Searching for standards of fairness in the transportation literature

Abstract

# Abstract

This work provides a synthesis of how transportation fairness, justice and equity literature has operationalized standards. We first outline a flexible framework for engaging fairness questions and then apply it to collate the review’s results. We find most articles were published within the last half decade and center urban areas, with a minority of work (40%) exploring Global South case studies. Income groups, followed by specific age groups (i.e., elders) and people with disabilities, are most commonly the subjects of justice. Transit and pedestrian modes are the most frequently studied mobility tools; with many analyses being multimodal and comparative in nature. The benefits and burdens, the “What” of mobility, focuses on movement (i.e., quality of trips taken) or the potential for movement (i.e., accessibility). How the reviewed works conceptualizes fairness is varied (e.g., Vertical Equity, Wellbeing, Rights-Based); but is often delineated with a supporting opportunity standard (37%) (i.e., number of parks within a 30-minute travel time) or population standard (36%) (i.e., bottom income quartile), though Infrastructure (i.e., level of service) and Environmental+ (i.e., air pollution) standards are also prominent. While the reviewed literature covers plenty of ground, we conclude with calls for action directed at researchers, practitioners, and transportation advocates.

# Introduction

Transportation systems are technologies essential for social inclusion and activity participation, and therefore important from an equity perspective (Karner et al., 2024; Martens, 2016; Vecchio et al., 2020). Beyond ethical motivations, tracking objective and perceived inequalities is of interest for governing bodies to respond to popular demands for fairness. However, this has proven to be a challenging task: transportation systems are notoriously complex, with benefits and burdens that are diffuse over space and time. To compound matters, emerging technologies and service models can swiftly change the balance of benefits and burdens among a population (Guo et al., 2020). Transportation systems that are engineered to offer higher mobility for people *somewhere* can simultaneously cut others off from essential opportunities *elsewhere* (Raje, 2004). The shades of policies cast long shadows, as shown by the legacy of U.S. urban highways (Archer, 2020) and impacts of transportation-related climate change (Markolf et al., 2019).

Responding to this topic, a plethora of academic literature has emerged in recent decades. For instance, much research has been devoted to the issues of *measuring* equity in transportation, including (among many others) (Delbosc & Currie, 2011b; Martens et al., 2019; Pritchard et al., 2022). Further, there are multiple works that discuss the conceptual and philosophical foundations of equity and fairness in transportation (e.g., Martens, 2016; R. H. M. Pereira et al., 2017; Vanoutrive & Cooper, 2019). Previous reviews of equity in planning documents have been tightly scoped to cover accessibility (e.g., Boisjoly & El-Geneidy, 2017) or a particular mode of transportation (e.g., cycling in Doran et al., 2021). These efforts are valuable, but in our estimation there remains a gap in terms of understanding *how* standards for equity are developed and implemented for transportation systems.

The objective of this work is to broadly scan the state of this knowledge. Through a distributive justice lens (R. H. M. Pereira et al., 2017; R. H. M. Pereira & Karner, 2021), our work seeks to make two contributions. First, it outlines a conceptual and flexible framework for engaging and analysis of transportation fairness questions, based on the questions “Why?”, “Where?”, “When?”, “Who?”, “What?”, and “How?” (5WH). Second, it applies the framework to collate the existing knowledge about fairness standards. To achieve this, we scan the state of academic knowledge in defining standards of fairness in transportation. In contrast to previous reviews on measuring inequality in transportation systems, this work is concerned with the implicit or explicit standards used to judge whether inequalities are fundamentally “fair” or unacceptable.

# Background

## Defintions

Fairness, equity and justice are closely related and often colloquially used interchangeably. In this section, we clarify these concepts definitions to facilitate their precise use throughout the manuscript.

**Fairness** is a subjective and moral assessment of a treatment, outcome, or both, in relation to a given state of affairs. Within the transportation domain, the fairness of the distribution of transportation “goods” and “burdens” (e.g., access to opportunities, transportation-related externalities) for individual, groups and society is often at issue (R. H. M. Pereira & Karner, 2021). As examples: congestion pricing schemes could be unfair if they disproportionately disadvantage lower income groups (Eliasson, 2016), systems designed to service “mandatory” destinations like employment or commercial retail that are not as relevant to all populations like those intangled in caring-work (Hail & McQuaid, 2021; Ravensbergen et al., 2023), or even the application of justice such as Title VI of the U.S. Civil Rights Act of 1964 for the purpose of accessibility planning as discussed in Martens & Golub (2021). Individuals may feel certain situations are unfair, processes can be seen as unfair, or even outcomes of these processes and situations can be unfair.

There are a multitude of aspects to **fairness** in transportation (Hail & McQuaid, 2021), namely because the distribution of transportation “goods” and “burdens” are often ambiguous. Individuals’ ability to access and benefit from transportation-related outcomes varies continuously, often in ways that are unrecognized (implicitly or explicitly) or inadequately considered by transportation planners and other influential actors in the system. To put it briefly, when it comes to the distribution of “goods,” fairness can be understood as a *moral* appraisal concerning the amount and strength of moral claims to those goods (Wintein, 2024). Hence, in this manuscript, we define **fairness** as the moral evaluation of the rightness or wrongness of a given state of affairs (e.g., the impartiality and consistency of treatment or associated outcomes); fairness serves as a yardstick for justice.

Relatedly, **justice** can be viewed as the formalized goal of fairness, an analytically reasoned *fair* state of affairs. Justice is attained when people “give and receive whatever they are due” (Jaggar, 2009, pp. 1–2), and it ceases to exist when there are persons or groups that are denied “access to the opportunities they need to lead a meaningful and dignified life” (Karner et al., 2020, p. 440). Different scopes and approaches to justice have been develop, as formalizing fairness depends on the desirability of different states of affairs, which depend on populations, places, times, and different scopes. For instance, several forms of justice can be distinguished (Jaggar, 2009; Karner et al., 2020; R. H. M. Pereira et al., 2017):

* **Retributive justice** is concerned with the proportional retribution of wrongdoers relative to legitimate punishers and the innocent (Walen, 2023).
* **Reparative (or restorative) justice** focuses on the reparation of caused harm; it centers the needs and voices of victims to restore wrongdoers and the community according to moral values (Braithwaite et al., 2003; Tyler, 2006). In planning and policy contexts, reparative justice involves accountability mechanisms (material, powers, rights, processes) to compensate victims (Safransky, 2022; Williams & Steil, 2023).
* **Procedural justice** strives to ensure that the views and preferences of all stakeholders are fairly accounted for in the decision-making and inter-personal procedures affecting their lives and communities (Tyler, 2006).
* **Distributive justice** is perhaps the most studied form of justice in transportation (R. H. M. Pereira et al., 2017) and elsewhere (see Jaggar, 2009, p. 2). Its main concern is the collection of benefits and burdens of the tangible and intangible products of society by different segments of a population. The just distributive aspects of transportation systems is also of focus in this work.

Wile justice (i.e., formalized fairness) is a broad moral concept, **equity** and **standards** can be understood as the ‘instruments’ of justice- the tools through which society moves towards a just state of affairs.

**Equity**, as conceptualized alongside distributive justice, tends to encompass tools to understand the distribution of benefits and burdens of things among a population (e.g., disparities), emphasizing those with the least advantage or most disadvantage. In the transportation domain, equity analysis often flows from the top: stemming from the authority of the state and meant to assist with decisions about regulating and financing spending (Karner et al., 2020). As in Karner et al. (2020), equity and disparity analysis should not be seen as an end in and of itself, but rather as a means to gather information about actual, observed, and perceived inequities.

And lastly, in this work’s context, a **standard** is a concrete statement about fairness; it is a formalized threshold in understanding disparities (i.e., related to equity) as part of the goal of formalized fairness (i.e., justice). A standard establishes criteria for how benefits or burdens should be distributed or allocated in a way that aligns with moral or formalized principles. For example, a weak standard might be a Pareto improvement, where benefits may be concentrated in certain groups (even those already advantaged), as long as no group is made worse off compared to the existing situation (Tan et al., 2016; S.-X. Xu et al., 2018). As another example, a more strict standard could be based on egalitarian principles (e.g., proportional equity) where the benefits or burdens are weighted by population; in the consistent application of this standard, each group would give or receive in proportion to their relevant ‘size’ (Bills & Walker, 2017; Martens et al., 2012). In contrast, an affirmative action standard (i.e., could be related to restorative justice) could be an even stricter standard, requiring the benefits to be distributed in a non-egalitarian way to favour people still harmed by past or present discriminatory practices (Bierbaum et al., 2021).

To summarise, we use **justice** to describe a moral target, **fairness** as an evaluation or yardstick of justice, **equity** as a set of related disparity measurement tools, and **standards** as statements of fairness.

## A framework to analyze questions of justice: 5WH

Having defined justice, fairness, equity and standards, we approach the literature with an analytical apparatus inspired by the framing of Jaggar (2009) for philosophical questions of justice.[[1]](#footnote-1). According to Jaggar (2009), Western philosophy has approached the issue of justice by asking “Why?”, “Where?”, “When?”, “Who?”, “What?”, and “How?” (5WH), applying them to a particular domain or sphere of life relevant to justice.

In the case of transportation the question of **“Where?”** is paramount, as transportation by its very nature concentrates the benefits (e.g., access points to the system are not ubiquitous). The burdens, in contrast, are often diffuse: they are incrementally paid, for example by a distributed population in the form of taxes, or by a (possibly different) population in the form of poor health. As such, the answer to “Where?” is the definition of the spatial boundaries.

