Equity conceptualizations and standards within transportation literature: a scoping review

# Introduction

An equitable transportation system involves the fair production, distribution, and management of transportation benefits and costs within a community (R. H. M. Pereira, Schwanen, and Banister 2017; Sheller 2018; R. H. M. Pereira and Karner 2021). Transportation equity is a multi-dimensional topic centered on the distribution of transport-related benefits and burdens across population groups and communities within urban, suburban or rural areas. Identified equity dimensions include, but are not limited to, accessibility, mobility, affordability, health outcomes, and environmental exposures that impact individuals, marginalized members of a community, and the community overall (Lucas et al. 2019).

Transportation systems simultaneously move people, goods, and information, with emerging technologies and service models complicating the balance of benefits and burdens (Guo et al. 2020). Consequently, achieving an *equitable* system is not a positivist goal; it is inevitably defined normatively, through the planning process (R. H. M. Pereira and Karner 2021; Páez, Scott, and Morency 2012), and iterations of measurement, operationalization, and improvement. Both researchers and planners are grappling with how to set equity goals along spatial, temporal, environmental, and socio-economical dimensions (Boisjoly and El-Geneidy 2017; R. H. M. Pereira and Karner 2021). Synthesizing methods on how to operationalize transportation equity is urgently needed as planners and decision-makers seek guidance on how to distribute existing transportation resources and simultaneously invest in future transportation infrastructure *fairly*.

The application of equity within the realm of transportation planning has proliferated in the academic literature while adoption of new methods in practice remains limited by technical and political constraints (R. H. M. Pereira and Karner 2021; Boisjoly and El-Geneidy 2017; Doran, El-Geneidy, and Manaugh 2021; Linovski 2020; Litman 2022). Academic research has approached equity through measures such as accessibility and activity participation (Páez, Scott, and Morency 2012; Allen and Farber 2020), affordability (Isalou, Litman, and Shahmoradi 2014), environmental impacts and safety (Guo et al. 2020), and health (Fransen et al. 2015; M. Smith et al. 2017), and also conceptualizations such as frameworks for equity and social exclusion (Lucas 2006; Lucas et al. 2016), and distributive justice theories (Behbahani et al. 2019; Lewis, MacKenzie, and Kaminsky 2021; R. H. M. Pereira, Schwanen, and Banister 2017; Vecchio and Martens 2021), among others. However, a gap in the literature is the absence of a comprehensive review that examines how equity is conceptualized and then operationalized through measures and standards. These inquiries are vital to give planning agencies and decision-makers a comprehensive but comprehendible overview of possible methods for equity analysis and their application to different contexts, and as such, this review aims to definitively benchmark the knowledge in the literature from this perspective.

Though aspects of transport equity in metropolitan planning documents such as accessibility (Boisjoly and El-Geneidy 2017) or mode-specific equity (Doran, El-Geneidy, and Manaugh 2021) have been reviewed, no review to date captures how equity has been theorized and translated into standards across different dimensions of equity listed above. Our work contributes in this direction, reviewing which equity dimensions, standards, and conceptualizations have been applied in the academic literature and identifying where gaps in the literature exist across spatial. Ultimately, this review aims to collate the academic knowledge and present it in an operationalizable manner to both academics and decision-makers in hopes to catalyze the uptake in equitable planning practices and guide future research programmes which develop definitions, measures, and recommendations for evaluating transportation equity.

This paper is structured as follows. In Section 2, we set the stage by defining what do we mean by equity dimensions, conceptualizations and types of standards used in the literature search and throughout the paper. In Section 3, we outline the methods used in the scoping review conducted. In Section 4, we summarize the findings of the literature. In Section 5, we discuss the methods connects to standards, conceptualizations and dimensions. In Section 6, we summarize the findings and link them to future transport planning agendas in addition to visioning ways the findings can be used to build *just* transportation planning processes.

