Measuring and Moving on the Street: A Scoping Review of Street Space Allocation Studies

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A field of research is emerging that examines the allocation of street space to different transportation infrastructures, backgrounded by the increasingly recognized need to redesign city streets away from the dominance that cars have held over them for the past century. In this scoping review, we systematically search the literature to identify 12 peer-reviewed journal articles that use empirical methods to study street space allocation to transportation modes, synthesizing and reflecting on the studies' methodologies, results, and identified policy implications and future research areas. From this synthesis, key themes emerge around how the studies frame their work in the transportation justice literature and towards conceptualizing an equitable streetscape, the differences in the methodologies employed and promising avenues to improve their methods, and the difficulties in comparing results across studies. Stemming from the reviewed studies, this review offers several directions for future research to encourage the development of street space allocation research, a field well-positioned to contribute to research and policy around critiquing and improving city streets and urban liveability.

Keywords: street space; spatial allocation; transportation infrastructure; transportation justice; spatial analysis

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Introduction

The prioritization of automobiles in urban planning and design since the 20th century has harmed, and continues to harm, non-automobile travelers, communities, public health, and the environment. While many experts, safety advocates, and urban planners have recognized the dangers posed by automobiles from the early stages of their mass production and commercial viability, their voices were overshadowed by powerful pro-car interests that championed the expansion of car-centric infrastructure and policies (Norton, 2008). Now, with pressing concerns over collision rates (World Health Organization, 2023), automobile pollution (Environment and Climate Change Canada, 2023; Ritchie & Roser, 2020), the health of drivers (Christian, 2012; Ding et al., 2014; Petrunoff et al., 2018), the dissolution of public life and community spaces (Beckmann, 2001; Kay, 1998), and the marginalization of non-automobile travelers (Urry, 2006), there has emerged a powerful social movement seeking to redress the historical wrong of car-oriented cities (Petzer et al., 2021; Sadik-Khan & Solomonow, 2017). The locus of action for this change is the street, which "ha[s] a profound yet often underestimated role in shaping the urban experience" (Prytherch, 2018, p. 1). This trend has led to recent changes to city streets, including "complete streets" projects (National Complete Streets Coalition, 2023), COVID-19-era street redesigns (Prytherch, 2022), and the installation of micromobility[1] infrastructure and sharing systems (DeMaio et al., 2021; McGovern, 2020; Pucher & Buehler, 2017).

The fight over the street is in essence a fight over public space (Bodnar, 2015; Gössling et al., 2016); changes to the built environment for mobility around one transport mode, will always represent barriers to the built environment for another mode, necessitating negotiations of public space (Graham & Marvin, 2001). Redesigning the streetscape often means reducing the

[1] "Micromobility" refers to lightweight vehicles, including bicycles, e-scooters, and e-bikes (Behrendt et al., 2022; Dediu, 2019).

space allocated to automotive vehicles, and this is often met with fierce resistance from portions of the public (Wild et al., 2018; Wilson & Mitra, 2020) – drivers in particular – and the entrenched social-economic-political system of automobility (Banister, 2008; Lefebvre-Ropars et al., 2021b). In 2012, Colville-Andersen of *Cophenhagenize Design Co.*, a prominent cycling-focused design consultancy, wrote about the "Arrogance of Space" to describe the "obscenely unbalanced distribution of space" afforded to the automobile, characterized by "the nauseating arrogance of obscenely wide car lanes and the vehicles sailing back and forth in them like inebriated hippopotamuses" (Colville-Andersen, 2019). He illustrated this concept by taking images of streets and manually drawing over them to highlight the inequal distribution of space per transport mode.

Understanding how street space is allocated for different modes is a foundational layer of information required to understand a mobility regime. This approach to understanding the street through its spatial allocations emerged from the grey literature, with perhaps the earliest examples including a 2013 blogpost measuring street space in Oklahoma (Hampton, 2013), a 2014 report from the German "Agency for smarter Cities" (Agentur für clevere Städte, 2014) (cited and discussed in Gössling et al. (2016)), and Colville-Andersen's "Arrogance of Space" blog posts (from 2012 through 2019) (2019). Measuring street space continues to find purchase in non-academic texts, reflecting the topic's relevance to ongoing conversations around urban mobility transitions in policy and public communication (see, for example International Transport Forum (ITF), 2022; NYC Department of Transport & Gehl Architects, 2014; van Liere et al., 2017). In academic publications, researchers have also begun examining street space allocation, as cities grapple with how to redesign their streets.

In this article, we conduct a scoping review of studies that use empirical methods to examine street space allocation of transportation infrastructures. With a systematic search of the literature, we set out to answer the following questions:

(1) How do studies of street space allocation measure street space?

(2) Which results are common, and which are different between studies?

(3) What policy implications and future research areas do the studies identify?

(4) How are street space allocation studies developing as a field of research?

In doing so, we scope the emerging field of street space allocation studies, provide useful information for researchers conducting such work, and discuss the prospects of the field. In what follows, we first overview our methodology, including how the search was conducted and how we extracted data from the included studies. We continue by presenting the findings from our search and extraction, in terms of their measurement methods, the synthesized results, and the policy implications and future research areas they identify. Following this, we discuss some key themes: framing around conceptualizing an equitable streetscape, differences between methodologies and their future development, difficulties in comparing results, and suggestions for continued research.

Methodology

We searched for English-language peer-reviewed journal articles in three databases: Scopus, ProQuest, and Web of Science, on 21 March 2025. Though grey literature exists that measures street space allocation, we focus on scoping the emerging academic literature as it coheres into a field of research. We intend for this review to inform and help guide the development of this research, as well as to act as a resource in summarizing existing studies. We searched for abstracts contained in the databases containing the concepts of street space, transportation infrastructure, spatial allocation, and critical examination (see Table A1 for detailed search terms). We used Covidence[2], a literature review tool, to filter duplicate records, and then screened the remaining records using criteria related to the topic, approach, and method. Studies were included if they critically examined the allocation of street space to different transportation infrastructures by empirically measuring street space through spatial analysis, and were excluded if they did not examine transportation infrastructure, did not examine the allocation of space on the street, only considered one transportation infrastructure type, or did not actually measure street space. Two of the authors of this paper screened abstracts independently, retaining any record which did not obviously merit exclusion. Then, wherever a discrepancy existed, and one reviewer retained a record where the other did not, the two reviewers jointly decided whether to exclude the record based on the abstract. Where there was uncertainty, the record was retained for full-text assessment. The remaining studies were independently assessed according to the inclusion/exclusion criteria. Where there was uncertainty, the study was set aside for later discussion, at which point the reviewers jointly decided whether the study merited inclusion.

Following the search and screening process, we extracted data from the included studies related to publishing details, the methodology, the results, and the discussion. From the collected studies, the results in terms of street space allocation were collated, except for three studies, though they were still included in the review. The first of these studies excluded from collation duplicated the results of another study included in the review by the same authors (Lefebvre-Ropars et al., 2021b). The second study used methods acknowledged to be inaccurate to derive street space figures, as the author's aim was not accurate measurement but the ability to measure quickly across many cities (Szell, 2018). The third study reported average street space allocation

[2] https://www.covidence.org/

across the study sites in a manner that is not conducive to collation, with averages that could sum to more than 100%, because the calculation of overall averages excludes zero values in some sites (De Gruyter et al., 2022). While studies measured different street features and used different terminology to refer to the same type of feature, this was standardized in collation: only dedicated automobile parking was recorded separately from general automobile area, all shared road space classifications were combined into one shared road space area category, and all forms of non-transport areas were merged into one category.

Findings

The search and screening process resulted in 12 included studies (see Figure 1, Table A2). There was little ambiguity in whether a study met the criteria. Papers were excluded, for example, because they conducted no empirical analysis (Petzer et al., 2021), only examined one type of transportation infrastructure (Tait et al., 2022), or used simulated data (Gosse & Clarens, 2013).

