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Addressing the Urgent Need for E-scooter Regulation in Hungary

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Abstract

The role of electric scooters is becoming increasingly important for sustainable transport development. E-scooters and other light electric vehicles are generally more efficient in urban environments than electric cars, taking up less road space and resulting in lower energy consumption per trip. Our research involved a systematic literature review to investigate the integration of e-scooters into the existing transport infrastructure network. An online survey was conducted to explore public perceptions and usage patterns of e-scooters, assessing factors such as safety, comfort and preferred speeds. The survey presented five different scenarios in two locations, each illustrating different infrastructure solutions for e-scooters. A total of 137 valid responses were analyzed.

Our study showed that infrastructure with dedicated space for bicycles should be preferred for e-scooters. Respondents indicated that the safest solution for e-scooters would be to use the bicycle facility where it is provided followed by the sidewalk, while using the traffic lane received a low rating. There were significant differences in the perception of safety and comfort by different user groups, with cyclists being the only group where we found the smallest deviation in safety and comfort ratings across scenarios. Speed limit preferences for e-scooters also depend on infrastructure provision. Speeds of 15 km/h or less are preferred for sidewalks, 15 km/h or more for bicycle infrastructure, and slightly higher for traffic lanes. In conclusion, our study highlights the need for proactive regulation to address the increasing presence of e-scooters on our existing infrastructure.

Keywords

e-micromobility, e-scooters, regulation, infrastructure, speed

1 Introduction

Transport policy faces major challenges in mitigating the adverse effects of individual motorized transport, such as traffic congestion, accidents, and environmental pollution. E-scooters and other micro-mobility options represent a promising alternative to promote sustainable urban mobility and improve the negative externalities associated with traditional transport modes. Recognized as an expanding growth sector, the micro-mobility market is expected to reach a staggering global value of $40–$50 billion by 2025, with key markets in Europe and the USA expected to drive this growth (Rose et al., 2020). The recent spread of shared micro-mobility options, such as e-bikes, e-scooters, and electric mopeds in cities worldwide, including Hungary, has contributed to a more complex and diverse mobility landscape. This expanded ecosystem offers significant opportunities, especially if multimodal optimization is prioritized over a single modal approach. However, for e-scooters to compete effectively with cars in the long term, comprehensive political support, safe and comfortable transport infrastructure with optimal speed limit is essential to promote their adoption. Simultaneously, creating a regulatory framework that ensures safety and acceptance by all road users remains a daunting challenge for planners and policy makers. What road surfaces e-scooters should use remains an open question. Our paper attempts to fill this gap.

This study aims to explore public perceptions and usage patterns of e-scooters, assessing factors such as safety, comfort, and speed limits. The rest of the paper is structured as follows. Section 2 presents a systematic literature review, Section 3 the methodology including data collection, Section 4 the results, Section 5 the discussion, followed by conclusions in Section 6.

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2 Systematic literature review

A systematic literature review was conducted to examine the impact of e-scooters on urban mobility and the environment, as well as their potential integration into existing transportation systems. The review also focused on the demographics and usage patterns of e-scooter riders and aimed to understand user preferences and rider safety.

2.1 Impact of e-scooters on urban mobility and the environment

E-scooters have emerged as a transformative force in urban transportation, offering innovative solutions to some of the most pressing challenges in sustainable urban mobility. A growing body of academic literature highlights their potential to alleviate traffic congestion and serve as an effective last-mile solution within integrated public transport systems. These studies highlight the environmental implications of e-scooter use compared to traditional modes of transportation, providing critical insights into their role in reducing greenhouse gas emissions by potentially replacing more polluting options such as cars.

Neves et al. (2024) reviewed 25 studies and analyzed the environmental impacts of e-scooters, mainly from European cities, using life cycle assessments. While e-scooters show potential for urban sustainability, the evidence of their benefits is inconsistent, highlighting the need for a better understanding of their effectiveness. Key phases (production, charging, and rebalancing) significantly affect their environmental footprint. To maximize their positive impact, the study suggests responsible production, extending scooter lifespan, and improving charging practices, emphasizing the importance of strategic interventions in promoting sustainable urban mobility (Neves et al., 2024).

2.2 Integrating e-scooters into existing urban transport

Urban planners face the challenge of integrating different micro-mobility vehicles, especially e-scooters, into existing transport systems. As cities integrate these innovative options – often classified alongside bicycles in Europe – research highlights the vital role of e-scooters in enhancing public transport networks.

