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Learning from the Evidence: Insights for Regulating E-scooters

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ABSTRACT: As a trending mobility choice, e-scooters have become popular in many cities. Many authorities have initiated shared e-scooter trial schemes to assess the feasibility of the vehicles prior to enacting official legalisation. This paper aims to provide an evidence review of shared e-scooters and investigate how existing evidence may inform long-term policies. This carries significant relevance for jurisdictions that are in a conflicting position with e-scooters, such as New South Wales (NSW), Australia whose context motivates this study. The evidence review focuses on three themes derived from experience with shared e-scooters within the broader micromobility landscape, namely: safety; where shared e-scooters fit into the modal landscape; and the environmental impacts. Findings confirm that ensuring the safety of shared e-scooters requires complex solutions, which may include a clear regulatory framework for e-scooters, safety education and skill training, innovative data collection and analysis methods, and an approach to safety management that is user-based, location-based, and time-based. In terms of modal fit policymakers should encourage first and last-mile combinations with public transport, with consideration of user characteristics; while environmental impact is strongly correlated to the mode replaced by e-scooter trips. The paper provides insights for policymakers on the regulation and positioning of shared e-scooters.

KEY WORDS: ***shared e-scooter, micromobility, policymaking, regulation, New South Wales, Australia.***

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1. Introduction

As e-scooters become more widespread, there has been a heated debate regarding their utilisation and governance among supporters and opponents. Cities have witnessed escalating safety concerns regarding e-scooters' collisions, parking predicaments, and inadequate infrastructure (National Academies of Sciences Engineering Medicine, 2022). Meanwhile the allure of e-scooters lies in their potential to cut car travel and emissions, leading toward more environmentally sustainable outcomes (Félix, Orozco-Fontalvo, & Moura, 2023).

Being a nascent mode of transport, the definition and categorisation of e-scooters can sometimes be vague and exhibit different delineations across jurisdictions. The term 'e-scooter' (either seated or standing), based on a widely adopted definition, refers to one type of powered micromobility vehicle with a centre column and floorboard, but without operable pedals and self-balancing (SAE International, 2019). It is easy to confuse e-scooters with mopeds[1], which are different in engine size (the key differential index), speed, cost, portability and weight. Broadly, e-scooters fall in the categories of 'micromobility' and 'powered two-wheeler (PTW)'. The term 'micromobility' is commonly used in relation to lightweight, personal vehicles and includes both e-bicycles and e-scooters (Cook, Stevenson, Aldred, Kendall, & Cohen, 2022). The term 'Powered Two-Wheelers (PTWs)' refers to vehicles that utilise batteries and an electric powered drivetrain, which covers a wide-ranging category of vehicles from low-powered e-bikes to high-powered motorcycles (Hardt & Bogenberger, 2018). Additionally, there have been debates on whether micromobility should be defined as a form of 'active transport'. A useful taxonomy proposed by Cook et al. (2022) depicts e-scooters as motorised rather than active and they acknowledge that the boundaries between these categories are blurry - there would likely be some exercise benefits to an e-scooter ride, for example, particularly if used as part of a multimodal journey not involving a car.

Gossling (2020) suggests that with the growth in e-scooter use, it seems plausible to dedicate entire road systems to micromobility to support modal shift. Such thinking has led Governments to conduct large-scale trials of micromobility interventions. *Shared e-scooters* refer to a type of shared transport service in which e-scooters are made available for short-term rentals (Badia & Jenelius, 2023). In some countries, including Australia, it is not unusual to see governments adopt shared e-scooter schemes as a means to assess the feasibility of the vehicles prior to enacting official legalisation. This paper aims to provide an evidence review of shared e-scooters and investigates how existing evidence may inform long-term policies on shared e-scooters in jurisdictions that are in a conflicting position with e-scooters, including New South Wales (NSW), Australia. The paper focuses on three key themes relevant to jurisdictions considering implementation and motivated by the NSW context: *safety; where shared e-scooters fit into the modal landscape;* and *what are environmental impacts*. Based on the three themes, the paper examines evidence of shared e-scooters within the broader micromobility context in relation to private e-scooters, mopeds, and bikes/e-bikes. Reference

[1] Mopeds refer to powered vehicles with a seat (two to three wheels, with or without pedal) (International Transport Forum, 2020).

is made to experience from different contexts including large cities, small towns, and regional areas, drawing from both scholarly and grey literature.

Following this introduction, we first outline the motivations behind this study, referencing the shared e-scooter context in NSW. Then the methodological approach is explained, followed by discussions on existing evidence of the three key themes mentioned above. This evidence underpins the policy recommendations around shared e-scooters to jurisdictions which are discussed next together with their enablers and barriers. Finally, the concluding section summarises key findings and future research avenues.

2. Motivations for the study

While e-scooters have been around since the late 19th century (Fluidfreeride, 2023), their popularity only surged in 2018. This is related to the widespread adoption of dockless bike rental services in cities, prompting rental e-scooter companies to recognize the potential of the burgeoning micromobility market (Holder, 2018). E-scooters have been identified as an opportunity for jurisdictions to explore sustainable transport alternatives (Badia & Jenelius, 2023). There is a pressing need for sustainable transportation solutions in an urban landscape that is not inherently cycling-friendly, as exemplified by Sydney (Committee for Sydney, 2021) with a cycling mode share less than 2% (Transport for NSW, 2022) or New York City where it is 3% in New York City (New York City Department of Transportation, 2018). By contrast the mode share is 22% in Hamburg (Hamburg Authority for Transport and Mobility Transition, 2022) and 26% in Netherland (Harms & Kansen, 2018). It has been argued that the general enthusiasm for e-scooters may help to drive a culture change considering e-scooters' popularity especially among young populations (Chatterjee, Parkin, Bozovic, & Flower, 2023). Micromobility devices may also drive the much-needed expansion or upgrade of sustainable infrastructure, which is already promising in Queensland, Australia (Queensland Government, 2023).

In NSW, initial interest in shared e-scooters was expressed to the state government in 2018 by private operators, local councils, and individuals. In 2019, Transport for NSW (TfNSW) established an Electric Scooter Advisory (ESA) Working Group to develop advice for a potential e-scooter trial in NSW (Transport for NSW, 2020). The government faced many obstacles that (still) need to be addressed, with the categorisation and regulatory problem being the most significant issue (Transport for NSW, 2020, p. 3). Moreover, there were rising safety-related concerns and regulation tightening was observed in jurisdictions that embraced e-scooters early (Crellin, 2019; Westcott, 2019). In 2020, TfNSW decided not to go ahead with e-scooters. In 2022 the (then) Minister for Active Transport, Cities, Infrastructure, announced a shared e-scooter trial scheme to launch (Angus Thomson, 2022), making NSW the last state in Australia to roll out a shared e-scooter scheme (Table 1).

