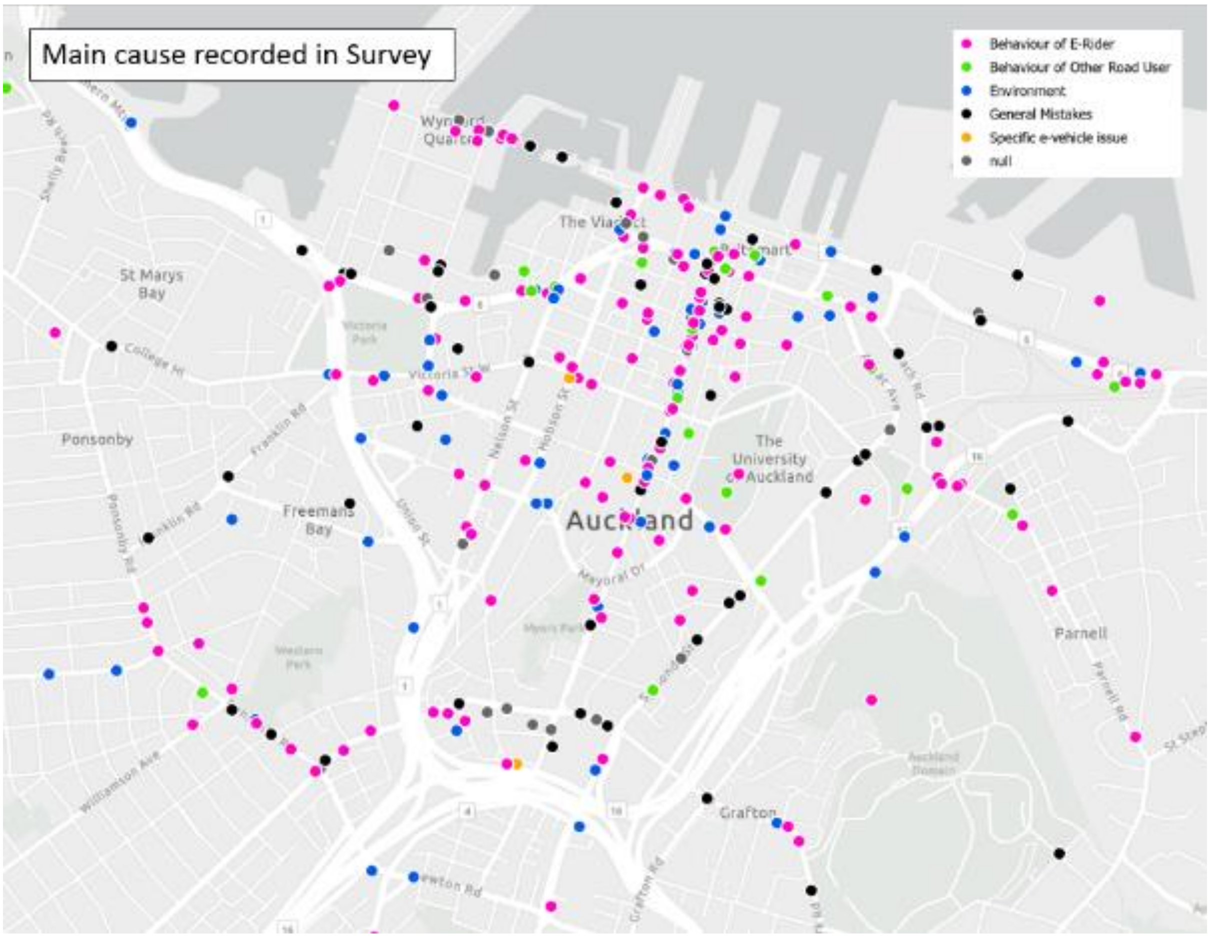


Figure 6.22 Map of main cause recorded in Survey (Auckland city centre)

Figure 6.23 shows a map of the main causes recorded in the survey that resulted in an injury being sustained. When non-injury incidents are removed, Queen Street becomes far less of a hot spot for incidents. This indicates that, while this kind of enviroment with high pedestrian demand results in a high number of conflicts, these conflicts do not necessarily result in injuries. Figure 6.26 shows that injury incidents on Queen Street tend to occur on footpaths, so the risk may occur be mitigated by lower speeds due to the high volume of pedestrians.

When the main causes of crashes are considered, at least in the city centre, environmental effects do seem to play a more significant role in injury incidents when compared to all incidents.

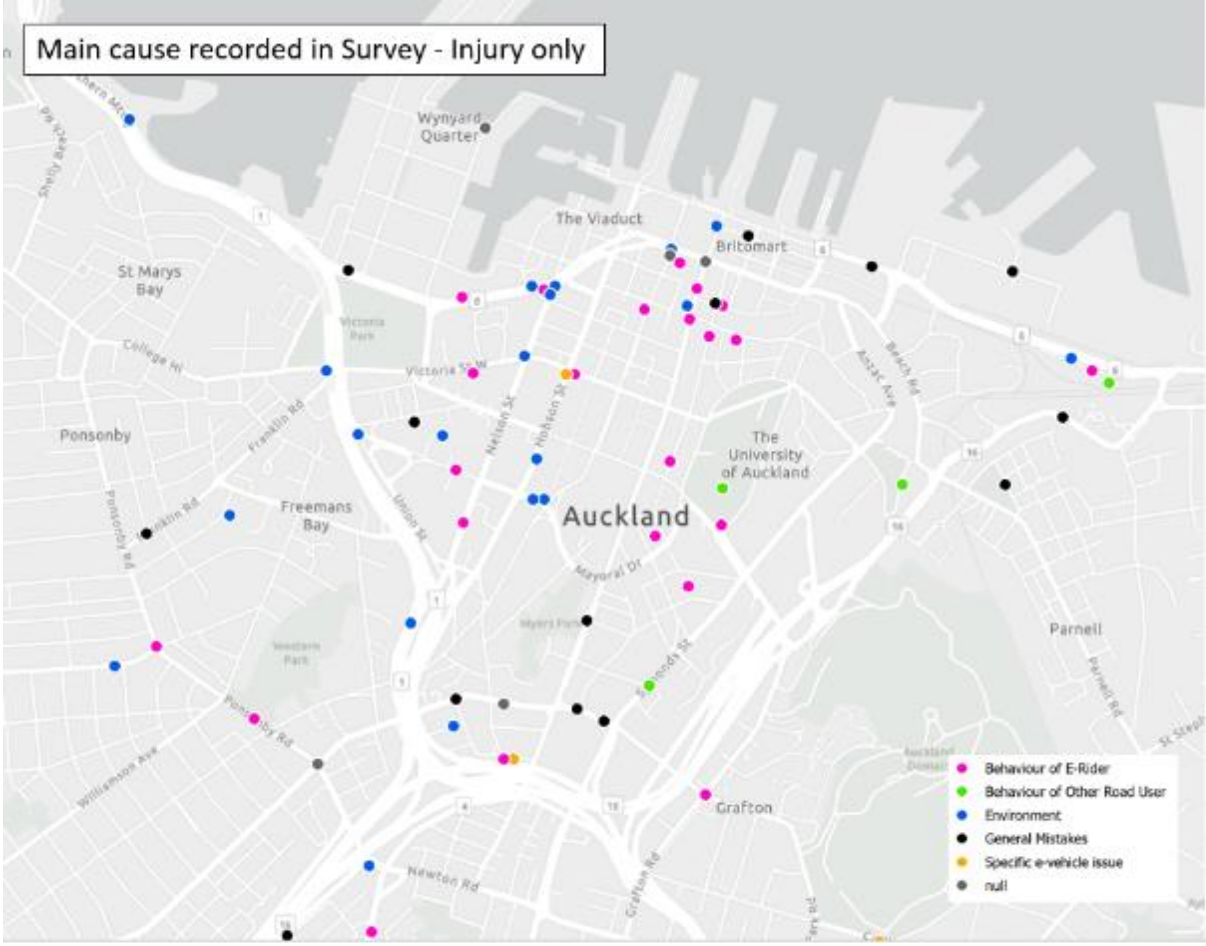


Figure 6.23 Map of main cause recorded in Survey (Auckland city centre) - Injury only

Incidents were surface quality was recorded as a main cause

To interrogate this information futher, only incidents where bumpy or uneven surfaces were recorded as a cause of the incident were plotted. This was done with the intent of identifying any specific location(s) where a cluster of incidents might be occuring, thus indicating where remedial works could be implemented to result risk. **Figure 6.24** belows shows the recorded survey results where bumpy or uneven surfacing was recorded as the main cause of the crash . From the Figure, it can be determined that there is no sigificant cluster of incidents from the survey that have occurred in close proximity.

It is important to note that while poor surfacing may be a cause in some incidents, if clearly visible, it can also lead to slower speeds that might result in lower severity incidents.

Figure 6.24 Map of incidents where the main cause was recorded as bumpy or uneven surfacing (Auckland city centre)

On-road and off road incident comparison

To gain an understanding of how micromobility incidents relate to road classification, the location of injury points (i.e. the infrastructure used at the time of the incident) was overlaid on the road classification. **Figure 6.25** shows the outcome.

It can be seen from the Figure that many injuries are happening on higher classification roads.

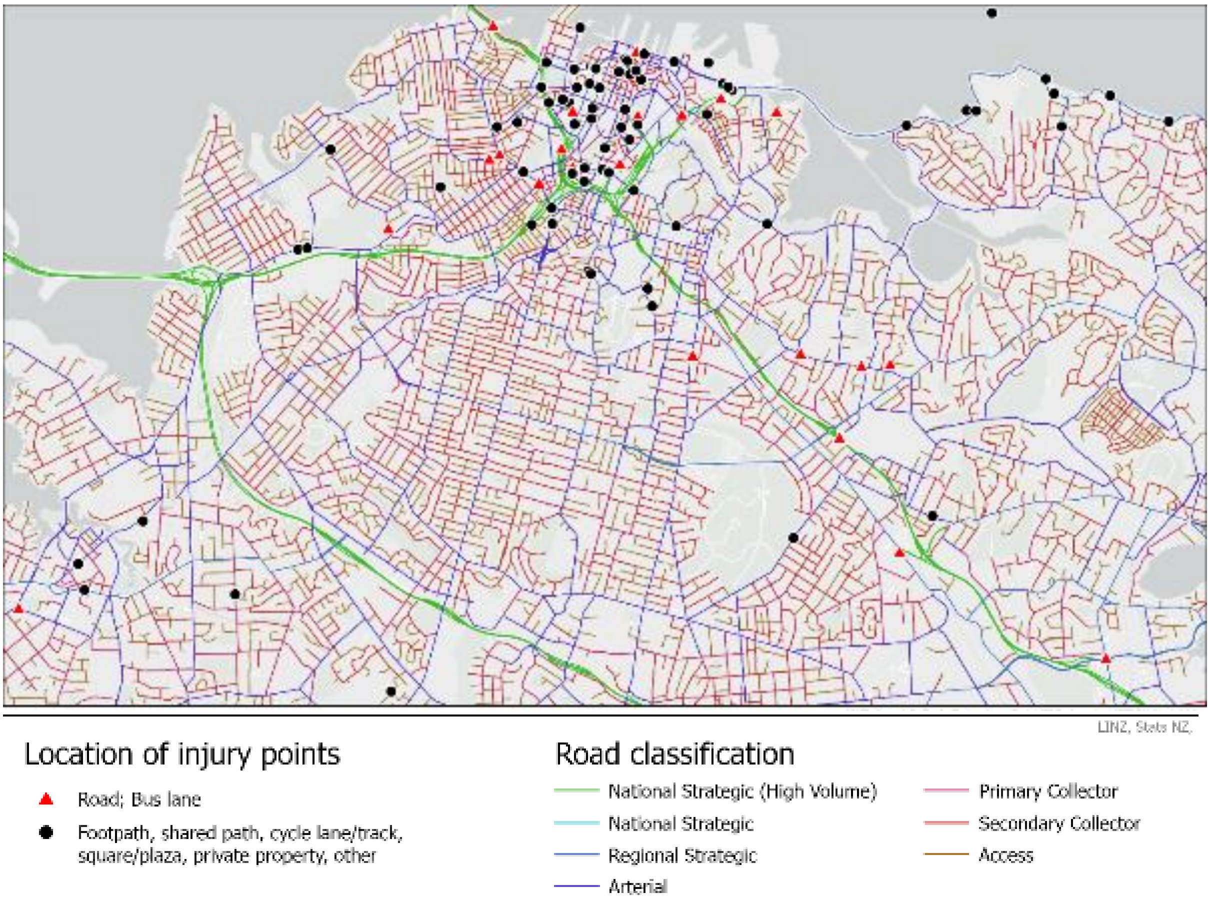


Figure 6.25 Map of on road and off road incidents (Auckland city) - Injury only

As the map is zoomed in, **Figure 6.26** shows this relationship more clearly, with the many off road and on-road incidents that resulted in injury occuring on higher classification roads. From these images, it is also clear that signicantly more injury incidents are resulting off-road rather than on-road. While theoretically, VRU collisions with vehicles are more likely to be severe, this data is not indicating that this is the case. This is likely due to the high amount of footpath use in the city centre rather than road use, combined with the fact that though these are injury incidents, the severity of the injury is unknown. Thus, despite the low number of on-road injuries recorded in the survey, the survey doesn't prove where the highest severity incidents are likely to occur.

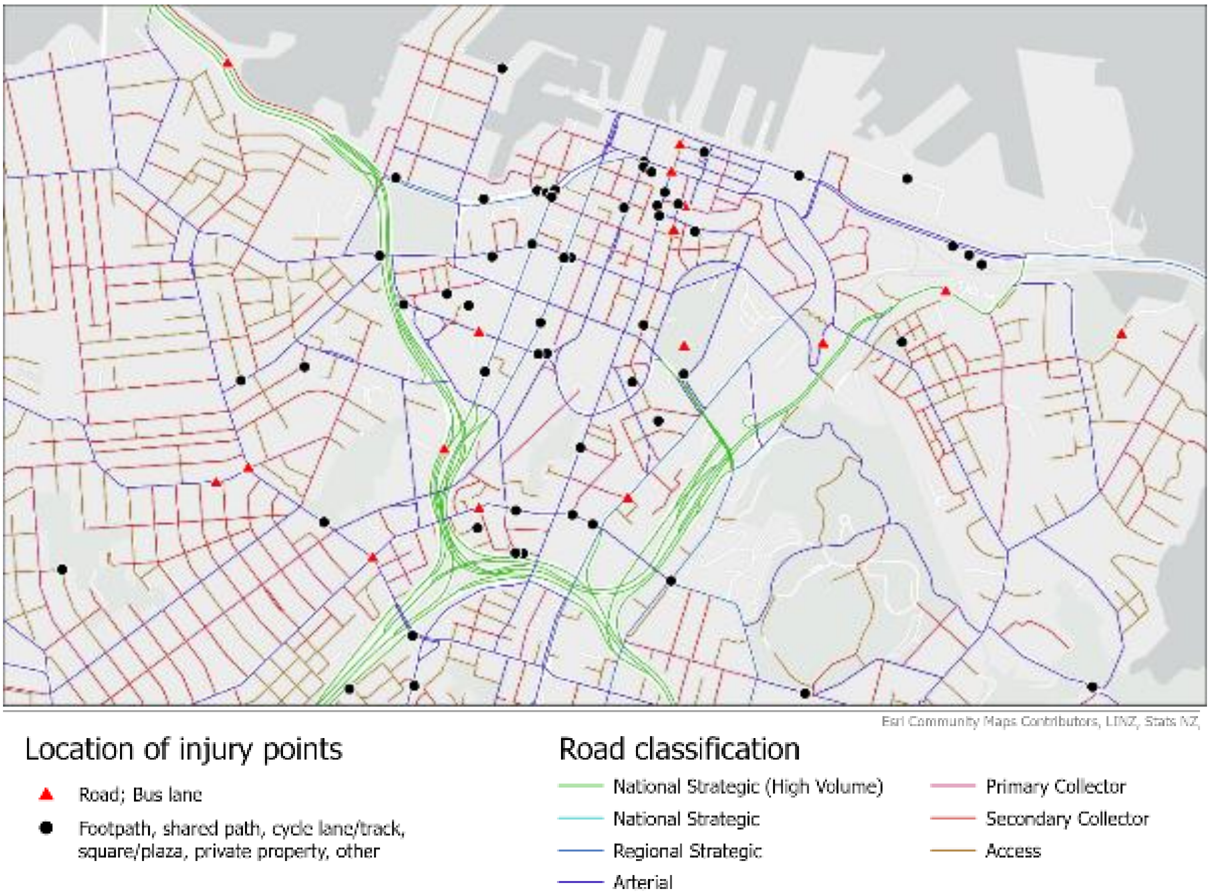
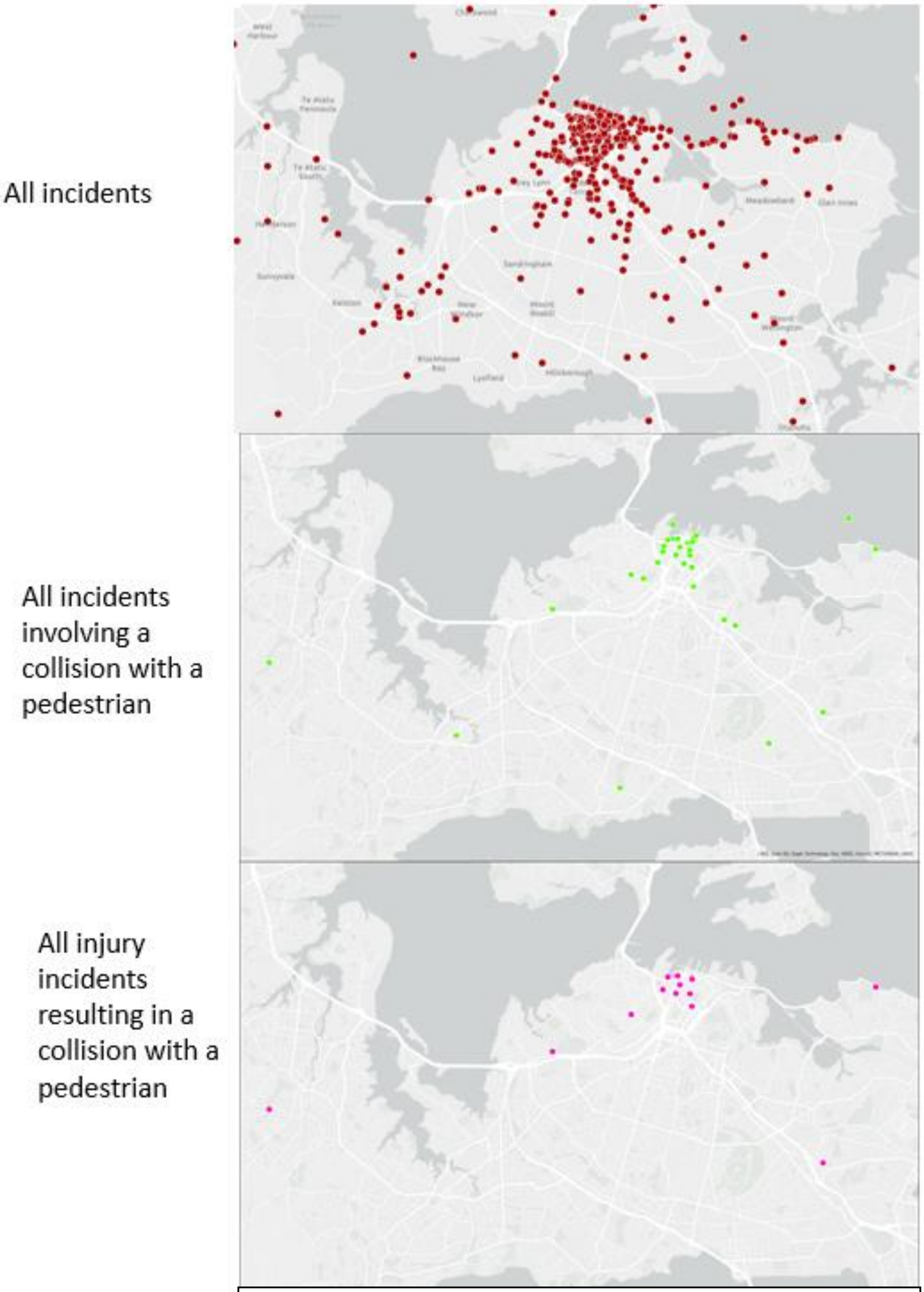


Figure 6.26 Map of on road and off-road incidents (Auckland city) - Injury only

Pedestrian Micromobility Collisions - Incident Comparison

Figure 6.27 illustrates the volume of micromobility pedestrian collision incidents and their locations in comparison with all incidents recorded. While pedestrian collisions represent a small proportion of total incidents recorded, around 50% of these collisions result in injury. Injury incidents are clustered in the city centre, but occur across the city, indicating that injury collisions with pedestrians are not restricted to high pedestrian volume areas.



All incidents

All incidents involving a collision with a pedestrian

All injury incidents resulting in a collision with a pedestrian

Esri Community Maps Contributors, LINZ, Stats NZ, Eagle Technology, Esri, HERE, Garmin, METI/NASA, USGS

Figure 6.27 Pedestrian collision incidents compared to all incidents

Micromobility timeline

While the geospatial information provides interesting insights, it is also important to look back at the context of micromobility alongside the survey data. This context has been evolving and changing in Auckland due to improving regulation, new trials and the effects of Covid.

As a lot of the changes including the introduction of the low-speed zone (refer **Figure 2.2**) have primarily affected Auckland Central, this was the main area considered in this stage of the analysis. **Figure 6.28** shows the number of incidents in Auckland Central, not including near misses, where the date of the incident was entered by the respondent. It also shows the volume of hired e-scooters and e-bikes available in Auckland.

Unfortunately, due to the limited data available to this specific search the information was not considered to be statistically significant and no comprehensive findings could be made, although it demonstrates that there is a recency bias with a spike in remembered incidents from November 2020 onwards, suggesting that earlier incidents may have been forgotten.

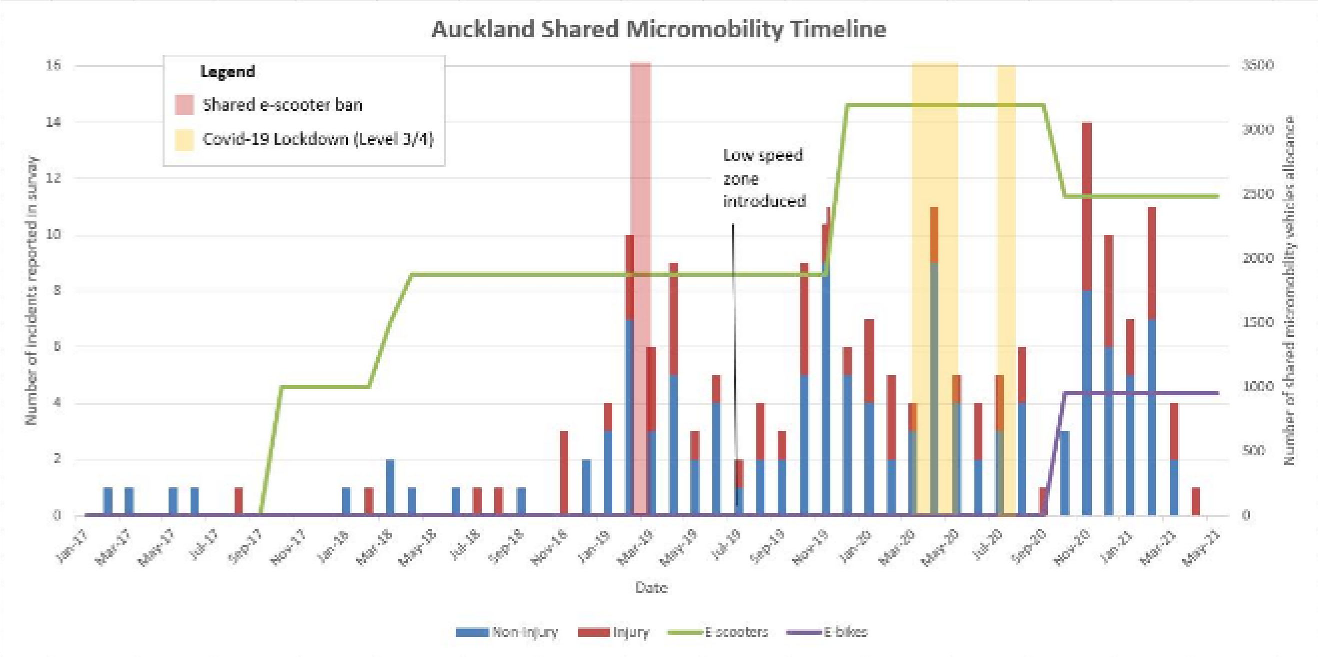


Figure 6.28 Auckland Central Shared Micromobility injury timeline

High level overview

The result of the report highlights a tension between micromobility riders and other road users. Kantar reported that e-scooters are the most common target of this irritation (as noted from verbatim comments) and are overrepresented in incident statistics. While usage is similar between e-scooters and e-bikes, e-scooters made up 79% of the incidents reported in this research. One in three reported collisions resulted in injury, and around half of those result in time off work.

Solutions appear to fall into two main areas – changes to infrastructure and improving e-scooter rider behaviour.

Infrastructure

Many incidents are a result of poor surfaces (uneven, slippery), moving between types of infrastructure and a lack of places for micromobility riders to safely ride, especially when pedestrian traffic is high at busy times of the day. E-scooters in particular struggle to find places to safely ride, where they are separated from both motor vehicles and pedestrians. They tend to default to the footpath, as they feel it is the safest place, but this can result in collisions and near misses with pedestrians and non-moving objects.

Improving e-scooter rider behaviour

E-scooter riders are over-represented among younger males, and this reflects in the high number of incidents involving younger males, however, there is no evidence that young males are over-represented in crashes when factoring how much they use e-scooters.

Survey results provide limited subjective evidence of behaviours which may increase risk, such as double riding, low helmet use, and limited experience of the rider, although there is no evidence that such behaviours are leading to increased crash risk. Additional policing and education could be considered to help address the behaviour issues at play. Two thirds of e-scooters involved in these incidents were rented, so rental companies could also be included in solutions.