A case study of Palermo, Italy, evaluates proposed interventions and offers actionable recommendations for urban administrators. The findings indicate that e-scooters complement public transport and are crucial for the development of a comprehensive urban mobility framework. By improving accessibility and supporting multimodal transport, e-scooters significantly enhance sustainable urban mobility, underscoring their importance in the contemporary public transport landscape (Ignaccolo et al., 2022).

Another study from Gothenburg emphasizes that e-scooters are essential for integrated urban transport, serving as key connectors in multimodal systems and improving urban mobility with convenient last-mile connectivity. It underscores the integration of e-scooters with public transport, which improves energy efficiency and enables seamless transitions between transport modes. By increasing access to transport hubs and reducing dependence on private vehicles, e-scooters contribute significantly to sustainable urban mobility (Zhang et al., 2024).

The rise of e-scooters in USA cities also highlights the necessity for municipalities to develop effective regulatory frameworks. An American study evaluates current e-scooter deployments and identifies emerging policy trends to improve governance. By benchmarking practices and encouraging dialogue, it demonstrates that urban areas are increasingly embracing micro-mobility. Insights gained from these discussions can inform best practices for regulation, enhancing urban mobility, improving public safety, and promoting sustainable transport systems. In the same time, strong regulations are crucial for maximizing the benefits of e-scooters within current urban transport frameworks (Riggs et al., 2021).

2.3 Demographics and usage patterns of e-scooter riders

Jaber and Hamadneh (2024) highlight the demographics of users of active transportation modes – shared micro-mobility, private micro-mobility, and walking – among 219 residents of Budapest, Hungary. Using classification and regression tree analysis, the research identifies key demographic factors influencing mode choice, revealing that age and ownership of micro-mobility vehicles are significant predictors. The findings indicate that individuals without personal micro-mobility are more likely to use shared options or walk, while those over 25.5 years old and vehicle owners prefer private modes. Gender-specific preferences emerged, with men prioritizing cost and weather conditions, while women emphasized safety (Jaber and Hamadneh, 2024).

The Department for Transport (2022) notes that e-scooters are mainly used for leisure, with peak usage at weekends, while frequent users often make longer trips, increasing the risks, particularly for work-related riders. Although only e-scooters from official public trials are allowed on UK roads, illegal practices such as tandem riding and mobile phone use are common, particularly among younger riders with limited knowledge of the rules. Importantly, those familiar with e-scooter laws are less likely to engage in illegal activities, highlighting the need for targeted educational campaigns and safety training to increase compliance and mitigate risks in urban settings (Ventsislavova et al., 2024).

2.4 Users' preferences and riders' safety

A subsequent study made in Austin, TX, USA examines the travel behavior of non-vehicle users, such as pedestrians, cyclists, and e-scooter riders. Researchers sampled data from 2,245 travelers, finding that dog walkers, cyclists, and micromobility users often navigate across various infrastructure types. Observations show that 20% of travelers switch between different types of infrastructure, while 35.8% use non-recommended paths. Their behaviors are influenced by their understanding of local regulations and situational awareness. The study highlights the importance of infrastructure design for user satisfaction, efficiency, and safety, and calls on municipalities to create supportive environments that enhance the experience of all users in urban transportation networks (Lanza et al., 2022).

Another study analyzes the use of e-scooters in Austin, Texas, focusing on their use on sidewalks, bike lanes, and roadways. Utilizing trajectory data from over 80,000 trips collected under the Mobility Data Specification (MDS), the research protects users' personal information. Key findings show that the average distance travelled by e-scooters is spread across a variety of surfaces: 18% on sidewalk, 11% on bike lanes and 33% on roads, with 38% on other unclassified surfaces. In addition, around 60% of road trips are made on main roads, and users in bike lanes prefer routes that offer a medium to high level of comfort. Trips on sidewalks are slightly slower, with speeds reduced by 6 to 8 percent, while higher speeds are recorded on weekdays and morning hours. These insights emphasize the need to understand e-scooter interactions with urban infrastructure to improve micromobility regulations and policies and underscore the importance of trajectory data in improving urban mobility while protecting user privacy (Zuniga-Garcia et al., 2021).

