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This is the Accepted Manuscript of the following article published by Spinger, Cham in Lecture Notes in Computer Science [3. July 2021]:

Siebert F.W., Hoffknecht M., Englert F., Edwards T., Useche S.A., Rötting M. (2021) Safety Related Behaviors and Law Adherence of Shared E-Scooter Riders in Germany. In: Krömker H. (eds) HCI in Mobility, Transport, and Automotive Systems. HCII 2021. Lecture Notes in Computer Science, vol 12791. Springer, Cham. https://doi.org/10.1007/978-3-030-78358-7_31

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Safety related behaviors and law adherence of shared e-scooter riders in Germany

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Abstract. Shared e-scooters, whose supply and coverage keeps increasing in many cities around the globe, are rapidly changing mobility in urban road environments. As rising injury rates have been observed alongside this new form of mobility, researchers are investigating potential factors that relate to safe/unsafe e-scooter use. In Germany, e-scooter sharing platforms were only recently permitted in the middle of 2019, and their number has increased steadily since then. The aim of this study was to assess key factors that relate to their safe use, through a direct observation of e-scooters conducted at three observation sites around Berlin. Helmet use, dual use, type of infrastructure use, and travel direction correctness were registered for 777 shared e-scooters during 12.5 hours of observation. Results reveal a high level of rule infractions, with more than one quarter of observed shared e-scooter riders using incorrect infrastructure, and one in ten e-scooter users riding against the direction of traffic. Dual use (i.e., two riders per e-scooter), was observed for 5.1% of shared e-scooters. Moreover, none of the riders observed in this study used a helmet on their shared e-scooter. These results point to a need for better communication and enforcement of existing traffic rules regarding infrastructure use and dual use. Further, they indicate a lack of efficacy of safety-related advice of shared e-scooter providers, who promote helmet use in their smartphone application and directly on their e-scooters.

Keywords: E-scooters, Helmet Use, Law Adherence, Observational Study.

1 Introduction

Electric scooters, or *e-scooters*, are part of a larger micro-mobility wave that has primarily hit urban regions around the world in recent years (Gössling, 2020; Tuncer & Brown, 2020). The scooter rental market has grown rapidly, and today e-scooters from sharing providers can be easily found across many cities of Asia, Australia, Europe, and North and South America. The use of e-scooters by the general public has been facilitated through a number of sharing providers, who have supplied e-scooters in urban environments. These are for-profit companies that, based on convenience strategies (i.e., relatively cheap prices, quick accessibility and reduced travel times) rent out shared e-scooters (or *rental scooters*), which they distribute station less around cities, and which can be activated simply through a smartphone application. After each ride, e-scooters can be parked directly at the destination, where they are then ready for the next customer. In Germany, shared e-scooters have been allowed after the *Elektrokleinstfahrzeuge-Verordnung* (eKFV, engl. ordinance on small electric vehicles) was enacted on June 15, 2019. Only two months later, five sharing providers were active in more than 20 German cities (Agora Verkehrswende, 2019). At that time, the total number of e-scooters in Germany was already around 25,000 (Civity, 2020).

Despite their popularity among urban users, shared e-scooters have received a fair share of criticism in the media. One reason for this is the uncompromising strategy of the sharing providers which are profit driven and have at times introduced e-scooters in cities without first consulting city administrations (Fearnley, 2020). Furthermore, recent studies have found rising numbers of e-scooter related injuries in hospital-based studies, raising further questions about the safety of shared e-scooter use in urban environments (Bekhit, Le Fevre, & Bergin, 2020; Mayhew & Bergin, 2019; Moftakhar et al., 2020; Uluk et al., 2020).

While both national and local authorities have been strict on the regulation of users' behaviors, such as the correct use of infrastructure, they count on the voluntary compliance of shared e-scooter riders for other safety-related behaviors, such as using helmets. In light of the increasing number of shared e-scooter related injuries, and existing differences in terms of regulations, the aim of this study is to assess the safety related behavior of shared e-scooter riders in real traffic situations.