Key insights

The survey results lead to some interesting findings. Combined with the other data sources these findings help to tell a story around micromobility safety. Some of the key insights that came from the survey are as follows:

- The majority of reported incidents include e-scooters, rather than other micromobility vehicles – generally shared use e-scooters.
- When including near misses, incidents involving micromobility vehicles with other road users are the most commonly reported, and these are generally with pedestrians (60%), although cars were also involved in around a third.
- When excluding near misses, falls represent half of all incidents, with a further quarter involving a collision with a non-moving object. Collisions with other road users represent around a quarter of all incidents.
- Although relatively fewer, incidents involving non-moving objects are usually with a permanent street object (51%).
- The footpath is the most common place for an incident (both a crash or a near miss) involving an e-scooter to occur. Incidents involving e-bikes are more likely to happen on the road.
- Collisions and falls often occur when moving between different types of infrastructure, for example from a footpath to the road.
- While most incidents occurred in the daytime, on sunny days, which is likely to reflect general usage on those days, collisions especially between e-mobility vehicles and non-moving objects occur more often in partial light and in wet conditions
- 50% of crashes involving pedestrians are likely to result in injury, and of these injuries, 50% resulted in time off work.
- Incidents involving e-bikes were generally reported on privately owned vehicles with users who were experienced – 60% of e-bike incidents reported involved riders who had ridden more than 100 times.
- Half of the incidents involving e-scooter riders occurred within their first ten rides.

7. Interest Groups Feedback

A number of interest groups were approached as part of the process of promoting the survey. Each of them was asked to distribute the survey to their users, and if they wished to provide feedback on micromobility they were invited to do so. The organisations approached were:

- Blind and Low Vision Foundation
- CCS Disability Action
- Living Streets Aotearoa
- Bike Auckland
- Heart of the City
- Greater Auckland
- Waka Kotahi

To assist with feedback, the organisations were supplied with the following questions:

1. Do you see e-micromobility pose a greater safety threat to users and/or non-users than non-powered mobility devices? If so, to what extent and why?
2. What do you see as being the key differences between hired and privately owned micromobility vehicles from a safety standpoint? Do you see one type as being safer than the other, and why?
3. Notwithstanding potential/upcoming regulatory changes from the Ministry of Transport, what is your position on micromobility riders using the footpath? Feel free to differentiate types of micromobility in your answer.
4. Notwithstanding potential/upcoming regulatory changes from the Ministry of Transport, what is your position on micromobility riders using cycle lanes/tracks? Feel free to differentiate types of micromobility in your answer.
5. Which interventions or policies do you think would improve the safety of micromobility in Auckland the most, both for riders and non-riders?
6. Is there anything else you would like to point out?

Responses were received from Blind and Low Vision NZ, CCS Disability Action and Bike Auckland. These are summarised below and provided at Appendix D.

Bike Auckland

- Where micromobility mixes with heavy vehicle traffic, small mistakes can be fatal. This is the greatest safety threat to micromobility users.
- Differences in rider behaviour between a cautious beginner and a confident experienced rider may be negligible.
- Where other safe, suitable infrastructure is not available and usable, tolerating the use of the footpath may be the safest option for micromobility users.
- Formal speed limits on footpaths may cause resources to be wasted attempting to check and control speeds.
- Micromobility can share cycle lanes and tracks.
- Separated infrastructure is the greatest priority to enhancing safety.

Blind and Low Vision NZ

Blind and Low Vision NZ supplied their submission on the Accessible Streets Regulatory Package. The comments pertinent to this consultation include:

- Active modes are supported but not at the detriment of the safety and confidence of other footpath users.

- Footpaths should be prioritised as safe and accessible for pedestrians.
- 15km/hr is too fast for people to be travelling on footpaths: 5km/hr is more appropriate
- E-scooters should be kept off footpaths and shared paths.
- Enabling transport devices to use cycle lanes and cycle paths is supported.
- The installation of physically separated cycle paths are supported
- Shared paths are not supported. Physically detectable separation between pedestrians and users of wheeled recreation vehicles should be provided.

CCS Disability Action

Personal views of a respondent were supplied, which were clarified to not be representative of an official position.

- Familiarity of user is likely to enhance safety.
- Where cycleways exist, e-scooters and other micromobility devices that can achieve similar speeds to bicycles and e-bikes should use them.
- E scooters should use footpaths but with speeds 10km/hr or less.
- Suggestion that sensors on micromobility devices could control speed of users in congested environments.

8. X-Kemm-X Modelling

8.1 KEMM Risk Relationships for Unprotected Road Users

In this analysis kinetic energy modelling methods have been used, and relationships developed, to understand the link between relative speeds of different road users and the potential for a serious injury or fatal crash (FSI) occurring, when a collision does occur. This analysis is built on work undertaken by the Monash University Accident Research Centre (MUARC) in kinetic energy modelling of road collisions.

The initial work undertaken by MUARC in this field considered the kinetic energy transfer and associated probability of a FSI crash associated with two motor vehicles colliding at an intersection with different operating speeds. More recently this work has looked at collisions between motor-vehicles and VRUs, including cyclists and pedestrians. Building on this work, in this study MUARC has considered different types of road users and collisions, including a proxy for e-scooters 'moving pedestrians' and pedestrians, and collisions between VRUs.

This work commenced with a literature review to identify what current research is available to help inform the risk relationships (see Appendix E for details on the literature assessed). Previous work in this area has identified a scarcity of studies explicitly examining these risk relationships. For some modes of transport, like e-scooter and e-bikes this is partly due to relatively recent emergence of these modes in sufficient numbers to examine the risk relationships. Despite this being the case three risk models have been developed for looking at various crash types, being.

1. Car versus pedestrian
2. Car versus two-wheelers
3. Two-wheeler versus pedestrian

Details on the model forms are provided in Appendix E. Based on the limited research it is not possible to go into the level of detail of road user types that we would like at this stage. Instead, more generalised relationships are produced that can be used to inform the desired maximum speeds and appropriate sharing of infrastructure that should be encouraged in Auckland. This has been used to inform the risk management framework. As safety research progresses in the field of micromobility and other assisted devices this approach could be revisited to provide more insight on how to safely accommodate emerging transport modes.An excel worksheet has been developed for each of the three models, to identify the probability that a collision will be a fatal or serious injury crash for various speeds

8.2 Model 1 – Car versus Pedestrian

Figure 8.1 shows the application of Model 1 considered to represent the risk between cars and pedestrians. In the example the pedestrian age is assumed to be 15 to 59 years of age (i.e. excludes young people and elderly that have elevated risk levels). The collision is with a standard car. Crashes involving trucks and buses are much more likely to lead to serious or fatal injuries. The Figure shows that while the probability of a death is still relatively low at 50km/h, at 10%, that the probability of a serious injury is relatively high (70%).

We appreciate these results do differ from some of the other risk relationships that appear in safe system documentation, which show a higher probability of a fatality. MUARC's models refer to more recent research that shows fatalities level are lower at 50km/h for average pedestrians and light vehicles. For the young, elderly and for crashes involving larger vehicle the risks of death at 50km/h are much higher.

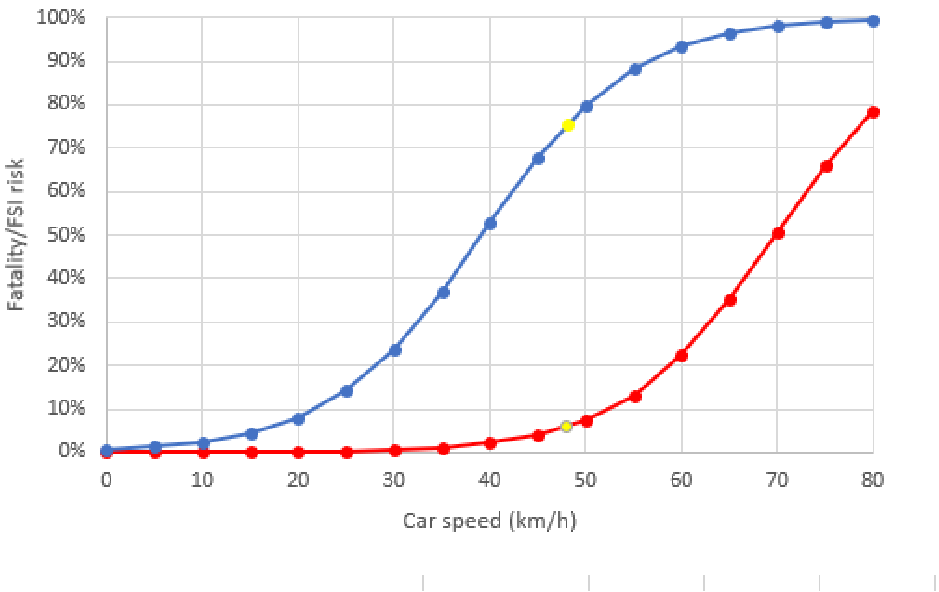
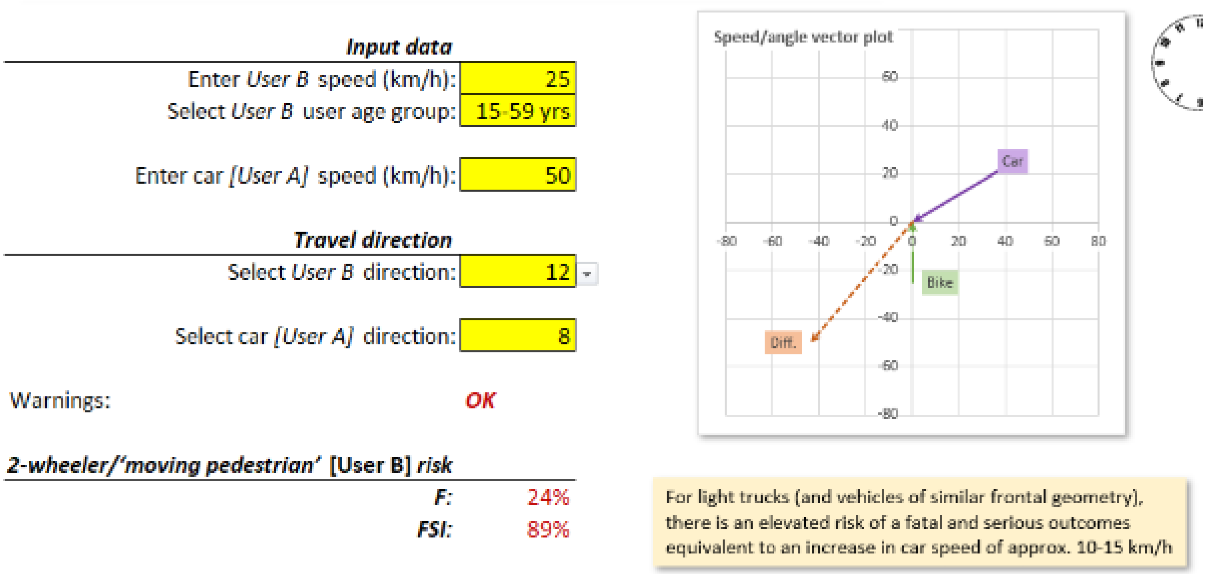


Figure 8.1 Probability of a Pedestrian fatality or serious injury for a given car speed. Red is fatality risk and blue is fatal and serious injury risk.

8.3 Model 2 – Car versus two-wheelers

Figure 8.2 shows the speed and angle variables that are key predictors in the level of crash severity in a collision involving a car and a two-wheeler, be it a bike, e-bike or moving pedestrian (e.g. pedestrian on a scooter). While there are subtle differences between crashes involving these modes, at this point in time separate models cannot be developed by mode types. In this example the speed of the two-wheeler is 25km/h and the car's is 50km/h. The angle that each user approaches the conflict point is based on the point on a clock. So, the two-wheeler is coming from 12 o'clock and the car from 8 o'clock. For this combination of speed and impact angles, for an average pedestrian, the risk of death is 24% and for death or serious injury (FSI) is 89%.



Input data

Enter *User B* speed (km/h): 25
Select *User B* user age group: 15-59 yrs

Enter car *[User A]* speed (km/h): 50

Travel direction

Select *User B* direction: 12

Select car *[User A]* direction: 8

Warnings: *OK*

2-wheeler/'moving pedestrian'* [User B] *risk

F: 24%
FSI: 89%

For light trucks (and vehicles of similar frontal geometry), there is an elevated risk of a fatal and serious outcomes equivalent to an increase in car speed of approx. 10-15 km/h

Figure 8.2 Probability of a two-wheeler being killed or seriously injured for a given speed of the two road users and impact angle.

Table 8.1 Theoretical probability of fatality or serious + fatal crash risk for a given two-wheeler and car speed, for the given angles and average pedestrians.

Fatal Risk %						
	Bike Speed					
Car speed	**5**	**10**	**15**	**20**	**25**	**30**
30	1	1	1	2	3	5
40	3	3	5	7	10	14
50	9	11	14	19	24	30
60	26	30	35	41	47	52
70	55	60	64	67	70	73
FSI Risk %						
	Bike Speed					
Car speed	**5**	**10**	**15**	**20**	**25**	**30**
30	28	33	39	45	51	56
40	57	62	66	70	73	75
50	83	85	87	88	89	90
60	94	95	96	96	96	97
70	98	99	99	99	99	99

Figure 8.1 shows that the speed of the car is the key determinant in the severity of the collision. It indicates that 30km/h or lower operating speeds are the safest for two-wheelers, including bikes and e-scooters. At low speeds of the two-wheelers (under 15km/h) 40km/h vehicle operating speeds still have low fatality risk, but the severe crash risk is much higher. This result is for a given impact angle between the road users and so these results will differ for other collision types. These are just theoretical results that provide some level of guidance on appropriate speed limits when these road user types are mixing (i.e. do not have separate facilities).

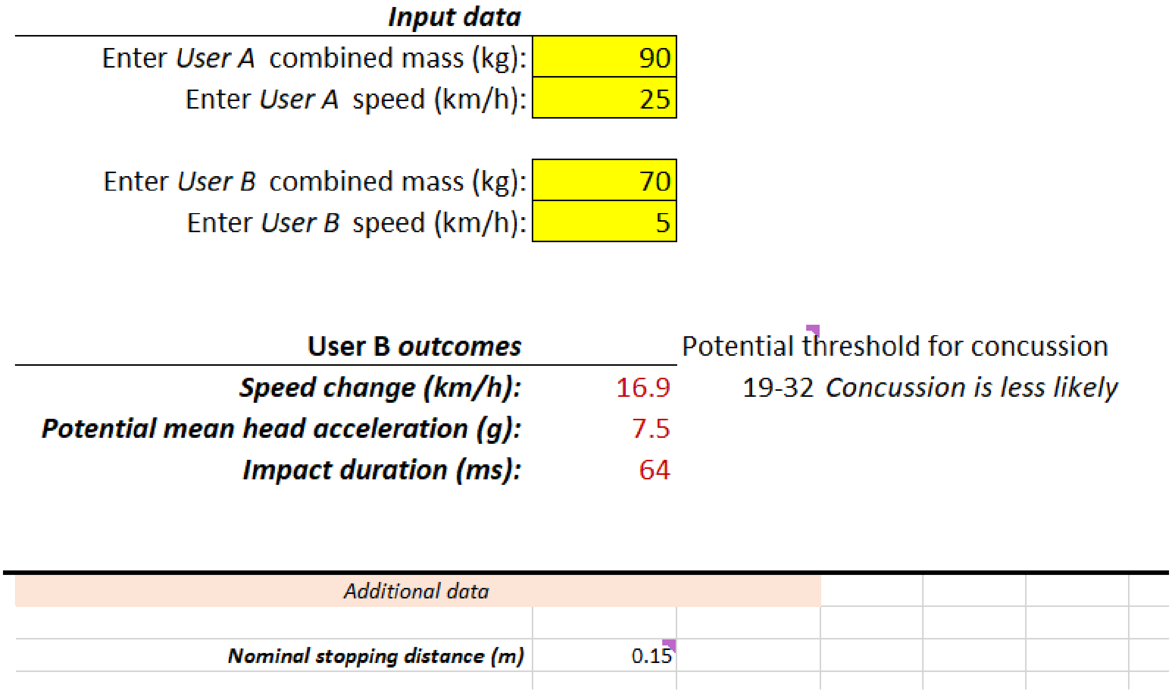
8.4 Model 3 – Two-Wheelers versus Pedestrians/Moving Pedestrian

The Two-Wheelers versus Pedestrians/Moving Pedestrian model is a concussion model based on speed changes of 19-32 km/h which has been derived from NFL concussion research and an assumed stopping distance of 0.15 m,

Figure 8.3 shows the crash severity calculator that has been developed for collisions between two-wheelers and pedestrians. It considers the mass and speed of each user. The current model does not allow a prediction of the risk of severe or fatal injury, but rather the likelihood of a concussion, with concussion being a surrogate measure for crash severity.

The model indicates that at higher speed the level of concussion is more likely to lead to serious injury or death. In the **Figure 8.3** example, the two-wheeler user (bike or e-scooter) is travelling at 25km/h and the pedestrian (user B) is travelling at 5km/h. The overall weight of the two-wheeler including the bike/scooter is 90kg and the pedestrian 70kg. For this impact speed (just under 17km/h) the risk of concussion for the pedestrian (user B) is considered to be low assuming typical pedestrians or bike riders. If the pedestrian were elderly, then this risk of concussion may be higher and hence the risk of serious injury or death higher.

Note that concussion can occur at very low speeds and this analysis just indicates when that risk of concussion is more likely.



Input data

Enter *User A* combined mass (kg): 90
Enter *User A* speed (km/h): 25

Enter *User B* combined mass (kg): 70
Enter *User B* speed (km/h): 5

User B *outcomes*
Speed change (km/h): 16.9
Potential mean head acceleration (g): 7.5
Impact duration (ms): 64

Potential threshold for concussion
19-32 *Concussion is less likely*

Additional data
Nominal stopping distance (m) 0.15

Figure 8.3 Likelihood of a pedestrian having concussion as a result of a collision with an e-scooter, bike or fast moving pedestrian (e.g. runner).

Table 8.2 Theoretical speed change for a collision between a two-wheeler and a pedestrian

Speed change						
	Pedestrian speed (up to jogger)					
Device Speed	**2**	**5**	**8**	**10**	**12**	**15**
5	4	6	7	8	10	11
10	7	8	10	11	12	14
15	10	11	13	14	15	17
20	12	14	16	17	18	20
25	15	17	19	20	21	23
30	18	20	21	23	24	25

Table 8.2 shows the range of speeds over which the impact speed is highly likely to cause a concussion, being above 19km/h for average weight pedestrians (around 70kg) plus a device (bike or e-scooter) with a weight of 20kg. The shaded cells indicate where a critical speed change for severe concussion is 19km/h or higher. Note the lighter person is more likely to experience the speed change. Bike and e-scooter speeds below 20km/h tend to have a low likelihood of concussion and hence severe injury to the pedestrian. Even bike and e-scooter speeds of around 20km/h are acceptable in respect to risk of concussion, except at high end speeds of pedestrian movement (e.g. joggers or also on a device like a e-scooter).

Limitations

This model relates only to the likelihood of concussion as a result of collision impact. As noted above even low speed collisions can lead to concussion and may also cause other serious injury. In addition, a collision may have the knock-on impact of a fall, the result of which could also be serious injury. There is insufficient data to model the concussion or injury impact of a fall.

9. Video Analysis

9.1 Micromobility Count data

Auckland Transport have fixed video cameras in certain locations around Auckland City. Five of these camera locations were identified as being suitable for carrying out video analysis to identify micromobility device usage and certain characteristics of the use.

The counts looked at video recordings over just under 90 hours, featuring, in each location, data relating to the AM peak (7.30-9am), interpeak (10-11am), and PM peak (4-6pm) for both a weekday and weekend. This count looked at five different locations: Grafton Bridge, Tamaki Drive, Queen Street, Beach Road and Dominion Road. These locations are illustrated in **Figure 9.1**.

Figure 9.1 Camera Locations - Video Analysis

Each location was selected as it offered different features and potential choices for the micromobility user in terms of road positioning.

Grafton Bridge

Includes footpath and roadway (bus/bike lane). Footpath widths are below 2m and pedestrian traffic is heavy.

Tamaki Drive

Includes segregated off-road cycleway and roadway. Pedestrian traffic is light to moderate.

Queen Street

Includes footpaths, temporary extended footpath/bus lane and road. Footpath widths are generous and pedestrian traffic is heavy.

Beach Road

Includes segregated cycle lanes, unsegregated on road cycle lanes, footpaths and roadway. Pedestrian traffic is light to moderate.

Dominion Road

Includes bus lanes, footpaths and roadway. Pedestrian traffic is light to moderate.

The methodology for this count was to record five different aspects every time a micromobility device was spotted as follows:

- Micromobility mode
- Infrastructure used (i.e. footpath, cycle path, roadway, etc)
- Hired or privately owned device
- Helmet use
- Riders on device.

These data were then aggregated and analysed to provide insight to the following questions:

- How does available infrastructure affect user behaviour?
- Do different micromobility modes act differently?
- How do e-powered bikes compare to push bikes?
- Does behaviour differ at different times of day?
- How does owned vs rental e-scooter use differ?
- Do e-scooters use infrastructure they are not supposed to?
- How does width of footpath affect behaviour?
- How does behaviour and infrastructure relate to safety?

As riders could transition between different infrastructure, a virtual line was drawn determining where the count would take place. When the device crossed this line, it was counted. If the device did not cross this line at all it was not counted.

The results of the video count can be found in Appendix F.

Data Limitations

Where possible the details listed above were recorded. A summary of the total numbers recorded is provided in **Table 9.1**. However, due to the resolution of the videos, it was not possible to identify the following details consistently:

- Riders on device
- Helmet use
- Hired or privately owned device
- E bike or bicycle.

Table 9.1 Total Video Capture by Device and Location

	Site 1	Site 2	Site 3	Site 4	Site 5	All sites	
Device	**Grafton Bridge**	**Queen Street**	**Tamaki Drive**	**Beach Road**	**Dominion Road**	**Number**	**%**
E-bike	249	38	87	129	61	564	15%
E-scooter	194	275	19	243	26	757	20%
Kick scooter	1	1	3	0	109	114	3%

Push Bike	440	142	349	326	0	1257	34%
Unknown Bike	343	66	232	277	59	977	26%
Unknown Device	20	32	5	15	1	73	2%
Total	1247	554	695	990	256	3742	100%

9.2 How does count information relate to safety?

Count information was gathered as it:

- Gives insight into what are the effect of current guidance and legislation on safety. It does this by indicating where micromobility and non-powered mobility device users are located in the road environment, and where visible, helmet use.
- Provides insight into infrastructure geometry and design requirements by showing the effect of different designs on road user choices
- Helps indicate how the risk of different micromobility modes compares with each other. One of the key elements of risk is exposure. The more users of a micromobility device the more likely crashes will occur relating to this device. This will also later be compared to the number of injuries related to different modes to get an idea of the individual risk to a person of riding a given micromobility mode.

9.3 How does available infrastructure and footpath width affect user behaviour?

E Scooters

Looking at the video footage data, on Grafton Bridge, where there is a footpath of around 1.8m width and heavy pedestrian demand, only 18% of e-scooter riders used the footpath. On Queen Street on the other hand, where there is similarly high pedestrian demand but a wider footpath, 80% of e-scooter riders used the footpath or temporary extended footpath. This is consistent on Beach Road where the footpath is also wide: 76% of e-scooter riders at this location used the footpath or off-road cycle lane.

On Dominion Road and Tamaki Drive, where speed limits were 50km/h, the road width could be considered medium and pedestrian volumes light to moderate. 65% and 80% of e-scooter riders respectively used the footpath.

Though this count data is limited, it indicates that there is a large increase of e-scooter uptake on the footpath when the width increases from narrow to medium. The change is less significant however when the width of the footpath is increased further.

E bikes

When considering e-bikes, on Grafton Bridge less than 1% used the footpath. On the wider footpaths on Queen Street and Beach Road 37% and 89% of e-cyclists used the footpath, temporary extended footpath or cycle lane respectively. The reason for the much higher use of the off-road infrastructure on Beach Road seems to be that e-cyclists are more comfortable using the off road cycle lane rather than the temporary extended footpath. 85% of e-cyclists used the cycle lane on Beach Road and only 29% of e-cyclists used the temporary extended footpath on Queen Street.

Overall, available infrastructure significantly impacts whether both e-scooterists and e-cyclists use on-road or off-road facilities. Locations with wider footpaths lead to higher uptake of footpath use by e-scooterists.

9.4 How do e- bikes compare to bikes?

Looking at the infrastructure used by bikes and e-bikes in the video surveys, they have very similar results. On Grafton Bridge over 99% of e-bikes and over 99% of bikes travelled on the road. On Queen Street 60% of bikes and 63% of e-bikes travelled on the road, while 15% bicycles and 8% of e-bikes travelled on the footpath. The remainder used bus lanes. On Tamaki Drive, 34% of bikes and 31% of e-bikes travelled on the delineated footpath. At the same location, 39% of bikes and 37% of e-bikes travelled on the road. At Beach Road, 84% of bikes and 92% of e-bikes travelled in the off-road cycle lane. Finally on Dominion Road, 84% of bikes and 86% of e-bikes travelled in the bus lane.

E-scooters and e-bikes use very different forms of infrastructure. On Queen Street for example, while 63% of e-bikes travelled on the road, only 20% of e-scooters travelled on the road.

9.5 How does owned vs rental e-scooter use differ?

It should be noted that in many cases the video resolution was insufficient to conclusively determine whether e-scooters were rented or privately owned. However, **Figure 9.2**, which aggregates information across all video data sites, shows that there is a clear difference between hired e-scooters and privately owned e-scooter positioning where it was possible to differentiate them. While 64% of privately owned e-scooter riders positioned themselves on road, only 15% of hired (shared use) e-scooters positioned themselves on the road with the majority (61%) positioning themselves on the footpath.

One reason for this could be that hired users have had less practice on e-scooters and therefore feel safer off road. Alternatively, the slow speed zones that are in place for the shared use e-scooters could restricts their speed such that they do not feel comfortable on the road, where there will be a speed differential between them and other road users. Privately owned e-scooters are not subjected to speed restrictions and the speed differential between them and other road users may be less significant.

