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# Urban Environment's Contributory Factors for the Adoption of Cargo Bike Usage: A Systematic Literature Review

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**Abstract:** The supply chain sector plays a crucial role in driving economic development and globalization. However, the environmental repercussions of logistics and freight transport have become more pronounced. Nowadays, there is an ever-increasing acceptance regarding the opinion that the use of more sustainable urban freight transport has the potential to offer great social, economic, and environmental benefits. This study examines and highlights, via a systematic literature review, the urban environment's factors that can essentially influence the promotion and usage of cargo bikes for last-mile deliveries in the urban environment. The aforementioned literature review revealed the importance of the quality of the urban environment's components for the perceived and objective safety of people who make use of cargo bikes. In particular, the most essential factors for the increased use of cargo bikes were found to be traffic load, speed limits, and heavy vehicle traffic. Bicycle infrastructure is also an important factor in bicycling acceptance, as it provides the backbone for a comfortable and safe bicycle ride. Two other factors that can seriously affect cyclists' sense of safety are street intersections and the width and number of road lanes, as the interaction between cargo bikes and motorized vehicles increases the possibility of traffic accidents. All the above factors need to be considered via various public policies that are not isolated countermeasures but form part of Sustainable Urban Mobility Plans that are currently being implemented in many European cities to ensure continuity and create a sustainable future.

**Keywords:** cargo bikes; sustainable mobility; city logistics; sustainable freight transport; bike mobility



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## 1. Introduction

The supply chain sector is on the rise as it plays a crucial role in driving economic development and globalization [1]. However, the environmental repercussions of logistics and freight transport have become more pronounced. In today's world, a grand majority of the global population resides in urban areas, while by 2030, approximately 60% of the world's population will be concentrated within urban areas [2]. The continual growth of urban populations and the expansion of city territories contribute to a higher demand for urban freight activities, known as city logistics [3]. This gives rise to a range of issues, including escalating traffic congestion, air and noise pollution, road accidents, energy consumption, and substantial greenhouse gas emissions from fuel use [4]. According to the European Union's analysis, road freight transport represented 76.3% of total land freight transport in 2021, followed by rail transport at 17.6% [5].

In recent years, there has been a growing consensus regarding the imperative to decrease carbon emissions as a critical step in slowing down and mitigating the impacts of climate change [6]. Governments and various organizations have been establishing objectives in line with the Paris Agreement, which was adopted by 196 countries in 2015.

This agreement aims to prevent global warming from surpassing 2 °C and places significant emphasis on curbing carbon dioxide ($CO_2$) emissions due to their profound effects on economic progress and societal well-being [7]. Nevertheless, among the economic sectors posing the most formidable challenge in emission reduction is the realm of logistics and transportation, primarily due to its heavy reliance on fossil fuels and the sector's expansion propelled by globalization [8]. As highlighted by McKinnon, carbon emissions associated with logistics are predominantly attributed to the global freight transportation sector, accounting for 80% to 90% of the total [8].

According to the International Energy Agency (IEA), the transportation sector was responsible for 24% of the world's $CO_2$ emissions and 41% in Latin America in 2019 [9]. This underscores the significance of curtailing carbon emissions within the logistics and transportation industry, a pursuit commonly referred to as logistics decarbonization. Within this context, green logistics emerges as a comprehensive framework encompassing a spectrum of strategies aimed at achieving logistics decarbonization and the fulfillment of sustainability objectives [10]. These strategies encompass a range of measures, including transitioning to more environmentally friendly modes of transportation, advancing the development of greener vehicles such as airplanes and ships, optimizing vehicle usage, refining vehicle routing protocols, and enhancing fuel efficiency in the road freight domain [11].

However, according to the reviewed literature, it was not until 1990 [12] that the significance of green logistics was acknowledged as a substantial economic and social concern. Since the early 1990s, businesses have been compelled by environmental regulations and consumer expectations to integrate environmental considerations into their supply chain management practices [13]. Historically, the responsibility for ensuring environmental integrity was divided across various functions like new product development, planning, marketing, supply chain, and waste management. Yet current trends underscore the need to integrate environmental management into day-to-day operations [12]. This not only complicates supply chain dynamics but also introduces conflicts between ecological and economic demands [14].

Environmental considerations can influence various logistical choices throughout the supply chain's lifecycle, including transportation planning, site selection, and choice of transport mode, among others [13]. In this study, we focus on transportation, a pivotal factor at the operational level of green logistics. Transport activities result in significant negative impacts on the environment, such as congestion, road accidents, oil dependency, noise, and air and water pollution. Therefore, efficient and effective utilization of transport resources, encompassing vehicle selection, delivery scheduling, freight flow control, and fuel choice, among other factors, can help mitigate these issues. However, these decisions also reflect strategic responses to a range of factors like external conditions, company attributes, and available technology [15].