# Setting the stage

Transportation equity literature exists within cross-cutting categories. We borrow a “Where?”, “When?”, “Who?”, “What?”, and “How?” framing to categorize aspects of how equity is assessed. This categorization is outlined in Jaggar (2009) to describe substantive sets of answers to questions of distributive justice (and further discussed in the context of justice within the critical human geography discipline (Przybylinski 2022)). For questions of *justice*, convincing answers to these questions require a rationale: a “Why?” (Jaggar 2009). For the purpose of this review focused on *equity*, the focus is on studies that substantively answer “Where?”, “When?”, “Who?”, “What?”, and “How?”; the answer to “Why?” may be incidental. Though critical, answers to “Why?” are not overwhelming common in the transportation equity academic literature that also address “Where?”, “When?”, “Who?”, “What?”, and “How?”. This is discussed as a next step in planning for *justice* transportation literature in Section 6.

Furthermore, it is important to distinguish between equity and justice. Our focus is on equity, which is nested within and can be interpreted as the application of justice theories. For instance, *mobility justice* seeks to understand how broader power inequities that inform the governance and control of movement are reproduced by mobility systems (Sheller 2018). In understanding what is *just* and *unjust,* equity is the application of processes to move towards justice. Justice is the goal of equity processes. It must be decided at a community level, and cannot be captured in a single academic text.

### Definitions

For all literature reviewed in the transportation domain, equity *dimensions*, *conceptualizations*, and *standards* are discussed through the “Where?”, “When?”, “Who?”, “What?”, and “How?” framings. As follows, we define each of these categories and how they inter-connect.

**Equity dimensions**: the assessment of transportation equity encompasses various dimensions, mirroring the multifaceted nature of transportation systems. These dimensions can be distinguished as follows:

* **“What?”**, specifically: (1) mobility/accessibility, (2) traffic-related pollution, (3) traffic safety, and (4) human-health as provided in a conceptual framework by Lucas et al. (2019).
* *When* and *Where*: includes the article’s publication year, the geographic context (i.e., urban, suburban and rural areas, countries) and location.
* *Who*: includes the type of population group, mode type, activity/opportunity type, and transport network status.
* *How*: includes the measure used to assess equity dimensions as supported by an **equity conceptualization** and **equity standard**. **Equity conceptualizations** are some type of motivating equity principle, philosophy or theory. For example: theoretical and conceptual frameworks (e.g., transport-related social exclusion, transport disadvantage, transport poverty, horizontal equity, vertical equity) and equity principles (e.g., Utilitarism, Capabilities Approach, Sufficientarism). **Equity standards** are thresholds that when operationalized can be used to define when an aspect of the transportation system is in/equitable. They can be quantitative thresholds, qualitative descriptions, and/or mixed-method thresholds. Examples include: maximum travel distance/cost/time to or from key destinations, levels of maximum exposure to externalities (i.e., noise or air pollution), distributional assessment (e.g., composite indicator, range, maximum distance or gap, etc.), a dis/satisfaction with travel scale, among others.

Papers that include equity **dimensions**, **conceptualizations**, **standards** and substantive answers to the “When?”, “Where?”, and “Who?” in relation to equity in transportation systems (i.e., the users, the infrastructure, the service, the outcomes, or a combination of all) are used to answer the following research questions:

* What are the equity dimensions, equity standards, and equity conceptualizations found in the existing transportation equity academic literature and how are they applied?
* Based on how equity has been applied in the literature, what may be paths forward in theorizing justice in the context of transportation systems?

# Literature review methods

This review examines the breadth and depth of the academic literature on transportation that analyses equity within at least one equity dimension and implements equity conceptualizations and equity standards as defined in the previous section. This review follows the Joanna Briggs Institute (JBI) approach to the conduct of scoping reviews which builds upon the Arksey and O’Malley (2005) framework (Peters et al. 2020). The JBI is a global organization that creates frameworks, protocols and guidance for the synthesis of research. This review is also guided by the Preferred Reporting Items for Systematic Reviews and Meta-Analyses extension for scoping reviews (PRISMA-ScR), consistent with the JBI approach (Tricco et al. 2018). Using these methods allows us to explore the broad topic of transportation equity within the literature and collate knowledge from across methodologies in the academic literature.

The primary research question and the protocol was drafted and refined from preliminary searches of related-reviews (e.g., Iglesias et al. 2019; Sagaris, Berrios, and Tiznado-Aitken 2020; Vecchio and Martens 2021), consultations with the authorship team who are engaged in transportation equity related research, and a University of Toronto Research Services Librarian and Liaison Librarian in City Studies. The methods are described in two parts: (i) the development of the search strategy and (ii) the evidence selection and data extraction.