At the time of writing, the NSW government has not made final decisions on how to treat private e-scooters, however, private e-scooters have been legalised in many other Australian states and territories (Table 1). NSW is currently in a controversial position on e-scooter regulation. On one hand, the state government classified e-scooters as motor vehicles (or motorcycles), but e-scooters do not meet the Australian Design Standards of a motor vehicles so they are ineligible for registration, which is a requirement of motor vehicles (Khayesi & Amekudzi, 2011). Currently, the only legal option for riding private e-scooters in NSW is privately owned land since e-scooters are not allowed on any road or any road related areas such as footpaths and public car parks. At the same time however, private e-scooters have entered the Australian market, including NSW where there were more than 50,000 privately-owned scooters ridden in 2022 (Coulter, 2023)., In Victoria, where private e-scooters are legal, there are more than 100,000 (VicRoads, 2023). NSW, South Australia, and Northern Territory are the only three jurisdictions in Australia that haven't legalised private e-scooters, and have only enabled shared e-scooter trials. There are other countries and cities that have not made final decisions with e-scooters regulation (either shared or private vehicle), such as Seattle (Williams, 2023) and China (Yuanyuan Wang, 2023). The situation supports the case for evidence-informed policy recommendations that can guide the prudent and effective integration and development of e-scooters, which this paper seeks to provide.

Table 1 summarises e-scooter relevant regulations and rules across Australian states and territories. Most have legalised private e-scooters, and all have legalised e-scooter shared schemes. The maximum riding speed, minimum riding age, and requirement for Blood Alcohol Concentration (BAC) vary but fall into a similar range. There are some consistent rules in all Australian states and territories: helmets are mandatory for e-scooter riders; bell, horn, and lights are required; no driver's licence is required; no insurance is required; mobile phone usage is not allowed while riding; and carrying passengers is not allowed.

Table 1. E-scooter regulations in Australian states and territories (as of September 2023)

State/Territory	New South Wales	Tasmania	Victoria	Queensland	Western Australia	South Australia	Northern Territory	Australian Capital Territory
Private e-scooters	×	√	√	√	√	×	×	√
Shared e-scooters	√ (trial)	√	√	√	√	√ (trial)	√ (trial)	√
Year of first shared e-scooter trial	2022	2021	2019	2018	2018	2019	2020	2020
Max speed (kph)	20	25	20	25	25	15	15	25
Minimum age (y/o)	16	16	16	12 (with supervision) 16 (without supervision)	16	18	18	12
To carry on public transport	×	Depends on the public transport driver/manager	×	Depends on the public transport driver/manager	×	×	×	Depends on the public transport driver/manager
Blood Alcohol Concentration (BAC) (grams)	0.05	0	0	0.05	0.05	0.05	0.05	0
Riding e-scooters in public	×	√	√	√	√	×	×	√

Riding e-scooters on private property	√	√	√	√	√	√	√	√
Helmet	Required							
Bell, horn, and lights	Required							
Driver’s license	Not required							
Insurance	Not required							
Mobile phone usage	Not allowed							
Carrying passengers	Not allowed							

*× indicates an illegal status. √ indicates a legal status.

Source: Based on e-scooter regulations in Australian states and territories.

3. Methodological approach

The purpose of this paper is to provide policy implications on shared e-scooter policies for jurisdictions that are in a conflicting position with e-scooters, such as NSW. The NSW government established the shared e-scooter regulation agenda with a firm emphasis on “safety” (Transport for NSW, 2023), and the same is observed for many other jurisdictions around the world (European Transport Safety Council & Parliamentary Advisory Council for Transport Safety, 2023; New York City Office of Mayor, 2023a). Therefore, the first theme we investigate in this paper is *safety,* from perspectives of risky rider behaviours, vehicle safety, and infrastructure, and effective regulation. There are other two themes that are also clearly important from a sustainable perspective: *where shared e-scooters fit into the modal landscape,* i.e., whether journeys shift to e-scooters from walking/cycling, public transport, or private cars; *and the social and environmental impacts on sustainability*.

Evidence discussed in the paper is primarily drawn from scholarly literature and augmented by grey literature since much of the recent evidence has yet to be formally documented. Scholarly literature was sourced from Scopus and Web of Science Core Collection. Grey literature was drawn from news pieces, blogs and reports. Search results were limited to English, OECD countries, and dated from 2011 to March 2023. The approach adopted is a snowball method in nature informed by the context of the study. The following section explores the three themes in detail and examines the existing evidence that may shed light on policymaking around shared e-scooters.

4. Key issues identified

4.1 Safety and the role of regulation

Commonly expressed major concerns of e-scooters are related to safety, parking and road congestion, with safety being the most significant reason for aversion to use (Timsit, 2022), which can overshadow the e-scooters’ environmental and economic benefits (Félix et al., 2023). Transport regulators worldwide commonly take safety as their primary regulation goal around the use of e-scooters. In practice, the media has reported many tragedies regarding incidents involving e-scooters. In the literature, e-scooter safety is commonly understudied in comparison to other modes like cycling due to a lack of available data (Sexton et al., 2023).

4.1.1 E-scooter rider behaviour

Helmets, speed, and alcohol are important issues relevant to e-scooter safety. Data from hospital emergency departments confirms that among the consequences of collisions relating to standing e-scooters, head injuries are one of the most commonly seen (Serra, Fernandes, Noronha, & de Sousa, 2021). This is influenced by the design of e-scooters – with small wheels and the rider's centre of gravity located forward, the rider's head can be in great danger in a fall (Winchcomb, 2022). The literature supports the idea that helmets can provide crucial (if not full) head protection for e-scooter users in a traffic collision (Iroz-Elardo & Currans, 2021; Wei, Petit, Arnoux, & Bailly, 2023). However, many riders do not wear a helmet, either in a shared scheme or on a private-owned e-scooter (Basch, Ethan, Fera, Kollia, & Basch, 2023; Brauner et al., 2022), even in jurisdictions where it is mandatory to wear one (Farid, 2023).