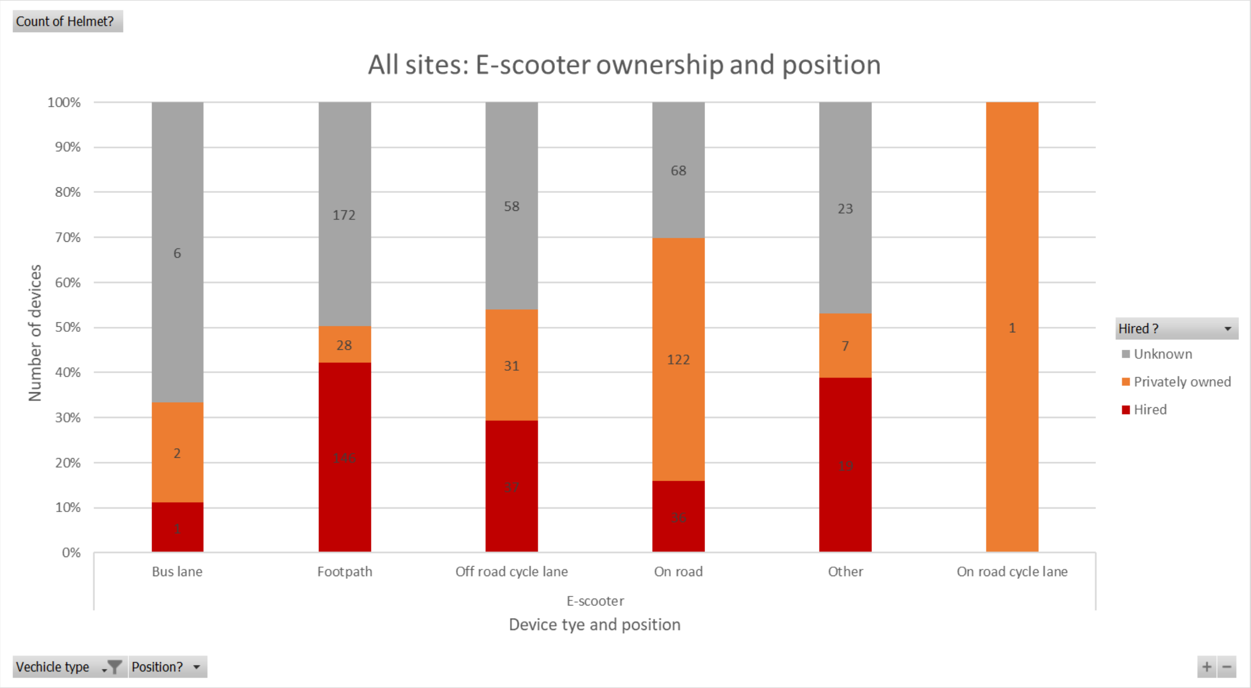


Figure 9.2 Aggregated E scooter usage across all video sites

9.6 Do e-scooters use infrastructure they are not supposed to?

The website of Waka Kotahi states:

"E-scooters can be used on the footpath or the road – except in designated cycle lanes that are part of the road (which were designed for the sole use of cyclists)." (https://www.nzta.govt.nz/vehicles/vehicle-types/low-powered-vehicles/, NZTA

In our limited sample, this rule, relating to on-road cycle lanes, seems to have been followed. Out of the 5 video count sites, Tamaki Drive and Beach Road had on-road cycle lanes. It was found that only one e-scooter rider at Tamaki Drive, out of 19 was using this on-road cycle lane. At Beach Road, one e-scooter rider used the on-road cycle lane of a total of 243 e-scooters recorded.

9.7 Variation by Time of Day/Time of Week

The data across all sites clearly shows significantly higher usage during weekdays as opposed to weekends with no significant differences by type of vehicle. Evening peaks show slightly higher volumes than morning peaks across all modes.

10. Crash Statistics

Data has been collected and analysed from a multitude of different sources to develop a comprehensive understanding of what current information sources show about micromobility risk. Collision information has been gathered from ACC, hospitalisation data and the Waka Kotahi Crash Analysis System. Additionally, movement data has been collected from micromobility counts that have been carried out at several location within Auckland's central business district (city centre).

10.1 ACC DATA

Purpose

ACC data is a comprehensive data pool that tracks all the injury claims people make to ACC and categorises the information. ACC data is powerful because of the magnitude of data available and because it covers accidents across different transport modes, sports and all other activities that could end in an injury. All injuries are categorised the same way, this includes categories such as the types of injuries that were experienced, the year in which the injury/ claim occurred and the age of the person that received the injury.

Though the literature review indicates a strong concern from the public, the actual safety performance of micromobility modes across the network can only be evaluated using data led methods. ACC data was considered to be important to this study as it provides insight to the number of people getting injured across New Zealand through the use of micromobility modes. This can then be compared to other activities to discuss the level of risks across activities.

This cross-platform categorisation and comparison allows for micromobility risk to be assessed, not emotionally, but instead analytically by taking a data led approach to determine the risk exposure of all similar activities.

A limitation of this data is that, though it can provide the total number of injuries, it cannot determine, without drawing on other sources of data, what the risk per trip, distance travelled or user, is.

Though a multitude of micromobility modes were considered, the majority of the data available was related to e-scooter incidents. This is perhaps unsurprising given that anecdotally e-scooters are currently the dominant micromobility mode used in hire schemes.

Data Gathering Methodology

ACC data was sourced in two different ways.

First, the ACC website: https://www.acc.co.nz/about-us/using-our-claims-data/ was searched and data was pulled from multiple sources from previously made claims. This data was not limited to claims related solely to micromobility and instead covered ACC claims related to sport injuries and other modes of transport.

Secondly, a data request was made to ACC requesting information based on transport and sports injuries.

All data provided was tabulated but not broken down to the personal injury information. Consideration was given to requesting more detailed information that broke down incidents to an individual level. This was determined not to be necessary as the level of ACC data already gathered was considered sufficient to extract key trends and conduct analysis.

New Zealand Wide Data Analysis

The key headline figures from the ACC data analysis are as follows.

- In New Zealand there were 5,051 new ACC claims for e-scooter injuries between 1 October 2018 and 30 June 2020
- 38.6% of ACC claims were made in Auckland
- 51.39% of ACC claims were made for soft tissue injuries

- 50% of claims were made by people younger than 30 years old (of the claims where individuals provided their age)
- In December 2019, in New Zealand, there was only 65.6% of the claims made in December the previous year.
- 54% of ACC claims were made by males (of the claims where individuals provided their gender). Note that this does not necessarily imply that males are at higher risk of injury since their frequency of use needs to be factored in.
- In New Zealand, there were 3,376 new ACC claims for e-scooter injuries in 2019 (281 every month on average).

Figure 10.1 shows the number of new ACC claims for e-scooter injuries with an accident date between 1 October 2018 and 30 June 2020, broken down by top 5 most common regions. It is important to note that the data for March, April, May and June 2020 is likely to be mpacted by COVID-19 related restrictions. Thus, these periods will not be considered with the rest of the data.

The graph shows that, for Auckland, there has been a general decrease in the number of ACC claims for e-scooter injuries since November 2018, when the number of injuries received in Auckland within a single month peaked.

What is interesting is that, while Auckland shows this trend, this is not similar for all other areas. Christchurch for example, as New Zealand's second largest city shows a stagnation in the number of ACC claims, which seems to be relatively constant compared to Auckland, though there has been some decrease from the initial rise in e-scooter usage back around November 2018.

As Auckland is the primary focus region of this study the differences between the injury data for Auckland and Christchurch will not be drilled into in more depth; however, it does open up interesting questions about effective treatments, campaigns or regulations that could have led to the decline of reported injuries in Auckland, and if this in turn is repeatable in other regions. As illustrated in **Figure 6.28**, low speed zones for shared e-scooters were instituted in central Auckland in July 2019; however, ACC claims were already declining by July 2019.

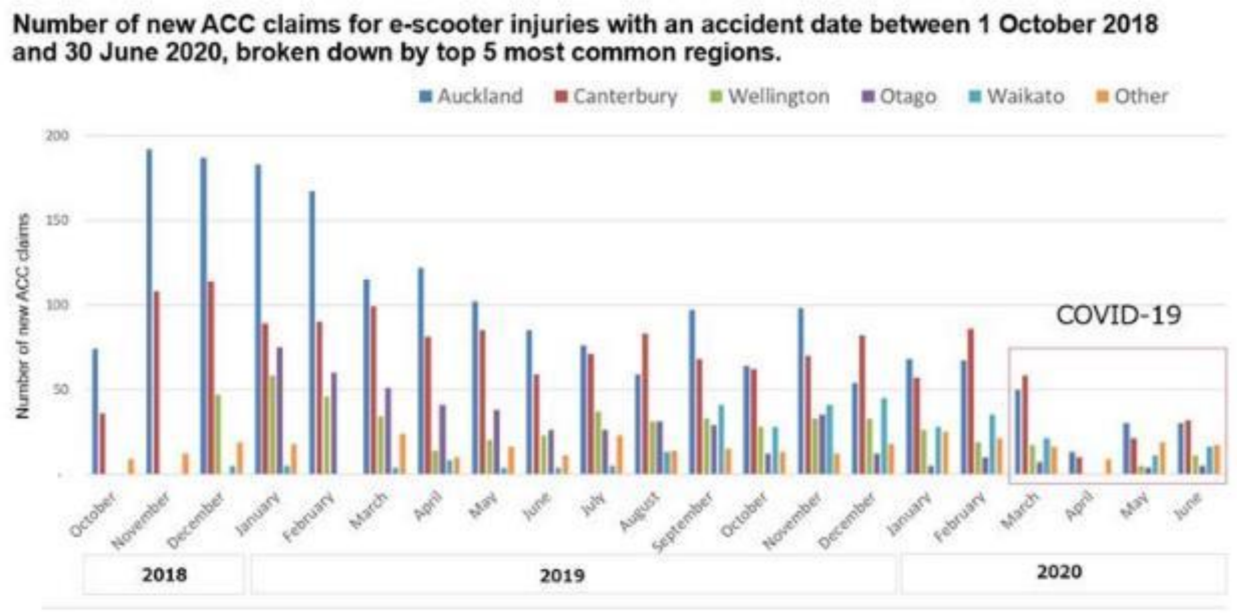


Figure 10.1 Number of ACC claims for e-scooter injuries from 1 October 2018-June 2020

ACC data also provides insights into other important background factors. **Figure 10.2** shows the percentage of ACC injuries from e-scooters against the age range of the injured person. The most prominent demographic group making ACC claims regarding e-scooter injuries are between 20-29 years of age, with 37.58% of people submitting claims within this age range.

Though anecdotally a higher number of elderly individuals seem to be concerned regarding e-scooter usage, only 50% of reported ACC injury claims were made by people 30 years of age or older and only 11.7% of people 55 years of age or older.

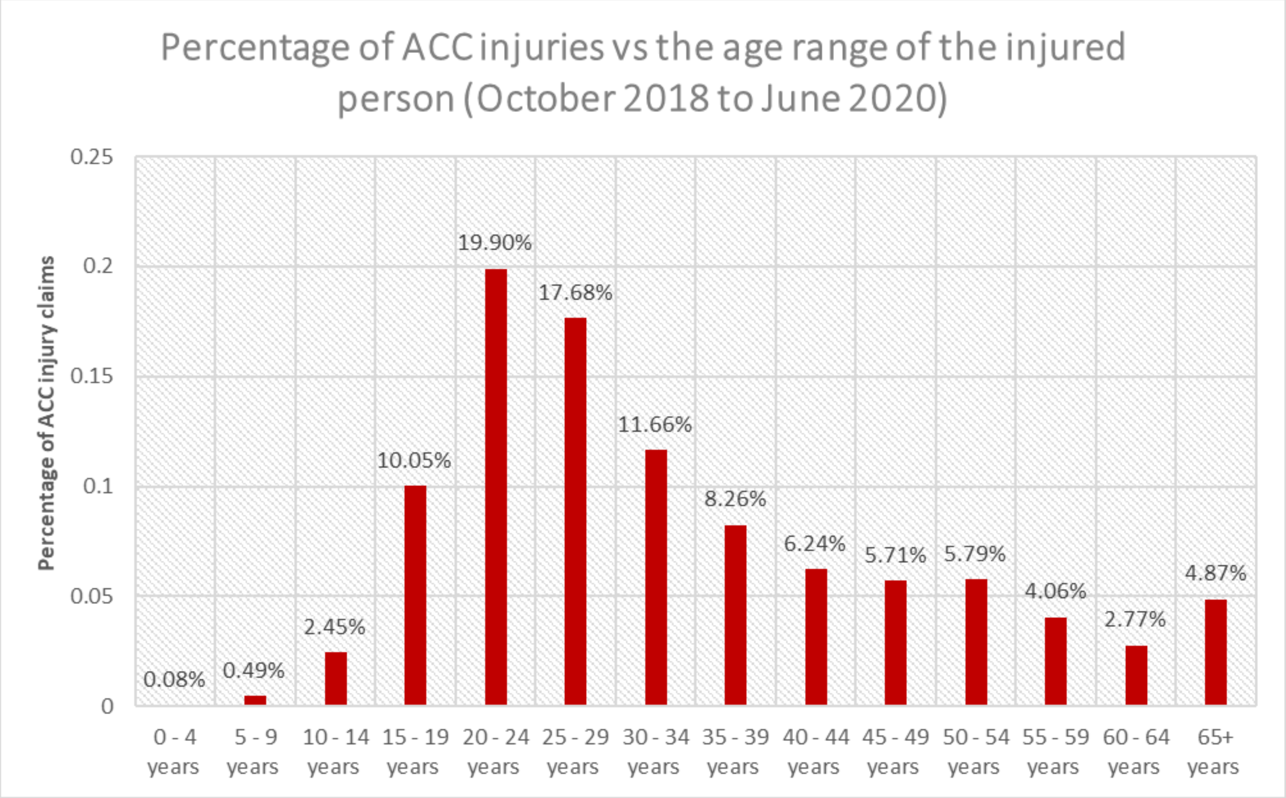


Figure 10.2 Percentage E-scooter ACC injuries against age range of injured person - All NZ

From the ACC data, over the period from October 2018 to June 2020, the types of injuries received relating to e-scooter usage can also be examined. **Figure 10.3** below demonstrates that the five most common types of injuries in New Zealand relating to e-scooter usage from most common to least, are: soft tissue injuries, laceration/punctures / sting, fracture/ dislocation, dental and concussion/ brain injury. The data shows that there have been approximately:

- 2,565 soft tissue injury claims,
- 1,229 laceration/punctures / sting claims,
- 828 fracture/ dislocation claims,
- 146 dental injuries claims,
- 106 concussion/ brain injuries and
- 117 other claims.

There are a number of what could be considered higher severity injuries such as fracture/ dislocation, dental and concussion/ brain injury, with concussion/ brain injuries making up approximately 21% of the total recorded claims. This proportion could however be due to lower severity injuries being less likely to be reported to ACC.

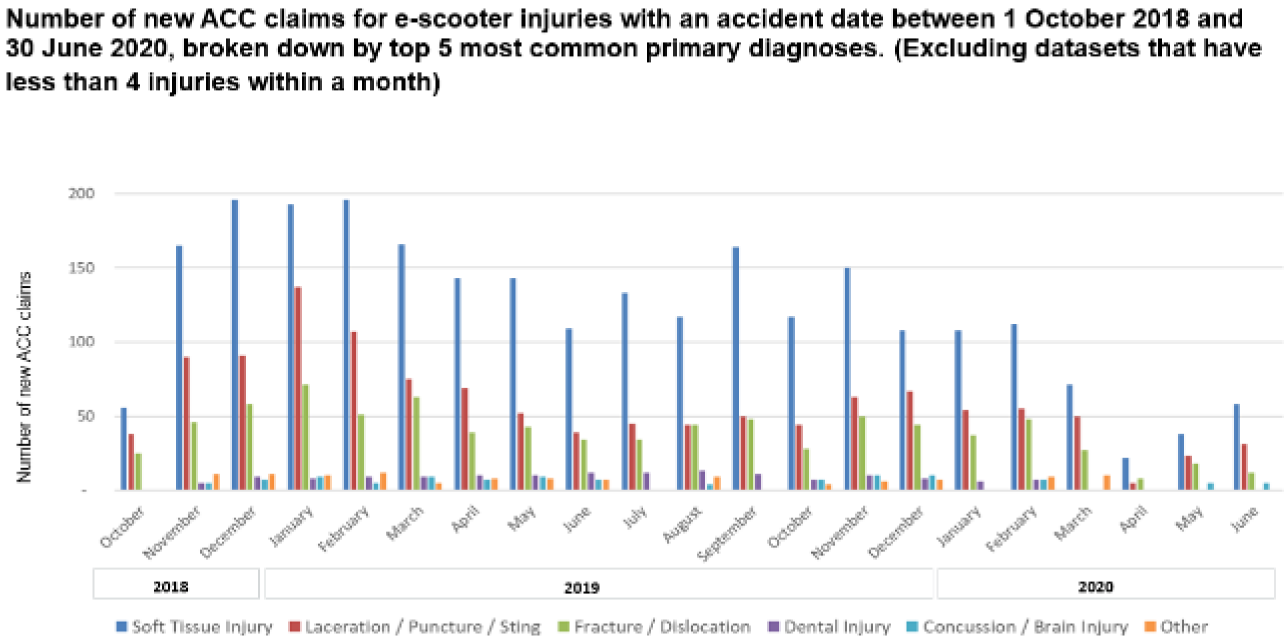


Figure 10.3 NZ ACC claims - E scooter injuries broken down into common primary diagnosis

To put the number and types of different injury claims into perspective against a comparable data source, the number of cyclist claims in 2019 have been recorded in **Figure 10.4** (2019 being a full year of data when e-scooters were in operation without COVID-19 disruptions). This shows that the profile of injuries incurred by cyclists and e-scooterists is similar, with soft tissue injuries being most common, though there are still a substantial amount more cyclist related claims than e-scooter related. This figure focuses on the proportions of each injury rather than numbers of injuries, which are influenced by usage frequency and distance travelled.

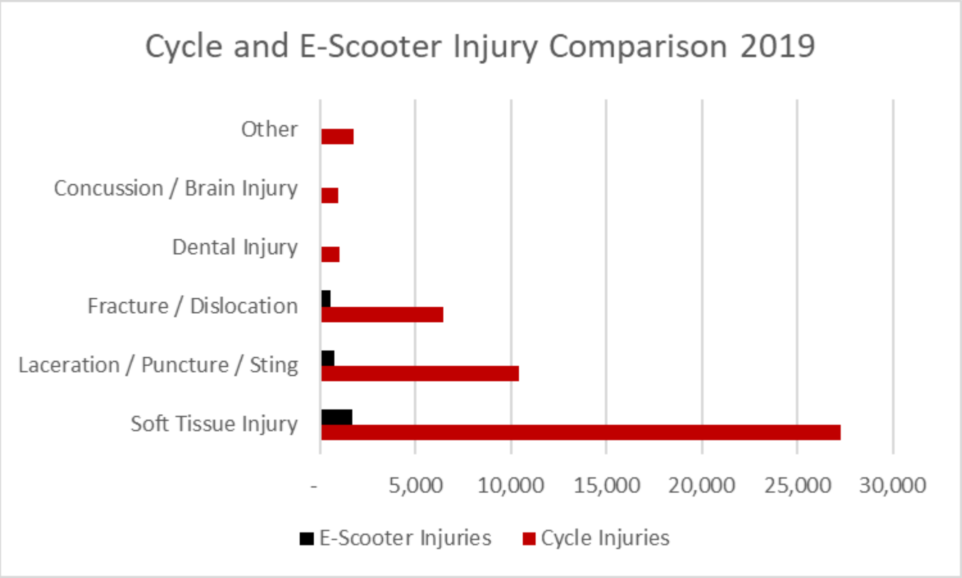


Figure 10.4 Comparison between Cycling and E Scooter related ACC Claims

Table 10.1 shows the breakdown percentage of injuries between e-scooter riders and cyclists for the same period. What is interesting here, though perhaps not surprising, is that there seems to be a close symmetry between the injuries sustained from e-scooter collisions and cyclists' collisions. Both riders share the top 5 most common injuries, in the same order and with similar percentages.

Some injury types may lead to more severe outcomes than others. As referenced in Chapter 8 of this document, the MUARC modelling, concussion injuries can also be linked with collision speeds. Noting this, it is interesting to see that the injury type with arguably the highest severity: the concussion/ brain injury has a slightly higher percentage for e-scooters than it does for cyclists (i.e. a person in the data that has fallen off a scooter is more likely to have received a concussion/ brain injury than a person who has fallen off of a bicycle). It should be observed that helmets are compulsory for cyclists but not for e-scooter riders.

Table 10.1 Comparison between percentage breakdown of cyclist and e-scooter related injury types

Primary Diagnosis	Cycle Injuries	E-Scooter Injuries
Soft Tissue Injury	56.8%	51.9%
Laceration / Puncture / Sting	21.7%	23.6%
Fracture / Dislocation	13.5%	16.4%
Dental Injury	2.2%	3.6%
Concussion / Brain Injury	2.0%	2.3%
Other	3.7%	2.3%

It is also possible to look at a range of data for other forms of micromobility. The graph in **Figure 10.5** shows the number of crashes per micromobility and non-powered mobility device mode between 2015 and October 2020. Scooters and skateboards have been included as proxies for micromobility devices for comparison. Over this period, it can be seen that there were 1,659 new e-scooter claims. It can also be seen that there have been more reported claims over this period for skateboards, scooters and roller skates, with 49,488 claims, 44,199 claims and 8,708 claims respectively. However, the number of e-scooter claims over this period is greater than the number of e-bike, hoverboard and Segway claims. E-bike, hoverboard, and Segway claims are at 1,329 claims, 1,096 claims, and 382 claims respectively.

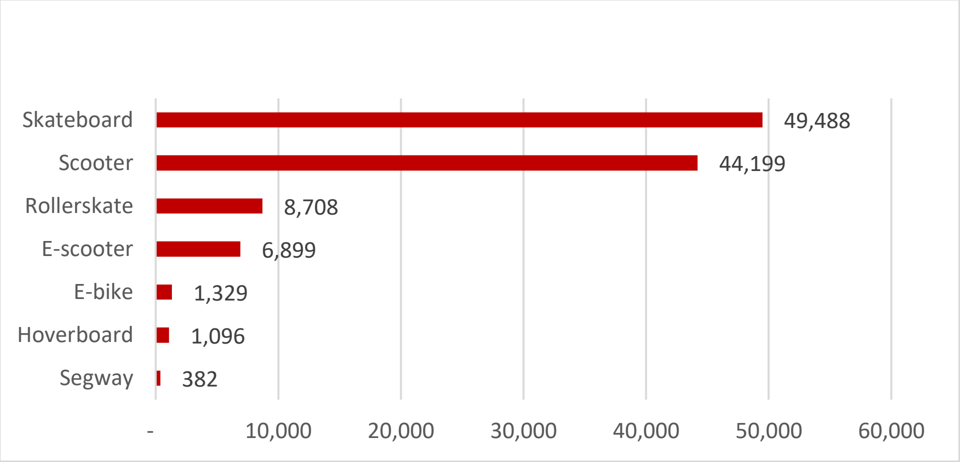


Figure 10.5 Micromobility ACC claims in NZ: 2015-October 2020

Breaking down this information per year in **Figure 10.6** shows that the majority of e-scooter injury claims occurred after 2017. The number of claims over 2015, 2016 and 2017 were very similar with 312 claims in 2015, 343 claims in 2016 and 309 claims in 2017. In 2018 however there were 939 new reported claims: an increase of 204% from 2017. There was another increase in claims in 2019, increasing 265% from 2018. From 2017 to 2019 there was a very substantial increase in new claims of 1009%. This increase occurred in parallel with the introduction of shared e-scooter schemes in Auckland during 2017, although actual data about e-scooter usage is unfortunately unavailable.

It is also interesting that although, as stated previously, there were more roller skating crashes from 2015 to 2019 than e-scooter injury claims, with the increasing trend of e-scooter injury claims in New Zealand there were 81% more e-scooter injury claims in 2019 than roller skating injury claims.

Looking at other modes of transport, there is a clear upward trend in e-bike injury claims. With only 6 injury claims in 2015 increasing as high as 450 in 2019 and with 574 claims already made in 2020 as of 31 October 2020.

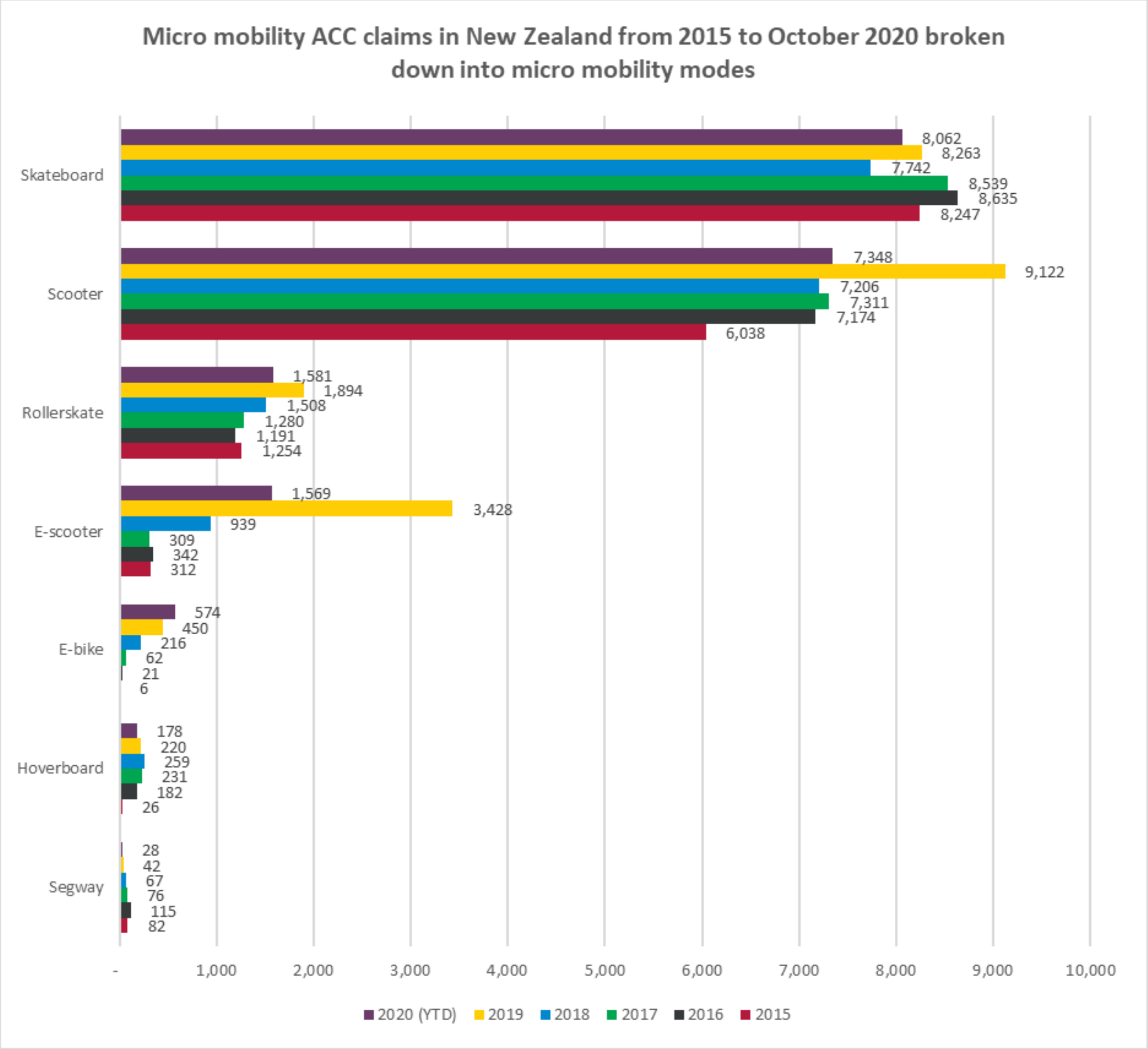


Figure 10.6 Micromobility ACC claims in NZ: 2015-to October 2020 by mode

Auckland ACC Data analysis

When just the Auckland region is considered, **Figure 10.7** shows the number of e-scooter injuries from 2015 to November 2019. The most common micromobility injury claims, of the modes shown below, come from skateboarding related incidents with 15,649 claims reported. E-scooters are the third most common with 2,442 related claims and e-bikes are the sixth most common with 301 recorded claims.