## Search strategy

To guide the selection of terms within the search query, **inclusion** and **exclusion** criteria were developed (Peters et al. 2020). The search strategy was developed iteratively, at each stage adding topic search terms (e.g., terms in the title, abstract or key words) to the set of terms tied together with logical connector terms “AND” and “OR”. These stages are summarized in what follows and the full search term queries are detailed in Appendix [Figure 7](#fig-A1).

1. An initial limited search of the core collections within the Web of Science (WoS) platform was undertaken to identify key papers. Terms for ‘transportation’ and ‘equity’ were generated, respectively. The text words contained in the titles and abstracts of relevant papers, the index terms used to describe the papers, and subject heading searches when available (depending on the database within WoS). This search was iterated on and took the form: (“Transport” OR “Transit” OR “Car\*” OR “Walk” OR “Bike”…**1**) AND (“Equity” OR “Justice” OR “Equity” OR “Fair”…**2**), where **1** and **2** signify additional terms that relate to ‘transportation’ and ‘equity’, respectively.
2. Upon inspection of the preliminary search results and team consensus, the ‘equity’ set of search terms was expanded into three sets of terms describing equity theories, equity dimensions, and standards. All three sets of terms were iteratively augmented. The finalized 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” logical connectors.

The search strategy, including all identified keywords and index terms, were applied to each database and platform searched (i.e., Web of Science General Collection -Science Citation Index Expanded, Social Sciences Citation Index (Web of Science), and Transportation Research International Documentation (TRID)). The exports of the final search query were completed by the first author on March 21st 2021.

## Evidence selection and data extraction

Evidence selection consists of scanning the exported literature from the search strategy and retaining the papers that fit the inclusion and exclusion criteria. This process was pilot-tested with a subset of papers before being implemented on the full set. Then, *Covidence*, an online application for literature screening, was used for all steps of selection and data extraction on the full export of literature. All steps are visualized in [Figure 1](#fig-fig1).

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

The process is summarized in the following three steps:

1. The first step (orange box in [Figure 1](#fig-fig1)) included screening all titles and abstracts of papers on whether they included transportation equity as defined by the PCC. All papers were voted on by two independent reviewers for inclusion, exclusion, or uncertain inclusion. All uncertain papers, conflicting papers, and papers missing abstracts were voted on by a third reviewer for inclusion or exclusion.
2. The second step (green box in [Figure 1](#fig-fig1)) included reviewing all full-text papers which passed step 1. These papers were reviewed based on if their study design included an equity standard and equity conceptualization. All papers are voted on by two independent reviewers for inclusion or exclusion. If an article was voted to be excluded, it was tagged with one of five possible reasons, namely (1) no standards included, (2) no conceptualizations included, (3) no standard and no conceptualization included, (4) send back – QA issue, (5) other. Discrepancies were resolved by a third reviewer.
3. A data extraction template was filled out for each record: one reviewer for the third and final step (purple box in [Figure 1](#fig-fig1)). The data extraction template was created to balance complexity of categories and simplicity of summary; information related to “What?” (equity dimension), “Who?” (population group, mode type, type of destination/activity), “Where?” (region of study), and “How?” (the equity standard(s) and associated conceptualization(s)) was filled out for each study. [Figure 8](#fig-A2) contains the template that was input into *Covidence* and used within this review.

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| Figure 2: PRISMA flow diagram for the evidence selection process. ES signifies equity standard and EC signifies equity conceptualization. |

The evidence selection process is also represented using the PRISMA flow diagram (Page et al. 2021) in [Figure 2](#fig-fig2). 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 inclusion was initially too generous, and some papers did not have a sufficiently strong equity standard and/or equity conceptualization. As such, 322 papers were further excluded and data extraction was completed for the remaining 165 papers. A summary of the reasons for exclusion of the 1545 papers (between steps 2 and 3) are included in [Figure 2](#fig-fig2).

# Summary of findings

A synthesis of the findings from the data extraction template (shown in [Figure 8](#fig-A2)) is detailed in this section. The presentation of findings is less granular than the template to highlight key trends in the literature.