Conventionally, the question of **“When?”** refers to the temporal circumstances within which the demands of justice apply. When it comes to transportation, questions regarding temporarily are important, as for example: *when* did the analysis take place and under what historical policy context; when is *the right time* to invest in infrastructure and as a result when to generate a spatial inequality (Rabello Quadros & Nassi, 2015); for *how long* the burdens and benefits can be associated to a specific intervention; or even the *timeline* of reparative justice to reconcile the shadows of past transport-related injustices.

When asking **“Who?”** we think about the entities that should be regarded as subjects/arbiters of justice. For tractability, this question is often approached through the filter of population groups, which may include several concurrent traits, including gender identity, ableness, ethnicity, age, caste, and income. Often, it is appropriate to consider the intersections between traits, given differences in a person’s lived experiences. A complication in the case of transportation is that disentangling the “Who” from their mobility tools is not always straightforward. Although a person is not their mode of transportation, there are large segments of the population who cannot extricate themselves from the mobility tools they use, either because they have driven themselves out of choices (Lavery et al., 2013), or have been driven out of choices by factors beyond their control (Jacques et al., 2012). While it is important to avoid conflating the “Who” with the “What”, for analytical purposes we need to be mindful of the connection between a person and their mobility tools.

**“What?”** refers to which entities should be regarded as objects of inequities, meaning which categories of things should be distributed in a just manner. To understand the distributional implications of transportation systems, it is essential to understand what they *produce*. Transportation systems are technologies to improve the rate at which space is traded for time by increasing the speed of movement. But as the adage goes, travel is derived demand (Mokhtarian et al., 2001). For this reason, we cannot stop at considering only mobility but must consider its ulterior goal–reaching destinations. Coupled with land use, mobility creates accessibility to opportunities as well as varied burdens. Transportation justice, thus, involves proximate (mobility tools and mobility) and ulterior (accessibility and activity opportunities) objectives.

The next question is **“How?”**, and it relates to the allocation of various objects of justice (“what”) to various subjects of justice (“who”) in various circumstances (“when” and “where”). Fairness standards are an equity tool for answering this distributive question. The thresholds can be quantitative (e.g., square meters of green space per capita), qualitative descriptions (e.g., do not knowingly discriminate) or a mix of the two. Some examples include: maximum travel distance/cost/time to or from key destinations, levels of maximum exposure to externalities (i.e., noise or air pollution), un/fulfilled needs, and dis/satisfaction with travel. To support us when approaching this question, we draw from concepts in transport-related social exclusion, transport disadvantage, and transport poverty, which are typically based on utilitarian or sufficientarian philosophies. The “How?” is supported by fairness conceptualisations along with standards.

Above all, convincing answers to the above questions require a supporting rationale: a **“Why?”** (Jaggar, 2009). This is perhaps the most slippery of 5WH. Justice is inherently a social construct. Asking **Why?** amounts to asking what sort of social contracts regulate human interactions, that is, the self-imposed rules that result from our collective will to believe. These contracts can be defined by constitution, but there are often unwritten and possibly contested variants. In this way, analyzing the “Why?” in the corpus is not the focus of this review, partly because answers to “Why?” are seldom explicitly stated. Instead, our focus is on the standards of fairness that, combined with the use of analysis, can help us understand how better to move towards just transportation systems and better formulate answers to “Why?”.

## Review methods

This work examines the academic literature on transportation to identify the extent to which standards for equity are defined and employed. In this task, we follow the Joanna Briggs Institute (JBI) approach to the conduct of scoping reviews, an approach that builds upon the Arksey and O’Malley (2005) framework (Peters et al., 2020). The review is also guided by the Preferred Reporting Items for Systematic Reviews and Meta-Analyses, particularly the extension for scoping reviews (PRISMA-ScR) which is consistent with the JBI approach (Tricco et al., 2018).

The primary research question and the protocol were initially defined by the authors, a group of experts in the field of transportation. The initial draft of the protocol was refined from preliminary searches of related reviews (R. H. M. Pereira et al., 2017; Vecchio & Martens, 2021; e.g., Zhang & Zhao, 2021) and in consultation with research services librarians. The final protocol was released on OSF (Soukhov et al., 2022), the methods are summarised as follows.

The search strategy was developed iteratively using **inclusion** and **exclusion** criteria (Peters et al., 2020). For the inclusion criteria, the mnemonic PCC (population, concept, and context) was adopted. The search strategy was refined by adding search terms. The terms were bundled by means of Boolean operators. These stages are summarised as follows (see Appendix section [Section 7.1](#sec-sect61) for details):

1. An initial limited search of Web of Science (WoS) Core Collection (containing journals, conference proceedings, and books published all over the world) was undertaken to identify key documents. Separate searches using the terms ‘transportation’ and ‘equity’ were generated. From these searches, we examined the text contained in the titles and abstracts, the index terms, and subject heading searches when available. As we developed a clearer outline of the literature, we refined the terms used for the search. This took the form: (“Transport” OR “Transit” OR “Car\*” OR “Walk” OR “Bike”…**1**) AND (“Equity” OR “Justice” OR “Fair”…**2**), where **1** and **2** signify additional terms relating to ‘transportation’ and ‘equity’, respectively.
2. Upon inspection of the preliminary search results and after achieving a consensus among the authors, the set of search terms related to ‘equity’ was expanded into three sets of terms. The first describes theories and concepts of equity, the second describes the object of justice (i.e., the “what” in our analytical framework), and the third describes terms referring to standards (i.e., the “how”). These sets of terms were augmented iteratively. The final search query took the following general form: (“Transport” OR “Transit” OR “Car\*” OR “Walk” OR “Bike”…**1**) AND (“Equity” OR “Justice” OR “Equity” OR “Fair”…**2**) AND (“Accessibility” OR “Mobility” OR …**3**) AND (“Standard” OR “Threshold” OR …**4**) where **1**,**2**,**3**, and **4** signify additional terms included in the sets combined with “OR” operators.

After testing the search strategy on WoS Core Collection, we applied it to an augmented list of databases. The databases used were: WoS General Collection-Science Citation Index Expanded, WoS Social Sciences Citation Index, and Transportation Research International Documentation (TRID). The definitive version of the search was completed and exported by the lead author on March 21st, 2021. The number of documents identified in this was was 6,382.

The semi-automated nature of the search strategy was overly inclusive, thereby reducing the risk of omitting relevant material. The next stage was to trim the corpus; the authors worked with a group of undergraduate research assistants to scan the documents and assess their relevance based on titles and abstracts. Two research assistants voted on each document, and a third vote from the authorship team broke ties. After this step, 1,710 documents were assessed based on full-text, again with each being voted on by two research assistants and an authorship team member tie-breaker. Next, using a data extraction template and workflow that was pilot-tested with a subset of papers, the authorship team extracted data from the eligible documents using *Covidence* (Covidence, 2023), an online application for literature screening. The evidence selection workflow, flow diagram, data extraction template, and some sample data extractions can be consulted in Appendix [Figure 4](#fig-figA2). The end result of this scan was a corpus of 165 documents retained for data extraction.

# Synthesis of findings

This section threads together the trends identified from the reviewed transportation literature. Specifically, a thematic overview of “When?” and “Where?” transportation fairness is considered, “Who?” are the subjects of justice, “What?” could be considered the objects of justice, and lastly “How?” is fairness measured. As an overview, [Figure 1](#fig-fig1) illustrates the prominence of each thematic category for “When?”, “Where?”, “Who?”, and “What?”, while [Figure 2](#fig-fig2) presents an overview of the types of fairness conceptualizations and thresholds, addressing the “How?”.

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| Figure 1: The proportion of papers in each ‘When’, ‘Where’, ‘Who’, and ‘What’ by topics in each category. Topic categories were generated by the authors based on the reviewed literature. |
| Figure 2: The proportion of papers by topics in the ‘How’ categories. ‘How’ is split into two categories: topics related to fairness conceptualisation (horizontal axis) and topics related to standards (vertical axis). Topic categories were generated by the authors based on the reviewed literature. |

## “When” and “Where” is transportation fairness considered

Within our corpus, most papers (60%) focus on studies in the Global North, with many studies from North America (particularly U.S. and Canada), Europe (France, Spain and Northern Europe), Oceania (Australia and New Zealand), and Asia (Japan and Israel). Though their subject matter is varied, their spatial context mainly pertains to North America and Europe, and thus more often than not deals with more developed and formal government transport planning apparatuses and technologies e.g., planning for equitable high-speed rail (Monzon et al., 2013), autonomous vehicle technology (Eppenberger & Richter, 2021), or on the public consultation processes (Reddy et al., 2010).

Of note, work included in the reviewed literature does not often explore the historical or temporal aspects of transportation fairness in depth. Therefore, in this section we provide a thematic overview of the temporal and spatial contexts associated with the studied case studies and the publication location.

The smattering of studies from the Global South are predominately from Asia, notably China, but also India, Thailand, Iran, Philippines, and Indonesia. The next most common focus within the literature from the Global South is from South America. Many of these studies mention a systemic absence of evidence relevant to the region (Vecchio et al., 2020). Despite a growing recognition of the interconnections between transport development, social exclusion, and poverty (Benevenuto & Caulfield, 2020), a number of studies underscore ongoing neglect of the social dimension of transport during the planning stage (Benevenuto & Caulfield, 2020; Boisjoly et al., 2020). Many studies also point at affordability as one of the main mobility barriers in the region (Falavigna & Hernandez, 2016; Rivas et al., 2018), while some highlight multi-dimensional concerns such as public transport accessibility and quality of walking environments that contribute to mobility inequalities (Tiznado-Aitken et al., 2018). Studies pertaining to Africa are even less numerous.