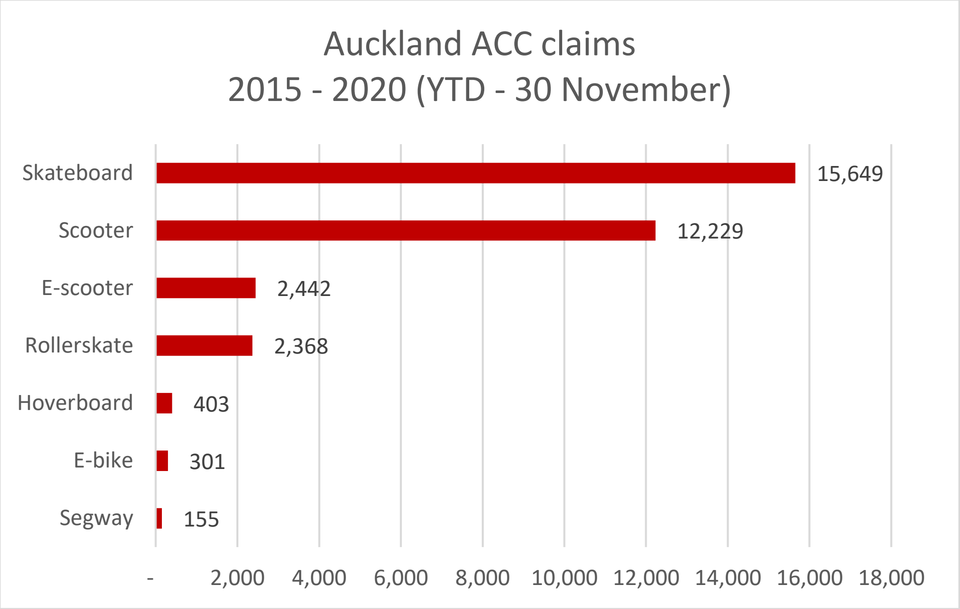


Figure 10.7 Auckland Micromobility ACC Claims

Comparing the percentage breakdown of the different micromobility modes considered, it was interesting to see, from **Figure 10.8** and **Figure 10.9**, that there is a very similar split between the new ACC claims for the different modes. Auckland does show a 1% higher proportion of claims attributed to e-scooter injuries. It is possible that this is due to the data period for Auckland including November 2020 where the NZ data ends at October 2020.

This indicates that the changing roading environments across different regions of New Zealand may have a similar impact across different micromobility modes. This in turn could indicate that altering the safety features in a road environment might have a similar impact across different micromobility modes (e.g. increased number of cycle lanes may have a similar impact on e-scooter injury claims users to cyclists injury claims).

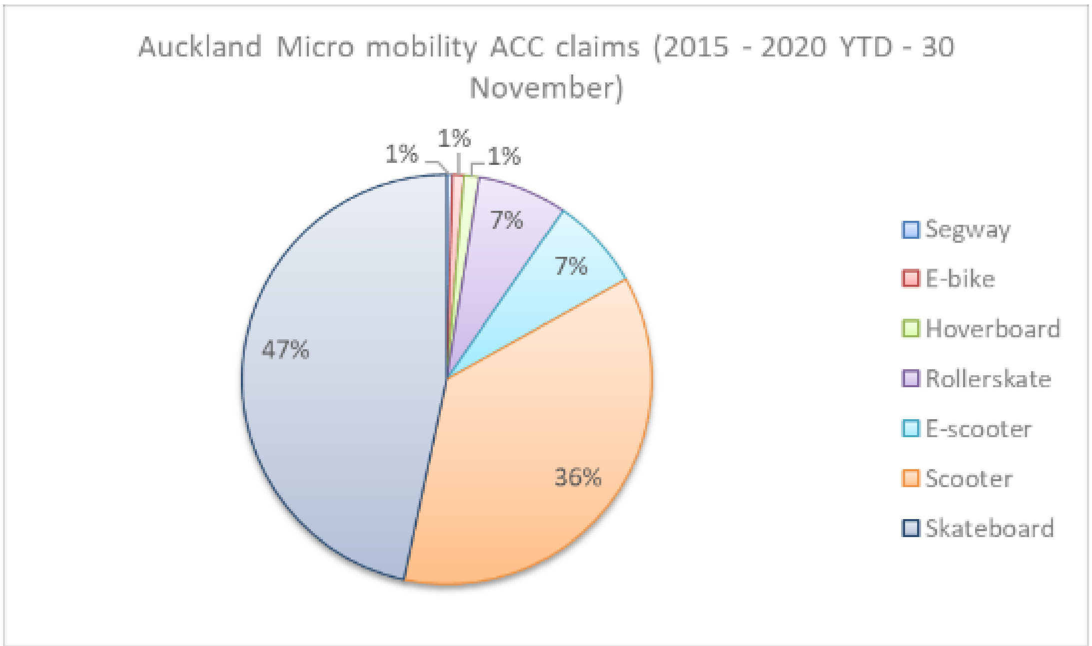


Figure 10.8 Auckland Micromobility ACC Claims (2015 - 2020)

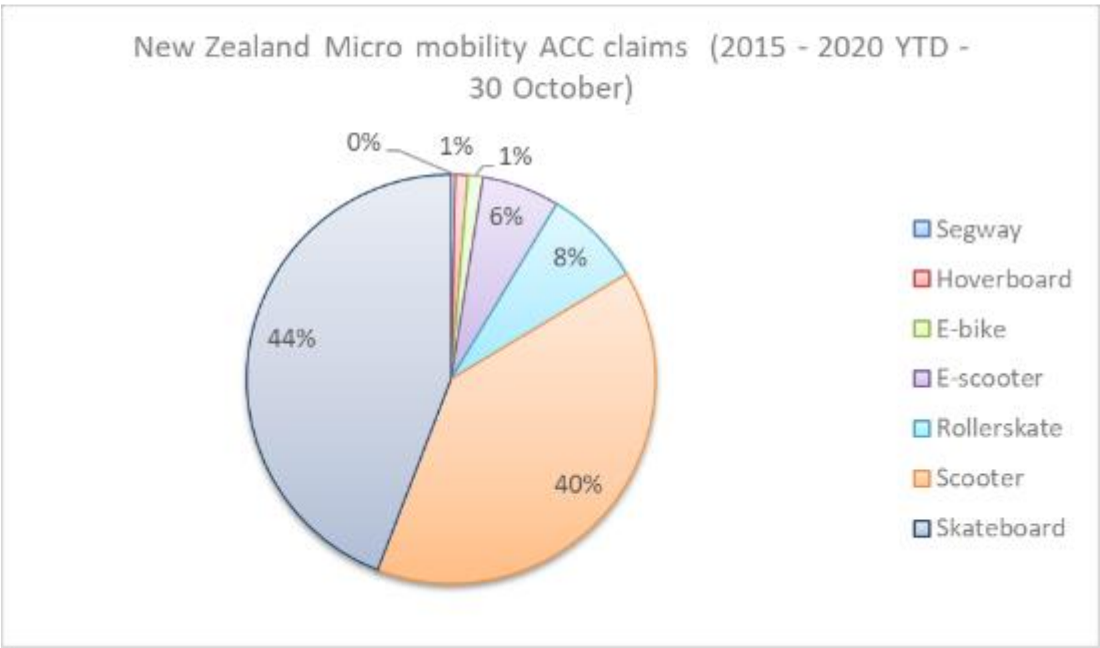


Figure 10.9 NZ Micromobility ACC Claims (2015-2020)

Looking at the different micromobility modes and the different areas around Auckland, shown in **Table 10.2**, it can be seen that for e-scooters approximately 2,268 ACC claims occurred in Auckland City (94.15%) with substantially fewer elsewhere. It is unsurprisingly a reoccurring trend across the other micromobility modes with 79-94% of claims across modes occurring within Auckland City. The percentage does, however, vary slightly between modes with e-scooters having the highest percentage used within Auckland City and push scooters having the lowest at 79%. This is likely to reflect the placing of shared e-scooter in the central city.

Table 10.2 Micromobility Claims Across Auckland: 2015 - November 2020

	Ebike	E Scooter	Hoverboard	Rollerskates	Scooter	Segway	Skateboard
Auckland City	223	2,268	305	1,982	9,624	73	12,535
Manukau City		33	29	73	740		589
North Shore City	13	53	4	129	558	9	875
Papakura District		7		10	245		190
Rodney District	10	24	13	41	632		973
Waitakere City	5	24	8	75	430		487
Total	251	2,409	359	2,310	12,229	82	15,649

Breaking down injuries for different forms of micromobility, it can be seen in **Table 10.3** and **Table 10.4** that soft tissue injuries are most common for all types of micromobility. Interestingly the most serious injury type – concussion/brain injury appears to be most common on e-bikes, despite the need to wear helmets, although numbers of incidents are also small. Brain injuries/concussions also represent 4.7% of injuries on scooters, for which devices helmets are not compulsory.

Table 10.3 Total Injury Type Claims in Auckland by type of Micromobility : 2015-2020

	E-bike	E-scooter	Hoverboard	Rollerskates	Scooter	Segway	Skateboard
Soft Tissue Injury	192	1,213	216	1,592	4,746	98	8,406
Laceration / Puncture / Sting	45	683	98	490	4,684	16	3,149
Fracture / Dislocation	32	373	38	173	1,769	4	3,145

	E-bike	E-scooter	Hoverboard	Rollerskates	Scooter	Segway	Skateboard
Concussion / Brain Injury	13	52	12	29	574		360
Dental Injury		50		17	132		218
Other		59		43	324		371
Total	282	2,430	364	2,344	12,229	118	15,649

Table 10.4 Percentage Injury Type Claims in Auckland by type of Micromobility: 2015-2020

	E-bike	E-scooter	Hoverboard	Rollerskates	Scooter	Segway	Skateboard
Soft Tissue Injury	68.1%	49.9%	59.3%	67.9%	38.8%	83.1%	53.7%
Laceration / Puncture / Sting	16.0%	28.1%	26.9%	20.9%	38.3%	13.6%	20.1%
Fracture / Dislocation	11.3%	15.3%	10.4%	7.4%	14.5%	3.4%	20.1%
Concussion / Brain Injury	4.6%	2.1%	3.3%	1.2%	4.7%	0.0%	2.3%
Dental Injury	0.0%	2.1%	0.0%	0.7%	1.1%	0.0%	1.4%
Other	0.0%	2.4%	0.0%	1.8%	2.6%	0.0%	2.4%

Key findings

Below is a list of the key findings from the ACC data analysis:

- 38.6% of ACC claims were made in Auckland.
- 51.39% of ACC claims were made for soft tissue injuries.
- 50% of claims were made by people less than 30 years old (of the claims where individuals provided their age).
- In December 2019 in New Zealand there were only 65.6% of the claims made in December the previous year.
- 54% of ACC claims were from males (of the claims where individuals provided their gender).

When looking just at the Auckland ACC data:

- There is no significant difference between injury types experienced from different micromobility and mobility modes.
- There are approximately 6.7 times as many skateboard ACC claims in Auckland compared to e-scooter claims.
- There are more than 8 times as many e-scooter claims than e-bike claims.
- Approximately 94.15% of Auckland Region ACC claims occurred in Auckland City.
- Arguably the most serious injury type, concussion/brain injury is approximately twice as common (4.6%) for e-bike users as e-scooter users (2.1%) although it is noted that it is on a par with scooters (4.7%).

10.2 CAS data

Methodology

All crashes within New Zealand were extracted from Waka Kotahi's CAS system from 2015 -2020. These were then filtered to only include crashes related to the Auckland region. Code was then written up for each form of micromobility to search through all lines within the CAS crash data. This code searched for key words related to the forms of micromobility. If a crash entry includes one of these key words (such as escooter or e-scooter) it was noted down along with its year and severity. All crashes related to micromobility modes were then aggregated.

Limitations

Given that the CAS data held significantly less recorded injuries than ACC it cannot be considered a comprehensive database for micromobility injuries. However, with the limited number of crashes that are available, some key findings have been made from the CAS data.

Unfortunately, as the other data sources have no information relating the location and infrastructure on which a collision occurred, it is not possible to use the other data sources to validate the findings from the CAS data.

The quantity of data for micromobility related injuries in CAS is much smaller than the data available from ACC. This is due to CAS only having crashes related to traditional vehicles; i.e., any micromobility crash recorded involves a collision with a motor vehicle. It is important to note however, that the literature review does suggests that a high percentage of micromobility rider fatalities occur in crashes involving traditional vehicles.

Auckland Data

In Auckland, there have been 3,808 crashes from 2016 – 2019 recorded on CAS relating to the following modes of transport: pedestrian, skateboard, bike/ cycle and e-scooters.

The following forms of micromobility were also analysed but were found to have no crashes relating to them on the CAS system for the Auckland region:

- Hoverboard
- Handcycle
- Mobility scooter
- Onewheel (board)
- Roller skates
- Segway
- Unicycle

In the CAS analysis e-bikes were excluded as it was expected that police who record the crash data, may not often differentiate between e-bikes and bikes, and instead record both as cyclists. A search for e-bike crashes in CAS yielded no results.

Figure 10.10 shows the breakdown per year of the number of crashes for the different forms of transportation. From this graph, it is clear to see that the number of recorded e-scooter crashes on CAS in the Auckland region has increased from no crashes in 2016 and 2017 to 10 crashes in 2018 and finally, 26 crashes in 2019. This included one serious injury collision in 2018 and five serious injury collisions in 2019. However, when this is compared with more traditional forms of transport such as cyclist crashes, recorded e-scooter crashes in 2019 are only just over 3% of the number of cyclist crashes in 2019, of which there were 821.

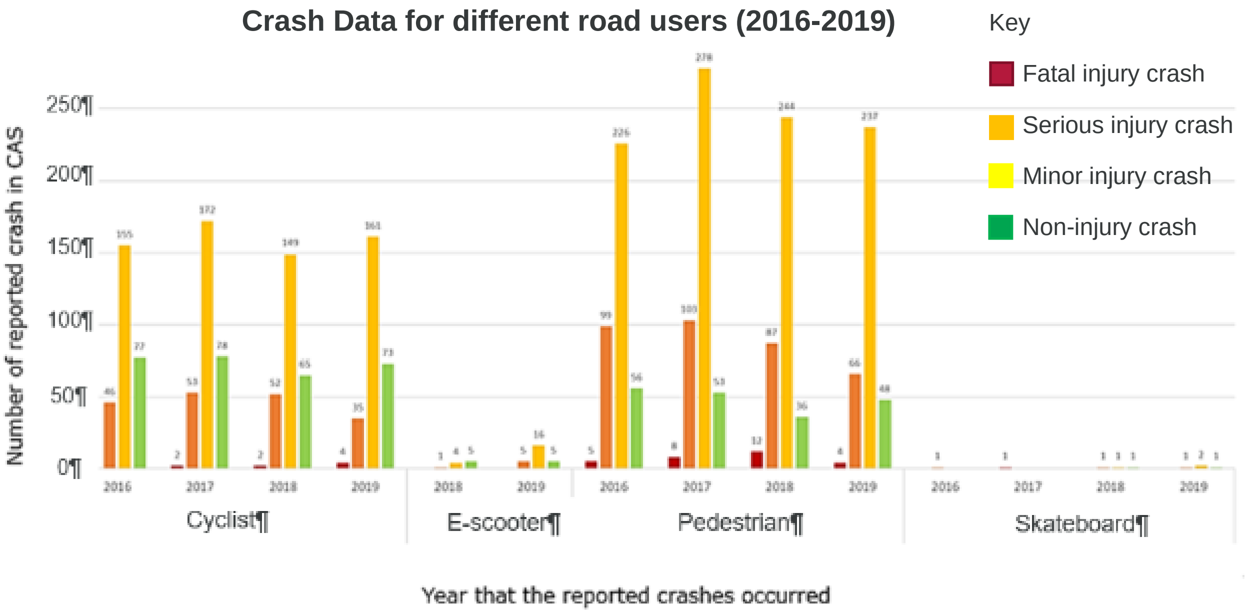


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Figure 10.10 Micromobility related CAS data (2016-2019)

A detailed analysis of e-scooter crashes was conducted as these were the only e-micromobility modes that had CAS data available. This analysis included crashes that occurred in 2020 and had been recorded on the CAS system at the time of data extraction. This data analysis was conducted by reading through all of the police reports and classifying useful information about the crashes that had not already been individually identified in the CAS data. This was then aggregated in the Figures below to provide an insight into the crash patterns in the data.

Crash Locations in Auckland

Figure 10.11 shows Auckland Central has the highest number of reported e-scooter crashes followed by Grafton, which has less than 40% of the crashes in the city centre. This indicates, without consideration to other data, that e-scooter safety improvements will likely have the greatest benefit if only carried out in the city centre.

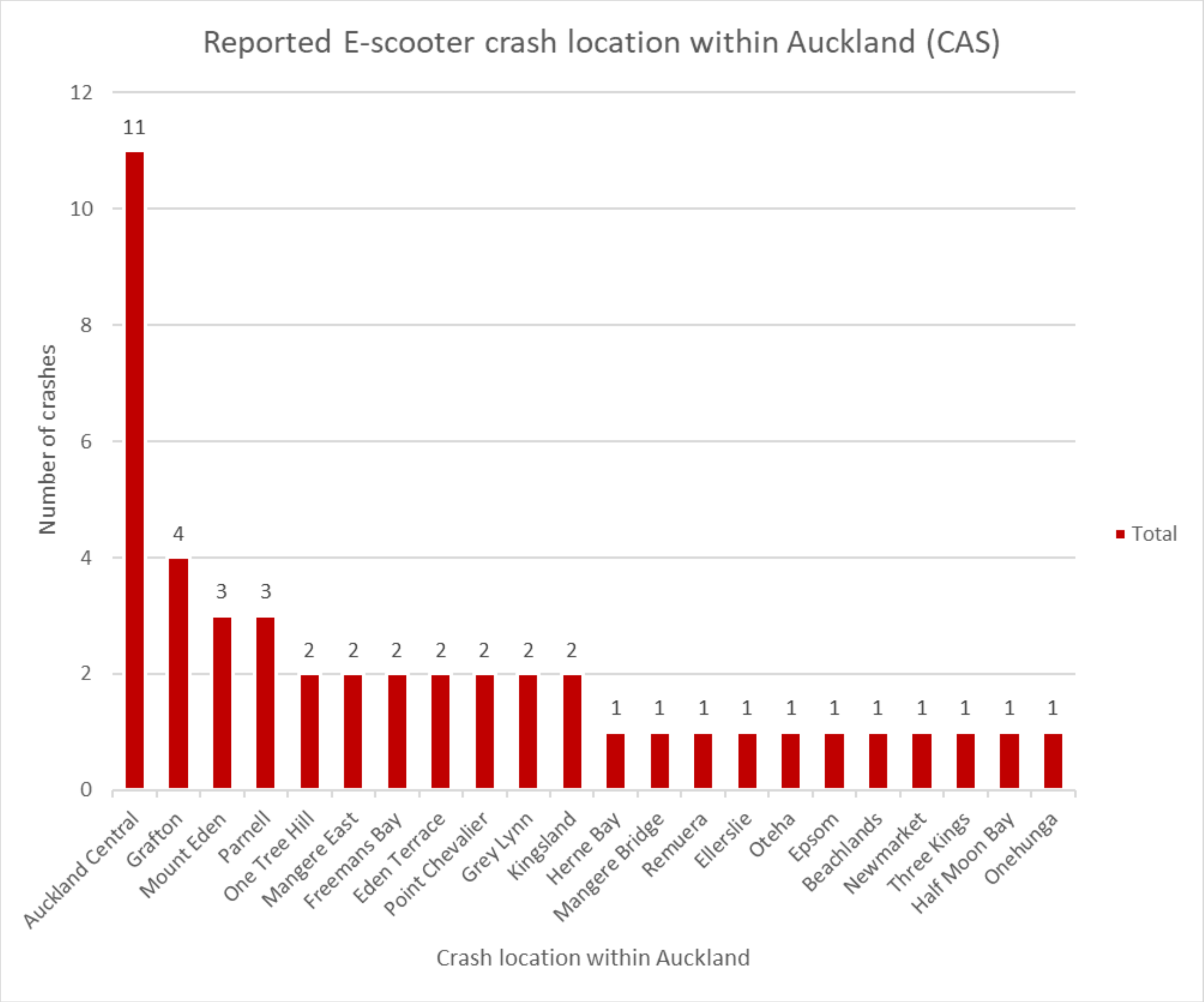


Figure 10.11 Location for CAS E-Scooter Crashes in Auckland

Location of Crashes within Road Corridor

Figure 10.12 shows the breakdown of where in the road environment the crash occurred. Though every crash has its own road environment surrounding it, certain patterns did start to emerge in the data. “On road” was the most common location for a crash to occur, with 19 out of the 46 crashes occurring on the road. This also represented more than 70% of the crashes that resulted in a serious injury. This is perhaps not surprising given that out of all of the potential collision locations, “on-road” crashes are likely to have involved the fastest moving vehicles in the collision.

There were also a lot of crashes (11) that occurred either on a driveway or a pavement crossing point. Interestingly, these crashes often occurred with the vehicle either stationary or moving at very low speeds. This indicates that if the e-scooter was moving slower, then crash likelihood could be reduced.

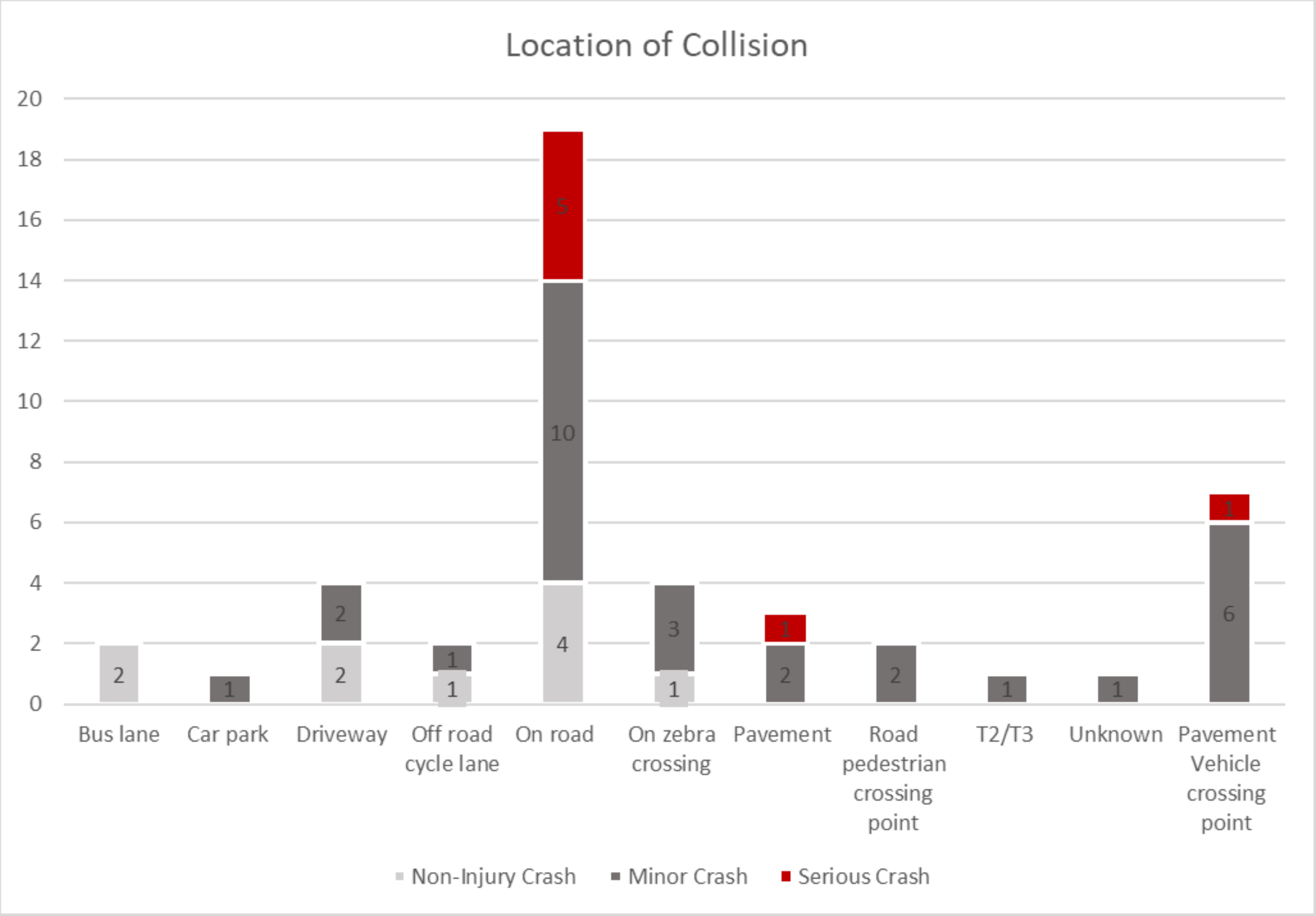


Figure 10.12 Breakdown of location of crash by infrastructure type

Age Profile of those involved in Incidents

Figure 10.13 clearly shows that, out of all 5-year age ranges, an injured e-scooter rider was most likely in the age range from 21 to 25, with 14 out of the 46 crashes involving an e-scooter rider in this age range.