Hence, substituting a portion of conventional vehicle deliveries with alternative, eco-friendly transportation modes could substantially curtail global negative impacts. This would encompass improvements in road safety, enhanced comfort through reduced conflicts between heavy vehicles and vulnerable road users, better air quality, reduced congestion, cost savings, and increased trip time reliability. In essence, addressing the adverse consequences of urban freight transport through the strategic replacement of cars with more environmentally friendly alternatives is viable and could bring about immediate changes in commuting impacts for both urban and rural areas.

Numerous studies have examined the integration of cargo bikes into the supply chain, particularly for last-mile transportation tasks. The anticipated benefits indicate their suitability for a significant portion of freight movements [16]. Furthermore, a considerable enhancement in road safety is noted due to accident reductions [17,18]. Nowadays, in addition to cargo bikes, drones are increasingly finding use in various commercial applications as well. The objective of this paper is to transfer knowledge to researchers, the private sector of logistics, and policymakers by identifying factors that are related to cargo bike adoption, so that cargo bike implementation may become possible to a larger degree and

deliver even more value and benefits to logistic companies and whole communities that are directly or indirectly impacted by the current shortcomings of the conventional methods of last-mile delivery. Moreover, in order to enhance the scope of the present study, two research questions have been established and can be appreciated in the following lines:

RQ1: What are the enablers and challenges related to the urban environment's components that can facilitate or hinder the usage and adoption of cargo bikes?

RQ2: How can the aforementioned components be associated with public policy schemes and measures in order to promote sustainable mobility?

The structure of the paper is as follows. Section 2 presents the research method followed to perform the systematic literature review. Section 3 provides the results and discussion parts of the paper, in particular providing information about the factors and the parameters that have been identified, via the systematic literature review, and are capable of affecting the utilization of cargo bikes. Section 4 provides the conclusions of the paper and proposes directions for future research on the issues of sustainable freight transport.

## 2. Research Method

The authors implemented a systematic literature review in order to distinguish the underpinning factors of the phenomenon examined (the promotion of cargo bike usage) and the elements that need to be investigated even further via data analysis to assist the establishment of sustainable mobility schemes in freight transportation.

A systematic literature review (SLR) stands as a potent methodology within the realm of social science research. It revolves around the meticulous process of systematically pinpointing, assessing, and amalgamating all accessible data related to a specific effect or topic area [19,20]. In contrast to the conventional narrative literature review, an SLR adheres to a set of principles designed to minimize potential biases in the selection of studies [21,22]. By amalgamating research outcomes, an SLR presents a higher-level overview of evidence [23], rendering it satisfactory for constructing a distinct theoretical foundation that contextualizes the pivotal concepts influencing the adoption of cargo bike usage in the sector of city logistics and more specifically in last-mile deliveries.

Our systematic literature review aligns with the methodological approach utilized by Bask and Rajahonka (2017), Yigitcanlar et al. (2020), Tsigdinos et al. (2022), Bretones and Marquet (2022), and Oliveira et al. (2017) [24–29]. Initially, in the first stage, termed "Designing", the formulation of the research questions (RQ1 and RQ2 seen previously) that will guide the research are established, along with a systematic review protocol. The next stage is related to the determination of the location of the relevant literature. In this stage, the search database and also the search keywords are defined. Following this, the next stage, denoted as "Implementation", encompasses the execution of the review procedure by applying the specified criteria for inclusion and exclusion. The inclusion criteria were established to consider matters such as source type (we decided to use only peer-reviewed journals), the language used (we decided to utilize papers written in English), and date of publication (due to the dynamic nature of the cargo bike concept, only papers published within the last ten years were selected). Lastly, the final stage, referred to as "Concept Identification", entails the synthesis of results focused on the objectives at hand, considering the characterization and analysis of the identified articles.

First, a research strategy was devised by Yigitcanlar and colleagues (2019), outlining key elements such as research objectives, inquiry topics, search terms, and criteria for including or excluding materials [29]. The primary objective of this research was to uncover transformative concepts and predominant viewpoints concerning the promotion and adoption of cargo bikes in sustainable freight transportation. Consequently, a diverse array of search terms was compiled into four distinct groups. The first group, centered on vehicle characteristics, encompassed terms like "bicycles", "cargo bikes", and "electric cargo bikes". The second group, focusing on sustainability and urban planning, featured terms such as "emerging cycling cities", "sustainable freight mobility", "commuter cyclists", and "sustainable urban logistics plan". The third group, addressing traffic safety

and behavior issues, included terms like "cycling motorists crashes", "fear of traffic", and "bicycle safety". Lastly, the fourth group, related to the urban environment, incorporated terms such as "bicycle infrastructure" and "cycling facilities". This comprehensive list of keywords reflected the holistic nature of the research.

The inclusion criteria were established to include English-language academic journal articles aligning with the research objectives, published after 2013 due to the dynamic nature of cargo bike adoption in sustainable freight mobility. Conversely, "grey literature", such as conference proceedings, books, and technical reports were excluded to maintain the quality of selected papers [30]. The search process was conducted through Scopus.