Generally speaking, a decreased riding speed is associated with an increased safety level (Che, Lum, & Wong, 2020). However, imposing lower speed limits on e-scooters could potentially promote sidewalk riding, consequently reducing pedestrian safety (Young, 2023). Both the rider's control and vehicle design (speed range) can affect the e-scooter operating speed. E-scooter speed limits vary in different countries. Depending on the road space they are allowed to operate on, the maximum speed limit is commonly 20–25 kph (Voro Motors, 2019).

Alcohol is the one of the most common types of drug influence regarding e-scooter riding (Gioldasis, Christoforou, & Seidowsky, 2021). There is consensus that regulations should consider an alcohol unit limit that is safe for e-scooter riding, specific population groups the enforcement should target, and when. Currently, regulations in some jurisdictions apply the blood alcohol limit for motor vehicle drivers to e-bikes and e-scooters, but with extra requirements. For example, in Germany the blood alcohol limit is 0.05%, but people under 21 years old must be completely alcohol-free (Criminal Law Germany, 2023). Research on e-scooter alcohol impact is currently limited but growing, indicating that the young population, frequent e-scooter users, people with limited education and/or lower perceived accident risk tend to have more Number of Alcohol Units perceived to be Safe (NAUS)[2] (Karpinski, Bayles, Daigle, & Mantine, 2022, p. 61; Mehdizadeh, Nordfjaern, & Klöckner, 2023).

Beyond individual behaviours, e-scooter riding often involves interactions with other road users. In many countries, infrastructure cannot keep pace with the number of e-scooters on the roads. As a result, e-scooters often operate on roadways, bike paths or footpaths. This phenomenon has increased the possibility of congestion and therefore collisions between e-scooters and other road users, such as pedestrians, cyclists, and car users. Existing literature has addressed such interactions on safety-critical nodes with a focus on intersections, where traffic streams join each other (della Mura, Failla, Gori, Micucci, & Paganelli, 2022; Lyons, Choi, Park, & Hassan Ameli, 2020), and a focus on micromobility-pedestrian collisions (Che et al., 2020; Liu, Jafari, Shim, & Paley, 2022; Maiti et al., 2022; Valero et al., 2020). It is also important to

[2] Instead of a regulated limit, NAUS here means the personal perception of the number of alcohol units perceived to be safe.

consider future e-scooter interaction such as with autonomous vehicles (T. Sanders & Karpinski, 2022). Road intersections, sidewalks, and subway entrances are common places for micromobility-pedestrian collisions (Shin & Choo, 2023). There is a big difference in the speed of e-scooters and pedestrians; the average speed of e-scooters varies from 24 kph to 48 kph depending on the vehicle design, while the average walking pace of an adult is only 4 to 6 kph. The speed difference puts pedestrians in extreme danger when a collision happens (Kazemzadeh, Haghani, & Sprei, 2023). Children, the aged, and the disabled are more vulnerable in micromobility-pedestrian collisions. Walking is older adults' second most preferred mode of transport, after driving, and their preferred recreational activity (Jancey et al., 2013). Walking is of great importance for the health of children and the aged. E-scooters also pose risks to individuals with disabilities, such as the visually impaired (Karlsen, Weyde, Nielsen, & Dale, 2023).

There are differences in rider behaviours in shared and private schemes. Although press reports suggest private e-scooters are more likely to be involved in fatal crashes than shared scheme scooters (probably because there are a greater number of private e-scooter trips), users of shared schemes usually perform more risky behaviours than private e-scooter users (Haworth, Schramm, & Twisk, 2021). The risky behaviours include not wearing a helmet, riding on the road, or carrying a passenger. Generally speaking, dockless e-scooters are more convenient compared to docked ones, but mis-parked e-scooters generate a bigger problem for other road users (Brown, Klein, Thigpen, & Williams, 2020; James, Swiderski, Hicks, Teoman, & Buehler, 2019). The e-scooter parking controversy is among many regulatory gaps around dockless e-scooters and requires further consideration (Carroll, 2022). There have have been calls for integrated management of parking spaces, accommodating the needs of different vehicles (Brown et al., 2020) and also pedestrians (James et al., 2019).

4.1.2 Safety of the vehicle

Vehicle design is highly relevant to e-scooter safety. E-scooters, like bicycles, are single-track vehicles that lack lateral stability when stationary, and the balance can only be generated when moving. Thus, many experiences that a user learnt from bicycles may be applicable to e-scooters. However, bicycles and e-scooters have quite different parameters: e-scooters have smaller and more rigid wheels and e-scooter riders commonly stand on the device instead of sitting on it (García-Vallejo, Schiehlen, & García-Agúndez, 2020). To achieve a safe outcome for e-scooters, there is a need for further exploration on the ergonomics of vehicle design and safety management. Issues identified which may increase the safe use of e-scooters mainly focus on the effects of the braking system and wheel design (Lee, Yun, & Yun, 2021; Paudel & Fah Yap, 2021; Siebert et al., 2021).

Battery explosions have become one of the most reported problems associated with e-scooters and e-bikes, with a rising number of reports both in Australia and worldwide (McMillan, 2023; Postans, 2023). The key debate is on the material of the batteries. Almost all e-scooters on the market use lithium-ion batteries, which can cause fire in situations of overcharging and overheating. There is potential for other more-sustainable materials to replace lithium-ion batteries, such as aluminium-ion (Australian Institute for Bioengineering and Nanotechnology, 2021) and hydrogen (Sugiyama, Muramatsu, Ikeya, Eguchi, & Shimura, 2018). Product standards also play a role in preventing battery explosions of electric personal mobility devices. Importing laws are relevant because many of the devices in Australia come from overseas manufacturers (Australian Government, 2021) who may have lower quality. On this issue, New York City USA, has set a good example by announcing the *Charge Safe, Ride Safe: New York City's Electric Micromobility Action Plan* on March 20, 2023 (New York City Office of Mayor, 2023b) to tackle the issue of battery explosions (Wilson, 2023).

4.1.3 Infrastructure

Infrastructure significantly affects the safety of micromobility. Table 2 is a summary of micromobility path features deemed to be helpful in increasing the safety of users.

Table 2. Features of safe micromobility paths

Safety feature	Scholarly literature
Dedicated infrastructure	(Austin Public Health, 2019)
Curbed by concrete or vegetation	(Fonseca-Cabrera, Llopis-Castelló, Pérez-Zuriaga, Alonso-Troyano, & García, 2021)
One way instead of two ways	(Thomas & DeRobertis, 2013)
Separated away from parked or moving motorized traffic	(Fonseca-Cabrera et al., 2021)
Adopt pavement materials with great skid resistance but less vibrations, such as concrete, asphalt, and rough painted tile pavements	(López-Molina, Llopis-Castelló, Pérez-Zuriaga, Alonso-Troyano, & García, 2023; Q. Ma et al., 2021)
Softer (soil, for example, is safer than concrete)	(Chontos, Grindle, Untaroiu, Doerzaph, & Untaroiu, 2022)
Highlighted with colours (commonly red, green and blue) to improve attraction, legibility and intuitiveness of riders and others, which is especially helpful at intersections and junctions	(Autelitano & Giuliani, 2021)
Clear legislation and information	(Useche et al., 2022)

Source: the authors, based on the evidence review.

