2025

Research Report

Reducing the incidence and severity of shared e-scooter injuries via designed interventions

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Authenticity Statement

This is to certify that to the best of my knowledge, the content of this report is my own work. This report has not been submitted for any subject or for other purposes. I certify that the intellectual content of this report is the product of my own work and that all the assistance received in preparing this report and sources have been acknowledged.

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05-09-2025

AI Use Statement

I have utilised Generative AI (ChatGPT) in this report to assist in various ways. The way I have used Generative AI includes, helping to reduce word count (particularly for background research and discussion), proof reading, and assisting with thematic analysis (Atlas.ti). Generative AI also assisted in the creation of interview and survey questions (when prompted with objectives and current research) of which were refined manually.

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Sample Generative AI Prompts similar to those used:

- *Considering this analysis I have written, can you please make recommendations for sentences I can shorten. I am needing to reduce this section's word count by 100 words?*
- *Could you please recommend a way to reword these 3 sentences for better clarity? I am trying to get across that the council favours safety but ultimately, their reactive style of governance always creates a grey area of operation.*
- *Can you please highlight any areas of this section that are too wordy or are poorly phrased?*

Prompt for survey questions:

- *This is my research and the questions I have so far. Are there any other questions I should ask e-scooter riders in my survey to gain a better understanding of environmental and behavioural factors associated with their safe use?*

Word Count: 4903

Executive Summary

This report investigates the factors contributing to injuries incurred by shared e-scooter riders and proposes design intervention opportunities in order to reduce the incidence rate and severity. Use of e-scooters within Brisbane, Australia, has seen significant uptake, and with it, a sharp increase in the rate of accidents. Through the exploration of background research, benchmarking of leading e-scooter models, and primary research including surveys, interviews, and observations, this study examined the influence of design, behavioural and environmental risks, and governance on safety outcomes.

It was found that injuries were not caused by any one factor, but rather multiple that culminated into an accident event. Design factors centred the theme of instability and consisted of small deck sizes, high centres of mass, inconsistent braking designs and applications, as well as poor suspension. Low lighting and uneven, loose terrain were common environmental contributors to accidents. Riders were found to have little regard for helmet and intoxication laws, both of which were linked to serious head injuries. This was only made worse by the limitations of the Queensland Police Service and their inability to proactively police, which created an opt-in mindset regarding these laws when operating a personal mobility device.

Four critical intervention areas were identified, including enhancing rider stability and control, integrating compliance mechanisms to enforce regulations, improving rider visibility and communication, and encouraging greater helmet use through design and hygiene innovations. Implementing these four opportunities into a designed intervention offers a pathway to safer use for e-scooters and has the capacity to reduce the occurrence and severity of injuries.

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Introduction

In the past 75 years, cities have experienced a phenomena known as 'rapid urbanisation,' where mass amounts of people have moved to metropolitan areas in order to accommodate a city-based lifestyle. This large-scale relocation has resulted in over half of the world's population living in metropolitan areas (United Nations, 2025). Australia's capital cities have undoubtedly witnessed this narrative, with an urban growth rate of 3% in the 2022-23 financial year alone (ABS, 2024). Amongst the plethora of challenges that arise as a result of this, traffic congestion remains a constant concern for the public.

In Australia, commute times have increased by 23% since 2002, with city workers taking 66 minutes on average to travel to and from work (McCrindle, 2025). Causes for this dramatic increase in travel time have been linked to traffic congestion, inadequate public transport, and living further distances from the city (McCrindle, 2025). Personal mobility devices, particularly e-scooters, have recently gained traction as they attempt to alleviate CBD traffic and fast-track the first- and last-kilometre commute for many workers.

Since 2018, the Brisbane City Council has allowed Lime, Beam, and Neuron providers to operate shared e-scooter businesses within city limits (Field & Jon, 2021). While the uptake of these transportation devices has been positive, their usage have closely been tied to trends concerning unsafe and improper use. This rapid adoption has exposed gaps in governance, where user behaviour and provider practices have outpaced the city's ability to ensure their safe operation (Field & Jon, 2021). As such, there remains opportunities for a designed intervention to deliver meaningful solutions that mitigate safety concerns and increase rider compliance.

Aim

The aim of this study is to identify and examine the contributing factors that lead to injuries incurred by shared e-scooter riders, then propose opportunities that could effectively mitigate their occurrence and severity.

Research Study Process

The below structure has been adopted to explore, analyse, and draw conclusions concerning e-scooter design and safety in this report.

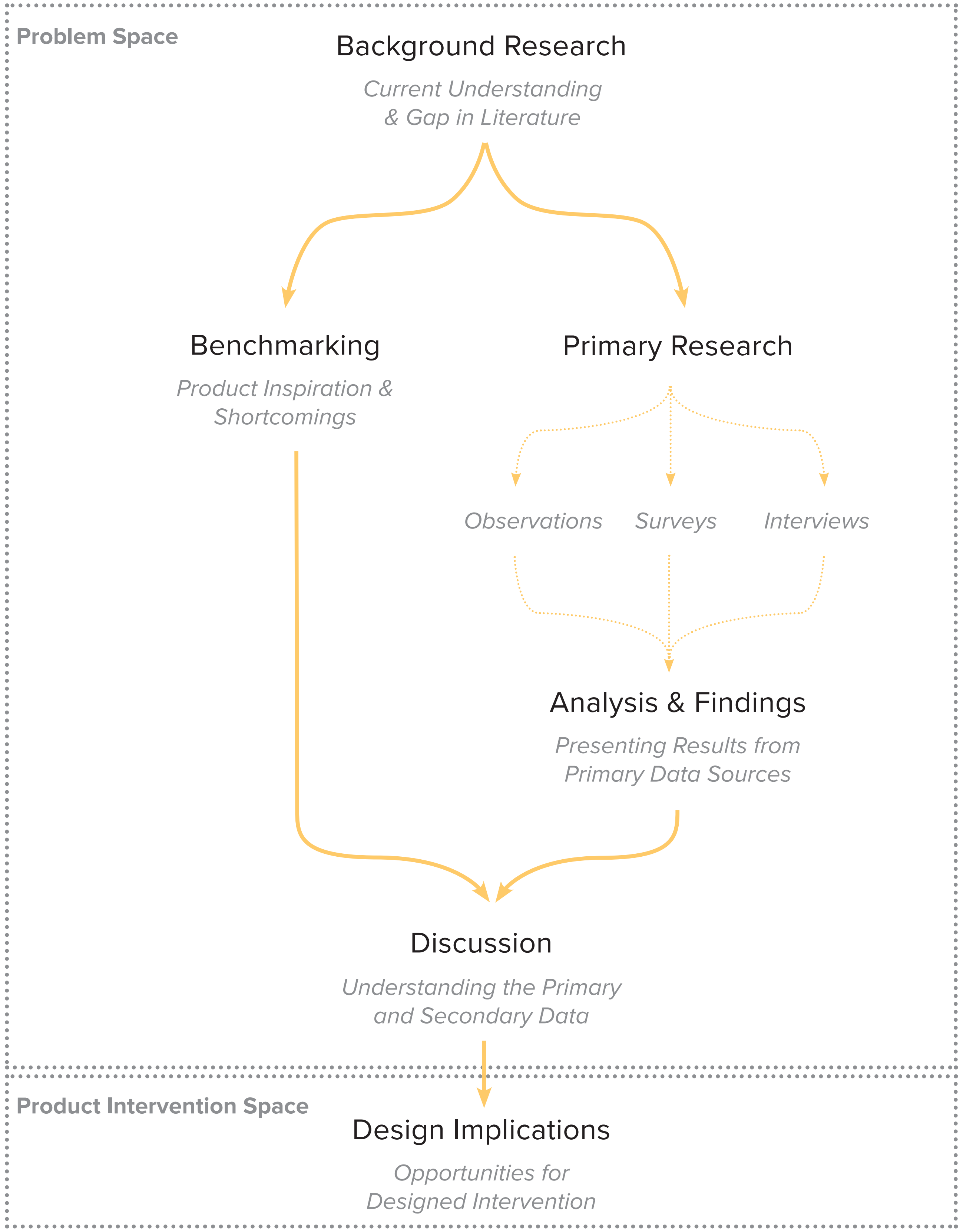


Figure 1: Research Study Graphical Structure

Background

During the first two weeks of their deployment in 2018, Lime scooters experienced over 50,000 trips within Brisbane City (Field & Jon, 2021). Since then, personal mobility device (PMD) usage has grown steadily, with approximately 300,000 trips per month and an average travel distance of just 0.88km (Tjong, Mihaita, Mao, Saleh, & Herran, 2024; Brisbane City Council, 2025). Nationwide, this growth has coincided with a sharp rise in injuries, increasing by up to 350% in Western Australia alone between 2019 and 2024 (Briotti, et al., 2024). As such, this review seeks to critically analyse the governance, design, and common injuries incurred from shared e-scooters and highlight current issues with their use.

Governance

Since the introduction of e-scooters, the Brisbane City Council has struggled to govern their use; always favouring safety-focussed designs but enacting regulations in a reactive manner. This favourability was evident in 2019 when Neuron was invited to increase their fleet over Lime solely because of their speed-limiting geofence feature (Hawthorn, Schramm, & Twisk, 2021). A similar theme was witnessed in 2018, when Lime fell under scrutiny from the government for failing to promote helmet use as they were often stolen, however, Lime were unable to be fined in this instance due to the lack of proactive governance instituted prior to their introduction. (Field & Jon, 2021). With no clear expectations from BCC before deployment due to the expedited regulations, the government had no grounds to stand on. Even with the updated helmet locks that were provided a year later, helmet adherence has remained as low as 30% (Briotti, et al., 2024). This highlights a key issue with BCC's reactive regulatory approach which is slow to create new laws only once a problem arises. Law compliance is only worsened by the limitations that exist for the Queensland Police Service (QPS). Particularly, QPS is unable to enforce geofenced speed limits that aren't governed by state law and cannot perform DUI (driving under the influence) testing on non-road assets (e.g. bikes, scooters, etc.) (Pace, Pollard, Bunker, & Baczynski, 2021; Alexander & Bates, 2024). This gives rise to cost/benefit decisions concerning the time to pursue an offender, often leading to a non-pursuit. Ultimately, these unclear rules and weak enforcement, reveal a governance system that has prioritised rapid adoption over safety regulation.

Design

Geofencing and braking features were recurring concerns from reports considering shared e-scooter design. Geofencing has proven to be a problematic feature on shared devices and is more noticeable when riding in groups, with sudden stops, slowing, and uneven speeds across scooters both confusing riders and unbalancing them while at speed (Field & Jon, 2021). The variation of braking systems further adds to this confusion, with mental models created by scooters that have one, two, or three brakes, all with different layouts (Bailey, Ponte, Woolley, & Van Den Berg, 2024). The electromagnetic brake, commonly used to regenerate power, has been know to introduce further instability as its automatic application when the throttle is released can often be a surprise to riders. (Bailey, Ponte, Woolley, & Van Den Berg, 2024; Siebert, et al., 2021). Disc brakes, drum brakes, tyre pressure, and rider mass were amongst the other factors that added to this inconsistency (Bailey, Ponte, Woolley, & Van Den Berg, 2024). It is clear that variation and deficiencies in e-scooter design are contributing factors to safety concerns.

