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Effects of freight curbside management on sustainable cities: Evidence and paths forward

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ABSTRACT

Freight curbside management has become a contentious issue as various stakeholders claim access to public urban space. Although prior research has offered solutions to mitigate freight-related conflicts in the use of space, a deeper understanding of the extent to which those interventions contribute to cities' sustainable development goals is needed. This paper presents the results of a *meta*-analysis that examines the effects of four freight curbside interventions: curbside space allocation for freight, data sharing, parking duration limits, and enforcement. The paper pinpoints benefits and drawbacks of those interventions on last-mile deliveries, the urban environment, and the use of public transport infrastructure. The findings suggest positive impacts and underscore the necessity of incorporating people-centred approaches in the design, implementation, and evaluation of policies concerning public space. Nevertheless, trade-offs when implementing those interventions have been identified. The paper concludes by outlining directions for future research and suggesting implications for urban freight policies.

1. Introduction

Urbanisation has steadily increased, such that more than 56 % of the global population resided in cities in 2021, a number that is projected to reach 68 % by 2050 (UN-Habitat, 2022). Parallel to that trend, the e-commerce retail market has quadrupled in size in the past decade (eMarketer, 2022), especially during the COVID-19 pandemic (Jaller & Dennis, 2023). In turn, urbanisation, emerging transport technology, and intensified demand for freight (e.g. driven by e-commerce) have exacerbated the shortage of public space. Currently, public space comprises, on average, less than 20 % of the cities' surface worldwide (UN-Habitat, 2021), which falls short of the recommended range of 30 %–45 % proposed by UN-Habitat. Consequently, citizens' quality of life is being threatened due to imbalances between the supply and demand of public space (Papachristou & Rosas-Casals, 2018) and the lack of effective tools for managing and controlling space utilisation to achieve sustainability goals (Butrina et al., 2020).

Public space comprises several types of urban areas—streets, boulevards, beaches, parks, squares, and plazas, among others—-where the segment including roads, curbs, and sidewalks (i.e. streets), constitutes more than 80 % of public space in cities. In playing host to more than 160 distinct uses that satisfy movement, place-making, and environmental functions (Allen & Piecyk, 2022), streets thus play a pivotal role in advancing urban sustainability.

The on-street (un)loading of goods in urban areas occurs amid intricate competition for street space. Such competition arises due to

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the scarcity of such space and the rising demand for freight deliveries along with parking for private cars, sidewalks for pedestrians, bike lanes, space for street furniture and al-fresco dining, parking for e-scooters and bikes, public transport stops, construction sites, and space for service vehicles, among other competing needs. Consequently, the management of street space for freight deliveries has become a source of debate, with different users asserting their right to access such a public urban asset (Castrellon et al., 2024).

Although past research has proposed solutions to improve conditions for on-street freight (un)loading (Comi et al., 2022), or "freight curbside management", the associated implications for sustainability have received only partial consideration. Moreover, freight operations have traditionally been overlooked in urban planning and strategies for liveability (Williams & Carroll, 2015). Those gaps in research and practice highlight the need for a more comprehensive understanding of how freight curbside management leverages urban sustainability targets, such as those outlined in the UN's Sustainable Development Goals (SDGs). As awareness grows about the importance of addressing the freight curbside management in both research and urban mobility planning, bridging the mentioned gap becomes increasingly relevant.

Therefore, this paper's aim is to investigate the different approaches documented in the literature for freight curbside management and to analyse their impacts on SDGs related to sustainable cities and communities. To that purpose, a *meta*-analysis of sustainability-related impacts of freight curbside management based on a systematic literature review was conducted that included data from 57 academic publications and grey literature. The analysis considered key performance indicators such as delivery time, emissions, occupancy rate, cruising, last-mile cost, and parking violations, as well as empirical evidence, context(s) studied, and methods employed. Such a *meta*-analysis of reported cases worldwide informed the identification of future courses of action in terms of policy and research in freight curbside management.

The rest of this introductory section describes SDGs targets related to sustainable cities, along with recent trends in managing public space and freight curbside management. Section 2 presents the methods adopted in the study, while Sections 3 and 4 provide the results and discuss them, respectively, by examining the implications of freight curbside management on SDGs targets. Section 5 concludes the paper by indicating directions for future research and insights for urban planners.

1.1. UN's sustainable development goals

In 1987, the Brundtland Report launched one of the first definitions of *sustainable development* as development that "meets the needs of the present without compromising the ability of future generations to meet their own needs" (World Commission on Environment and Development, 1987). That definition points to three fundamental components of achieving sustainable development: economic growth, social equality, and environmental protection. Because cities generate 70 % of global emissions, host more than 50 % of the global population, and contribute to 85 % of the global GDP, they are in the spotlight of sustainability-focused actions. At the city level, sustainable development implies overcoming challenges regarding air quality, modal shift, road safety, decarbonisation, and congestion, among others (Papachristou & Rosas-Casals, 2018; Węziak-Białowolska, 2016).

Aware of the relevance of policies and practices aimed at providing conditions of accessibility, equity, and safety in cities, the United Nations (UN) has explicitly mentioned targets for urban liveability and the efficient use of public space in one of the seventeen SDGs—namely SDG11, "Sustainable Cities and Communities", which promotes "policies and actions that leverage universal access to safe, inclusive, and green public spaces" (United Nations, 2015). Regarding public space, SDG11 entails measures about the effectiveness of managing competing demands for public space for uses that respond to human needs for social interaction, mobility, access to supplies, economic activation, and healthy environments. Emanuel et al. (2020) have paraphrased the UN's definition of *sustainable development* as involving the fair allocation of urban space, whereby "one person's mobility does not come at the expense of another's mobility in the present or future generations".

SDG11 also focuses on boosting capacities for urban planning, improving public transportation access, and enhancing waste management. Along those lines, 4 of 10 of SDG11′s targets relate to the implementation of actions in accessing public space and healthy urban environments that suit the scope of this paper (see Table 1).

UN-Habitat utilises the targets shown in Table 1 to facilitate and monitor advancements in urban development and to call for action in cities across the world in response to gaps in current efforts to reach those targets. For instance, regarding Targets 11.3 and 11.a, the

Table 1
Targets of SDG11 included and excluded in the study.

Target	Description	Included in the study?
11.1	Proportion of the urban population living in slums, informal settlements, or inadequate housing	No
11.2	Proportion of the population with convenient access to public transport, by sex, age, and persons with disabilities	No
11.3	Participation of civil society in urban planning and management	Yes
11.4	Strengthened efforts to protect and safeguard the world's cultural and natural heritage	No
11.5	Effects of disasters and related economic losses on people	No
11.6	Mean levels of fine particulate matter	Yes
11.7	Average global share of the urban area allocated to streets and open public spaces	Yes
11.a	Development of urban public policies	Yes
11.b	Implementation of integrated policies and plans for inclusion, resource efficiency, mitigation and adaptation to climate change, and disaster risk management	No
11.c	Support of the least-developed countries in building sustainable and resilient buildings using local materials	No

Source: UN-Habitat (2021).

adoption of sustainable urban mobility plans is recommended and monitored. In turn, stakeholders' involvement and interdisciplinary dialogues are cited as the cornerstone for addressing issues concerning transport decisions (UN-Habitat, 2022). As for Target 11.6, actions are encouraged to reduce the exposure to particulate matter (i.e. PM2.5) in cities, for instance, according to this measure, only 18 of 2457 cities worldwide met the guideline for the average annual concentration of PM2.5 (i.e. 5 $\mu g/m^3$) in 2019 (World Health Organisation, 2021). Data pertaining to Target 11.7 also showed a concerning trend: that more than three-quarters of the 1072 cities monitored (UN-Habitat, 2021) allocated less than 20 % of their total area to open public spaces and streets in 2020, thereby falling significantly short of the recommended proportion that is at least twice that size. Those disparities highlight the limited availability of open public spaces in urban settings and the environmental challenges that need to be addressed with policies and active participation of communities.