An alternative study, using similar research methods to the previous one, examines the infrastructure preferences of e-scooter riders using data from 2,000 GPS tracked trips at Virginia Tech. The analysis shows that riders are willing to travel longer distances for better infrastructure:

- 59% more for bike lanes;
- 29% for multi-use paths;
- 15% for tertiary roads;
- 21% for one-way roads.

Riders prefer shorter and simpler routes, and gradient does not significantly affect their choice. The findings highlight the importance of adapting infrastructure to the preferences of e-scooter riders, which can increase the effectiveness of e-scooter systems in urban areas (Zhang et al., 2021).

Ringhand et al. (2024) investigated the route choice behavior of e-scooter riders and cyclists in Dresden, Germany, with 52 participants traveling to specific destinations. The results show that e-scooter riders prioritize road surface quality and safety more than cyclists and often face a more complex decision-making process. While route lengths are similar for both groups, e-scooter riders tend to choose longer routes in unfamiliar areas or when looking for scenic routes, highlighting the influence of safety and infrastructure on their choices. The study emphasizes the need for high-quality cycling infrastructure to support e-scooter use and suggests the provision of real-time road quality information to improve safety.

Further research investigates the factors that influence the route choices of e-scooter users in German urban areas where e-scooters must use bicycle lanes. An online survey and stated choice experiment collected data on 3,246 route decisions from 424 participants. The results show that longer travel times, more intersections, and heavy traffic reduce the likelihood of route choice, while smooth surfaces and dedicated bike lanes increase it. These findings highlight the importance of infrastructure quality and design in determining e-scooter route preferences and suggest that improving bicycle infrastructure is essential for the safe integration of e-scooters into urban transport networks (Huber and Friedrich, 2023).

Another study looks at how road features affect e-scooter trip volume (ETV) in Calgary, analyzing 29,544 road segments. The results show that segments with sidewalks, bike lanes, lower speed limits, and more streetlights have higher ETV. Higher income areas and those with more commercial zones also show higher usage. E-scooter users prefer safe environments, preferring dedicated bicycle lanes and lower vehicle speeds. The authors highlight the need to evaluate road features for improved infrastructure planning and recommend future research on causal relationships (Yang et al., 2022).

A study by Gössling (2020) examines the challenges of integrating e-scooters into urban transportation across ten major cities. Analysis of 173 media reports reveals a mix of public enthusiasm and skepticism, primarily due to concerns about reckless riding, clutter, and vandalism. Many cities have adopted a trial-and-error approach to effective legislation. The study suggests that urban planners should implement policies such as speed limits, mandatory use of bike lanes, designated parking, and restrictions on the number of e-scooter operators to address space, speed, and conflicts. While e-scooters have the potential to transform urban transport, proactive regulations are needed to address public concerns. The paper also calls for further research into their impact on trip purposes, accident rates, and media portrayal, emphasizing the importance of comprehensive policies and ongoing investigation into their impact on mobility.

Dibaj et al. (2021) analyzes factors affecting e-scooter trip density in Louisville, Kentucky, using data from 159 Traffic Analysis Zones. They found that commercial land use increases, while industrial land use decreases trip density. Higher Walk Scores and Bike Scores are associated with more e-scooter use, especially during peak hours. The strong predictive models suggest that improving walkability, bikeability, and public transit access can improve e-scooter services. Overall, the findings provide valuable insights for optimizing e-scooter distribution and infrastructure improvements and highlight the link between e-scooters and sustainable urban development.

Several studies address the safety risks associated with the rapid expansion of dockless shared micromobility systems, particularly e-scooters. With many cities imposing restrictions, the research by Zakhem and Smith-Colin (2024) introduces the Micromobility Guidance Tool (MGT), designed to guide users along routes that prioritize safety and compliant infrastructure. The MGT focuses on infrastructure type and condition, optimal parking locations, and warnings of prohibited areas. Using a shortest path routing algorithm combined with user preferences, the tool was tested in a case study of tens of thousands of e-scooter trips in Dallas, TX, USA. The results showed a significant increase in the use of safe infrastructure and a reduction in violations when comparing MGT-generated routes to actual user routes. Overall, the findings suggest that the MGT can improve rider safety and compliance, providing essential resources for municipalities and service providers looking to reintroduce or expand shared e-scooter services while addressing ongoing safety risks.