Looking at high severity crashes (serious crashes), of the 5 known crashes where the age of the e-scooter rider was known, 40% were in the age group 21 to 25, 20% were in the age group 26 to 30 and 40% were in the age group 41 to 45. Though people over the age of 25 only account for 37% of the crashes, they account for 60% of these more serious injuries.

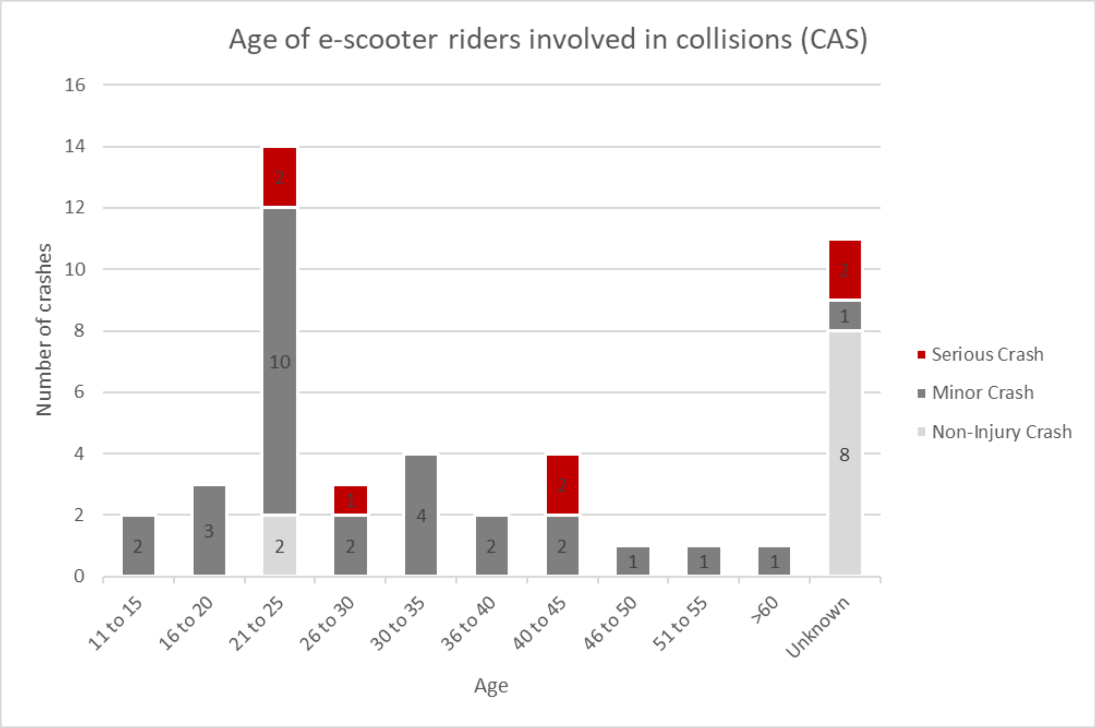


Figure 10.13 Age Profile of Riders involved in E-Scooter Crashes

Gender Profile

Out of the injured riders with recorded genders, **Figure 10.14** shows that not only were there just under 70% more males injured than females but males also had 300% more serious injury collisions than females.

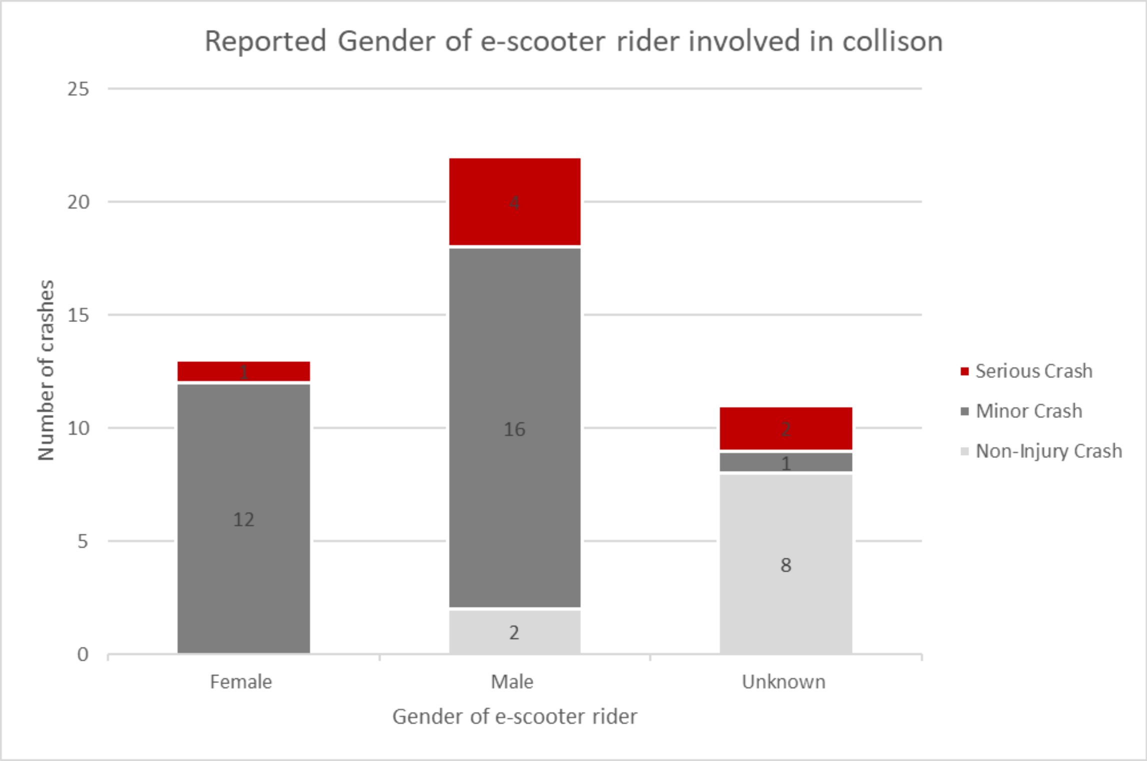


Figure 10.14 Gender Breakdown of E-Scooter Rider Crashes

Gradient

Figure 10.15 shows the clearest trend from the CAS data detailed analysis. While 30% of crashes occurred on what was reported as a “hill road” (i.e. a steep gradient), 71% of serious injury crashes that occurred were on a “hill road”. This shows that crashes that occur on a “hill road” are more likely to result in a serious injury than crashes that occur on flat roads.

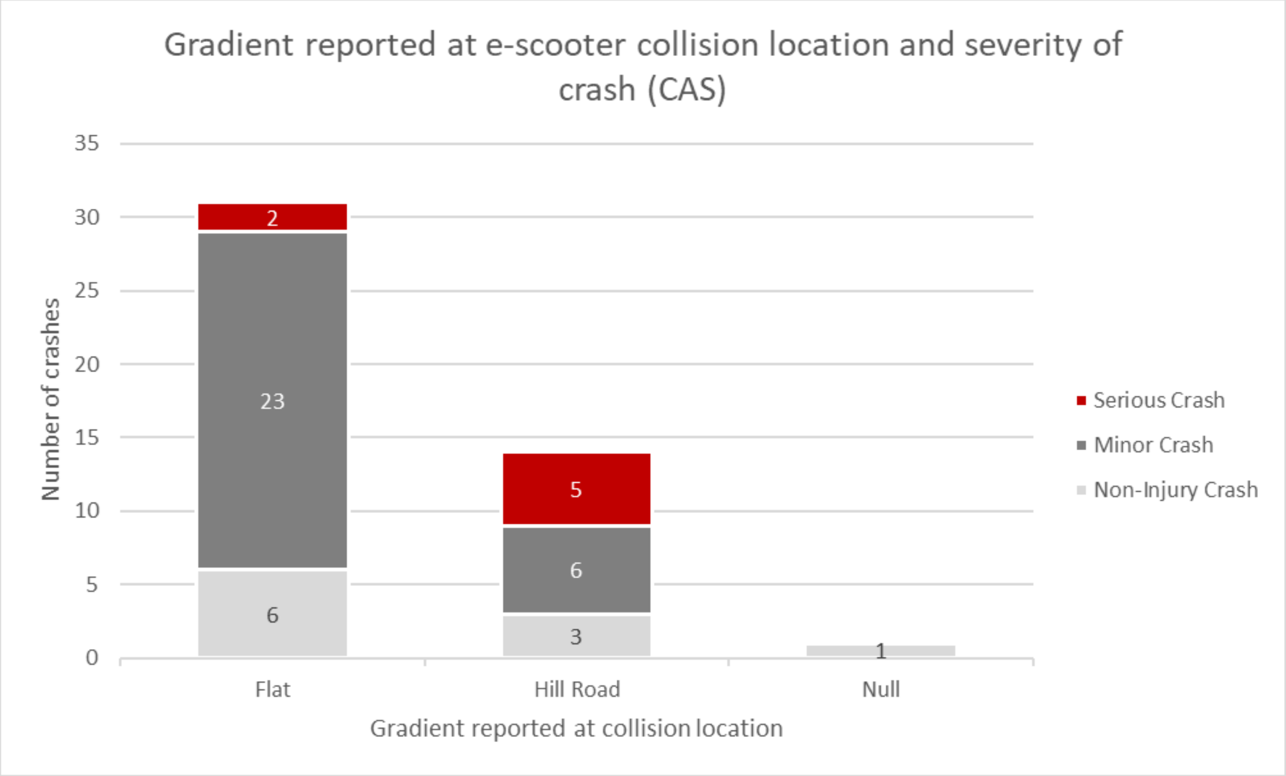


Figure 10.15 Gradient at Collision Location

Multiple Riders

Out of the 46 crashes reported, only one occurred with multiple riders. This could indicate that the number of users may not be a main contributing factor to the risk related to e-scooters. Alternatively, injuries related to multiple e-scooter riders on a single device could be less.

Movement of Colliding Vehicle

Figure 10.16 shows that out of the 42 crashes where the movement of the vehicle was known just under 70% involved a vehicle that was moving at a reasonable speed. It also shows that all of the serious injury crashes that occurred involved a vehicle moving at a reasonable speed.

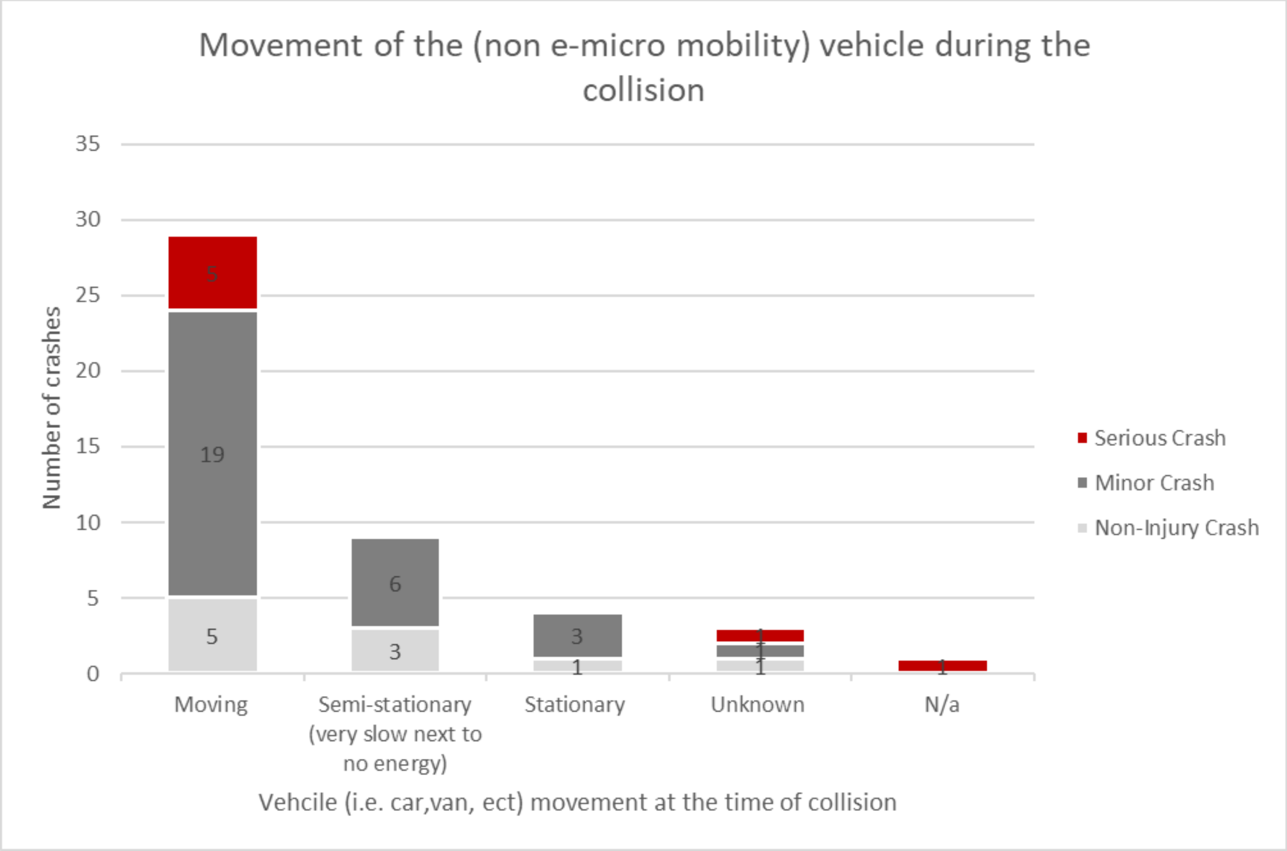


Figure 10.16 Movement of Colliding Vehicle

Wet/Dry Roads

Figure 10.17 below shows that over 80% of crashes reported occurred in dry surface conditions. It also shows that all of the high severity injuries occurred in dry surface conditions.

It is unlikely that this indicates that wet weather conditions are safer than dry weather conditions. Other factors might have instead come into play, it is possible that users are less likely to use e-scooters in wet weather conditions or that they compensate in wet weather conditions by using e-scooters at lower speeds.

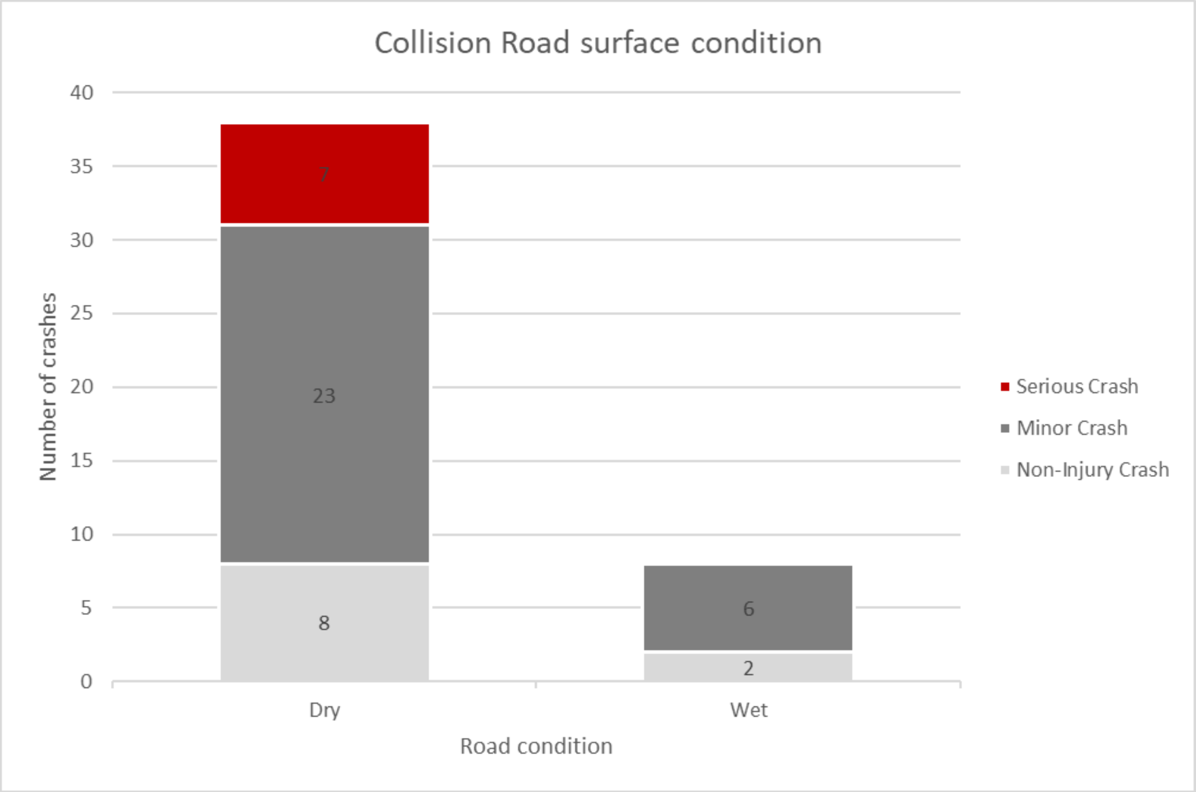


Figure 10.17 Surface Condition (Wet/Dry)

Speed Environment

From **Figure 10.18**, it can be seen that crashes that occurred were reported to have taken place in 20km/h, 30km/h and 50km/h speed environments, with one, three and forty-two crashes occurring respectively. As 50km/h speed limit zones are more common than 20 or 30km/h zones, this is likely to reflect exposure, however, given a lack of data on use of e-scooters, there may also be a link to crash severity. It is notable that all of the high severity, serious injury collisions, occurred in 50km/h speed limit zones. This suggests that lower speed limits might decrease the likelihood and severity of e-scooter crashes.

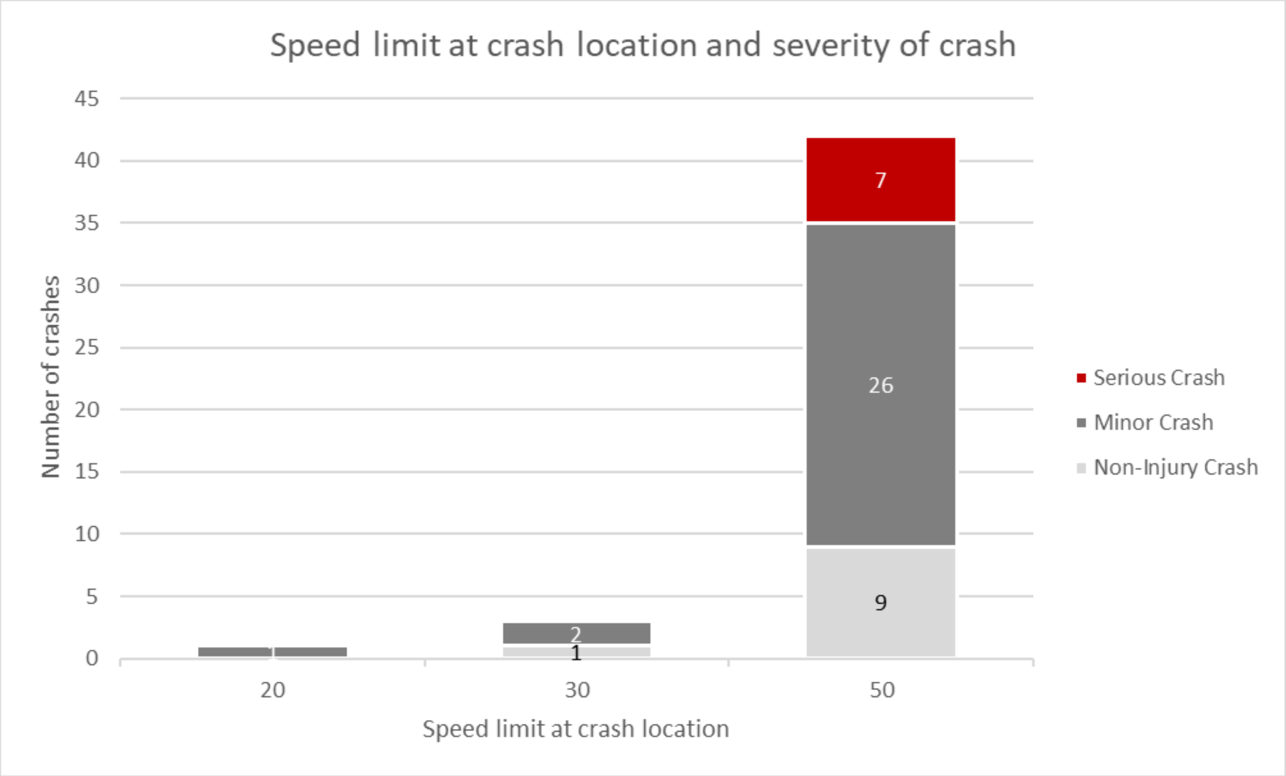


Figure 10.18 Speed Limit at Crash Location

Potential Crash Causes

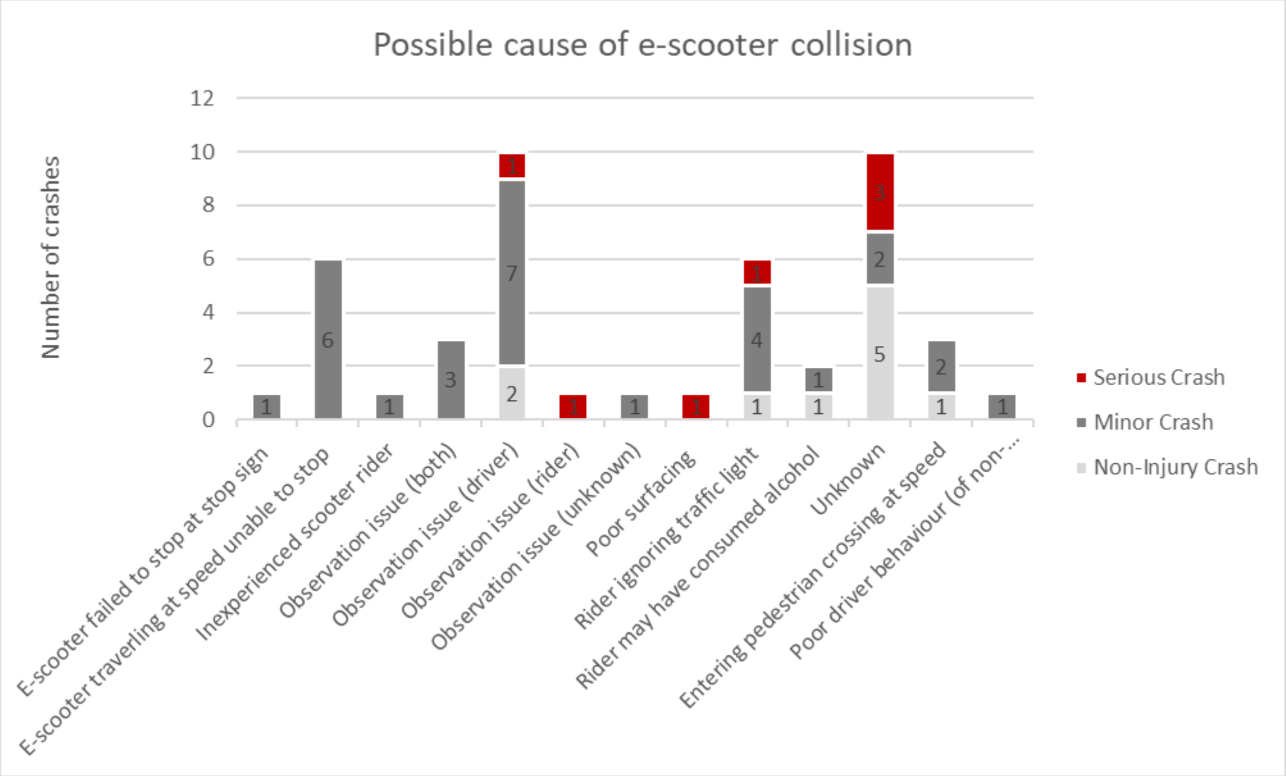


Figure 10.19 Potential Crash Cause

Figure 10.19 above was created by reading through each crash report and making a subjective judgement, based off the information available, as to the crash cause. For some cases this was a straightforward decision as it was clear from the description what took place. In cases where there wasn't enough information to make an accurate judgement, the crash cause was classified as "unknown".

The same Figure shows that of the 46 crashes that took place, driver observation issues were the most common with just over 21% attributed to that cause. It was also interesting to see that six crashes or 13% of crashes, including four minor injury crashes and one serious injury crash, resulted from riders ignoring traffic lights.

This was not the only rider related cause however, as three crashes resulted from riders travelling on to a pedestrian crossing at speed. Though this could also be attributed to rider error, it does indicate that riders could make small changes to the way that they ride to increase their safety.

Poor surfacing was only mentioned in one of the police's written reports; however, this did result in a serious injury collision.

10.3 Hospitalisation data

Purpose

Hospitalisation data was requested for both e-scooters and e-bikes over the 5-year period from 2015-2019. Though other forms of powered micromobility were considered for inclusion, they were omitted. This was because the hospitalisation data is coded in such a way that it would have been very difficult to extract a range of different micromobility devices. Each individual device has several codes. These link to that specific device as well as several other types of transport that may not fall within the category of powered micromobility device. Thus, the accuracy of an analysis carried out on specific uncommon forms of micromobility was expected to be low.

Methodology

All hospitalisation data that could be related to e-scooter and e-bike crashes was requested from the Ministry of Health. For the Auckland region, this was filtered on the Agency codes for treatment: 1021, 1022, 1023 (Waitemata, Auckland and Counties Manukau). Code was then written up for each form of micromobility to search through all lines within the hospitalisation data. This code searched for key words related to the forms of micromobility. If a crash entry includes one of these key words (such as "escooter" or e-scooter) it was noted down along with its year and severity. All crashes related to micromobility modes were then aggregated.