Injuries

Injury cases and patient statistics provide valuable insight into factors that contribute to e-scooter accidents. One of the most frequently cited factors found in literature was inexperience, which can be linked with both unfamiliarity and low-confidence in device usage. Hospital studies across Texas and Washington found that on average 33% of patients were injured during their first ride (Austin Public Health, 2018; Cicchino, Julie, & McCarthy, 2021). Common injuries that were sustained included upper-body fractures and facial injuries (Hawthorn, Schramm, & Twisk, 2021). Another factor is time of day, and by association, intoxication. A study in Western Australia focussing on 251 patients, found that 75% of riders were operating between 6pm – 6am, of which 72% were intoxicated (Briotti, et al., 2024). The injuries that were sustained echoed a similar story to those incurred by the inexperienced riders, with upper-limb fractures, head and facial injuries, and intracranial bleeds being the most common, while frontal head injuries were the most severe (Hawthorn, Schramm, & Twisk, 2021; Wei, Petit, Arnoux, & Bailly, 2023). Although low helmet adherence (26%) was listed among the factors that contributed to these injuries, studies have suggested that the current bicycle-focussed design has little impact on reducing severity (Wei, Petit, Arnoux, & Bailly, 2023; Briotti, et al., 2024). Overall, these patterns highlight that inexperience, intoxication, and inadequate protective headwear are contributors to the severe injuries.

Summary

The rapid growth of shared e-scooters in Brisbane, Australia, has surpassed the ability of local councils and police services to effectively create and enforce laws that govern speed, intoxication, and helmet wearing. The variations identified in braking and geofenced systems have been leading causes for rider instability, with upper-body injuries the prevailing result. To gain a better understanding of the factors contributing to this failing personal mobility system, an investigation must ensue.

Benchmarking

Benchmarking exists to critically assess 'best practice design' – allowing designers to draw inspiration from leaders in industry, as well as learn from their shortcomings. In this method, design features are first compared to consider their popularity, then scrutinised to understand why they've been used (Hosseinpour, Peng, & Gu, 2015). The benchmarking contained in this report fousses on shared e-scooters and is complimented by those designed for private use.

Outline of Existing Products

To understand existing products, this analysis has examined those available for both private and public use, with consideration for seated and standing designs. The study considers four providers of e-scooters in Australia, including Lime, Beam, Neuron, and Ario, of which the former three are available in Brisbane. 15 e-scooter models were considered in total – all of these are summarised in Table 1 below, while a complete analysis is available in Appendix A.

Table 1: Bencmarking Summary

		Product	Description
Seated	Public	Lime Gen 4	Built on the Lime Gen 4 base and sporting both padded-seat and carry-box over the rear axle, this scooter is capable of travelling 55km on a single charge
		Ario TS 1.5	Ario places emphasis on rider experience through an innovative reverse-trike design. With double-wishbone suspension in the front, and C-suspension in the rear, comfort is a priority. These scooters can also be remotely operated to prevent device littering.
		Superpedestrian Link	This scooter focussing on durable, low-cost production and repairability. It sports an integrated self-diagnosing electronic system that can flag faults.
	Private	Windgoo B9	The Windgoo B9 is for the commuter with a compact, folding design and basket over the rear axle. Its circle-hollow-section (CHS) construction is lightweight and provides users up to 20km of range.
		Engwe S6	The telescopic and swingarm suspension on this model, paired with wide and thick tyres, allows riders to traverse mixed terrain. It also has a shock-absorbing seat and 60km of range for a standalone commute.
Standing	Public	Lime Gen 4	The Generation 4 devices from Lime are durable, weatherproof, and can withstand abuse from riders. The stance of the scooter allows for an exposed battery that is hot-swappable and capable of reaching 55km.
		Beam Satrn 5	Beam's Saturn 5 is intended to counteract the need to swap batteries often, with a staggering 120km of range within its dual in-deck batteries. It has the longest deck of any Australian shared e-scooter.
		Neuron N4	The N4 has two smaller batteries with a combined range of 60km. The design of this scooter favours operational efficiency by halving charging time at night. The wider deck allows for a side-by-side stance from the rider, while the bright orange paint is good for visibility at night.
		Ario TS 1.0	New to Australia, Ario is bringing a reverse-trike configuration to the market which favours turning stability. It also maximises braking power with dual disk brakes at the front for a short stopping distance.
		Dott Gen 2	Dott is all about minimalism as a brand in order to reduce failures from their products. Because of this, their scooter sports a simple geometry that is highly repairable, with hot-swappable batteries and large wheels for rolling over obstacles.
		Bird Three	Bird's third generation device with a sleek style that has cue repetition conducive of a cohesive appearance. It has the longest deck of any e-scooter with long-range in-deck batteries. It does, however, have smaller wheels, so is less proficient at traversing uneven terrain.
		Bolt Gen 6	Prioritising rider control by means of wide handlebars and a deck with splash guards. The advanced sensors are beyond other shared e-scooter models and can monitor tandem riding behaviours.
	Private	Vmax VX5 Pro GT	The VX5 Pro GT is targeted for performance and manoeuvrability, sporting a slik deck and small tyres. It is the lights of all e-scooters and has a foldable stem for portability.
		Niu KQi2 Pro	Aesthetically pleasing design with a curved deck that is supported by wide tyres. This design is focussed on grip and the driving dynamics can be altered from economy to sport for any occasion.
		Segway Ninebot Max GT	The only scooter analysed with a reversed brake layout and no front brake. The heavy steel construction is also unique and plants the device. Rider control may be hindered by the weight and stopping power.

Insights

By comparing the aforementioned e-scooters using a benchmarking table, several insights were gathered.

Concerningly, all designs except one utilised a deck too short for the 95th percentile Australian male to ride with their feet in tandem (Fraysse, Wade, Furnell, Kirsch, & Murray, 2023). Only one-third were beyond 460mm; what has been proposed as a 'safe, stable, and comfortable' length (Bird Three, 2021).

Scooters that utilised in-deck batteries were found to raise the rider's centre of mass (CoM), while those that located theirs above deck toward the front, sacrificed the devices CoM. All scooters except one employed an aluminium design, including the handlebars and stem, further increasing this height. This can leave riders susceptible to an over-the-bar accident under braking. No devices have explored an alternative to lower both the rider and the scooter's CoM.

The use of regenerative braking as found on nearly all e-scooters, creates further instability for the rider due to sudden and unpredictable rates of braking when the accelerator is released. The front brake lever has been consistently placed on the same side of the handlebar and is often considered a more efficient brake but can only be accessed if the hand is removed temporarily. This configuration, along with an inability to toggle regenerative braking off, creates instability for riders when cornering.

Nearly all scooters were designed with telescopic suspension at the front but no damping at the rear. Implementation of a double-spring, C-suspension, or alternative design would help reduce instability over mixed terrain. This should be complemented with large wheel diameters as is fairly common.

There are also yet to be any innovations regarding helmet cleanliness for shared e-scooters that would increase the inclination of the rider to wear one. No impact systems exist within the body of the scooter either to reduce the impact during an accident.

Summary

The current design of shared e-scooters demonstrates recurring shortcomings regarding safety. Riders are particularly susceptible due to the unergonomic deck sizing, poor scooter geometry and centre of mass location, unpredictable regenerative braking systems, and lacklustre suspension systems. In addition, there has been no innovation into maintaining helmet cleanliness, hence, their use is unlikely. Design opportunities exist to:

1. Reposition the combined rider and scooter centre of mass rearward and groundward.
2. Redesign the rider deck to allow an array of rider positions for a wider population.
3. Reconfigure the throttle and braking interaction on the right handlebar.
4. Introduce alternate suspension systems suitable for front and rear wheels.
5. Improve helmet hygiene to encourage rider compliance.

02 Research

Research
Analysis & Findings

Research

Primary research helps to form a holistic understanding of the design problem, bridging the gap between what the problem is and why it is occurring. The engagement of stakeholders, whether these be users or those directly affected by the product, uncovers insights that are challenging to find from secondary sources (Eisenberg, 2023). This project employs 'triangulation,' a method that seeks to eliminate the limitations of any singular research source through cross validation.

In all studies, the researcher should offer a multi-dimensional perspective of the topic along with unbiased data. From this, the validity of the research forms the basis that confidence can be extracted and conclusions drawn. Triangulation seeks to strengthen the reliability and quality of the data by employing two or more qualitative research methods that enable the possibility of perspective convergence (Thurmond, 2001). Three primary research methods were deployed in this study, including surveys, interviews, and observations. This process is graphically presented below in Figure 2.