1.2. Recent trends in public space management

Public space management plays a central role in meeting the above challenges and building liveable cities. Despite the local scope of public space management, balancing the supply of and demand for open public spaces is a matter of international relevance. Following the UN's guidelines and targets, cities worldwide are moving towards building more liveable environments. For instance, recent policies concerning mobility focus on increasing space for human interaction, promoting active and mass modes of transportation, and reducing congestion and pollution levels. Such is the case in Paris, where up to half of the street parking capacity will be removed by 2025. Amsterdam is also removing 10,000 parking spots in its city centre, while Stockholm is implementing a plan for dynamic curbside parking spaces.

Nonetheless, when extrapolating that policy to freight delivery operations, unintended outcomes result because demand and modal choice for freight vehicles differ wildly (Malik et al., 2017). For example, whereas commercial establishments are part of strategies for activating streets, little attention has been paid to the demand for curbside parking space for freight (Al-Turjman & Malekloo, 2019). Similarly, home deliveries are part of consumption trends that the COVID-19 pandemic has accelerated and that now require special attention in terms of fair access (Sanchez-Diaz et al., 2021) and parking infrastructure to avoid curbside conflicts in neighbourhoods (Macário, 2021). Ignoring freight transport activities in policies and urban plans spawns inappropriate conditions for people and businesses' provision of goods and services, which results in congestion, pollution, and productivity loss. In the specific case of freight delivery operations, limited space for parking and its misuse (e.g. double-parking or searching for parking) are major threats to cities' sustainability (Mingardo et al., 2015).

Thus, for last-mile deliveries, the challenge centres on how to allocate and use curbside space to encourage the efficient movement of goods without hampering environmental and social welfare (Castrellon, 2023). That provision of public space for freight deliveries is physical evidence of an urban dialogue—a back-and-forth conversation between citizens, businesses, and city planners—that is sometimes otherwise ignored or disregarded (Smith, 2020). By engaging different stakeholders in decision-making about freight curbside management, urban planners ensure that priorities in allocating space do not depend on biased influences from actors with political power or ad hoc assessments but on carefully designed plans grounded in an understanding of the demand for freight deliveries and the impacts of curbside management interventions on social, economic, and environmental aspects.

Comi et al. (2022) have argued that the provision of curbside space for freight delivery operations, ideally with loading zones (LZs), ranks among the most promising tools for reducing the negative sustainability impacts of last-mile deliveries in urban areas. Manzano dos Santos and Sanchez-Diaz (2016) found that parking infrastructure is the chief obstacle to efficient urban freight transport from the carriers' perspective. In a global survey conducted by Holguín-Veras et al. (2018), practitioners, freight companies, and society at large praised initiatives for space provisions (e.g. LZs) as effective solutions for problems with urban mobility. In Europe, de Marco et al. (2017) found that 24 of the 70 European cities considered in their study had implemented LZ-oriented initiatives. Aside from allocating curbside space, those initiatives include integrating fragmented data, monitoring the use of curbs, communicating and enforcing rules about such use, and reporting curbside performance (DeBow & Drow, 2019).

Although the impacts of those interventions have been quantified in specific contexts, the perspective of private companies dominates in the literature, often with estimations about savings in last-mile costs and delivery times. By contrast, little research has been conducted from the perspective of city planning, even though it could provide tools and insights for urban planners that inform better decision-making and leverage the achievement of SDGs targets.

Against that backdrop, the aim of the study presented here was to examine interventions in freight curbside management from the perspective of the public sector, particularly by assessing both the benefits for companies and their potential to minimise adverse impacts on cities' sustainability, assessed, for example, through the lens of SDG11′s targets.

1.3. Approaches to freight curbside management

While performing last-mile deliveries, freight vehicles demand curbside space for parking due to limited off-street parking coupled with the need to park as close to destinations as possible. Freight parking operations are part of the microscopic level of the concept of urban freight transport (Sanchez-Diaz & Castrellon, 2023). At that level, public urban space is often provided for freight operations in the form of *(un)loading zones*, typically defined by departments of transportation as areas reserved for loading or unloading goods (Regal-Ludowieg et al., 2022). The set of decisions regarding those LZs is referred to as *freight curbside management*.

The concept of freight curbside management has emerged recently in the academic literature (Olsson et al., 2019). Research on the topic has been encouraged to reflect on ways to transform conflicting conditions on the curb into more sustainable systems with innovative, creative solutions that make the most of the benefits of having dynamic, flexible-use, self-adjusting spaces. Such solutions involve strategic (i.e. long-term), tactical (i.e. midterm), and operational (i.e. short-term) decisions that public and private actors make to enhance the efficiency and sustainability of freight delivery operations (Castrellon et al., 2024). Decisions about LZs concern the number, location, and size of LZs, as well as parking duration limits, monitoring technology, and enforcement, among other aspects. Castrellon et al. (2022) have identified four factors as determinants of successful freight curbside management: data sharing, an understanding of parking durations, dynamic regulations for curbside use, and enforcement capabilities.

The effects of freight curbside management have been measured primarily via microsimulation and optimisation tools to evaluate several performance measures. Butrina et al. (2017) proposed a set of performance measures according to the objectives of curbside management decisions. For the study presented here, curbside management factors, or “freight curbside interventions,” were adapted from Castrellon et al. (2022), and data were collected about their impacts on performance measures in terms of delivery time, last-mile cost, cruising for parking, occupancy levels, emissions, and parking violations (Butrina et al., 2017). Thus, freight curbside interventions are linked to SDG11 depending on the extent to which they impact the selected performance measures (Fig. 1).

Although several researchers have quantified the effects of freight curbside interventions on the performance measures proposed by Butrina et al. (2017), there remain gaps in understanding how such interventions contribute to cities’ sustainability, for instance, in terms of SDG11′s targets. The compilation of case-specific research findings hints at the potential effect of curbside interventions and, in turn, identify fields for the future development and implementation of research and policy.

2. Method

The systematic literature review conducted in the study was designed to support a *meta*-analysis of reported effects of freight curbside interventions on SDG11′s targets.

In general, *meta*-analysis is a technique for extracting quantitative data necessary to conduct a statistical combination of multiple studies (Xiao & Watson, 2017). In the systematic literature review, summary statistics (e.g. performance measures of freight curbside interventions) in each paper were searched for to serve as the dependent variable. Because effect measures vary from paper to paper, the approach described by Ewing & Cervero (2010) was followed, who obtained statistics at comparable scales (e.g. elasticities or percentage of change) by either copying them from published papers, if reported explicitly, or calculating them from regression coefficients or performance evaluation tables. Afterwards, data extraction considered the percentage of change in performance measures of curbside management interventions and linked them to the selected targets of SDG11.