## Temporal and spatial focus (the “When” and “Where”)

[Figure 3](#fig-fig3) displays the papers included in this review by year of publication and case study continent. Evidently, research on transportation equity increased throughout the years, particularly since 2019. Of note is the geographic scope of the case studies present in the papers. Most papers (60%) contain case studies based in the Global North e.g., North America (particularly USA and Canada), Europe (particularly UK, France, Spain and Scandinavia), and Oceania (Australia and New Zealand). How *equity* is operationalized is context-specific, and with the majority of transportation systems *not* in the Global North, the literature included in this review falls short in representing the global perspective.

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| Figure 3: Papers included in the review by year of publication and case study continent. |

The few studies in the Global South are predominately in the **Asian** continent, specifically China but also India, Thailand, South Korean, Iran, Philippines, Indonesia, Israel, and Japan. These studies focus on a variety of modes, population groups, and equity conceptualizations and standards that cannot be succinctly summarized.

The next most common focus within the literature from the Global South centers on **South America**. Many of these studies mention a systematic absence of evidence relevant to the region (Vecchio, Tiznado-Aitken, and Hurtubia 2020). Despite the growing recognition in the literature of the interconnections between transport development, social exclusion, and poverty (Benevenuto and Caulfield 2020), studies underscore an ongoing neglect of the social dimension of transport during the planning stage (Benevenuto and Caulfield 2020; Boisjoly et al. 2020). Many studies also indicate affordability as one of the main mobility barriers in the region (Falavigna and Hernandez 2016; Rivas, Serebrisky, and Suárez-Alemán 2018), while some highlight multi-dimensional concerns such as public transport accessibility and quality of walking environments that contribute to mobility inequalities (Tiznado-Aitken, Munoz, and Hurtubia 2018).

Within the reviewed literature, studies pertaining to **Africa** are less numerous compared to the South American literature. A shared characteristic among the studies from the two continents is a scarcity of official transport data (Fried et al. 2020) and reliance on external policy guidelines. These studies also incorporate the utilization of informal transportation options and pressures to developm physical road network infrastructure (supporting car dependency) over meeting mobility/accessibility needs of citizens (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, Martinez, and Verplanke 2014), and focus on advancing transport justice for low to medium income countries (LMIC) by aligning with external policy guidelines such as the Sustainability Development Goals (SDGs), particularly those related to universal accessibility (Fried et al. 2020).

From all the studies included in the review, 85% focus on the urban and suburban context and are highly varied in their research aims. To give an example, from the perspective of cycling as a mode, Cox and Bartle (2020) qualitatively examines cycling as a mode for people with disability in a typical mid-size town in the UK and Ampe et al. (2020) identifies the lateral clearance that motorists should maintain when passing cyclists with children seats; both focus on understanding barriers to cycling from different perspectives, but within different urban environments.

The remainder of the studies focus on rural regions (14%). To illustrate examples, Cao and Stanley (2017) examined transportation disadvantage in remote places which rely on inter-island ferry trips in rural Philippines. Similarly, Parry et al. (2018) studied remote communities in the Amazon and suggests that “increasing accessibility through road building would be maladaptive, exposing marginalized people to further harm and exacerbating climatic change by driving deforestation” (pp. 125).

## Populations of interest (the “Who” pt.1)

[Figure 4](#fig-fig4) showcases the categories of population group types that are the focus of the reviewed papers. From this tally, papers that consider equity across different income groups are most common in the literature. Most papers that focus on income pay particular consideration to the lowest-income groups, as they experience the greatest burden of transport inequalities, be it accessibility, affordability, or other dimensions (Peungnumsai et al. 2020; Zhao, Li, and Liu 2020; Falavigna and Hernandez 2016).

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| Figure 4: The proportion of papers that focus on each type of population group. Categories for population groups were generated upon data extraction. |

An abundance of literature suggests that income is a significant determinant of transport-related inequities (e.g., access to public transport supply in Bangkok region (Thailand) (Peungnumsai et al. 2020), access to employment opportunities in various cities in Brazil (Boisjoly et al. 2020), and less environmental noise and air pollution, and higher green space per resident ratios in Rijnmond region (Netherlands) (Kruize et al. 2007). But this should be kept in context, as low-income does not necessarily mean lower transport-related benefits. For instance, in Sheffield (UK), Mears et al. (2019) demonstrates that historically working-class neighbourhoods (i.e., lower income working population) have more access to green space than other neighbourhoods due to urban planning approaches during the Victorian-era. However, the quality of green spaces are less than average. Similarly, Bertrand, Therien, and Cloutier (2008) finds that lower income groups do not always have below average accessibility depending on the granularity of analysis (i.e., the distance-to-food threshold for the cumulative opportunity measure).