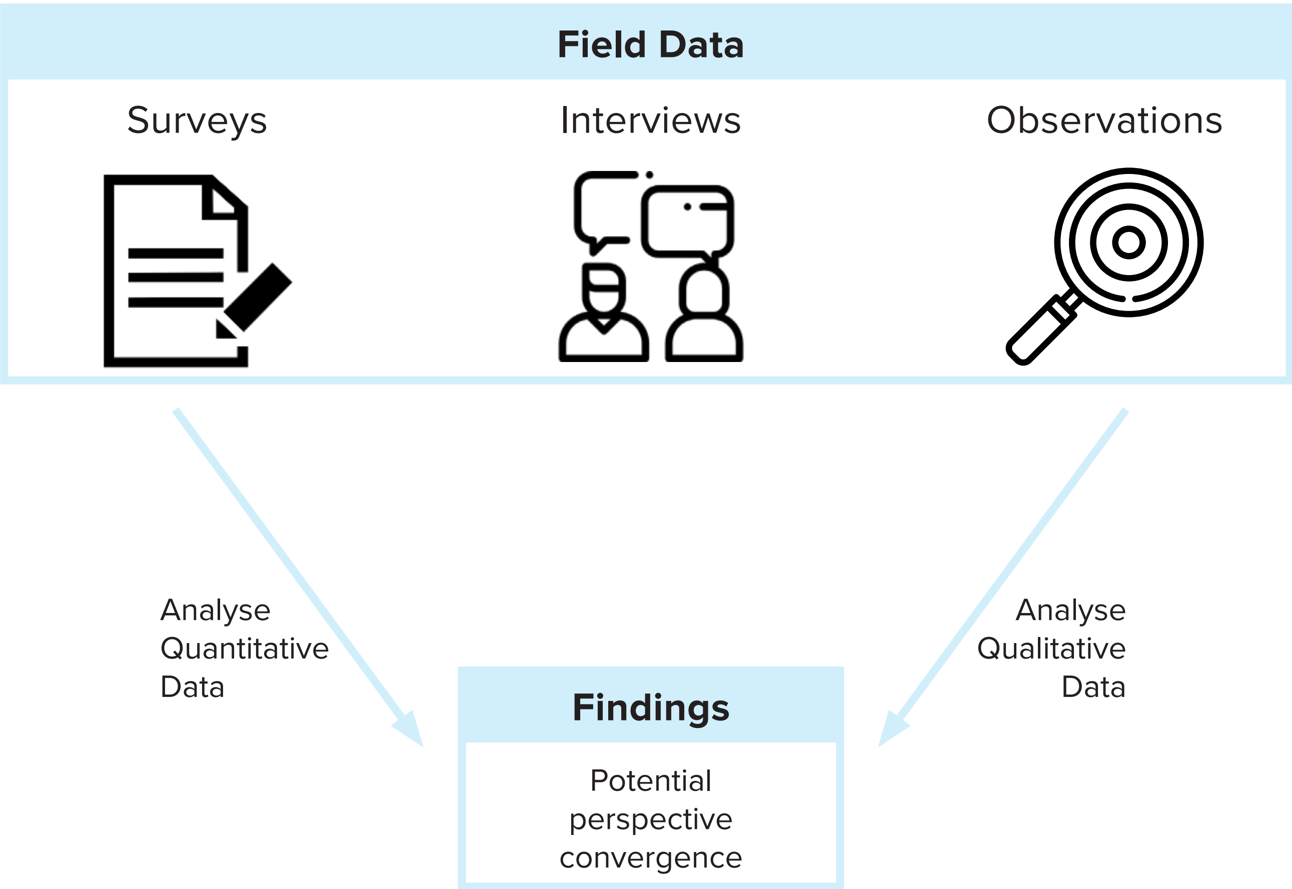


Figure 2: Triangulation Method

Primary research concluded with twenty-seven survey responses, three semi-structured interviews, and two observations. These were analysed using thematic analysis techniques to gain insight into challenges and opportunities for designed interventions. Summaries of these processes are presented on page 17.

Surveys

Surveys provide a means to acquire large samples of data quickly and allow for analysation of qualitative topics in a quantitative manner. The survey deployed for this project was both exploratory and descriptive as it sought to understand emerging themes regarding safety preferences and incident history from riders. Produced using Google Forms, the survey challenged the respondents to admit behavioural patterns in riding and compliance with laws, safety concerns, and opportunities for improved product design.

Two key limitations exist for survey studies. Firstly, multiple-choice and multiple-answer responses lack in-depth insight and diminish the nuance of the respondents answer. It was intended that some follow-up short-response answers would limit the degree of this, however, engagement with the study would likely have been low if an explanation was required for every question. Secondly, since the questions were retrospective, they relied on the participant's memory recall. This may have introduced memory bias, particularly for questions regarding accidents which may have occurred months or years prior. Limiting the survey to those who had recently been in an accident was seen as too limiting.

Interviews

Interviews were conducted using a semi-structured format that balances structure and sponteneity. These were developed with predetermined questions based on secondary research. Interviews consisted of 15 – 30-minute phone calls which were then transcribed and coded with the aid of Atlas.ti for analysis (Atlas.ti, 2025). A registered nurse and final-semester medicine student were interviewed about their firsthand accounts and medical opinions regarding how and why accidents occurred as well as injury trends and possible preventative measures that may be taken. Both professionals have experienced multiple years of placement and witnessed e-scooter injuries. In order to understand e-scooter behaviours and challenges from a governance perspective, a law enforcement officer with 2-years of experience was also interviewed. This provided insight into how the police-force govern PMD usage in metropolitan areas as well as limitations that their general duties impose on ensuring compliance.

Several limitations existed for the interview process. Firstly, interviews often utilise a small sample size of participants which can allow one perspective to skew the data. This could have been eliminated via a larger group, however, is impractical given the timeframe of the study. Secondly, because the participants in this study largely operate as employees of the public sector, they may limit the personalisation of their responses and opt to provide a standardised response as to not tarnish the sectors reputation. Lastly, interviewer bias, including the wording of questions, can at times guide a response from the participant. This was mitigated by perusing the question set with a supervisor and colleague before deployment.

Observations

Observations were the final primary research method conducted. The purpose of this method is to gather context-rich information by inserting oneself into the environment and observing interactions. Two observations were taken, both lasting fifty minutes. The intention of these observations was to investigate riding style, helmet use, and incidents of interest, as well as their correlation to contextual features of the location. The first observation took place along one of the main thoroughfares in the Botanic Gardens ('The River Lookout'), while the second observation took place at the entrance of the Goodwill Bridge on the university side.

Observations in this study were taken as written notes to respect the privacy of those examined, which presented several limitations. Firstly, observations were only multiple-second events that relied on memory recall. This can introduce bias from the researcher but is limited due to the short time period with which events are consequently noted. Also, the detail of events are likely of lower quality due to the short time period. Furthermore, the location that the researcher takes notes from may impact their perspective of the event occurring. This was minimised by sitting in open areas with a full-frame view of the study space.

Analysis & Findings

Surveys

In this survey, 26 questions were asked of participants, of which 14 were multiple choice, 6 were multiple selection (checkbox), and 6 were short response. The survey was distributed to social groups of the researcher via group-chats, as well as through their personal social media. This was also released to 100 engineering students of a gender-equity university club via email newsletter. Participants were required to have been 18 years of age or older and either seen or ridden a shared e-scooter. This yielded 27 responses with the key findings below. The full list of survey questions is perusable in Appendix B.

Demographic, Context, & Intoxication

Majority of survey respondents had rented or doubled on a shared e-scooter and their use was strongly associated with evening operation (Figure 3). For what is conventionally a time and context that riders may be intoxicated, only 36.4% of respondents stated that they were certain of UIL laws (Under the Influence of Liquor). After being told these laws, 59.1% indicated that they would never or only sometimes follow them, and hence, illegally operate a shared e-scooter.

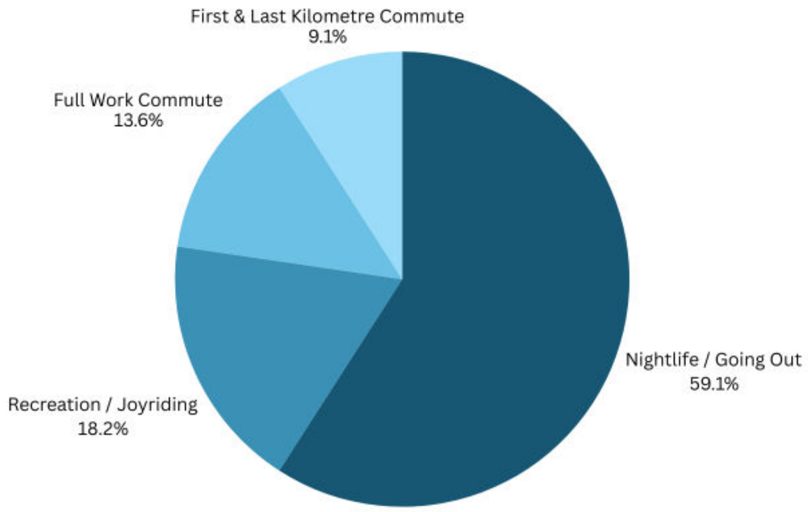


Figure 3: Indicated reasons for use of shared e-scooters

88.9%

of participants are aged between 20 - 24

81.5%

of participants have rented or doubled on a shared e-scooter

100%

of riders use shared e-scooters less than once per month

Risks & Design

There was a close alignment between the locations that riders most often operated an e-scooter and where they felt least safe – particularly roads and high-traffic CBD areas (Figure 4). Interestingly, all riders who responded to the survey utilised shared e-scooters less than once per month, adding inexperience and unfamiliarity to this danger. Despite this, majority felt that they actively balanced safety and comfort in their rider behaviour (68.2%), while only 4.5% felt that they prioritised safety. They expressed the least confidence in the brakes, stability, and light projection from shared e-scooters in being able to safely ride.

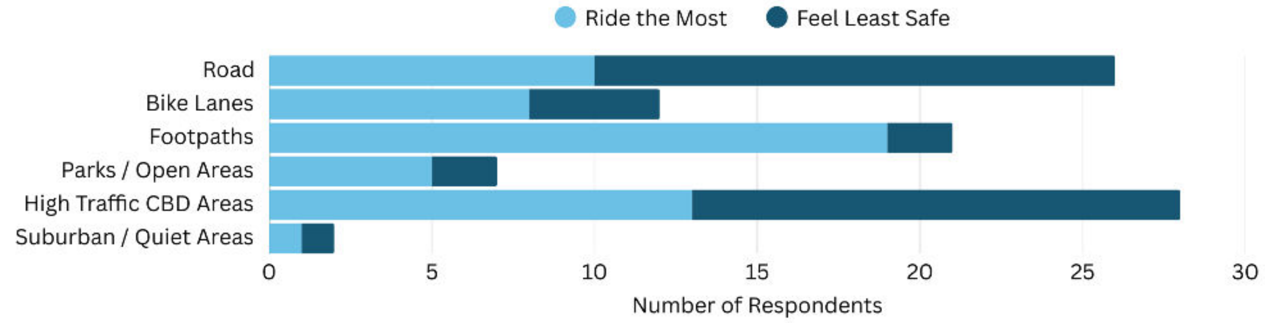


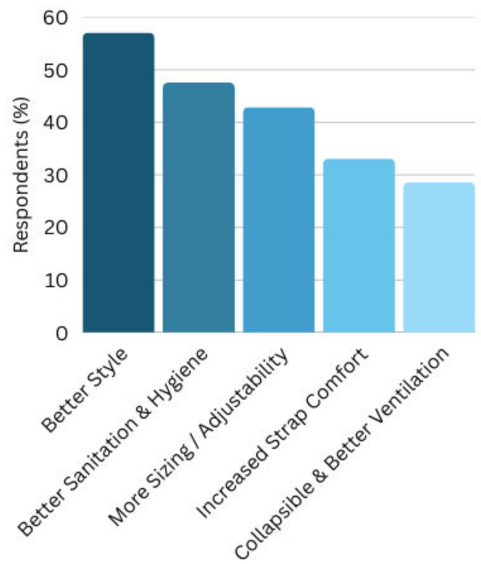
Figure 4: Rider's perception and use of different environments

Incidents

Two major themes emerged as causes for accidents that occurred by respondents, including loss of control due to environmental conditions and rider behaviour. Environmental factors were recorded at twice the frequency of behavioural factors with eight entries. These included poor lighting, uneven, loose, cracked and wet surfaces, and sudden drops. In three out of the four cases concerning rider behaviour, the respondent indicated that they were distracted.

"I was crossing the road and tilted forward at the edge of the sidewalk. My body was nearly thrown over the front of the scooter since it was downward and I braked. I accidentally touched the front brake as well which didn't help."