The systematic literature review was built upon the search query (“freight parking” OR “loading zone” OR “loading bay”) AND (“curbside” OR “curb side” OR “kerbside” OR “street”) AND (“impact” OR “effect”) AND (“sustainability” OR “sustainable development” OR “environment”) AND (“urban” OR “city”). To avoid sources of sample bias such as publication bias, Google Scholar was used to access grey literature (i.e. unpublished reports, theses, preprints, and white papers). Publications from Web of Science, ProQuest, and Scopus databases were also included. The search process was conducted in April 2022 and updated in June 2023.

The Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guided the review process (Sarkis-Onofre et al., 2021). The depuration of the initial results consisted of selecting papers based on information from the title and abstract. Only papers that contained the keywords connected coherently to aspects related to the purpose of the research were selected. The screening process ended in the deletion of 143 duplicate results and the filtering out of 375 records that suited the topic of interest. After the deletion and exclusion criteria shown in Fig. 2 were applied, 57 records remained for data extraction.

The selection of papers was based on the possibility of accessing quantitative results regarding the performance measures shown in Fig. 1 when implementing curbside freight interventions. Aside from the summary statistics, information about data collection methods, assessment tools (e.g. microsimulation and optimisation), and context in terms of country, city, and zone of study (i.e. city population, city population density, and congestion index) were extracted from external sources (Tomtom, 2023). Performance measures were assigned to the corresponding targets of SDG11 based on each paper’s aim and practical implications. Appendix A shows the list of the selected papers after the application of the deletion and exclusion criteria of PRISMA.

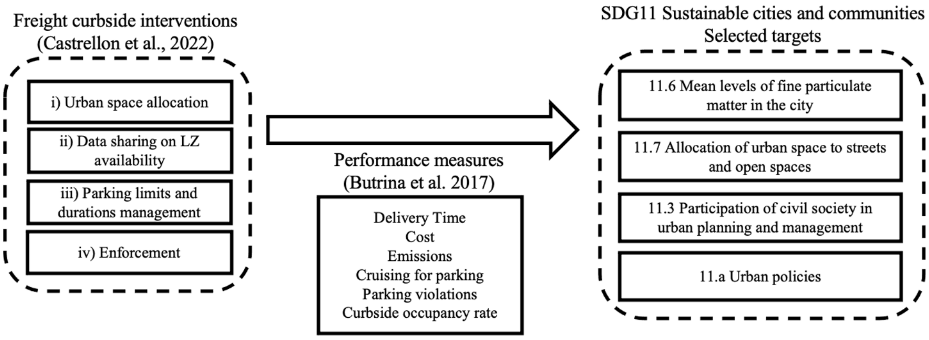

Fig. 1. Framework for assessing freight curbside management impacts on SDG11.

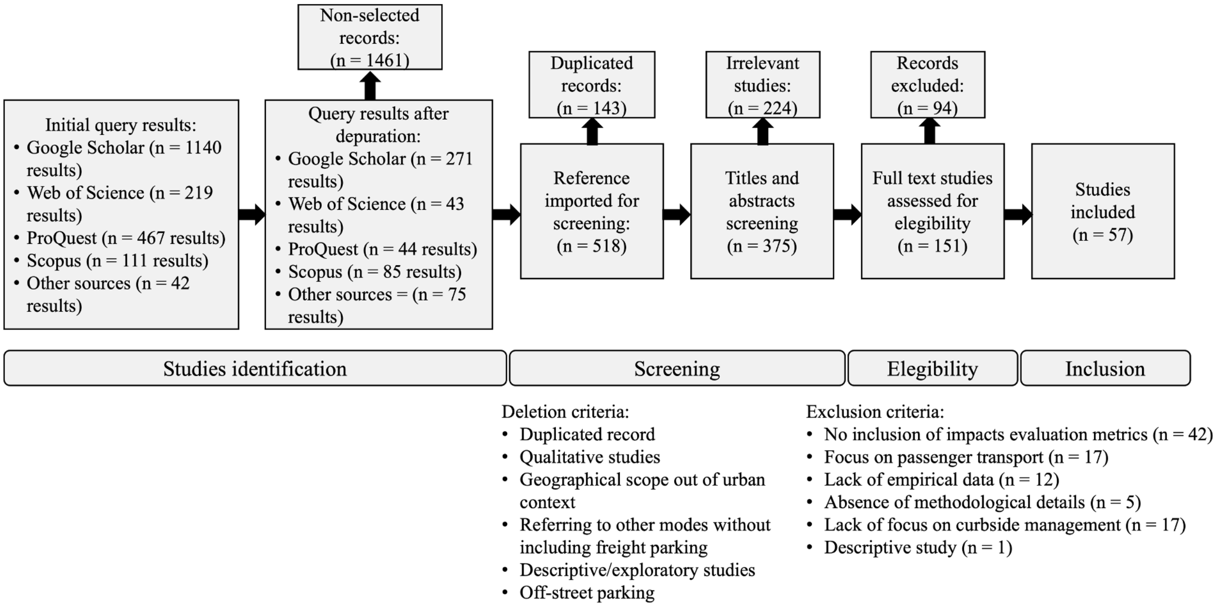

Fig. 2. PRISMA diagram of the systematic literature review.

3. Results

Among the results of the systematic literature review, Table 2 shows the distribution of the cities examined in the papers according to their size and congestion index to clarify the type of cities studied. In total, results from 31 different cities are reported in the 57 papers. As shown, few cities (i.e. 5 of 31) fall in the large category by population (i.e. > 8 million inhabitants). In terms of population density, most cities (i.e. 24 of 31) had fewer than 8000 people/km^2, and their congestion index fell in the low and medium category of the variable extracted from Tomtom (2023). Regarding the context of study, most of the papers report metrics from cities in developed countries. Querétaro (Mexico), studied by Ochoa-Olán et al., 2021 and Fransoo et al. (2022), and Casablanca (Morocco), assessed by Errousso et al. (2020), were the only cities in developing countries. That result showcases the ongoing opportunity to open research venues in cities in developing countries that face unique demographic, traffic, social and economic challenges. Findings from those contexts could contribute to a broader understanding of factors affecting freight curbside operations and the impacts of curbside interventions.

Approaches used to study freight curbside management differed in terms of geographical scope, type of land use analysed, stakeholders' perspectives, input data, and system modelling. Although those differences challenge the comparability of practices and results between the studied cases, they provide complementary insights about the diverse range of conditions that delivery operations face in urban areas.

The geographical scope ranged from entire districts (Campbell et al., 2018; Lopez et al., 2021; Organisation for Economic Co-operation and Development, 2018) and neighbourhoods or areas—for example, 1 km^2 (Figliozzi & Tipagornwong, 2017; Fransoo et al., 2022; Kawamura et al., 2014; Marcucci et al., 2015; Simoni & Claudel, 2018) to particular streets (Voegl et al., 2019) and specific

Table 2
Overview of cities included in the reviewed papers.