4.1.4 Effective regulation

The absence of uniform regulations around e-scooters is widely acknowledged as a major obstacle of safe use (Kazemzadeh et al., 2023; Salas-Nino, 2022) without any clarity on a comprehensive code of conduct. The literature points to a need for statutory recognition and definition of emerging types of micromobility devices, which should serve as a base of road rules and possible risk analysis to increase safety (Iroshnikov, Nemova, Shevchenko, & Utkin, 2020).

Safety education and skills training are crucial to realise a safe outcome with micromobility, because many safety issues are related to inexperience, lack of protective gear, and poor riding skills. Existing literature has touched on micromobility vehicle licensing (Bach, Marquet, & Miralles-Guasch, 2023) but not rider licensing. Generally speaking, adopting licences for riding e-scooters may lead to a better safety outcome by enhancing people's riding skills, and raising awareness level of relevant rules. However, rider licensing can come with implementation and management costs for the regulator and also decrease the affordability and accessibility for individuals, which may lead to reduced adoption of e-scooters and/or enforcement challenges. Persuasive messaging can also play a positive role in increasing e-scooter safety. Research has found that in the social media accounts of popular e-scooter companies in USA and Europe, there is little promotion and demonstration of the use of safety gear like helmets (Dormanesh, Majmundar, & Allem, 2020). In the active transport domain, research has explored the potential for persuasive messaging to increase active transport in transport and health apps (Pangbourne, 2023). These findings could be mirrored in e-scooter safety publicity. Media such as newspapers is another potential platform for safety persuasion (Boufous & Aboss, 2019).

Traditionally, road safety has been evaluated based on motor vehicle data, but the popularity of micromobility requires new data sets with often tech-driven collection and interpretation methods (Karpinski, Bayles, & Sanders, 2022). E-scooter-related collision data generally comes from police and emergency departments. However, a road collision only involving the e-scooter rider, especially without presenting to hospital, is commonly unnoticed and uncounted. Based on the data from the recently published UK national evaluation of e-scooter trials, for five percent of e-scooter users who have experienced a collision, the majority were caused by the rider error and did not involve other road users (UK Government, 2022). Existing literature touches on relevant solutions such as low-cost data acquisition systems installed on e-scooters (Pérez-Zuriaga et al., 2022), or by gaining data from virtual reality simulated environments (Brunner, Locken, Denk, Kates, & Huber, 2020; Valero et al., 2020). Moreover, most data were gained directly or indirectly from e-scooter users, while data from external raters (via survey, for example), such as non-cyclists and non-e-scooter riders, can also be useful in evaluating e-scooter safety (Useche et al., 2022). As many e-scooter-related injuries happened to non-e-scooter riders (Blomberg, Rosenkrantz, Lippert, & Christensen, 2019), the data is able to provide a different perspective on e-scooter riders’ interactions with other road users and also opinions from the general public which may include future users.

In terms of micromobility safety solutions, there is a growing body of innovative methods. For example, an American research team emphasises the importance of a vehicle-to-micromobility communication system, which can alert the car driver about an imminent collision to allow for reaction time (Baqer, Lowry, & Krings, 2022). Another team created a 'smart android system' named STEADi to help university students who are new to e-scooters to safely travel on campus by altering unforeseen conditions (Gupta, Xu, Yu, & Huang, 2021). A study in Italy proposed an indicator for micromobility safety assessment in urban areas, which has helped some local governments in Italy to make relevant decisions to mitigate the risk of collisions (Prencipe et al., 2022). There are other methods mentioned in the literature to mitigate safety risks such as real-time risk management strategies (Sobreira & Cunto, 2021) and data-driven frameworks which can automatically assist urban planners in maintaining the micromobility network (Folco, Gauvin, Tizzoni, & Szell, 2022).

To better regulate micromobility safety, policymakers should consider the demographics of micromobility riders, to adjust the intensity, frequency, and timing of regulation enforcement. Compared to other transport modes, e-scooter fatality victims are more likely to be male and younger (Karpinski, Bayles, Daigle, et al., 2022). Frequent users tend to be involved in more crashes (Tian, Ryan, Craig, Sievert, & Morris, 2022) which is expected as they ride more. Within the e-scooter rider group, although young and middle-aged males appear to be the most frequently injured, the groups of female, young, and older riders may be at higher risk of injury when considering their physical condition (Iroz-Elardo & Currans, 2021). Moreover, data shows women are less likely than men to ride shared e-scooters due to various reasons such as road safety concern and bag carrying (Haddad, Sanderson, & Goodman, 2022; Steer & Dott, 2022). Besides age and gender, there are also differences in ethnicities, neighbourhoods, and household compositions in terms of e-scooter safety (Heydari, Forrest, & Preston, 2022; R. L. Sanders, Branion-Calles, & Nelson, 2020). Many of these demographic differences are associated with people's socio-economic characteristics, where low socio-economic neighbourhoods and population groups are disadvantaged by limited access to transport resources like infrastructure and rule enforcement. Micromobility could be a good opportunity to increase transport social equity for these groups.

4.2 Modal benefits

It has been asserted that the deployment and adoption of shared and privately-owned e-scooters and e-bicycles have changed the nature of urban transport (Attard & Balbontin, 2023). While there is growing evidence that micromobility can support public transport service provision (for example, by serving areas that bus services do not reach or are withdrawing from) (Aarhaug, Fearnley, & Johnsson, 2023), there is also evidence that it can abstract, or extract, from the demand for public transport and taxis as well as other active modes (Bocker, Anderson, Uteng, & Throndsen, 2020). This tension is explored in this section.