Figure 5: Factors that would encourage helmet



Governance & Regulation

When respondents were asked about their understanding of helmet laws which apply to both e-scooters and cyclists alike, 68.2% of the population understood what was required of them. Despite this, only 31.8% said that they always complied with these laws. The most common reasons that people listed as to why they didn't wear helmets was because they weren't left on scooters, they weren't commuting far, or they found them uncomfortable and inconvenient. They suggested that improving style, hygiene, and adjustability would encourage their use (Figure 5).

Interviews

The transcripts for each interview were generated via voice-memo's on iPhone, then exported and reviewed to adjust any errors. Atlas.ti, an AI powered thematic analysis tool, was then used to provide initial theme generation, from which two iterations of manual refinement ensued to create codes and sub-codes. Four themes were derived from the data, including design, governance and legislation, injuries, and risks. The full coding structure is available in Appendix C, while a coded diagram is presented below (Figure 6). In this, the size of the circles are representative of the number of insances that a sub-code emerges.

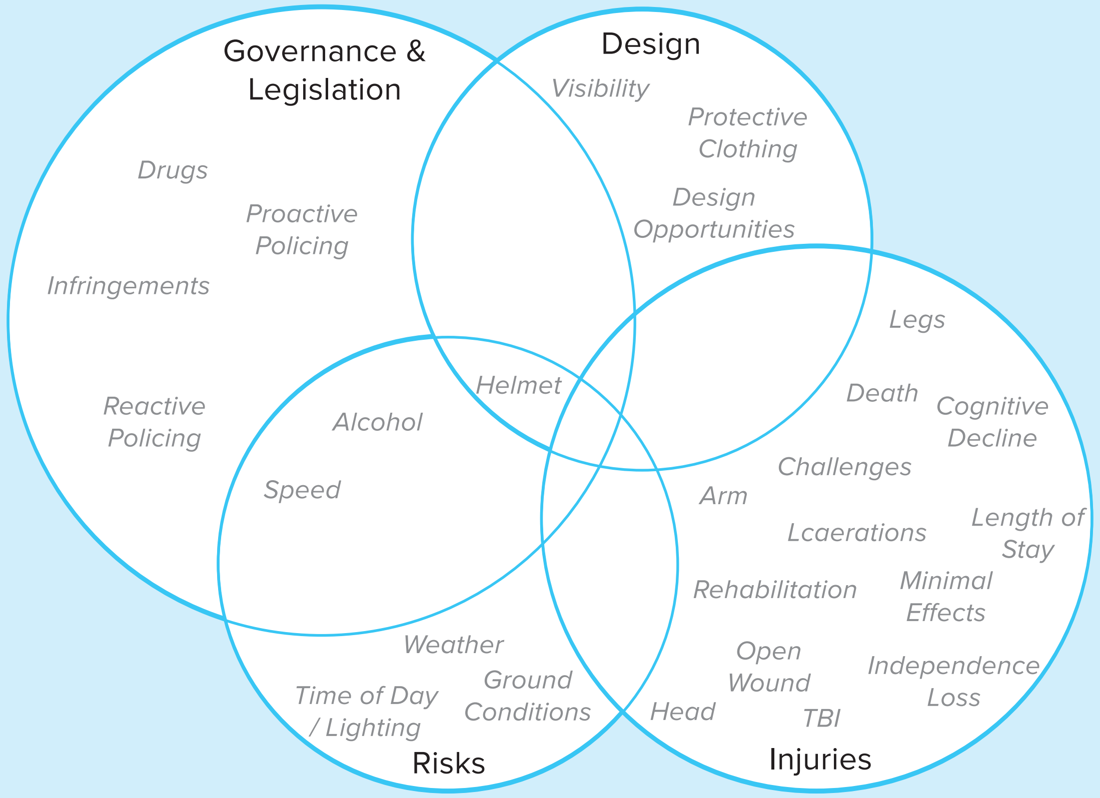


Figure 6: Relationship Between Emergent Sub-Codes and Themes

Design [13]

Despite those interviewed being from medical and law-enforcement backgrounds, e-scooter design emerged as a prevalent topic. Codes were largely split into two categories: opportunities and shortcomings. Opportunities stemmed mostly from a legislative perspective, with participants expressing their beliefs that certain features (e.g. lights, smooth surfaces free from protrusions, indicators) should be engrained within the law. Shortcomings arose directly from incidents that had been recalled, noting that factors such as damaged helmet reuse, long-sleeve clothing, and poor lighting, had in some way effected the outcome of their patients.

"Normally with helmets for a motorbike or anything that's electric, you can't or shouldn't buy them second hand... you don't know if they've been knocked about and aren't as good anymore. But with e-scooters, they just share the helmets around."

- Registered Nurse

Governance & Legislation [34]

Governance and legislation was the most emergent theme throughout the interview process. Insight was provided into the infringements enforceable upon PMD riders concerning faulty brakes, lights, bells, and dangerous operation. The limitations of policing e-scooter activities was made known, especially concerning the inability to random breath test and force blood-sample analysis. General duties policing held its own limitations with officers having minimal time to proactively police riding incidents between the many calls they receive. This combination of staffing deficiencies and time-pressures has become a considerable factor for reduced law enforcement.

"We don't have RBT power over them... What we can do is arrest them for under the Influence of liquor, and we can take them back to a police station to obtain a specimen of breath analysis on a machine."

- Law Enforcement

"Really, there's less police down the road doing proactive policing and pulling over people, because obviously there's domestic violence jobs or mental health jobs they're being called to."

- Law Enforcement

Injuries [29]

The injuries recounted by medical professionals were primarily concentrated to the upper-body, specifically the arms and head. The reported injuries favoured those with poor long-term outcomes such as traumatic brain injuries (TBI), cognitive-decline, and even death, since these are the injuries that often require medical intervention. It was proposed, however, that this does not accurately represent the common injury type for an e-scooter accident, but rather lacerations are more often faced. Both medical professionals who were interviewed stated that intoxication and failing to wear a helmet served as leading causes for their patients injuries. Intoxication was also revealed to significantly compromise the effectiveness of diagnostic tools, leading to a slower diagnosis which ultimately could have negative implications.

"I think the common thread would probably just be superficial lacerations – like its uncommon to have major long-term effects."

- Registered Nurse

"When you're assessing somebody for a critical intracranial lesion or pathology, altered mental status is an important part of the clinical exam. So, if you're intoxicated, it makes it harder to delineate. It serves as a confounder.

- Student Doctor

Risks [23]

Risks were an important indicator of potential behaviours and environments that made riders especially susceptible to having an accident. Alcohol was again the leading sub-code discussed for behavioural risks, followed by helmet wear and speeding. When it came to environmental conditions, factors such as potholes, curbs, breaks in paths, and poor lighting were sighted as frequent causes for incidents not requiring medical intervention.

"[Common accidents] like potholes and curbs – that stuff happens often."

- Law Enforcement

"I think that not wearing helmets and then going on really speedy scooters is a recipe for disaster."

- Student Doctor

Observations

Observational analysis sought to understand the rider-pedestrian interaction process and shortfalls which could not be extracted from surveys. Twenty riders were observed adjacent to the 'Across the River' viewing platform in the Botanic Gardens, while forty-nine were observed by the Goodwill Bridge entrance at QUT. Figures 7 and 8 identify the areas studied and the vantage point from which they were observed. Common paths travelled by pedestrians are shown in blue, while those of PMD users are in red. Raw data is available in Appendix D.

Incidents

The most prevalent incident type from the observations was where riders negotiated other path users; whether this be a pedestrian or PMD. These interactions were evident by swerving, hard braking, and evasive manoeuvres. These all link to a lack of communication of riding intent from the PMD's perspective. It was found that transitional zones, such as the Goodwill Bridge entrance, caused significant confusion between riders and pedestrians as they there were multiple crossing paths and speeds of traffic. This same issue was witnessed in the gardens by tourists who were entering and leaving the viewing platform to rejoin the main traffic; riders travelling at high speeds were required to take evasive actions due to the uncertainty in movement. Across both of these locations, helmet usage remained relatively low at 60% on average.