Population size and density	Congestion level			Total
	Low	Medium	High	
Large	**1**	**1**	**3**	**5**
High density	1		2	3
Medium density			1	1
Low density		1		1
Medium	**7**	**5**	**2**	**14**
High density	1	1		2
Medium density	2	3		5
Low density	4	1	2	7
Small	**8**	**4**		**12**
High density		2		2
Medium density	5	1		6
Low density	3	1		4
Total	**16**	**10**	**5**	**31**

loading zones (Abhishek and Fransoo, 2021; Cao and Menendez, 2018; Castrellon et al., 2024; Comi et al., 2018; Dey et al., 2019; Dezi et al., 2010; Gardrat and Serouge, 2016; Hammami, 2020; Iwan et al., 2018; Letnik et al., 2020; Mor et al., 2020; Yang et al., 2019; Zhang and Thompson, 2019; Alho et al., 2018). Differences in geographical scope imply variations in the sample size and design, the amount of data collected, and the number of stakeholders from the public and private sectors involved.

As for the type of land use analysed, a few studies focus on residential areas (Chen et al., 2019; Conway et al., 2016; Gopalakrishnan et al., 2020; Jaller et al., 2021; Kawamura et al., 2014; Kim & Wang, 2021; Lopez et al., 2019) or mixed areas (Aiura & Taniguchi, 2005; Ezquerro et al., 2020; Zanni & Bristow, 2010), while the vast majority examined operations in commercial areas such as central business districts (CBDs). Significant differences shaped the reported freight curbside operations in that regard given the distinct nature of commodity and vehicle types, built environments, parking durations, and traffic access between residential, mixed, and CBD deliveries.

Stakeholders' perspectives depended on the provider of data in each study, including parking operators (Castrellon et al., 2024), enforcement agencies (Nourinejad & Roorda, 2017; Rosenfield et al., 2016), retail establishments (Thompson & Zhang, 2018), transport operators (Aiura and Taniguchi, 2005; Dalla Chiara and Goodchild, 2020; Kijewska et al., 2018; Clarke et al., 2018; Ochoa-Olán et al., 2021; Errousso et al., 2020), and in-field counting (Chen et al., 2019; Kijewska et al., 2018; Nourinejad et al., 2014). Because each stakeholder has different purposes in tracking freight curbside operations, attributes of the data varied according to those interests. For instance, parking operators were shown to possess data about vehicle types, parking durations, and economic activities but to lack information about, for instance, destination points and vehicle routes. Private operators provided the latter, however, and from that perspective the representativeness of studies is challenged by the number of companies involved in the projects.

In terms of input data, only 10 reported studies used probed operations data, which are generally expected to provide more accurate estimates of system-related behaviour than survey data, given the availability of population-based data instead of data from random samples (Jaller et al., 2021). With the adoption of new technology in parking management systems, additional studies using probed parking data for impact assessments could be possible in the future. Regarding tools for estimating impacts, simulations seemed to be the most popular in the selected studies, 31 of 57 of which involved using simulation as the primary method of assessment.

3.1. Unsustainable impacts of freight curbside operations

Although freight transportation represents 20 % to 30 % of the total traffic in cities, it accounts for up to 60 % of transport-related CO_2 and particulate matter emissions (Dablanc, 2007). The time that a freight vehicle is parked represents more than 40 % of the time that it spends in a city (Sanchez-Diaz et al., 2020), and, in some contexts, it is up to 80 % (Fransoo et al., 2022). Cruising (i.e. searching for parking) or double parking are the most common practices in scarcity-laden scenarios of allocating curbside space to freight operations, with highly negative impacts on urban sustainability. Apart from environmental emissions, the unsustainable effects of poor conditions for freight parking operations also include economic losses, congestion, noise, and the intimidation of users of public space due to vehicle size and safety risks. This section summarises findings from the reviewed papers that have quantified the unsustainable effects of freight curbside operations regarding social, economic, and environmental impacts.

3.1.1. Social impacts

The lack of parking spaces drives cruising practices and sometimes the illegal use of public space (e.g. double parking or parking in prohibited areas). The social implications of these practices are linked to their effect on congestion, resulting in traffic delays, increased noise levels, and the associated consequences on citizens' health.

Regarding cruising, Lopez et al. (2016) found that cruising for parking occurs in 70 %–80 % of last-mile deliveries in European cities. In the United States, Dalla Chiara & Goodchild (2020) found that cruising represents 28 % of total trip time and contributes to 15 %–74 % of downtown traffic (Steimer et al., 2022).

Concerning illegal parking, Kawamura et al. (2014) found that double parking is the third-most important cause of nonrecurrent traffic congestion after construction projects and crashes. Along similar lines, Roca-Riu et al. (2017) observed that illegal double parking occurred in up to 50 % of freight movements in Paris, and generate an aggregated daily loss accounted for 2777 h (Beziat, 2015). In the United States, illegal freight parking generates 476 million vehicle hours of delay each year (Wenneman et al., 2015). In Athens, Greece, Kladeftiras & Antoniou (2013) concluded that eliminating double parking could reduce traffic delays by up to 33 %.

As reported, both practices (i.e. cruising and illegal parking) intensify traffic congestion, which negatively affects noise exposure, citizens' stress and, in general, the liveability of cities. For instance, Kijewska et al. (2018) documented the impacts of traffic noise on the quality of sleep, rest, and work.

3.1.2. Economic impacts

Freight curbside operations are part of last-mile logistics—that is, the last leg of supply chains aimed at meeting customers' demands. Estimated costs of the last-mile differ from city to city and are conditioned by the type of commodity delivered. The Council of Supply Chain Management Professionals has estimated that last-mile deliveries represent 28 % of the cost of the entire supply chain (Butrina et al., 2017). Gevaers et al. (2011), meanwhile, have reported that last-mile deliveries can account for 13 %–75 % of total logistics costs. Dablanc & Rodrigue (2017) concluded that due to low levels of operational efficiency, last-mile operations are the weakest link of the supply chain, accounting for up to 50 % of the total cost. Low payload ratios (i.e. average load factor of 30 %–40 %), empty trips, fragmented deliveries, congestion, and cruising are among the leading causes of those inefficiencies (de Marco et al., 2017).

The economic consequences of cruising and illegal parking practices have been quantified in various contexts for freight curbside operations. In New York City, for instance, Holguín-Veras (2008) found that freight vehicles are often forced to park illegally with costly consequences due to parking fines of USD $500–1000 per truck per month. In Toronto's case, freight vehicles incurred more than CAN $27 million in parking fines (Wenneman et al., 2015).

Congestion, affected by cruising and illegal parking practices, has also implications for the overall economy of the city. According to researchers at the Harvard School of Public Health, congestion had an economic impact of USD $100 billion in 83 US cities in 2020 (Fahim et al., 2021). Although that impact accounts for general traffic, it indicates an order of magnitude of the economic effects of contributors to congestion, including cruising for parking and illegal parking of freight vehicles.

3.1.3. Environmental impacts

Freight vehicles contribute to 15 % of greenhouse gas emissions in urban contexts (Hammami, 2020) and to 50 % of PM2.5 (de Marco et al., 2017). Those impacts relate directly to kilometres travelled, the technology of freight vehicles, and traffic conditions during urban freight operations. High levels of congestion and travel delays due to illegal parking and cruising exacerbate the negative impacts of freight curbside operations on urban environments, as shown by Iwan et al. (2018). The consequences of high levels of emissions are lethal for human life. The UN Environment Program has estimated that approximately 7 million premature deaths globally relate to air pollution (Fahim et al., 2021).