In the second step of the research process, a keyword-based search was carried out in August 2023, spanning one month. Initially, this search yielded a total of 30,459 articles, including journal articles and conference proceedings in various languages available on Scopus. Subsequently, by filtering for papers written in English and published between 2013 and 2023, the number was reduced to 9820 papers. These underwent a title and abstract screening, and only those found relevant were further examined for consistency and precision in relation to the search keywords [31]. This initial screening identified 128 papers, whose full texts were then reviewed in light of the research objectives. Ultimately, this process yielded a review pool consisting of 33 articles, which were subsequently categorized, analyzed, and thoroughly reviewed. The entire literature selection process is visually represented in a PRISMA diagram (refer to Figure 1) to ensure transparent and comprehensive reporting of the systematic literature review (SLR) process [32].

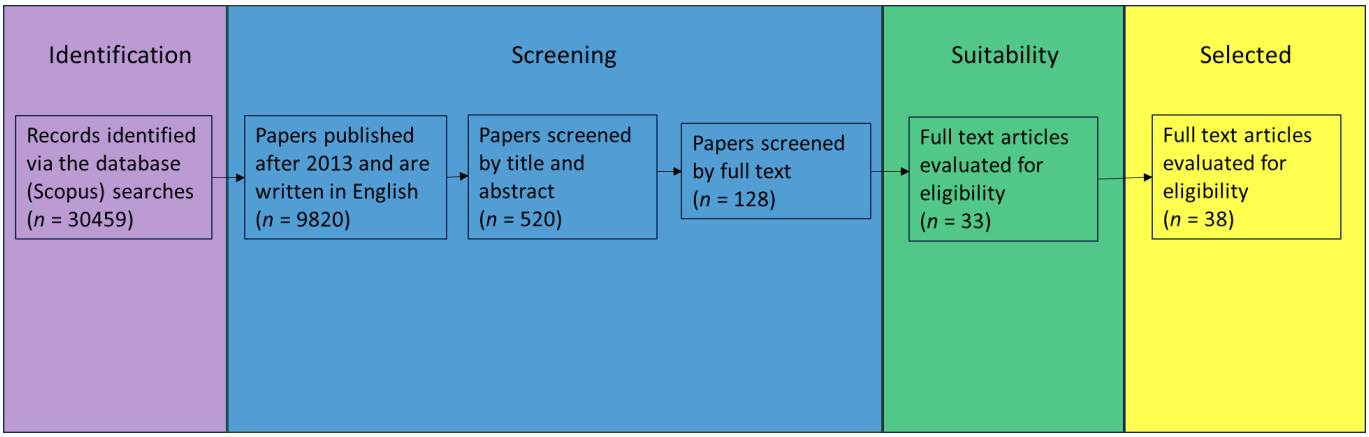


**Figure 1.** PRISMA scheme and number of papers processed in every stage.

In the third step of our research process, which involves reporting and concept identification, our efforts were centered on articulating and conveying our discoveries related to the evolving ideas connected to the use of cargo bikes within the context of sustainable freight mobility. More specifically, we engaged in a synthesis procedure where we emphasized and amalgamated various elements to articulate the aforementioned concept. During this phase, we also incorporated other publications authored on the same subject as supplementary sources of literature to gain a deeper understanding of the issue and enhance the quality of our findings. In total, we examined and referenced a collection of 38 sources.

## 3. Results

In total, 38 papers were identified that met the inclusion criteria mentioned before. Ten examined infrastructure related to the adoption of cargo bikes [33–42]. Five papers examined land use and cycling crash parameters as indicators to measure bicyclist safety [43–47]. Seven papers examined injury risk and safety perceptions to facilitate the transition toward cycling [40,48–53]. Six were associated with modeling approaches and route choices in order to enhance the decision making of people [41,53–57]. Four more papers examined the sector of city logistics [58–61], while four more works are related to environmental

factors affecting cyclists' experiences and cargo bike usage [62–65]. The last two papers are associated with cargo bikes and the travel patterns of vulnerable groups along with the relationship between cyclists and air pollution [66,67]. All of the studies, as mentioned before, had been published since 2013 in international peer-reviewed journals in order to assure the quality of the selected corpus. Most of the study designs were observational.

Sixteen of the studies were published in public health-related journals (mainly *Accident Analysis & Prevention*, *Traffic Injury Prevention*, *BMC Public Health*, and the *Journal of Safety Research*), and seventeen were published in transportation engineering journals (mostly the *Transportation Research* family such as part A: *Policy and Practice*, part C: *Emerging Technologies*, part F: *Traffic Psychology and Behaviour*, *Transport Research Procedia*, along with *Research in Transportation Business and Management*). The remaining studies were published in several high-quality journals like the *American Journal of Economics and Sociology*, *Environment and Behavior*, *Landscape and Urban Planning*, *Sustainability*, and *Environmental Monitoring and Assessment*.

Through the literature analysis, the following factors/parameters were identified as the ones mainly affecting the routes of cyclists and the feeling of cyclists' safety that can severely affect the usage and adoption of cargo bikes in a negative way.