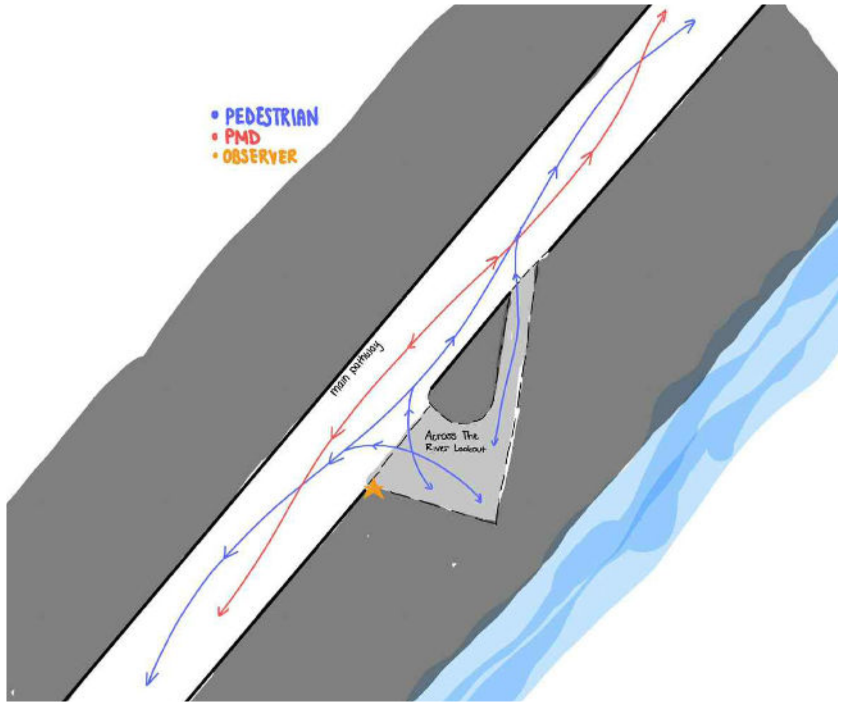


Figure 7: 'Across the River' Lookout Observational Schematic

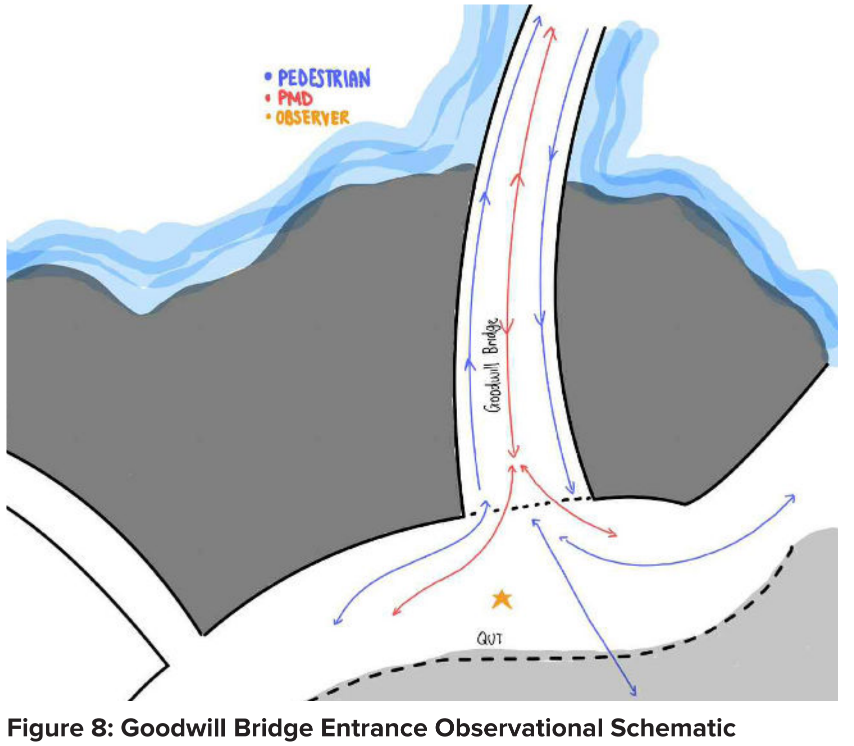


Figure 8: Goodwill Bridge Entrance Observational Schematic

Research Analysis Summary

Across the 27 survey studies, 3 medical and law-enforcement interviews, and two structured observations, there were several consistent safety issues. The low helmet wear rate was a concern identified across all three processes and was as low as 31.8% in the survey group and 60% in the observed group. Interviews with medical professionals highlighted the correlation between helmet usage and serious upper-body injuries. Unurprisingly, minor crashes such as those described by survey respondents, often didn't require medical intervention and went unreported. The survey group showed low wareness of speed and intoxication laws, while some knowingly went against these. Environmental hazards were also mentioned twice as often as beavioural factors in interviews as the cause of an accident. This aligned with the findings from the surveys. Nonetheless, behavioural risks were well established by interviewee's and confirmed by the swerving, speeding, and abrupt braking found in observations. These instances of danger were found to often go unnoticed, with the restricted style of policing that law-enforcement are able to perform.

03
Discussion & Design Implications

Discussion

An investigation was launched into the use of shared e-scooters in Brisbane, with journal articles and medical reports indicating potential dangers in scooter design, rider behaviour, and injury patterns. Benchmarking followed with the scrutinisation of private and public e-scooter models. This exposed several design shortfalls, including rider positioning and centre of mass, poor throttle and braking interactions, limited suspension, and a lack of appropriate helmet hygiene. The aim of this primary research study was to further investigate these behaviours, features, environmental contexts, injuries, and laws, related to unsafe and improper use of shared e-scooters. The findings are presented below.

As found in the survey responses, riders of share e-scooters possessed weak risk perception and a high disregard for the law. During background research, it was found that helmet law compliance was as low as 30%, close to that expressed in the surveys. The low sample size of observations may have explained why this was up to 60%, since this is believed to be lower. There was also a disregard for intoxication laws with majority of riders having consistently expressed that they operate while intoxicated. This could be linked with an awareness of the police force's limited ability to enforce the law, almost making compliance voluntary. Despite there being solid evidence of intoxication and lack of helmet usage coinciding with traumatic brain injuries, riders continue to operate under these illegal conditions. More than this, they decide to operate scooters in the high-risk settings they claim to feel unsafe in, despite being considered irregular users of the devices. This is especially true for high-traffic CBD locations, where poor communication between riders and pedestrians resulted in manoeuvres that involved hard braking and swerving. Hence, it is clear that riders are afforded too much capacity to make their own decisions concerning the safe operation of PMD's, especially concerning intoxication and helmet use.

Instability was a recurring issue throughout both secondary and primary research studies, with serious injuries often being linked to the upper-body extremities. Benchmarking highlighted that short decks, high centres of mass, and poor suspension were recurring design limitations. This was validated during the observations, where riders using a surf stance to operate the PMD were unable to fit both feet onto the scooter's deck and had to rest their rear foot on the slippery wheel enclosure. Survey respondents further verified instability as a major issue, with braking performance, stability, and suspension noted as their key concerns. Furthermore, interviews with medical professionals highlighted that serious injuries caused by e-scooters are often found on the upper limbs, consistent with over the bar falls and stability loss. This corresponds with the secondary research conducted that described upper-limb fractures and forehead injuries as those most frequently occurring.

Lastly, helmet design and perception still remains a limiting factor in reducing the severity of head injuries. Survey respondents cited that they didn't feel they needed to wear one since they were travelling short distances, are typically uncomfortable and often not left on the scooters. This is concerning since the average trip for a shared e-scooter is just 0.88km, which could be considered a short distance. An improvement in style, hygiene, and adjustability, were listed as reasons they would be more inclined to wear them, despite having identified no company attempting any of these improvements during benchmarking. Regardless, the effectiveness of helmets in preventing serious head injuries as has been proposed, is questionable. Both the secondary research and medical professionals expressed their concern about the bicycle-focussed design and its limitations for e-scooter use.

Design Implications

Through the completion of both primary and secondary research studies, several design implications can be established. The conclusions drawn from such studies aid in the development of opportunities that should be applied to future design interventions in order to improve the safety of shared e-scooters. These opportunities are detailed below.

01: Improving Rider Stability & Control

Riders seek comfort in knowing they can control an e-scooter and traverse through unexpected environmental conditions even when inexperienced. E-scooter design should focus on rider stability through the adoption of longer and wider decks, lower centres of mass, and improved suspension that can accommodate grounded rider stances. Likewise, standardised and effective braking and throttle interactions should be employed to ensure riders can predict riding dynamics and prevent uncontrolled body movement. These cannot come at the expense of manoeuvrability which will only hinder rider performance further.

02: Embedding Smart Technology to Enforce Regulations

Since governance of intoxication and helmet wear is largely based on an opt-in model, regulators and scooter providers must introduce forced use. Opportunities exist for integrating smart technologies such as intoxication screening and helmet-wear detection for riders before and during an e-scooter trip. While this may be circumvented in certain instances, such approaches could alleviate the staffing pressures of the police force in enforcing these laws.

03: Increase Rider Visibility, Awareness, & Communication

Shared e-scooters currently have minimal scooter-pedestrian interaction tools. Bells currently serve as the only warning device mandated to communicate intentions with the public, while some providers have started instituting turn signals. An opportunity exists for e-scooter riders to communicate their direct intentions with the general public through means of light projection, audible notifications, Bluetooth warnings, or similar, to reduce collision risks during the day but especially at night. Real-time prompts offer a clear statement of intent and minimise the assumptions required on both ends.

04: Encouraging Rider Protection

Poor helmet uptake signals and opportunity to provide an e-scooter focussed designed intervention. The context in which e-scooters are used often differs from bicycles, and so, rider preferences are vastly different. Several sub-opportunities exist in this space. Firstly, this could include redesigning helmets to better protect the head locations impacted by an e-scooter fall. Secondly, increasing the usage of helmets in general by considering a colour, material, and finish more suited to the users preferences. Lastly, the design could consider how to improve the hygiene of a shared helmet, whether this be through a cleaning process or alternate helmet design that only deploys during a crash.

Conclusion

This report sought to identify and examine the contributing factors to injuries incurred by shared e-scooter riders, then propose opportunities that could effectively mitigate their occurrence and severity. It was able to achieve this through the analysis of background research, the benchmarking of 15 leading e-scooter designs, and exploration of design, behavioural, environmental, and governance-based issues that arose through primary sources. The use of thematic analysis helped to narrow the most prevailing issues, while triangulation helped prevent bias within the data sets.

The findings highlighted that there were four areas of opportunity for a design intervention to improve. These included improving rider stability and control, embedding compliance mechanisms into the devices to assist in regulation enforcement; increasing rider visibility, awareness, and communication with pedestrians; and encouraging greater rider protection through integrated helmet solutions. The combination of these opportunities represents a shift toward a shared governance structure between regulators and designers. By addressing these core issues, it is hoped that both the incidence rate and severity of injuries may be minimised.

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Appendix

A: Benchmarking Table (Raw Data)

Classification	Seated					Standing									
	Public			Private		Public							Private		
Model	Lime Gen 4 (Seated)	Ario TS 1.5	Superpedestrian Link	Windgoo B9	Engwe S6 (Seated)	Lime Gen 4	Beam Saturn 5	Neuron N4	Ario TS 1.0	Dott Gen 2	Bird 3	Bolt Gen 6	Vmax VX5 Pro GT	NIU KQi2 Pro	Segway Ninebot Max G2
															