A shared characteristic among studies from Africa and South America is a scarcity of official transport data (Fried et al., 2020). These studies also incorporate the use of informal transportation options and tensions in developing road network infrastructure (which tends to support car dependency) over meeting the mobility/accessibility needs of citizens more equitably and sustainably (Thondoo et al., 2020). To address these challenges, researchers compile databases based on open and geo-referenced data, calculate objective and/or subjective measures (Berhe et al., 2014), and focus on advancing transport justice for low to medium income countries by aligning their goals with external policy guidelines such as the Sustainability Development Goals (SDG), particularly those related to universal accessibility (Fried et al., 2020).

Of all the studies reviewed, 85% focus on urban and suburban settings and are highly varied in their research aims. To give an example, Cox & Bartle (2020) qualitatively examine cycling as a mode of travel for people with disabilities in a typical mid-size town in the U.K. Ampe et al. (2020), on the other hand, work to identify the lateral clearance that motorists should maintain when passing cyclists with children seats. The remainder of the studies focus on rural regions (14%), or remote regions, such as those that rely on inter-island ferry trips in the Philippines (Cao & Stanley, 2017). Similarly, Parry et al. (2018) studied remote communities in the Amazonian region, and suggest that “increasing accessibility through road building would be maladaptive, exposing marginalized people to further harm and exacerbating climatic change by driving deforestation” (pp. 125).

Overall, studies from the Global South often have some key differences in focus compared to the Global North:

* affordability as a barrier at the user- or policy maker- level is more often the motivation in work from the Global South;
* the expression of greater tensions in investing in new transportation infrastructure, such as roads in rural/under-developed areas, compared to prioritization of non-car modes. Studies centered in the Global North often focus on the later; and
* more significant data availability limitations and reliance on ‘informally’ collected data.

These differences center on the direct economic outcomes tied to transport infrastructure. Often, work from the Global South does not engage as intimately with emerging mobility technologies. As well, the informal aspects of transport planning are more overbearing. Clearly, countries in the Global South still struggle with the consequences of past colonialism, which has left them more reliant on primary sector exports (lower efficiency, lower national GDP) under growing global financial markets, and with more fragile democracies. Due to lower data availability, reliance on crowd-sourced or ‘informally’ collected data, and more extreme needs for ‘sufficient’ transport, analysis of transportation inequities is often cast along economic lines in the Global South.

We gather that the literature on the Global North and South tend to focus on different aspects of transport inequities, related to the level of their transportation infrastructure. Formal planning processes in the South operate under greater financial precariety, they rely on more informal processes to address unmet needs. This turns out to be a significant source of equity concerns e.g, informal transit (Fried et al., 2020), populations living in informal settlements (Sharma & Patil, 2021). International standards are more highly relevant in literature from the Global South e.g., using the WHO noise and air pollution standard (Apparicio et al., 2021), while not as frequently featured in the Global North literature e.g., in Carrier et al. (2014), disadvantaged populations are disproportionately impacted by higher pollution near roadways in Montreal but these levels are still consistently below the WHO standard. This difference in focus present interesting opportunities for the Global South, to adopt potentially successful enhancements from Global North formal equity planning processes (e.g., indicator creation for disadvantages groups (Cui et al., 2020)) and to avoid past and on-going mistakes (e.g., from entrenched car-centric development (Warren et al., 2015) to the disproportionate contribution to carbon-intense mobility (Chancel & Piketty, 2015)). For the Global North, there is an opportunity to reckon with its own contributions to uneven development globally and environmental impacts as well as adopt relevant aspects from informal planning processes.

## “Who” are the subjects of transportation justice and their mobility tools

### Population groups

Turning to the question of “Who?” in [Figure 1](#fig-fig1), the focus of the literature tends to be on “Income”, especially the lowest-income groups who simultaneously face lower mobility and accessibility *and* higher costs and exposure (Falavigna & Hernandez, 2016; Peungnumsai et al., 2020; Zhao et al., 2020). Evidence suggests that low household income is a significant determinant of transport-related inequities e.g., urban access to public transport (Peungnumsai et al., 2020), access to urban employment opportunities (Boisjoly et al., 2020), and unfavorable rates of environmental noise, air pollution, and green space (Kruize et al., 2007). Yet, low-income is not universally associated with lower transport-related benefits for every object of justice. For instance, in Sheffield, U.K., Mears et al. (2019) demonstrate that historically working-class (lower-income) neighbourhoods have *more* access to green space than other neighbourhoods, but of lower quality, likely due to historic urban planning approaches. Similarly, Bertrand et al. (2008) find that the granularity of the analysis matters, and lower income groups do not always have lower accessibility, something echoed in other spatial and temporal contexts (Allen & Farber, 2019; Foth et al., 2013)

“Age” is the second most common “Who?” focus. In this regard, Martinez-Jimenez & Salinas-Perez (2019) and Arranz-Lopez et al. (2019) investigate travel distances/times to various opportunities, demonstrating how age is associated with differences in opportunity access. School-aged children and older populations are a common focus. For children, analysis of wellbeing (Laszkiewicz & Sikorska, 2020), safety and access to schools (Corazza et al., 2020; Sharma & Patil, 2022), and promoting active travel (Mackie, 2009; Mehdizadeh et al., 2017) are common-place. Papers that focus on older adults similarly investigate transport-related wellbeing (Y. Chen et al., 2020), access to age-specific destinations (Cheng et al., 2019), and options to reduce unmet travel needs (Nordbakke & Schwanen, 2015).

Many papers focus on intersecting characteristics. As an exception, we classify some studies as focusing on “(Dis)abilities” or “All Populations”. Studies with a “(Dis)abilities” focus assess travel capabilities, namely through physical accessibility and universal design guidelines (Chiscano, 2021; Orellana et al., 2020; J. Park et al., 2017). “All Populations” papers make no distinction in population. This is done, for instance in Kita et al. (2020), who investigates disparities in accessibility to food-stores and self-reported capability/frequency of going outdoors. Often, the implicit or explicit motivation of these papers is access (to necessities and desired destinations) for all.

A large proportion of papers apply composite vulnerability indices that combine several individual traits like low income, unemployment, and/or immigrant status. These indices are generated from government sources or author-informed census data creation methods. As an example, the Neighbourhood Equity Index is a measure of vulnerability created by the City of Toronto and used in Awuor & Melles (2019) to examine disparities in premature death. Other works use national census indicators such as the social and housing deprivation index (Pucci et al., 2019) or explore transport disadvantage, equity in policy implementation, or transport-related mortality burden by means of census measures (e.g., household poverty) and transport-related accessibility indicators (Aldred et al., 2021; Iungman et al., 2021; Scheurer et al., 2017; Sun & Thakuriah, 2021). Similarly, Environmental Justice (EJ) indicators have been used in the U.S. literature to identify neighbourhoods that have a higher than average proportion of low-income and non-white populations and evaluate the equity impacts of transportation projects (K. Park et al., 2021; Reddy et al., 2010; Rowangould et al., 2016).

Multi-dimensional considerations are so prevalent in the reviewed literature that “Gender”, “Race/ethnicity”, “Education”, or “Employment” are infrequently studied in isolation. Only a few papers focus exclusively on gendered differences in active transportation Xie & Spinney (2018), race/ethnicity’s relationship to green space proximity (Silva et al., 2018), and culturally-appropriate opportunities (Wang & Roisman, 2011). Papers that focus *solely* on “Employment” status or “Education” level are completely absent in the corpus. Furthermore, “Other” population groups are also frequently considered: this is a catch-all category that includes populations less commonly targeted by research e.g., veterans and access to specific-healthcare needs (Mooney et al., 2000), pregnant people and access to maternity services (Vadrevu & Kanjilal, 2016), and youth who live in foster care (Batsche & Reader, 2012). Overall, the diversity of population groups considered in the corpus demonstrates the variety of transportation-equity concerns addressed.

### Modes (mobility tools)

Travel mode, though modifiable, is intertwined with individual identity, presenting challenges for the analysis of disparities. In this subsection, we choose to view the mode of travel primarily as those who use the mode, hence as subjects of justice (i.e., the “Who?”). However, at times, travel mode will also be considered as an object of justice (i.e., a “What?”, such as disparities in rural transit service).

To begin, transit characterises the majority of the reviewed literature ([Figure 1](#fig-fig1)), reflecting some intuitive sense. Despite transit being perceived unfavourably by some (e.g., Mella Lira & Paez (2021)), it is often viewed as the only or primary mobility option mode for many (Jacques et al., 2012). Overall, we can infer that transit is largely considered a public good and, therefore, a natural object of justice. As such, public transportation is especially amendable to being modified to meet the demands of justice by ensuring adequate funding to provide barrier-free transport for most, despite challenges such as low densities, fiscal constraints, and political will (Markard et al., 2023). As such, papers that focus on transit assess a variety of related topics, including food deserts (McKey et al., 2020) and barrier-free transportation for people who face disabilities (Feeley, 2019; Jiménez-Espada & González-Escobar, 2021; Lim et al., 2021; Liu et al., 2019).