Though codes were specified for different injury vehicles, often these would be categories involving multiple vehicles (i.e. Code W029 is not exclusive to falls from e-scooters, the code can be assigned for falls from non-powered scooters, shopping trolley, mobility scooter and sandboards). Thus, these codes could not be fully relied upon when determining if a crash involved a given micromobility device. Unfortunately, this means that many hospital cases were likely missed during the analysis as there was no reliable way to determine that these were related to a specific mode of transport.

From 2015 to 2019, The New Zealand hospitalisation data shows 172 patients have been admitted to hospital with e-scooter related injuries and 3 patients have been admitted to hospital with e-bike related injuries. The data also indicates that 84 patients have been admitted to hospital with e-scooter related injuries in Auckland and no patients have been admitted to hospital with e-bike related injuries in Auckland.

There are far more reported e-scooter injuries than e-bike injuries recorded both in New Zealand and specifically in Auckland. However, comparing the hospitalisation data to the ACC data, it is clear that there is far more ACC data available. There could be several reasons for the difference between the ACC data and the hospitalisation data.

It is possible that not all ACC claims relate to someone who has been admitted to hospital. It is also possible that e-scooter or e-bike related hospitalisations have occurred; however, these have not included terms related to e-scooters and e-bikes in the entry and thus they have not been picked up by the methodology.

Figure 10.20 shows the number of recorded e-scooter injuries by Length of Stay in days (LOS) and year of crash occurring. As with the CAS data, the information provided within the data will vary greatly depending on who enters the data. Unfortunately, it is possible that several hospitalisations that occur due to e-scooter related injuries are not recorded as such. This in turn means that the Figure below underrepresents the actual number of hospitalisations.

The longest reported length of stay in hospital related to an e-scooter incident was 28 days.

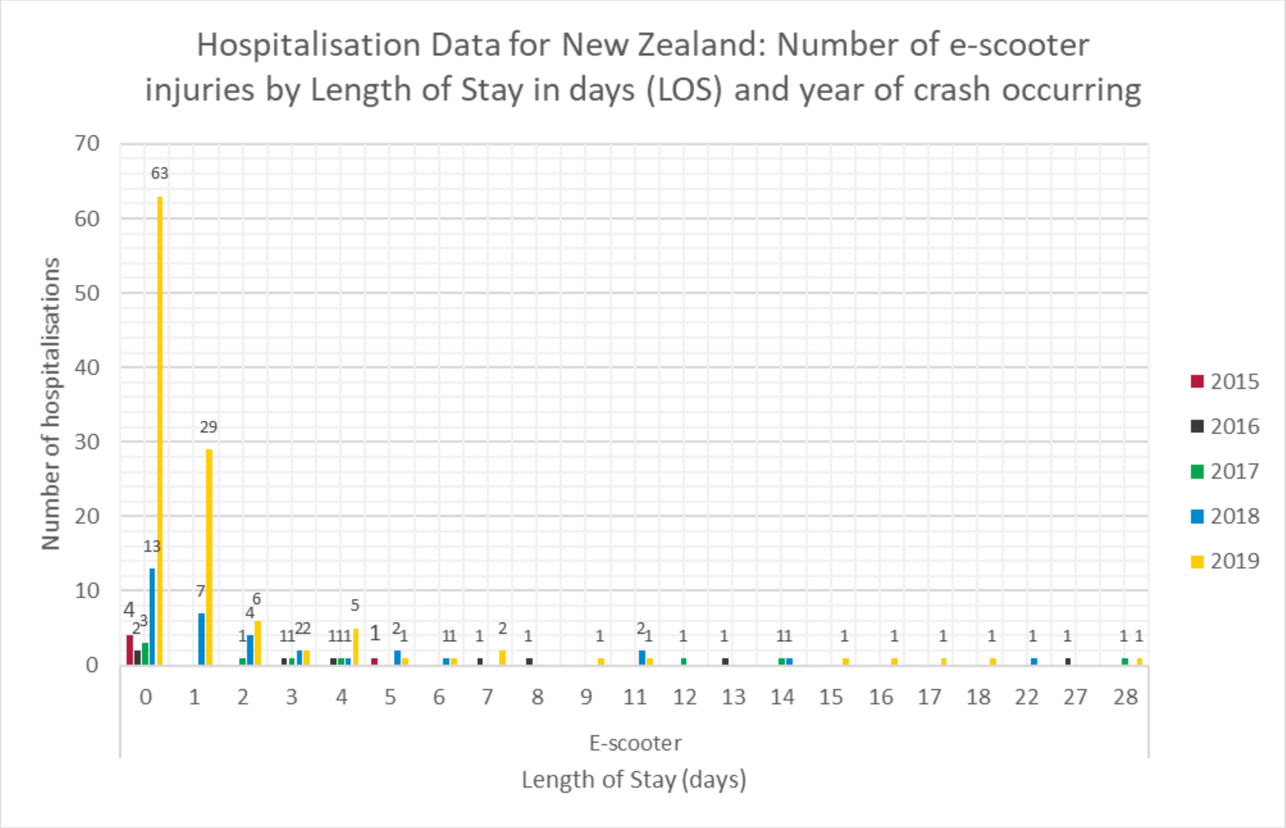


Figure 10.20 Hospitalisation Data for E-scooters

Figure 10.21 illustrates the hospitalisation data for e-scooter riders in Auckland. It shows that the longest length of stay was 28 days, with most incidents requiring either no overnight stay or a single day's stay in hospital.

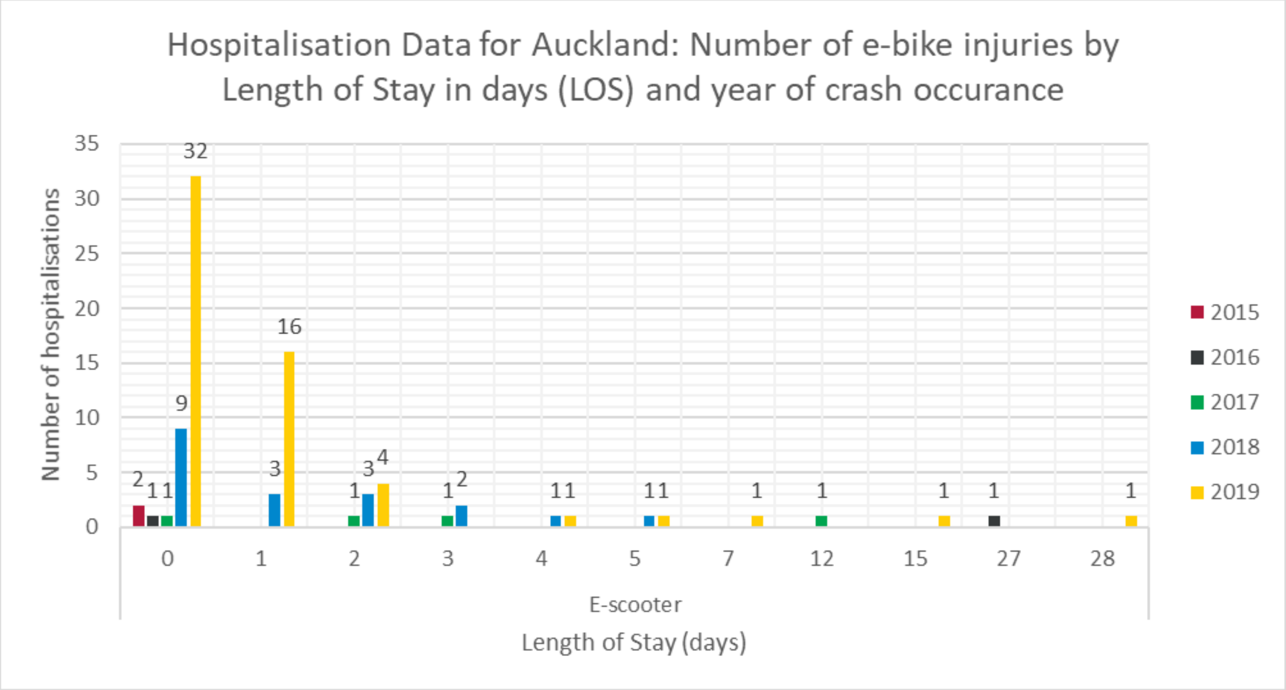


Figure 10.21 Hospitalisation Data for E-Scooters in Auckland

10.4 Incident data comparisons and findings

How does the quantity of e-scooter related injuries compare across data sources?

Whilethere have been 2,442 Auckland based e-scooter ACC injury claims from January 2015- November 2020, there have only been 46 traffic accidents related to e-scooters that have occurred identified from 2016- 2019 and only 84 hospitalisations that were able to be matched to e-scooter related injuries. The reason for this disparity is believed to be due to several reasons.

CAS data does not include crashes not related to motor vehicle (e.g. car, van and truck). Thus, if a motor vehicle was not involved in the crash, it would likely not have been included in the CAS data. Additionally, some of the crashes that do relate to these vehicles, as well as micromobility modes may have also been missed. This is because there is no specific code entered by police to identify the incident as e-scooter related.

With hospitalisation data, the same coding problem exists, where there is no specific code that relates to e-scooter crashes and instead general codes that could cover forms of micromobility not related to e-scooters. For this reason, key words have been searched relating to the specifics of micromobility. However, it is possible that many incidents did not include the key words being searched for.

This discrepancy also exists with e-bikes. Though there were 301 Auckland based e-bike ACC injury claims from January 2015- November 2020, there were no e-bike crashes identified in CAS and only 3 hospitalisations that could be linked to e-bike related incidents.

The CAS data is still useful as it contains vehicle crashes which the literature review showed to result in higher severity injuries and it had more detail than any of the other data sources. The hospitalisation data on the other hand was found to be less useful given the lack of reliable data on vehicles involved.

ACC data appeared to be the most reliable data source for a reliable indication of the total number of e-scooter incidents in Auckland.

SECTION 3: PRACTICAL OUTCOMES

11. Risk Assessment Framework

In this stage, learnings developed throughout the research are utilised to construct Risk Assessment Frameworks (RFAs).

The intent of the RFAs is to assist Auckland Transport as part of its decision-making process for accepting and regulating new shared mobility, and for prioritising infrastructure to support micromobility.

The frameworks, although built off findings in the research also involve a number of theoretical considerations where data is not available. Thus, they should only be used at a high level to provide an indication of the risk present at the site or for devices, rather than a prediction of the number of crashes that will occur. In later studies, this model should be developed further as more data becomes available.

There are two aspects to the safety of a given micromobility mode: the device itself (with all its functions and properties) and the environment in which it is found. Thus, there are two different aspects that can be evaluated for risk. To evaluate these two different aspects two RFAs have been created. The first is the Micromobility Device Risk Framework, which as the name suggests, looks at determining the risk inherent to the device. The second is the Micromobility Infrastructure Risk Framework, which looks at the risk that the infrastructure poses to micromobility devices, and does not depend on the micromobility device itself. The Micromobility Infrastructure Risk Framework does however consider exposure as one of its key criteria. This means it considers both the inherent risk of the infrastructure and also the infrastructure risk given the number and types of road users present.

As the research was conducted through a safe system lens, it was considered appropriate to model the micromobility Risk Assessment Framework on the Safe System Assessment Framework.

The benefit of evaluating a micromobility mode for risk is to identify what safety issues exist for that device in different infrastructure. Alternatively, evaluating the environment (which could be thought of as a given homogeneous road segment) allows for a risk level of different environments to be compared against each other and for the prioritisation of improvements to different road segments.

Both these Risk Assessment Frameworks and their distinct methodologies can be found in Appendix G.

12. Speed Analysis

12.1 Speed Analysis Premise

The research has shown that both the speed environment and travel speed of micromobility modes is the key factor in micromobility risk. Changing the speed environment to increase micromobility safety is the same as changing the speed environment for any VRUs. Thus, generic speed management principles in urban areas can be applied here. This includes increasing the perception of risk to drivers to decrease the actual risks.

There are many existing speed management implementations, that have already been trialled. Many of these have been proven to decrease the risk to VRUs. Unfortunately, given the limited data that is collected regarding the location of micromobility crashes, it would be difficult to determine if a given trial had been successful without using a surrogate measure– a measure of one variable that is used to indicate the outcome of another variable that is more difficult to measure. In this case, the surrogate measure is the travel speed of vehicles.

This is a normal surrogate measure in all speed management projects, not just those related to micromobility. Thus, there are many historical case studies that could be examined to indicate how to accomplish this outcome rather than conducting another trial in this area.

The best example for Auckland, is the recent decrease in speed limits within the city centre as part of the 2019 Speed Management Bylaw. This is a good example as it covers a large enough area that there is likely to be a measurable difference between crashes, operating speeds are being measured as part of evaluation process, and there is a high density of micromobility activity within the city centre.

For this reason, the intervention concepts considered in this study will not include those related to adapting a speed environment. It is instead advised that after a suitable period has passed -since the 2019 Speed Limit Bylaw implementation in the city centre - micromobility risk before and after these changes are investigated to see what measurable change a decrease in speed environment has to micromobility risk.

The Intervention concepts will instead focus on the travel speed of micromobility in this study. Thus far, the research has shown that stationary objects are a risk to riders. For this reason, it is possible that normal tactical urbanism techniques may not work, as they introduce additional temporary objects into the road space and thus additional collection hazards. Rather than implementing temporary physical changes to the environment, different environments could be compared to each other.

The current concept is therefore to measure micromobility speeds on different infrastructures, gradients and road environments; to see what existing features have an effect on micromobility modes. This can be used two-fold, first as a surrogate measure to determine where crashes are more likely to occur and secondly to help determine what permanent road environment changes can be made to decrease micromobility risk.

12.2 Speed Analysis Methodology

Micromobility surveys were undertaken at four Auckland city centre sites – Grafton Bridge, Queen Street, Quay Street and Nelson Street. The locations were selected as they experience high volumes of micromobility traffic due to their present infrastructure and strategic locations. Nelson Street and Quay Street have cycle lanes segregated from vehicle traffic, Grafton Bride is a key cycle connection between Newmarket and Auckland city centre and, as Auckland's central urban street, Queen Street typically has high volumes of pedestrian and micromobility traffic. **Figure 12.1** illustrates the survey locations. The micromobility surveys also include bikes, skateboards, and scooters. These mobility devices are not defined as micromobility but are included in the surveys to act as a comparison.

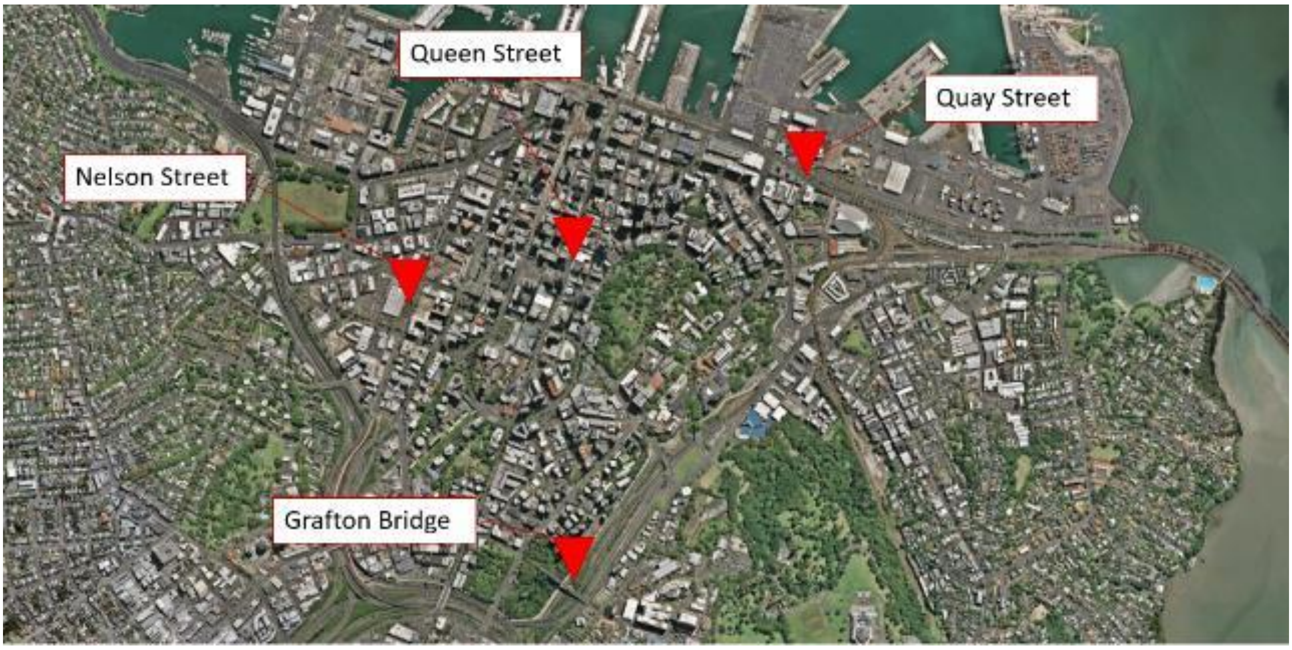


Figure 12.1 Survey Site Overview Map

Table 12.1 illustrates the specific positions from which the surveys were undertaken for each site. These positions were chosen in order to maintain surveyor safety whilst minimising disruption to micromobility and pedestrian traffic.

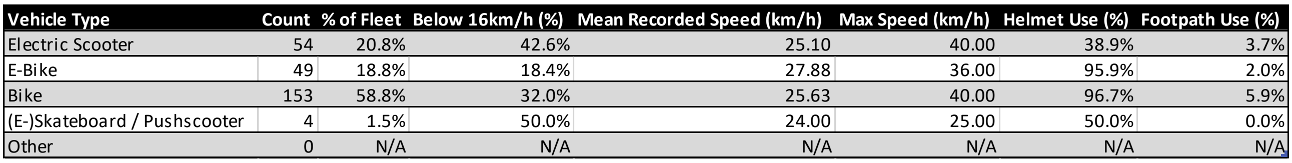
Table 12.1 Site Survey Positions (Clockwise: Grafton Bridge, Nelson Street, Quay Street, Queen Street)

The surveys captured information including mode, operating speed, direction of travel, helmet use, and whether the device was private or hired. Speeds were captured with the use of a hand-held radar speed gun – the speed gun had a minimum threshold of 16km/h so speeds below this could not be recorded. One surveyor operated the speed gun and relayed key information to the second surveyor, who recorded the data using a laptop computer. Any notable trends or unusual behaviours were also recorded. The surveyors would stand as close to where the micromobility users travel to get speed readings as straight on as practicable without interfering with micromobility users. On Nelson Street and Quey Street, the speed surveys were conducted directly adjacent to the cycleways resulting in high accuracy data. On Queen Street, speed readings were taken of users on the footpath or road. On the surveyor's side of the street, readings were taken close to straight on to the users. Speed readings of micromobility on the other side of the street are less accurate due to the greater angles relative to the line of motion of the users and interference with vehicles on the street. The survey at Grafton Bridge was again less accurate. Buses caused some interference as they would sometimes be blocking the clear, straight on speed reading of micromobility. The surveyors were located at the traffic lights, so speed readings of micromobility users would often capture users slowing down or speeding up from stationary.

12.3 Speed Analysis Site Specific Results

Grafton Bridge

A summary of results for the Grafton Bridge survey is provided in **Figure 12.2**



Vehicle Type	Count	% of Fleet	Below 16km/h (%)	Mean Recorded Speed (km/h)	Max Speed (km/h)	Helmet Use (%)	Footpath Use (%)
Electric Scooter	54	20.8%	42.6%	25.10	40.00	38.9%	3.7%
E-Bike	49	18.8%	18.4%	27.88	36.00	95.9%	2.0%
Bike	153	58.8%	32.0%	25.63	40.00	96.7%	5.9%
(E-)Skateboard / Pushscooter	4	1.5%	50.0%	24.00	25.00	50.0%	0.0%
Other	0	N/A	N/A	N/A	N/A	N/A	N/A

Figure 12.2 Results Summary: Grafton Bridge

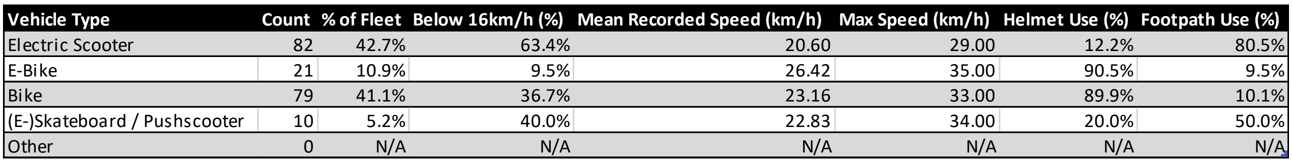
The survey location on Grafton Bridge was in very close proximity to the Symonds Street intersection. As a result, riders would frequently have to reduce their approach speed to stop on red. Although surveyors on site observed that operating speeds were higher further from the intersection, riders were often too far away for a reading to be taken or were obstructed by stationary buses stopped on red. For these reasons, speed values could not be recorded for 31% of devices in this survey. While the majority of riders were located on the roadway in this location, many riders would traverse the intersection during the pedestrian green phase by navigating through pedestrian traffic, rather than waiting for the vehicle green phase.

For speeds recorded at the Grafton Bridge site, e-bikes had the highest mean speed out of all the devices, with only 18% travelling below the 16 km/h threshold – comparatively, 32% of bikes were travelling below 16 km/h. Whilst this was primarily a result of e-bikes travelling faster than bikes, it was also a result of the intersection. The higher acceleration of e-bikes allowed riders to accelerate off the mark more quickly than bikes, enabling speeds to be recorded for some e-bike riders who had stopped at the intersection. Helmet compliance was extremely high amongst bikes and e-bikes, but use was only 39% for e-scooters, many of which were privately owned. Due to the narrow footpaths and high pedestrian volumes along Grafton Bridge, footpath utilisation rates were extremely low across all device types. As Grafton Bridge is a popular cycle connection between Grafton and Auckland city centre, bikes comprised the majority of the device fleet.

Grafton Bridge is a heavily trafficked bus route and has quite a narrow carriageway. Thus, when buses were stopped on red, riders would have to wait behind the stationary bus or navigate past, either onto the footpath, between the bus and the kerb, or around the bus into opposing traffic lane. This poses a significant safety risk for riders on the road and pedestrians using the footpath, which is quite narrow along Grafton Bridge. There was also a section of footpath near the Symonds Street intersection where the footpath had an obvious raised bump – riders perceived this as a potential safety risk, clearly reducing their speeds to negotiate the uneven section.

Queen Street

A summary of results for the Queen Street survey is provided in **Figure 12.3**



Vehicle Type	Count	% of Fleet	Below 16km/h (%)	Mean Recorded Speed (km/h)	Max Speed (km/h)	Helmet Use (%)	Footpath Use (%)
Electric Scooter	82	42.7%	63.4%	20.60	29.00	12.2%	80.5%
E-Bike	21	10.9%	9.5%	26.42	35.00	90.5%	9.5%
Bike	79	41.1%	36.7%	23.16	33.00	89.9%	10.1%
(E-)Skateboard / Pushscooter	10	5.2%	40.0%	22.83	34.00	20.0%	50.0%
Other	0	N/A	N/A	N/A	N/A	N/A	N/A

Figure 12.3 Results Summary: Queen Street

During the Queen Street survey, over 80% of e-scooter riders travelled on the footpath, likely a product of Queen Street's extremely wide footpaths. Additionally, the section of Queen Street at which the survey was performed lacks a dedicated cycle lane, further encouraging riders to use the footpath. As Queen Street experiences high pedestrian traffic on the footpath, e-scooters travelling on the footpath are constrained to lower speeds than those travelling on the road. Hired e-scooters also have a speed restriction in the Queen Street area, resulting in most of the e-scooter speed results being below the 16km/h minimum threshold.

Helmet compliance was once again extremely high amongst bikes and e-bikes, but use for e-scooters was only 12%, even worse than in the Grafton Bridge survey. Surveyors on site noted several hired e-scooter riders not wearing helmets despite them being clipped onto the front of their e-scooters.

The survey was carried out at a short midblock distance between two signalised intersections, with queuing during red light phases. Queen Street also facilitates many bus routes which added to the congestion, particularly in the downhill direction. As a result, bikes and e-bikes travelling downhill were noticeably slowed down – without this congestion, their mean recorded speeds would likely have been higher than 23 km/h and 26 km/h respectively, as would maximum speeds. Similar to the Grafton Bridge survey, e-bikes had a mean recorded speed around 3 km/h higher than that off bikes.

Quay Street

A summary of results for the Quay Street survey is provided in **Figure 12.4**

Vehicle Type	Count	% of Fleet	Below 16km/h (%)	Mean Recorded Speed (km/h)	Max Speed (km/h)	Helmet Use (%)	Footpath Use (%)
Electric Scooter	50	17.4%	24.0%	23.66	44.00	34.0%	0.0%
E-Bike	51	17.8%	5.9%	27.75	36.00	94.1%	0.0%
Bike	182	63.4%	14.3%	25.67	37.00	97.8%	0.5%
(E-)Skateboard / Pushscooter	2	0.7%	0.0%	23.00	24.00	50.0%	50.0%
Other	2	0.7%	0.0%	27.00	30.00	100.0%	0.0%

Figure 12.4 Results Summary: Quay Street

Quay Street has a dedicated cycle path which micromobility riders predominantly used rather than riding on the footpath or the road, hence the low footpath utilisation rates across all modes. This cycle path also accounts for bikes and e-bikes comprising over 80% of the fleet surveyed.

The flat nature of Quay Street, along with the uninterrupted cycleway facility, allowed for higher maximum speeds and mean speeds than those of Queen Street. Once again, e-bikes had a mean recorded speed around 2 km/h higher than that of bikes. The flat topography also meant that very few devices were travelling below the 16 km/h threshold. Helmet compliance was once again extremely high amongst bikes and e-bikes, but use for e-scooters was only 34%.

Nelson Street

Nelson Street was chosen for this survey study due to its significant gradient, enabling comparison of trends between uphill and downhill directions. **Figure 12.5** provides a summary of results for the uphill direction on Nelson Street, whilst **Figure 12.6** provides a summary of the downhill results.