A substantial body of literature underscores the identified important safety concerns associated with single-vehicle incidents involving e-scooters. Several measures are recommended to improve safety, including segregating e-scooter lanes from pedestrian paths, implementing licensing and training for users, and enforcing helmet laws. The findings indicate that users of shared e-scooter schemes often lack knowledge of safety regulations, highlighting the need for targeted educational interventions. In addition, the study shows that the non-use of helmets is more related to individuals' perception of risk rather than a lack of awareness. Consistent data collection is critical to making informed safety decisions and reducing the risks associated with e-scooter use (Mehranfar and Jones, 2024).

A comprehensive study in Hungary examines electric scooter regulations and user perspectives, explores the vital role of electric scooters in Hungary's urban transportation system, and highlights their environmental and economic benefits in reducing congestion and emissions. Using a Quality Function Deployment (QFD) approach, the authors analyze data from literature reviews, interviews, focus groups, and surveys to capture user perspectives and regulatory expectations. The study reveals strong user demand for new legislation on speed limits, dedicated infrastructure, and parking regulations, emphasizing the need for maximum power and speed regulations to ensure safety (Szemere et al., 2024).

3 Methodology

The rapid integration of electric scooters into urban environments has sparked a need for a deeper understanding of their impact on urban mobility, particularly in Hungary. This study aims to explore public perceptions and usage patterns of e-scooters, evaluating factors such as safety, comfort, and speed limits. An online survey was conducted to encourage broad participation from a diverse demographic. The research focused on key aspects: identifying demographic profiles and capturing user expectations for infrastructure and operational practices. The survey presented five scenarios, with images of streets in Győr, and clear infrastructure illustrations. These scenarios were designed to simulate real-world conditions, allowing respondents to imagine practical applications and provide informed feedback. By examining these scenarios, the study aims to offer valuable insights into the role of e-scooters in sustainable urban transport, and to guide future infrastructure developments in line with the needs and expectations of the community.

3.1 Data collection

The present study used an online survey to gather data. The survey was designed without geographical or categorical restrictions, allowing a wide range of respondents to participate, whether they use electric scooters or not.

The survey consisted of 22 questions focusing on three key areas such as safety, comfort, speed limits, and the role of e-scooters as both public and private transport.

The survey aimed to:

- Capture demographic information, including gender, age, and prior experience with e-scooters.
- Evaluate different types of infrastructure for e-scooters use.
- Gain insight into public perceptions of e-scooters, including preferred road surfaces, appropriate speed limits, safety and comfort.

The comfort and safety evaluation of each scenario was done from the perspective of all road users, pedestrians, cyclists, vehicles and e-scooters. Through these methods, the study aimed to provide a detailed understanding of the use and perception of e-scooters in Hungary and their implications for future urban mobility solutions.

3.2 Scenarios

In this study, hypothetical scenarios were created to obtain more precise responses from participants, ensuring that their answers were not merely based on general opinions. These scenarios, inspired by actual urban conditions, aimed to reflect the current, diverse use of electric scooters.

Five different scenarios were presented, each illustrating various infrastructure solutions for e-scooters. To enhance clarity and comprehension, each scenario was supported by images of the streets of Győr. In the images the proposed road surface for e-scooters is highlighted in yellow. A cross-section is also added to better illustrate the location of the e-scooters. These visuals provided context and guidance, helping respondents to understand the infrastructure details without requiring an engineering background.

The scenarios are implemented in two locations with different cross-sections:

- Location 1 (Scenarios 1, 2, and 3) is a two-lane urban road where there is dedicated infrastructure for both pedestrians and cyclists.
- Location 2 (Scenarios 4, and 5) is a two-lane urban road where there is dedicated infrastructure for pedestrians, cyclists share the road with vehicles.

The scenarios are as follows:

- Scenario 1: a two-lane urban road with a separated bicycle-pedestrian path, where the proposed road surface for e-scooters is the pedestrian path (Fig. 1).

Fig. 1 Scenario 1

- Scenario 2: a two-lane urban road with a separated bicycle-pedestrian path, where the proposed road surface for e-scooters is the bicycle path (Fig. 2).
- Scenario 3: a two-lane urban road with a separated bicycle-pedestrian path, where the proposed road surface for e-scooters is the right side of the traffic lane (Fig. 3).
- Scenario 4: a two-lane urban road with a sidewalk, and no dedicated surface for bicycles, where the

Fig. 2 Scenario 2

Fig. 3 Scenario 3

proposed road surface for e-scooters is the right side of the traffic lane (Fig. 4).