### *3.1. Bicycle Infrastructure*

Existing bicycle infrastructure (either as bicycle lanes or separated cycling routes) is one of the main factors that increase safety (both objective and subjective) for cyclists [33,34,68,69]. On-road bicycle lanes, as well as segregated cycle infrastructures, are safer and are associated with lower accident probability compared to co-existing (bikes and motorized vehicles) bicycle conditions on major roads [35,43]. Segregated infrastructure in particular is safer and significantly increases safety levels in suburban areas [44]. The existence of on-road bicycle infrastructure at signalized intersections is a critical parameter to consider for the reduction of traffic accidents [36]. Comparing the two (separated and shared bike lanes), separated bicycle infrastructure is considered safer than shared infrastructure on main roads [48]. Additionally, many cyclists do not wish to ride with cars [49] while the reverse is also true in order to avoid road accidents. Nevertheless, the above condition applies when the maximum speeds of vehicles are established at 50 km/h or more; with a speed limit of 30 km/h, the coexistence of motorized vehicles and bicycles is considered safe. Moreover, protected cycle lanes (semi-separated) are also considered safe by many cyclists [37]. However, some cargo bike users do not prefer physical separation methods, as their vehicle is wider and can be trapped within this type of infrastructure. Mixed bus–bike infrastructures, although generally unpopular among less experienced cyclists, as they do not make them feel safe, are preferred by some cargo bike users as these lanes are much wider than normal bike lanes [50].

### *3.2. Street Lighting Elements (Horizontal Signings, Public Lights)*

Lack of lighting increases the likelihood of an accident [33,34,68] and is often a cause of road crashes [51]. Street lighting elements (horizontal reflective markings, light poles, etc.) are beneficial because they make points visible that would otherwise be dangerous and could cause cyclists to fall, such as curbs, road narrows, etc. [45]. Furthermore, low-light conditions can cause driver fatigue, decreasing reaction times and increasing the likelihood of accidents. Although cyclists tend to avoid traffic lights on their routes, the presence of traffic light signaling increases their feeling of safety [54,62]. In general, street lighting elements such as public lights have the capacity to enhance the overall safety feeling of an area and mitigate crime phenomena [70]. It is imperative for governments, city planners, and transportation authorities to prioritize the implementation of effective street lighting in order to safeguard the well-being of road users during darker hours.

### *3.3. Number of Car Lanes*

The increase in cyclist risk appears to be proportional to the number of road traffic lanes, as more accidents occur on roads with more than two traffic lanes per direction [71]. Such a result is logical because on such roads, cars accelerate more, and therefore cyclists become more vulnerable. The feeling of safety is also lower on two-lane roads in comparison to one-lane roads [49]. Boettge et al. (2017) concluded that road hierarchy (highway, arterial, collective road, etc.) and the number of traffic lanes are also significantly correlated with the level of stress experienced by cyclists [38]. Finally, it should be mentioned that one-way roads increase accidents in urban centers but limit them in suburban areas [44]. This conclusion should be examined further because the majority of roads within historical centers are one-way roads and are capable of attracting lots of people.

### *3.4. Width of Road Lanes and Bike Lanes*

What significantly affects safety is also the width of road lanes, with wide roads being able to increase the possibility of accident occurrence [33,34,68]. In particular, the research of Hamann and Peek-Asa (2013) showed a 37% increase in the probability of an accident occurrence for every 3 m increase in the total width of the road [39]. Street width was also significantly associated with the sense of safety [52], as narrow streets can reduce cyclists' feeling of safety [62]. Inversely proportional is the relationship of safety with the width of cycleways, where a higher probability of an accident occurs when the width of a one-way bike lane is minimal (i.e., 1.5 m) [70]. The feeling of safety is also greater for wider bicycle lanes (3 m) [72]. The latter are very useful for cargo bike usage as they are wider than conventional bikes [50].

### *3.5. Slopes*

Another parameter that is directly related to lower safety levels and consequently constitutes an inhibiting factor for bicycle utilization is the factor of uphill and downhill slopes, which considerably increase the probability of an accident [68] and the likelihood of injury for cyclists [35,72]. Cyclists also consistently choose routes with the least uphill slopes [73]. According to Broach et al. (2012), cyclists are willing to travel significantly more kilometers on an alternative flat route instead of traveling just 1 km on a road with a 6% slope or more [74]. In general, cyclists avoid roads with uphill slopes [54,57], and it is obvious that the same tendency is valid for the case of cargo bikes as they are heavier vehicles.

### *3.6. Bicycle Infrastructure in Pedestrianized Areas*

The most numerous and serious accidents occur in mixed bicycle–pedestrian infrastructures. Only 1/5 of cyclist accidents are related to motorized traffic [46]. Similar investigations, indicating significant rates and numbers of accidents due to pedestrian involvement with cyclists, have also been carried out by Poulos et al. (2015) and Gustafsson and Archer (2013) [47,75]. Also, the proximity of cyclists to pedestrians often creates a sense of insecurity [51]. The primary reason for the prevalence of significant accidents between cyclists and pedestrians occurring in pedestrianized areas is the shared space, where pedestrians and cyclists coexist in a confined environment meant primarily for walking. Within this framework, several elements need to be considered, such as the lack of clearly defined and separate spaces for cyclists and pedestrians, the differing speeds among cyclists and pedestrians, and increased pedestrian activity, which can create congestion and make it challenging for cyclists to navigate safely.