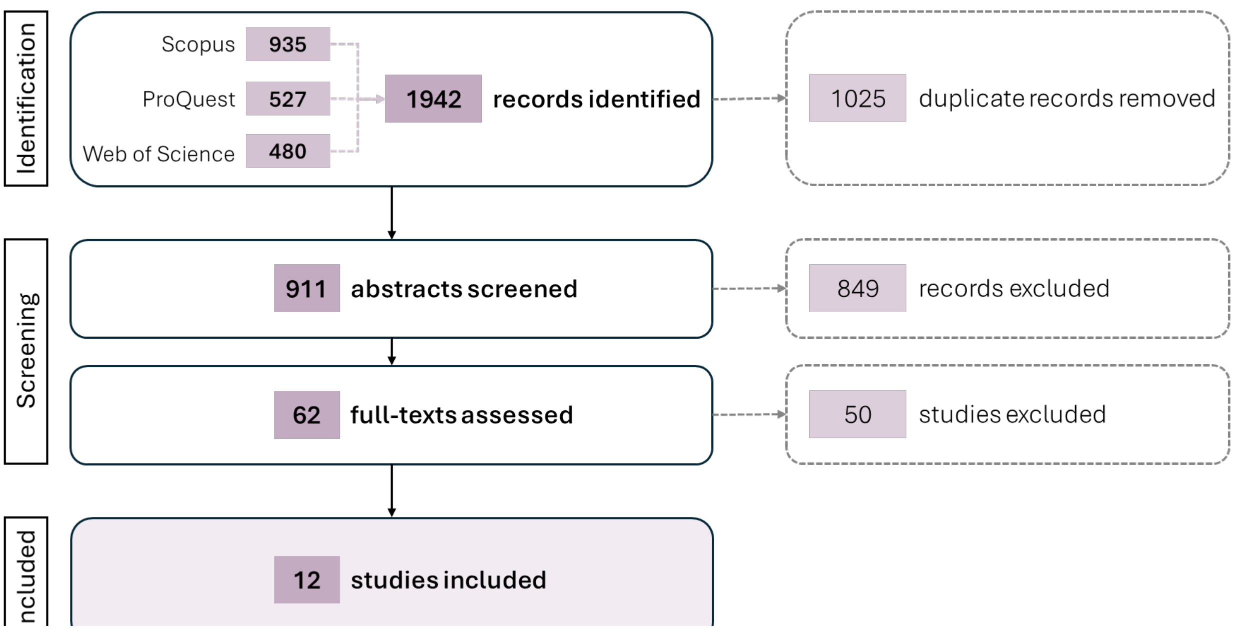

Figure 1. Search and screening process of the systematic search in a flow diagram.

The 12 remaining studies spanned 10 journals in urban planning and design, and transportation:

- Case Studies on Transport Policy (two studies)
- Environment and Planning B: Urban Analytics and City Science
- International Review for Spatial Planning and Sustainable Development
- Journal of Transport and Land Use
- Journal of Transport Geography
- Journal of Urban Design
- Transport Reviews (two studies)
- Transportation Research Part D: Transport and Environment
- Transportation Research Record
- Urban Planning

The first study was published in 2016 (Gössling et al., 2016), and the second in 2018 (Szell, 2018), with almost all publications appearing in the past five years, perhaps indicating some confluence of factors leading ostensibly disconnected author groups to converge on this topic in recent years. Most authors have only published once on the subject, with two exceptions (Attard et al., 2023; Guzman et al., 2021; Lefebvre-Ropars et al., 2021b, 2021a).

With two exceptions, the included studies cite previously published studies identified in the search. The first exception is Eom & Suzuki (2019), which examines the balance of spatial allocation between pedestrian and automobile infrastructure, with special consideration of off-street level (above- or under-ground) infrastructure. The other is Lamour et al. (2019), which measures street space but focuses on walkability. These two papers are excluded from the citation network; they neither cite nor are cited by any other included study. The extent of the inter-citation in the remaining papers indicates that studies of street space allocation are emerging as a distinct, if nascent, research topic.

Methodologies

Table A3 summarizes the methodologies of the included studies. Research on street space allocation is geographically dispersed, with study areas selected in South America (Attard et al., 2023; Guzman et al., 2021; Lamour et al., 2019), North America (Lefebvre-Ropars et al., 2021a, 2021b), Australia (De Gruyter et al., 2022), East Asia (Eom & Suzuki, 2019), Africa (Attard et al., 2023), and Europe (Creutzig et al., 2020; Gössling et al., 2016; Nello-Deakin, 2019; Palominos & Smith, 2023). Most studies investigate one city at a time, though Attard et al. (2023) compares three: Valletta, Malta; Bogotá, Colombia; and Freetown, Sierra Leone. Meanwhile, Szell (2018) works with 23 cities around the world, using OpenStreetMap (OSM) data, but less rigorously in order to allow for examining many cities at once. Most cities (and countries, for that matter) have only been investigated in one study, with two exceptions. First, Lefebvre-Ropars et al. (2021a, 2021b) study Montréal, Canada, in two separate papers. Then, both Attard et al. (2023) and Guzman et al. (2021) investigate Bogotá, Colombia, with two of the three authors of Attard et al. also participating in Guzman et al.

Measurement method

There are three types of measurement methods employed in the included studies. The first type is manual, meaning physically measuring the street, employed by two studies. Creutzig et al. (2020) manually measure 18 street sections averaging 250m in length, though no further details are provided on the measurement procedures. De Gruyter et al. (2022) also perform manual measurements using a measuring wheel in Melbourne, Australia, for 57 sites within 36 "activity centers" (planning units), all within 10km of the central business district.

The second measurement method involves digitizing satellite imagery, employed by two studies. Gössling et al. (2016) work with high-resolution satellite images, visually identifying infrastructural features and manually digitizing geometrical layers corresponding to the transportation infrastructures. The authors validate their work through on-site visits and with high-resolution maps provided by the city (Freiburg, Germany). In this manner, they select portions of four quarters within the city, totaling approximately 8.79km^2, and note that digitizing this information for the whole city would be too labor-intensive. Attard et al. (2023) follow this same methodology, likewise using satellite imagery "and other publicly available remote sensed data", but with few on-site visits for validation. The authors apply this method to 2km^2 in Valetta, 2.06km^2 in Bogotá, and 4.2km^2 in Freetown. They note certain challenges to this methodology: that each study area applies different rules for the distribution of street space; that a level of subjectivity is involved in deciding how to classify certain spaces; variance in image quality; variance in infrastructure maintenance; visibility of road paint and limited visibility due to shadows in narrow areas, in satellite imagery; orderliness around informal settlements; and cultural differences in the design, allocation, and use of space. For example, the authors note the difference in walking culture in Freetown, where road space is expected to be shared by all modes, meaning that a lack of dedicated pedestrian infrastructure may have different consequences for a mobility regime than in other cities. The authors also remark on the difficulty of scaling this method due to the amount of work required (Attard et al., 2023).