2 Background

Since e-scooters are an emerging form of mobility in Europe, specific laws and regulations concerning their use have just recently been implemented (most of them with little empirical support). Responsibility for the regulation of e-scooter in the European Union is placed with individual member states according to the EU's Type Approval Regulation of January 2016 (Bierbach et al., 2018). Consequently, on June 15, 2019, the eKFV was enacted by the German legislator, which regulates the use of *small electric vehicles* on German roads, which includes e-scooters. For legal participation in road traffic, small electric vehicles and accordingly also e-scooters need a general operating permit, which is issued by the Federal Motor Transport Authority if the technical requirements specified in the eKFV are fulfilled (eKFV §2(1)).

According to the eKFV, no driver's license is required to drive an e-scooter, but the law stipulates a minimum age of 14 years (eKFV §3). The transport of passengers on the scooter, so called *dual use*, is prohibited (eKFV §8). In urban environments, e-scooter riders must use the bicycle infrastructure. If no bicycle infrastructure is available, e-scooter riders are allowed to use the road (eKFV §10(1&2)). Unlike cyclists, e-scooter riders are not allowed to choose freely between a bicycle lane and the road (StVO §(4)). In addition, e-scooters can be assigned additional traffic areas by the road traffic authorities, which are marked with the sign "Elektrokleinstfahrzeuge frei" (engl. “small electric vehicles free”).

There is no requirement to equip e-scooters with a physical turn indicator (eKFV §8 and StVZO §67). Nonetheless, e-scooter riders are required to indicate their turns by using their hands, according to eKFV §11(3). Since small electric vehicles are considered motor vehicles, the general alcohol limit of 0.5 per mill applies, analog to driving a car (StVG §24a). The *0.0 per mill* limit also applies to persons under 21 or during the probationary period after the driving test (StVG §24c). The eKFV applies to vehicles with a maximum speed of 20km/h, hence faster e-scooters are outside of the regulatory focus of the eKFV (eKFV 63 §1(1)).

In addition to the eKFV, some cities have entered into voluntary agreements with e-scooter sharing providers. For example, the agreements of the cities of Hamburg, Munich, and Stuttgart -which share general concepts and wording- define (dynamic) fleet limits, requirements for the installation of e-scooters and an obligation for providers to pick up defective or incorrectly parked e-scooters. Local authorities also design maps with (e.g.) no-parking, no renting, and no driving zones, which are to be enforced by the providers by means of geofencing or visual inspections, among other things. An example of such no-parking zones is shown in Fig. 1 for a temporary change of prohibited e-scooter parking and driving zone during the 2019 Oktoberfest in Munich (Abendzeitung München, 2019). In addition, the providers commit themselves to inform their customers about how the E-Scooters work and to educate them about the main traffic rules. This is usually done via the providers' smartphone applications, as shown in Fig. 2. Finally, the agreements state that a long-term evaluation of the integration of e-scooters in urban traffic will be carried out in cooperation with the providers (Freie und Hansestadt Hamburg, 2019; Landeshauptstadt München, 2019; Landeshauptstadt Stuttgart, 2019).