Addressing these issues requires a comprehensive approach that involves urban planning, infrastructure development, and educational initiatives. Designing pedestrianized areas with well-defined lanes, clear signage, and appropriate traffic management measures can help minimize accidents and enhance the overall safety of these shared spaces. Additionally, public awareness campaigns can educate both cyclists and pedestrians about responsible behavior and the importance of mutual respect in shared environments.

### *3.7. Velocity and Speed Limits*

Speed limits on roads (and by extension the actual speeds that the vehicles are allowed to develop) significantly affect the concept of objective safety and the sense of danger for cyclists. Indeed, most accidents occur for speed limits of 64 km/h and above [70]. When there is no bicycle infrastructure, speed limits constitute one of the most important safety factors [63]. Anxiety increases significantly when there is a speed limit of more than 40 km/h on a certain road [38]. Conversely, cyclists' feeling of greater safety is strengthened by low-speed roads (30 km/h) [71]. That is why cyclists tend to systematically avoid high-speed roads [42,76].

### *3.8. Intersections and Joints*

Much of the literature mentions intersections (signalized or not) as high-risk points for cyclists. Consequently, the number of accidents increases in accordance with the number of signalized intersections [70] that a cyclist encounters on his/her route, as well as non-signalized ones, while intersections are considered even more dangerous in suburban areas because higher velocities can be reached there [44]. In fact, separated cycling infrastructures, which are considered particularly important, do not reduce the risk of accidents at non-signalized intersections. On the contrary, drivers there do not pay attention to cyclists, forgetting their existence, since they move on separate infrastructures, and they are not obliged to stop at traffic lights. On the other hand, signalized intersections do reduce the risk of road accidents by half [40], and most of these accidents are the outcome of red light violations by cyclists. Intersection problems are the most important reason considered when incidents between bicycles and cars occur [51,77].

In comparison between the two (signalized and non-signalized intersections), accidents that generally occurred at signalized intersections are 2.5 times more prevalent than accidents at non-signalized intersections [40]. This paradoxical result can be justified since signalized intersections are often located at the intersections of major arterials. Hence, the vehicles there can reach higher speeds, raising cyclists' feelings of road insecurity. Moreover, people in signalized intersections are confident that everybody will respect traffic lights and therefore they avoid double-checking before starting. Signalized intersections increase the sense of danger for cyclists [53,78], as the highest levels of stress are recorded there [41]. Broach et al. (2012) and Krenn et al. (2014) also identified and showcased the tendency of cyclists to avoid intersections [54,75]. A special mention is also needed for roundabouts, which are judged by Kaplan and Giacomo Prato [44] to be the least safe as they increase the sense of danger [78] and insecurity in accordance with cyclists' perspectives [62].

### *3.9. Traffic Load*

Increased vehicle traffic is a major factor in reducing the safety of cyclists. Traffic load is considerably associated with feeling safe [52], in contrast to light-traffic roads, which were judged to be the most suitable environments [37]. The only exception is observed at saturated signalized intersections, where due to the very low speed of vehicles, the probability of an accident is reduced [36]. Outside intersections, whether there is bicycle infrastructure or not, high traffic density is considered a safety issue [63]. Such roads are avoided by those who use cargo bikes as well, as among other things, the large size of the vehicle does not allow easy maneuvering between cars stopped by traffic [50]. In addition to the increased traffic load in general, the literature also emphasizes the share of heavy vehicles, such as trucks and buses, an increase of which has very serious implications for the safety of cyclists [44], causing feelings of insecurity [70,71]. In a survey in Stockholm and Amsterdam among people who use cargo bikes, the traffic load of heavy vehicles emerged as the most important (negative) criterion for choosing routes [50]. Finally, on roads with significant traffic, cyclists know that they are exposed to dangerous pollutants that affect their health [66].

### *3.10. Sharp Turns*

Lack of visibility due to sharp turns is a frequent cause of accidents [51]; however, particular importance is given in the literature to left turns, which increase the sense of danger [53,77]. According to Zimmermann et al. (2017) and Broach et al. (2012), cyclists do not choose left turns on high-traffic roads, preferring to perform detours to avoid them [57,75].

### *3.11. Routes Length*

Cyclists generally prefer shorter routes [42,57,74], something that is totally expected, since for them, any extra pedaling increases fatigue. On the other hand, as can be seen from previous parameters, cyclists are more sensitive to the characteristics of the environment through which they travel and are therefore willing to increase the length of their route in search of a safer environment. This factor is heavily interconnected with the factor of severe slopes as the latter generally are avoided by cyclists even if this means that they would cover longer distances. In the study by Broach et al. (2012) in Portland, Oregon, one of the attributes considered most important for cyclists' route choice and the actual distance covered was the slope [74]. The researchers found that some cyclists were willing to go 37% longer distances on a flat route to avoid slopes greater than 2%. Winters et al. (2010) claim that there is no consensus on the threshold above which the slope is considered unsuitable for cycling, but in their study, this limit was considered to be 10% [79].