The third method employs already prepared digital data sources, often released by municipalities, facilitating larger-scale analyses (typically city-wide) by removing the substantial task to researchers of themselves creating geometries. The increasing availability of these municipal data through open data portals may serve in part to explain the recent growth of this field of study. The majority of included studies compile digital data sources, some private and proprietary but most public, containing geometries of transportation infrastructures (Eom & Suzuki, 2019; Guzman et al., 2021; Lefebvre-Ropars et al., 2021a, 2021b; Nello-Deakin, 2019; Palominos & Smith, 2023). The extent to which this data is already prepared for the requirements of street space allocation analysis varies, ranging from requiring (nearly) no further preparation (Nello-Deakin, 2019) to requiring substantial processing. Lamour et al. (2019), a study which principally is concerned with walkability around a metro station, uses a laser distance measure to measure pavement width along each block, assumes width is constant for each block, and applies that width to the block length derived from a digital city map. The authors manually, through visits, identify street parking spaces. In this manner, Lamour et al. derive street space allocation in a 600m radius around a metro station. Lefebvre-Ropars et al. (2021a) create a detailed street space map of Montréal based on already available data sources, but with heavy processing of that data. The authors associate the city roadway inventory attributes to the road centerline, divide streets into 3m segments, and estimate the shapes and locations of street buffers according to average sidewalk widths wherever trees or signposts are detected. They use this data, alongside information on parking rules, transport priority lanes, and cycling networks, to derive parking rules across the city in 30-minute segments. In their subsequent work, the authors further refine this dataset by better accounting for street margins (Lefebvre-Ropars et al., 2021b). Owing to the significant data requirements for this thorough methodology, and limited data availability, the authors perform this analysis for 11 of the 19 boroughs in Montréal (44% of the island of Montréal's area). Palominos and Smith (2023), without available data for roadway widths, combine road centerline data with sidewalk position data and draw a cross-section line across every street segment to obtain widths, later verifying the accuracy of this method with satellite images. Szell (2018), the second-earliest included study, develops a method of extracting and collating transportation infrastructure data from OpenStreetMap (OSM), allowing for a simultaneous analysis of 23 cities. The main purpose of this work is for public communication about the spatial dominance of automobile transport, and so the author consciously foregoes accuracy in order to enable a larger scale of analysis; Szell makes rough estimates to derive road widths, and the study is sensitive to numerous OSM data quality issues.

Features measured

A criterion for inclusion in this review was measuring more than one type of transportation infrastructure, to ensure that the studies examined the distribution of street space *between* transportation modes. The particular street features measured vary between studies (see Table 1), barring two features which were always measured: automobile infrastructure and pedestrian infrastructure. Two studies examine only these two infrastructure types (Eom & Suzuki, 2019; Palominos & Smith, 2023), with Eom and Suzuki (2019) also distinguishing between street-level and off-street-level (above- or under-ground) roadways and footpaths. Excepting those two studies, every other included study also examines dedicated micromobility and dedicated public transit infrastructure spaces. Non-transport infrastructure area is considered in five studies: De Gruyter et al. (2022) measure greenspace ("landscaping"), Attard et al. (2023) and Guzman et al. (2021) measure median strips, and Lefebvre-Ropars et al. (2021a, 2021b) measure greenspace, median strips, street buffers and margins, and go so far as to separate between "mineral" (i.e., concrete, asphalt) and vegetal buffers.

Five studies measure shared road space areas (Attard et al., 2023; De Gruyter et al., 2022; Gössling et al., 2016; Lefebvre-Ropars et al., 2021a, 2021b), with all but Attard et al. (2023) endeavoring to separate out different shared road space areas in some way, though doing so is a challenge noted in several studies. This is especially sensitive in two cases: roadways shared between automobiles and public transit, and roadways shared between automobiles and micromobility modes. Some studies separate out each shared use type (e.g., shared general traffic and tram lanes, shared general traffic and bus lanes, bicycle lanes and public transport lanes), where possible (De Gruyter et al., 2022; Gössling et al., 2016). Guzman et al. (2021) examine roadways shared between automobiles and buses and design a proxy of the dynamic space occupied by buses, derived from the features of the bus line geometries, travel time, headways, frequencies, and the fleet size. In this manner, they separate out 7.4% of total street space allocation to buses, compared to 55.8% identified as allocated to cars and motorcycles. Shared road space areas are sometimes "shared" by virtue of temporality, with permissions for a particular travel mode varying throughout the day. Lamour et al. (2019) note the challenge of separating car parking from bus lanes, with the latter only operating at some times of the day. Similarly, Lefebvre-Ropars et al. (2021a) measure street space allocation in 30-minute intervals throughout the year to account for changes in parking rules.

Other analyses performed

The included studies often investigate matters ancillary to street space allocation and perform analyses other than street space measurement. For example, Lamour et al. (2019) are primarily interested in walkability, Creutzig et al. (2020) and Nello-Deakin (2019) are interested the concept of "fairness" with reference to street space, and Eom and Suzuki (2019) investigate how urban renewal and redevelopment projects relate to pedestrian infrastructure.

Most common is to compare street space allocation to modal share (Creutzig et al., 2020; De Gruyter et al., 2022; Gössling et al., 2016; Guzman et al., 2021; Lefebvre-Ropars et al., 2021a; Nello-Deakin, 2019; Szell, 2018). While generally the contrasting figures of street space allocated per transportation mode, and modal share of that transportation mode, are simply placed side-by-side, Creutzig et al. (2020) report a ratio of the percentage of space of a transportation infrastructure to the percentage of modal share that transportation infrastructure represents. Usually modal split figures are taken from municipally-run commuting or origin-destination surveys, though Creutzig et al. (2020), De Gruyter et al. (2022), and Lamour et al. (2019) perform manual counts of travelers. Lefebvre-Ropars et al. (2021a) derive modal shares at the borough (neighborhood) level by modelling routes from an origin-destination survey, and summing travel not as modal share, but as passenger kilometers travelled (PKT). Lefebvre-Ropars et al. (2021b) instead aggregate travel into "street corridors" rather than boroughs, providing a finer level of aggregation. Both Lefebvre-Ropars et al. (2021a, 2021b) articles also model potential demand by identifying automobile and public transit trips that are substitutable by walking or cycling, with consideration for the age and gender of the traveler, the length of the trip, the structure of the trip chain, and the purpose of the trip. In both studies, the authors use this to perform a needs-gap analysis of how much additional space (need) is missing from both observed and potential demand, with Lefebvre-Ropars et al. (2021b) repeating this analysis under different ethical principles of street space distribution.

Some studies conduct other analyses. Correlation analyses have been used to evaluate the relationship between street space allocation and different items of interest. De Gruyter et al. (2022) calculates correlation coefficients between street space allocation and various characteristics of the 57 sites they measure, such as local population and employment c distance to car-sharing vehicles, car ownership, income, and age. Eom and Suzuki (201 perform a regression on place characteristics, but are interested in proximity to railway building density, and whether places are part of redevelopment projects. Guzman et al. are interested in questions of cost, and so consider how street space allocation relates to and the costs of transportation infrastructures. Lamour et al. (2019) investigate walkab conditions through field observations and surveys of pedestrians. Similarly, Palominos Smith (2023) study the access cost of walking to trains through different routes, using s space allocation as a proxy for the quality of street design. Both the Palominos and Sm and Lefebvre-Ropars et al. (2021b) draw on the link-and-place design framework (Jon 2008), which proffers that streets function both as *links* (transportation infrastructure) a *places,* in and of themselves. Palominos and Smith (2023) use this framework to under footways as places and roadways as links, contraposing the two in a trade-off relations Lefebvre-Ropars et al. (2021b) conceptualize links as being transport infrastructures, p being constituted of sidewalks, buffers, and non-parking margins, and a third introduce *environment* dimension as being vegetal spaces, with features possibly belonging to m one dimension; the balance between these is calculated using Shannon's entropy index.