Transit also plays a central role in multimodal comparisons in transport disparities, especially comparing “Walk”, “Car”, or some other category in [Figure 1](#fig-fig1). For instance, Brussel et al. (2019) compares transit, pedestrian and road network accessibility measurements in the context of SDG 11.2. Renne & Mayorga (2018) reviews natural disaster evacuation plans, focusing on carless households and emphasizing transit and pedestrian networks. A few papers also frame transit as a direct competitor of car travel or use it as a benchmark (Golub & Martens, 2014; Martens et al., 2012). For instance, Warren et al. (2015) proposes car ownership standards while acknowledging the tension between mobility needs in transit under-served areas and emission reduction goals. However, this framing is not universal, and transit is sometimes seen as a mode to fulfill individual capabilities. As an example, Smith et al. (2012) explores perspectives about transport needs and costs to achieve perceived sufficient living standards for those living in rural areas. Notably, papers vary in the importance they place on climate urgency, with some focusing more on satisfying *all* sufficient individual needs while planning for less car-dependent cities in the future.

After transit, pedestrian travel (“Walk”) is the second most studied object of justice. Pedestrians represent a unique convergence of “what” and “who,” utilizing their own bodies for mobility. Papers focusing primarily on walking often use walkability scores to assess neighbourhood quality (Evans, 2015), mobility by different demographics (H. Kim et al., 2016; Towne et al., 2016), or urban peripheral regions (Blecic et al., 2021). Some use walkability to gauge public health and urban vitality (McCormack et al., 2012; Sung & Lee, 2015). Papers with a pedestrian focus also often see walking as a bridge to connect multiple modes: they discuss ‘walkability’ as part of active transportation, which focuses on both walking, bicycle and/or transit. Concepts discussed include how active transport contributes to children’s physical activity levels (Mammen et al., 2014), walkability as an alternative to car predominance (Bertrand et al., 2008) or tension that exists between modes, creating unsafe conditions for walking (Ferenchak & Marshall, 2019; Siu, 2019).

The third most studied mode in the reviewed literature is “Car”. Unlike transit and walking, these studies rarely feature car as the mode of primary focus. Car is often assessed against transit and active modes (e.g., low traffic neighbourhoods Aldred et al., 2021) or in areas with inadequate transit service (Aljoufie, 2016; Kimmel et al., 2018). Under our appraisal, transit and walk modes are of most interest because they represent a reckoning with automobility’s legacy and ongoing demands for space, public subsidies and government supports that underestimate their true cost (Gössling et al., 2019; Timperley, 2021). Upon the rise of the automobile, pedestrian spaces were distinguished, non-car modes came to be seen as a hindrance to full automobility, and transit seen as a social service. We ascertain that for these reasons, “Car” is often compared against non-car modes and never put forward as the only mode that should be expanded. Furthermore, some papers reflect on “Other” forms of mobility ([Figure 1](#fig-fig1)), including wheelchair accessible taxi and/or paratransit services (Marquez et al., 2019; Wilkinson-Meyers et al., 2015), travel on waterways (Cao & Stanley, 2017; Parry et al., 2018; Vadrevu & Kanjilal, 2016), motorcycle or other micro-mobility (Berry et al., 2016; Schmitz et al., 2019; Tiwari & Phillip, 2021), or emergency vehicles (Patel et al., 2007; Pedigo & Odoi, 2010).

Papers that pay no particular attention to any mode are “Unspecified”: as examples, a focus on road infrastructure or road network distances (Mishra et al., 2014; Wismadi et al., 2014), travel needs generally (Benevenuto & Caulfield, 2020; Titheridge et al., 2008), realized travel (Abasolo et al., 2001), or externalities of realized travel (Iungman et al., 2021).

## “What” could be the objects of transportation justice

The objects of fairness assessment, the “What”, are often motivated by mobility or accessibility. A fundamental benefit of transportation systems is mobility (enabling or impeding movement). This benefit is sometimes valued by itself but is often seen by the literature as instrumental to achieve an ulterior goal (e.g., activity participation and associated benefits). For example, although vehicle kilometers traveled (VKT) is sometimes seen as a useful policy instrument (Zhao & Li, 2021), travelling more is not necessarily a sign of advantage when accessibility is low, and short trips may actually be a sign of advantage (K. Park et al., 2021). For this reason, although the right to the road (and transportation systems more generally) is important, the literature leans heavily on the ulterior object, namely accessibility to (the ease of reaching) destinations.

### Mobility

Most papers in the reviewed literature take a broad approach, with 47% focusing on “Unspecified” destinations ([Figure 1](#fig-fig1)). They examine various equity dimensions across different transportation modes. Some papers focus on factors that impact the trip itself like infrastructure quality, safety, and service level (Fürst & Vogelauer, 2013 ; Lattman et al., 2016; Prasertsubpakij & Nitivattananon, 2012; Zhe et al., 2008). Others analyze trips tailored for specific groups like women or people with disabilities (Russell et al., 2021; Wilkinson-Meyers et al., 2015), often with a consideration of what constitutes ‘sufficient’ quality of life (Churchill & Smyth, 2019). In sum, these papers reveal the multifaceted nature of transportation systems: they serve utilitarian purposes while also shaping user experiences.

### Accessibility

In terms of destinations, “Healthcare” services (18%) and “Employment” (25%) are the most common in the reviewed literature ([Figure 1](#fig-fig1)). Papers on healthcare often highlight disparities in services, like Wang & Roisman (2011), who assess access to Mandarin-speaking family physicians for Mainland Chinese immigrants in Toronto. Similarly, papers focusing on employment are often aimed at identifying transportation-poor neighbourhoods (Allen & Farber, 2019; Churchill & Smyth, 2019). Employment is frequently used as a proxy for overall accessibility since it is the most common trip purpose and employment is usually co-located with destinations like shops, recreation, and other services. These studies typically use travel surveys, census data, and point-of-interest databases, and benefit from well-developed institutional data. This especially holds in the Global North where these data are more readily available.

Other destinations have received less attention despite serving essential needs. “Shopping” destinations (19%) often aim to identify food deserts (Choi & Suzuki, 2013; Jiao et al., 2012; D. Kim & Park, 2020; McKey et al., 2020). “Education”-related papers (18%) explore children’s active transportation to school (Larkins et al., 2011) or universal design (Larkins et al., 2011). Places of “Leisure” (18%) prompt questions about their spatial distribution (M. Xu et al., 2017) and accessibility (Mavoa et al., 2015). Fewer papers cover “Community” destinations (e.g., public service centres, places of community support or worship) (10%) or “Childcare” (5%), but they are integral to holistically study activity participation (Alberts et al., 2016; Smith et al., 2012). The lack of information about community destinations in the reviewed literature, especially for children, is noticeable (Desjardins et al., 2022).

## Standards: “How” fairness is measured

### Conceptualisations of fairness

The conceptual foundations of fairness are not always made explicit within the reviewed literature, they often had to be inferred. Though not exhaustive, the following categories emerged from our review and in broad terms are ([Figure 2](#fig-fig2) details definitions):

* Vertical equity (27%)
* Transport-related social exclusion (27%)
* Well-being (27%)
* Spatial equity (26%)
* Horizontal equity (17%)
* Inequitable externalities (17%)
* Rights (14%)
* Emerging theories (5%)
* Utilitarian (1%)

A slice of the reviewed literature is supported by broader “Rights” conceptualisations of fairness: these papers often focus on equity for people with disabilities or non-car users and associated challenges accessing transport infrastructure (Bharathy & D’Souza, 2018; Daamen et al., 2008; Jiménez-Espada & González-Escobar, 2021). While many papers are underpinned with the right to the city (the *right* to participate in the production of urban space (Adli & Donovan, 2018; Lefebvre, 1967)), others emphasize legal *Rights* like regulations aligned with The Americans with Disabilities Act (ADA) (Bharathy & D’Souza, 2018) or the goal of *access for all* in land-use transportation master plans (Lim et al., 2021).

In another subset of the reviewed literature, distributions are examined through concepts of “Horizontal” and “Spatial equity”, often using quantitative methods to assess distributional disparities without explicit justice rationales. Examples include setting travel impedance thresholds (Shen et al., 2020) and mapping accessibility indices spatially across populations (Monzon et al., 2013) or population-groups (Sharma & Patil, 2021). These papers may also address traffic-related air and noise pollution or urban temperatures. In these papers, equity is theoretically achieved if similar levels are attained for all populations (horizontal equity) or spatial areas (spatial equity). This egalitarian perspective rarely delves into minimum or maximum levels associated with harm or need satisfaction.

Papers that center “Well-being” assess what constitutes a satisfactory life in relation to transportation; mixed-methods are often used and, in contrast to the last set, the objects of injustice are often identified. Some papers use physical activity guidelines and surveys to understand the effect of active transportation infrastructure (Adlakha & Parra, 2020; Auchincloss et al., 2020; McCormack et al., 2012). Mixed or qualitative methods combined with health-related outcome standards lead to more concrete statements of fairness e.g., travel times for emergency treatment (Schmitz et al., 2019) or premature mortality (Awuor & Melles, 2019).