Vehicle Type	Count	% of Fleet	Below 16km/h (%)	Mean Recorded Speed (km/h)	Max Speed (km/h)	Helmet Use (%)	Footpath Use (%)
Electric Scooter	8	30.8%	62.5%	32.67	51.00	62.5%	0.0%
E-Bike	3	11.5%	33.3%	26.00	27.00	100.0%	0.0%
Bike	13	50.0%	92.3%	28.00	28.00	100.0%	0.0%
(E-)Skateboard / Pushscooter	2	7.7%	100.0%	N/A	N/A	0.0%	100.0%
Other	0	N/A	N/A	N/A	N/A	N/A	N/A

Figure 12.5 Results Summary: Nelson Street (Uphill)

Vehicle Type	Count	% of Fleet	Below 16km/h (%)	Mean Recorded Speed (km/h)	Max Speed (km/h)	Helmet Use (%)	Footpath Use (%)
Electric Scooter	53	19.1%	1.9%	29.46	54.00	47.2%	0.0%
E-Bike	67	24.2%	0.0%	34.18	49.00	98.5%	0.0%
Bike	152	54.9%	0.7%	35.56	52.00	98.7%	0.0%
(E-)Skateboard / Pushscooter	2	0.7%	50.0%	25.00	25.00	50.0%	0.0%
Other	3	1.1%	33.3%	27.00	30.00	66.7%	0.0%

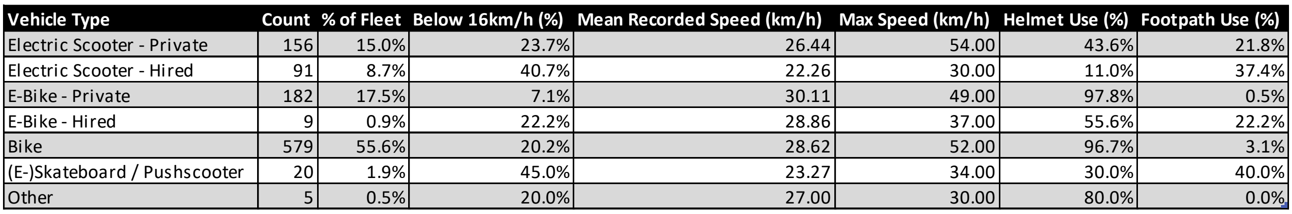
Figure 12.6 Results Summary: Nelson Street (Downhill)

Nelson Street has a dedicated two-way cycle lane segregated from the traffic lanes by a series of kerbed islands. Whilst this cycle lane offers protection for riders, it also encourages higher speeds due to a lower level of perceived risk, as evidenced by the higher mean speed and maximum speed values compared to other sites. The cycle lane also resulted in very low footpath utilisation rates across all modes.

The Nelson Street survey was undertaken during the morning peak, with most commuters travelling downhill into the city centre. An aggregated summary would therefore have skewed mean speed results due to downhill speeds being higher overall. The effect of the gradient can be clearly seen by comparing the respective mean speeds of bikes and e-bikes in each direction, with the downhill mean speeds being around 8 km/h greater for both modes. The maximum speeds tell a similar story, though the maximum e-scooter uphill speed was a significant outlier – this was provided by a private e-scooter rider.

12.4 Speed Analysis Aggregate Results

Figure 12.7 below provides a summary of the aggregate survey data across all four city centre sites. Electric scooters and electric bikes are segregated into private and hired devices to illustrate the similarities and differences between the groups. It should be noted that footpath use reflects only two sites where footpaths were available: Grafton Bridge (where footpaths tended not to be used) and Queen Street. Additional sites would be required to provide a clearer picture of footpath use by mode.



Vehicle Type	Count	% of Fleet	Below 16km/h (%)	Mean Recorded Speed (km/h)	Max Speed (km/h)	Helmet Use (%)	Footpath Use (%)
Electric Scooter - Private	156	15.0%	23.7%	26.44	54.00	43.6%	21.8%
Electric Scooter - Hired	91	8.7%	40.7%	22.26	30.00	11.0%	37.4%
E-Bike - Private	182	17.5%	7.1%	30.11	49.00	97.8%	0.5%
E-Bike - Hired	9	0.9%	22.2%	28.86	37.00	55.6%	22.2%
Bike	579	55.6%	20.2%	28.62	52.00	96.7%	3.1%
(E-)Skateboard / Pushscooter	20	1.9%	45.0%	23.27	34.00	30.0%	40.0%
Other	5	0.5%	20.0%	27.00	30.00	80.0%	0.0%

Figure 12.7 Results Summary: Aggregate

Speeds Across Micromobility/Mobility Device Modes

As noticed at each site individually, the overall mean speed for e-bikes was around 2 km/h higher than for bikes. Furthermore, 20% of bikes had speeds recorded below 16 km/h, compared to only 8% for e-bikes. Thus, the actual speed discrepancy between the two modes is likely larger than 2 km/h but could not be determined exactly due to the minimum threshold of the speed gun.

Differentiating between hired and private e-scooters reveals large differences in both mean recorded speeds – 4 km/h – and maximum speeds – 24 km/h. Furthermore, 41% of hired e-scooters had speeds recorded below 16 km/h, compared to only 24% for private e-scooters. Thus, the actual discrepancy between the two modes is likely larger than 4 km/h but could not be determined exactly due to the minimum speed threshold of the speed gun. Whilst the 4 km/h difference underlines the effectiveness of the speed restrictions on hired e-scooters, it also reflects differing rider confidence levels – owners of private e-scooters will be more confident riders and travel faster than those hiring e-scooters due to riding more frequently. This would also explain the differences in footpath utilisation rates, with nearly half as many private e-scooter riders opting to ride on the footpath, typically considered the safer environment, compared to hired e-scooter riders.

Helmet Use

Helmet compliance for bikes and private e-bikes were excellent at 97% and 98% respectively, while hired e-bikes had a compliance rate of only 55%, though the sample of hired e-bikes was very small. Helmet use was only 43% for private e-scooters and an even worse 11% for hired e-scooters, both far below the rates observed for cyclists. These numbers are particularly concerning given the maximum speeds recorded for e-scooters, particularly the 54 km/h maximum for private e-scooters. These discrepancies in helmet use between modes are likely a result of legislation – e-bike riders are legally required to wear a helmet whilst e-scooter riders are not.

Speed Distribution

A frequency distribution of device operating speeds is outlined in grey in **Figure 12.8** , along with an overall trendline shown in red.

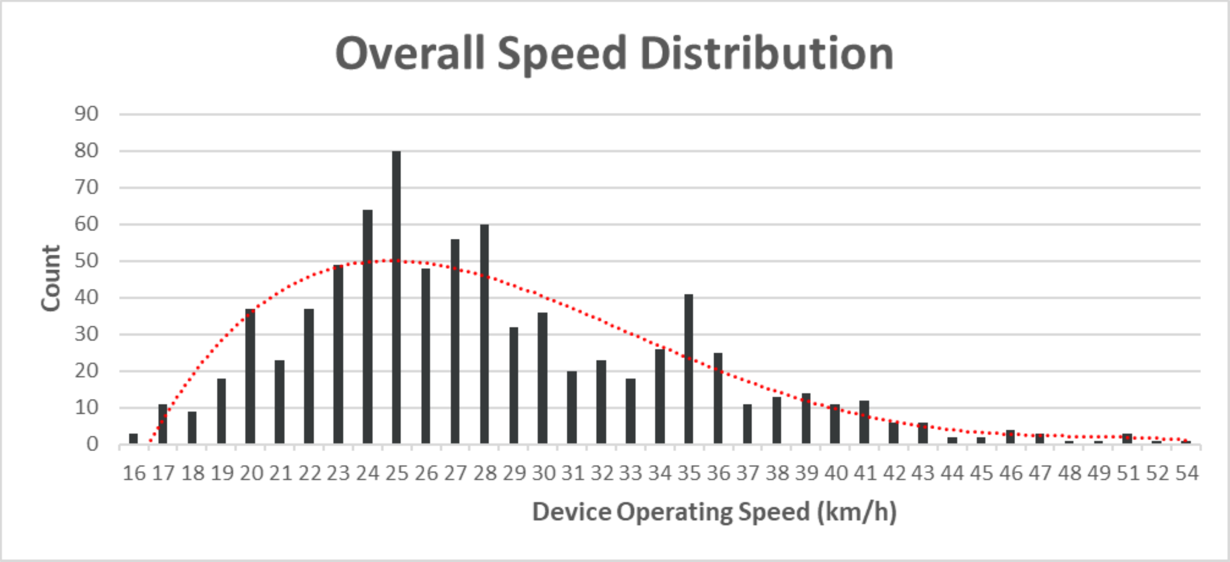
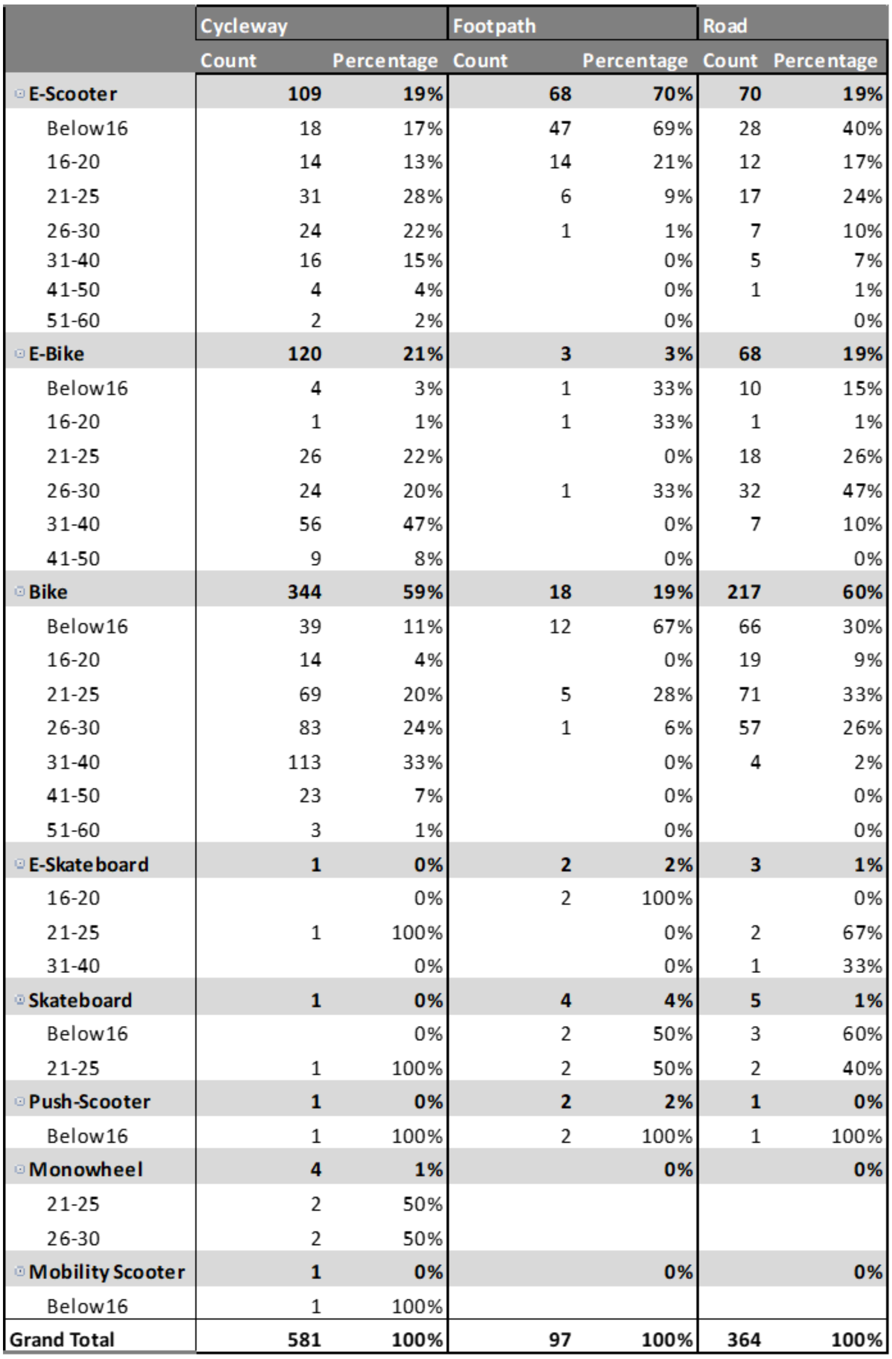


Figure 12.8 Operating Speed Frequency Distribution

Figure 12.8 reveals that the majority of micromobility devices operate below 30 km/h, particularly when accounting for those with readings below 16 km/h.

Speeds by Position

In order to obtain a better understanding of where potential physical intervention should be directed, micromobility device speeds have been analysed based on their operating position. Count and percentage statistics are provided in **Error! Reference source not found.** with speed recordings grouped into ranges for ease of analysis.



	Cycleway		Footpath		Road	
	Count	Percentage	Count	Percentage	Count	Percentage
⊖ **E-Scooter**	**109**	**19%**	**68**	**70%**	**70**	**19%**
Below16	18	17%	47	69%	28	40%
16-20	14	13%	14	21%	12	17%
21-25	31	28%	6	9%	17	24%
26-30	24	22%	1	1%	7	10%
31-40	16	15%		0%	5	7%
41-50	4	4%		0%	1	1%
51-60	2	2%		0%		0%
⊖ **E-Bike**	**120**	**21%**	**3**	**3%**	**68**	**19%**
Below16	4	3%	1	33%	10	15%
16-20	1	1%	1	33%	1	1%
21-25	26	22%		0%	18	26%
26-30	24	20%	1	33%	32	47%
31-40	56	47%		0%	7	10%
41-50	9	8%		0%		0%
⊖ **Bike**	**344**	**59%**	**18**	**19%**	**217**	**60%**
Below16	39	11%	12	67%	66	30%
16-20	14	4%		0%	19	9%
21-25	69	20%	5	28%	71	33%
26-30	83	24%	1	6%	57	26%
31-40	113	33%		0%	4	2%
41-50	23	7%		0%		0%
51-60	3	1%		0%		0%
⊖ **E-Skateboard**	**1**	**0%**	**2**	**2%**	**3**	**1%**
16-20		0%	2	100%		0%
21-25	1	100%		0%	2	67%
31-40		0%		0%	1	33%
⊖ **Skateboard**	**1**	**0%**	**4**	**4%**	**5**	**1%**
Below16		0%	2	50%	3	60%
21-25	1	100%	2	50%	2	40%
⊖ **Push-Scooter**	**1**	**0%**	**2**	**2%**	**1**	**0%**
Below16	1	100%	2	100%	1	100%
⊖ **Monowheel**	**4**	**1%**		**0%**		**0%**
21-25	2	50%				
26-30	2	50%				
⊖ **Mobility Scooter**	**1**	**0%**		**0%**		**0%**
Below16	1	100%				
Grand Total	**581**	**100%**	**97**	**100%**	**364**	**100%**

Figure 12.9 Device Speeds by Position

As seen in **Figure 12.9Figure 12.9**, speeds varied by position for most modes. Micromobility travelling on footpaths tended to have lower operating speeds than those travelling on roads or dedicated cycleways, but this discrepancy was most notable for e-scooters. This was caused by a combination of pedestrian volumes limiting device operating speeds and many footpath-operated e-scooters being hired. Hired e-scooter riders may be less confident and thus travel at lower speeds on the footpath, whereas more confident private riders will drive on the road where their speeds are not constrained by pedestrian traffic.

Interestingly, the maximum speeds for e-scooters, e-bikes and bikes were all recorded from devices travelling on dedicated cycleways. In fact, mean speeds for all three modes were notably higher on dedicated cycleways than for devices on roads or footpaths. This may be a reflection of riders' lower perceived level of risk on a cycleway compared to on road – the resulting level of perceived safety empowers riders to travel faster.

E-scooters accounted for 70% of devices travelling on the footpath but made up only 19% of devices travelling on both roads and cycleways. Bikes and e-bikes accounted for around 60% and 20% of the fleet respectively on both cycleways and roads. There were three times as many bikes as e-bikes. Based on this composition information, potential intervention methods could be targeted towards specific modes by targeting the position in which they are most commonly operated.

13. Intervention concepts

This study has indicated that micromobility users are utilising infrastructure which is shared with other road users. There are differing risks associated with different infrastructure use. While tactical urbanism measures have been proposed throughout Auckland as part of the Innovating Streets programme, many of these focus on road space reallocation for cyclists and pedestrians with limited analysis of the impact on micromobility. This study therefore seeks to identify two sites which can be used as a test concept for the impact of an intervention on micromobility usage on both pedestrians and micromobility users. In addition, a third trial concept has been identified to supplement knowledge of infrastructure provision for micromobility in future.

Intervention concepts can be found in Appendix H.

SECTION 4: CONCLUSIONS

As per the study objectives, Auckland Transport (AT), in conjunction with ACC, want to better understand the safety risks associated with new and emerging micromobility, and develop a practical approach to assessing risk and accommodating these modes on the network. This in turn is expected to improve both AT's and their partners' ability to deliver better, safer travel options for their customers, by influencing micromobility licensing, design and policy.

This conclusion answers research questions, draws out key learnings, and recommends next steps in line with study objectives.

14. Evaluation

14.1 Research Questions

The research questions investigated in this study are shown in **Table 3.1**. This section compares the evidence from this study and how it responds to each of the questions posed.

14.2 How significant is skill level in crash results?

Research stage	Findings
Discussion	In order to measure the skill level of a rider, the proxy measurement of the number of rides a given rider has already had before a given incident occurs was used. This is not a perfect substitute measurement of the skill level, as not only can trip durations be different but also some skills might be transferable. However, it was considered to be suitable, as it is generally accepted that skill rises through repetition. Both the literature review and the survey were able to contribute findings towards answering this question. Moreover, the survey and the literature review both support the fact that e-riders in general are more likely to have a collision if an micromobility vehicle has been ridden fewer times. In the literature review two studies showed that 33 to 37% of injuries occurred on the first ride, while one added that another 30% of injuries occurred within ride number 1 to 9 (APH, 2019; Cicchino et al., 2021). The results from the survey aligned with the literature and found that 31% of e-scooter crashes occurred within the first four rides. Interestingly, the survey did not present the same findings for e-bike riders . The survey instead found that most e-bike riders involved in incidents are experienced riders. This may be due to the skills obtained in bike riding being more transferable to e-bikes than scooter riding is to e-scooters and/or that e-bike riders have often transferred from bicycles, such that they already have some core transferable skills whereas e-scooter riders often were new the device, powered or unpowered.
Conclusion	Overall, it can be determined from the research that skill level appears to be a key risk factor in micromobility safety in general, however, there is less evidence to suggest skill level is a factor in e-bike incidents.
Practical use	From the conclusions, it is likely that early training for e-riders (excluding e-bike riders) would help safely progress them through their first few rides where risk of experiencing an incident is at its highest.

14.3 What are the effects of current guidance and operations on safety?

Research stage **Findings**

Discussion

Effects of current guidance and operations on safety takes the form of three categories: helmets, legal use of vehicles, and speed. Given that speed is covered in great detail by other questions, this question will cover legal use of vehicles and helmet use.

Helmets

The literature review shows that there are a high number of injuries to the head, face or neck from using e-scooters. This indicates that protective head gear could help to reduce the severity in some crashes. It should be noted that current helmet designs do not protect the face andmay be partly inadequate for a forward fall mechanism.

The ACC data, albeit of limited sample sizes, showed that concussion/brain injury appears to be more than twice as common on e-bikes compared to e-scooters. Given that these internal injuries can be life threatening, this indicates that it may be more relevant for e-bike riders to wear helmets than e-scooterists. This is aligned with AT’s safe system thinking which looks at the likelihood of a collision occurring and also takes into consideration the risk of that collision resulting in serious or fatal injuries.

E-bike injuries also resulted in a higher proportion of concussion/brain injury than bike injuries. Given that their speeds in the speed analysis were very similar (for data above 16km/h) this may be due to lower helmet compliance historically with a greater proportion of the fleet being rental vehicles. The speed survey indicated that helmet compliance is lower for rental vehicles.

Interestingly, the literature review showed bike injuries less often involve head injuries than e-scooter injuries but are more likely to involve internal injuries. The ACC data had slightly different findings, with a very similar proportion of e-scooter and cycle crashes resulting in a concussion or head injury. Looking at the speed data e-scooters were also traveling at relatively similar speeds to cyclists, with bikes traveling only 2km/h higher on average (for results greater than 16km/h). As the X-KEMM-X analysis shows that speed change is one of the key factors in head injuries, for micromobility vs pedestrian crashes, this indicates that there is only a slightly higher risk for cyclists if a crash occurred. Thus, while some of the limited sample sizes from ACC data suggests that e-bikes crashes are more likely to result in serious brain injuries, it is interesting that cyclists are required to wear helmets and e-scooterists are not.

There are a higher number of cyclist crashes than e-scooter crashes recorded from ACC data. While comparative mode splits are unknown, video count data and 2020 Auckland cordon data suggests significantly more cycle use than e-scooter use, so higher crash levels are expected. There is also evidence of higher likelihood that an e-bike crash will result in a serious injury, supporting helmet use for cycling and e-cyclists.

Legal Use of Micromobility Vehicles

While the literature review shows that many cities or states have banned micromobility on footpaths, the data suggests this may not be the best approach to take. This is because the literature review also showed that injuries occurring on the road are more likely to be severe than on the footpath or other types of infrastructure (Cicchino et al., 2021) – Washington DC and collisions with motor vehicles are likely to be overrepresented in hospital data since their severity is likely higher (80% of the first 24 e-scooter deaths in the US involved motor vehicles (Harmon, 2020)). Thus, the research would argue that, to decrease the chance of serious and fatal injuries and align with a safe system approach, some forms of micromobility such as e-scooters should be managed to avoid vehicles rather than pedestrians where traditional vehicle speeds are greater than 30km/h. Alternatively, the road environment and speed limit could be changed such that if a collision does occur, between a vehicle and a micromobility rider, this is less likely to result in a serious outcome.

Conclusion

Helmets undisputedly reduce the risk of serious and fatal injuries, and the legal requirement for helmet use on both bicycles and e-bikes appears justified. However, e-scooters are capable of achieving similar speeds to bicycles and e-bikes and where riders are exposed to higher speed vehicles, will be similarly vulnerable to head injury as cyclists and e-bicyclists. There appears to be an inconsistency in helmet regulation between these vehicles.

When it comes to legislation and regulations, research would suggest that to decrease the chance of serious and fatal injuries and align with a safe system approach, avoidance of vehicles rather than avoidance of pedestrians should be prioritised for some forms of micromobility. This is in cases where traditional vehicle speeds are greater than 30km/h.

14.4 What are the infrastructure geometry or design requirements for micromobility?

Research stage	Findings

Discussion

While the literature review shows that many cities or states have banned micromobility on footpaths, the data suggests this may not be the best approach to take. Some studies showed that injuries occurring on the road are more likely to be severe than on the footpath or other types of infrastructure (Cicchino et al., 2021) and collisions with motor vehicles are likely to be overrepresented in hospital data since their severity is likely higher (80% of the first 24 e-scooter deaths in the US involved motor vehicles (Harmon, 2020)). Thus, the research would suggest that, to decrease the chance of serious and fatal injuries and align with a safe system approach, some forms of micromobility, such as scooters, should be managed to avoid vehicles rather than pedestrians, where traditional vehicle speeds are greater than 30km/h.

This was supported by the survey that showed, while almost 2 in 3 (65%) reported incidents occurred on a footpath, injuries on footpaths are less likely to result in higher severity crashes than those that occur on the road. Moreover, the video analysis showed that there was a far greater proportion of people using the footpath rather than the roadway, (except where footpaths are comparatively narrow and pedestrian flows high), thus the crashes occurring on the roadway could be due more to exposure rather than individual risk.

Interestingly another aspect of infrastructure found to be a primary contributing factor to severity of crashes in the CAS analysis was the gradient of the road. While only 30% of crashes occurred on what was reported as a “hill road” (i.e. a steep gradient), 71% of serious injury crashes occurred on a “hill road”. As this includes only crashes between vehicles and micromobility modes, and these have been determined to be of a higher severity, this indicates that high gradient roads are especially dangerous to micromobility. Thus, treatments targeting micromobility modes should consider steep roads.

Conclusion

Infrastructure projects that are designed to reduce micromobility risk, should look at infrastructure that encourages micromobility vehicles away from the road, particularly where speed limits exceed 30km/h. This includes off road cycle lanes and extended footpaths. Alternatively, infrastructure that reduces vehicle speeds would also create a safer environment, even if this does in turn encourage more e-riders into the roadway.

It is also recommended that when determining the location of slow speed zones, roads with a high gradient should be considered.

14.5 What is the impact of facility condition and maintenance on risk?

Research stage	Findings

Discussion

The literature review revealed intriguing but insufficient evidence that surface features and obstacles can be significant factors of risk. It did note that, in one study, respondents reported, falls due to adverse surface features (e.g., pothole, uneven pavement) accounted for 25% of injury crashes and infrastructure (e.g. driveway lip) accounted for 16% (Cicchino et al., 2021). The survey showed similar results determining that environment factors, such as road surface, are the leading cause of e-rider collisions with non-moving objects, while the cause of collisions with others is often assigned to rider behaviour. However, only 22% of the total incidents were reported as due to environmental impacts while 50% were reported as behavioural.

In the survey results, incidents where bumpy or uneven surfaces were recorded as a cause of the incident were plotted. However, it was determined that there is no significant cluster of incidents that occurred in sufficient proximity. Thus, it was not possible to identify any specific location with particularly poor surfacing.

The CAS data opposed the hypothesis that poor surfacing affected crashes further. Where individual CAS reports were read to understand possible crash causes, less than 3% indicated in the analysis that poor surfacing was one of the key causes. However, noting that there were a number of unknown causes and a small overall sample size and this only considered crashes involving traditional vehicles, this could not be considered a good representation of all e-micromobility incidents.

Conclusion

While surfacing appears to be less of a risk than other factors, it does have an effect on risk and is worth considering when designing new infrastructure or creating a maintenance plan. Unfortunately, the research was not able to identify any specific locations in Auckland where clusters of incidents had occurred due to poor surfacing.

14.6 How does the risk of different micromobility modes compare with other activities?

Research stage	Findings

Discussion

One study from the literature review indicated that powered micromobility leads to significantly higher rates of severe injuries than non-powered micromobility (Tan et al., 2019). The ACC data showed that the injury types sustained in both cyclist and e-scooter crashes were very similar: both riders share the top 5 most common injuries, in the same order and with similar percentages. Arguably the highest severity: the concussion/ brain injury, has a slightly higher percentage for e-scooters than it does for cyclists. Scooterist who made an ACC claim were15% more likely to have received a concussion/ brain injury than a cyclist making an ACC claim.

When the numbers of claims made regarding different modes of transport were considered in 2019, this showed that substantially more cyclist ACC claims were being made compared to e-scooter ACC claims, with even lower numbers of e-bike claims. Without data on trips or distances travelled, these numbers cannot be compared as risk indicators.