Providing the proper conditions for freight curbside operations can reduce travel time, pollutant emissions, and levels of congestion (Comi et al., 2018). Given the relevance of the impacts of freight curbside operations on urban sustainability, the following section presents the results of curbside management interventions regarding their impact on SDG11′s targets.

3.2. Impacts of curbside interventions on selected targets of SDG11

Concerning the impacts of curbside interventions on SDG11′s targets and curbside performance measures, Fig. 3 graphically summarises the data extracted from the 57 papers. Results are grouped by intervention (i.e. urban space allocation, data sharing, parking limits, and enforcement) and linked to the corresponding target of SDG11 based on the reported performance measures. The figure shows in parentheses the number of studies that referred to the specified performance measure, the freight curbside intervention, and SDG11′s target. On the left-hand side, the thickness of the links indicates the proportion of studies aimed at assessing interventions through each performance measure. Meanwhile, the right side, the thickness of the links represents the number of studies associated with each target of SDG11. Based on the evaluated performance measures and practical implications, one study could contribute with multiple performance measures and fall into more than one classification of freight curbside intervention and SDG11′s target, as detailed in Appendix A.

Although the field of freight curbside management is relatively new (i.e. all the selected papers fall within the past 20 years), several contributions have already assessed interventions related to urban space allocation and its impacts, mainly on delivery time, curbside occupancy rates and parking violations, as shown in Fig. 3. These assessments are aligned with SDG11 targets regarding freeing up space and shaping urban policies. Further exploration to understand the impacts on emissions could provide insights into the relevance of this intervention in meeting SDG targets (e.g. 11.6). Similarly, additional research is needed to comprehend the environmental implications of data sharing, parking duration limits, and enforcement.

Fig. 3 also illustrates how few studies consider cost and cruising as performance measures, potentially due to data limitations; however, future studies could uncover the association of these measures with more accessible ones such as delivery time. Moreover, a

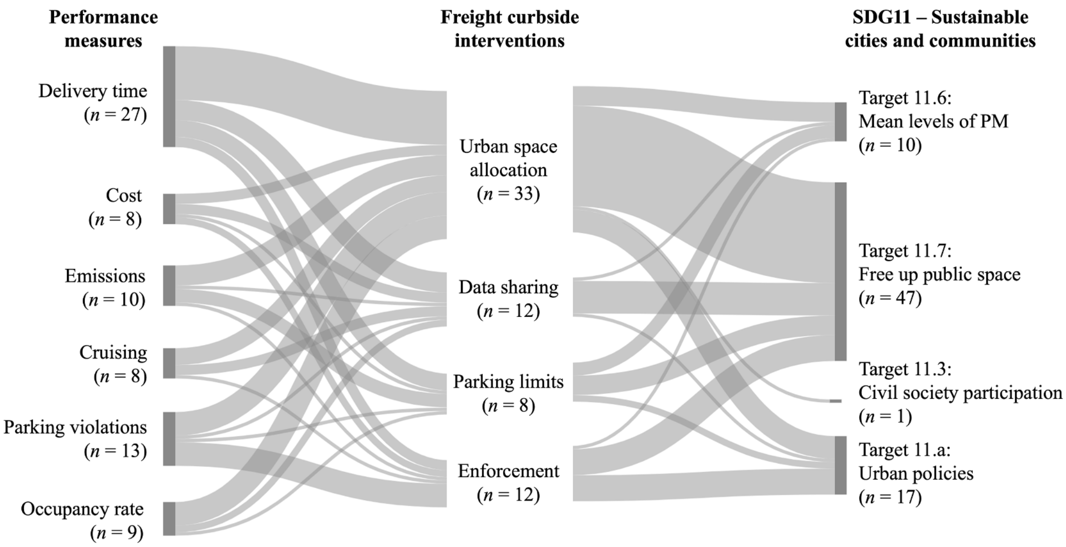

Fig. 3. Number of papers and links between freight curbside interventions, performance measures and the targets of SDG11.

research opportunity arises in assessments that involve civil society participation in identifying solutions to curbside conflicts and even evaluating the effects of interventions. Contributions from social sciences, urban planning and architecture could help bridge this gap. Insights from the collected studies are presented below for each of the freight curbside interventions.

3.2.1. Allocation of urban space

Thirty-three studies reported analyses regarding the *allocation of public space* to freight operations. Table 3 displays the collected change rates corresponding to each performance measure reported after assessing the implementation of actions aimed at allocating and managing curbside space for freight (un)loading. The evidence suggests that providing space for freight operations benefits cities' sustainability and operational efficiency, as it reduces cruising by an average of 25 %, last-mile emissions by 41 %, and delivery times by 28 %.

These performance measures of the effective management of space for freight align with the targets of SDG11 by reducing mean levels of particulate matter and freeing up space for other users. The latter is achieved due to the improved use of the available curbside space (i.e. 32 % of average improvement in occupation levels), and reductions in congestion when fewer parking violations, (i.e. a 41 % drop on average) and less cruising occur. Nonetheless, these impacts can be overshadowed if a static allocation of space for freight aggravates supply–demand imbalances for curbside uses other than freight.

For instance, singular, static uses of the curbside to freight may prompt the overcapacity of infrastructure at specific times of the day or week, at the expense of other users' needs for space. Some studies have reported reductions of space allocated to freight due to loading zones overcapacity as performance measure, (e.g. Ochoa-Olán et al., 2021 and Castrellon et al., 2024).

Regarding economic impacts, few studies made direct reference to the implications in cost, showing a wide dispersion of the change rate ranging from ↓24 % to ↑50 %, explained, for example, by variations in pricing policies for using loading zones.

3.2.2. Data sharing

Data sharing, the second-most popular initiative together with enforcement, refers to the implementation of technology that enables the exchange of data between curbside infrastructure, users, and managers of space.

As presented in Table 4, most benefits in the papers are quantified in terms of decreased delivery times (i.e. by 32 % on average) because the intervention made the availability of LZs visible and supported pre-booking systems that, on average, reduce cruising by 32 %, emissions by 46 % and costs by 37 %. Although data-sharing schemes increasingly contribute to curbside interventions that work towards achieving SDG11′s targets regarding urban policies on the use of public space, they remain underdeveloped, partly because drivers, in the case of booking systems, find it challenging to comply with booking times due to traffic delays in congested areas. Interoperability-related challenges and a lack of trust in sharing data between private and public organisations also hinder the widespread adoption of data-sharing schemes for curbside management.

Although there were only twelve studies assessing the direct effects of curbside digitisation, the development of this field is promising, given the motivation of public and private actors for improving freight curbside decisions with the use of big data, thereby contributing to sustainability targets. For instance, parking technology can incentivize operations during non-peak hours (Jaller et al., 2021), design pricing incentives (Rosenfield et al., 2016), and enforce access regulations (Chen et al., 2019), leading to operational and sustainability gains while freeing up space for other users as needed. It also plays a role in influencing drivers' behaviour (Alho et al., 2022), ensuring compliance with curbside regulations and reducing the stress of finding available parking spaces.

3.2.3. Parking limits

The management of *parking limits and durations* aims to encourage better utilisation of the available space, achieved through higher parking turnover and tailor-made regulations that facilitate flexible curbside access for users based on their needs and priorities. Eight studies included performance measures related to interventions about parking limits, with only one observation for metrics such as curbside occupation, cost, and parking violations, as shown in Table 5.