4.2.1 Mode substitution

Given the dominance of both e-bicycles, and more latterly e-scooters, this review of evidence focuses on these modes and the experience when they are offered on a shared basis[3]. The profile of shared e-scooter users is rather similar to that of station-based and free-floating bikeshare so the literature on bike sharing is considered for the pointers it offers as to what might be expected from the introduction of shared e-scooter schemes (K. Wang et al., 2023; Zuniga-Garcia, Tec, Scott, & Machemehl, 2022). The integration of bike-sharing and public transport, discussed further below, has been found to strengthen the benefits of both modes. In this respect there is an important land-use dimension. Studies have found that bike-sharing tended to be more of a substitute to public transport in larger and denser cities and more complementary as a first/last mile integration in small to medium size and less denser cities (Mitra & Hess, 2021; Shaheen, 2014). There is evidence that many bikeshare members are substituting docked bikesharing for bus trips in Manhattan and Brooklyn, New York City (Campbell & Brakewood, 2017). In the Netherlands, dockless bike-sharing users are more likely to be non-Dutch and often have no driving license, whereas the situation is the opposite for docked bike-sharing, bicycle lease and non-bike-sharing users. Importantly, commuters are less likely to shift to docked bike-sharing if the trips are short or easily made by personal bicycles (X. Ma, Yuan, Van Oort, & Hoogendoorn, 2020). Above all however, the literature suggests that the success of bikeshare schemes requires a strong active transport culture and a supportive environment for slow-moving pedestrians and vehicles.

A European study found that e-bike and e-scooters were primarily used for leisure trips rather than on a regular basis (this is particularly true for Copenhagen, Munich, and Stockholm) with most users shifting from walking and public transport modes (Esztergar-Kiss & Lizarraga, 2021). Public transport was found to be the most vulnerable to replacement when respondents

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[3] For a review of the impacts in cities of growing private ownership of e-scooters see Leung and Burkea (2022). Findings from Europe suggest that e-scooter owners mode substitute walking, public transport and car much more frequently than renters, especially for work- or education-related, and leisure trips.

were asked if e-mobility could potentially replace any trips they made by other modes. Another study in Canada found the majority of survey respondents would replace their existing walking (60%) and public transport (55%) trips with shared e-scooters (Mitra & Hess, 2021). Concerning mode substitution they find a land-use dimension and suggest that shared e-scooters would largely substitute walk and public transport trips, probably in more central locations and that in suburban settings, e-scooters may in fact support public transport use through their utility in making first- and last-mile connections (Mitra & Hess, 2021). Also relevant in this context is the possibility that e-scooters may be considered less cumbersome, and therefore require less effort to use, compared to e-bikes.

The use of shared e-scooters as a complement to public transport varies highly by local context. K. Wang et al. (2023) conclude that many people in USA cities use shared e-scooters in place of cars. Empirical data suggests that, as with bikeshare, shared e-scooters tend to be more widely adopted by male, relatively young, well-educated individuals, and local residents. Using e-scooter trip data from Nashville, Tennessee USA, Ziedan et al. (2021) found that on a typical weekday, utilitarian e-scooter trips are associated with a 0.94% decrease in bus ridership and social e-scooter trips are associated with weekday bus ridership increases of 0.86%. Luo, Zhang, Gkritza, and Cai (2021) propose a modelling framework to identify the potential impacts of e-scooter trips on the existing bus system, considering the spatio-temporal availability of bus service. Their results show that about 27% of e-scooter trips could potentially compete with buses and these are concentrated in downtown. Complementary trips (29%) are mainly located outside of downtown where the bus coverage is low. This confirms earlier findings from Shaheen (2014) and Mitra and Hess (2021). A practical outcome of these findings is that repositioning e-scooters to areas with limited bus service can better promote synergistic relationship between the two systems (Luo et al., 2021).

A comprehensive review of e-scooter use patterns, perceptions and environmental impacts is provided by Badia and Jenelius (2023). In their study less than 10% of trips feed public transport in 7 of the 13 cities where information is available. However, these findings must be interpreted cautiously since public transport is the main complementary mode for shared e-scooters according to the surveys in France and Brussels, Belgium (Badia & Jenelius, 2023). Considering impact on modal split based on the results of the survey question "what transport mode would you have taken if an e-scooter was not available?" Badia and Jenelius (2023) conclude that at least 5 out of 10 shared scooter travellers substitute other kinds of sustainable modes (walking, public transport and cycling). However, this is clearly linked with urban form with substitution of 80% in (compact) European and 50-60% (dispersed) North American urban areas.

Whilst the popularity of micromobility has grown over the past decade it is also relevant to note that, shared e-scooters were seen as a viable option for short distance trips in many cities during the COVID-19 pandemic. They became associated with social distancing and were seen as a healthier alternative to private cars for those who were concerned about using shared transport (Dias, Arsenio, & Ribeiro, 2021).

4.2.2 Mode integration

Given that issues relating to micromobility and mode substitution are strongly influenced by local context it is relevant to ask what measures have been introduced to encourage greater mode integration. Van Oort (2023) states that the relationship between shared micromobility and public transport is thought to highly depend on how well integrated the modes are. He rehearses the two strong (and well-known) arguments for shared micromobility being a potential complement to public transport, namely as access/egress modes to improve the accessibility to public transport; and to effectively extend the reach of public transport via consequential increases in coverage.

Bocker et al. (2020) use slightly stronger language in calling for bike sharing to implemented in a way that synergises with, rather than cannibalises, public transport. Their study investigates bike sharing use in conjunction with public transport in Oslo Norway, using 2016–2017 trip records. They found that bike sharing ridership was substantially higher on routes that either start or end with metro/rail connectivity when controlling for other factors, such as route distance, elevation, urban form, time of day and bike dock capacities.

Badia and Jenelius (2023) identify strategies that can be used to promote the combination of shared scooters and public transport to compete with cars, or to promote the use of scooters for commuting trips. Last mile transport is encouraged by dedicated infrastructure such as lanes for micromobility vehicles and traffic calming paths to connect public transport stations with their surroundings. Additionally, there is a demand for e-scooter parking slots around public transport hubs. Esztergar-Kiss and Lizarraga (2021) suggest that where most micromobility users combine with public transport that parking facilities should be implemented near public transport stations. Parking is frequently mentioned as an area where local government intervention is required, e.g. Gossling (2020); Esztergar-Kiss and Lizarraga (2021), and is discussed further below under social impacts.

The means by which greater integration between micromobility and public transport integration can be achieved is specifically addressed by Oeschger, Carroll, and Caulfield (2020) who argue strategies to encourage and improve mode integration should take due account of the characteristics of users. K. Wang et al. (2023), for example, found that e-scooter sharing is used more often and viewed more positively than station-based bikesharing among low-income groups.