Study Results

Table 2 collates the measured street space allocation figures across the included studies. Directly comparing results between studies is challenging because the features measured vary between studies, as do the methods of measurement. There is wide variation among the results, yet the pattern is broadly similar. In all cases, the allocation of automobile space is largest, followed by dedicated pedestrian space. Dedicated micromobility space is generally miniscule – only exceeding 2.5% in two cases: Nello-Deakin (2019) reports 7% dedicated micromobility space in Amsterdam, a prototypical cycling city, and Creutzig et al. (2020) report 8% in studied street segments of Berlin. Where dedicated automobile parking is measured, Berlin has the most space allocated to this purpose, at 22% of street space, though this high value may be a result of how street parking is tabulated in the study (Creutzig et al., 2020). Where dedicated public transit space is measured, Berlin leads with 7% of total spatial allocation (Creutzig et al., 2020). In all cities studied, automobile space coupled with parking space forms the majority street space allocation (>50%), with the lowest two values being for Bogotá at 50.9% of space (Attard et al., 2023) and Amsterdam at 51% of space (Nello-Deakin, 2019). Eom and Suzuki (2019) report 87% of street space in Central Tokyo being automobile space, though the authors only contrast this with pedestrian space, and no other street feature. Palominos and Smith (2023), also only examining automobile and pedestrian infrastructure space, find 60.42% of street space allocated to roadways in London. Following Tokyo, Montréal has the most street space allocated to automobiles, at 81.6% (Lefebvre-Ropars et al., 2021a), with Lefebvre-Ropars et al.'s Montréal study measuring a wider range of street features.

While street space allocation certainly varies across study areas – between, and even within, streets – few studies report their findings in a manner that allows for an analysis of variance within their study areas. Where possible, we have reported population variance and range in Table 2, though this was only viable for three studies (Gössling et al., 2016; Lamour et al., 2019; Lefebvre-Ropars et al., 2021a), though other studies consider variance in their analysis or discussions (e.g., De Gruyter et al., 2022, especially Appendix A). In the three studies for which it was possible to derive the variance in street space allocation, the variance was significant. For example, Gössling et al. (2016) finds the average space dedicated to pedestrian infrastructure is 24.8% across four neighborhoods ("quarters") studied, with a variance of 49.96 and a range of 18.

Policy Implications and Recommendations

Nine of the twelve studies explicitly highlight policy directions based on their research (Attard et al., 2023; Creutzig et al., 2020; De Gruyter et al., 2022; Eom & Suzuki, 2019; Gössling et al., 2016; Guzman et al., 2021; Lamour et al., 2019; Palominos & Smith, 2023; Szell, 2018). Six of those nine studies advocate for reallocating space from cars to micromobility infrastructure. Attard et al. (2023) propose enhancing sustainable mobility through investments in active and public infrastructure, along with campaigns to educate drivers and car users about the necessity for change. The authors also note that historical changes in the urban mobility policy agenda of Bogotá, for example, has led to a greater proportion of space allocated to non-automobile uses, when contrasted with Freetown and Malta, underscoring the importance of agenda-setting in shaping street space allocation. Creutzig et al. (2020) suggest converting on-street car parking into cycling infrastructure and improving design in congested areas. De Gruyter et al. (2022) argue for reallocating on-street parking to pedestrian spaces, enhancing existing cycling infrastructure with safety measures, and promoting sustainable transportation through community-oriented activities. Gössling et al. (2016) call for increasing street space dedicated to cycling infrastructure, and similarly, Guzman et al. (2021) recommend expanding spaces for walking and cycling while limiting car usage. Palominos and Smith (2023) cite Barcelona's superblocks (Mueller et al., 2020; Rueda, 2019) as a model for neighborhood-scale street reallocation schemes. Each of these approaches supports an overall shift towards reallocating street space from automobiles to micromobility infrastructure, with researchers often emphasizing the potential of such reallocation to support sustainable transportation.

Three of the twelve studies included in this review focus on improving transportation planning approaches (Eom & Suzuki, 2019; Lamour et al., 2019; Szell, 2018). While Eom and Suzuki (2019) do not advocate specifically for reclaiming street space from automobiles, they suggest transportation planners implement "soft approaches", like adding street furniture and redesigning roads to reduce vehicle speeds, to enhance pedestrian safety and comfort. They recommend expanding such pedestrian-focused redevelopment projects to create more walkable cities. Similarly, Lamour et al. (2019) advocate for integrating walking into Transit-Oriented Development (TOD) plans. They propose policies to upgrade commercial ground floor facades and enhance the public environment to encourage walking and other sustainable transportation modes. Szell (2018) suggests that transportation planners should adopt more data-driven, scientific methods to optimize urban mode mixes and allocate infrastructure effectively.

Table 2. Reported street space allocation of transportation infrastructures in the included studies. Where possible, population variance and range are reported. "NI" indicates when a given feature was not measured. (*) Figures are for ground-level values, excluding off-ground level values (i.e., above- or under-ground). (**) Authors separate out bus space from general road space, but here this is added to automobile space because it is not dedicated public transit space. (***) Averaged between two study sites. (****) Authors study parking and shared road space areas, but do not report the figures in the text.

Three studies did not identify explicit policy interventions or recommendations based on their findings. Nello-Deakin (2019) advances theoretical approaches to analyzing street space allocation, while Lefebvre-Ropars et al. (2021a, 2021b) focus on methodological advancements. Although these studies influence policy indirectly by shaping future research agendas, they do not weigh in on specific recommendations for policymakers and transportation planners.

Future Research Areas

Of the included studies, only Szell (2018) did not provide recommendations for future research areas, though the article makes many suggestions for the use of its method for urban planning and public communication. Guzman et al. (2021) also did not specify precise areas for future research, but instead emphasized the need for future studies to address the inequalities and practices associated with how transport infrastructure investment and policies are implemented. The other papers provided specific directions for future research.

Among these ten papers, six recommend specific adjustments to future research methodologies. For example, Creutzig et al. (2020) propose integrating environmental allocation mechanisms and economic efficiency considerations into studies focused on human well-being-centered allocation. They also suggest accounting for parked cars alongside moving cars in future studies. De Gruyter et al. (2022) caution against using averages to represent street space allocation across study areas, as this can obscure crucial site-specific differences necessary for practical changes in street space allocation. Lamour et al. (2019) suggest that researchers assess a more appropriate distance to potentially expand Transit-Oriented Development (TOD) precincts, taking into account that pedestrians often walk more than ten minutes. Lefebvre-Ropars et al. (2021b) recommend that future studies include more granular data, including shared street space, and include corridor and street levels in their analysis. Lefebvre-Ropars et al. (2021a) suggest a suite of recommendations, including incorporating municipal mode share targets or greenhouse gas emission reduction targets in future studies. Palominos and Smith (2023) urge future studies to include complementary data where possible, such as bus and bicycle lanes, speed limits, street parking, and curb space data, to provide a more comprehensive picture of how the street is

Study	**Site**	**Automobile**
Attard et al., 2023	Valletta, Malta	52.4
Attard et al., 2023	Bogotá, Colombia	50.9
Attard et al., 2023	Freetown, Sierra Leone	60
Creutzig et al., 2020	Berlin, Germany	18 32
Eom & Suzuki, 2019*	Tokyo, Japan	87
Gössling et al., 2016	Freiburg, Germany	48.6 *(33.46, 15.3)*
Guzman et al., 2021**	Bogotá, Colombia	63.2
Lamour et al., 2019***	São Paulo, Brazil	52.3 (100, 20)
Lefebvre-Ropars et al., 2021a***	Montréal, Canada	81.6 (10.74, 10.9)
Nello-Deakin, 2019	Amsterdam, The Netherlands	41
Palominos & Smith, 2023	London, U.K.	60.42
AVERAGE		**55.95**

Street space allocation to transportation infrastructure % (population variance, range)					
Dedicated Automobile Parking	Dedicated Pedestrian	Dedicated Micromobility	Dedicated Public Transit	Shared Road Space Areas	Non-Transport Space
19.8	26.8	0	0.6	0.4	0
0	36.1	0.4	4.8	0	7.7
7	14	0	5	14	0
22	31	8	[illegible]	NI	NI
NI	13	NI	NI	NI	NI
6.6 (10.8, 8.1)	24.8 (49.96, 18)	2.4 (1.34, 2.8)	6.1 (34.11, 14.9)	11 (43.85, 17.1)	NI
NI	34.4	0.9	1.5	NI	NI
11.6 (36, 12)	29.85 (41.6, 12.9)	1.2 (1.21, 2.2)	5.1 (1.96, 2.8)	NI	NI
NI	16.4 (7.24, 8.8)	1.8 (0.72, 3.1)	0.2 (0.01, 1.4)	NI	NI
10	40	7	2	NI	NI
NI	39.68	NI	NI	NI	NI
12.25	**28.25**	**3.37**	**5.47**	**10.08**	**2.57**

organized. They also propose that examining how street space is allocated across the city could improve the understanding of the implications of reallocation across different scales.