Most assessments computed the benefits of this intervention in terms of delivery times, (i.e. reduced by 13 % on average), and emissions (i.e. reduced by 21 % on average). Further research from a public sector perspective could enhance the understanding of the impacts of parking limits and duration management on curbside occupancy and parking violations.

3.2.4. Enforcement

Regulating on-street parking and enforcement are common actions that policymakers take in curbside management. Most of the reported interventions to that end have contributed to achieving SDG11′s targets when it comes to urban policies and freeing up public

Table 3
Reported impacts of urban space allocation.

Performance measure	# of collected change rates	Average	Variation range
Delivery time	16	↓28 %	↓78 % — ↑2 %
Cost	3	↑3 %	↓24 % — ↑50 %
Emissions	6	↓41 %	↓5 % — ↓95 %
Cruising	4	↓25 %	↓7 % — ↓61 %
Parking violations	7	↓41 %	↓9 % — ↓74 %
Curbside occupancy	7	↑32 %	↑2 % — ↑72 %

Table 4
Reported impacts of data sharing.

Performance measure	# of collected change rates	Average	Variation range
Delivery time	6	↓32 %	↓66 % — ↑37 %
Cost	3	↓37 %	↓20 % — ↓68 %
Emissions	1	↓46 %	—
Cruising	3	↓32 %	↓17 % — ↓60 %
Parking violations	1	↓100 %	—
Curbside occupancy	2	↑64 %	↑56 % — ↑72 %

Table 5
Reported impacts of parking limits and durations management.

Performance measure	# of collected change rates	Average	Variation range
Delivery time	5	↓13 %	↓3 % — ↓20 %
Cost	1	↓75 %	—
Emissions	4	↓21 %	↓2 % — ↓47 %
Cruising	—	—	—
Parking violations	1	↓58 %	—
Curbside occupancy	1	↓59 %	—

space because they encourage higher turnover, modal shifts, and compliance with regulations. As shown in Table 6, their performance measures are primarily parking violations, delivery time, and cost, although ranges of increase and decrease vary from one case to another. According to the reviewed papers, enforcement can reduce parking violations by 36 % on average.

Stakeholders' engagement has been overlooked in developing curbside freight regulations and enforcement, which has stifled the potential effects of curbside management on urban sustainability. It has also led to users' insufficient knowledge about right-of-way rules, which only adds pressure to means of enforcement that may cause confrontations between users and parking wardens as well as over costs due to fines issued or illegal uses of the curb. Further research could explore the involvement of society in promoting good practices of curbside use and enforcement.

As evident in Tables 3–6, performance measures exhibit a high dispersion in their range of change rates, challenging the formulation of general conclusions about the impact of curbside interventions. These variations can be attributed to factors such as the diverse sample of city typologies, the geographical scope of the studies, and the varied data collection techniques and methods for impact assessments. Nevertheless, certain trends, including delivery time savings, reduction of parking violations, and positive environmental impacts, are starting to emerge. Table 7 summarises the impacts of freight curbside interventions on the performance measures, with the average rate of change computed for each category of city in terms of population size and levels of congestion when data were available.

4. Discussion

Implications of freight curbside interventions, policy recommendations and trade-offs are discussed in accordance with the results in Table 7, and the four selected targets of SDG11: (i) Target 11.6 – mean levels of fine particulate matter, (ii) Target 11.7 – average global share of urban space allocated to streets and open public spaces, (iii) 11.3 – participation of civil society in urban planning and management, and (iv) 11.a – development of urban public policies.

Target 11.6 Mean levels of particulate matter in cities: Ten studies involved quantifying the impact of curbside interventions on emissions, which is rather low compared with other targets of SDG11 (e.g. allocation of urban space). For that reason, more research quantifying the environmental impacts of curbside initiatives is needed. The aggregated analysis of cities included in the review (Table 7) shows how initiatives regarding freight curbside management can reduce pollutants by 32 % on average. In this regard, research has suggested that increasing public space for parking and information about its occupancy levels would decrease greenhouse gas emissions and local emissions due to reduced traffic levels achieved with less cruising and illegal parking. Beyond that, the promotion of modal shifts (e.g. to cargo bikes and electric trucks) and increased transport and fuel efficiency are expected outcomes of

Table 6
Reported impacts of enforcement.

Performance measure	# of collected change rates	Average	Variation range
Delivery time	3	↓18 %	↓3 % — ↓43 %
Cost	2	↑32 %	↓16 % — ↑81 %
Emissions	1	↓33 %	—
Cruising	1	↓60 %	—
Parking violations	7	↓36 %	↓2 % — ↓64 %
Curbside occupancy	—	—	—

Table 7
Summary of reported impacts on performance by city size and level of congestion.

Population size and congestion level	Average rate of change					
	Delivery time	Cost	Emissions	Cruising	Parking violations	Occupancy rate
Large	**↓27 %**	**↓49 %**	**↓3 %**	**↓60 %**	**↓50 %**	**↑2 %**
High congestion	↓36 %	↓24 %	↓2 %	↓61 %	↓50 %	↓5 %
Medium congestion	↓38 %	–	–	↓60 %	↓50 %	↑25 %
Low congestion	↓5 %	↓75 %	↓4 %	–	–	–
Medium	**↓28 %**	**↓4 %**	**↓71 %**	**↓29 %**	**↓32 %**	**↑13 %**
High congestion	↓47 %	↑50 %	–	–	–	–
Medium congestion	↓25 %	↓16 %	↓71 %	↓60 %	↓32 %	–
Low congestion	↓15 %	↓22 %	–	↓13 %	–	↑13 %
Small	**↓31 %**	**↓68 %**	**↓28 %**	**↓19 %**	**↓62 %**	**↑72 %**
High congestion	–	–	–	–	–	–
Medium congestion	↓20 %	–	↓18 %	↓18 %	↓29 %	–
Low congestion	↓33 %	↓68 %	↓36 %	–	↓79 %	↑72 %
Total	**↓29 %**	**↓25 %**	**↓32 %**	**↓35 %**	**↓44 %**	**↑15 %**

the enhanced management of parking and delivery practices.

Decarbonising transport in curbside management is easily achievable because it does not require high investments compared with infrastructure or energy-transforming technology and, with managerial commitment, can lead cities to reduce particulate matter emissions generated by freight transport. Nevertheless, it is imperative to evaluate the new space demands linked to emerging modes, such as the need for charging stations or the intensified demand for space resulting from the replacement of trucks with low-capacity vehicles. This assessment should be conducted while considering the constraints and heightened competition for curbside space.

Target 11.7 Allocation of urban space to streets and open spaces: Most of the papers (>80 %) address the allocation of urban space due to the evident alignment between the related target of SDG11 and the core function of city authorities responsible for managing public space. The findings reveal how public authorities face dilemmas between several options for curbside uses according to users' demands (e.g. for bike lanes, parking spaces for private vehicles, public transport stops, service times, and LZs). Evaluations concluded that effectively managing space for freight could free up space for other users—by up to 70 % in one study—and, most often, reduce cruising for parking by 35 % and costs by 25 % on average, via the allocation of LZs, enforcement, data sharing, and parking limit initiatives.

The most popular performance measure was delivery time, in which average improvements ranged between 5 % and 47 %. Data sharing related to parking availability or pre-booking systems reported reductions of 32 % on average. However, equilibrium in the allocation of space and enforcement are common challenges in managing parking spaces because they either cannot improve the system or negatively impact it.