Another research branch, often quantitative with some qualitative or mixed-methods studies, focuses on “Transport-related social exclusion”, “Vertical equity”, and/or “Sufficientarian/capabilities”. Here, the objects of justice are often clearly identified and link standards to tangible welfare-informed outcomes. They focus on groups from perspectives of disadvantage such as: social exclusion and transport poverty (Allen & Farber, 2019; Churchill & Smyth, 2019; Delbosc & Currie, 2011a), food deserts (McKey et al., 2020), and energy poverty (Berry et al., 2016; Berry, 2019; Robinson & Mattioli, 2020).

### Standards and methods of measuring fairness

We identify several categories of standards that overlap with at least one of the conceptualisations of fairness discussed above (see [Figure 2](#fig-fig2) for definitions):

* Opportunity standards (66%)
* Population standards (64%)
* Infrastructure standards (41%)
* Environment+ standards (7%)

Papers with “Opportunity” standards often employ quantitative methods to analyze disparities and assess distributional fairness. Many deal with travel impedance thresholds based on speed, distance, or cost (Z. Chen & Haynes, 2017; Shen et al., 2020; Yenisetty & Bahadure, 2020). Inequality measures like the Gini coefficient and poverty measures are used to empirically define travel impedance thresholds (Tiznado-Aitken et al., 2018; van der Veen et al., 2020). Further, methods tangential to travel impedance, like limiting transport expenditure to 10% of monthly income (Rivas et al., 2018), addressing spatial mismatch (Mulley et al., 2015), or pinpointing areas of relative regional inequities are also used. Notably, many papers with “Opportunity” standards consider multiple dimensions, employing similar methods but tailored to different focal points. For instance, Peungnumsai et al. (2020) suggest service benchmarks of equal supply and demand of transit, revealing horizontal inequities as well. Others conceive the externalities of transportation system as trade-offs and aim to maximize transport-related benefits (i.e., time savings, emissions reductions, congestion reductions, user fares) through optimization/location-allocation methodologies (Fakhrmoosavi et al., 2021; Wismadi et al., 2014; Zheng & Geroliminis, 2020).

“Population” standards are often founded on “Well-being” conceptualisations from a variety of socio-demographic and spatial angles. Methods include: establishing thresholds based on questionnaires and comparisons to recommended physical activity levels (Auchincloss et al., 2020; H. Kim et al., 2016; McCormack et al., 2012; Timperio et al., 2015), region-relative comparisons in health outcomes in a spatial unit such as premature mortality rates (Awuor & Melles, 2019), spatial access benchmarks based on population-related characteristics like supermarket access (Murphy et al., 2017) and hospital access (R. Pereira et al., 2021), summative per capita benchmarks such as decent living energy consumption levels (Rao & Baer, 2012), and community-informed spatial boundaries like EJ defined communities (Rowangould et al., 2016). While most of these papers use quantitative or mixed-methods approaches, some employ exclusively qualitative methods (Berhe et al., 2014).

Papers that feature both “Population” and “Opportunity” standards are often founded on “Vertical equity”, “Well-being”, and/or “Transport-related social exclusion” conceptualisations. They feature mixed-methods, with questionnaires and qualitative approaches for “population” standards and quantitative methods like accessibility indices for “opportunity” standards. Census data and household estimates within specific travel distances or times to key destinations identify social exclusionary situations (W.-H. Chen, 2010; Daniels & Mulley, 2011; Sharma & Patil, 2021; Sun & Thakuriah, 2021), linkages between transport disadvantages (Delbosc & Currie, 2011a), areas experiencing transport poverty (Allen & Farber, 2019; Churchill & Smyth, 2019), food deserts (McKey et al., 2020), or transport-related energy poverty (Berry et al., 2016; Berry, 2019; Robinson & Mattioli, 2020). They employ various methods, such as clustering techniques (Mohri et al., 2021). Some exclusively use qualitative methods to analyze survey data on travel willingness/barriers or conduct interviews on unmet activity needs (W.-H. Chen, 2010; Mehdizadeh et al., 2017; Nordbakke & Schwanen, 2015).

“Infrastructure” standards offer another perspective on fairness, commonly grounded in “Rights” conceptualisations, which are twice as frequent in this segment of the corpus compared to other conceptualisations. These papers most frequently address the rights of non-car users and populations with disabilities. Though various methods are applied, infrastructure and environmental audits as well as qualitative approaches are most prominent. Infrastructure audits compare existing infrastructure against universal design best practices (Jiménez-Espada & González-Escobar, 2021; Larkins et al., 2011; Odeck et al., 2010; Perez-delHoyo et al., 2021) or investigate elements correlating with mode use by specific population groups (Moniruzzaman & Paez, 2016). Qualitative methods include interviews/surveys on perceived access (Desjardins et al., 2021; Fürst & Vogelauer, 2013; Lim et al., 2021; Marquez et al., 2019; Mateo-Babiano et al., 2017; J. Park et al., 2017; Stjernborg, 2019; Velho et al., 2016) and assessment of standards under best-practice criteria (Bharathy & D’Souza, 2018; Daamen et al., 2008; Velho et al., 2016).

Additionally, “Infrastructure” standards papers sometimes encompass multiple dimensions, moving beyond rights (to the infrastructure) to provide “Opportunity” and/or “Population” standards. These papers often employ “Vertical”, “Horizontal”, and “Spatial equity” lenses. These papers often refer to guidelines and propose composite indices. For example, (Rachele et al., 2017) integrate various transport network properties to define an indicator supporting walkability and public transport access. Others evaluate infrastructure quality (M. Xu et al., 2017), accident severity (Appleyard et al., 2017; Benevenuto & Caulfield, 2020), and user-groups, especially disadvantaged ones with respect to vertical equity of multi-criteria indicators (Prasertsubpakij & Nitivattananon, 2012). Some focus explicitly on affordability and barriers, proposing infrastructure enhancements for better inclusivity, especially for the most disadvantaged (Basu & Alves, 2019; Song et al., 2019; Welch, 2013), grounded in transport-related social exclusion (Kent & Karner, 2019) or capabilities approaches (Smith et al., 2012).

“Environmental+” standards are featured less prominently in the reviewed literature, possibly because the environmental burdens of transportation are addressed more broadly in other literature (e.g., environmental justice). However, the papers included in our corpus present some interesting insights. They often use traffic-related air and noise pollution, green space, urban design, urban air temperature, health outcomes, and physical activity guidelines to assess transport-related “inequitable externalities”. Methods employed are primarily quantitative or mixed-methods, identifying inequalities through Gini coefficients (Feng & Timmermans, 2014) or composite indices (Agost-Felip et al., 2021; Corazza et al., 2020; Miranda & da Silva, 2012), occasionally incorporating spatial analysis (Carrier et al., 2014; Jephcote & Chen, 2013). Many use established thresholds or health guidelines e.g., WHO guidelines for Active Aging and targets included in the United Nations’ SDG (Agost-Felip et al., 2021) and OECD or WHO standards for traffic noise level, levels, available green space and levels (Apparicio et al., 2021; Iungman et al., 2021; Khomenko et al., 2020; Kruize et al., 2007; Mueller et al., 2018). These metrics are sometimes criticized for their general applicability. Nonetheless, their use provides interpretable values for tracking progress, offering comparability across communities, unlike accessibility measures, which vary in methods and assumptions. # Moving forward: discussion and calls for action

This work makes two contributions to the literature. First, it outlines a conceptual and flexible “Why”, Where”, “When”, “Who”, “What” and “How” (5WH) framework with supporting definitions for approaching questions about transportation justice. Second, it applies the framework in the synthesis and appraisal of 165 academic articles drawn from the transportation justice literature; these studies use equity analysis as instruments to gauge proximity to their context’s just situation. We summarise what is in the literature in the preceding section using the 5WH framework as appropriate, the following is a discussion on what may be missing from the literature:

* **“Who?”**: While who is subject of inequities in the literature is extensive, dimensions are still missing. There is a need to go beyond the focus on low-income transit riders; positioning intersectional considerations within the creation of community-based equity definitions and tailored standards are critical, as the act of delineating equity-deserving communities impacts results e.g., (Rowangould et al., 2015). Standards should be sensitive to evolving community-based definitions of inequities. Are issues of economic inequity at the root of transport inequities for a particular community? Are inequities in access provided by certain modes emphasised because access offered by other modes are *relatively* better? Access to what types of opportunities are driving transport inequities? How do populations, travel modes, and opportunities sought intersect to define the “who” of inequities? A community-informed understanding of inequities and tracking how it changes are needed. There is also a need for further intersectional considerations, as clear “Who?”-specific standards are lacking.
* **“What?”** and **“How?”**: The connection of what is the focus of inequity measure to some sort standard. Specifically, “What?” are the benefits and burdens of a transportation system that could link accessibility or mobility to some sort of tangible fairness object of justice. Could it be some environmental externalities (eg.), or human-health externalities (eg.), or traffic related safety (eg.), or multi-criteria mix (eg.). We believe that all forms of these standards, when linked to tangible outcomes can be used to track “fairness” in a region and can be used to track multi-dimensional progress towards justice depending on how robustly these standards are justified. Justification is exceptionally important, and we believe that a lot of the literature reviewed may miss this mark. However, literature that does not, usually connects to qualitative results and/or operationalizes mixed-methods.
* **“Why?”** is not within the scope of this review. Also, **“When?”** and **“Where?”** are only reviewed from a cursory perspective. These dimensions were not clear enough in the literature to be explicitly commented on.

Based on the preceding sections of what is in the literature, and what is lacking from our perspective, we conclude with the following five calls to action.