### *3.12. Quality of Road Surface*

The quality of road surface could not be missing from the environmental parameters; its importance is highlighted by Ghekiere et al. (2018) and it is associated with a significant number of accidents [63]. A good pavement surface ensures better handling and control of the bicycle. Cyclists need a stable and predictable surface to maneuver safely, especially when making turns, changing lanes, or navigating through obstacles. Uneven or rough surfaces can make it challenging for cyclists to maintain control. Riding on a smooth and well-paved surface is less physically demanding for cyclists. Rough or uneven terrain can lead to increased vibration and jolts, causing fatigue and discomfort over longer distances. A quality surface allows for a more comfortable and enjoyable cycling experience. Especially for cargo bikes, the quality of pavement is of particular importance as it can seriously affect the health of the cyclist and the condition of the cargo transported [50]. Finally, constant exposure to rough or uneven surfaces can lead to increased wear and tear on bicycle components. A quality pavement surface helps preserve the longevity of bicycles, reducing the frequency of maintenance and replacement of parts.

### *3.13. Bibliometric Analysis*

In addition to the previously identified factors, a co-occurrence analysis helped to determine and agglomerate the most pertinent concepts and terms discussed within the selected articles. This analysis was made feasible via the capacities of the VOSviewer software (version 1.6.20) in clustering the articles' keywords and abstract terms. The result appreciated in Figure 2 suggested the five thematic clusters present in the literature sample:

(i) Road Safety and road crashes (red cluster): contains keywords and terms associated with urban road security and accident prevention;
(ii) Delivery methods via cargo bike usage (yellow cluster): maps the relation between green delivery methods in modern-day cities (city logistics) and the contribution of weather phenomena upon their usage;
(iii) Demographic factors (purple cluster): groups terms related to the adoption of alternative vehicles such as cargo bikes and their usage by vulnerable users (older adults, women, and children);
(iv) Bike infrastructures and schemes (green cluster): fundamentally related to biker-friendly infrastructures like bike lanes, bike facilities, and bicycle paths to transform current roads and facilitate sustainable transportation;

(v) Perceived risk of cyclists (blue cluster): consists of terms associated with cyclists' feelings of security, especially regarding cycle paths and intersections.