Two of the papers outlining future research recommendations suggest replicating studies in different contexts for comparative analysis and to further strengthen the methodology. Specifically, Attard et al. (2023) underscore the importance of increasing visibility and research into cases of spatial reallocation, examining their transferability and replicability across different geographic contexts, and Eom and Suzuki (2019) highlight the necessity of international comparative research to advance methodological development. Gössling et al. (2016) and Nello-Deakin (2019) advocate replicating their approaches in cities and countries with different structures to enable cross-context comparisons and establish standardized methodologies. Gössling et al. (2016) also advocate comparing space distribution with modal shares using trip numbers and distances travelled, emphasizing that cars typically account for a larger share of longer trips. Additionally, Nello-Deakin (2019) suggests considering traffic speed in study replications, among other recommendations.

Discussion

Conceptual Framework and Theorizing an Equitable Streetscape

Most included studies build on one another by citing similar sources and working with similar frameworks, or by employing comparable methodologies. They are often rooted in transport or mobility justice theories and focus on addressing the impacts of automobility, with all but one (Lamour et al., 2019) contributing to discussions on "fair" or "equitable" allocation of street space across modes. The framing in these papers expands the discourse on transportation justice (Karner et al., 2020; Martens, 2016) by focusing on how equity, justice, and fairness shape street design and configuration. Many also emphasize environmental sustainability and public health as key motivations for their research, reinforcing shared goals of advancing equity and fairness in street space allocation, and promoting sustainable transportation. As articulated by Nello-Deakin (2019), this contrasts with traditional urban transportation discourse that focuses on broader equity implications such as accessibility, travel times, and infrastructure investments, rather than specific street-level considerations. This emerging literature provides a detailed conceptualization of how to apply concepts of social equity and justice at a finer granularity, through scrutinizing the dimensions of equity and justice in the configuration of streets. This convergence around similar frameworks and aims reflects the emergence of a field of research, driven by a logical response to overlapping crises and the ongoing urban mobility transition.

In terms of policy directions based on the findings from these studies, there are two primary takeaways: (1) the call to reallocate street space from automobiles toward micromobility infrastructure, and (2) the potential for coordinated engagement and campaigns around street space reallocation across national and local levels. Expectedly, six of the nine studies offering policy recommendations explicitly support reallocating street space toward micromobility infrastructure, with studies emphasizing that the automobile is overprivileged in the configuration of the street. As many cities globally are enacting these recommendations, to some extent (see, for example, National Complete Streets Coalition, 2023), and implementing micromobility infrastructure (Pucher et al., 2011; Pucher & Buehler, 2017), the communication and education around these projects is critical.

Changes to land use in cities, especially for mobility infrastructure, are among the most contentious issues in urban land use politics (Bodnar, 2015). Cities implementing micromobility infrastructure, such as bicycle lanes or pedestrian streets, are often met with adverse reactions from communities (see Bubbers, 2019; Goodman, 2010; Nunn, 2022; O'Sullivan, 2017; Rodrigue et al., 2023; White-Crummey, 2023). Aldred et al. (2019) find that the top three barriers to investing in this infrastructure is this public opposition, alongside a lack of political leadership and funding or financial barriers. Though, as they and others (Crane et al., 2016; Ferster et al., 2021) have noted, public opposition is highest at the beginning of an implementation and decreases over time, as people adapt to the changed infrastructure. Among the policy recommendations outlined in the results, the call for educational campaigns to inform drivers and car users about the necessity for change (Attard et al., 2023) stands out as a critical consideration when implementing new micromobility infrastructure. This approach mirrors strategies outlined in the literature on "bikelash", a term for the fierce and commonplace public resistance in response to micromobility improvement projects (Wild et al., 2018), emphasizing the potential for coordinated campaigns across national, regional, and community levels to shift public attitudes in an evolving mobility landscape (Field et al., 2018). In this model, community actors play a crucial role in building trust in the benefits of proposed changes and mobilizing local support. City-level actors are tasked with transparently communicating data and integrating new infrastructure, while national actors can establish policies, strategies, case studies, and campaigns to foster social acceptance and justify infrastructural changes. This approach is aligned with findings in the cycling literature that highlight the critical role that clear communication with the public plays in improving public support for such infrastructural changes (Rodrigue et al., 2023). In addition to reallocating space away from automobiles and correcting the inequitable distribution of street space across modes, educational campaigns are essential to building public buy-in. Street space allocation studies, and especially their numerical and graphical outputs, may have a uniquely valuable role to play here.

Methodological Differences and Development

While this field of study is nascent, the geographical dispersion of the studies is useful in elucidating the non-specific features of problems of street space allocation. That cities around the world, and researchers in those cities, are not only arriving at the same problem – of inequitable street space allocation – but also finding similar methods of research useful, indicates some level of convergence and cohesion on street space allocation as an analytical method for modern cities. However, as the field develops, more comparative studies that consider more than one city would be valuable in increasing confidence in the external validity of methodologies, and in identifying commonalities and differences across cities. Of the included studies, only Attard et al. (2023) and Szell (2018) assess more than one city, with the former suggesting that doing so provided valuable insights on methodological challenges, and on the structural and cultural differences in street space between the cities, and the latter offering that comparing cities in this manner is a useful public communication tool.

Each paper employs a different methodology, with two notable exceptions. Attard et al. (2023) adopt Gössling et al.'s (2016) methodology, and Lefebvre-Ropars et al. (2021a, 2021b) build on their own methodology across the two papers. Nello-Deakin (2019), while not following any other study's methodology, takes advantage of the excellent data available for Amsterdam and devotes almost no writing to the methodology, with street space allocation figures being readily available; all other studies to some extent devote time to the methodological challenge of measuring street space allocation.

The included studies use one of three types of methods: manual, digitizing remote sensed imagery, or working with already prepared digital data sources. While the studies clearly adopt one of these three methodological approaches, some employ complementary approaches for portions of their analysis. Creutzig et al. (2020) principally digitize remote sensed imagery, but validate this work with site visits and cross-referencing with municipal maps. Lamour et al. (2019) validate a digital dataset with satellite imagery, and Palominos et al. (2023) augment already prepared digital data with manual measurement.

The manual approach appears useful either when other data sources are not available or when there are particular and specific sites or features the researchers want to measure. De Gruyter et al. (2022) undertake manual measurement across 57 small study areas, allowing the researchers to separate out shared road space areas in detail (e.g., distinguishing between shared general traffic/tram lanes, shared general traffic/bus lanes, and shared general traffic/tram/bus lanes). The researchers were also interested in conducting traveler counts on site, alongside measuring the street. However, they note the high cost of this manual labor, and the scaling limitations are readily apparent. Barring cases where researchers are pursuing not otherwise available data, including measurement of particular features not captured in digital datasets, the manual method seems unfavorable.