## Call 1: Develop standards based on rigorous concepts of justice

The conceptual grounding for standards is often left implicit within the literature: for example, Mueller et al. (2018) suggests the relative risk of mortality from transport-related air pollution should not be higher in deprived groups than the general population. While the conceptual justice foundations are not explicitly declared, we infer an egalitarian focus. But, what level of relative risk is acceptable for the general population? What purpose does mortality risk serve and who benefits from it? To move equity analysis outputs towards just transport futures, explicit inclusion of justice rationales (the “Why?”) should become more common place. We must be clear with our terms–what is equity and for whom?

Standards are statements of fairness, yet some standards are seemingly arbitrary in the reviewed literature–in other words, set arbitrary justice goals. For example, Cao & Stanley (2017) proposes 20 ferries per day to avoid social exclusion for inter-island transport planning, though acknowledging the standard should be politically determined. It is unclear if selecting a different benchmark such as 10 or 30 ferries would make a difference in any specific object of justice (e.g., accessibility to particular destinations) or if that number is tied to funding or resource constraints. Another example is the conceptual underpinnings of the 15-minute city, where 15 minutes is the standard for travel times. Is this sufficientarism? Or egalitarianism? The standard can be interpreted in a multitude of ways. We argue that conceptualization of justice must guide the selection of the standard. As Martens & Golub (2021) demonstrate, being explicit about “Why” is important. Recent work by Karner et al. (2024) provides several concrete examples for developing standards that follow directly from different justice conceptualizations.

For decision-makers, setting standards, measuring inequities, and developing flexible guidelines for standards that are also compatible with community-informed calls for justice, are the next steps for transportation equity planning. If we assume that one function of the academic literature is to recommend standards, researchers must connect compatible conceptualisations and standards to justice frameworks. Currently, these fundamental connections are mostly missing.

## Call 2: Develop creative methods for systems-thinking approaches to fairness

On the methodological side, transportation justice research would benefit from wider use of mixed-methods. Concepts and standards are often discussed from purely qualitative or quantitative approaches. This is a missed opportunity to combine the strengths of both approaches, whether by diving deeper into some particular experiences or perceptions through qualitative methods or tailoring more meaningful quantitative analysis after qualitative explorations. As mixed-method examples, Xie & Spinney (2018) find through interviews and go-alongs with women cyclists that the standard Cycling Level of Service tools used by engineers to plan cycling infrastructure misses a critical gendered perspective. Further, Somenahalli & Taylor (2007) survey older adults to understand their mobility issues, revealing factors that are unseen in standard daily travel surveys.

While disparity analysis is frequently used, the resulting standards do not often align with practical applications. For example, metrics of accessibility (usually measured with travel impedance cut-offs of between 15 to 60 minutes depending on the destination, population group and mode) are used to show descriptive differences among areas and groups but with scarce implications as to the experience of travelers. How low must an accessibility index be before it is too low? Relatedly, once sufficient accessibility levels are reached, excessively high accessibility values can result in high inequalities. Are inequalities of a certain level an issue? A lack of discussion poses a challenge to translating results from these analyses into policy and practice. Creative methods and discussions of quantitative accessibility metrics should be paired with results; they should yield interpretable results. The explicit discussion of minimum *and* maximum values in the distribution of the object of justice (the “What?”), as applicable, is critical.

Other times, when analysis engages with metrics that may be tied to particular concepts of equity (like the Gini coefficient or Theil index), they fall short in assessing whether the results are good or bad (Mijares et al., 2013). For example, a Gini coefficient of 0 would mean that all people have the same access to public transport stops. But is this level of access good enough or lacking? And what does it mean if the result is 0.2, 0.3, or 0.4? Is this good or bad news? How should a decision-maker interpret this? Are new policies needed to reduce that number to a certain threshold, orienting future interventions? These questions usually remain unanswered in the literature despite their importance. These measurements can also bring some challenges and pitfalls as summarised by Karner et al. (2024) but are necessary for more effective equity analysis.

## Call 3: Making data available is a matter of justice

In our review of the literature, we were left wondering specifically– what are the motivations for the inclusion of some destinations and the choice to not include others? For instance, leisure (e.g., green space, parks, recreation) and certain care destinations (e.g., community organizations, government services, banking locations, daycares) are infrequently studied or missing altogether. We suspect that since the methods used in the reviewed literature are predominately quantitative, the reliance on commonly used point of interest databases is also high. These databases typically include education, health and occasionally include aggregated categories for leisure and community destinations, but are less generous for points of interest that are more often associated with understudied mobility patterns.

However, through the reviewed literature, we know that transport systems are more than just facilitators to work or as a source of economic development (though in underdeveloped regions, transport systems as a force of economic development is pronounced, e.g., high-speed rail (Z. Chen & Haynes, 2017; H. Kim & Sultana, 2015; Monzon et al., 2013)). As such, data availability matters. In the context of the Global South and rural geographies fewer official data sources and public research resources exist relative to urban communities and areas in the Global North. As well as in the operationalization of emerging conceptual theories in equity analysis, such as sufficientariansm (van der Veen et al., 2020).

The calls for and relevant issues of data availability are not new, but they have at least three pieces. What and who is the subject of justice? When/Where/How is it measured? And, who gets to consult and use the data? Deciding who is the subject of justice frames the data collection activity; if it is the mobility of those that do domestic work, the classification of who does this work and how it changes over time/space is fundamental. How we classify mobility and access has implications for our understanding of just who is a subject of justice, as illustrated by the history of racial classifications in the U.S. (Lee, 1993). The methods we use, the spatio-temporal boundaries for data collection, and who has (and does not have) access to the collected data, can all impact how we think about justice. In the case of transportation, the issue of data collection/availability as a matter of justice is gaining traction as digitization of data casts a starker light on these questions (Behrendt & Sheller, 2023; Sourbati & Behrendt, 2021).

## Call 4: Develop more direct and explicit links between standards and lived experiences

Robust assessments of the implications of standards on lived experiences are still lacking in the literature, but are essential for equity analysis that translates into just practice. While the estimation of the benefits of increased mobility or accessibility, or reducing burdens is commonplace in the literature, there is a need to associate them to outcomes, including life and neighbourhood satisfaction, subjective well-being, mental and physical health, and social capital.

Composite measures such as the transport-land-use index proposed by Appleyard et al. (2017) is an example of systems-thinking approach that links findings to quality-of-life proxies; they ground their measure in the principle of *livability* along corridors of varying levels of estimated transport-land-use integration. However, the methods could go further: they could be tied to absolute goals of integration or livability. Relatably, Higgs et al. (2019) develops an urban livability index and demonstrates the relationship between the population’s use of a certain mode in a neighbourhood and a one unit increase in the index. However, are there absolute minimums or maximums for the index or the mode-choice goals that should not be crossed?

More explicit discussion of the boundaries in the distribution of the object of justice (the “What?”) alongside these creative methods are needed. These links may be used to track progress towards justice across time and space, a critical point for practitioners.

## Call 5: Rigorously evaluate interventions and policies

There is a need to evaluate equity interventions and policies: track their before, during, and after. In this review, a small proportion of studies assess specific transport-related policy interventions through an equity lens. Examples include mode-shift from driving to active school travel (Mammen et al., 2014), transit fare restructures (Hickey et al., 2010) and spatial analysis of Low Traffic neighbourhoods (Aldred et al., 2021). The assessment of interventions and tracking associated outcomes can be thought of as a key step towards transport justice. Similarly, for how long the burdens and benefits can still be associated to a specific transportation intervention remains a critical avenue to explore.

Outcomes of interventions can be compared within and between communities, and cross community comparisons can be created that may expedite the adoption of effective policies that move towards just outcomes; the presence of these synthesis and comparative studies could support brave decision-makers in the application of research into practice.

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# Appendix

## Evidence search strategy

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| --- |
| Figure 3: PRISMA flow diagram for the evidence selection process. ES signifies standards and EC signifies conceptualisations. |

The evidence selection process is also represented using the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) flow diagram (Page et al., 2021) in [Figure 3](#fig-figA1). Notably, two rounds of exclusion occurred during the assessment for full-text eligibility. 1710 studies entered step 2, 1223 were excluded and the remaining 487 papers entered step 3. The data extraction template used by the reviewers (authorship team) in step 3 revealed that, as expected, inclusion was initially too generous, and some papers were not sufficiently relevant, because of a lack of content on standards and/or conceptual/theoretical elements. In this fashion, 322 papers were further excluded and data extraction was completed to give a final corpus of 165 papers. A summary of the reasons for exclusion of the 1545 papers (between steps 2 and 3) are included in [Figure 3](#fig-figA1).

|  |
| --- |
| Figure 4: The search query. TS = topic search (keywords, abstract, title). TASCA = subject categories. Green text area transportation system related terms, blue text are equity dimension related terms, purple text are equity/justice conceptualization related terms, and orange text are standards related terms. Hits corresponds the number of papers that the search yielded and was retained into the evidence selection process. |

Definitions of the population-concept context (PCC) used in the creation of the inclusion and exclusion criteria for the search strategy.