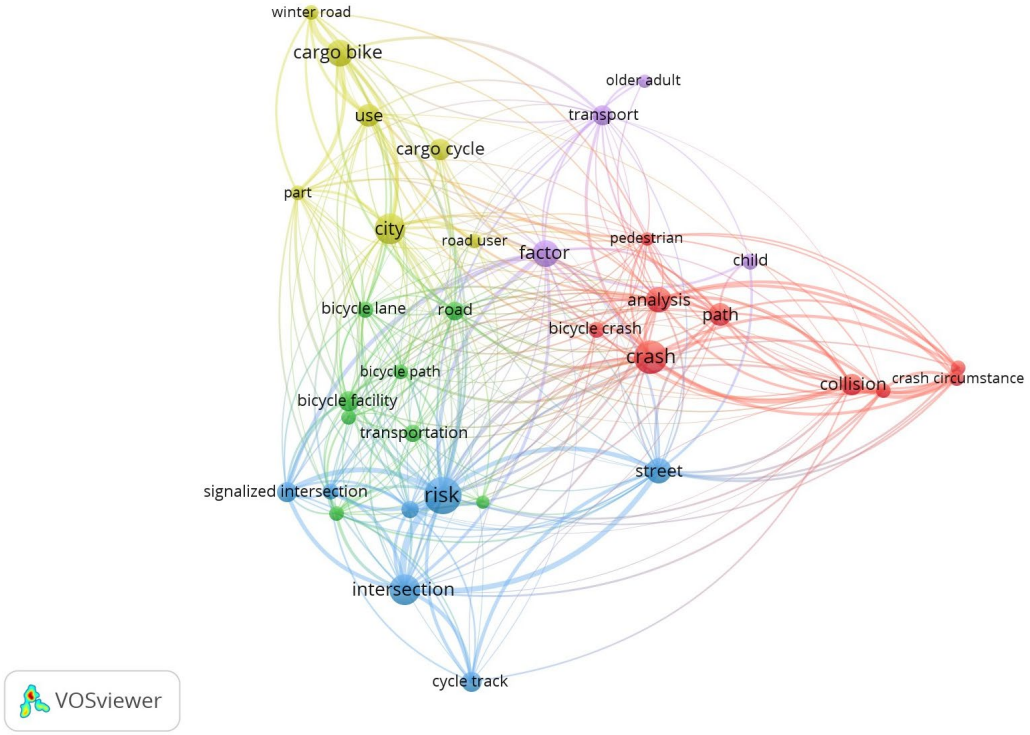


**Figure 2.** Co-occurrence map of the cargo bike literature.

## 4. Discussion

In this research, a systematic literature review has been implemented on the factors that are related to the usage of cargo bikes and can positively or negatively affect the adoption of such sustainable modes to enhance the paradigm of green logistics. The scientific problem solved within this paper is the insufficient knowledge of researchers, the private sector of logistics, and policymakers concerning the identification of factors that are related to cargo bike adoption, so their implementation can become more popular and deliver even more value to logistics companies and society. In more detail, this research can contribute to urban transportation planning and infrastructure development via the understanding of the factors capable of influencing the adoption and usage of cargo bikes in urban areas, via the identification of the infrastructure requirements and challenges associated with integrating cargo bikes into existing transportation systems and the investigation of the role of policies and regulations in promoting or hindering the use of cargo bikes. Hence, this type of review is capable of assisting evidence-based decision-making and policy development in fields related to sustainable transportation, urban planning, and infrastructure development.

The nature of the present study is similar to the studies of Segadilha and PenhaSanches as well as the studies of Nunes de Sousa and Penha-Sanches, Kirner Providelo and Penha-Sanches, and Hardinghaus and Papantoniou [80–84]. All of the aforementioned studies are based on the role that the built environment, traffic features, environmental characteristics, and trip features have on cyclists' route choices. Most of the factors presented here have been determined in the previous studies; nevertheless, two factors were identified in this study that have not been mentioned before and can seriously affect the safety of cyclists; these factors are (a) left turns and (b) sharing pedestrianized roads between pedestrians and cyclists. Hence, the consideration of these two factors constitutes a gap that our study fills in comparison to the studies mentioned previously [79–83]. Furthermore, this study goes a step further and connects the identified factors with public policies pertaining to the powerful Sustainable Urban Mobility Plans scheme to generate considerations associated with cargo bike adoption. This aspect adds a level of applicability, making the

review not only academically valuable but also relevant for urban planners, policymakers, and practitioners.

The field of cargo bike adoption and usage is relatively new and rapidly evolving. Thus, conducting a systematic literature review at this stage will assist researchers in capturing the latest developments and emerging trends in this specific area of study. There is an urgent need for cargo bike adoption to consider holistic perspectives, including urban planning, transportation studies, and public policy. Hence, the systematic review seen in this paper is able to contribute to a comprehensive overview of urban environment factors influencing cargo bike adoption. The novelty of the present study rests in the capacity of the review to identify the essential factors that consistently emerge as influencers of or barriers to cargo bike adoption. This synthesis can provide a clearer picture of the most critical determinants, offering valuable guidance for future research and policy development. However, beyond identifying factors, our systematic review can also highlight the policy implications and practical considerations associated with cargo bike adoption. This aspect adds a layer of applicability, making the review not only academically valuable but also relevant for urban planners, policymakers, and practitioners.

The usefulness of the proposed research lies in its capacity to transfer knowledge to researchers, the private sector of logistics, and policymakers, by identifying the factors that are related to cargo bike adoption, so their implementation can become more popular and deliver even more value to logistics companies and society.

A systematic literature review based on the factors related to the usage and adoption of cargo bikes can have several theoretical implications, contributing to the development and refinement of existing theories in various domains. Here are some potential theoretical implications:

- Sustainable transportation theories: this review may contribute to theories related to sustainable transportation by providing insights into the role of cargo bikes in promoting environmentally friendly and sustainable urban mobility. It can also explore how factors such as perceived and objective safety as well as convenience contribute to the adoption of sustainable transportation modes.
- Behavioral change theories: understanding the factors influencing individuals' decisions to adopt cargo bikes can contribute to behavioral change theories. This review may shed light on the psychological and social factors that play a role in the decision-making process related to alternative transportation choices.
- Urban planning and design theories: this literature review will have implications for theories related to urban planning and design by exploring how cargo bikes fit into the broader context of urban mobility. Hence, it can contribute to discussions on designing bike-friendly infrastructure and integrating cargo bike usage into urban transportation planning.
- Policy and regulation theories: the exploration of policies and regulations influencing cargo bike adoption has the capacity to contribute to theories related to policy implementation and regulatory impact. This review will highlight the role of government interventions and incentives in shaping transportation choices.

The present study can be enriched by participatory methods to rank the above factors and help researchers, practitioners, and policymakers improve their paradigm for freight transportation and urban logistics toward green and clean solutions. Furthermore, the urban fabric differs from city to city and region to region, each offering its own challenges and opportunities. Extending research to these different urban contexts is crucial in determining the true potential of cargo bikes. By examining the adaptability of cargo bikes in different environments—from densely populated metropolitan areas to sprawling suburban landscapes—we can identify the specific barriers and facilitators in each context. Such a comprehensive approach would not only provide a holistic view of the potential of cargo bikes but also provide customized strategies for their successful integration into different urban ecosystems.