Target 11.3 Participation of civil society in urban planning policies: Only one study addressed the goal of involving civil society in defining parking policies by considering different stakeholders' perspectives (Trott et al., 2021). That finding represents an opportunity for future research to consider citizens' perceptions and interactions with freight parking activities in the formulation and/

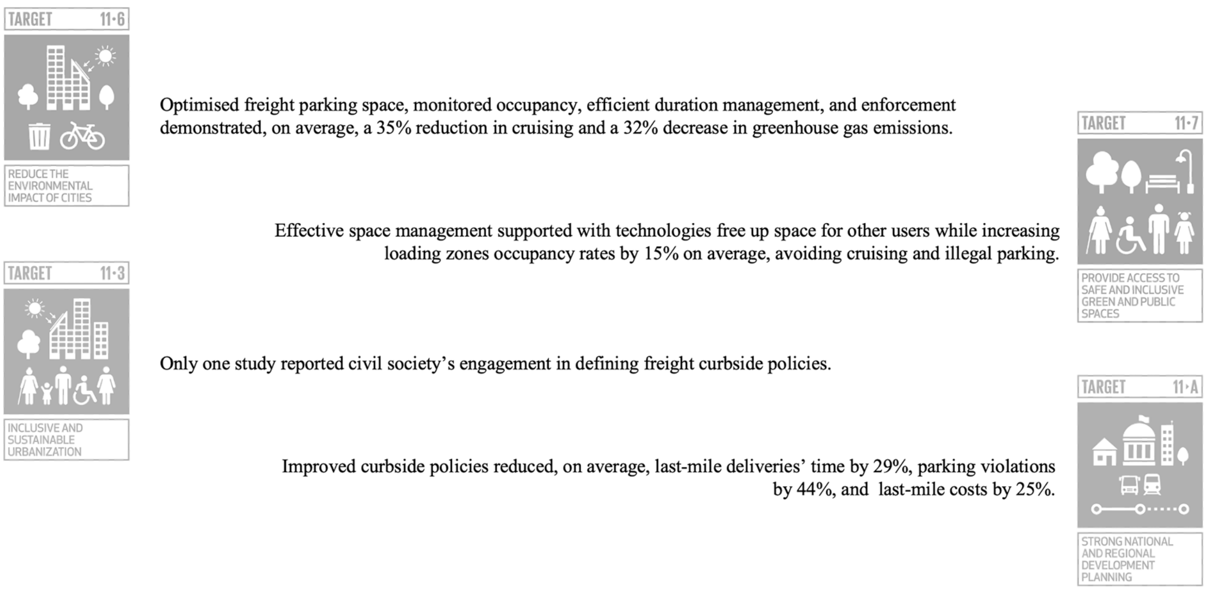

Fig. 4. Summary of impacts on the targets of SDG11.

or evaluation of policies. By understanding users' needs for public space and assessing conflicting conditions, public policies can better suit stakeholders' interests, reallocate rights-of-way, and strive for fairer decisions in people-centred curbside solutions.

Target 11.a Urban policies: The target of urban policies was assessed based on this review's aim of including public policies and regulations whereby urban systems can be improved. Overall, 70 % of the papers in that category report policy evaluations regarding delivery times and parking violations. A generalised finding related to reduced delivery times was evidenced by policies regarding data sharing, enforcement, duration limits, and the allocation of urban space. The findings in the papers agree that adopting certain technology improved public and private decision-making processes and reduced the cost of the last-mile by preventing cruising and illegal parking. Introducing data-driven policies for managing curbside space also opens the possibility of introducing dynamic curbside management, which presents an array of opportunities for new business models and innovations (e.g. on-street lockers, charging stations for e-vehicles, parking for scooters, and new dynamic commercial or recreational parking spaces). Only nine papers report measures of occupancy rate despite its importance for public authorities. Improvements in data collection about cruising for parking could reverse that trend.

Fig. 4 outlines the main insights from the previous discussion regarding curbside interventions impacts on each SDG11 target.

5. Conclusions and limitations

The study presented here investigated the effects of curbside management interventions on the targets of a UN's SDG. The findings suggest that actions in the allocation of public space, data sharing, parking limits, and enforcement, contribute to the goals of reducing emissions, managing congestion, improving delivery times, and affording equitable access. However, there are some trade-offs between the different initiatives.

The study's chief contribution was pinpointing how freight curbside management impacts the achievement of the UN's SDG prescribing universal access to safe, inclusive, and green public spaces—that is, SDG11. Outputs from the systematic literature review can foster reflection among stakeholders in urban mobility regarding the implementation of policies and initiatives that include freight operations while providing open public space for all citizens, free of stress, noise, pollution, and traffic hazards. In essence, knowledge about the enhanced management of curbside space can help with designing actions that positively impact SDG11′s targets. Nonetheless, more research is needed on the people-centred design, implementation, and evaluation of freight curbside management practices by understanding conflicting conditions, demands for urban space, and social equilibrium.

Future research could develop *meta*-analytical methods to examine the collected statistics and propose techniques for the standardisation of performance measures given the multiple scales and metrics found. Additionally, this research avenue could be further broadened by studies that develop frameworks for standardising performance measures based on systematic literature review of existing studies, and the new technologies available for data collection and curbside management.

CRediT authorship contribution statement

Juan Pablo Castrellon: Conceptualization, Formal analysis, Investigation, Methodology, Writing – original draft, Writing – review & editing. **Ivan Sanchez-Diaz:** Conceptualization, Methodology, Supervision.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

Appendix A. Selected papers after the PRISMA statement process

Source	Case study	Population Size level	Population Density level	Congestion level	Data collection method	Quantification method	SDG11 Target	Curbside intervention	Performance measures
Aiura & Taniguchi (2005)	Kyoto, Japan	Medium	Low	Medium	Survey	Simulation, optimisation	11.7	i and iv	5
Dezi et al. (2010)	Bologna, Italy	Medium	Low	Low	Survey	Optimisation	11.7	i	3
Zanni & Bristow (2010)	London, UK	Large	Medium	High	Official statistics	Projections based on official statistics	11.6 and 11.a	iii	2
Boussier et al. (2011)	La Rochelle, France	Small	Low	Low	Official statistics	Simulation	11.6 and 11.7	ii	2
McLeod & Cherrett (2011)	Winchester, UK	Small	Low	Low	Survey	Simulation	11.7	ii	1