* **Population**: the focus of the included studies should be on individuals, groups, communities, or entire regional areas that are impacted by passenger transportation infrastructure and systems (i.e., all modes and flows) from the perspective of equity (i.e., fair distribution, production, and re-production of burdens and benefits). This criteria is reflected in the creation of the first set of topic search terms that relate to transportation modes (e.g., “walking” OR “cycling” OR “transit” - see green text in [Figure 4](#fig-figA2) for the full list).
* **Concept**: the included studies should also include equity dimensions and conceptualizes equity as discussed in the previous section. This inclusion criteria is reflected in the second and third set of topic search terms developed in the search strategy. These terms relate to types of equity dimensions (e.g., “accessibility” OR “mobility” or “transport-related air pollution” - see blue text in the [Figure 4](#fig-figA2) for the full list) and fairness conceptualizations (e.g., “Justice” OR “equity” - see purple text in [Figure 4](#fig-figA2) for the full list).
* **Context**: the included studies should also be limited to publications that include types of standards. Context can be more difficult to explicitly search for with key terms so synonyms for ‘standards’ were added to the query as a four set of topic search terms (e.g., threshold, indicator, criteria - see orange text in [Figure 4](#fig-figA2) for full list). Additionally, journal article and conference papers, English-language literature from any country, any study design (e.g., quantitative, qualitative, or mixed-method studies, or conceptual frameworks), and any record published within the past 30 years are included (January 1992 to March 2022). The time period is selected as the first (to the authors knowledge) peer-reviewed article which operationalized standards and fairness conceptualization was published in 1996 (Khisty, 1996); we are broadening the search by a few years for completeness. English is selected as it is the common language spoken across the authorship team. Furthermore, papers that explicitly fall within the Transportation or related topic/category is included in the query (e.g., “Transportation”, “Social Sciences”, “Geography”, “Civil Engineering”, “Philosophy” - see the [Figure 4](#fig-figA2) for full query).

The **exclusion criteria** for the search are papers that are not within the inclusion criteria. Specifically:

* Literature published before January 1992.
* Papers which do not include transportation equity dimensions.
* Grey literature, as concepts contained within are frequently published in a more developed form in journals.

## Evidence selection and data extraction

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| Figure 5: Evidence selection workflow. Step 1 (orange) is title and abstract screening, step 2 (green) is full-text review, and step 3 (purple) is data extraction. |

The following steps summarise the evidence selection process:

1. The first step (orange box in [Figure 5](#fig-figA3)) included screening all titles and abstracts of papers on whether they included transportation equity as defined by the PCC. Each paper was screened by two independent reviewers who then voted for inclusion, exclusion, or uncertain inclusion. All uncertain papers, conflicting papers, and papers missing abstracts were reviewed by a third person for inclusion or exclusion.
2. The second step (green box in [Figure 5](#fig-figA3)) included scanning all full-text papers which passed step 1. These papers were reviewed to determine if they included a relevant “how”, i.e., an standard and/or relevant theoretical or conceptual discussion. At this stage, papers were evaluated again by two independent reviewers who voted for inclusion or exclusion. If an article was voted to be excluded, it was tagged with one of five possible reasons for exclusion, namely (1) no standards included; (2) no relevant conceptual elements included; (3) no standard and no conceptual elements included; (4) send back – QA issue; or (5) other. Discrepancies were resolved by a third reviewer.
3. In the last step, a data extraction template for each record was filled by one reviewer (purple box in [Figure 5](#fig-figA3)). The data extraction template was created with the aim of striking a balance between the complexity of categories and the simplicity of summary; information related to “Where?” (the geographical context and sphere of life), “When?” (temporal circumstances for the application of justice), “Who?” (the subject of justice), “What?” (the object of justice), and “How?” ( standards and conceptualisations) was filled out for each study. The following table contains the template that was input into *Covidence* and used throughout.

Data extraction for each document that passed through all three steps was then extracted using this template:

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| Figure 6: The data extraction template with associated defintions. |

To provide further example of data extraction, a table of the resulting literature looked like:

| Dimension | Continent | Conceptualization | Standard |
| --- | --- | --- | --- |
| What?: \*\*mobility and accessibilty\*\* | Where? [@rivasHowAffordableTransportation2018] - South America (select cities) | Analyses how affordable urban public transportation is in select Latin American and Caribbean countries. They look at the estimated average monthly cost of transit trips and average monthly household income and conceptualize \*\*transport-related\*\* \*\*affordability\*\*, especially for the most economically vulnerable (\*\*vertical equity\*\*). | How?: The financial burden of a basket of urban public transportation trips (60 trip fares, representing 30 round-trips per month) should not exceed 10% of household monthly income. |
| What?: \*\*mobility and accessibilty\*\* | Where?: [@bharathyRevisitingClearFloor2018] - North America (USA - National) | This study designed a web-based tool and took a representative sample of wheeled mobility device (WhMD) users anthropometry measurements to determine if the minimum standard suggested by the ADA is sufficient. We understand this conceptualization as a type of \*\*Rights\*\* conceptualization that WhMD should have minimum clear floor space (as described the guidelines in line with the American Disabilities Act) to access bus shelters, bus stop pads, and transit terminals. | How?: The clear floor area for wheelchairs: 760 mm (30 in.) wide by 1220 mm (48 in.) in length as described by the ADA standards. Of note, this minimum clear floor area is insufficient for a variety of the WhMD users. |
| What?: \*\*mobility and accessibilty\*\* | [@ryanWhatAreWe2021] - Europe (Stockholm, Gothenburg and Malmo cities in Sweden) | Investigates what the literature and planning process is missing when we measure accessibility by comparing objective and self-reported accounts of accessibility among older people. This paper conceptualizes accessibility as from the position of the \*\*capabilities approach\*\* and \*\*vertical equity\*\* (particularly acknowledging that older people have capabilities that differ from the general population). | How?: Specifically for older populations (aged 65+), the following travel distances are suggested as equitable trip lengths to grocery stores per mode: Walking: less than or equal to 1500m, Combined transit and walking (less than or equal to 1000m (walking element)), Combined car and walking: less than or equal to 1000m less than or equal to 1000m (walking element)), Bicycle: less than or equal to 3000m in addition to travel time threshold of less than 15 mins. |
| What?: \*\*mobility and accessibilty\*\* | Where?: [@wismadiSpatialPreferenceModelling2014] - Asia (Yogyakarta, Indonesia) | Explores the equitable provision of transport infrastructure provision: an application of Sen's \*\*capability approach\*\*. Conceptualizes equity through Sen's capability approach and spatial equity. | How?: Areas below the relative poverty line (of its neighbours) can only be located transport resources (i.e., measure in person\*kms that can be travelled at car speed, i.e., mobility) based on the following 2 benchmarks (they can be considered, together as the floor/minmum access): 1) Global: standard deviation (SD) distance to mean should be minimized. 2) Local: priority to minimise the differences with its neighbourhood |
| What?: \*\*mobility and accessibilty\*\* | Where?: [@zhengAreabasedEquitablePricing2020] - North America | This paper conceptualizies equity in the multimodal network (transit, car) being fair toll-pricing across differences in populatins value of time (VOT). VOT is determined based on household income, with lower income households having lower VOT and thus deserving of lower tolls (vertical equity). From this perspective, a utilitarian perspective that seeks to minimize multimodal traffic congestion through introducing toll-pricing based on VOT is implemented. | How?: suggest that a toll-pricing scheme based on individuals travel value-of-time (lower income people have a lower VOT) is equitable. |
| What?: \*\*environmental pollution\*\* | Where?: [@carrierApplicationThreeMethods2014] - North America (Montreal, Canada) | This work examines the statistical association between different social groups and the concentration of air pollutants. They frame their work from the perspective of environmental equity. We interpret the conceptualizations to be along the lines of \*\*inequitable externalities\*\*, \*\*spatial\*\* and \*\*vertical equity\*\* - transport-related air pollution is a product of road transport and it impacts the air of residents in unequal spatial ways. The paper then frames this impact as unfair, particularly from the perspective of disproportionately disadvantaged residents | How?: The literature suggests that the health implications from the transport-related air pollution from major roadways is most acute at residential distance locations of 200 m or less. Residential locations should not be located within this distance threshold from the perspective of human health. \*\*Environmental+\*\* and \*\*Population standards\*\*: Uses the WHO NO² threshold as a point of comparison (annual concentrations of NO² should not exceed 40 μg/m-3). They argue that even through no neighbourhood, even those disproportionately low income, exceed the WHO limit in this case study, they still suggest that air pollution should not be disproportionately impacting disadvantaged neighbourhoods. It can be interpreted that they use the WHO threshold as a minimum threshold and suggest that air pollution levels should not be impacting disadvantaged populations disproportionately ( a relative population standard) |
| What?: \*\*environmental pollution\*\* | Where?: [@jephcoteGeospatialAnalysisNaturally2013] - Europe (Leicester, UK) | Geospatial analysis of naturally occurring boundaries in road-transport emissions and childrens respiratory health across a demographically diverse cityscape. Emperically identifies at what distance away from major roadways children are most impacted by transport-related pollution. This is framed in the perspective of children’s \*\*well-being\*\*. Children are at most risk for acute respiratory distress from elevated levels of air pollution, and as such planning should consider this point of public health. | How?: Finds that children (most vulnerable to air pollution - related to motoized traffic) are most impacted by air pollution within 283 m of a road way. This should be the distance threshold that schools and other childrens facilities are located. |
| What?: \*\*health impacts\*\* | Where? [@adlakhaMindGapGender2020] - Asia (Chennai, India) | From the perspective of disparity in gendered physical activity, this paper focuses on women's cycling as both transport and exercise. They advocate for all people achieving physical activity thresholds (\*\*horizontal equity\*\*) but prioritize women and especially women in neighbourhoods with low-walkability and socio-economic status (\*\*vertical equity\*\*). | How?: All people should get 150 min of moderate activity a week or 75 min of vigorous physical activity per week. |
| What?: \*\*health impacts\*\* | Where? [@savingmothersDidSavingMothers2019] - Africa (Select urban and rural regions in Uganda) | The \*\*well-being\*\* of mothers, this paper examines the timely access to emergency obsteric and newborn care for child-bearing aged women in Uganda. | How?: 2 hours to the nearest facility with surgical capacity with anesthesia services - this threshold is determined through the onset of bleeding to death if a women with obstetric hemorrhage does not receive adequate treatment). |
| What?: \*\*health impacts\*\* | Where?: [@iungmanImpactUrbanTransport2021] - Europe (Madrid and Barcelona, Spain) | They use environmental pollution guidelines, but from the position of health. They investigate the impact of urban and transport planning on attributable mortality burden in Madrid and Barcelona and its distribution by socioeconomic status . Pre-mature mortality is linked to the exposure to pollution and motorized vehicles (\*\*inequitable externalities\*\*). These externalities should not be impacting people disproportionately (\*\*vertical equity\*\*) and should be even across space (\*\*spatial equity\*\*). | How?: All minimum thresholds, if exceeded this is inequitable: NO² concentration 40 μg/m³; PM 2.5 concentration 10 μg/m³; Noise 53dB for average 24 hours; Living with 300 m crow-flies distance from at least .5 hectares of greenspace; and a Change of air temperature of at least 1 ⁰C. |
| What?: \*\*health impacts\*\* | Where?: [@mehdizadehWalkingTimeSchool2017] - Asia (Rasht, Iran) | From the perspective of children’s \*\*well-being\*\*, assesses the walking time to school. They frame walking to school as health-related. | How?: perceived walking time to school for students aged 7-9 yrs is 10 mins, and the longer the PWTS the less likely they were to use an active mode to travel to school. |
| What?: \*\*health impacts\*\* | Where? [@murphySupermarketAccessTransport2017] - Oceania (Melbourne, Australia) | Assesses the relationship between supermarket access and transport mode used, the body mass index (BMI) of the mode-user (\*\*wellbeing\*\*) and the equity in access distribution by income (\*\*vertical equity\*\*). | How?: all households should be sufficiently active (greater than 150 min and at least 5 sessions) and households should be within 1 km euclidean distance to supermarket (80-90% of the dwellings should meet this). Planners should prioritize socially disadvantaged areas to meeting these standards first. |
| What?: \*\*transport-related safety\*\* | Where?: [@ferenchakEquityAnalysisProactively2019] - North America (Denver, USA) | Operationalizes and compares an equity analysis of proactively- and reactively-identified traffic safety issues from the perspective of \*\*Spatial equity\*\*, \*\*Vertical equity\*\* and \*\*Inequitable exposure to externalities\*\*. | How?: standards are suggested for both reactive and proactive analysis. First, the lower the number of collisions on the road with pedestrians/cyclists (i.e., reactive safety analysis), the better. No/minimal inequalities for general population vs. equity seeking groups (high proportion of POC and/or low income in tract). Second, the lower the perceived safety, the better (i.e., if travel to school by ped. or bike is unsafe due to traffic conditions). No/minimal inequalities for general population vs. equity seeking groups (high proportion of POC and/or low income in tract). |
| What?: \*\*transport-related safety\*\* | Where?: [@zheEvaluationSharedUse2008] - Asia (Tokyo, Takamatsu, and Tokushima) | Evaluates the observed safety of shared use pedestrian and bicycle paths from the perspective of \*\*well-being\*\*. | How?: the study suggests that the safety threshold for bicycles and pedestrians to coexist on shared infrastructure is less than 0.5 pedestrians/minute per metre of sidewalk (width) and less than 3.0 cyclists/minute per metre of sidewalk (width). The standard for pedestrian/bicycle share use in terms of hourly traffic volume is less than 26 pedestrians / hour and 108 cyclists / hour for 2m wide sidewalks. |
| What?: \*\*mobility/accessibility and health impacts\*\* | Where?: [@aldertonWhatMeaningUrban2019] - Asia (Bangkok, Thailand) – \*\*Mobility/ accessibility\*\* and \*\*health\*\* | Establishes short-, medium-, and long-term goals for the city in collaboration with technical leaders within the municipal government for the perspective of \*\*well-being\*\* (urban livability): the standards included in this table relate directly to transportation systems. Indicators are inspired by the Sustainable Development Goals (SDGs) as well other global planning standards. | How?: 1) Green space: % of residents living < 400 m from public open space, a large park (> 1.5ha), and/or local park, 2) transit access: % of residents living < 400 m of a local bus stop and <800 m of train station, 3) Facilities: % of residents living < 400 m of a community centre. The following \*\*Infrastructure standard\*\* is suggested: Canal water quality - dissolved oxygen content of equal to or less than 2.0 mL/L |
| What?: \*\*Mobility/ accessibility\*\* and \*\*health impacts\*\* | Where?: [@berheAdaptationDissonanceQuality2014] - Africa (Mekelle, Ethiopia) | Examines adaption and dissonance in the quality of life (QoL) of residents. QoL is conceptualized along the lines of \*\*well-being\*\* and aspects of QoL directly tie into transport systems. They conduct a qualitative QoL survey of residents on the topic of three QoL domains: housing quality, access to important destinations, and affordability. They also measure quantitative indicators associated with these domains. We assume the equity goal for this paper is that subjective and objective QoL measures should not be mismatched: as discussed by the authors of this study, subjective QoL is higher than objective QoL the participant is experiencing adaption and in the reverse scenario the participant is experience dissonance. | How: 1 & 2) Access to primary or secondary education facility, percentage of households living within 1 km or 2km (walking distance), respectively from a primary school or secondary school. 3) Access to health facility, percentage of households within 40 min walking time from a health facility. 4) Access to public transport, percentage of households within a distance of 500 m from a mini-bus stop. \*\*Population standards\*\*: 1) Adequate family income, percentage of households earning more than the official poverty line. 2) Subjective QoL is constructed based on the households level of satisfaction for each of the eight indicators using a six point Likert-scale (1=very satisfied to 6=very dissatisfied). |
| What?: \*\*mobility/accessibility, health impacts, and safety\*\* | Where? [@agostfelipInclusiveModelAssessing2021] - Europe (Castellon, Spain) | Conceptualizes equity through age-friendly urban spaces that reduce (and eliminate) conditions for \*\*transport-related social exclusion\*\* for older populations and prioritize those who are economically vulnerable (\*\*vertical equity\*\*). These guidelines are inspired by the SDGs in addition to planning guidelines used national, regional, and local guidelines used in Spain. | How: 1) Access to facilities needed for old age health. Minimum distance thresholds from the geometric center of neighbourhood are suggested: at least: 1000 m from health facilities (600 m or less is preferred), elderly-specific care facilities and shops should be 600 m (300 m or less is preferred). \*\*Population standards\*\*: 1) Certain neighbourhoods should be prioritized above others. From this papers focus on age-friendly urban environment, they suggest that if the neighbourhood has an average old age indicator (i.e., greater than 64 years, and/or greater than 79 years, and/or aging ratio of persons aged greater than 64 relative to 15 to 64 age) should be prioritized. 2) Economic vulnerable and non-civically engaged neighbourhoods should also be prioritized. If the neighbourhood has a lower percentage of civic associations within the neighbourhood than average, and/or household income, and/or a higher than average interventions for dependency and/or social subsidies, they should be priorized. \*\*Infrastructure standards \*\*: 1) Green space: should be at least 10 m2 per inhabitant in the neighbourhood, greater than 15 m2 per inhab. is the goal. 2) As related to sidewalk infrastructure at least 50% of all sidewalks (preferably 75% or greater) should: have a width of 1.5m or larger, ramps should have a grade of 8% or less, be well maintained (free from deficiencies), be paved for pedestrian use, and cover transit stops. 3) Lighting is critical for traffic-safety and a sense of safety overall. As such, at least 50% roads should: have a min. of 35 lux (road traffic) and 20 lux (pedestrian streets), and adapted traffic lights. 4) Buildings should be age-friendly. As a proxy for the quality of residential living space quality, at least 50% of residential buildings in a neighbourhood should be built within the last 50 years (preferably 75% or more). In terms of physical access into the buildings, at least 10% should have elevators and accessible entrances (preferably 25% or more). \*\*Environment + standards \*\*: 1) Noise at the street level should be less than 55 dB and 45 dB (but preferably less than 50 dB and 40 dB) in the daytime and nighttime, respectively. |
| What?: \*\*mobility/accessibility and safety\*\* | Where?: [@mateobabianoPedestrianNeedsMatter2016] - Asian (Manila, Philippine) | The perception of pedestrians’ walking environments should be sufficient across 6 themes. Equity is conceptualized around \*\*spatial equity\*\* (equally fair walking environments for all locations) and \*\*rights\*\* (the right to mobility/accessibility for pedestrians) | How?: perceived pedestrian perception on protection, ease, equitable access, mobility, identity, and enjoyment must be met. |

1. Similar questions are found peppered throughout the literature. This is done either explicitly, as for example in Karner et al. (2020), who ask “of what”, “for whom,” and “how much” in reference to equity; or implicitly, as in Gössling (2016), who asks of the outputs (“what?”) of transportation (exposure, space, access) and “for whom?” (gender, age, ethnicity). [↑](#footnote-ref-1)