In their study from Nashville, USA, Ziedan et al. (2021) found that some shared e-scooters social trips complement public transport use and suggested offering discounts or advertisements like “do not drink and ride, use transit.” Additionally, public transport and shared e-scooter operators could offer integrated trip planning and fare payment. Better placement of shared e-scooters near bus stops could encourage their combined uses (Ziedan et al., 2021). A similar point is made by Attard and Balbontin (2023) who note that the integration of services needs to be supplemented by fare systems which allow for seamless travel and the possibility for shared offers.

In the City of Austin, Texas, USA, Zuniga-Garcia et al. (2022) explored the interaction of e-scooters and bus services to provide an overview of e-scooter trips and user characteristics. Within their survey of the university population, 12 percent of e-scooter users used public transport to complement their trips. The relationship between public transport and shared micromobility (bicycle and e-scooters) using stated preference data collected in Rotterdam in the Netherlands is discussed by Van Oort (2023). The findings suggest that shared micromobility modes are viable alternatives as egress modes for metro trips. They also found that micromobility can be a viable option as individual modes for longer distance trips. Aarhaug et al. (2023) exploring e-scooter use and the interaction with public transport in the city of Oslo, Norway found that 20% of e-scooter trips were made in combination with other modes, mainly public transport. They conclude that while e-scooters compete with public transport, it also functions as a complement.

Attard and Balbontin (2023) cite some examples of collaboration between government and shared micromobility operators. In Brisbane, Australia, the local government and the shared e-scooter operator are providing and guiding users to dedicated parking spots adjacent to major public transport stations. In contrast, in Paris France, e-scooter parking has been a serious issue and a recently held referendum (April 2023) has banned shared e-scooters from the city (BBC News, 2023), although only 7.5% of registered voters participated.

Finally, Esztergar-Kiss and Lizarraga (2021) suggest, as an outcome of their investigations in five European cities, that service providers and local authorities should be more proactive by including micromobility in their sustainable urban plans and should focus on the regulatory environment for micromobility use.

4.3 Impacts on sustainability

4.3.1 Social sustainability

One aspect of social sustainability relates to urban development. Greater sustainability is generally associated with the aim of encouraging active transport for short trips and public transport for longer trips and as such is associated with more walkable neighbourhoods, smart growth, transit oriented development and new urbanism (Prillwitz & Barr, 2011). The literature is rich with policies to encourage walking and public transport use, with higher densities, mixed land use often being identified as key factors. A study based on Louisville, USA, where e-scooters were first introduced in 2018 found higher percentages of commercial use with high employment potential was significantly positively related to the density of e-scooter trips along with higher walk, public transport and bike scores (Hosseinzadeh, Algomaiah, Kluger, & Li, 2021). However, whilst higher walk scores were associated with higher e-scooter use, it did not appear to be a determinant of e-scooter use, unlike higher public transport scores, suggesting the presence of public transport increases e-scooter use and thus may play a part in satisfying first and last mile trips. A comparative study of four USA cities (Austin, Minneapolis, Kansas City, Louisville and Portland) found a positive correlation between usage and population density, employment density, intersection density (higher intersection density is associated with more walkable environments), mixed land use and bus stop density (Huo et al., 2021) confirming results of Caspi, Smart, and Noland (2020).

Separately from the impact on global emissions, the use of e-scooters has an impact on the users which has a societal impact. The evidence on mode shift identifies a relatively high proportion of e-scooters substituting trips by e-scooter from lower emission-emitting modes. From a public health perspective, e-scooter users who do substitute from a more active mode (cycling or walking) will suffer from a decreased health benefit from lower activity. Perhaps more importantly, because of the way in which e-scooter users typically travel close to traffic, they are exposed to a complex mixture of pollutants known to adversely affect health (Mukherjee & Agrawal, 2017). These have a well-documented literature identifying premature mortality, cardiovascular, respiratory, developmental effects and cancer (Vallamsundar, Jaikumar, & Venugopal, 2022) and is particularly an issue when travelling alongside main roads because of the relatively longer exposure times, given the relatively longer travel times. Exposure analysis based on a sample of trips in the central area of Austin, USA, found high exposure during the midday period when the number of trips were high and in the evening when concentration levels were higher and the number of trips were high, with higher levels of pollution at the times of the year when dispersion was affected by weather, such as in the autumn and winter (Vallamsundar et al., 2022). Overall, an analysis of the benefits and costs of e-scooters suggests that any benefits from the substitution of e-scooter trips from trips with lower physical activity are very much outweighed by the impact of health exposure and the incidence of traffic collisions (Félix et al., 2023).

There is some evidence (Sherriff, Blazejewski, & Lomas, 2022) that e-scooters are being used to make journeys that would not otherwise be made. Whilst this would have an adverse effect on emissions, it would have a positive impact on social inclusion and hence a positive social impact. There is also some evidence that e-scooters are providing a cheaper alternative to ride-hailing and taxis and, to the extent that this makes access to work – particularly for shift workers – less expensive it would also be more positive in environmental terms (Sherriff et al., 2022). The National UK trial report specifically identifies journeys to medical appointments and other key destinations such as essential shopping being identified as easier, particularly for those with mobility problems (Department for Transport, 2022).

A separate question is the extent to which e-scooters are filling a mobility gap in the overall transportation system. A survey in Manchester, UK, found that respondents who did not own either a car or a bike were more likely to have been an e-scooter user. This would also improve social inclusion, giving a positive social impact (Sherriff et al., 2022).

For shared dockless e-scooter schemes, parking is identified as a particular problem affecting residents (Department for Transport, 2022) and pedestrians (Sherriff et al., 2022). Even when there is a requirement to park in specified bays, such as in the centre of Birmingham, UK, this is not followed uniformly. The Birmingham trial has been paused from 1 March 2023 on safety grounds (Storer, 2023). The impact of haphazard parking is an issue from the point of view of interrupting pedestrians. Although a study of e-scooters in San Jose, USA found 72% of e-scooters were parked on pavements, only 10% were making progress difficult for pedestrians (Fang, Agrawal, Steele, Hunter, & Hooper, 2018). Parking issues more generally are the concern of policy and regulation.