Ergonomics															
Drive	Rear	Rear	Rear	Rear	Rear	Rear	Rear	Rear	Rear	Rear	Rear	Rear	Rear	Rear	Rear
Location of Throttle	Right (Lever)	Right (Lever)	Right (Lever)	Right (Hand Grip)	Right (Hand Grip)	Right (Lever)	Right (Lever)	Right (Lever)	Right (Lever)	Right (Lever)	Right (Hand Grip)	Right (Lever)	Right (Lever)	Right (Lever)	Right (Lever)
Location of Rear Brake Lever	Left	Left	Left	Left	Left	Left	Left	Left	Left	Left	Left	Left	Left	Left	Nil
Location of Front Brake Lever	Right	Right	Right	Right	Right	Right	Right	Right	Right	Right	Right	Right	Right	Right	Left
Handlebar Angle	Swept	Swept	Straight	Straight	Straight	Swept	Straight	Swept	Swept	Straight	Straight	Straight	Straight	Straight	Straight
Handle Bar Grips	Smooth	Smooth, faceted edges	Dotted Surface	Grooved	Grooved	Smooth	Dotted Surface	Straight Grooved	Smooth, faceted edges	Straight Grooved	Smooth	Smooth	Dotted (Large and Small)	Smooth, faceted edges	Diamond groove
Deck Size (L x W)	420mm x 150mm	Unspecified	Unspecified	Unspecified	450mm x 240mm	420mm x 150mm	500mm x 160mm	450mm x 190mm	Unspecified	Unspecified	635mm x Unspecified	515mm x 220mm	440mm x 160mm	570mm x 133mm	521mm x 170mm
Manoeuvrability															
Vehicle Mass (kg)	30	Unspecified (Heavy)	30.4	24.2	26	27.7	25	25	Unspecified (Heavy)	21.5	Unspecified	Unspecified	16.7	18.4	24.3
Material	Aluminium	Aluminium	Aluminium	Aluminium	Aluminium	Aluminium	Aluminium	Aluminium	Aluminium	Aluminium	Aluminium	Aluminium	Aluminium	Aluminium	Steel
No. of Wheels	1 + 1	2 + 1	1 + 1	1 + 1	1 + 1	1 + 1	1 + 1	1 + 1	2 + 1	1 + 1	1 + 1	1 + 1	1 + 1	1 + 1	1 + 1
Wheel Diameter (Front / Rear)	12" / 12"	12" / 10.5"	10" / 10"	12" / 12"	10" / 10"	12" / 12"	11.5" / 11.5"	11.5" / 11.5"	12" / 10.5"	12" / 12"	10" / 10"	12" / 10"	9" / 9"	10" / 10"	10" / 10"
Suspension (Front / Rear)	Telescopic / Nil	Double-wishbone / C-suspension	Telescopic / Nil	Nil	Telescopic / Swingarm + damper	Telescopic / Nil	Telescopic / Nil	Telescopic / Nil	Double-wishbone / C-suspension	Telescopic / Nil	Nil	Telescopic / Nil	Nil	Nil	Telescopic / Double-Spring
Location of Battery	Above deck, behind stem	In-deck	In-deck	In-deck	In-Deck	Above deck, behind stem	In-deck	In-Deck	In-deck	Above deck, behind stem	In-deck	In-deck	In-deck	In-deck	In-Deck
Brake Type (Front / Rear))	Drum / Drum + Electric	Dual Disk / Drum + Electric	Drum / Drum	Disk / Disk	Disk / Disk	Drum / Drum + Electric	Drum / Drum + Electric	Drum / Drum + Electric	Dual Disk / Drum + Electric	Drum / Drum + Electric	Drum / Drum + Electric	Drum / Drum + Electric	Drum / Drum + Electric	Drum / Drum + Electric	Drum
Safety															
Geofenced Speed Limiter	Yes	Yes	Yes	No	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No	No
Crowd/Obstacle Monitoring	Sidewalks, Misuse	Sidewalks, Misuse	Sidewalks, Misuse	No	No	Sidewalks, Misuse	Sidewalks, Misuse	Sidewalks, Misuse	Sidewalks, Misuse	Sidewalk, Misuse	Sidewalks, Misuse	Sidewalks, Misuse, Tandem	No	No	No
Turn Signals	No	Yes	No	No	Yes	No	Yes	Yes	No	No	No	Yes	Yes	No	Yes
Speedometer	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Lighting	Headlight, Tail Light	Headlight, Tail Light	Headlight, Tail Light	Headlight, Tail Light	Headlight, Tail Light	Headlight, Tail Light	Headlight, Tail Light	Headlight, Tail Light	Headlight, Tail Light	Headlight, Tail Light	Headlight, Tail Light	Headlight, Tail Light	Headlight, Tail Light	Headlight, Tail Light	Headlight, Tail Light
Audible Alerts	Yes	Yes	Yes	No	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No	No
Traction Control (ASR)	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No
Anti-Braking System (ABS)	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No
Descent Max. Speed Control	Yes	Yes	Yes	No	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No	No
Regenerative Braking Toggle	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No
Helmet Use															
Helmet Integration	Yes	Yes	No	No	No	Yes	Yes	Yes	Yes	No	Free to order, cover shipping	No	No	No	No
UV Cleaning	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No
Disposable Liners	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No
References	(Levy Electric, 2024) (Lime Micromobility, 2025)	(Ario, 2025)	(Superpedestrian, 2023)	(Electroheads, 2025)	(Electroheads, 2025) (E-Wheels Warehouse, 2025)	(Levy Electric, 2024) (Lime Micromobility, 2025)	(Beam Mobility, 2025)	(Neuron, 2023)	(Ario, 2025)	(Dott, 2025)	(Bird Three, 2021)	(Bolt, 2023)	(VMAX Escooters, 2025)	(Niu Mobility, 2025)	(Segway, 2024)

Appendix

B: Raw Survey Questions

	Questions	Response Type
Demographics	Which age bracket do you fall under?	Multiple Choice
	What gender identity do you most closely resonate with?	Multiple Choice
	Select your previous riding / observing experience	Multiple Choice
Rider Context	On average, how often would you ride a shared e-scooter?	Multiple Choice
	For what purpose do you usually rent an e-scooter?	Multiple Choice
	Which of the following apply to your riding attire & accessories?	Multiple Answer
Riding	Select 1 - 2 locations where you most commonly ride	Multiple Answer
	Select 1 - 2 locations where you feel most unsafe	Multiple Answer
	What obstacles, interactions, or behaviours make you feel unsafe in these indicated areas?	Short Response
Rider Positioning & Incident History	In what position do you usually operate an e-scooter?	Multiple Choice
	Which best describes your riding priorities?	Multiple Choice
	If you answered previously "It depends on where I am or who I'm with," could you please elaborate	Opt-in Short Response
	Have you experienced or nearly experienced an accident?	Multiple Choice
	Could you please elaborate on: - how it happened - what happened	Opt-in Short Response
	If you received any injuries, which part of the body was this to?	Short Response
Awareness & Regulation	Are you aware of the speed limits on roads and footpaths for shared e-scooters in your area?	Multiple Choice
	How often do you abide by speed limits? (Footpaths 12km/h, Roads 25km/h)	Multiple Choice
	Are you aware of the alcohol consumption laws when riding an e-scooter in your area?	Multiple Choice
	How often do you abide by intoxication laws? (BAC <0.05)	Multiple Choice
	Are you aware of the helmet laws in your area?	Multiple Choice
	How often do you wear a helmet while riding a shared e-scooter?	Multiple Choice
	If you didn't answer 'Always,' why is this?	Opt-in Multiple Answer
Design Preferences	What do you think is the biggest limitation to safe riding on current rental e-scooters? (Select up to 3)	Multiple Answer
	Which features would increase your likelihood of wearing a helmet while riding?	Multiple Answer
Observers	What behaviours from e-scooter riders have made you feel unsafe or uncomfortable?	Short Response
	What design or legislative changes would you like to see for shard e-scooters that could improve safety?	Short Response