In addition, future research can explore the integration of smart technologies, automation, and advanced materials in cargo bikes. For example, the integration of real-time tracking, route optimization, and energy-efficient systems can significantly improve operational efficiency. Ultimately, the success of any transportation planning depends not only on its functional characteristics but also on how it fits with the behavior and perception of its users and those with whom they share the road. Understanding the behavioral dynamics associated with cargo bikes is critical. This includes examining the motivations, fears, and preferences of cargo bike users as well as the perceptions and reactions of pedestrians, motorists, and other road users. From these findings, strategies can be derived that promote harmonious coexistence on the roads and ensure safety, efficiency, and positive acceptance of cargo bikes in the urban transport mix.

## 5. Conclusions

In modern societies, the mass accumulation of people in urban centers has led to increased emissions of carbon dioxide. The goal of modern urban centers, especially because of the climate crisis, is to reduce these pollutants. Therefore, the integration of cargo bicycles in freight transport can contribute to the achievement of this goal. The benefits derived from the use of cargo bikes in urban freight transport are important because they contribute to society by reducing greenhouse gasses, reducing congestion, and reducing air pollution and noise. In this context, the purpose of this article is to identify the environmental features and elements that are important to bicyclists during their commute in order to promote and facilitate the use of cargo bicycles. Overall, bicycles, whether e-bikes, cargo bikes, or others, are key to transitioning to sustainable urban mobility and making our cities carbon neutral. Well-connected urban transport systems combining bikes, public transport, and trains need to be introduced and combined with measures that actively discourage the use of private cars to make our cities livable, citizen-centric, and sustainable.

### *5.1. Theoretical and Managerial Implications*

Traffic load, speed limits, and heavy vehicle traffic were identified as the most important factors for the increased use of cargo bikes. The study found that increased traffic volumes and higher speed limits pose a greater risk to cyclists. Cyclists also feel particularly uncomfortable when riding alongside heavy vehicles, as the number and severity of accidents increase when the proportion of heavy vehicles in the traffic composition is high. Cycling infrastructure is also an important factor in the acceptance of cycling, as it forms the backbone for comfortable and safe cycling. Two other factors that can strongly influence cyclists' perception of safety are road intersections and the width and number of lanes, as the interaction between cargo bikes and motorized vehicles increases the possibility of traffic accidents.

All of the above factors can be interlinked and addressed through various public policies that are not isolated countermeasures but are part of the powerful tool of Sustainable Urban Mobility Plans currently being implemented in many European cities to ensure continuity and create a sustainable future. Sustainable Urban Mobility Plans are robust tools that help cities reduce the environmental, economic, and social impacts caused by fragmented mobility systems that prioritize the use of private vehicles. The development of these plans requires that decision-makers understand the complexity of mobility planning as a guiding axis of urban development.

The policies that form part of Sustainable Urban Mobility Plans that have been identified as closely related to cargo bikes' environmental factors can be seen in the following lines:

- Reorganization of road network hierarchy and speed limit reduction.
- Creation of peripheral roads around the settlements to avoid through flows.
- Upgrade of intersections in the road environment to enhance road safety.
- Creation of exclusive and mixed-use cycling infrastructure and bicycle parking spaces.
- Implementation of traffic-calming measures.

- Creation of a smart freight supply system with innovative tools.
- Promotion of Urban Air Mobility schemes.
- Traffic management of heavy vehicles.
- Replacement of asphalt paving materials on the streets.

Therefore, it is crucial to prioritize the consideration and implementation of these policies to support the sustainable mobility paradigm, particularly in relation to cycling and non-motorized transportation approaches. Furthermore, it is important to note that a successful implementation of a Sustainable Urban Mobility Plan should take into account the following characteristics:

- Establishing clear and measurable objectives that are easily understood, evaluated, and monitored by both the government and the public.
- Promoting integration among the environmental, land-use, and transportation sectors to foster sustainable urban development.
- Encouraging participation by facilitating communication between the government and civil society, involving people in the urban management process, and promoting co-management.
- Maintaining a long-term perspective by ensuring that the plan has the necessary tools and public institutions in place to guarantee its continuity over time.
- Striking a balance between economic development, social equity, and environmental quality within the city.

### *5.2. Research Limitations*

While this systematic literature review is a useful tool for synthesizing existing knowledge and identifying patterns in research on cargo bikes, it also has certain limitations. The restriction to studies published in English may lead to a certain bias, as relevant high-quality research published in other languages is excluded, limiting the validity of the study. In addition, the quality of the individual studies included in the review may vary. Some studies may have limitations in terms of design, methodology, or data collection, which may affect the overall reliability of the conclusions of the review. We have tried to keep the quality of the studies as high as possible by excluding gray literature. However, there are still high-quality papers published as gray literature that we have not included. Although we have tried to keep our review as comprehensive as possible, it is possible that certain factors influencing the adoption of cargo bikes have not been taken into account. Unexplored dimensions or emerging factors may not be adequately represented in the literature, especially when considering social factors such as social norms, mobility cultures, and land-use types. Finally, the process of selecting studies and defining inclusion criteria involves a degree of subjectivity. In our case, for example, it was decided to review papers published between 2014 and 2023, published in peer-reviewed journals, and written in English. Different reviewers may make slightly different decisions, leading to variations in the scope and content of the review.

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