- Scenario 5: a two-lane urban road with a sidewalk, and no dedicated surface for bicycles, where the proposed road surface for e-scooters is the sidewalk (Fig. 5).

4 Results

A total of 138 individuals responded to the survey, resulting in 137 valid responses after filtering. Of the respondents, 59.85% (82 individuals) identified as male, while 40.15% (55 individuals) identified as female. The survey revealed that the demographic was predominantly young, with an average age of 24 years; additionally, and 54% of the participants were residents of the city of Győr. 86% of the respondents did not own an e-scooter, but 30% had used an e-scooter before.

The online survey covered several aspects, focusing primarily on safety, speed, and comfort. An important component of the survey was dedicated to the appropriate usage contexts for electric scooters, examining respondents' preferences for different modes of transportation, including walking, cycling, private car use, public transport, and e-scooters. Firstly, respondents were asked how often they used different transportation modes (Fig. 6). The frequency distribution of transport mode use shows that most of the respondents walk daily, bicycles, vehicles and public transport are less frequently used and e-scooters are used the least.

Fig. 4 Scenario 4

Fig. 5 Scenario 5

A general question about where in the infrastructure e-scooters should be used (Fig. 7) produced a fairly unanimous result. Infrastructure for e-scooters should be preferred where some type of cycling facility is provided, such as a bicycle path, a bicycle lane, a separated pedestrian and bicycle path or sharrows. Although sharrows require cyclists to share the road with vehicles, they received a similar score to separated pedestrian and bicycle paths. Respondents mostly disagreed with the provision of dedicated infrastructure for e-scooters and strongly disagreed with the use of e-scooters on the sidewalk and in the traffic lane.

Another general question addressed the ideal speed limit for e-scooters depending on the infrastructure they use. In Fig. 8, speeds increase from 5 km/h in 5 km/h increments to 30 km/h. An additional category was that no speed limit is required. For sidewalks, the majority of votes remain at or below 15 km/h. As for the different types of bicycle infrastructure (sharrows, bicycle lanes, bicycle paths and separated pedestrian and bicycle paths) the majority of required speed limits are 15 km/h or above. Interestingly, in these cases on average 15% of respondents think that no speed limit is required. In the case of traffic lanes, there is a slight shift towards higher speeds, and 30% of respondents would not even require a speed limit for e-scooters when using traffic lanes.

As described in the methodology, the scenarios were evaluated in terms of safety, comfort and ideal speed limit. For safety, Fig. 9 shows how safe the respondents felt the scenarios were for the user groups such as e-scooters, pedestrians, cyclists and vehicles. Clearly, the safest solution for e-scooters would be to use the bicycle facility where it is provided (Scenario 2) followed by the sidewalk (Scenario 1 and 5). Using the traffic lane received a low score in both locations. We see a diverse pattern of safety ratings from the perspective of pedestrians, cyclists and vehicles. For pedestrians, safety is rated almost equally in three scenarios where e-scooters are not on the sidewalk, in other words, as long as they do not share the sidewalk with pedestrians. For cyclists, there are no significant