Age is the second most common category of population group of focus within the reviewed literature. Many papers focusing on this category highlight differing age-related capabilities; for instance, Martinez-Jimenez and Salinas-Perez (2019) and Arranz-Lopez, Soria-Lara, and Pueyo-Campos (2019) investigate travel distances and times to various opportunities for specific age groups, acknowledging that age is an important consideration for opportunity access variability between populations. The most commonly focused on age groups are school-aged children and older populations. School-aged children-oriented papers analyze wellbeing (Laszkiewicz and Sikorska 2020), exposure to green space (Corazza et al. 2020), access to schools (Sharma and Patil 2022), and understanding and encouraging active travel journeys (Mackie 2009; Mehdizadeh, Mamdoohi, and Nordfjaern 2017). Papers focusing on older-populations typically have similar aims as the children-focused articles e.g., understanding transport-related impacts on wellbeing e.g, (Y. Chen et al. 2020), measuring accessibility to population-specific key destinations e.g. (Cheng et al. 2019), and seeking to understand how to better meet travel needs e.g., (Nordbakke and Schwanen 2015).

The third most commonly focused on population category is what we call ‘composite vulnerable population groups’. These papers use some sort of composite vulnerability index that captures multiple population vulnerabilities (e.g., low-income, unemployment, immigrant status, family household characteristics, etc.) typically generated by official government sources or from author-informed census data creation. These indices are varied in methodology, reflecting the intersectionality of population vulnerabilities. For instance, Awuor and Melles (2019) uses the Neighbourhood Equity Index (NEI) to measure disparities in premature death in Toronto (Canada). The NEI is a composite index that was developed by the city to capture the differences in the City’s neighbourhoods by ranking them based on socio-economic characteristics (e.g., social assistance, unemployment, income) and physical environmental characteristics such as green space availability. Other works use national census indicators such as the social and housing deprivation index e.g., (Pucci et al. 2019), while others use census household poverty measures and calculated transport-related indicators like accessibility to estimate transport disadvantage (Sun and Thakuriah 2021; Scheurer, Curtis, and McLeod 2017), evaluation of equity in policy implementation (Aldred et al. 2021), and inequitable transport-related mortality burden (Iungman et al. 2021). Similarly, Environmental Justice (EJ) indicators have been used in US literature to identify neighbourhoods that have a higher than average proportion of low-income and non-white populations (i.e., a composite vulnerable population group). Many studies have used EJ analysis to evaluate the equity impacts of transportation projects e.g., (Rowangould, Karner, and London 2016; K. Park et al. 2021; Reddy, Chennadu, and Lu 2010).

. Papers that focusing on populations with disabilities as the sole indicator of marginalization are relatively common in the reviewed literature . They mainly assess universal design guidelines and the ability for people with disabilities to travel. However, from another perspective papers with an exclusive focus on gender, race/ethnicity, or education level/employment are much less common in the reviewed literature. Only two papers focus on gendered differences in cycling and active transportation (e.g., Adlakha and Parra (2020)‘s case study in Chennai (India) and Xie and Spinney (2018)’s case study in Cardiff (UK)). Only two papers focus on race and ethnicity exclusively focusing on how minority ethnicity communities are in proximity to green space (Silva et al. 2018) and culturally diverse family physicians in Toronto (Canada) (Wang and Roisman 2011). Furthermore, papers that focus *solely* on education andemployment status are not present in the reviewed papers. This is to say, papers that feature gender, race/ethnicity, or education level/employment population groups often feature them alongside other population group characteristics (or within ’composite vulnerability measures’). This contrasts the prominence of studies that exclusively center on disabilities as a population category.

The *Other* category contains papers with population groups that are more difficult to classify. Examples include: veterans and access to specific-healthcare needs (Mooney et al. 2000), pregnant women and access to services (Vadrevu and Kanjilal 2016), and youth populations who live in foster care (Batsche and Reader 2012). Overall, the diversity of the *Other* population group classification demonstrates the diversity of transportation-equity concerns across population groups in the reviewed literature and the interplay of characteristics in the literature (Vecchio et al. 2022).