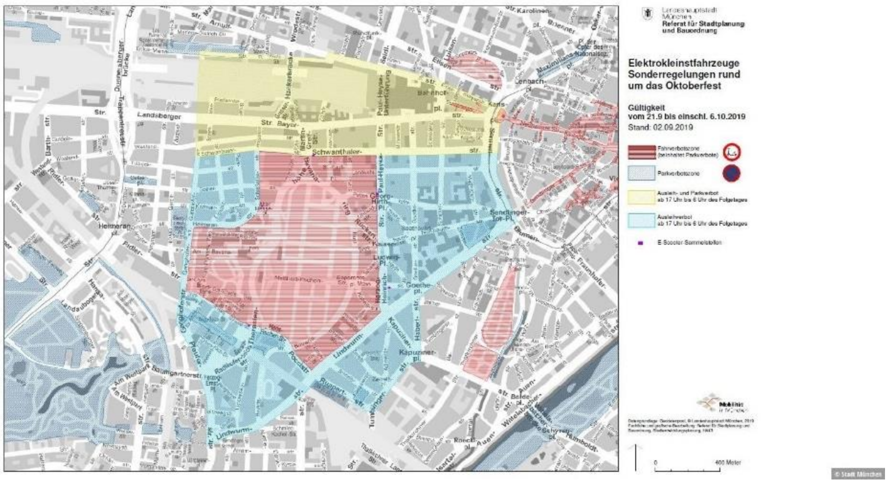

Fig. 1. Visualization of temporary changes to permitted shared e-scooter operating area during the 2019 Oktoberfest in Munich (red areas: no driving allowed; dark blue: no parking; light blue: no renting of e-scooters between 5pm and 6 am; yellow: no renting and parking of e-scooters between 5pm and 6 am).

2.1 Helmet use

A highly relevant passive safety-related behavior of e-scooter riders is helmet use, as helmets can decrease injury severity of riders in case of a crash. Studies have found a high frequency of head injuries among hospitalized e-scooter riders, highlighting the need of riders to use helmets when riding e-scooters (Aizpuru et al., 2019; Trivedi et al., 2019). One of the first studies on general e-scooter helmet use was conducted in Brisbane, Australia, in early 2019 (Haworth & Schramm, 2019). At the time of the study, rental scooters had been available in Brisbane for three months and helmet use was mandatory for private and shared e-scooters. About 800 private and shared e-scooters were observed, registering helmet use among their riders. Helmet use for shared e-scooters was found to be 61%, that is significantly lower if compared to the rate of 95% observed for private e-scooters. The authors concluded that helmet use is related to the type of e-scooter, i.e., if a private of rental/shared e-scooter is used (Haworth & Schramm, 2019). Other studies have found even lower helmet use for shared e-scooters, e.g., between 2% and 10.9% in California, U.S.A. (Arellano & Fang, 2019; Todd, Krauss, Zimmermann, & Dunning, 2019) and 0.4% in Berlin, Germany (Siebert et al., 2020). While helmet use is not mandatory in Germany, e-scooter providers advise for helmet use in their apps and directly with pictograms on e-scooters (Fig. 2 and Fig. 3).

Fig. 2. Screenshots of safety related information found in the Lime smartphone app during the time of this study. Left: “Drive careful! We suggest using a helmet”; Center left: “Use bike lanes, not the sidewalk”; Center right: “Tandem riding is forbidden! Just one person per scooter is allowed”; Right: “Rules and regulation. Please agree to the following rules before you start your Lime ride. Use a helmet. I won’t ride on sidewalks or in pedestrian zones. Just one person per scooter. I am sober. […]”. Button text: “I agree”.

2.2 Dual Use

Dual use, i.e., the simultaneous use of an e-scooter by two people, has been an early focus of observational studies on e-scooters use, as it can obstruct access to the foot brake on the rear-wheel of some e-scooter models, and decrease stability and maneuverability of the scooter. In Germany, eKFV §8 explicitly prohibits transporting other passengers. In Brisbane, Australia, Haworth and Schramm (2019) registered dual use in 2% of all shared e-scooters observed. In California, USA, Todd et al. (2019) registered dual use in 1.8% of observations, while in Berlin, Germany, Siebert et al. (2020) registered 3.1% of dual use. The explicit ban on dual use is generally mentioned in shared e-scooter apps (Fig. 2), as well as directly on the scooters themselves (Fig. 3).

Fig. 3. Driving instructions on a Jump e-scooter. “Minimum age 18+”; “Wearing a helmet is safer”; “1 person per scooter”; “Don’t ride on the sidewalk”; “Follow all traffic rules”; “Only park in areas designated in the smartphone app”.

2.3 Infrastructure Use

While most countries have different rules on permitted infrastructure use for e-scooters, and differ in regulation on allowed directions of traffic, illegal infrastructure use has been observed among e-scooter riders of various countries. In Brisbane, Australia, 6.9% of e-scooters were observed to use prohibited infrastructure (i.e., driving on the road instead of the footpath; Haworth & Schramm, 2019). In California, USA, 6.7% of riders were observed to drive in the opposite direction of traffic, a finding similar to a video-based observation study in Berlin, Germany, where 5.5% of e-scooters were observed to drive opposite the direction of traffic (Siebert, Ringhand, Englert, Hoffknecht, Edwards, Rötting, under review). In Germany, e-scooters riders generally need to adhere to right-hand side traffic unless a specific exemption is made. As stated before, riders also must use the bicycle infrastructure, and can only use the road if no bicycle infrastructure is available. Also, information on the regulations on infrastructure use is presented in the e-scooter smartphone app (Fig. 2), as well as directly on the e-scooter (Fig. 3).

2.4 Study Aim

In light of existing regulation and multiple advisory instructions in e-scooter smartphone apps and directly on shared e-scooters, the goal of this study was to assess actual behavior of shared e-scooter riders in urban environments concerning four safety-related behaviors: helmet use, dual use, type of infrastructure use, and direction of travel.

3 Methods

In order to register e-scooter riders’ behavior in traffic, a direct observation was conducted at three observation sites in Berlin, Germany between September and October 2019. In line with earlier studies and existing regulation for shared e-scooter use, five parameters were observed: (1) e-scooter provider, (2) infrastructure used [bicycle lane/sidewalk/road], (3) direction of travel [correct/incorrect], (4) helmet use [yes/no], and (5) dual use [yes/no].

3.1 Selection of Observation Sites

Observation sites were selected with two variables in mind, frequency of shared e-scooter use at individual sites, and distance between different observation spots. At the time of this study, six providers offered shared e-scooters in Berlin: Bird, Circ, Jump, Lime, Tier, and Voi. Through geofencing, all providers limited the operational area of e-scooters to the (large) urban center of Berlin, only differing slightly in operational area boundaries. Within providers' operational areas, main points of e-scooter use were identified around transportation hubs of subway/urban railway stations, tourist attractions, and main shopping streets.

Three sites with high inter-site distance were selected, in order to facilitate a broad data collection of Berlin e-scooter riders, and to ensure that different e-scooters riders would be observed at the different sites (Fig. 4). The first observation site (Observation Site 1 in Fig. 4) was selected in the west of Berlin at the *Kurfürstendamm*, a main shopping street adjacent to a main transportation hub for interurban and interregional trains (*Bahnhof Zoologischer Garten*). Available infrastructure at Observation Site 1 consisted of a sidewalk and the street, according to the eKFV, e-scooter riders must use the street at this site.

The second observation site (Observation Site 2 in Fig. 4) was selected in central Berlin (*Potsdamer Platz*), at a main public square with multiple public transport connections. Available infrastructure at Observation Site 2 consisted of a sidewalk, a bicycle path, and a multi-lane road. According to the eKFV, e-scooter riders must use the available bicycle path at this site.

The third observation site (Observation Site 3 in Fig. 4) was selected in the eastern part of Berlin, it is a smaller transport hub with adjacent shopping streets. Available infrastructure at Observation Site 3 consisted of a sidewalk and a multi-lane road, hence e-scooter users must use the road at this location according to the eKFV. At all three observation sites, shared e-scooter traffic was observed from the roadside, between September 21, 2019 and October 23, 2019. Traffic was observed on ten afternoons for a total of 12.5 hours. The total observation time at the individual observation locations was 5 hours and 35 minutes (four observations) at Observation Site 1, 4 hours and 55 minutes (five observations) at Observation Site 2, and 2 hours (one observation) at Observation Site 3. The exact positions of the observation sites are shown in Fig. 4. Observation variables were collected on notepads and transferred to an Excel table after each observation. Only *shared* e-scooters were registered; therefore, data on private e-scooters was not collected.

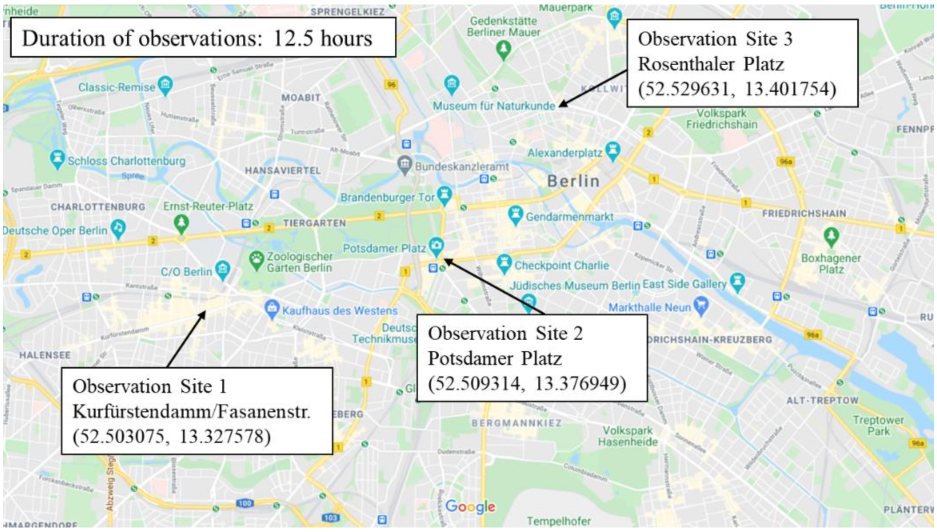

Fig. 4. Distribution of observation sites within Berlin (street names and latitudinal and longitudinal coordinates).

4 Results

A total of 777 shared e-scooters were observed during this study. Of these, *n*=20 were *Bird* scooters, *n*=25 were *Circ* scooters, *n*=51 were *Jump* scooters, *n*=446 were *Lime* scooters, *n*=150 were *Tier* scooters, and *n*=82 were *Voi* scooters. For *n*=3 scooters, the provider was not clearly recognized. Hence, the large majority of shared e-scooters at the three observation sites consisted of *Lime* e-scooters (57.6% of identified scooters). Data for helmet use, type of infrastructure, direction of travel, as well as dual use is presented in Table 1.

Table 1. Observed e-scooter rider behavior at the three observation sites.

Variable		Observation Site 1	Observation Site 2	Observation Site 3
# E-scooters observed		270	405	102
Helmet use	Yes	0% (*n*=0)	0% (*n*=0)	0% (*n*=0)
	No	100% (*n*=270)	100% (*n*=404)	100% (*n*=102)
Dual use	Yes	5.2% (*n*=14)	5.2% (n=21)	4.9% (n=5)
	No	94.8% (*n*=256)	94.8% (*n*=384)	95.1% (*n*=97)
Infrastructure use	Correct	68.1% (*n*=184)	78.0% (*n*=316)	55.9% (*n*=57)
	Incorrect	31.9% (*n*=86)	22.0% (*n*=89)	44.1% (*n*=45)
Direction of travel	Correct	90.7% (*n*=245)	82.7% (*n*=335)	93.1% (*n*=95)
	Incorrect	9.3% (*n*=25)	17.3% (*n*=70)	6.9% (*n*=7)

Overall helmet use of shared e-scooter riders was observed to be 0%, i.e., not a single observed rider at any of the three observation sites used a helmet. Overall dual use was observed to be 5.1% (*n*=40) varying only slightly between observation sites (4.9-5.2%). Overall, shared e-scooter riders used prohibited infrastructure in 28.3% (*n*=220) of all observations, with relatively large variations between different observation sites, ranging from 22.0% to 44.1%. The observation of direction of travel revealed opposite direction (wrong-way) driving for 13.1% (*n*=102) of riders, with relatively large variation between sites (6.9-17.3%).

5 Discussion

With this study we have conducted one of the first in-traffic observational data collections on shared e-scooter use in Germany. While the study was exploratory in nature, a number of important results related to rule adherence and safety-related behavior of shared e-scooter riders were found. These results mainly indicate a lack of rule compliance observed among a relatively large proportion of riders, underlining the inefficacy of shared e-scooter providers' safety-related information approaches commonly facilitated through their smartphone applications and on-board driving hints available on their e-scooters.

For adherence to the prevailing legal regulation for e-scooters in Germany, we found that a relatively large percentage of shared e-scooters riders violate existing road rules for infrastructure use that, apart from not being exclusive for e-scooters, are of wide knowledge among different road users (Johnson et al., 2010 and 2014). Close to one third of riders use a shared e-scooter on prohibited infrastructure. Similarly, more than one in ten shared e-scooters was observed to be ridden in the wrong direction. Both of these illegal behaviors were found to vary between observation sites, indicating a need to further investigate factors that relate to this kind of illegal infrastructure use by shared e-scooter riders. The share of incorrect road infrastructure use and wrong direction of travel found in this study is considerably higher than what other studies had found on illegal infrastructure use (Haworth & Schramm, 2019; Siebert, Ringhand, Englert, Hoffknecht, Edwards, Rötting, under review). Illegal dual use was observed for 5.1% of riders, a higher share compared to other observational studies on shared e-scooter dual use (Haworth & Schramm, 2019; Siebert et al., 2020; Todd et al., 2019).

As for helmet use, we did not observe a single shared e-scooter user wearing a helmet during the 12.5 hours of observation in Berlin. This finding of 0% helmet use, shared with other previous studies addressing e-scooter riders' safety in Germany (Störmann et al., 2020) is critically smaller than findings from other countries (Arellano & Fang, 2019; Haworth, Schramm, & Twisk, 2021; Todd et al., 2019). The non-use of helmets by shared e-scooter users in Germany is especially alarming in light of findings of frequent head injuries of hospitalized e-scooter riders (Aizpuru et al., 2019; Trivedi et al., 2019).

For all observed behaviors that impede riders safety, i.e. lack of helmet use, dual use of e-scooters, and incorrect infrastructure use, e-scooter providers include advisory warnings in their smartphone applications (Fig. 2), as well as directly on the e-scooters (Fig. 3). For advisory warnings, shared e-scooter user must explicitly agree that they will adhere to the stipulated rules regarding regulations and road safety. Nonetheless, our observational data indicates that a considerable share of riders disregards these advisory warnings and uses shared e-scooters against prevailing road traffic laws. Regulators as well as shared e-scooter providers are tasked with developing effective strategies and measures to counter these rider behaviors which are detrimental to riders' wellbeing.

This study has a number of limitations. While the sample size for observed shared e-scooter riders is sufficient for a first exploratory analysis of safety-related behavior, data collection was limited to one city that, although registering the highest number of daily e-scooter trips in Europe (Civity, 2020), may differ from other German cities' dynamics and behavioral trends. Hence, future studies should collect data in multiple cities, to be able to detect potential regional effects on safety-related behavior of shared e-scooter riders. Our results of high variations in incorrect infrastructure use between different observation sites point to a need to better understand factors in the road environment which potentially relate to safety critical behavior of e-scooter riders.

In conclusion, this observational study found a critically high share of illegal behavior of shared e-scooter riders in Berlin, which can be detrimental to riders' safety. These findings can be used to develop targeted strategies and measures to increase riders' law-abiding behavior.

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