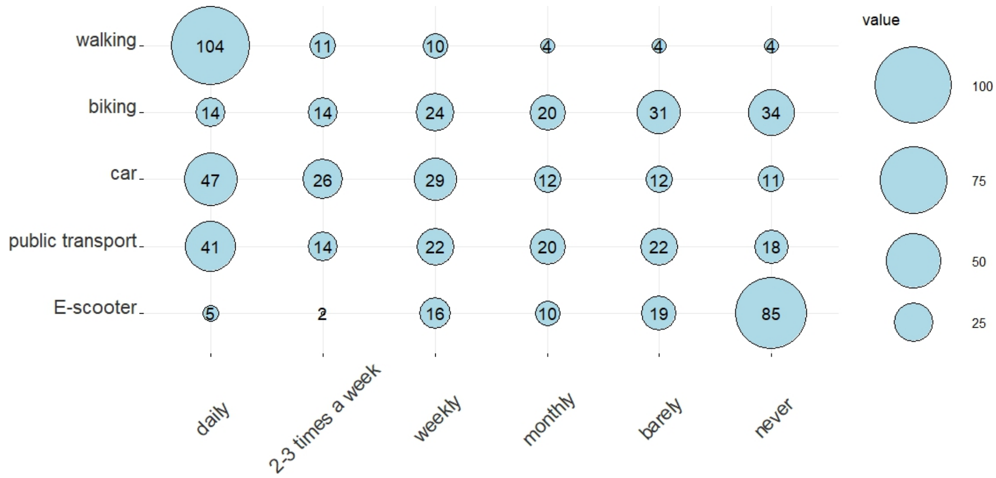

Fig. 6 Use of transportation modes by the respondents

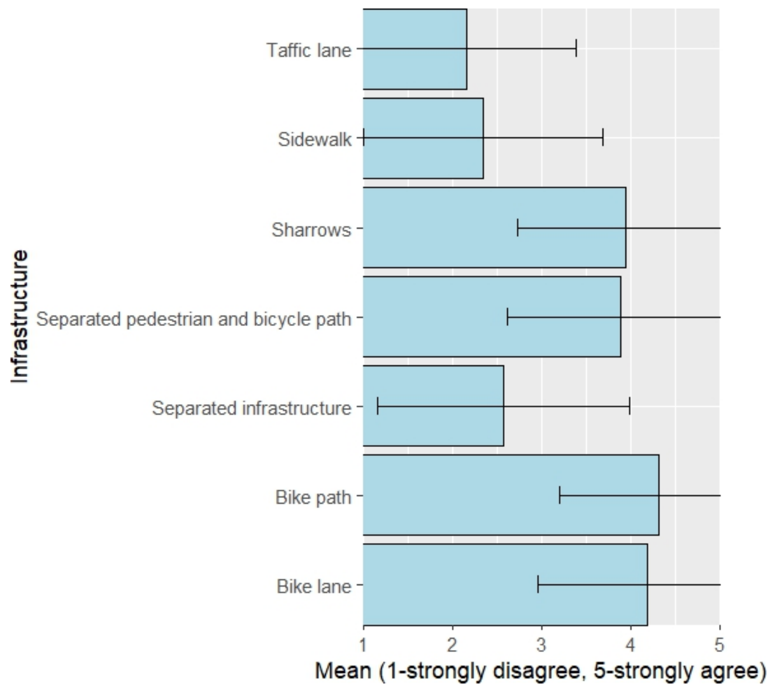

Fig. 7 Preferred place for e-scooters

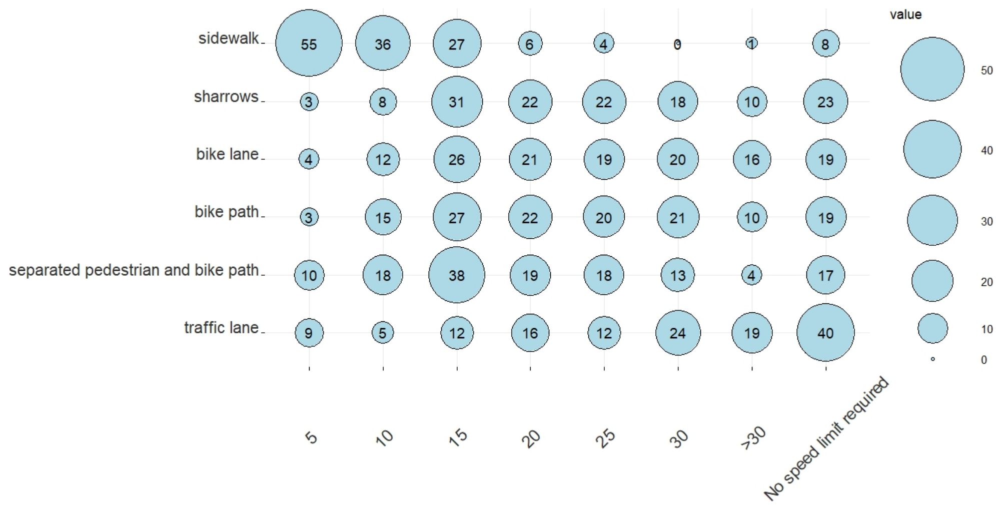

Fig. 8 Ideal speed limit for e-scooters depending on the infrastructure

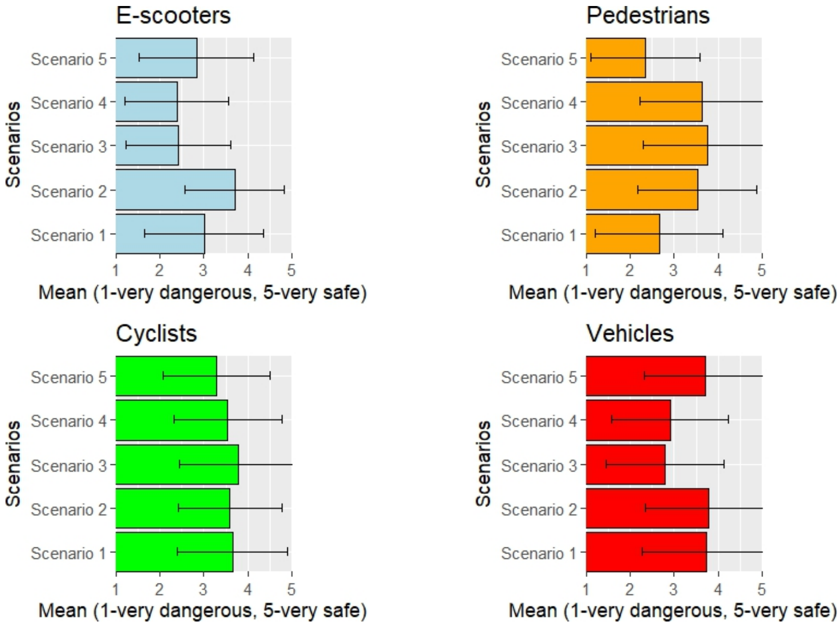

Fig. 9 Evaluation of safety

differences between the scenarios, while vehicles sharing the road with e-scooters (Scenarios 3 and 4) are considered slightly less safe.

Evaluation of comfort (Fig 10.) shows a very similar pattern to safety, which was expected as there is normally a strong correlation between the perception of safety and comfort.

Finally, the preferred speed limits for e-scooters per scenario are shown in Fig. 11. There are clearly two distinct clusters depending on whether e-scooters use the sidewalk or not. Scenarios 1 and 5, where e-scooters are on the sidewalk, show lower speed preferences, with the majority of ratings below 25 km/h. This is almost identical to the results shown in Fig. 8, but here there is a slight shift towards higher speeds. The other cluster (Scenarios 2, 3 and 4) is the bicycle path and traffic lane, where the preferred speed limits are generally above 15 km/h, with a slightly stronger preference for higher speeds in the case of traffic lanes.

To further analyze speed, the ideal speeds (Fig. 8) and the preferred speed limits (Fig. 11) are compared using statistical tests. These pairs are:

- Scenario 1 *vs*. sidewalk;
- Scenario 2 *vs*. bike path;
- Scenario 3 *vs*. traffic lane;
- Scenario 4 *vs*. traffic lane;
- Scenario 5 *vs*. sidewalk.