There were over 7 times as many ACC claims made in 2019 relating to skateboards rather than e-scooters and approximately 6.5 times more roller skating injuries than e-bike injuries. This is of particular interest because the survey information showed that e-scooters are ridden weekly by 11% of Auckland residents and e-bikes by 8%. Anecdotally, this is unlikely to be higher for rollerskates and skateboards. This is supported by the video surveys that show much higher levels of e-scooters and e-bikes than skateboards and rollerskates (noting that this data is just for the city centre where micromobility use is higher) Thus, while injuries are being sustained from micromobility modes, these do not seem to be substantially more frequent than injuries from other non-electrically powered modes of transport.

In the CAS data, from 2016 to 2019, e-scooter and e-bike injuries were also far less common than cyclist injuries; however, given that there was a “tick box” for cyclist crashes and no “tick box” for either e-cyclists or e-scooters, this was not considered to be a conclusive data score to pull on for this comparison.

Conclusion

Unfortunately, due to a lack of data around micromobility use across Auckland it was not possible to come to a data led conclusion on the rate of injury per km travelled for different modes. However, the number of micromobility injuries was much lower than other modes on a whole and it seemed unlikely that micromobility devices had a much higher risk than other substitute modes such as cycling, roller skating and skateboarding.

14.7 What is a safe speed environment for micromobility modes?

Research stage	Findings

Discussion

Vehicle speed environment

The X-KEMM-X crash model between motor vehicles and micromobility modes shows that the speed of the car is the key determinant in the severity of the collision. It indicates that 30km/h or lower operating speeds are the safest for two-wheelers, including e-bikes and e-scooters. This was supported by the CAS data that indicated that crashes were more likely to occur at higher speeds between vehicles and micromobility modes and that the severity was more likely to be higher. This indicates that high vehicle speeds are a key risk to micromobility safety.

This was also supported by the survey that found that injuries on footpaths are less likely to result in higher severity injuries than those that occur on the road. This indicates that though there may be a high number of incidents occurring on the footpath, it should perhaps be the on-road incidents that are designed for, to create a system free from deaths and serious injuries.

This is supported by the literature review that showed that injuries occurring on the road are more likely to be severe than on the footpath or other types of infrastructure (Cicchino et al., 2021) and that collisions with motor vehicles are likely to be overrepresented in hospital data since their severity is likely higher (80% of the first 24 e-scooter deaths in the US involved motor vehicles (Harmon, 2020)).

This is perhaps unsurprising as micromobility riders are VRUs with little to no protections and thus, if a collision does occur between a vehicle and a micromobility rider, there will be a similar outcome to a collision between a pedestrian and a motor vehicle.

Micromobility speed environment

When it came to micromobility speeds, there was insufficient data for the X-KEMM-X data to tell how different micromobility modes compared in terms of crash severity risk. It was also not possible to provide a chance of death and serious injury for collision between micromobility modes and pedestrians. This was unfortunate as it was the research group’s hope that this could be compared to the car vs pedestrian crash risk. The X-KEMM-X data was, however, able to indicate the risk of a collision resulting in a concussion, for collisions between micromobility modes and pedestrians at different speeds. Combined with the speed data, this provided an indication of what risks there are on different areas of the network.

From the X-KEMM-X analysis, it was determined that collisions between micromobility modes and pedestrians had a low likelihood of concussion (and hence severe injury) for micromobility speeds below 20km/h. Even bike and e-scooter speeds of around 20km/h are acceptable in respect to risk of concussion, except at high end speeds of pedestrian movement (e.g. a collision with a jogger or also on a device like an e-scooter), although it should be noted that this model specifically relates to the risk of collision impacts and that collisions could lead to falls with their own consequent injuries.

Regarding e-bikes specifically, interestingly, the speed survey (albeit limited in data) showed that bikes and e-bikes travel at similar speeds (apart from in lower speed brackets where e-bikes can accelerate more quickly and particularly travel faster uphill). As speed can be used as a suitable indication of crash severity, this indicated that e-bikes should be thought of and treated similarly to unpowered cyclists.

The difference in the lower speed bracket (speeds less than 16km/h) is likely due to e-bikes travelling faster up hills. Due to the exponential relationship between speed and severity risk, these low speeds are not considered an area of concern.

When it comes to determining a suitable speed for micromobility devices, it is important to remember that, using a safe system lens, the greatest concern is not between pedestrians and e-scooters, but between all VRUs and vehicles, as this is where the higher risk of severe and fatal outcomes exists. However, as falls can result in serious injuries at even low speeds, especially when the head is hit, this means that not only should the severity of the initial collision be considered but also the subsequent collision with the ground, an element for which insufficient data is available to provide insight as to chance of concussion or other injury. The speed of the micromobility user will affect both the likelihood of collisions occurring and the severity of the outcome. It will also, in many situations, increase the likelihood of a collision with a vehicle.

Low speed zones for shared e-scooters were instituted in central Auckland in July 2019. However, ACC claims were already declining by July 2019 so this change in micromobility speeds is not clearly linked to a reduction in ACC claims.

Conclusion

For e-bikes, given that they have similar operating speeds to bikes, have similar preferences in terms of infrastructure use, and can be treated similarly to bikes in terms of collision severity; speed environments for e-cyclist should be similar to that of cyclists.

For other micromobility modes, as with all VRUs, the speed environment of vehicles should be managed to survival levels. In this case, 30km/h or lower operating speeds are appropriate for two-wheelers, including e-bikes and e-scooters.

Regarding micromobility speeds in terms of collisions with pedestrians, the speeds below 20km/h tend to have a low likelihood of concussion and hence severe injury to the pedestrian and micromobility user. However, for certain individuals with a disability or impairment, the outcome of a collision could be significant even at lower speeds.

Higher micromobility speeds do, however, increase the likelihood of the higher severity injuries with traditional vehicles. Thus, where traditional vehicle speeds are not managed to survivable levels, vehicle collisions rather than pedestrian collisions should be the key consideration.

14.8 What are the effects on non-user safety?

Research stage	Findings

Discussion

The most common type of e-scooter crash identified in the literature consists of riders falling or colliding with a non-moving object on their own (Harmon, 2020). The literature also noted that this can represent over 90% of crashes (Brownson et al., 2019; Trivedi et al., 2019). Thus, indicating that overall, these crashes are far more likely than pedestrian crashes. Portland data counted 13.6% of e-scooter injury crashes involving cars or trucks and 1.7% involving pedestrians (PBOT, 2018). Another piece of literature stated that little data is available on pedestrians getting injured by micromobility riders. Although sample sizes are small, pedestrians may only rarely receive injuries from collisions with micromobility riders where they require medical attention. For example, a study of injuries treated at two southern Californian medical centres over the course of a year found that 8.4% of victims of crashes involving e-scooters were non-riders (Trivedi et al., 2019). This data is based on 21 individuals only (11 were hit by an e-scooter, 5 tripped over a parked scooter, and 5 were attempting to lift or carry a scooter not in use).

The initial findings from the survey seemed to lead towards a similar conclusion. While one in two micromobility riders have experienced an incident in the past 3 years they were most commonly near misses or e-rider falling off their device - only 2% having collided with another road user. However, later findings show that of 138 pedestrian incidents, 17 resulted in a collision with a micromobility vehicle, resulting in 9 injuries, 5 of which were to the pedestrian. There were also 21 collisions between pedestrians and stationary micromobility devices.

While these incidents did result in injury and arguably affect travel equity, the risk of high severity outcomes resulting from these incidents is likely much lower than other incidents that pedestrians face, such as vehicle vs pedestrian collisions. Where a pedestrian is involved in a collision, around half of the time one party or another was injured, and around half required time off work.

The X-KEMM-X data showed that at travel speeds 20km/h and higher, collisions between pedestrians and e-riders could result in a concussion. At higher speed changes the level of concussion is more likely to lead to serious injury or death. However, in terms of the overall safety risk attributable to micromobility, collisions between pedestrians and e-riders are relatively small.

Conclusion

In terms of the overall safety of micromobility, collision between pedestrians and e-riders are relatively small and the risk of high severity outcomes resulting from these incidents is likely much lower than other incidents that pedestrians face. However, for certain individuals with a disability or impairment, the outcome of a collision could be significant even at lower speeds.

14.9 How does perception relate to a real safety concern?

Research stage	Findings

Discussion

Due to micromobility being a relatively new travel mode and share-use schemes bringing them into prominence in the public's eye, there is a significant concern regarding the safety of these devices.

The literature showed that safety is the main barrier to trying an e-scooter (Fitt and Curl, 2019; Kantar, 2019) and it remains a concern for many riders including other types of micromobility. 50% of micromobility users (all types of vehicles) responding to the French insurance industry survey agreed that micromobility is a dangerous travel mode (Smart Mobility Lab, 2020).

When it comes to the feeling of safety while not riding micromobility, the literature confirmed the general worry of pedestrians when around e-scooters or other forms of micromobility. In the Auckland survey, carried out when the first shared e-scooter operations had just been introduced to the city (late 2018), 69% of pedestrians thought the speed of e-scooters was 'a bit' or 'very' unsafe and three in five respondents felt at least a bit unsafe when sharing footpaths with e-scooters (Kantar, 2019). Getting hit because of poor rider behaviour (e.g. riding too fast or too close) was the main concern, and the elderly or people with disability felt particularly at risk. **Figure 5.2** illustrates the difference in perceptions between users and non-users.

Thus, the perception from non-users seems to be that micromobility devices pose a relatively high threat.

In contrast to these concerns, the data from the literature showed that while collisions with motor vehicles are likely to be overrepresented in hospital data (since their severity is likely higher - 80% of the first 24 e-scooter deaths in the US involved motor vehicles (Harmon, 2020)); crashes that do not involve motor vehicles may be less severe and may not result in hospital care. 2018 Portland data counted 13.6% of e-scooter injury crashes involving cars or trucks and only 1.7% involving pedestrians (PBOT, 2018). An Auckland study found only 2.8% of e-scooter injuries treated at Auckland City Hospital had a car as "mechanism of injury" and 0.6% had "pedestrian" (Brownson et al., 2019)

The survey agreed with these studies showing that most incidents reported by the rider included near misses or falling off, with only 2% having collided with another road user.

Additionally, the ACC data showed that when different forms of micromobility and non-powered mobility devices are considered, micromobility modes have far lower reported injuries. As an example, in Auckland, there were 15,649 ACC skateboard claims reported while only 2,442 E-scooters claims and 301 e-bike claims. Because this cannot be determined from the research to a per user basis, it is not possible to determine how this compares to individual risk. It does, however, give an indication of the collective risk these e-micromobility modes pose to Aucklanders.

Coupling these two findings, this indicates that there are relatively few e-scooter incidents compared to other modes and that only a very small number of involve a collision with pedestrians. However, without verifiable data about usage and exposure, the confidence level around the risk is low.

When considering the severity of injuries for pedestrian collisions, the survey showed half of the time one party was injured, and around half required time off work. Of the pedestrians that received injuries, approximately half also sought medical attention. Comparing this to all injury collisions, the number of incidents resulting in injuries that sought medical attention was slightly higher. This indicates that pedestrian crashes may be slightly more serious than other micromobility crashes.

Conclusion

While the risk to an individual rider could not be determined due to a data gap in the research, it was determined that overall the risk micromobility poses to pedestrians on a whole is relatively low, with the risk micromobility poses to its riders being much higher. However, for certain individuals with a disability or impairment, the outcome of a collision

Research stage	Findings
	could be significant even at lower speeds. It was also found that when it came to collisions involving motor vehicles, although these were relatively uncommon, they do pose a significant threat to e-riders.

14.10 How does hired vs owned micromobility safety relate?

Research stage	Findings
Discussion	

One study from the literature stated that a 2020 France-wide survey commissioned by the insurance industry looked at all forms of micromobility including e-bikes and gathered 5,014 responses. 23% of owner-riders reported having been involved in a micromobility related fall or crash against 13% of shared micromobility users. This on face value might seem to indicate that owner-riders are of a higher risk that shared micromobility riders. However, an owner is likely to ride their micromobility far more often than a shared micromobility users; thus, this does not tell us much about the actual risk to either rider.

The survey this study conducted, showed that of the incidents that occurred 60% occurred with shared use micromobility vehicles, 21% with privately owned, with the remaining 20% unknown. In other words, a micromobility vehicle involved in an incident was approximately 3 times as likely to be a shared-use device rather than a privately owned device. When this is taken into consideration with the video count and speed survey data, which showed that in Auckland city centre there was only a slightly higher number of hired micromobility vehicles compared to privately owned, this indicates that shared-use riders are at higher risk of being involved in an incident than owner-riders. This is also supported by our previous findings that showed that less skilled riders are more at risk than skilled riders. However, further survey work is required to ascertain both overall usage levels and proportions of hire scooters.

An additional factor is helmet usage. The speed survey indicated significantly lower levels of helmet use for those users on hired devices, both e-scooters and e-bikes, while hired e-scooters even within the lower speed area were able to reach speeds of 30km/h. Lower helmet use on a vehicle travelling over 20km/h means increased risk of concussion.

Conclusion

Shared-use riders appear to be at higher risk of being involved in an incident than owner-riders, this is likely due mainly to lower skilled riders being more at risk than skilled riders. They are also more likely to suffer severe concussion due to significantly lower rates of helmet use.

15. Key Learnings

This section of the report summarises the key learnings from the study. These findings do not necessarily relate directly to the research questions, and a further analysis of the evidence base underlying each of those questions and responses is detailed in Section 14.

15.1 Similarities and Differences between Micromobility types

This study specifically investigated micromobility rather than all mobility devices. In the course of this study various pieces of evidence have emerged in relation to the different types of micromobility.

Micromobility Types

E-scooters and e-bikes make up the majority of devices observed, and incidents recorded. E-skateboards, segways, monowheels and other devices represent only a small proportion of usage (2.4% recorded in speed surveys). Therefore, the majority of findings relate to e-scooters and e-bikes. There is generally insufficient data to provide specific learnings on modes other than these two.

E-Scooters vs. E-Bikes

The overall learning is that e-scooter and e-bike users behave completely differently. A summary of the different behaviours is as follows:

- E scooter and E-bike usage is similar, but e-scooter incidents represent 79% of the incidents reported in our survey.
- E-scooter riders usually use the footpath, e bike riders usually use the road.
- E-bike riders typically wear helmets, e-scooter riders do not.
- Though examples of use of drugs and alcohol are rare, e-scooter riders involved in incidents are far more likely to have been using drugs or alcohol than e-bike riders.
- Skill level is a far more significant factor in e-scooter incidents than e-bike incidents. This is likely because a lot of the skills required to ride an e-bike are transferable from riding traditional cycle.

In addition, it is noted that inexperience plays a significant part in new micromobility crashes for e-scooters, whereas e-bike users involved in crashes or incidents tend to be experienced users.

E-Bikes vs. Bicycles

This study specifically investigated micromobility, which includes e-bikes. In the course of this study various pieces of evidence have been presented in relation to the similarities and differences between e-bikes and bicycles. A summary of the key points emerging are:

- Average speeds for e-bikes are very similar to bicycles, at around 2km/h faster than bicycles (for speeds recorded above 16m/h). There is a significant difference in speeds uphill however where e-bikes are noticeably faster
- E-bike helmet compliance recorded in the speed survey is marginally lower than bicycles at 95.9% as opposed to 96.7%; it appears that the majority of non-helmet wearers are those on hired e-bikes.
- E-bikes and bicycles both use the footpath/cycleways at very similar proportions. If anything e-bikes are slightly less likely to ride on the footpath than bicycles.

- ACC data shows injuries sustained by e-cyclists are more than twice as likely as injuries sustained by traditional cyclists to result in concussion / brain Injuries. Though it was not clear why this was the case, it is suspected that this is due to an older rider demographic.

Hired vs. Private Ownership

There are some clear differences in the behaviour of those on hired as compared with privately owned devices. This is mainly observed from speed data, but also the Kantar survey data

- Privately owned devices make up 95% of the recorded e-bikes in the speed survey, but 61% of e-scooter users.
- The majority of e-scooter incidents in the survey (68%) were on rental devices, while the majority of E-bike rider incidents (68%) were on privately owned devices
- Helmet use is much higher amongst privately owned e-scooter riders (43.6%) than hired (11%) in the speed survey.
- Helmet use is also higher amongst privately owned e-bike riders (98% against 56% for hired e-bikes) in the speed survey. Private e-scooter users tend to use the road more than hired e-scooter users.
- Mean speeds are higher for private e-scooters than hired e-scooters (some of our samples were within the shared-use e-scooter low-speed zones in Auckland).
- Private e-scooter users tend to use the road more than hired e-scooter users. This is likely due to a combination of e-scooter owners having more experience and being more comfortable in higher speed environments and shared-use devices having restricted speeds in low-speed zones.

15.2 Crash Comparison

Key Trends

Some key trends relating to profiles of crashes observed for micromobility devices include:

- Most high severity incidents occur in 50km/h speed limit zones or above (NB this CAS data may not accurately reflect speed limit changes in Auckland).
- Crashes occurring on gradients resulted in more severe injuries
- Crashes occurring on the roadway (rather than footpath) are more severe
- Profile of injuries is similar between e-scooters and e-cyclists.
- Crashes tend to be of a higher severity away from the city centre.
- Injuries occur as a result of around one in three collisions or falls.
- Collisions were typically thought to be due to behaviour, while falls were often caused by the environment (e.g. bumpy environment).

Injury Risk

The profile of injuries received from e-scooter riders and cyclists is similar, with similar types and percentage split of injury types. In both types the likelihood of concussion is similar.

Monash University’s model suggests a change in speed greater than 20km/h could result in a concussion. This would mean that speed of devices below 20km/h would tend to have a low likelihood of concussion.

15.3 Infrastructure

- Locations with wider footpaths and lower pedestrian flows have higher uptake of footpath use for e-scooter riders.
- Slippery/bumpy or uneven surfaces are the leading cause of solo micromobility crashes.
- The footpath is the most common place for an e-scooter incident to occur.

15.4 Perception vs. Reality

- Pedestrian incidents were widely reported. However, only 12% of pedestrian incidents resulted in a collision.
- Near misses were 51% of all reported incidents; they are also strongly linked to heavy pedestrian movements (e.g. Queen Street).
- Micromobility users are more likely to be injured on the road than on the footpath.
- Despite heavy pedestrian flows on Queen Street, injury crashes involving micromobility and pedestrians are rare.

15.5 Pedestrian Collisions

- Concussions can occur at very low speeds and are more likely to be severe for elderly pedestrians.
- Bike and e-scooter speeds below 20km/h tend to have a lower likelihood of resulting in a concussion if a collision with a pedestrian occurs, hence a lower risk of severe injury to the pedestrian.
- Micromobility crashes involving pedestrians are slightly more likely to result in injury than rider-only falls from the device (this is likely due to two VRUs being involved).

15.6 Key Observations

- Globably this is a rapidly evolving field, with rules changing all the time to adapt to new understandings around micromobility.
- Numbers of privately owned e-scooters are growing rapidly to the point where there will soon be more private use e-scooters in use on Auckland city centre’s streets than shared-use e-scooters.
- The number of e-bikes is also growing rapidly with over 40% of total bikes now being e-bikes in Auckland city centre.

There is inconsistency between the treatment of cycles and e-scooters with respect to helmets. There is no evidence of difference in injury type or severity between e-scooters and bicycles; while a greater severity of injury on road is observed, and there is also greater risk of concussion at speeds greater than 20km/h. Based on this research the evidence suggests helmets should be compulsory on road for all non-enclosed micromobility, capable of exceeding 30km/h. However, for practical reasons of enforcement and given micromobility users tend to jump on and off footpaths depending on footpath width, it may be more pragmatic to expand this consideration to all use of micromobility both on and off road.

15.7 Recommendations

The following recommendations are made for micromobility modes:

The key findings have led to the following recommendations:

1. E-bikes can be treated as bicycles for planning/policy purposes
2. Allow e-scooters and other forms of micromobility to use on road cycling infrastructure depending on their speed capability and helmet use.
3. Review requirements for helmet use in context of infrastructure use, speed capability of devices, and the forward fall mechanism specific to standing micromobility devices. Where devices are capable of exceeding 20km/h, risk of concussion is higher.
4. Speed restrictions of 15km/h on footpaths are appropriate
5. Where speed limits exceed 30km/h, seek segregation for micromobility or provide wider footpaths to allow more space for micromobility to avoid pedestrians, especially where pedestrian flows are high. Where this is not possible and micromobility (excluding e-bike) volume are moderate to high, then the speed limits on the road should be lowered to 30km/h, especially where lane widths are narrow, to facilitate road sharing.
6. Policy makers should give priority to safely getting hired micromobility users past their first few rides (where their chance of an incident is much higher), including through training.
7. Priority for transport policy and design standards should be directed at reducing the likelihood of vehicle vs micromobility crashes.
8. Consideration of low speed zones should be made for roads with higher gradients for shared-use e-micromobility devices.
9. Prioritise designs of downhill facilities that manage conflicts at access and side-roads and between users of the facility
10. Prioritise designs of downhill facilities to manage e-micromobility rider speeds.
11. Technologies that decrease downhill speed/acceleration should be advocated for and shared-use operators that implement these are recommended.
12. Additional steps are required to increase shared use micromobility helmet use. One option would be to consider helmet check locking systems.

16. Next Steps

16.1 Trials

As detailed in Section 13 a number of trials are recommended; firstly further investigation into flows and speeds of micromobility on footpaths and roads, in a greater variety of environments and outside the city centre are needed. This can be done through counts with the aim to identify usage and hence exposure to incidents. It can also be done by reproducing the video counts carried out in this study and extending them to longer timeframes and more repetitions.

Secondly two practical physical trial interventions are recommended, detailed in Appendix H.

16.2 Further Research

In the course of this study a number of items of further research have been identified to supplement the data gaps noted in this study. These recommendations have been prioritised below and would require detailed scoping before progressing; for clarity the behavioural elements are considered of highest priority:

Behaviour

- Does posted speed limit affect behaviour/ use of footpath for micromobility? This could be investigated through further (more systematic) video counts.
- Fall risk research to supplement research on collision impact.
- What age group is buying e-bikes? Does age profile/frailty affect safety outcomes?
- Are people put off from walking as a result of micromobility use on footpaths?
- Risk taking behaviour of micromobility users.
- Base level of fitness / balance skills of e-scooter riders versus e-bike users.

Device Characteristics

- Degree of protection associated with protective equipment.
- Wheel size impact on safety.
- Braking systems impact on safety.
- Method of charging for use of rental devices, whether by distance or time.
- Style of rental vehicle.
- More data on device stability.
- Protective equipment use. This could be investigated through further (more systematic) video counts.

Other

- Designs of downhill facilities to manage conflicts at access and side-road and between users of the facility.
- Fitness level – impact on injuries.

- Behaviour/attitudes of different types of users.
- Trip substitution/impact on walking/fitness.
- Comparison survey between micromobility and cyclists.
- Relative proportion of common diagnosis types in micromobility and cyclist injuries compared with all diagnosed injury types.
- Intervention Concepts Trials

Three potential trials have been identified in this report. Each has different merits and would require differing degrees of effort. It is recommended that further speed and observation trials are carried out in the first instance, in order to provide better context around the two physical interventions proposed and their benefits.

16.3 Periodic micromobility counts

Micromobility is a fast-evolving field with new modes becoming available all the time and existing modes rapidly growing in popularity. As highlighted in the risk assessment framework, exposure is one of the key variables that affects risk and thus: as this exposure rises so too will the number of incidents experienced across the network.

Periodic counts will provide an indication of what types of modes are growing in popularity and how the use of these devices is adapting over time. It is recommended that these surveys be conducted every 6 - 12 months.

The three key aspects that the surveys should consider are:

- The type of micromobility modes present;
- Whether the device is owned by the user or part of a shared use scheme;
- The infrastructure used by the rider.

Using the same location every time will allow for better tracking over time. It would also be good to conduct counts at new locations to see if there are new findings that can be made for different infrastructure layouts and help validate existing assumptions.

16.4 Periodic Literature review

Given the fast-changing nature of the field, new literature is constantly becoming available on the topic, with new insights constantly being made. This creates a low cost extensive pool of knowledge that can be tapped into. These insights help either validate or change existing assumptions, as required. Thus, leading to a greater level of accuracy in existing models.

Conducing a periodic literature review into this area would assist with capturing these new findings and make sure that the direction taken in Auckland aligns with international best practise.

16.5 Periodic CAS and ACC data analysis

The ACC data and CAS data combined has provided good insight into micromobility safety. As micromobility evolves, it is important to continue to check back over this data to determine if additional injuries have occurred. It is recommended that the same methodology is followed for both data sources to ensure that the data from one period to the next is comparable. This review doesn’t necessarily require the same level of depth however, instead a shallow investigation into these incidents should be conducted. The main purpose should be to determine to what degree micromobility safety should be prioritised compared to traditional modes of transport.

16.6 Risk mapping

Due to the limited information on micromobility crash locations within Auckland and the difference between perceived and actual crash risk, it is difficult to determine where design interventions should be made to improve micromobility safety. While the risk assessment framework allows for micromobility risk to be assigned to a given road segment, this takes time and doesn't give a holistic view of all roads across Auckland.

It is recommended that a map be created for micromobility risk across Auckland using the infrastructure risk assessment framework. This map would provide a clear communication of the findings covered in the research and steer treatments away from perceived safety risks and towards actual risks.

High-level assumptions of some of the variables will need to be made to produce this map. Though the output would not be as accurate as running through the entire risk assessment framework for every road segment, it would allow for a strategic overview without extensive work being required.

This could also be used to determine the risk of micromobility death and serious injury crashes per segment and thus, compare the risk between a multitude of different transport modes.

16.7 Update Risk Assessment Framework

Learnings developed throughout the research have been utilised to construct a Risk Assessment Framework. The intent of the Framework is to assist Auckland Transport as part of its decision-making process for accepting and regulating new shared mobility, and for prioritising infrastructure to support micromobility. It is identified that there are certain aspects of the Framework where further research is required to validate it. Once research data is available, the Framework can be updated.

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Appendix A

Research Question Refinement Process

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Appendix B

Cordon Counts 2020

Appendix C

Kantar Survey Output

Appendix D

Interest Group Feedback

Appendix E

Monash Report - X-Kemm-X Modelling

Appendix F
Video Count Data

Appendix G

Risk Assessment Framework

Appendix H
Intervention Concepts