4.3.2 Environmental sustainability

Whether e-scooters are likely to improve the level of greenhouse emissions associated with mobility is linked also to their usage and the degree to which e-scooter trips replace trips using vehicles with higher emissions. A study based on household travel data in Germany suggests looking at replaceable short car trips that could be replaced by e-scooters and this would account for 13% of daily car trips and 2% of car kilometres (Gebhardt, Ehrenberger, Wolf, & Cyganski, 2022). The calculation of savings to greenhouse emissions is complicated by the diversity of the fleet but at best 5.500 tons for the daily CO_2 caused by personal daily motorised mobility could be saved which the authors identify as 'modest' given the high hopes for sustainability with the introduction of, particularly shared e-scooter systems. Emission savings are also crucially dependent on the carbon intensity of the battery production and the lifetime and lifetime use of the e-scooter. Drawing from a study in (Gebhardt et al., 2022) identify greater savings are likely to come from private e-scooter use as these appear to substitute for a greater number of car trips than from shared e-scooter use.

The charging of e-scooter batteries requires energy, largely derived from fossil fuel, which has an impact on their sustainability and on their overall life cycle assessment. The energy efficiency of e-scooters has been considered by Yuxuan Wang, Wu, Chen, and Liu (2021) using data from Gothenberg in Sweden. They found a 40% wastage of e-scooter battery arises from the machines being idle and they related this to a usage rate of 83%. Scenario testing using parameters from a regression based on real data suggested the wastage rate could rise to over 50% if the usage rate fell to 50%.

Studies on the relationship between the use of e-scooters and emissions do not always consider the emissions involved in the production and ending of life of e-scooters. Few studies have looked at the lifecycle analysis although a study by Hollingsworth, Copeland, and Johnson (2019) suggests that greenhouse gas emissions would be 65% higher, based on then current use, as compared to the use of the mode of transport the trips replaced. Similar results were found in a study based on data from Paris, France which was accredited to e-scooter trips replacing modes with lower emissions (de Bortoli & Christoforou, 2020). Increasing the life span of e-scooters can reduce the environmental impact - a study in Lisbon, Portugal, suggests extending the shared e-scooter life expectancy reduces environmental impacts by 26 to 47%, and increasing the km per day could reduce the impact by between 50-80% (Reis, Baptista, & Moura, 2023). Interestingly, similar results were identified in the developing country context in Peru (Echeverría-Su, Huamanraime-Maquin, Cabrera, & Vázquez-Rowe, 2023). Chester (2019) identified the manufacturing and materials to be the most significant part of the emissions in the life cycle, followed by the method of distribution and collection and charging of the machines. Similar results have been identified by Reis et al. (2023). Overall, these studies suggest that the sustainability of e-scooters in use may well be overshadowed by a lifetime emissions consideration.

5. How should jurisdictions treat e-scooters?

This paper has reviewed the existing evidence regarding shared e-scooters within the broader micromobility context, aiming to direct policymaking around shared e-scooters. This section provides policy recommendations around the three themes identified in this paper which may. be useful for to any jurisdictions that have not yet reached a definitive conclusion regarding e-scooter regulations.

5.1 Safety

With the purpose to reduce possibility of injuries in a traffic collision either only involving the rider or collisions with others, the main policy recommendations to address e-scooter safety are discussed below.

First, the regulatory framework should include requirements for the legalisation of e-scooters. Specifically, the framework needs to address an explicit definition, categorisation and product standard of micromobility vehicles; clearly outline responsibilities and obligations of riders of micromobility vehicles and other road users; align with existing and future road infrastructure facilities; be supported by sufficient enforcement; share consistency in shared schemes and the use of private e-scooters; and acknowledge the holistic and interdependent nature of infrastructure treatments and other interventions to achieve a comprehensive and effective approach to safety.

Next, mandatory safety education and skill training is critical in ensuring safety. This should be accompanied by school education programs and persuasive messaging relying on multi-media to raise awareness on micromobility safety. Subject to government decisions, the riding licencing could be an option to consider.

Thirdly, policy making on micromobility safety should rely on new ways of data collection and analysis methods enabled by technological developments and emerging research. Besides making use of rider data from police and emergency departments, data directly from the vehicle and data from non-riders should also be considered.

Lastly, safety management should be user-based, location-based, and time-based. As a foundation to effectively design and enforce micromobility safety policies, policymakers should consider the demographic characterises of riders, such as age, gender, past experience, and user frequency; locations with high safety risks, such as road intersections, sidewalks, areas near bars, low socio-economic neighbourhoods, and neighbourhoods with a high population of children; and time periods with high safety risks, such as night and days with bad weather (rainy or foggy).

5.2 Mode substitution and integration

The evidence suggests that the future of micromobility lies in supplementing and complementing existing public and private transport services (Attard & Balbontin, 2023) although mixed impacts on the public transport system of both competing and complementary relationships may coexist in the same region (Luo et al., 2021).

This review suggests that understanding how micromobility and public transport systems are interrelated is vital for planning a mutually reinforcing sustainable transport network (Campbell & Brakewood, 2017). Similarly, understanding how the shared e-scooters compete with or complement the bus system in different areas and during different time (Luo et al., 2021) periods is critical to informing strategic e-scooter system development alongside public transport. Empirical evidence on user characteristics and preferences is needed to help planners, professionals, and e-scooter companies better understand the displacement effects of shared e-scooters (K. Wang et al., 2023). Technology, regulations, and incentives have a role to play in ensuring greater modal integration. Furthermore, micromobility needs to be inclusively accessible to all population segments (Bocker et al., 2020).

In terms of infrastructure, the perceived walkability/bikability and street safety has been found to increase the likelihood of considering future shared e-scooter use (Mitra & Hess, 2021). Gossling (2020) argues that urban planners should introduce policies regarding maximum speeds, mandatory use of bicycle infrastructure, and dedicated parking, as well as to limit the number of licensed operators.

A very practical point is made by Aarhaug et al. (2023) who note in their Oslo, Norway, study that for most e-scooter trips, the public transport alternative would take twice as much time, or more. This explains why a sizable share of e-scooter trips in Oslo are to access and egress to/from public transport. It also emphasises that the issue of whether micromobility is complementary or competitive to public transport is likely to be context dependent.

All this suggests that service providers and local authorities must consider micromobility in their sustainable urban plans (Esztergar-Kiss & Lizarraga, 2021). Abouelela, Chaniotakis, and Antoniou (2023) emphasise the need for further detailed evidence-based examination of shared-e-scooters and regulatory processes to inform policy decisions regarding the future place of micromobility in the overall mobility offer. Where negative public opinion can be averted, e-scooters stand a chance of becoming a disruptive niche innovation with the potential to transform urban transport systems (Gossling, 2020).

5.3 Environmental and social sustainability

Greater urban development sustainability is likely to be achieved in areas with denser population and employment density, mixed land use and bus stop density.