The approach of digitizing remote sensing data may otherwise be necessary when already prepared digital data is unavailable, and researchers can use this to great effect to investigate contexts that are difficult to study but provide valuable insight (e.g., Attard et al., 2023). The limitations of this method are substantial, however. For one, as Attard et al. (2023) notes, there is some subjectivity involved in the researcher deciding how to interpret the remote sensed images, undoubtedly introducing possible variation in the process, especially in contexts where the division between different infrastructures is unclear. Interestingly, the authors suggest that in the difficult process of working with the data across study areas, they become attuned to the cultural, structural, etc. particularities distinguishing the cities from each other. The process is also labor-intensive, albeit less so than manual measurement, but still to an extent that makes city-wide processing impractical (Attard et al., 2023; Gössling et al., 2016).

The final methodological approach, of using already prepared digital data, is for obvious reasons most popular – the intensive work of creating digital geometries of street space is already complete. For this reason, it is possible that future street space allocation research will be conducted in cities with these datasets already available, possibly turning researchers away from studying places that may benefit from a street space allocation investigation, but lack governmental resources to develop transport infrastructure geometry datasets. A key benefit of working with these datasets is the ability to study transport infrastructure across the city, and not just in key sites, facilitating assessments of differences between areas in the city (Lefebvre-Ropars et al., 2021a; Palominos & Smith, 2023), or between cities (Szell, 2018). While Szell (2018) utilizes OpenStreetMap (OSM) data and generic processing to allow for a large-scale data analysis across 23 cities, the limitations of OSM data in terms of quality and accuracy may make this approach unattractive to other researchers. Even with better data sources, there may still be significant processing required, as with Lamour et al. (2019) and Palominos and Smith (2023), where the absence of pavement width data was addressed with manual measurement in the former case, and in the latter case with an additional dataset and some processing, as well as validation with remote sensed imagery. Lefebvre-Ropars et al. (2021a, 2021b) perform the most thorough and extensive methodology to derive accurate and detailed street allocation figures across a large area, also accounting for street features not considered by other studies (see Table 1); their methods may be valuable to other researchers, though the length to which the authors go to map the street may be unnecessary for most street space allocation analyses. One investigation their study enables with this rigorous approach, that may otherwise be impossible, is studying the temporal variation in allocation throughout the day or across the year, with rules around street space use varying across time (2021a).

Studies also vary considerably in the street features they measure (see Table 1). In general, researchers measure the features in which they are interested, though it could well be the case that methodological challenges in measuring other features constrain their analysis. Given the potential difficulty of measuring some of these features, it may be advisable to consider beforehand what is necessary for a particular study. Palominos and Smith (2023), for example, focus on the street network through only analyzing automobile and pedestrian infrastructure, though the authors note that other transportation infrastructure features would be desirable for analysis, if data were available. In a similar manner, Creutzig et al. (2020) and Nello-Deakin (2019) are mostly interested in discussing ethical principles and issues of fair allocation, and so the measurement of non-transportation infrastructure features (e.g., medians, street buffers), may not be necessary. Likewise, there is a trade-off between increasing measurement accuracy and the time spent at this stage of the analysis, especially when using manual measurement or digitizing remote sensed imagery, and the improved accuracy may not significantly affect the analysis. There is also a point here about context: in Bogotá, for instance, street medians occupy substantial portions of the street space, particularly along boulevards and throughfares, and so failing to account for median space may add a proportionally large area to what is identified as automobile space; in Montréal, medians occupy relatively little space in city streets (though this varies across boroughs), and so omitting median space from measurement may not change a study's findings considerably.

An important decision researchers make in terms of the features they measure is how to deal with shared road space areas. Guzman et al. (2021) separate out bus space from car space on roadways by deriving a measure of the dynamic spaces buses occupy, which is valuable for their analysis of how travelers occupy space; however, if researchers are instead interested, for example, in dedicated infrastructural space for public transit, this operation of separating out the two modes would be unnecessary, as the roadway is not, by design, allocated separately. Another special consideration is how to treat non-dedicated micromobility infrastructure (e.g., bicycle infrastructure marked by paint on the road rather than fully separated lanes). In some cases, this infrastructure may be adequate – if the road is low-speed, low-traffic, and well-designed, for instance – and in others it may be wholly dangerous (Nello-Deakin, 2019), but the task of identifying this difference at scale is challenging.

Few of the reviewed studies reported their findings in a manner allowing for an assessment of variance in street space allocation within the study area, though we know that street space allocation can vary considerably between streets and neighborhoods of the city, as well as on the same street (e.g., a dedicated bus lane may only be present for one segment of a longer street). Researchers may want to further consider and report on how street space allocation varies within their study areas, and how this shapes the result of their analysis. Alongside considering these spatial variations, Lefebvre-Ropars et al. (2021a, 2021b) demonstrate that a temporal variation may exist in street space allocation (e.g., through on-street parking only being available at certain hours of the day, temporary priority bus lanes, etc.). Depending on the study context and how street space rules manifest in a particular site, researchers may also find it valuable to additionally consider this temporal variation.

The most common analysis performed alongside street space allocation measurement is the comparison of the split in spatial allocation with modal split, as some measure of the fairness of the former judged against the latter. Nello-Deakin (2019) explicates some problematics with this approach, though subsequent studies by other researchers have continued to employ it (with Creutzig et al. (2020) dedicating some space to this discussion). Measures of street space use that look at flow are biased towards higher-speed modes, especially the automobile (De Gruyter et al., 2025). Creutzig et al. (2020) also note that comparing current modal shares with current spatial allocations risks reproducing existing (potentially unfair) patterns. Lefebvre-Ropars et al. (2021a, 2021b) attempt to account for this by considering, in addition to current modal share patterns, potential modal share if car and public transit trips that might be done by walking or cycling were substituted, though this still works within the current infrastructural limitations. This challenge remains largely unsolved.

Comparing Results

The variation in methodologies, in both the features measured and the ways they are measured, limits the ability to make comparisons between and interpretations across studies. As street space allocation figures are often reported as percentages of the total, the number of types of features measured may significantly affect results. Whether shared road space areas are classified separately from automobile area, and how shared road space is defined, also varies considerably between studies and stymies comparison. Attard et al. (2023), using the same methods to study three cities, find important differences in spatial allocation between them. The results from Gössling et al. (2016) are comparable to these findings, as Attard et al. (2023) replicate their methods. Across these four comparable results, there is significant variation in automobile space from 48.6% (Freiburg) to 60% (Freetown), dedicated pedestrian space from 14% (Freetown) to 36.1% (Bogotá), and dedicated public transit space from 0.6% (Valletta) to 6.5% (Freiburg). The authors highlight that, through their comparative case study, they are able to investigate and underscore the potential effects of geographically specific characteristics, including historical developments, culture, planning traditions, politics, and others, on street space allocation. This indicates that if future studies were either to study several cities at once, or otherwise to replicate the methodologies of other studies, valuable insights may be found in the comparisons made possible.

Future Research

In terms of research directions, key priorities include establishing a standardized methodological approach for examining equitable street space allocation or following existing methodologies, replicating the approach across diverse contexts, investigating the policy transferability of findings, and integrating additional street data and municipal targets into analyses. Clear opportunities for future research emerge, both from the articles themselves and through the process of synthesizing them.