B: Raw Survey Results

Appendix

B: Raw Survey Questions

Which age bracket do you fall under?	What gender identity do you most closely resonate with?	Have you?	On average, how often would you ride a shared e-scooter?	For what purpose do you usually rent an e-scooter?	Which of the following apply to your riding attire & accessories?	Select 1 - 2 locations where you most commonly ride:	Select 1 - 2 locations where you feel most unsafe:	What obstacles, interactions, or behaviours make you feel unsafe in these indicated areas?	In what position do you usually operate an e-scooter?	Which best describes your riding priorities?	If you answered previously "It depends on where I am or who Iâ€™m with," could you please elaborate	Have you experienced or nearly experienced an accident?	If you answered 'yes' to the previous question, could you please elaborate on what / how it happened:	If you received any injuries, which part of the body was this to?	Are you aware of the speed limits on roads and footpaths for shared e-scooters in your area?	How often do you abide by speed limits? (Footpaths 12km/h, Roads 25km/h)	Are you aware of the alcohol consumption laws when riding an e-scooter in your area?	How often do you abide by intoxication laws? (BAC<0.05)	Are you aware of the helmet laws in your area?	How often do you wear a helmet while riding a shared e-scooter?	If you didn't answer 'Always,' why is this?	What do you think is the biggest limitation to safe riding on current rental e-scooters? (Select up to 3)	Which features would increase your likelihood of wearing a helmet while riding?	What behaviours from e-scooter riders have made you feel unsafe or uncomfortable?	What design or legislative changes would you like to see for shard e-scooters that could improve safety?
20 - 24	Man	Rented and ridden a shared e-scooter	< 1 per month	Recreation / Joyriding	Backpack / Tote;Casual / Active Footwear;Activewear	Footpaths;Parks and Shared Open Areas	Road;CBD / High Traffic Areas	Cars, pedestrians, uneven surfaces, potholes, edge of sidewalk, lots of braking	Side-by-side foot stance close to handle bars	Prioritise comfort, even if slightly less safe		Yes	I was crossing the road and tilted forward at the edge of the sidewalk. My body was nearly thrown over the front of the scooter since it was downward and I braked. I accidentally touched the front brake as well which didn't help.	Scraped my face	No	Some of the time	Yes	Some of the time	Yes	Sometimes	Helmet not left on scooter;Inconvenient / uncomfortable;Short trips (don't feel like I need to);Social pressure / looks bad	Brake Performance	Easier Sanitisation or Hygiene;Better Strap Comfort		
20 - 24	Woman	Ridden as a passenger on a shared e-scooter	< 1 per month	Nightlife / Going out	Restrictive Footwear (e.g. high heels or thongs)	Bike Lanes;Footpaths;CBD / High-Traffic Areas	Road;Parts & Shared Open Areas		Side-by-side foot stance close to handle bars	Try to balance comfort and safety		No			Yes	All of the time	No	Never	Yes	Sometimes	Inconvenient / uncomfortable;Short trips (don't feel like I need to);Social pressure / looks bad	Heavy Scooter;Handlebar Comfort;Stability When Riding	Easier Sanitisation or Hygiene;Better Strap Comfort		
20 - 24	Man	Rented and ridden a shared e-scooter	< 1 per month	Recreation / Joyriding	Casual / Active Footwear	Footpaths;CBD / High-Traffic Areas	Footpaths;CBD / High Traffic Areas	Bus stops, persons, other people and cars	One foot forward, one back (surf stance)	Try to balance comfort and safety		Yes	Almost drove straight into a bus stop and almost watched a friend slip on the scooter and get run over by a ford ranger whilst crossing the road with it	No	No	Never	No	Never	Yes	Often	Helmet not left on scooter;Inconvenient / uncomfortable	Brake Performance;Poor Lighting;Speed Control in Different Zones	Crash Alerts / Smart Tech Integration;More Sizing Adjustability	Reckless driving and UIL driving	Donâ€™t know
20 - 24	Man	Rented and ridden a shared e-scooter	< 1 per month	Last-kilometre connection with public transport	Casual / Active Footwear	Footpaths;CBD / High-Traffic Areas	Road;Bike Lanes	Proximity of motor vehicles to bike lines	Side-by-side foot stance close to handle bars	Prioritise safety, even if uncomfortable		No			No	Some of the time	Yes	All of the time	Yes	Often	Helmet not left on scooter	Size or Manoeuvrability;Inadequate Suspension (Bumpy Ride)	Foldable / Collapsible Design;Easier Sanitisation or Hygiene	Riding on roads with cars	Not sure
20 - 24	Man	Rented and ridden a shared e-scooter	< 1 per month	Last-kilometre connection with public transport	Backpack / Tote;Casual / Active Footwear	Footpaths;CBD / High-Traffic Areas	Road	Cars, potholes, amount of people/vehicle in the area to be aware of while riding through.	One foot forward, one back (surf stance)	Try to balance comfort and safety		No			No	Never	Somewhat	All of the time	Yes	Always		Heavy Scooter;Brake Performance;Stability When Riding	Better Strap Comfort;Stylish Appearance;More Sizing Adjustability	Going too fast on footpaths or bike lanes. Cutting in and out of crowds, traffic or between roads and paths.	Using the same technology as the lock off of a certain time in a certain zone they could have certain zone such as CBD be capped at a slower speed. This way if intoxicated people use em or if itâ€™s busy thereâ€™s a max someone can hurt themselves going at, reducing death and serious injuries. This technology would be similiar to golf carts at courses cutting off near greens or slowing inbetween fields.
20 - 24	Woman	Ridden as a passenger on a shared e-scooter	< 1 per month	Nightlife / Going out	Handbag / Cross Body Bag	Footpaths;CBD / High-Traffic Areas	Road	Cars	One foot forward, one back (surf stance)	Try to balance comfort and safety		No			Yes	Some of the time	Yes	Some of the time	Yes	Never	Social pressure / looks bad	Size or Manoeuvrability;Stability When Riding	Foldable / Collapsible Design	Speeding in the way of pedestrians	Not allowed on foot paths in high traffic areas, bike lanes inly
20 - 24	Man	Rented and ridden a shared e-scooter	< 1 per month	Nightlife / Going out	Casual / Active Footwear;Business / Formal Attire	Road;Bike Lanes;Footpaths;Parks and Shared Open Areas;CBD / High-Traffic Areas;Suburban / Quiet Areas	Road	Cars/ oncoming traffic etc.	One foot forward, one back (surf stance)	Prioritise comfort, even if slightly less safe		Yes	I was not looking where I was going and nearly got hit by a car :(		No	Never	No	Never	Somewhat	Always		Size or Manoeuvrability;Brake Performance;Poor Lighting	Foldable / Collapsible Design;Stylish Appearance		
20 - 24	Man	Rented and ridden a shared e-scooter	< 1 per month	Nightlife / Going out	Casual / Active Footwear	Footpaths	Road;CBD / High Traffic Areas	Cars, poorly maintained footpaths, stairs, drunk individuals	One foot forward, one back (surf stance)	Try to balance comfort and safety		Yes	Slippery surface - fell sideways, bumpy uneven service- fell forward	Hip and hands	No	Never	Yes	Never	Yes	Often	Helmet not left on scooter	Brake Performance;Handlebar Comfort;Stability When Riding	Ventilation for Hot Weather;Crash Alerts / Smart Tech Integration;Stylish Appearance;More Sizing Adjustability	Erratic driving, drunk behaviour, too fast	Unsure
20 - 24	Woman	Rented and ridden a shared e-scooter	< 1 per month	Nightlife / Going out	Handbag / Cross Body Bag	Bike Lanes	CBD / High Traffic Areas		One foot forward, one back (surf stance)	Try to balance comfort and safety		Yes	Nearly hitting someone		No	Never	No	Never	Yes	Always		Heavy Scooter;Size or Manoeuvrability;Brake Performance;Poor Lighting;Handlebar Comfort;Speed Control in Different Zones;Stability When Riding;Inadequate Suspension (Bumpy Ride)		They go fast and donâ€™t obey road laws	
20 - 24	Man	Rented and ridden a shared e-scooter	< 1 per month	Recreation / Joyriding	Backpack / Tote;Restrictive Footwear (e.g. high heels or thongs);Casual / Active Footwear	Footpaths;CBD / High-Traffic Areas	Road;Suburban / Quiet Areas	Big vehicles with big blind spots	One foot forward, one back (surf stance)	Prioritise comfort, even if slightly less safe		No			No	All of the time	Yes	All of the time	No	Sometimes	Short trips (don't feel like I need to)	Brake Performance;Inadequate Suspension (Bumpy Ride)	Stylish Appearance		
20 - 24	Woman	Rented and ridden a shared e-scooter	< 1 per month	Nightlife / Going out	Handbag / Cross Body Bag	Road;Footpaths	Road;CBD / High Traffic Areas	Traffic and busy footpaths	Side-by-side foot stance close to handle bars	Try to balance comfort and safety		Yes	Uneven footpath - fell forward over bars		No	Some of the time	No	All of the time	Yes	Often	Short trips (don't feel like I need to)	Heavy Scooter;Size or Manoeuvrability;Stability When Riding	Crash Alerts / Smart Tech Integration;Better Strap Comfort;Stylish Appearance	Riding recklessly on road	Uneven surface setting on E-scooter
20 - 24	Man	Rented and ridden a shared e-scooter	< 1 per month	Commuting to / from work	Backpack / Tote;Business / Formal Attire	Road;Bike Lanes;Footpaths	Road;CBD / High Traffic Areas		One foot forward, one back (surf stance)	It depends on where I am or who Iâ€™m with		No			Yes	Never	Yes	Some of the time	Yes	Always		Speed Control in Different Zones	Ventilation for Hot Weather;Easier Sanitisation or Hygiene		
20 - 24	Man	Rented and ridden a shared e-scooter	< 1 per month	Nightlife / Going out	Backpack / Tote;Handbag / Cross Body Bag;Business / Formal Attire	Road;Footpaths;CBD / High-Traffic Areas	CBD / High Traffic Areas		One foot forward, one back (surf stance)	Prioritise comfort, even if slightly less safe		Yes	Went over the curb while driving in the CBD and dropped down suddenly.		No	Never	No	All of the time	No	Sometimes	Helmet not left on scooter;Inconvenient / uncomfortable;Short trips (don't feel like I need to)	Size or Manoeuvrability;Poor Lighting;Inadequate Suspension (Bumpy Ride)	Ventilation for Hot Weather;Easier Sanitisation or Hygiene;Stylish Appearance;More Sizing Adjustability	Swerving	That they are only allowed to be in bike lanes
20 - 24	Woman	Rented and ridden a shared e-scooter	< 1 per month	Nightlife / Going out	Casual / Active Footwear	Road;CBD / High-Traffic Areas	Road;CBD / High Traffic Areas	Cars going fast, not leaving space if no footpath available	One foot forward, one back (surf stance)	Try to balance comfort and safety					No	All of the time	No	Never	Yes	Sometimes		Poor Lighting;Speed Control in Different Zones;Stability When Riding	Foldable / Collapsible Design;Ventilation for Hot Weather;Stylish Appearance;More Sizing Adjustability	Driving along road in unsafe behaviour, for example: switching lanes, riding across lanes on road	More rules for regulating behaviour to minimise risk on road, possible breath tests before riding to ensure they are safe to ride before using
20 - 24	Woman	Rented and ridden a shared e-scooter	< 1 per month	Nightlife / Going out	Handbag / Cross Body Bag;Casual / Active Footwear;Business / Formal Attire	Road;Footpaths	Footpaths;CBD / High Traffic Areas	Uneven surfaces and the amount of traffic or unsafe drivers	One foot forward, one back (surf stance)	Try to balance comfort and safety		Yes	Crack in the footpath, lost balance but didnâ€™t fall off		No	Never	No	Never	Yes	Always		Size or Manoeuvrability;Brake Performance;Inadequate Suspension (Bumpy Ride)	Easier Sanitisation or Hygiene;Stylish Appearance;More Sizing Adjustability	Going to fast	
20 - 24	Woman	Rented and ridden a shared e-scooter	< 1 per month	Nightlife / Going out	Backpack / Tote;Handbag / Cross Body Bag;Restrictive Footwear (e.g. high heels or thongs)	Road;Footpaths;CBD / High-Traffic Areas	Road;CBD / High Traffic Areas	Cars driving fast	Side-by-side foot stance close to handle bars	Try to balance comfort and safety		No			No	Some of the time	No	Some of the time	Yes	Always		Brake Performance;Poor Lighting;Stability When Riding	Easier Sanitisation or Hygiene;Stylish Appearance	Reckless driving	
20 - 24	Woman	Only observed others riding, and not ridden or been a passenger																						Riding on the road, close to cars, serving in traffic	It would be really good to have automatic brake lights, turn signals, and better front and rear visibility. Also creating designated scooter lanes, similar to bike lanes, would separate riders from both pedestrians and cars would make me and the rider feel more safe.
20 - 24	Woman	Ridden as a passenger on a shared e-scooter	< 1 per month	Nightlife / Going out	Handbag / Cross Body Bag;Casual / Active Footwear	Road;Footpaths	Road;CBD / High Traffic Areas		Side-by-side foot stance close to handle bars	Try to balance comfort and safety		No			No	Some of the time	No	Some of the time	No	Never	Short trips (don't feel like I need to)	Heavy Scooter;Poor Lighting	Foldable / Collapsible Design		
18 - 19	Man	Rented and ridden a shared e-scooter	< 1 per month	Commuting to / from work	Backpack / Tote;Casual / Active Footwear;Activewear	Road;Bike Lanes;Footpaths	Road;Bike Lanes;CBD / High Traffic Areas	When Iâ€™m on the road I feel unsafe especially in high traffic areas because I feel overwhelmed by how many cars they are around me,	One foot forward, one back (surf stance)	Try to balance comfort and safety		No			No	Some of the time	No	All of the time	No	Never	Helmet not left on scooter;Short trips (don't feel like I need to);Don't feel safer	Size or Manoeuvrability;Speed Control in Different Zones;Stability When Riding;Inadequate Suspension (Bumpy Ride)	Ventilation for Hot Weather;Crash Alerts / Smart Tech Integration;Easier Sanitisation or Hygiene;Better Strap Comfort;More Sizing Adjustability	In younger people especially in high school, speed and cut through people while on scooter's.	I would like to see a push in wearing helmets because I rarely see people on scooters wearing them, and it could save lives as being on a scooter is already a risk as it is.
20 - 24	Woman	Only observed others riding, and not ridden or been a passenger																						People riding fast and reckless and not aware of their surroundings	Stricter enforcement of rising while under the influence. More room to fit passengers so they feel safer when riding on the back