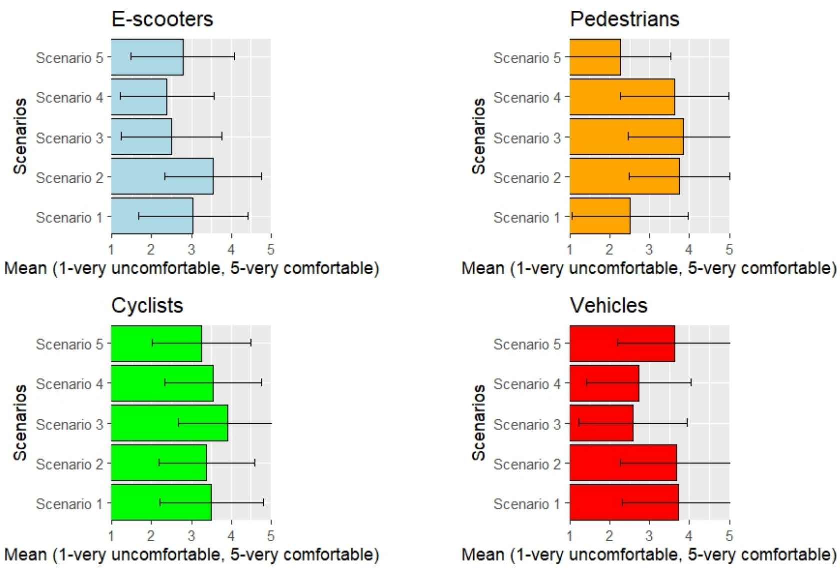

Fig. 10 Evaluation of comfort

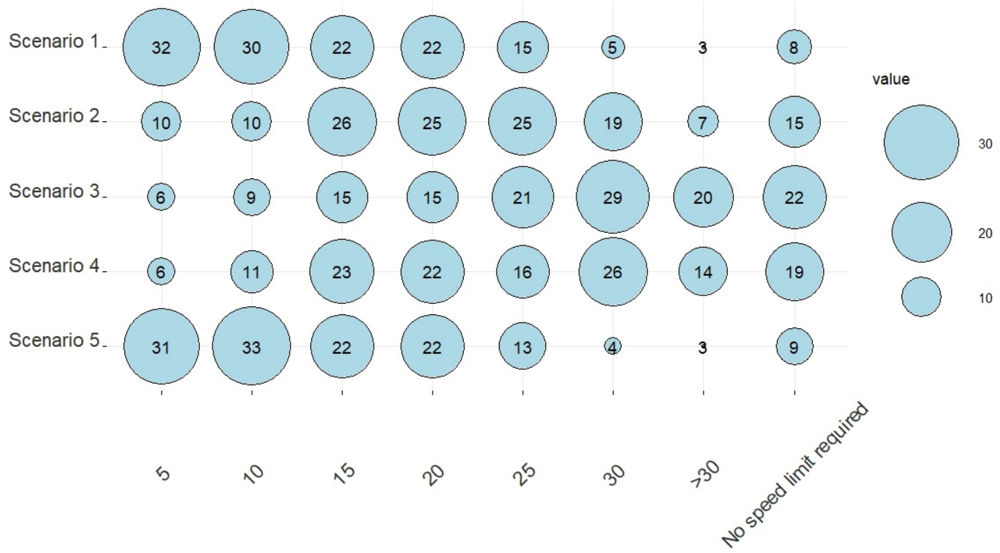

Fig. 11 Preferred speed limits for e-scooters per scenario

To test whether there is a relationship between these pairs, the Chi-square test was used, or alternatively, if the count in any of the cells was below 5, the Fisher's test. For all pairs, the null hypothesis (no relationship) can be rejected ($p < 0.05$) proving that there is a significant relationship between these pairs. In other words, what respondents stated as ideal speed limits for e-scooters on the sidewalk, on a bicycle path and in the traffic lane are consistent with their choices in the scenarios.

5 Discussion and limitations

Our results showed that the infrastructure used by/provided for e-scooters could primarily be some type of cycling facility (lane, path or sharrows). This is consistent with the results of the studies by Zuniga-Garcia et al. (2021), and Huber and Friedrich (2023), who concluded that e-scooter riders prefer bike lanes and that dedicated bike lanes increase the use of e-scooters.

Our results on speed preferences are comparable to other studies (Zuniga-Garcia et al., 2021), with e-scooter speeds expected to be lower on sidewalks and slightly higher on bicycle facilities. We agree with these studies, that preferably high-quality cycling infrastructure is needed to provide safe speeds for and meet the needs of e-scooters (Ringhand et al., 2024).

Our study has some limitations, which can also be considered as potential future research directions. Our study used five scenarios at two locations. The route choice of e-scooters is highly dependent on the type and quality of the infrastructure (Ringhand et al., 2024). Further aspects, such as traffic volume and pavement quality can also influence the behavior of e-scooters.

6 Conclusions

Our study aimed to explore the public perception of e-scooters, evaluating factors such as safety, comfort, and speed limits. A questionnaire survey was used, which, in addition to general questions, presented five different scenarios at two locations, each illustrating different infrastructure solutions for e-scooters. A total of 137 valid responses were analyzed.

Our main conclusion is that for e-scooters, infrastructure with dedicated surfaces for bicycles should be preferred. Respondents indicated that the safest solution for e-scooters would be to use the bicycle facility where it is provided followed by the sidewalk, while using the traffic lane received a low rating. There were significant differences in the perception of safety and comfort by different user groups from the perspective of e-scooters, pedestrians and vehicles across the scenarios. Cyclists were the only group where we found the smallest deviation in safety and comfort ratings across scenarios.

Speed limit preferences for e-scooters depend on infrastructure provision. For sidewalks, the majority of respondents remain at or below 15 km/h. For the different types of bicycle infrastructure the required speed limits are 15 km/h or above, and tend to be slightly higher in the case of traffic lanes.

In conclusion, our study highlights the need for proactive regulations to address the increasing presence of e-scooters on our existing infrastructure.

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