The importance of comparative studies, alongside the substantial methodological differences across existing studies that stymies comparative efforts, points to the potential utility of a standardized methodological approach. The reviewed studies vary by their measurement method (manual, digitizing remote sensed imagery, or working with already prepared digital data sources), the features measured, and other analyses performed. While an initial impulse may be to suggest a standard measurement method, and a standard set of features, this would belie the data limitations and contextual variance that motivates authors to adopt differing methods in the first place. For example, working with already prepared digital data relies on, of course, the existence of those sources; elsewise, researchers will find themselves relying on either manual measurement or digitizing remote sensed imagery. Yet, those working with already prepared data may be limited in the street features measured, depending on what is included in those data. Digitizing remote sensed imagery, while onerous, may provide researchers with insight into local contexts, as found by Attard et al. (2023). The requirements of the analysis ultimately shape methodological variation, a fact made evident by how researchers decide to deal with shared road space areas. Of course, a perfectly measured and mapped, already existing dataset with separate geometries for every conceivable street feature will generally, if not always, be preferable for researchers, but absent this and when one's own measurement must be conducted, there will always exist the question of whether the additional time spent on this stage of a study will provide sufficient additional utility to warrant that cost. Ultimately, any efforts to standardize methodologies will have to provide for these well-motivated differences in approach, with consideration for data limitations especially, and study purposes. Where possible and where it suits their purpose, researchers may wish to follow existing methodologies, as here detailed. Positive examples are the two sets of papers that adopt existing methodologies (Attard et al., 2023; Gössling et al., 2016; Lefebvre-Ropars et al., 2021a, 2021b).

There is a need for further comparative studies; of the included corpus, only two make comparisons between cities (Attard et al., 2023; Szell, 2018). The geographical dispersion of the cases examined by the studies indicates some universality to the problem of street space allocation, and the divergence in results seems to indicate context-sensitive particulars, the further investigation of which through comparative studies may be helpful in understanding the process of street space allocation, its relationship to local variables (e.g., income, population density), and promising ways forward for reallocation initiatives. Comparative studies may also reveal the relationship between differences in street space allocation between cities, and potential explanatory or causal factors, such as culture, historical urban development patterns, and governance systems, among others. Replicating existing methodologies (as Attard et al. (2023) demonstrate) will also facilitate comparison across studies, and takes advantage of some of the methodological development already in the field. For this, it is vital that authors ensure they sufficiently detail their methodology so it may be replicated by others in new study areas. As highlighted by Nello-Deakin (2019), future studies may want to adopt a unified methodology for this comparative purpose. Authors commonly recommend testing this approach in diverse geographic contexts (Attard et al., 2023), including different countries and cities with varying structural characteristics, such as density levels and transport mode shares, to facilitate meaningful cross-contextual comparisons.

Addressing the problematic discussed by Nello-Deakin (2019) and Creutzig et al. (2020) in comparing spatial allocation to modal split as a measure of fairness, equality, or equity in street space allocation, provides another future research direction. Nello-Deakin (2019) suggests that a focus on dynamic modal split based on speed may be a worthwhile alternative, specifically by examining the distribution of street speed limits with the assumption that lower speed limits are more equitable across modes. Guzman et al. (2021) later employ a consideration of speed by measuring the time-area occupancy of a vehicle in motion over the course of a trip. Another alternative approach considering speed is developed in De Gruyter et al. (2022), with a measuring of "people concentration" that is the flow of people using a certain mode (people per hour), divided by the "mean space speed" occupied by a traveler of a particular mode, which functions to estimate the number of people in a given area, per mode, in the study site. A small but growing literature explores this time-area concept (Brunner et al., 2018; Schnieder et al., 2020; Will et al., 2020), much following the seminal work of Bruun and Vuchic (1995), who provided an initial formulation of this measure. A recent publication by De Gruyter et al. (2025) calculates the space consumed per transport mode through six measures, developing the earlier approach (De Gruyter et al., 2022) by weighing people flow and people concentration, by the time-area space consumption of a mode and space efficiency per mode. A worthwhile avenue for researchers might be developing methodologies of measuring dynamic space consumption, perhaps alongside more conventional modal split measures, to better evaluate questions of fairness and equity in the spatial allocation of transport infrastructures.

The discussion over how to work together with spatial allocation and modal split, especially without reproducing existing patterns of injustice (Lefebvre-Ropars et al., 2021b), is a valuable one, and clearly points to the need for developing measures of spatial/modal inequality beyond comparisons of percentages of spatial allocation and traveler counts. Creutzig et al. (2020) and Nello-Deakin (2019) make headways towards this problematic conceptually, and Lefebvre-Ropars et al. (2021b) and Guzman et al. (2021) do so methodologically. Exploring the effect of potential reallocations on different measures and understandings of fairness may be productive here (Creutzig et al., 2020). Another avenue for future research is exploring who benefits from the current situation, and also from proposed changes to the streetscape (Nello-Deakin, 2019). Guzman et al. (2021) also emphasize how population income intersects with street space allocation, and through their investigation of the costs of transportation infrastructures in relation to street space allocation, offer a model for this type of analysis. This approach aims to refine our understanding of fairness, justice, and equity in urban street design.

Another future research direction emerges when looking at the included studies together. Szell's (2018) early work on this subject, and Colville-Andersen's (2013, 2021) non-academic work, focused on the public communication of street space allocation, though other included studies generally do not emphasize the utility of their research in communicating matters of spatial allocation to the public or to practitioners. In the context of the popular movement around street space reallocation initiatives, and in the closeness of this work to policy efforts to change city streets, a renewed consideration of the public communication around spatial allocation may support the translation of this research to policy and practice. An important consideration for future research, as articulated by Attard et al. (2023), is the examination of policy transferability – particularly how findings influence or interact with urban mobility policy. While the reviewed studies that provide policy recommendations are essentially unanimous in their call to reallocate street space away from cars, specific recommendations have not been studied for their adaptability across contexts, which presents a potentially valuable research direction in comparative studies that focus on the contextual factors around reallocation initiatives. Palominos and Smith (2023) highlight the potential to incorporate comprehensive street data, such as cycling infrastructure and street parking, and integrate municipal policy goals like urban mobility and greenhouse gas emission targets into the analysis of street space allocation. Future research could explore how these findings can inform urban policies on street space allocation and how they can integrate policy objectives, such as urban mobility and greenhouse gas emission targets, into their methodologies. A focus on the utility of measures and studies of street space allocation in improving public communication of reallocation proposals may improve the transferability of this research to policy.

Conclusion

Studies of street space allocation are cohering into a field of research that is well-positioned to study and contribute to the growing popular and policy discussions about the injustices of the contemporary streetscape. We conducted a systematic search of the literature for empirical investigations of street space allocation that compares transportation infrastructures, and found 12 articles meeting our search criteria. The first of these studies was published in 2016 (Gössling et al., 2016), with more studies appearing in the past few years. The citations between the included studies indicate the emergence of a field, with all but two of the studies routinely citing one another. While relatively few papers meet the search criteria, there are indications that suggest the emergence of an increasingly relevant and growing field of research, and we intend to extend this review in the future, as more studies are published that investigate street space allocation.

Studies generally frame their work around equity or fairness, positioning their analysis as a critique of the status quo. Street space was measured in three ways: manually, by digitizing remote sensed images, or by using already prepared digital data sources, such as municipal maps. The latter method alleviates much of the work for the researcher but is not available in all areas. Researchers vary considerably in which street features they measure, which generally reflects the purpose of their analysis, but makes the comparison of results across studies challenging. Future studies are encouraged to report the results of their street space allocation measurement in detail to facilitate later comparison with other research. The studies often perform other analyses aside from street space allocation, most commonly comparing spatial allocation to modal split as a measure of fairness, though some authors raise issues with this approach (Creutzig et al., 2020; Nello-Deakin, 2019). Most papers make policy recommendations, often for reallocating space away from automobiles towards other transportation infrastructures, particularly micromobility. At the same time, studies note that street space is markedly contentious, and so these policy recommendations may come against fierce opposition in practice. Through the literature review and synthesis, we have identified the following directions for future research:

(1) Developing standardized methodological approaches or toolkits for examining equitable street space allocation, or otherwise replicating existing methodologies to facilitate comparisons across studies.

(2) Conducting additional comparative studies, perhaps using existing methodologies.