Appendix

B: Raw Survey Questions

20 - 24	Woman	Only observed others riding, and not ridden or been a passenger																						People riding fast and reckless and not aware of their surroundings	Stricter enforcement of rising while under the influence. More room to fit passengers so they feel safer when riding on the back	
20 - 24	Man	Rented and ridden a shared e-scooter	< 1 per month	Nightlife / Going out	Casual / Active Footwear	Bike Lanes;Footpaths;Parks and Shared Open Areas	Parts & Shared Open Areas;CBD / High Traffic Areas	Other scooters or pedestrians	One foot forward, one back (surf stance)	Try to balance comfort and safety		No			No	Some of the time	Somewhat	Some of the time	No	Sometimes		Brake Performance;Handlebar Comfort;Inadequate Suspension (Bumpy Ride)	Better Strap Comfort;Stylish Appearance			
20 - 24	Man	Rented and ridden a shared e-scooter	< 1 per month	Recreation / Joyriding	Casual / Active Footwear	Road;Bike Lanes;Footpaths;Parks and Shared Open Areas;CBD / High-Traffic Areas	CBD / High Traffic Areas		One foot forward, one back (surf stance)	Try to balance comfort and safety		No			No	Some of the time	No	All of the time	Yes	Always		Brake Performance;Poor Lighting;Speed Control in Different Zones	Easier Sanitisation or Hygiene;Better Strap Comfort;Stylish Appearance;More Sizing Adjustability	Going too fast on a busy footpath.	Speed limits enforced in particular areas.	
25 - 29	Woman	Only observed others riding, and not ridden or been a passenger																						The speed limit. Walking or running on the footpath makes me feel unsafe when those scooters zoom past. Riders donâ€™t wear helmets and a lot of the time itâ€™s young reckless children.	The speed limit - reduce it!!	
20 - 24	Man	Rented and ridden a shared e-scooter	< 1 per month	Nightlife / Going out	Restrictive Footwear (e.g. high heels or thongs);Casual / Active Footwear	Parks and Shared Open Areas;CBD / High-Traffic Areas	Road;Bike Lanes	Cars and stupid parasitic cyclists	Seated on Deck	It depends on where I am or who Iâ€™m with	If Iâ€™m on my own I like to be comfy	Yes	I was got a rock jammed in wheel and went over the handle bars	My nose and armpit	Somewhat	Never	Yes	All of the time	No	Never	Helmet not left on scooter	Poor Lighting;Inadequate Suspension (Bumpy Ride)	Foldable / Collapsible Design;Ventilation for Hot Weather;Easier Sanitisation or Hygiene	Drunk driving. Racing on footpaths	Speed sensor/limiter. Better tyres	
20 - 24	Man	Only observed others riding, and not ridden or been a passenger																						riding at speed or when under the influence	higher visibility and designated lanes	
25 - 29	Man	Rented and ridden a shared e-scooter	< 1 per month	Commuting to / from work	Backpack / Tote	Bike Lanes;Footpaths;CBD / High-Traffic Areas	Road;Bike Lanes;CBD / High Traffic Areas	Pedestrians in footpaths	Side-by-side foot stance close to handle bars	Try to balance comfort and safety		Yes	Over the handle bars I was distracted , hit by an uber	Cuts and grazes elbows and knees and hands	Somewhat	Some of the time	Yes	All of the time	Yes	Often	Inconvenient / uncomfortable;Want to have my headphones on, or short ride	Brake Performance;Poor Lighting;Stability When Riding;Inadequate Suspension (Bumpy Ride)	Stylish Appearance;More Sizing Adjustability;Ability to connect phone	Drunk idiots	Suspension added	N/A
20 - 24	Woman	Only observed others riding, and not ridden or been a passenger																						They all donâ€™t know how to drive and have no helmets on, they also donâ€™t abide any speed rules	Mandatory helmets	No

Appendix

C: Thematic Analysis Coding Table

Theme	Code	Sub-Code	Example Quote
Design (13)	Design Opportunities (6)	Design Opportunities (6)	The personal mobility devices: they should have lights bright enough at night, you know and should having a working bell.
	Deign Shortfalls (7)	Helmets (3)	Normally with helmets for a motorbike or anything that's electric, you can't or shouldn't buy them second hand, and you shouldn't buy one that's been used because you don't know if they've been knocked about and aren't as good anymore. But with E-scooters, they just share the helmets around.
		Protective Clothing (1)	If they weren't wearing any sort of protective clothing or long sleeves, [a fall] would just skim on the limbs...
		Visibility (3)	[The driver] didn't really see him at all, and there was an LED light on his, scooter, but it wasn't that powerful... We think it was just an aftermarket fit.
Governance & Legislation (34)	Intoxication (13)	Alcohol (10)	We don't have RBT power over them. We can't pull them over into a roadside breath test with the little yellow, small handheld breath testing... However, what we can do is arrest for under the Influence of liquor, UIL, and we can take them back to a police station to obtain a specimen of breath analysis on a machine.
		Drugs (3)	We have done a incidents involving drug dealers, utilising scooters for to transport drugs. We actually classify as a factor in relation to our resource suspicion when we talk about detaining them for a search.
	Helmets (4)	Helmets (4)	But we have private infringement notices, which is a fine for like, PMDs specifically. We have these for not wearing a helmet.
	Laws & Policing (15)	Infringements (10)	If they're riding a personal mobility device without a bell, horn, or similar warning device, that's an offence. Also, if you're riding without lights at night or in hazardous weather conditions, and if they don't have a stopping system controlled by brakes, gears, or motor control, [these are all offences].
		Proactive Policing (3)	Really, there's less police down the road doing proactive policing and pulling over people, enforcing PMD laws, because obviously there's domestic violence jobs or mental health jobs they're being called to.
		Reactive Policing (2)	Let's say, hypothetically, there's an e-scooter incident and you have it on dash cam footage but just can't get to it right now. Statute of limitations for simple offences, which these all are, is 12 months. So that means that you have 12 months to charge them after the fact.
	Speed (2)	Speed (2)	Some of them, you know, they're going up to 40, 50 km/h, it was like a crazy amount. And, like, really, they should be on separate paths, bike paths.
Injuries (29)	Lower Body (2)	Legs (2)	... Another where it was just a fall with some lacerations on the legs and just in general fix-up up and head on home..."
	Upper Body (6)	Arms (3)	One case sustained mainly long bone injuries, i.e. radial fractures... so probably most in the context of yeah, you're about to fall on the ground and then you stick your hand out
		Head (3)	The second one was a bit more of a workup for a head injury. The verdict was a linear skull fracture to the left parietal region.
	Long-Term Outcomes (11)	Cognitive Decline (2)	Yeah, he was kind of like physically fine. Independent, getting himself up in the morning, and having a shower and all of that, but his ability to have to higher order thinking and executive thinking was significantly declined and they were worried about his ability to make good decisions and remember to do certain things that needed to be done when he was completely on his own.
		Death (2)	The kid who was riding an electric scooter this year in town was killed – he wasn't wearing a helmet from what I understand.
		Independence Loss (1)	He was with us purely for finding accommodation and a new living situation as it was the feeling from allied health and the medical team that he wasn't going to be able to live independently again because he had lost too much executive functioning.
		Minimal Effects (1)	I think the main common thread would probably just be superficial lacerations – like its uncommon to have major long-term effects.
		Traumatic Brain Injury (5)	But the problem with a brain injury, especially if there's a little bit of a bleed is that it's often not enough to surgically intervene and it can cause the brain to swell and things like that. Managing anything with the head is quite complex.
	Post-Accident Care (7)	Challenges (4)	When you come to me in a hospital and you're inebriated, obviously, you have some altered mental status because you're drunk. When you're assessing somebody for a critical intercranial lesion or pathology, i.e some sort of significant brain damage, altered mental status is an important part of the clinical exam. So, if you're intoxicated, it makes it harder to delineate. It serves as a confounder when I'm looking for things.
		Length of Stay (1)	Yeah, my long-term guy needed rehab and the short-term guy, just the ED.
		Rehabilitation (2)	Anything that's a laceration and superficial is quite easily managed. We can just patch you up more or less... Like you quite easily manage that.
	Type (4)	Lacerations (3)	... Another where it was just a fall with some lacerations on the legs and just in general fix-up up and head on home..."
		Open-Wound (1)	... there was no open wound when I had him but there was during the fall. I think it was more frontal... anterior frontal was the strike.
Risks (23)	Behaviours Risks (17)	Alcohol (10)	The juxtaposition of a bit of intoxication with a high mechanism of force, is never a good thing in relation to injuries. Making the wrong decisions and making them too slow, I think is a good way putting it.
		Helmets (4)	I think that not wearing helmets and then going on really speedy scooters is a recipe for disaster.
		Speed (3)	So, probably the two cases I saw were intoxication plus e-scootering too quickly.
	Environmental Risks (6)	Ground Conditions (3)	[Common accidents] like potholes and curbs – that stuff happens often.
		Time of Day & Lighting (2)	Lighting goes hand-in-hand with time of day, like, as we discussed before, there was not really too many streetlights during that motor vehicle accident. So that probably played a part in visibility for both the driver of the motor vehicle and the driver of the PMD.
		Weather (1)	I've never really known of weather to take part. Like obviously if its pouring down rain then nobody is going to be using a lime scooter.

Appendix

D: Observation Notes

Observation 1: Across the River Lookout

DATE: 15/08/25
TIME: 2:10 pm - 3:00pm
LOCATION: Botanic Gardens

LIME
BEAM
NEURON

- Runners, Council Trucks, E-bikes, E-Scooters, Walkers, Dog Walkers, Birds
- Many Walkers on phones
- Uneven Surfaces

\# Side by Side ||||||||||

* limited surf stance on lime -> deck not long enough -> lean toward bars

\# Surf |||||||||

\# Helmets ||||||||||||||||

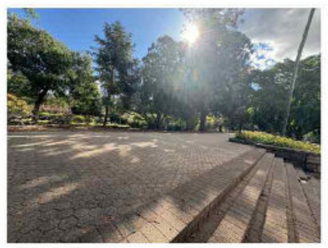
Incidents:

1. → Helmet ✓ Swerving (about 1m side-to-side), not too many people → those in distance looked uncertain where to walk. Narrowly avoided walker on their phone. standing in S-by-S stance close to bars.

2. ← Helmet ✓ Tall man. Full Woolworths bag on right handle. Had to slow down to move through crowd. Standing S-by-S. At slower speeds became slightly less stable pulling toward right bar.

3. → helmet ✓ 2:37pm Surf stance. lady. In tow of Lime bike. 5 tourist across paths – some with disabilities. Did not slow down. Tourist struggled to move fast enough. Hard braking. Evasive action by rider. Swerved around person. Leaned forward during braking. left tourist shocked (rider appeared to be moving @ max speed)... UNCERTAINTY

4. ← helmet ✓ 2:51pm Slow speed. Looked uncertain. ↗ uncomfortable that there were quite a few people to negotiate around. Swerving a little bit with the bumps. → jolted forward over bars with each bump. Suspension looked stiff + minimal absorption.

Observation 2: Goodwill Bridge Entrance (QUT Side)

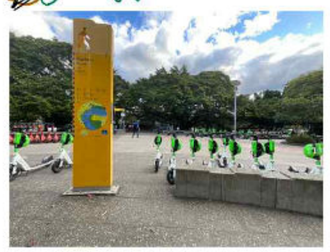
Goodwill Study:

DATE: 15/08/25
TIME: 3:30pm - 4:30pm
LOCATION: Goodwill Bridge East

LIME
BEAM
NEURON

- Runners, Council Trucks, E-bikes, E-Scooters, Walkers, Dog Walkers, Birds
- Many Walkers on phones
- Uneven Surfaces

* Riders seem more cautious and on lookout since its a high-use transitional zone
* 4 riders seen wearing helmet improperly
* Moderate + Varying Traffic



\# Side by Side ||||||||||||||||||||||||||||||

* limited surf stance on lime -> deck not long enough -> lean toward bars

\# Surf ||||||||||||||||

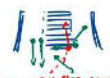
\# Helmets ||||||||||||||||||||

Incidents:

1. Two lime riders approach in transitional zone going full speed. Both applied max braking and took evasive action to prevent a collison. They were lucky that No pedestrians were nearby and they had the room to move.

2. Lime rider + skateboarder racing to squeeze through posts. Both looked uncomfortable when they got nearby. Scooter rider braked, wobbled, and narrowly missed the post. Moments later, cyclist passed through in opposite direction.

3. Direction change from pedestrians caused rider to come to complete standstill at entrance of bridge. Swift stopping from moderate speeds.



4. Rider alongside friend on bike. Swerved last minute into pedestrian lane to avoid hitting post. Misjudged gap: