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Review

Survey on e-Powered Micro Personal Mobility Vehicles: Exploring Current Issues towards Future Developments

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Abstract: Nowadays, the diffusion of electric-powered micro Personal Mobility Vehicles (e-PMVs) worldwide—i.e., e-bikes, e-scooters, and self-balancing vehicles—has disrupted the urban transport sector. Furthermore, this topic has captured many scholars and practitioners' interest due to multiple issues related to their use. Over the past five years, there has been strong growth in the publication of e-PMV studies. This paper reviews the existing literature by identifying several issues on the impact that e-PMVs produce from different perspectives. More precisely, by using the PRIMA's methodological approach and well-known scientific repositories (i.e., Scopus, Web of Science, and Google Scholar), 90 studies between 2014 and 2020 were retrieved and analyzed. An overview and classification into endogenous issues (e.g., impact on transport and urban planning) and exogenous issues (e.g., impact on safety and the environment) are provided. While several issues are deeply investigated, the findings suggest that some others need many improvements. Therefore, the status quo of these studies is being assessed to support possible future developments.

Keywords: micromobility; electric scooter; e-scooter; personal mobility vehicle; personal transporter; segway; micromobility problems

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1. Introduction

Nowadays, the increasing use of private transport has had multiple effects on the urban space (for parking lots, streets) and its livability, thus presenting the account of its unsustainability [1]. Moving and parked cars occupy valuable urban spaces useful for citizens. Therefore, traffic on the roads should be adapted to the existing urban road space with the help of public transport. Indeed, several guidelines have been developed and promoted by the European Union to encourage public transport [2,3]. The unsustainability of urban transport is also affected by urban freight transport. Although urban freight transport is essential to meet citizens' needs, it has led to greater concern for the global and local environment (e.g., air pollution, noise, and vibrations) and safety and security issues [4,5]. Thus, poor air quality, traffic congestion, and the growth of road crashes push towards the rising need for alternative urban mobility solutions. Hence, academics, mobility experts, and urban planners are trying to rethink people's transport mode selections by investigating less energy-intensive modes such as walking and the use of micromobility devices [6]. Although much has been written about pedestrian mobility (definitions, methods, etc.), micromobility is a recent topic, and a common accepted definition misses from the literature. In the United States, micromobility refers to vehicles with a mass of no more than 350 kg and a design speed of no more than 45 km/h. In Europe, there is no univocal definition of the term, but the European Union regulation No. 168/2013 has established the L-category vehicles as a reference for the member countries. L-category vehicles are two-, three- and four-wheeled motor vehicles. The category uses power, power source, speed, length, width, and height as classification criteria [7]. Generally speaking, micromobility refers to electric-powered micro Personal Mobility Vehicles (e-PMVs). These devices include general electric scooters (or e-scooters), e-bikes, and self-balancing vehicles (in this paper, e-PMVs include only electric scooters as the e-kick scooter, Segway, hoverboard, and monowheel. Therefore, micro vehicles that can be driven standing). In the e-scooter category, the e-kick scooter is one of the most popular due to its ease of use and handling. Segway is a two-wheeled electric device that exploits the presence of the handlebar to facilitate correct posture, balance, and safe driving. Hoverboard and monowheel are one-wheeled self-balancing vehicles and exploit the weight sensors by tilting the body forward to start and backwards to brake; hence, they require the right balance and much practice to be used.

The e-PMVs are gaining popularity as an environmentally friendly transport mode in urban contexts, and their use results in several benefits. Indeed, switching towards e-PMVs may increase community relationship, possible reduction of traffic congestion (for short trips) and emission levels, and improvement of the air quality. Moreover, they can be used privately or docked- or dockless-shared. A docked device has a specific location where it can be picked up and released, while a dockless device has no fixed home location and is dropped and picked up anywhere. Finally, the e-PMVs market is expected to grow at least until the year 2024 at a compound annual growth rate of 7.0% [8].

The diffusion of e-PMVs in the United States since 2017 and in several European metropolises (e.g., Barcelona, Milan, and Paris) since 2018 has raised several issues related to transport and urban planning, safety, and environment that disrupted the urban transport field and captured the attention of many scholars and practitioners. Therefore, several questions should be answered.

On the one hand, since the e-PMVs could provide an alternative transport solution, what is the trip pattern they follow (i.e., where, when, why, how they are adopted)? What quota of trips can they satisfy? Who are the users and the reasons that lead to their use? For instance, users prone to use e-PMVs devices praise their ability to provide a comfortable and fast trip, but above all their ability to make travel joyful: freedom and driving control, combining the pleasure of walking with the excitement of cycling and the comfort of skateboarding [9]. Moreover, what is the user's behavior while driving and/or parking e-PMVs? These devices can be admitted in public spaces like roads, squares, and parks. Therefore, what is the impact of them on e.g., shared infrastructures? To what extent are these new vehicles accepted by other users? How can their circulation be regulated? For instance, before enabling e-PMVs to circulate on shared infrastructures, it would be useful to assess the impact of these new vehicles on public spaces and on other road users.

On the other hand, the e-PMVs are small and light vehicles (foldable and manageable). This implies that they may conflict with other road users while on the move, hindering their transit, causing serious crashes. Therefore, road safety must be considered when introducing new vehicles. Evidence from the USA shows that crashes with e-PMVs cause more injuries than all other devices because users have to stand while driving, they move at relatively high speed (if compared to walking speed) and because no driving license or experience is required for their use [10]. Therefore, what are the effects of the crashes? What are the consequences when pedestrian and e-PMVs conflict? What are the behaviors of safe driving? For instance, it would be important to understand the psychophysical conditions of drivers and their impact when conflicts with other road users occur (especially pedestrians). Finally, e-PMVs are defined as sustainable transport because they have zero emissions. However, if the entire life cycle is considered, can they be still defined as sustainable? For instance, unfavorable users to e-PMVs question sustainability [9].

By scrutinizing existing literature, this paper aims to answer all these questions to provide an overview and classification of current knowledge on e-PMVs and suggests a possible research agenda. Despite the emerging interest in the research of e-PMVs, to the best of our knowledge, there are no detailed surveys investigating all the previous questions. O'Hern & Estgfaeller [11] provided a scientometric review to synthesize, sort rapidly, and analyze bibliographic data and display micromobility knowledge. However, the issues encountered with the introduction of e-PMVs regarding transport, urban planning, road safety, and environment were not investigated in detail. Moreover, they refer to micromobility as intended in the USA, whereas this paper focuses on e-PMVs according to the European definition. Therefore, this survey was carried out to be useful to public administrations and vehicle providers, in addition to the academia.

The remaining paper is organized as follows. Section 2 shows the methodology used, including the search strategy and type of analysis. Section 3 presents relevant descriptive statistics and introduces the issues investigated. Section 4 briefly analyzes the 90 publications deemed suitable. Section 5 provides insights for some future research developments. Section 6 concludes this survey.

2. Methodology

This paper follows the methodological approach proposed by Cooper [12] and Moher et al. [13] and applied in Barabino et al. [14]. It is organized into five stages:

1. Formulation of problem and research questions (see Section 1).
2. Definition of a data search strategy, including multiple channels to avoid biases in coverage.
3. Keywords evaluation and selection of retrieved data, including the selection criteria of suitable data.
4. Analysis and interpretation of the literature, including statistics about sources, number of retrievals and literature finally reviewed (see Section 3).
5. Results with a brief comment on each paper (see Section 4).

A computerized search strategy was adopted for the sake of fastness and efficiency. Scopus and Web-of-Science have been used as they are the largest abstracts and citations database of literature. Since these databases cannot contain all references, a separate search on Google Scholar was performed. It is a freely accessible web search engine that indexes the full text or metadata of scholarly literature across various publishing formats and disciplines. Despite providing a wealth of information, a free web search is disregarded due to the abundance of non-scientific information. Other papers have been retrieved using the references cited in the literature already studied (i.e., ancestry approach) and informal contacts.

The search included studies from 2014 to July 2020. The original review was updated due to the publication of recent papers. The same search and selection strategy was applied for the months of August 2020 to December 2020. The publications retrieved for these years are listed in Appendix A, but these papers were not reviewed. The choice to examine articles starting in 2014 was made because research on e-PMVs was not common before.

The papers search is based on the title, abstract and keywords. Several search terms are adopted, like combinations of keywords to cover different idioms of e-PMVs. Studies on “Micromobility”, “Electric Scooter”, “E-scooter”, “Personal Mobility Vehicle”, “Personal transporter”, and “Segway” were selected. The selection criteria of these keywords are as follows. “Micromobility” represents the category of e-PMVs to cover short distances in the European context. “Electric scooter” and its abbreviation “E-scooter” are the terms with which these vehicles are generally referred. Other related terms are “Personal Mobility Vehicle” or “Personal Transporter”. “Segway” is chosen because it defines a specific category of e-PMVs. The search was also carried out for the other types of e-PMVs, i.e., “hoverboards” and “monowheels” (the search for hoverboards only has produced studies referring to pediatric crashes because they are mainly used by children as toys. Therefore, these studies were excluded. In addition, the search for monowheels did not produce results). Unlike Scopus and Web-of-Science, Google Scholar allowed a search based on the title and along with the text. Due to the abundance of papers retrieved searching in the text, the only search criteria used in Google Scholar was the title.

The analysis and interpretation of the literature on e-PMVs may differ by country or area. Therefore, the “country of affiliation” (the workplace of scientists, not their nationality) and “country in which research is applied” are the geographical indicators retrieved from the analyzed literature. Conversely, "the number of scientists involved per country" and "the number of publications per year" quantified the impact of research.

Finally, the current knowledge base was assessed by analyzing the main issues to provide some possible contents of a research agenda.

3. Results

3.1. General Statistics about the Survey

According to PRISMA's statement [13], Figure 1 shows that 1486 papers were identified by database searching. Preliminary results showed two main categories in which the research on e-PMVs can be divided. The first focused on their mechanics and their components. The second category focused on the impacts e-PMVs have on transport, urban planning, road safety, and the environment. The review considers only studies of the last category because they are closer to the research field of practitioners and academic experts in mobility and urban planning. Consequently, 1127 articles were sooner removed after screening the title and 359 remains. An additional 278 papers were collected from an ancestry approach and informal contacts. After the removal of duplicates, 276 papers were included. Next, 175 papers were excluded after the screening of the abstract, as they were not directly focused on the impact of e-PMVs on urban planning and transportation (67), were not written in a language understood by the authors—i.e., Finnish and Chinese—(13), were not available for consultation (42), and were retrieved from commercial magazines, technical reports, and press releases that miss of the research background (53). Finally, only English publications in journal articles and conference papers were retrieved. Therefore, 101 papers were evaluated in the full text, and 11 were excluded since they discuss different topics from those chosen. Finally, 90 publications were reviewed: 69 in journals, 18 in conferences' papers, 1 meeting abstract, 1 position paper, and 1 report summary. The most frequent journals were Journal of Transport Geography, Sustainability and Transportation Research Part D (3 times). Recurrent journals were also Accident Analysis & Prevention, EMA—Emergency Medicine Australasia, Journal of Cleaner Production, Singapore medical journal, and Transport Findings and Transportation Research Record with two publications, respectively. These different outlets showed the fragmentation of the journals addressing e-PMVs for a varied audience.

We retrieved 47 unique studies from Scopus, 8 from Web of Science, 19 from Google Scholar, 14 by the ancestry approach, and 2 informal contacts.

Figure 2 clearly shows that micromobility is an emerging research area over the last years. From 2016 to 2019, the number of publications quintupled, and it was still growing in 2020.

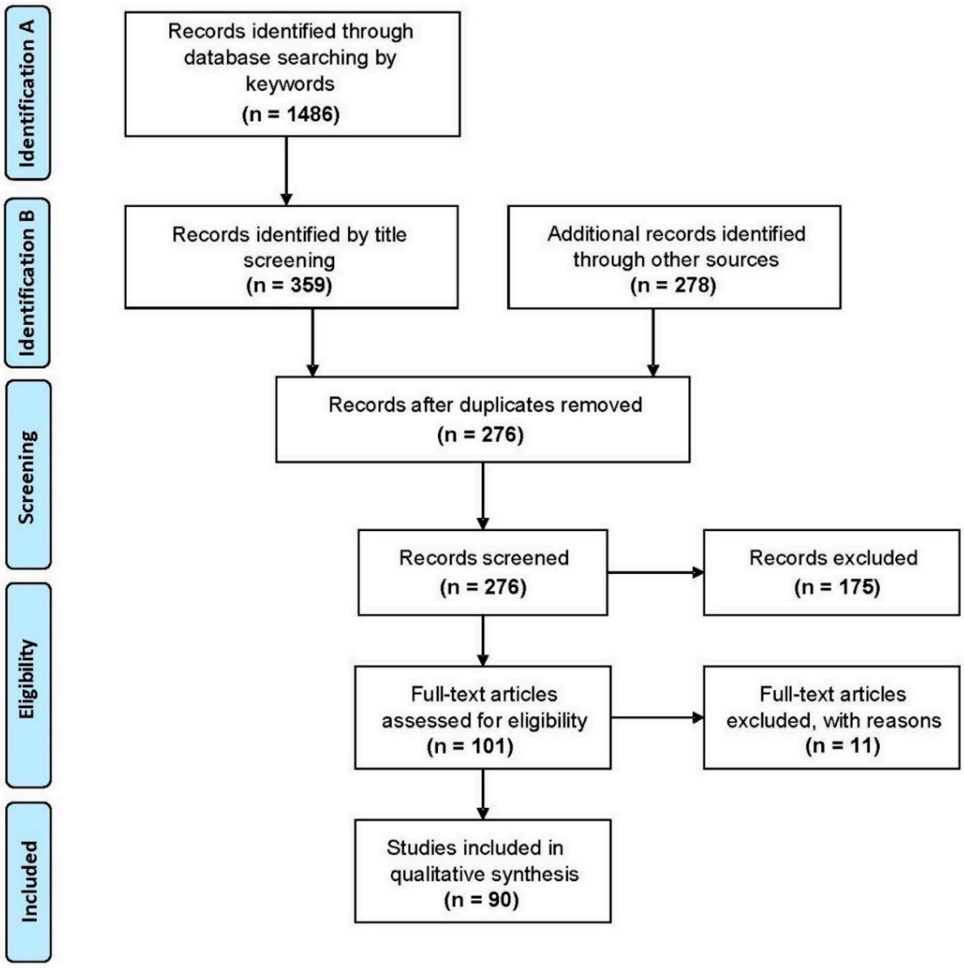

Figure 1. Flow diagram to identify the papers reviewed according to PRISMA's statement.

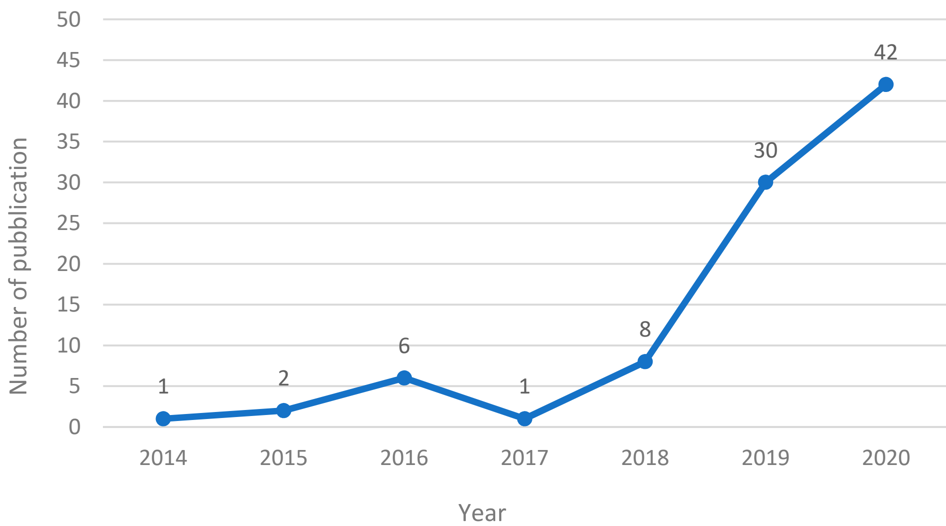

Figure 2. Number of publications reviewed per year: period 2014–July 2020.

Table 1 reveals the geographical distribution of the publications reviewed. The first column reports the name of the continent (in bold) and the related countries.

Table 1. Geographical distribution of the publications reviewed.

Country [a]	Number of Researchers Involved [b]	Number of Publications [c]	Country to Which Research Applies [d]
Asia	**67**	**20**	**13**
China	7	2	1
Japan	20	5	3
Korea	5	1	1
Saudi Arabia	1	1	-
Singapore	21	5	5
Taiwan	12	5	3
Vietnam	1	1	-
Europe	**73**	**26**	**28**
Austria	9	3	5
Belgium	6	1	1
Denmark	4	1	3
Finland	3	1	1
France	2	2	4
Germany	26	5	6
Greece	1	1	-
Italy	4	1	2
Lithuania	2	1	-
Norway	2	2	1
Russia	1	1	-
Spain	3	1	1
Sweden	2	2	1
Switzerland	3	1	2
UK	5	3	-
Not specified	-	-	1
North America	**175**	**45**	**67**
Canada	14	7	2
USA	161	38	65
Oceania	**25**	**8**	**12**
Australia	10	3	3
New Zealand	15	5	9
Not specified	**1**	**1**	**12**
Total	**341**	**100**	**132**

- No data are reported for the considered column. [a.] The authors are aware that the identified literature is not exhaustive of all the documents on e-PMVs, but it is driven by applying the previous search strategy. Additionally, some retrieved technical reports and press releases were excluded because the research background had been lacking. For instance, some reports can be available in other countries, but they were omitted according to our classification criteria. [b] Based on affiliation, not on the nationality of the researchers. Authors who wrote more than one paper are counted once. [c] >90 publications reviewed because some articles are written by authors from different countries. [d] Some studies refer to many countries. If some studies refer to the same country, it was considered as a separate study.

The second column shows that the research was carried out by 51% of researchers in North America, 21% in Europe, 20% in Asia, and 8% in Oceania. In the third column, the number of publications shows that North America, Europe, and Asia Europe provided 45%, 26%, and 20% publications, respectively. Other continents such as Africa, South America, and Oceania are barely or not at all covered by the literature we reviewed.

The last column reports the number of studies considering the country in which the research was conducted. The distribution of studies is as follow: North America 51%, Europe 21%, Asia 10%, and Oceania 9%. Another 10% is related to countries not specified.

3.2. e-PMVs Research Issues

The literature can be classified according to problems, methods, issues, etc. This paper presents a classification based on some research issues without neglecting the interrelationships between them. These issues may be clustered according to two lines of research, based on the different impacts of e-PMVs over the urban context: (1) endogenous issues concerning the impact on transport and urban planning, and (2) exogenous issues with respect to the indirect impact on road safety and the environment. The endogenous issues refer to problems strictly related to the use of e-PMVs in the public space, while the exogenous issues refer to the external effects of their use, therefore the impact on users' road safety and on the environment.

This classification is motivated by the following reasons.

First, the introduction of e-PMVs on a consolidated transportation system requires revisiting some "traditional" patterns related to transport and urban planning that may not be applicable to the new mode. The literature is studying the main pattens to understand where and when these vehicles are used, what transport system they replace, and users' type who use them the most. In addition, the movement of these vehicles in public spaces creates conflicts with other road users. Therefore, studies are looking at how the city regulates and organizes public space and how drivers behave while parking and using e-PMVs.

Second, e-PMVs may be subject to serious crash risks, owing to the small size and lightness. The consequences of crashes with these vehicles are often far more severe than other road crashes. Therefore, a growing literature is investigating the road safety conditions associated with the use of these devices. It includes studies on the effects of crashes for the user her/himself, the consequences of other vulnerable road users involved (e.g., pedestrians and cyclists), and some facets related to safe driving. Moreover, e-PMVs are believed to be a sustainable alternative to using cars for short trips. Therefore, other literature is investigating the environmental impact associated with its use.

The classification is structured as shown in Figure 3. In particular, the division of endogenous and exogenous problems is shown and, subsequently, the problems outlined. Furthermore, in Figure 3 the reference paragraph and the main topics addressed in this survey have been indicated.

This survey shows that the research is not evenly distributed between North America and Europe. Research objectives change in different countries due to the (differentiated time) development of e-PMVs. North America dominates the area in terms of road safety and urban and transport impact, while Europe dominates environmental impact. It should be noted that the greater attention of Europe to such impacts compared to North America could be explained by the implementation of major environmental policies [15]. Finally, in Asia and Oceania, there is a balanced distribution of studies on road safety and planning.

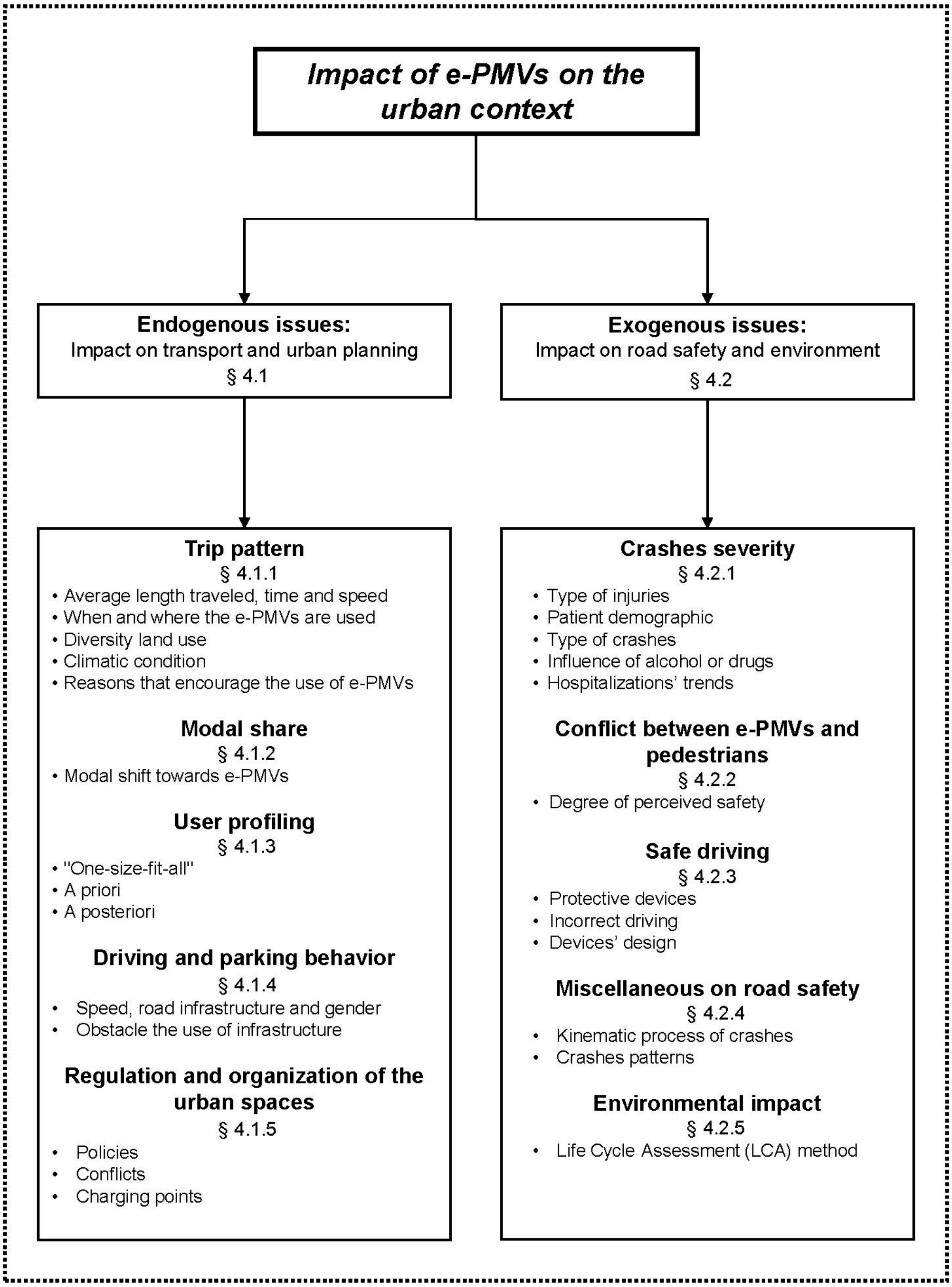

Figure 3. Structure flow chart.

4. Current Knowledge Base

This section presents the two lines of research as retrieved from the literature. All studies are summarized by tables, including the type of study, sample size, data sources, the period covered, analytical tool, and relevant insights. For instance, the sample size could help understand the impact of the study from a practical perspective, and the relevant insights help to understand the peculiarities of each study.

The types of study are distinguished among qualitative, quantitative, descriptive, and theoretical. Qualitative studies analyze the behavior and motivations behind the use of e-PMVs. Instead, quantitative ones are based on descriptive and statistics models and examine various data on e-PMVs. Descriptive ones discuss general information on how to address the impact of e-PMVs. Theoretical studies formulate models without experimentation in real case studies.

Data sources are very similar and usually include automatic data and surveys. Automatic data can be not specified, collected via the Application Programming Interface (API), smartphone or smartwatch applications, and weight sensors. Surveys usually concern questionnaires and/or personal interviews with providers and users. Finally, reference is made to on-site observations, with manual data collection, for observations without further specifications.

Analytical tools for qualitative studies include synthesized and encoded textual interviews, travel diaries, and survey. In quantitative studies, descriptive models (simple percentages, cluster analyzes, etc.), inferential models (linear regressions, structural equation models, etc.) and optimization methods are used. Descriptive studies adopt a qualitative description, while theoretical studies present different types of models.

Finally, the main findings of each study are briefly discussed.

4.1. Endogenous Issues: Impact on Transport and Urban Planning

Forty-four articles address the impact of e-PMVs on transport and urban planning. Real data and observations guide them to understand where, when, and how these devices are adopted (trip pattern). They also examine the motivations that lead users to use these new devices, the modal shift generated introducing e-PMVs, and attempting to profile users by several methods. Finally, some studies analyze the user's driving and parking behavior with these devices and the facets of the regulation and design of urban public spaces needed to accommodate e-PMVs.

4.1.1. Trip Pattern

Many studies investigated the trip patterns of the e-PMVs (Table 2). They largely showed the main characteristics of a trip in terms of average length traveled, time, and speed of the journey. Moreover, they reported where and when e-PMVs were used, including the diversity of land use, and the climatic conditions of the city. Finally, the main reasons that encourage their use were also reported.

Key findings concern trip characteristic of PMVs, which seem especially useful for short trips. Indeed, almost of studies showed that the average trips length is from 1.2 km to 2.7 km, the average time is from 10 min to 16 min, and the average speed is from 7 km/h to 10 km/h [16,21,24–26,33,36]. The speed differences might depend on the purposes of the trips. For instance, Almannaa et al. [16] and Hardt & Bogenberger [21] showed that users tend to drive at a lower average speed for recreational purposes, such as shopping or leisure, than for commuting or errands. Moreover, they travel at a slower speed than e-bikes. Hardt & Bogenberg [22] enforced the 2017 results in highlighting the advantages and disadvantages of using e-PMVs. The charging infrastructure and parking are the most obvious advantages, while the weather conditions, luggage restrictions, and road safety are disadvantages. Although it is claimed that they are mainly used for short trips, Markvica, Schwieger & Aleksa [26] argued that it is not clear whether these also cover first/last mile distances. Indeed, they show that e-PMVs could be a good solution, but it is necessary to focus on the user group of individual motorized transport.

Several studies investigated where and when e-PMVs were adopted. These studies agree that e-PMVs are mainly used near the city center (downtown, close to universities and/or university campuses), where there is greater access to multimodal transit (e.g., bus or metro) and greater land-use diversity. In addition, travel to/from bus stops or parking lots is also studied as a last-mile journey. The use is likely to begin and end in residential, commercial, and industrial areas [18,20], and e-kick scooters are the favorite devices [17,18,24]. Furthermore, Hawa et al. [23] pointed out that e-kick scooters are very often available near bike paths, while Jiao & Bai [24] noticed that the further away users are from these places, the less likely they are to travel by e-kick scooter. Contrasting results were also obtained looking at the day of the use of e-PMVs. Caspi, Smart & Noland [18] showed that they are used more on weekends and holidays, whereas Hawa et al. [23] on weekdays and during the afternoons and the evening [20,27,29,34,36]. Bai & Jiao [17] found these differences by comparing Austin's and Minneapolis's cities in the USA: in Austin, e-PMVs are used more on weekends, while in Minneapolis during the week. Mathew et al. [27] and Zou et al. [36] showed that e-kick scooter trips are mostly concentrated during the central daytime hours, followed by the evening rush hours. Specifically, between 4 pm and 9 pm during the week and between 2 pm and 7 pm on weekends.

The tendency to use e-PMVs most during the afternoon and evening may also depend on the climatic conditions of the city. Mathew, Liu & Bullock [28] showed how meteorological variables (i.e., amount of precipitation, snowfall, wind speed, visibility, and average temperatures) significantly affected the number of trips per hour (30%–80% in winter months). A quite similar result is pointed out by Noland [33] and Hardt & Bogenberger [21]; the latter also added the scarce use of clothing suitable for the climate. Hawa et al. [23] showed an association with the daily temperature: e-PMVs are used more in the afternoon (because the temperature is high) and during humid days, while during rainy days their use decreases. Finally, the temperature also affects the trip length performed by e-PMVs: higher average temperatures increase it, rain and snow reduce it, while stronger winds slightly reduce it [33].

A crucial issue of the trip pattern is to investigate the main reasons for using these devices. Tuncer & Brown [35] reported the feeling of freedom and fun while using them. In addition, the reduction in trip time is another key motivation in situations of need; therefore, they can be an alternative to public transport. The lack of human effort required to drive an electric scooter makes it a preferable and viable transport vehicle over a bicycle or skateboard. Moreover, e-PMVs are foldable and easily transportable and can be stored indoors to protect them from theft or vandalism. These results suggest that they may be adopted for both work and leisure trips [16,20,21,25,30]. Espinoza et al. [20] added that e-PMVs are used for business-to-business trips, business trips to/from parking, and for reaching bars or restaurants. Nevertheless, some studies show that among the various soft transport system available (e-PMVs, docked or dockless bikes and e-bikes), e-PMVs are mainly used for leisure and non-commuter travel. The large mid-day e-PMV travel concentration observed over the weekend supports this fact [30,34,36]. Unlike other studies Davies, Blazejewski, & Sherriff [19] showed how e-PMVs are useful for tourist tours, as they help to make tourist places less congested, more sustainable, and more desirable.

For trips to/from work or commuting, bike-sharing and e-bike sharing systems are preferred [30,34]. According to Reck et al. [34] devices' choice depended on trip-distance: dockless e-kick scooters for very short trips, docked bikes for medium trips on flat ground or downhill, and e-bikes for longer uphill trips. However, Zou et al. [36] found that high-traffic roads are the most popular facilities for shared e-kick scooters because they have cycle paths. McKenzie [31] pointed out that e-PMVs services offer faster journeys during peak hours, while in central areas of the city, the times are almost like ride-hailing services. Finally, Nocerino et al. [32] showed that e-kick scooters are effective for letter and small package deliveries, not bulky boxes.

4.1.2. Modal Share

Most studies agree that e-PMVs cover short distances (i.e., within 5 km) and help reach other stops and/or stations. Nevertheless, a controversial issue is what transport modes they are replacing.

Table 3 summarizes a few studies concerning the modal shift towards e-PMVs.

Table 2. Trip pattern studies with e-PMVs.

Authors (Year)	Location, City	Type of Study	Data Sources	Sample Size	Period Covered	Analytical Tool	Relevant Insights
Almannaa et al. 2020 [16]	USA, Austin	Quantitative	General automatic data	6 million trips	3 December 2018–20 May 2019	Cluster analysis	Compare the trip pattern between e-kick scooters and dockless e-bike
Bai & Jiao (2020) [17]	USA, Austin, Minneapolis	Quantitative	General automatic data	905 trips (Austin) 619 trips (Minneapolis)	n/a	GIS method and negative binomial regression models	Analyze the space-time patterns and the effects of the land use factors on e-kick scooters ridership
Caspi, Smart & Noland (2020) [18]	USA, Austin	Quantitative	General automatic data	2,237,588 dockless trips	15 August 2018–28 February 2019	Descriptive statistics and spatial regression models	Examine trips patterns of e-kick scooters and the effect of the built environment, land use, and demographics on trip generation
Davies, Blazejewski, & Sherriff (2020) [19]	n/a	Descriptive	n/a	n/a	n/a	Qualitative description	Show how e-PMVs can be used for tourism
Espinoza et al. (2019) [20]	USA, Atlanta	Quantitative	API automatic data	n/a	26 January–1 February 2019; 2–5, 10–13, 15–19, February 2019; 26 February–5 March 2019	GIS method and cluster analysis	Examine the role of e-kick scooters play in the mobility space (e.g., the purpose of each e-kick scooters trip)
Hardt & Bogenberger (2017) [21]	Germany, Munich	Qualitative	Travel diaries	38 participants	May–July 2016	Synthesis and codification of the travel diaries text	Understand the use, field of applications, and constraints of e-kick scooters
Hardt & Bogenberger (2019) [22]	Germany, Munich	Qualitative	Travel diaries and pre-post survey	38 participants	56 days	Synthesis and codification of the travel diaries text and pre-post survey	Understand the use, field of applications, and constraints of e-kick scooters with advantage and disadvantages
Hawa et al. (2020) [23]	USA, Washington DC	Quantitative	API automatic data	240,624 locations	12–14 May; 16 May; 1 June; 14 June 2019	Four multi-level mixed effects regression models	Examine the temporal, land use, transport infrastructure, and weather factors that influence the e-kick scooters presence and their variations throughout the day
Jiao & Bai (2020) [24]	USA, Austin	Quantitative	General automatic data	1,74 million trips	April 2018–February 2019	GIS and negative binomial regression models	Analyze the space-time patterns and the effects of the land use factors on e-kick scooters ridership
Krizek & McGuckin (2019) [25]	USA	Descriptive	Survey	9363 trips	2017	Qualitative description	Study who and for what kind of trips e-PMVs are used
Markvica, Schwieger & Aleksa (2020) [26]	Austria, Vienna	Descriptive	APP automatic data, online survey, course exercises	51 participants, 128 respondents, 94 pupils	September 2018–June 2019; May–July 2019; two days in June 2019	'Triangulation' research strategy	Investigate the potential of e-kick scooters as last-mile options and their spatial and infrastructural implications
Mathew et al. (2019) [27]	USA, Indianapolis	Quantitative	General automatic data	425,000 trips	4 September–30 November 2018	Descriptive statistics	Analyze the space-time patterns of e-kick scooters
Mathew, Liu & Bullock (2019) [28]	USA, Indianapolis	Quantitative	General automatic data	532,190 trips	4 September 2018–28 February 2019	Negative Binomial Model	Examine the weather impact on urban e-kick scooters utilization
McKenzie (2019) [29]	Canada, Montreal Germany, Berlin USA, Los Angeles	Descriptive	API automatic data	547,069 trips	60 days	Qualitative description	Examine space-time mobility trips data of e-PMVs to assess the similarity among cities
McKenzie (2019) [30]	USA, Washington DC	Quantitative	API automatic data (e-scooters), Open data (bike)	1,005,788 trips	13 June–23 October 2018	Descriptive statistics	Identify differences and similarities between dockless e-kick scooters and bike-sharing services
McKenzie (2020) [31]	USA, Washington DC	Quantitative	API automatic data (e-scooters), Open data (ride-hailing)	6 mobility services	December 2018–March 2019	Descriptive statistics	Identify space-time differences and similarities between e-PMVs services and between e-PMVs and ride-hailing services.

Table 2. *Cont.*

Authors (Year)	Location, City	Type of Study	Data Sources	Sample Size	Period Covered	Analytical Tool	Relevant Insights
Nocerino et al. (2016) [32]	Croatia, Italy, Netherland, Portugal, Slovenia, Spain, Sweden	Descriptive	General automatic data	39 companies test 74 electric vehicles	3–12 months	Qualitative description	Study the potential of e-bikes and e-kick scooters for goods delivery in urban areas
Noland (2019) [33]	USA, Louisville	Quantitative	General automatic data	88,042 records	8 August 2018–28 February 2019	Regression models	Show space-time data on shared e-kick scooters trip patterns
Reck et al. (2020) [34]	Switzerland, Zurich	Quantitative	General automatic data	46,000 trips of 5 shared e-PMVs providers	8 January–23 January 2020	Bivariate relationships and a Multinomial Logit Model (MNL)	Compare bike, e-bike, and e-kick scooters usage patterns
Tuncer & Brown (2020) [35]	France, Paris	Qualitative	Personal interviews	30 interviews	5 weeks of observation	Synthesis and coding of interview text	Examine how to move with an e-kick scooter and coordination with other road users
Zou et al. (2020) [36]	USA, Washington DC	Quantitative	API automatic data	138,362 records	11 March–14 April 2019	Descriptive statistics and spatial analysis	Analyze travel patterns and trajectories to understand the interaction with road design and vehicular traffic

Table 3. Studies referring to the e-PMVs' transport impact.

Authors (Year)	Location, City	Type of Study	Data Sources	Sample Size	Period Covered	Analytical Tool	Relevant Insights
Berge (2019) [37]	Norway, Oslo	Quantitative	Interviews	431 participants	Summer 2018	Descriptive statistics	Examine the modes of transport replaced by the e-kick scooters
Hyvönen, Repo & Lammi (2016) [38]	Finland	Quantitative	Online survey	1030 participants	n/a	Descriptive statistics	Examine how e-kick scooters could replace current transportation systems
Lee et al. (2019) [39]	USA, New York, Portland	Quantitative	General automatic data, National survey	700,000 trips	120 days	Log-log regression model and nonlinear multifactor model	Analyze the prediction of e-kick scooters demand and modal substitution of e-kick scooters
Tomita et al. (2016) [40]	Japan, Tsukuba	Quantitative	General automatic data	4 sharing stations; 4 personal mobility devices; 60 registered users	September 2014	Simulation multi-agent model	Analyze the modal shift due to the introduction of Segway

Tomita et al. [40] showed that, for the sharing system, 8% of potential users said they would use e-PMVs if there were enough availability of them. Furthermore, the possibility of using them to reach train stations did not strongly influence the share of potential users.

Hyvönen, Repo & Lammi [38] and Berge [37] agreed that consumers are interested in trying light electric vehicles, but most of them would use them as a substitute for regular cycling and walking, while only 1 out of 4 would replace public transport. Conversely, Lee et al. [39], calibrating the demand forecasting model on Portland data and then applying it to Manhattan, showed that 1% of taxi journeys to access/exit public transport was replaced by e-kick scooters.

Although no journal article provided exhaustive information on what transport modes e-PMVs are replacing, the EIT Urban Mobility Report [41] shows an interesting comparison between some US and European reports on modal share. Figure 4 shows how the shift is different according to each city and that e-kick scooters mainly replace walking except for San Francisco, where they are replacing taxis. However, more research is still needed to provide strong general conclusions.

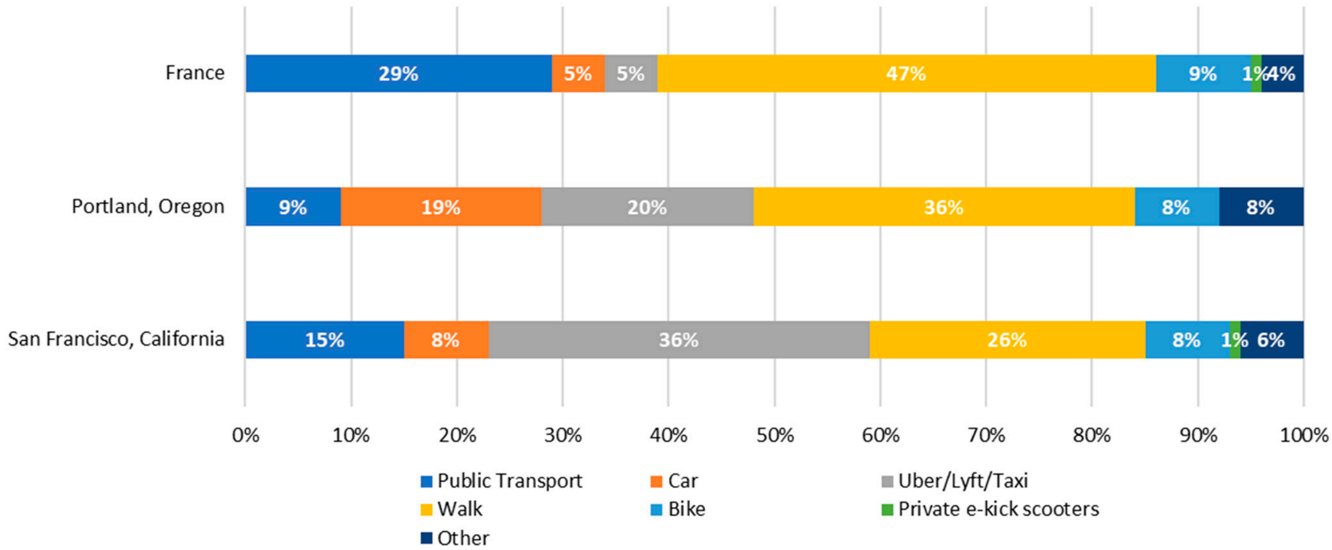

Figure 4. E-kick scooters and their impact on the modal share. Source: Authors' elaboration based on EIT Urban Mobility Report [41].

4.1.3. User Profiling

Some studies contributed to profiling e-kick scooters' users by investigating sociodemographic and travel characteristics (Table 4). User profiling was examined according to the "one-size-fits-all," a priori, and a posteriori (or post hoc) segmentation.

The "one-size-fits-all" segmentation outlined a representative e-kick scooters user. By multiple and logistic regression analysis, Huang & Lin [45] showed that age and gender differences affect the purchase and e-kick scooter use. In buying an e-kick scooter, men consider convenience, women consider the price, while under-20 consider the appearance. As for the reasons for using the e-kick scooter, respondents aged between 40 and 49 years showed a higher percentage for commuting purposes than younger respondents, and women showed a higher percentage in sport and leisure purposes than men. Furthermore, females felt stronger negative emotions than men. Otherwise, Fitt & Curl [44] defined that the most mentioned groups of e-kick scooter users were young people (118) and commuters and businesspeople (71).

Using a priori segmentation, possible users' characteristics on predefined segments have been identified and defined. More precisely, the literature aimed to learn more about the demographics and motivations of a specific category of e-kick scooters users. Using this approach, Eccarius & Lu [43] and Sanders, Brainon-Calles & Nelson [46] investigated a sample of university students and a sample of university staff and analyzed the frequency of use of the sharing service, respectively. Eccarius & Lu [43] showed that the compatibility of shared e-kick scooters with transport needs is the most relevant factor for the intention of use, but also awareness-knowledge and environmental values played an important role in the formation of intentions. Sanders, Brainon-Calles & Nelson [46] identified men with upper-middle-income (between $ 50,000 and 75,000 dollars), between 25 and 34 years old, as the main users. Furthermore, there are no significant differences regarding ethnicity.

By post hoc segmentation, Degele et al. [42] aimed to discover groups e-kick scooters-oriented by identifying specific user characteristics. Some clustering models and procedures have been adopted to identify segments within the data. They identified four main categories of users: expert (frequent users), occasional divided by age (over and under 40), and casual. Expert users are a small share of customers (4%) with an average age of 34, who travel mainly on Wednesdays in a distance of about 5.7 km and have an average time between rides of 4.6 days. Occasional users over 40 years have an average age of 48, represent approximately 24% of customers, use e-kick scooters more commonly on Fridays, and have an average time between rides of 25 days. Occasional users under 40 have an average age of 28, represent 58% of the market, use e-kick scooters more commonly on Saturdays, and have an average time between rides of 19.5 days. Finally, casual users are 14% of customers, with an average age of 35, who use e-kick scooters most commonly on Saturdays and have an average time between rides of 105.7 days.

4.1.4. Driving and Parking Behavior

Some papers studied the behavior of e-PMVs users when driving or parking (Table 5). These behaviors affect the relationship between e-PMVs users and other road users with reference to their circulation in the public space and the places where they park. The literature highlights as primary factors of driver behavior the speed, road infrastructure characteristics, and user types.

Concerning driving behavior, Arellano & Fang [47] showed that speed varies by infrastructures type (e.g., streets, sidewalks, and a mixed-use path) and gender. Indeed, e-kick scooters users' travel faster on roads and slower on pavements and mixed-use routes, move slower than cyclists and slow down encounter pedestrians. Furthermore, male users travel faster than females. Finally, e-kick scooter users are less distracted by cell phones, but they use headphones (16%) and few wear helmets (2%). Tuncer et al. [52] highlighted that to reach destinations faster and/or without being stopped, e-PMVs users quickly turn into pedestrians (getting off and on the device), "playing" with traffic rules. By getting off the device and walking, they can join pedestrians on sidewalks or cross with a red light, which gives them the right to keep moving. Furthermore, they try to blend in both in the public space in general and in encounters with pedestrians. Nishiuchi, Shiomi, & Todoroki [51] analyzed the driving behavior of experienced users and not on the phases of acceleration, deceleration, slalom, pedestrian overtaking, and emergency braking over a public road. Experienced users decelerate more gently, move faster during slalom, and drive in an agile and fast manner when they encounter pedestrians. Conversely, there is not much difference in emergency braking. Moreover, there is a similarity to the braking behavior of a bicycle.

Table 4. User-profiling studies with e-PMVs.

Authors (Year)	Location, City	Type of Study	Data Sources	Sample Size	Period Covered	Analytical Tool	Relevant Insights
Degele et al. (2018) [42]	Germany	Quantitative	General automatic data	53,000 data	22 April–20 October 2017	Cluster analysis	Analyze the behavioral and demographic segmentation of shared e-kick scooters
Eccarius & Lu (2020) [43]	Taiwan	Quantitative	Survey	425 respondents	n/a	Factor analysis and structural equation modelling	Investigate the factors influencing college students' intention to use shared e-kick scooters
Fitt & Curl (2020)[44]	New Zealand, Auckland, Hutt Valley, Christchurch, Dunedin	Quantitative	Online survey	491 respondents	February–March 2019	Descriptive statistics	Indicate the characteristics of e-kick scooters users
Huang & Lin (2019) [45]	Taiwan	Quantitative	Online survey	190 individuals	n/a	One-way analysis of variance, Multiple and Logistic Regression Analysis	Understand the age and gender differences that influence the use of e-kick scooters
Sanders, Branion-Calles & Nelson (2020) [46]	USA, Tempe	Quantitative	Survey	1256 responses	2 May 2019	Descriptive statistics	Indicate the socio-demographic characteristics and travel patterns of e-kick scooters users

Table 5. Studies on driving and parking behavior.

Authors (Year)	Location, City	Type of Study	Data Sources	Sample Size	Period Covered	Analytical Tool	Relevant Insights
Arellano & Fang (2019) [47]	USA, San Jose	Quantitative	Observation	330 e-kick scooter riders	October 2018–February 2019	Descriptive statistics	Observe the behavior of e-kick scooter drivers and how they compare with pedestrians and cyclists.
Brown et al. (2020) [48]	USA, Austin, Portland, San Francisco, Santa Monica, Washington DC	Quantitative	Observation	3666 data	July–August 2019	Descriptive statistics	Examine parking practices
Fang et al. (2018) [49]	USA, San Jose	Descriptive	Observation	530 shared e-kick scooters	June–July 2018	Qualitative description	Examine parking practices
James et al. (2019) [50]	USA, Rosslyn	Quantitative	Observation, survey	606 parked e-kick scooter, 181 e-kick scooters riders and non-riders	4 April–24 April 2019	Descriptive statistics	Analyze how shared e-kick scooters are parked and pedestrians' perceptions of vehicle safety
Nishiuchi, Shiomi, & Todoroki (2015) [51]	Japan	Quantitative	General automatic data	14 subjects	n/a	Two-way analysis of variance	Analyze user behavior in 5 driving phases
Tuncer et al. (2020) [52]	France, Paris	Descriptive	Video observation	3 e-kick scooter riders	2018	Ethnomethodology and multimodal conversation analysis	Examine the driving practices of e-kick scooter users and their interactions with pedestrians

As for parking behavior, it is observed whether e-PMVs users park (mainly e-kick scooters) in the appropriate areas or if they hinder the use of the infrastructure for other road users. Brown et al. [48], Fang et al. [49], and James et al. [50], agreed that even fewer parked e-kick scooters hinder traffic. The problems encountered so far in the car park concern possible access blocks for the disabled (2%, [49]) or to pedestrians (4%–10%, [50]), reducing the passage to less than 80 cm [48]. Further issues relate to comfort and perceived safety between users and non-users. According to James et al. [50], 76% of non-users and 24% of users reported feeling insecure while walking around dockless e-kick scooters.

4.1.5. Regulation and Organization of the Urban Spaces

Some studies addressed issues related to the regulation and organization of urban spaces (Table 6). These emerging vehicles constitute an additional transport system to already existing ones, occupy additional urban space (which is already diminishing) and, thus, need specific regulations. They also need additional infrastructures to be operated (e.g., charging points, parking slots).

To account for these issues, several authors investigated some facets.

For what concerns the providers of the e-kick scooter sharing system, Janssen et al. [58] showed that there are several common policies among cities. The number of providers is not fixed but has a maximum limit, each operator must pay a registration fee and a permit, and they have areas in which to circulate e-kick scooters. Also, not all e-kick scooters providers use the data-sharing platform. In some cities, there are restrictions on timetables, and on the reserved areas where e-kick scooters are or not allowed to park, but all cities reserve the right to remove improperly parked e-kick scooters.

As for the organization of urban spaces, some studies show how e-PMVs can create conflicts during traffic and how their diffusion increases the pressure on infrastructures. Regarding conflicts, Gössling [57] showed that e-PMVs create struggles in areas where they operate, with a difference in speeds and safety. Cases of irresponsible riders' behavior, disorder, and vandalism are frequent, especially in large cities. Instead, Jiménez, De La Fuente, & Hernández-Galán [59] showed that the integration between pedestrians and e-PMVs in the same urban space had not taken place yet. Therefore, they suggest different strategies to ensure urban accessibility, such as user regulation (i.e., training considers the functional diversity of pedestrians) and regulation for the use of devices (i.e., location of use and maximum speed). Conversely, to improve the road safety of coexistence with other pedestrians, they recommend ease of detection (e.g., using easily identifiable colors or inclusion of sound or light mechanisms) and consider the diversity in body size and reaction rates. On the other hand, as for the pressure on existing infrastructures, Butrina et al. [53] showed how several municipalities are adapting to changing sidewalk pressures because overcrowding on pavements spills into lanes, particularly acute impacts public road safety. Public administrations are analyzing data in real-time to be able to manage the flooring dynamically.

Table 6. Studies on regulations and organization of the urban spaces.

Authors (Year)	Location, City	Type of Study	Data Sources	Sample size	Period Covered	Analytical Tool	Relevant Insights
Butrina et al. (2020) [53]	USA	Qualitative	Interviews	One/two participants from the 10-interviewee city	May–July 2019	Synthesis and coding of interview text	Show how municipalities are adapting to the new pressures owing to e-PMVs services on their sidewalk
Chen et al. (2018) [54]	n/a	Quantitative	n/a	n/a	n/a	Mixed-Integer Linear Programming model and Particle swarm optimization algorithm	Identify the location of charging stations
Clark, Atkinson-Palombo & Garrick (2019) [55]	n/a	Descriptive	n/a	n/a	n/a	Qualitative description	Analyze the social acceptance of Segway
Fang, Chang & Yu (2014) [56]	Taiwan, Penghu Island	Quantitative	General automatic data	27 locations, 12,132 transactions	n/a	Quantitative statistical data processing and analysis methods	Identify the characteristics of users' charging behaviors, the optimal placement of charging stations, the users' charging time, and usage frequency.
Gössling (2020) [57]	Austria, Australia, Denmark, France, New Zealand, Spain, Sweden, Switzerland, USA	Descriptive	Local media report	173 news items	December 2017–August 2019 Depends on the cities	Qualitative description	Analyze the problems associated with the introduction of e-kick scooters and the different sharing operators
Janssen et al. (2020) [58]	USA, Austin, Charlotte, Denver, Indianapolis, Louisville, Memphis, Minneapolis, Nashville, Raleigh, Seattle	Descriptive	Multiple sources (e.g., police document, statistical data)	10 mid-sized peer cities	December 2018–June 2019	Qualitative description	Examine how scooter policies compare between cities and over time.
Jiménez, De La Fuente, & Hernández-Galán (2018) [59]	n/a	Descriptive	n/a	n/a	n/a	Qualitative description	Analyze the coexistence and accessibility problems between pedestrians and e-PMVs
Lo et al. (2020) [60]	New Zealand	Quantitative	Online survey	230 responses	May 2019	Descriptive statistics	Study the impact of legislation on the widespread use of e-kick scooters
Moran, Laa & Emberger (2020) [61]	Austria, Vienna	Quantitative	Automatic data manually digitized	6 e-kick scooters operators	June–August 2019	Spatial analysis	Analyze the spatial variance in e-kick scooter geofences

Moran, Laa & Emberger [61] focused on the spatial variation of geographic barriers of e-kick scooters and how these differences relate to existing regulations. The six providers analyzed have overlapping virtual fences and no-parking zones defined within the city but of different sizes.

Since e-PMVs need battery recharging, a handful of studies investigated some issues related to the charging points. Chen et al. [54] showed that the optimal location for e-PMVs charging systems is in the function of the greatest number of times a station is used. Moreover, the optimal location is affected by the minimum total cost and the maximum capacity of the service (i.e., the maximum number of rechargeable vehicles in a day), the land-pricing, the service distance, and the installed capacity. In addition, Fang, Chang & Yu [56] showed that occasional users recharge their e-PMVs for less than 2 h, while "repeated" and "high frequency" users (i.e., students or workers) occupy the recharging station more: about 4/5 h. It might be because the e-PMVs stay parked for more time, and the parking is adopted as a depot.

The regulation and the organization of the urban spaces originate challenges regarding the acceptance of e-PMVs among the users. Social acceptance of e-PMVs means the achievement of knowledge of the means of transport from different viewpoints (e.g., design, road safety, circulation). This level differs between non-users and experienced users, who are more likely to accept e-PMVs.

Clark, Atkinson-Palombo & Garrick [55] showed that high prices, legislative and spatial issues, and a lack of appeal to consumers presented challenges to e-PMVs acceptance. Therefore, their social, economic, and environmental costs and regulatory issues presented barriers to their diffusion. Lo et al. [60] confirmed the legislation could impact the widespread use of shared e-kick scooters. Frequent users (traveling more than 3 times a week) are strongly opposed to any regulation, while non-users would be more inclined to try e-kick scooters if there were mandatory helmet rules.

4.2. Exogenous Issues: Impact on Road Safety and Environment

Forty-three studies examined the impact of e-PMVs on road safety and the environment. They analyze the main types of injuries and most affected people (crashes severity), the road safety implications related to conflicts between e-PMVs and pedestrians, the use of user protection devices, and new technological systems for safe driving and a miscellaneous regarding the types of crashes. Furthermore, a handful of studies examine whether e-PMVs can be considered a sustainable means of transport and their environmental impact.

4.2.1. Crashes Severity

Many studies addressed the road safety of e-PMVs, considering the types and severity of injuries for both e-PMVs' drivers and the other road users involved (Table 7). Most of the studies focused on the types of injuries, including patient demographics, the type of crashes, and compliance with traffic rules (e.g., the use of personal protective equipment, a good psychophysical state of the driver). Conversely, a handful of studies focused on the historical trends of hospitalizations in terms of the number of patients, seasons, months, or days of the week. All these studies adopted crash data gathered from the emergency department visits, which are quite detailed from a medical perspective and include data on slight and minor injuries.

According to a general overview, the most reported injuries are neurological, maxillofacial, orthopedic, and thoracic types. They involve the upper and lower part of the body and head representing the more exposed and vulnerable parts of the overall body of an e-PMVs' user [63,75,79]. More precisely, details of type of injuries are shown in Figure 5.

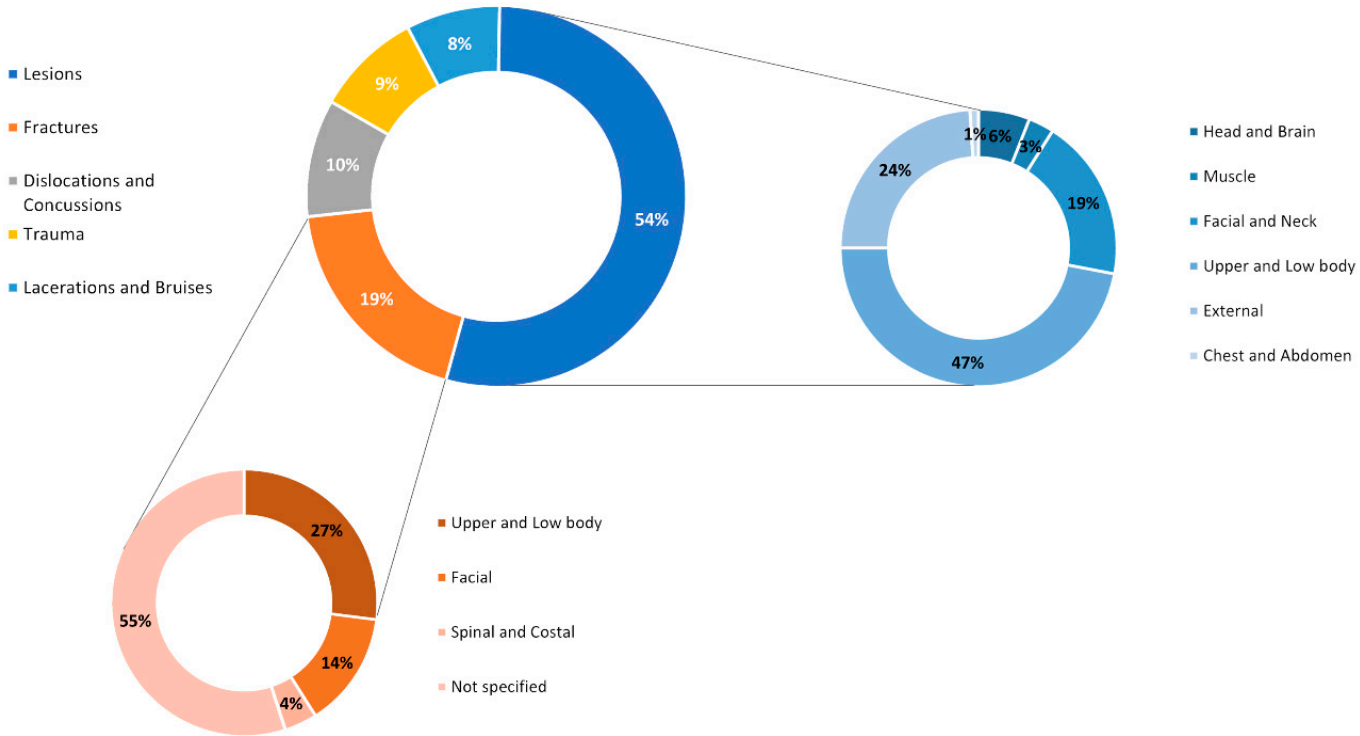

Figure 5. Type of injuries.

Further studies also correlated patient demographics such as age and gender to injury data. All these studies showed that patients are mostly males [78]. Moreover, patients involved in a crash are young aged between 18 and 25 [65] and middle-aged from 34 and 38 [64,66,70,73,74,81,83].

Other studies also specified whether the patient was the e-PMVs' driver or a road user, and the crash type. While confirming the results of type and severities of injuries and the age, they showed that 97% of patient were e-PMVs drivers [69]; they injured themselves by losing balance while driving (81%), were hit by an object (3%) [71,72], and 16% were hit by a car [67]. Several studies argued that injuries were reported due to incorrect driving behavior, such as driving under the influence of alcohol or drugs and considering violations to road regulation code. Puzio et al. [80] showed that no one of the hospitalized patients wore a helmet, and about 34% drove under the influence of alcohol or drugs during the crash. Following this type of misguided, Haworth & Schramm [68], Badeau et al. [62], and Mitchell et al. [76] crossed data on injuries and incorrect driver behavior and showed that the main types of injuries reported fall within those previously analyzed. Even Kobayshi et al. [73] and Bekhit et al. [64] confirmed it.

Störmann et al. [82] enlarged previous studies' results, grouping the main types of patient injuries, demographics, type of crashes, improper driving, and confirming the findings. They showed that crashes are greatest between August and September, many of them on weekends. While confirming the admission on the weekends, Vernon et al. [84] added the number of hospitalizations increased between April and July. In addition, Namiri et al. [77] showed that victims aged between 18 and 34 increased by 354% between 2014 and 2018.

4.2.2. Conflicts between e-PMVs and Pedestrian

Some studies investigated how pedestrians perceive e-PMVs and the interactions between them and congested pedestrian areas (Table 8). Additionally, they identified areas where there is a greater chance of encountering e-PMVs.

Table 7. Studies on crashes severity.

Authors (Year)	Location, City	Type of Study	Data Sources	Sample Size	Period Covered	Analytical Tool	Relevant Insights
Badeau et al. (2019) [62]	USA, Salt Lake City	Quantitative	Emergency department visits	58 patients	June 15–15 November 2017 and 2018	Descriptive statistics	Identify the type of injury
Beck et al. (2020) [63]	New Zealand, Dunedin	Quantitative	Emergency department visits	56 patients	6 weeks January 10–20 February 2018 and 2019	Descriptive statistics	Describe the injury patterns associated with e-kick scooters
Bekhit et al. (2020) [64]	New Zealand, Auckland	Quantitative	Emergency department visits	770 patients	20 September 2018–20 April 2019	Descriptive statistics	Show the main types of injuries, patient demographics, and incorrect driving
Blomberg et al. (2019) [65]	Denmark, Copenhagen	Quantitative	Emergency department visits	468 patients	January 2016–July 2019	Descriptive statistics	Describe injuries and patient demographics related to e-kick scooter use
Bloom et al. (2020) [66]	USA, Los Angeles	Quantitative	Emergency department visits	248 patients	1 February–1 December 2018	Descriptive statistics	Study the injuries related to e-kick scooters use
Dhillon et al. (2020) [67]	USA, California	Quantitative	Emergency department visits	87 patients	January-December 2018	Descriptive statistics	Show the variation in hospital admissions and outcomes for injuries related to e-kick scooters use
Haworth & Schramm (2019) [68]	Australia, Brisbane	Quantitative	Emergency department visits	785 e-kick scooters 109 patients	Two months in early 2019	Descriptive statistics	Track the number of e-kick scooters involved in crashes and the types of injuries
Ishmael et al. (2020) [69]	USA, Los Angeles	Quantitative	Emergency department visits	73 patients	September 2017–August 2019	Descriptive statistics	Show operational orthopedic injuries related to e-kick scooter crashes
Islam et al. (2020) [70]	Canada, Calgary	Quantitative	Emergency department visits	33 patients	8 July–30 September 2019	Descriptive statistics	Analyze data of injury related to the use of e-kick scooters
Kim et al. (2018) [71]	Korea, Incheon	Quantitative	Emergency department visits	65 patients	January 2016–December 2017	Descriptive statistics and logistic regression	Show injury types, patient demographics, and crashes dynamics
King et al. (2020) [72]	Singapore, Singapore	Quantitative	Emergency department visits	259 patients	1 January 2016–31 December 2016	Descriptive statistics	Analyze injury patterns related to the use of e-kick scooters
Kobayshi et al. (2019) [73]	USA, San Diego	Quantitative	Emergency department visits	103 patients	1 September 2017–31 October 2018	Descriptive statistics	Show the main types of injuries, patient demographics, and incorrect driving
Liew, Wee & Pek (2020) [74]	Singapore, Singapore	Quantitative	Emergency department visits	36 patients	From 2015 to 2016	Descriptive statistics	Characterize the severity of e-kick scooter-related injuries
Mayhew & Berging (2019) [75]	New Zealand, Auckland	Quantitative	Emergency department visits	64 patients	August 15–15 December 2018	Descriptive statistics	Quantify the severity of injuries caused by an e-kick scooter
Mitchell et al. (2019) [76]	Australia, Brisbane	Quantitative	Emergency department visits	54 patients	23 November 2018–23 January 2019	Descriptive statistics	Analyze the type of incorrect driving and crashes
Namiri et al. (2020) [77]	USA	Quantitative	National Emergency department visits	1037 injuries	2014–2018	Descriptive statistics and linear regression	Study the trends in injuries and hospital admissions
Nellamattathil & Amber (2020) [78]	USA, Washington DC	Descriptive	Radiology report database	54 patients	1 September 2017–1 December 2018	Qualitative description	Identify the pattern of injuries on diagnostic imaging
Pourmand et al. (2018) [79]	USA, Austria, Denmark	Descriptive	Scientific databases (PubMed)	6 studies 135 patients	January 1990–May 2017	Qualitative description	Examine the literature review to understand the types of injuries associated with Segway use, patient demographics, the context of injuries, and the cost associated with injuries
Puzio et al. (2020) [80]	USA, Indianapolis	Quantitative	Emergency department visits	92 patients	4 September–4 November 2018	Descriptive statistics	Characterize the epidemiology of injuries
Roider et al. (2016) [81]	Austria, Vienna	Quantitative	Emergency department visits	86 patients	January 2010–December 2012	Descriptive statistics	Analyze the injuries associated with the use of the Segway for sightseeing

Table 7. *Cont.*

Authors (Year)	Location, City	Type of Study	Data Sources	Sample Size	Period Covered	Analytical Tool	Relevant Insights
Störmann et al. (2020) [82]	Germany, Frankfurt	Quantitative	Emergency department visits	76 patients	July 2019–March 2020	Descriptive statistics	Identify injury patterns, patient demographics, type of accident, type of driving and growth in hospitalizations
Trivedi et al. (2019) [83]	USA, Los Angeles	Quantitative	Emergency department visits	249 patients	1 September 2017–31 August 2018	Descriptive statistics	Characterize injuries related to the use of e-kick scooters
Vernon et al. (2020) [84]	USA, Atlanta	Quantitative	Emergency department visits	293 patients	3 May 2018–15 August 2019	Descriptive statistics	Assess the health care impact of e-kick scooter crashes.

Table 8. Studies on conflicts between e-PMVs and pedestrian.

Authors (Year)	Location, City	Type of Study	Data Sources	Sample Size	Period Covered	Analytical Tool	Relevant Insights
Che, Lum & Wong (2020) [85]	Singapore, Singapore	Quantitative	Observation (Head-mounted displays)	60 people 12 scenarios	n/a	Descriptive statistics	Evaluate the safety perceived degree considering speed, even when overtaking between e-kick scooters and pedestrians
Hasegawa et al. (2018) [86]	n/a	Quantitative	General automatic data	32 participants	February–March 2017	Model based on social forced including acceleration and speed data	Evaluate the safety perceived degree considering the movement direction between Segway and pedestrians
Kuo et al. (2019) [87]	Singapore, Singapore	Quantitative	Online survey	303 responses	December 2018–February 2019	Descriptive statistics and structural equation model	Evaluate the pedestrians' levels of acceptance of e-PMVs, based on the intention to use a PMV, ease of use, usefulness, the perceived risk from PMV riders, and the environment.
Kuo et al. (2019) [88]	Singapore, Singapore	Quantitative	General automatic data, survey	4 types of PMV 39 participants	December 2018–March 2019	Descriptive statistics and machine learning algorithm	Understand the reaction of the pedestrians to the e-kick scooters, considering speed and gender
Maiti et al. (2019) [89]	USA, San Antonio	Quantitative	Smartwatch automatic data, post-study survey	77 participants	Three months	Descriptive statistics	Investigate the safety issues due to e-kick scooters services from the pedestrian's perspective
Pham (2019) [90]	n/a	Theoretical	n/a	n/a	n/a	Simple microscopic model	Propose an assistance system for study the interaction between an e-PMVs and pedestrians, considering the personal space
Pham et al. (2015) [91]	n/a	Theoretical	n/a	n/a	n/a	Refined microscopic model	Propose an assistance system for study the interaction between an e-PMVs and pedestrians, considering the personal space

On pedestrians' perception of e-PMVs in shared paths, assessments were made on the degree of perceived safety when the vehicle moves nearby, considering the speed of the e-PMVs, the pedestrians' gender, and the degree of acceptance e-PMVs on shared paths. The acceptance phase can be defined as completed when the new device no longer represents a novelty but a familiar vehicle that has been in circulation for some time (e.g., bicycles). Che, Lum & Wong [85] suggested that e-PMVs speeds between 10 and 15 km/h are considered safe when e-PMVs overtake a pedestrian, while a speed up to 15 km/h is safe when they are face-to-face with pedestrians. Indeed, pedestrians feel uncomfortable when a device approaches them faster than 15 km/h, and females usually feel more uncomfortable than males [88].

The results differ in the acceptance of e-PMVs by pedestrians. Kuo et al. [87] showed how this acceptance is more influenced by context than individual behavior. An e-PMV is less "dangerous" for pedestrians in relation to the space in which they circulate, rather than about the speed used or the direction of the device. Furthermore, there are also differences between experienced users and non-users.

Hasegawa et al. [86] showed that the subjective perception of danger depends on the movement direction in which both pedestrians and e-PMVs approach each other. Pedestrians consider e-PMVs to be more dangerous when they arrive from the front rather than from behind. In addition, when e-PMVs move in a pedestrian flow, they may generate a negative psychological effect. People can feel fear and discomfort when something invades their personal space, which induces psychological stress [92]. This effect was studied by Pham [90] and Pham et al. [91], who showed the levels of discomfort and fear of e-PMVs increase as the pedestrian density increases. The highest density of encounters between e-PMVs and pedestrians was recorded around campus residences, parking lots and off-campus apartment complexes during lessons and study hours [89]. Therefore, these zones are potentially the most dangerous to pedestrians.

4.2.3. Safe Driving

Some studies showed several elements that could contribute to safe driving (Table 9). In this sense, the researchers analyzed the social networks of some sharing companies to understand how much they emphasize the use of protective devices. Moreover, they showed new technologies developed to assess whether users are driving incorrectly (e.g., carrying people or things, driving drunk, etc.) and issues related to the design of the device itself. An in-depth analysis examined the dynamics of crashes, while others focused on the safety distance to be kept when overtaking.

Consumer behavior can generally be influenced by how companies promote and demonstrate their products on popular social media platforms, such as Instagram and Twitter. In fact, Allem & Majmundar [93] and Dormanesh, Majmundar & Allem [94] showed that only about 10% of Bird company's posts show users wearing protective clothing, while Tier Mobility about 26%.

The growing popularity of e-kick scooters has led to the rising of individual safety issues associated with unsafe driving behavior. Terrell [98] proposed a new technology: mounting a weight detection mechanism on an e-kick scooter that enables determining its driving behavior and indicates an unsafe and/or not permitted use. Identified driving patterns can indicate whether users are driving under the influence of alcohol or drugs, carrying passengers, driving recklessly, etc. Conversely, Kim et al. [96] examined the risks associated with electric scooter users by analyzing the influence of face direction while driving via a smartphone application. They showed that the greater the angle between the direction of the scooter and the direction of the gaze (face angle), the greater the deviation of the traveler in the direction opposite to that observed by the subject.

In terms of public safety, even vehicle design and overtaking maneuvers are relevant. Nisson, Ley & Chu [97] pointed out that e-kick scooters, being silent, dark-colored, and often light-free vehicles, are dangerous vehicles for drivers and road users. In addition, since collisions during overtaking maneuvers are defined as one of the main causes of fatal crashes on two wheels [99], the minimum distance that two-wheeled vehicles (bicycles, e-bikes, and e-kick scooters) should use to overtake a car should be 1.54 m [95].

4.2.4. Miscellaneous on Road Safety

Three studies cannot be classified in the previous sections, so a new one has been created (Table 10). Two studies analyzed the kinematic process of crashes by evaluating head injuries and crashes patterns.

Xu et al. [100,101] have investigated head trauma as a type of injury for pedestrians and e-PMVs users. They showed no appreciable differences on impact to the ground (i.e., the severity of injuries is quite similar). Conversely, the risk of injury increases with the vehicle and the e-kick scooters speeds.

As for the dynamics of crashes, owing to the scarcity of data, it is difficult to understand the number of crashes with e-kick scooters involved. For this, Yang et al. [102] tried to describe the crash patterns related to e-kick scooters' use. Results pointed out that both children and the elderly are prone to serious injuries and that crashes are more likely to occur at night than during the day. Additionally, the outcome of the crash may be related to the gender difference, with women involved in multiple falls. The main types of a reported crash are collisions with a car and falling alone.

4.2.5. Environmental Impact

Few studies addressed the issue of the environmental impact of e-PMVs (Table 11), but all of them agreed that although the emissions while driving are equal to zero, the entire life cycle must be considered. The Life Cycle Assessment (LCA) is a quantitative environmental impact assessment method, which enables to calculate the environmental impacts of a product or service through the whole life cycle. The main goal of LCA is to calculate impacts, compare different products and/or services, and highlight improvement options.

Severengiz et al. [106] showed that the Global Warming Potential (GWP) associated with the use of shared e-kick scooters is dominated by the production phase, especially the production of aluminum parts. In addition to production, the lifespan, the distances to collect the batteries or scooters, the type of collection vehicle, and the mix of electricity for charging the scooters are important factors. Hollingsworth, Copeland & Johnson [104] also agreed that materials, manufacturing, and automotive use for collecting e-kick scooters and charging them dominate the impacts of global warming associated with the use of shared e-kick scooters.

However, De Bortoli & Christoforou [103] argued that it is necessary to combine the useful life kilometers of e-kick scooters and the environmental impacts of maintenance phases to make these devices sustainable. Moreau et al. [105] showed that dockless e-kick scooters must be used for at least 9.5 months to be an ecological solution for mobility in the current usage situation.

All contributors agree that the GWP results are sensitive to the e-kick scooters' duration over the years. In the current situation, the use of the e-kick scooter causes between 64 and 237 g of CO2-eq * $p \cdot km^{-1}$ and, after at least two years, this number can decrease between 20% and 30%. The value is visibly lower than the emissions from cars causing between 147 and 414 g of CO2-eq * $p \cdot km^{-1}$. It shows how modal choice is relevant for the environmental impact: the modal shift could be positive, as in the previous comparison with cars, or negative if an e-kick scooter replaces a sustainable transport mode with a lower LCA. For example, the use of an e-bike causes about 40 g of CO2-eq * $p \cdot km^{-1}$, and a bicycle causes 8 g of CO2-eq * $p \cdot km^{-1}$.

Table 9. Studies on safe driving.

Authors (Year)	Location, City	Type of Study	Data Sources	Sample Size	Period Covered	Analytical Tool	Relevant Insights
Allem & Majmundar (2019) [93]	USA	Quantitative	Instagram posts	324 posts	22 September 2017–9 November 2018	Descriptive statistics	Examine Bird's official Instagram account to determine how much it emphasizes safety devices in its posts
Dormanesh, Majmundar & Allem (2020) [94]	n/a	Quantitative	Instagram and Twitter posts	Instagram posts: Bird 287, Ties Mobility 190. Twitter posts: Bird 313, Ties Mobility 67	9 November 2018–7 October 2019	Descriptive statistics	Examine Bird and Tier Mobility's official Instagram and Twitter accounts to determine how much they emphasize safety devices in their posts
Guo, Sayed & Zaki (2019) [95]	China, Kunming	Quantitative	Video observation	352 overtaking	1.30 h	Logit model	Examine the factors affecting the lateral distance when overtaking between two-wheeled devices and cars
Kim et al. (2018) [96]	Japan, Tsuruoka	Quantitative	App automatic data	4 participants	n/a	Descriptive statistics	Evaluate the impact of the face angle on the trajectory while driving
Nisson, Ley & Chu (2020) [97]	USA, Los Angeles	Descriptive	n/a	n/a	n/a	Qualitative description	Provide recommendation on personal and public safety associated with e-kick scooter design.
Terrell (2019) [98]	n/a	Qualitative	Weight sensor automatic data	n/a	n/a	Qualitative description	Determine driving behavior that indicates unsafe and/or impermissible use

Table 10. Studies on miscellaneous on road safety.

Authors (Year)	Location, City	Type of Study	Data Sources	Sample Size	Period Covered	Analytical Tool	Relevant Insights
Xu et al. (2016) [100]	n/a	Theoretical	n/a	n/a	n/a	Analytical model	Study the kinematic process in electric self-balancing scooters–vehicle crashes, evaluating only head injuries
Xu et al. (2016) [101]	n/a	Theoretical	n/a	n/a	n/a	Analytical model	Study the kinematic process in electric self-balancing scooters–vehicle crashes, evaluating head injuries during secondary contact with the ground evaluating
Yang et al. (2020) [102]	USA	Quantitative	Media reports	169 crashes	1 January 2017–31 December 2019	Synthesis and coding of newspaper text	Describe the crashes patterns due to the use of e-kick scooters

Table 11. Studies on the environmental impact.

Authors (Year)	Location, City	Type of Study	Data Sources	Sample Size	Period Covered	Analytical Tool	Relevant Insights
De Bortoli & Christoforou (2020) [103]	France, Paris	Quantitative	Survey data	445 responses	Spring 2019	Analytic model	Analyze the mathematical formalization of consequential Life Cycle Assessment of free-floating e-kick scooters
Hollingsworth, Copeland & Johnson (2019) [104]	USA, Raleigh	Quantitative	n/a	n/a	n/a	Monte Carlo analysis and scenarios	Analyze the Life Cycle Assessment of shared dockless e-kick scooters.
Moreau et al. (2020) [105]	Belgium, Bruxelles	Quantitative	General automatic data, Survey	1181 responses	June–August 2019	Descriptive statistics	Analyze the Life Cycle Assessment of dockless and personal e-kick scooters
Severengiz et al. (2020) [106]	Germany, Berlin	Quantitative	Survey with service providers	n/a	n/a	Descriptive statistics	Analyze the Life Cycle Assessment of shared e-kick scooters

5. Towards the Development of Research on e-PMVs

Currently, research focused on the endogenous and exogenous issues affecting the massive spread of e-PMVs in urban contexts. It showed how these vehicles were integrated into the built environment. However, new studies are suggested for both endogenous and exogenous issues without any priority order.

Endogenous issues research reported valuable results of trip pattern characteristics (such as average speed, distance, day, time, etc.). In addition, some key factors affecting ridership were isolated at an aggregate level. However, most of these studies refer to USA cities. Therefore, it would be interesting to replicate the same analyses in European cities, which differ in territorial conformations, climate, regulations, and population habits. For instance, many European cities are older than the USA cites and present built environments that are more consolidated and restricted, which could affect the characteristics of e-PMVs. Despite their introduction being conceived to increase the sustainability of transport in cities, both in Europe and USA, only a handful of studies showed that their use has mainly replaced soft mobility rather than hard mobility (i.e., cars) by providing descriptive statistics. This does not enable for strong conclusions. Therefore, new studies and more refined statistical models would be recommended to further investigate this important issue.

Studies on user profiling are still few and new research to evaluate the propensity to use e-PMVs by means of probabilistic models seems crucial. Thus, it would be possible to understand what leads the user to use them, considering the emotional and non-rational side other than classical socio-demographic and travel behavior characteristics.

As for the travel behavior linked to public space use, further research is desirable regarding the characteristics and parking spaces and pavement suitable for the circulation of these new devices. As this survey showed, the literature lacks contributions to the effect of different pavement types where e-PMVs can circulate. In addition, some European countries issued specific regulations for the circulation of e-PMVs, equating them to bikes (or e-bike), thus providing indications regarding their circulation in urban areas both on cycling paths and traditional roads. However, the effect of these regulations requires attention because they present different characteristics. For instance, cyclists are seated on their vehicle, whereas the e-PMVs users must stand above the footboard. Moreover, bikes have large wheels and tires, which can generate a stabilizing gyroscopic effect and dissipates the shocks induced by the pavement irregularities. Conversely, e-PMVs are generally equipped with small diameter wheels, often made of a rigid material, which may not induce significant stabilizing and dissipative effects. Therefore, the similarity between bikes and e-PMVs could be questionable: the few studies that compared them usually refer to trip patterns, and the dynamic behavior of the vehicles is not considered. Only a few indications on the city's transport policy emerged from the literature, perhaps because e-PMVs are new vehicles and the regulations for their circulation are constantly updated. Hence, guidelines and policies are needed to integrate e-PMVs into public space and investigate the parameters that drive the location of recharging points (especially for shared vehicles) and the monitoring of e-PMVs as a sustainable mode of transport.

Research should also be deepened on exogenous issues related to road safety and the environment. This survey highlighted a lack of studies that should separate the crashes and traumas involving e-kick scooters to provide specific information about them. Indeed, there is no specific filing of injuries caused by e-kick scooters in hospitals, which is useful for a detailed analysis of patients, the type of injuries, and the number of injuries. It would be interesting to include these data in an accessible national database, useful to detect appropriate safety measures and recommendations.

As for pedestrian safety, future developments could focus on the effects and usefulness of signaling devices to be installed on devices to warn of the presence of important pedestrian flows. Furthermore, experimental studies should be conducted on personal protective equipment and dynamics and reconstructions of crashes. In this context, driver training before using e-kick scooters is essential, and the research contributions are too limited on this aspect. Even more so, e-PMVs can circulate in promiscuity with individual motor vehicles (e.g., cars). Therefore, an analysis of the risk of crashes encompassing statistical models of the probability of the occurrence, the severity of crashes, and the exposure variables would be an important research topic for classifying the paths where e-PMVs can be admitted, as already applied in public transport [107].

Finally, further research on the environmental impact is also desirable: it would be interesting to understand how ecological e-kick scooters are, especially in the construction and disposal phases, or in relation to the types of mobility they replace. There are still few (and mainly European) studies that show the importance of considering the entire life cycle of the device.

6. Conclusions

Recently, the diffusion of electric-powered Personal Mobility Vehicles (e-PMVs) in many worldwide cities led to several issues that have captured the attention of many scholars and practitioners. The scientific community has grown considerably over the past three years. Although there are many more studies (such as scientific literature in many national languages and professional reports), extensive search is done to analyze studies in English only. Hence, 90 publications have been revised to understand the several issues associated with the spread of e-PMVs. This survey classified the studies according to both endogenous issues (i.e., impact on transport and urban planning) and exogenous issues (i.e., impact on road safety and environment) and showed that research has evolved over the years to the increasing use of e-PMVs and the data availability.

Studies aimed at endogenous issues were mainly conducted in North America and Europe. That research was dedicated to defining travel patterns (i.e., analyzing the average length traveled, the time and speed of the journey), understanding where and when e-PMVs were used, including the diversity of ground and climatic conditions of the city. Further, the main reasons that encourage using these devices were reported, and which existing means of transport e-PMVs are replacing. This survey showed that e-PMVs are mostly used on weekends during the afternoon hours for leisure and free time trips. During the week, they may be used for commuting to/from work or to reach stops/stations. E-PMVs are most used in areas where there is a greater diversity of land use. The weather is an important factor in the choice of use of these devices. E-kick scooters are considered an attractive transportation mode for the feeling of freedom and fun and for reducing trip time. Also, it appears that e-PMVs will replace walking and cycling without reducing the use of private cars for short trips, but more studies are required to confirm previous results because few are identified.

Subsequently, the studies enable us to profile the user type through the segmentation "one-size-fit-all," a priori, and a posteriori. This literature showed that the main frequently users of e-PMVs are young men between 20 and 40 years old. Their behavior towards other road users is analyzed in the use of public space, during the driving and parking phases (i.e., if they obstruct circulation or if driving on shared spaces is appropriate), and some aspects related to the regulation and design of urban public space. The studies on user behavior showed that, while driving, users move slower than bicycles, slow down when pedestrians are present, and are agiler when they gain more riding experience. In addition, users often respect the rules of parking lots but "play" with traffic rules by getting on and off the devices to move like pedestrians. Nevertheless, only a small percentage of parked e-PMVs may create severe problems for the pedestrian flows. Conversely, studies showed that better effort is needed in speed regulation and traffic areas to avoid conflicts with other road users, which could also improve their acceptance. Finally, many issues that should be further addressed concern the charging points (e.g., frequency of use, costs, and capacity of the service).

Exogenous issues studies on road safety were mainly carried out in North America and Asia. They analyzed the degree of crashes severity based on their number and type and to the profiling of people subject to impact. The average age of injured people is between 30 and 35, mainly men who did not wear helmets. Many of them also drive under the influence of alcohol and/or drugs. The most reported types of injuries are head trauma, brain injury, and upper body injuries or fractures. Research also analyzed safety towards other road users (mainly pedestrians), referring to the perception that pedestrians have when they are in proximity to these devices while traveling.

Subsequently, the literature showed that pedestrians who have already used e-PMVs are less frightened during an encounter. The direction and speed are essential when e-kick scooters are approaching the pedestrian and invading their space. Other studies analyzed the driver's safety, evaluating the use of personal protective equipment (such as helmets) and experimenting with several devices to understand (safe/unsafe) driving behavior. These studies showed that social networks and advertisements do not emphasize helmets or protective devices. Furthermore, the literature indicates that new technologies are being developed to understand how users drive. Studies also showed that the main dynamics of crashes are related to the single driver losing his balance or colliding with the public space infrastructure. Finally, studies on the environmental impact were mainly conducted in Europe (perhaps also due to greater attention to environmental issues). E-PMVs have zero emissions while driving. However, to be considered sustainable and zero-impact, studies showed that their entire life cycle must be considered, and e-PMVs should be used for at least 9.5 months.

Although this survey analyzed separate issues, overlapping research questions emerged. For instance, the creation of an accessible national database with hospital and crashes detection data would be useful in both transport planning and crashes occurrence and severity prediction models; the analysis of travel models would be useful to understand which paths are most used and, thus, to provide input for the design of new infrastructures. Finally, as some issues of e-PMVs have been examined from a general viewpoint, more detailed reviews on separate issues are recommended.

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Appendix A Overview on Publications between August and December 2020—Not Reviewed

Al Mamun, A., Zainol, N. R., & Hayat, N. (2020). Electric Scooter-An Alternative Mode of Transportation for Malaysian Youth.

Baek, K., Lee, H., Chung, J. H., & Kim, J. (2020). Electric scooter sharing: How do people value it as a last-mile transportation mode? Transportation Research Part D: Transport and Environment, 90, 102642.

Bell, J., Rogers, S., Mathew, J., Li, H., & Bullock, D. (2020, August). Comparing Speed Distribution of Micromobility Modes. In International Conference on Transportation and Development 2020 (pp. 59–67). Reston, VA: American Society of Civil Engineers.

Bieliński, T., & Ważna, A. (2020). Electric Scooter Sharing and Bike Sharing User Behavior and Characteristics. Sustainability, 12(22), 9640.

Button, K., Frye, H., & Reaves, D. (2020). Economic regulation and E-scooter networks in the USA. Research in Transportation Economics, 100973.

Cicchino, J. B., Kulie, P. E., & McCarthy, M. L. (2020). Severity of e-scooter rider injuries associated with trip characteristics.

Comer, A., Apathy, N., Waite, C., Bestmann, Z., Bradshaw, J., Burchfield, E., & Sabec, M. (2020). Electric Scooters (e-scooters): Assessing the Threat to Public Health and Safety in Setting Policies: Assessing e-scooter policies. Chronicles of Health Impact Assessment, 5 (1).

Curl, A., & Fitt, H. (2020). Same same, but different? Cycling and e-scootering in a rapidly changing urban transport landscape. New Zealand Geographer. (in press)

Dill, J., & McNeil, N. (2020). Are Shared Vehicles Shared by All? A Review of Equity and Vehicle Sharing. Journal of Planning Literature, 0885412220966732. (in press)

Douglass, K., Sikka, N., Boniface, K., Bhatt, K., McCarville, P., & Pourmand, A. (2020). Epidemiological Analysis of E-Scooter Injuries among Patients Presenting to the Emergency Department. Annals of Emergency Medicine, 76(4), S108.

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Lorne Platt & Greg Rybarczyk (2020) Skateboarder and scooter-rider perceptions of the urban environment: a qualitative analysis of user-generated content, Urban Geography, DOI: 10.1080/02723638.2020.1811554

Martínez-Navarro, A., Cloquell-Ballester, V. A., & Segui-Chilet, S. (2020). Photovoltaic Electric Scooter Charger Dock for the Development of Sustainable Mobility in Urban Environments. IEEE Access, 8, 169486–169495. (in press)

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