## Transport modes (the “Who” pt.2)

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| Figure 5: The proportion of papers that investiage each type of mode. Categories for modes were generated upon data extraction. |

Shifting to transport modes of interest, the primary emphasis within the reviewed papers centers on public transit ([Figure 5](#fig-fig5)). The variety of topics assessed from the perspective of public transit are varied. For instance, McKey, Kim, and Seo (2020) identifies ‘food deserts’ in Dallas (USA) considering public transit accessibility. Other contributions intersect public transport and individual needs, such as, universal design and barrier-free transportation for people with disabilities (e.g., Jiménez-Espada and González-Escobar 2021; Liu et al. 2019), or how public transport services can be assessed and improved for people with autism (Lim et al. 2021; Feeley 2019). There may be a strong focus on public passenger transport systems because they can be altered to improve equity - it is a collective social system that has the potential to be sufficiently funded in order to provide barrier-free transport for most but it requires a variety of inputs that cannot always be met (e.g., sufficient density as a result of land-use, economic development, political will).

Transit is also often central to multi-modal or holistic comparisons that may serve transport equity analysis. As an example, Brussel et al. (2019) compares three different approaches to measure accessibility within the context of the Sustainability Development Goals (11.2) for the case of Bogota, Colombia, all of which capture some/all of the public transit system while others capture road and/or pedestrian systems. From a different perspective, Renne and Mayorga (2018) reviews natural disaster emergency evacuation plans from the lens of the no-car (and oftentimes vulnerable) households in regions across the USA, paying particular attention to transit and pedestrian networks.

In contrast, a few papers in the reviewed literature frame transit modes as the ‘car-free’ option and compare transit to car access. This framing is notable as car travel can be seen as a direct competitor to transit or be viewed as a benchmark for travel times and accessibility levels (Golub and Martens 2014; Martens, Golub, and Robinson 2012). As an example, Warren et al. (2015) develops a goal for per capita car ownership for the developing economy of Havana (Cuba), in recognition that car mobility is needed to alleviate transportation disadvantage in the short-term where public transit is not yet sufficiently addressed. In this context, this paper acknowledges the tension between household vulnerability and their need for mobility against sustainability goals of GHG emission reduction and car-dependency cycles. However, not all papers see transit as a direct competitor, but as a mode that can be used to satisfy individual capabilities. For instance, N. Smith, Hirsch, and Davis (2012) focuses on households who live in rural areas in the UK and they synthesise their perspectives on their minimum transport needs and costs based on perceived minimum living standards for types of households (e.g., retired, no-children, with children, single, etc.). The papers reviewed 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, walking is the second most common mode examined in the equity literature. In the papers that focus exclusively on walking, many use or develop walkability scores to explore neighborhood perceptions (Evans 2015) or pedestrian mobility focusing on middle-aged and older adults (Towne et al. 2016), gender (H. Kim et al. 2016), or urban peripheries (Blecic et al. 2021). These papers use ‘walkability’ as a way to measure the equity in its distribution. Other papers use walkability as an indicator for public health and urban vitality (Sung and Lee 2015; McCormack et al. 2012).

Additionally, papers that focus on the pedestrian mode also often focus on multiple modes: they often discuss ‘walkability’ as part of active transportation, which focuses on both walking and bicycle and/or transit. Conceptualizations include how active transport contributes to children’s physical activity levels (Mammen et al. 2014), walkability as an alternative to car predominance (Bertrand, Therien, and Cloutier 2008) or tension that exists between modes, creating unsafe conditions for walking (Siu 2019; Ferenchak and Marshall 2019).

In terms of car-mode, cars are infrequently the only mode within a paper that is examined. When car-mode is studied, it is often used as a comparison with transit or as the only mode of transport for areas with sub-standard transit systems e.g., (Kimmel et al. 2018; Aljoufie 2016). Similarly, car studies focus on externalities such as air pollution and safety (Tao Feng and Timmermans 2014; Houston et al. 2006).