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Source	Case study	Population Size level	Population Density level	Congestion level	Data collection method	Quantification method	SDG11 Target	Curbside intervention	Performance measures
Jaller et al. (2013)	New York City, USA	Large	High	High	Survey	OLS	11.7	i	3 and 6
Kawamura et al. (2014)	Chicago, USA	Medium	Medium	Medium	Official statistics	OLS	11.7	iv	6
Nourinejad et al. (2014)	Toronto, Canada	Medium	Medium	Medium	Survey, counting, official stats	Simulation	11.a	iv	1 and 4
Zou et al. (2015)	New York City, USA	Large	High	High	Survey	Count data models	11.7	iii	1
Wenneman et al. (2015)	Toronto, Canada	Medium	Medium	Medium	Official statistics	Regression model	11.7 and 11.a	i and iv	6
Marcucci et al. (2015)	Rome, Italy	Medium	Low	High	Survey	Simulation	11.7 and 11.a	i	5
Gardrat & Serouge (2016)	Lyon and Bordeaux, France	Small	High	Medium	Official statistics	Statistical inference	11.7 and 11.a	i	6
Conway et al. (2016)	New York City, USA	Large	High	High	Official statistics	Survival analysis modelling	11.7 and 11.a	i	6
Holguín-Veras et al. (2016)	New York City, USA	Large	High	High	Cameras	Simulation	11.7	i	4
Rosenfield et al. (2016)	Toronto, Canada	Medium	Medium	Medium	Official statistics	Hierarchical logit-type choice	11.a	iv	6
Comi et al. (2017)	Rome, Italy	Medium	Low	High	Estimations from previous studies	Simulation	11.7	ii	1
Nourinejad & Roorda (2017)	Toronto, Canada	Medium	Medium	Medium	Survey	Theory of bilateral searching and meeting	11.a	iv	6
Figliozzi & Tipagornwong (2017)	Numerical case	n.a.	n.a.	n.a.	Simulated data	Queueing theory	11.7	iv	5
Muñuzuri et al. (2017)	Seville, Spain	Medium	Medium	Low	Survey	Simulation	11.7	i	1 and 3
Amer & Chow (2017)	Toronto, Canada	Medium	Medium	Medium	Survey	Optimisation, equilibrium theory, and traffic modelling	11.7	i	1 and 6
Cao & Menendez (2018)	Zurich, Switzerland	Small	Medium	Medium	Previous measurements	Simulation	11.7	ii	4
Letnik et al. (2018)	Luca, Italy	Small	Low	n.i.	Previous studies	Simulation, optimisation	11.6 and 11.7	i	1 and 2
Organisation for Economic Co-operation and Development (2018)	Lisbon, Portugal	Small	Medium	Low	Official statistics	Simulation	11.7	i	1
Comi et al. (2018)	Rome, Italy	Medium	Low	High	Survey	Simulation	11.7 and 11.a	ii	1
Kijewska et al. (2018)	Barcelona, Spain	Medium	High	Low	Direct observation, traffic counting	Live implementation	11.7	ii	4
Clarke et al. (2018)	London, UK	Large	Medium	High	GPS trackers	Pilot (i.e. live trial)	11.7	i	1 and 5
Campbell et al. (2018)	New York City, USA	Large	High	High	Survey	Statistical inference, OLS	11.7	iii	3
Iwan et al. (2018)	Szczecin, Poland and Oslo, Norway	Small	Low	Medium	Mobile traffic detectors and surveys	Simulation	11.6	i	2
Alho et al. (2018)	Lisbon, Portugal	Small	Medium	Low	Survey	Simulation	11.6 and 11.7	i and iv	1 and 2
Simoni & Claudel (2018)	Austin, USA	Medium	Low	Low	Previous studies	Simulation	11.7	i	1
Thompson & Zhang (2018)	Sydney, Australia	Small	High	Medium	Official statistics	Optimisation	11.6–7 and 11.a	iii	1 and 2
Yang et al. (2019)	Barcelona, Spain	Medium	High	Low	Literature review	Optimisation	11.a	ii	5
Dey et al. (2019)	Washington, DC, USA	Medium	Medium	Medium	Live implementation, video survey	Before–after assessment	11.a	iv	6
Chen et al. (2019)	New York City, USA	Large	High	High	Direct observation, traffic counting	Simulation	11.7	iii	1
Lopez et al. (2019)	Lyon, France	Small	High	Medium	Official statistics	Simulation	11.7	i	4
Zhang & Thompson (2019)	Melbourne, Australia	Large	Low	Medium	Literature review	Simulation	11.7	ii	1 and 4

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Source	Case study	Population Size level	Population Density level	Congestion level	Data collection method	Quantification method	SDG11 Target	Curbside intervention	Performance measures
Voegl et al. (2019)	Vienna, Austria	Medium	Low	Medium	Previous studies	Simulation	11.6	i	1 and 2
Errousso et al. (2020)	Casablanca, Morocco	Medium	High	n.i.	Direct observation, traffic counting	Simulation	11.7	ii	1 and 5
Gopalakrishnan et al. (2020)	Singapore, Singapore	Large	High	Low	Estimations based on official statistics	Simulation	11.7	i	1
Ezquerro et al. (2020)	Santander, Spain	Small	Medium	Low	Survey	Simulation	11.7	i and iii	6
Mor et al. (2020)	Lisbon, Portugal	Small	Medium	Low	Previous studies	Optimisation	11.7	ii	1, 5 and 6
Letnik et al. (2020)	Numerical case	n.a.	n.a.	n.a.	Simulation	Simulation, optimisation, machine learning	11.7	i	1
Dalla Chiara & Goodchild (2020)	Seattle, USA	Medium	Medium	Low	GPS data	Effects estimation	11.7	i	4
Hammami (2020)	Grenoble, France	Small	Medium	Low	Survey	Simulation, optimisation	11.7 and 11.a	i and iv	1
Trott et al. (2021)	Hanover, Germany	Small	Low	Low	Literature review	Simulation, optimisation	11.3, 11.6 and 11.7	i	1 and 2
Lopez et al. (2021)	Paris, France	Large	High	High	Official statistics	Optimisation	11.7	i	1
Jaller et al. (2021)	San Francisco, USA	Medium	High	Medium	Official statistics	Simulation	11.6 and 11.7	i and iii	1 and 2
Kim & Wang (2021)	New York City, USA	Large	High	High	Official statistics	One-inflated positive Poisson model	11.7 and 11.a	iv	6
Abhishek and Fransoo (2021)	Melbourne, Australia	Large	Low	Medium	Sensors	Queueing theory	11.7	i	3
Ezquerro et al. (2021)	Santander, Spain	Small	Medium	Low	GPS data and surveys	Simulation	11.7	i and ii	3
Ochoa-Olán et al. (2021)	Queretaro, Mexico	Medium	Low	n.i.	Survey	Simulation	11.7	i	1 and 4
Fransoo et al. (2022)	Queretaro, Mexico	Medium	Low	n.i.	GPS data and field observations	Field experimentation	11.7	i	1
Muriel et al. (2022)	Melbourne, Australia	Large	Low	Medium	Underground sensors	Simulation, optimisation	11.7 and 11.a	i and iv	6
Wang et al. (2022)	Guangxi, China	Large	Low	n.i.	Automatic vehicle identification	Optimisation	11.a	ii	3
Alho et al. (2022)	Singapore, Singapore	Large	High	Low	Official statistics	Simulation	11.6	iii	1, 2 and 5
Ramirez-Rios et al. (2023)	New York City, USA	Large	High	High	Survey and official statistics	Simulation	11.7 and 11.a	i	3
Castrellon et al. (2024)	City of Vic, Spain	Small	Low	n.i.	App-based data	Optimisation, machine learning	11.7	i	3

Notes:

GPS: Global Positioning System, OLS: ordinary least squares, n.a.: not applicable., n.i.: no information

Curbside interventions: i: urban space allocation, ii: data sharing on LZ availability, iii: parking limits and durations management, iv: enforcement.

Performance measure: 1: delivery time, 2: emissions, 3: curbside occupancy rate, 4: cruising for parking, 5: cost, 6: parking violations.

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