The benefits to users are strongly related to the mode which the e-scooter trip replaces. From a public health perspective, e-scooter users who do substitute from a more active mode (cycling or walking) will suffer from a decreased health benefit from lower activity and any benefits will be very much outweighed by the impact of health exposure and incidence of traffic collisions. However, there is evidence (e.g. from the Salford trial) that e-scooters are being used to make trips that would otherwise not be made giving positive social inclusion impacts, although negative impact on emissions.

Parking has been identified as a particular issue for dockless vehicles, particularly from residents and from the impact of 'parked' vehicles providing hazards for pedestrians.

For environmental impact, whether or not e-scooters improve the level of greenhouse gas emissions at the point of use again depends on the mode that the e-scooter replaces. However, when a lifetime perspective is considered, the outcome does not look good with a need to take account of the carbon intensity of the battery, vehicle production and end of life recycling possibilities and the strategies used in relocation. It is likely that greater savings may come from private e-scooter use as these appear to substitute for a greater number of car trips than from shared e-scooter use.

5.4 Enablers and barriers

Following the above discussions, Table 3 summarises the potential enablers and barriers of ideal scenarios to minimise safety risks and maximise the modal benefits of shared e-scooters, which could be useful to jurisdictions considering the (organised) introduction of e-scooters. In terms of responsible government entity this is illustrated in the Australian context and thus includes proposed roles of commonwealth (federal), state and local government entities. Generally speaking, different levels of government usually share responsibilities in regulating e-scooters and the context will identify the specific level of government that needs to be involved. In Australia, the federal government is largely responsible for introducing e-scooter supply to the market and also the consumer law; the state government takes care of roadworthiness, driver licensing, road rules and registration; and the local councils look after parking arrangements and local traffic management. Although state government usually plays a key role in establishing regulations, both survey and literature review data has shown that regulating of micromobility should rely largely on local jurisdictions like cities or regional councils (Kolpakov, Sipiora, & Huss, 2022).

Table 3. Potential enablers and barriers of ideal scenarios to minimise safety risks and maximise the modal benefits of shared e-scooters – Australian context

Category		**Potential barriers (to achieving success)**	**Potential drivers (to achieving success)**	**Responsible government entity**
Safety risks	Sound legislation/ regulatory framework	Increased traffic pressure Increased infrastructure cost Lack of agreement among road users regarding road space allocation for shared e-scooters Unfavourable press and citizen response to shared e-scooters (i.e., lack of public support) Inadequate resources for enforcement Lack of consensus among enforcement bodies Lack of agreement among government and private operators Inadequate awareness of interventions happened in different localities Lowered profits of private operators and increased costs for users because of tightened device importing clause	Commitment of key actors Compliance of shared e-scooter users Public support / Alignment of public cognition around e-scooter use Co-operation among stakeholders Agreement among different governmental bodies	Commonwealth, state, local
	Mandatory safety education and skill training (probably via rider licencing)	Inadequate resources for safety education or training Uncooperative behaviours caused by cultural differences	An increased interest from shared e-scooter users to improve the living conditions in the city and their health	Commonwealth, state

	Innovative decision-making process enabled by technology	The scale of the trial is too small or too short to collect enough data The unwillingness of private operators to provide relevant data	Evidence recording during the trial and review after the trial, such as for speed, vehicle standards, licensing, or road user interactions	Commonwealth, state, local
	Safety management that is user-based, location-based, and time-based	Data limitations	Citizens actively engage with relevant interviews and surveys Highly motivated key measure persons as 'local champions'	State, local
Modal benefits	Repositioning e-scooters to areas with limited bus service can better promote synergistic relationship between the two systems.	Objection of local communities	Acceptance of local communities	State, local
	Encouraging first and last mile combination with public transport, with user characteristics in consideration	Increased infrastructure cost Data limitation	An increased interest from shared e-scooter users to improve the living conditions in the city and their health Sufficient data on user characteristics	State, local
Impacts on sustainability	Social sustainability benefits strongly correlated to the mode replaced by e-scooter trip Parking is a particular problem with dockless e-scooters	Increased traffic pressure Increased infrastructure congestion and cost	Public acceptance Sufficient political will Sufficient funding	State, local
	The environmental impact depends on the mode replaced. Lifetime assessment of carbon impact is not good at taking account of battery production, end of life recycling and the impact of relocation strategies			State, local

6. Conclusions

As a young and promising transport disruptor, micromobility is expected to grow (Descant, 2023; O'hern & Estgfaeller, 2020). Based on an international evidence review of both scholarly and grey literature, this paper explores policy recommendations for shared e-scooter management.

Ensuring the safety of shared e-scooters requires complex solutions, which may include a clear regulatory framework for e-scooters, safety education and skill training, innovative data collection and analysis methods, and a safety management that is user-based, location-based, and time-based. This paper identified evidence on the main function of e-scooter services in the overall mobility offer and where it is appropriate for public transport (and other) trips to be replaced. Policymakers should encourage first and last-mile combinations with public transport, with consideration of user characteristics. Greater urban development sustainability is likely to be achieved in areas with denser population and employment density, mixed land use and bus stop density. Benefits strongly correlate to the mode replaced by e-scooter trips: to the extent trips are new, this enhances social inclusion although with a negative impact on emissions. Trips that replace active travel (walking or cycling) have negative health and emissions impacts. Environmental impact depends on the mode replaced. Lifetime assessment of carbon impact should be conducted, taking into account battery production, end-of-life recycling and the impact of relocation strategies.

When thinking about how to regulate e-scooters properly, it is worth recalling that it is common for new means of transport to receive criticism when they first emerge. Governments should consider what and how interventions can be effective in regulating shared e-scooters or with homogeneous vehicles available, it becomes a choice for cities to go with shared e-scooters or not. For example, Paris has decided to ban e-scooter rentals to ramp up e-bike fleets in the city (Reid, 2023). Given that most of the literature currently is about safety and injury prevention, future research avenues should emphasise how e-scooters can better integrate with urban transportation, such as being a "first and last mile" solution. The sustainability and environmental impact of rental e-scooters should be studied to understand energy consumption, emissions, and the lifecycle of the vehicles. Comparative studies with other modes of transportation (such as e-bikes) could help in understanding the benefits or drawbacks of e-scooter adoption.

This paper is motivated by the context of NSW and deliberately assesses selected literature to extract insights pertinent to this region and the broader Australian context. In light of the rapidly expanding body of shared e-scooter research, our study captures a current snapshot of available evidence. It is essential to acknowledge the inherent time lag between literature (especially scholarly) and practices, which underscores the ongoing relevance of continually reviewing the available evidence.

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