(3) Investigating the policy transferability of findings through comparative studies.

(4) Developing measures of street space use beyond modal split, to have better tools to evaluate the equitable allocation of street space, perhaps including dynamic space consumption.

(5) Integrating additional street data and municipal targets into analyses, alongside existing approaches.

(6) Studying how street space allocation measures can better inform urban policies of street space allocation, and be used to improve public communication of reallocation projects.

The included studies, taken together, make two key contributions: methodologically, in developing methods of measuring street space, so that the problem of unfair allocation is known and its contours defined; and conceptually, both in refocusing the analytical lens on the street, as the locus of contestation over mobility futures, and in discussing ethics, justice, and fairness in this context. As the field of street space allocation studies develops, we can expect advancements in these directions. From the studies themselves and from the process of our review, we identified clear and promising future research directions. Positioned, as the studies are, in the context of moving towards a future equitable streetscape, investigations of street space allocation have the potential to make important contributions to policy, practice, and research.

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Disclosure Statement

The authors report there are no competing interests to declare.

Appendix A

Table A1. Concepts searched for and associated search terms queried from the databases.

Concept	Search terms
Topic: Street space	"road*" *OR* "street*" *OR* "mobilit*" *OR* "transport*" *OR* "infrastructur*" *WITHIN 5 WORDS OF* "space" *OR* "spatial*"
Topic: Transportation infrastructure	"transport*" *OR* "mobilit*"
Topic: Spatial allocation	"road*" *OR* "street*" *OR* "mobilit*" *OR* "transport*" *OR* "infrastructur*" *OR* "space" *OR* "spatial*" *WITHIN 5 WORDS OF* "distribut" *OR* "allocat" *OR* "designat"
Approach: Critical examination	"fair*" *OR* "just*" *OR* "equit*" *OR* "uneven*" *OR* "priorit*" *OR* "allocat*"

Table A2. Publication details of the included studies.

Urban space distribution: The case for a more equitable mobility system	Attard, Maria; Guzman, Luis A; Oviedo, Daniel	2023	Case Studies on Transport Policy
Fair street space allocation: ethical principles and empirical insights	Creutzig, Felix; Javaid, Aneeque; Soomauroo, Zakia; Lohrey, Steffen; Milojevic-Dupont, Nikola;… Zausch, J Marco	2020	Transport Reviews
Understanding the allocation and use of street space in areas of high people activity	De Gruyter, Chris; Zahraee, Seyed Mojib; Young, William	2022	Journal of Transport Geography
Spatial distribution of pedestrian space in central Tokyo: Regarding building, public transportation and urban renewal projects	Eom, Sunyong; Suzuki, Tsutomu	2019	International Review for Spatial Planning and Sustainable Development
Urban Space Distribution and Sustainable Transport	Gössling, Stefan; Schröder, Marcel; Späth, Philipp; Freytag, Tim	2016	Transport Reviews
Buying a car and the street: Transport justice and urban space distribution	Guzman, Luis A; Oviedo, Daniel; Arellana, Julian; Cantillo-García, Victor	2021	Transportation Research Part D: Transport and Environment
Improving walkability in a TOD context: Spatial strategies that enhance walking in the Belém neighbourhood, in São Paulo, Brazil	Lamour, Quentin; Morelli, Adriano M; Marins, Karin R de C	2019	Case Studies on Transport Policy
Toward a framework for assessing the fair distribution of space in urban streets	Lefebvre-Ropars, Gabriel; Morency, Catherine; Negron-Poblete, Paula	2021	Transportation Research Record
A needs-gap analysis of street space allocation	Lefebvre-Ropars, Gabriel; Morency, Catherine; Negron-Poblete, Paula	2021	Journal of Transport and Land Use
Is there such a thing as a 'fair' distribution of road space?	Nello-Deakin, Samuel	2019	Journal of Urban Design
Examining the geometry of streets through accessibility: new insights from streetspace allocation analysis	Palominos, Nicolas; Smith, Duncan A	2023	Environment and Planning B: Urban Analytics and City Science
Crowdsourced quantification and visualization of urban mobility space inequality	Szell, Michael	2018	Urban Planning

Table A3. Summary of methodology details from the included studies. Wording in features measured reflects that of the study summarized.

Attard et al., 2023	Valletta, Bogotá, Freetown	Valletta: 2km²; Bogotá: 2.06km²; Freetown: 4.2km²	Satellite imagery, other "available remote sensed data"	Applied methodology from Gössling et al. (2016)	Deciding how to classify space; scalability; cultural differences in use of space; image quality; variance in infrastructure maintenance; visibility of paint; shadows; informal settlements	N/A
Creutzig et al., 2020	Berlin	18 street sections of ~250m length	N/A	Manual	Comparing modal shares with modal street allocations could reproduce existing patterns	Manual count of travellers to calculate space per traveller
De Gruyter et al., 2022	Melbourne	57 sites within 36 "activity centres"	N/A	Manual using measuring wheel	Cost of manually counting travellers, counts performed during some sorts of COVID-19 restrictions	Manual traveller count; allocation vs. use; correlation of site characteristics, traveller counts
Eom & Suzuki, 2019	Tokyo	Central Tokyo (217.8km²)	Various digital data sources	Compiled from digital data	N/A	Relationship between space and building density, railway proximity, renewal projects
Gössling et al., 2016	Freiburg	Sections of four city quarters, 8.787km²	Digital satellite images, municipal maps	Using GIS to derive measurements, on-site visits of all areas for validation, accuracy validation with high-resolution maps provided by the city	Digitizing images for whole city too labour intensive; sensitive to boundary problems; errors in map projection with satellite images	Compare to modal split survey
Guzman et al., 2021	Bogotá	All of Bogotá	Databases for each infrastructure	Compiled from digital data; busways separated with proxy calculated for space from bus line characteristics	Separating out bus space when they share street space with cars	Compare to mobility survey; cost for facilities; time-area indicator per mode; relationship to income
Lamour et al., 2019	São Paulo	600m radius around metro station	Digital map of the city	Pavement widths from laser distance measure, street length from digital map; street parking from parking rules	Separating out car parking from bus lanes when the latter is only for certain times of the day	Land-use mapping; observations of foot traffic and walking conditions; survey of pedestrians
Lefebvre-Ropars et al., 2021a	Montréal	11 of 19 boroughs	Public digital and proprietary datasets	See Lefebvre-Ropars et al (2021b), but also accounted for street margins (as off-street parking and other uses)	N/A	Link-place-environment balance; observed and potential demand; needs-gap analysis
Lefebvre-Ropars et al., 2021b	Montréal	11 of 19 boroughs	Public digital and proprietary datasets	Roadway inventory associated to street centre line, street buffers estimated by sidewalk width; space separated into 30-min. segments by parking rules, transport priority lanes, cycling networks	Computational load reduced by dividing street into 3m segments, which can create slight distortions in curved streets	Observed demand from origin-destination survey, summed as passenger-kilometers travelled; modelled potential demand; needs-gap analysis
Nello-Deakin, 2019	Amsterdam	All of Amsterdam	Public digital datasets	N/A	Certain road categories may accommodate more than one mode	Modal share data
Palominos & Smith, 2023	London	All of London	Public digital datasets	Combines road centre line and sidewalk data to draw a cross-section in every street segment, obtaining the width; validated with satellite images	Data availability for roadway widths	Access cost to trains; cost of walking through routes based on space allocation as a proxy for the quality of street design
Szell, 2018	23 cities	All of each city	OpenStreetMap	Lanes for transport infrastructures from OpenStreetMap; road lane widths are included, with rough estimates	OpenStreetMap data quality; missing on-street parking, pedestrian spaces; overlaps in mobility space	Comparison to modal share for selected cities

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