## Destinations (the “Who” pt.3)

The majority of the papers do not focus on any particular destination (e.g., 28% of studies). Within these papers, a variety of equity dimensions and modes are examined. Typically, they are multi-modal and focus on either dimensions that impact the **trip itself** (e.g., the trip experience, the quality of infrastructure, aspects of level of service) or the **people and relevant destinations that can be accessed** (e.g., a bundle of trips made for specific population groups, enough for ‘sufficient’ quality of life). For the first, the focus is on the quality of infrastructure, safety issues, perceived accessibility and dimensions of the level of service such as frequency (Zhe et al. 2008; Prasertsubpakij and Nitivattananon 2012; Fürst and Vogelauer 2013 ; Lattman, Friman, and Olsson 2016). For the second, the focus is a bundle of trips made for specific population groups, such as people who are physically impaired (Wilkinson-Meyers et al. 2015) or women (Russell et al. 2021) or broadly what is enough for ‘sufficient’ quality of life (Churchill and Smyth 2019). These papers further demonstrate the multi-dimensional role of transportation systems: they provide a utilitarian service that can be used to get from A to B but they too are experienced by the people that use them. The papers that examine ‘all trips’ best exemplify this trend in the transportation equity literature.

In terms of the papers that study specific destinations, the most commonly studied activity types include healthcare services (11%) followed by employment destinations (15%). Papers that exclusively focus on healthcare typically originate from the healthcare planning literature, and look to inform planners where disparities in services exist and what can be done about it. For instance, Wang and Roisman (2011) model access of the Chinese-language speaking population in Toronto (Canada) to Mandarin-speaking family physicians and suggests (inferred) that a spatial mismatch in the supply and demand is not equitable. Papers that exclusively focus on employment typically focus on these trips as they are the most common trip purpose and are often correlated with other trip activities like shops, recreation, and other services, generally speaking. For instance, Allen and Farber (2019) operationalizes a low employment-based accessibility threshold and a composite population vulnerability index to identify neighborhoods at risk of transport poverty for eight cities in Canada. Papers focused on healthcare and employment typically source data from representative travel surveys, census data, and point-of-interest databases. They often rely on well developed and institutional data that represents ‘typical trips’, especially in the Global North where this data is more readily available.

But what about non-healthcare and non-employment activity types? Papers that focus on other activities are not framed as a ‘typical travel pattern’ and they have different intentions. For instance, papers that focus on places for shopping such as grocery stores or markets (12%), often aim to identifying food deserts e.g., (Choi and Suzuki 2013; Jiao et al. 2012; McKey, Kim, and Seo 2020; D. Kim and Park 2020). Papers that focus on educational facilities including primary school, secondary school, and post-secondary school represent 11% of the studies, and examine children’s active transportation to school e.g., (Laszkiewicz and Sikorska 2020) and universal design e.g., (Larkins, Dunning, and Ridout 2011). When green space or other places of leisure is the exclusive focus (11% of papers), studies examine different accessibility questions such as the spatial distribution of green space e.g., (Xu et al. 2017), for whom its accessible to e.g., (Mavoa et al. 2015), and why e.g., (Mears et al. 2019). Very few reviewed papers include ‘community’ destinations (including public service centres, places of community support, and places of worship (6% of studies) or childcare activity types (3% of studies). In the few papers that do include them, these destinations are considered in a holistic representation of activity participation (Alberts, Pfeffer, and Baud 2016; N. Smith, Hirsch, and Davis 2012).

Conclusions and recommendations from the papers are varied: they span across population groups, modes, and activity types – in addition to across equity dimensions, conceptualizations, as we exemplify below.

## Methods used across equity conceptualizations and standards (the “How”)

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| Figure 6: The proportion of equity standards (vertical axis) within each type of equity conceptualization (horizontal axis) category. |

. Broadly summarizing how equity standards connect with conceptualizations, some trends emerge in methods used. **Opportunity** and **population** standards appear in the literature at similar proportions (37.2% vs. 35.8%), but frequently correspond to different conceptualizations. Referring to [Figure 6](#fig-fig6), over 40% of papers that focus on **horizontal equity** and **spatial equity** conceptualizations suggest **opportunity** standards. Within these papers, travel impedance standards (a type of opportunity standard) are often suggested and accessibility indices are operationalized (i.e., a measure of the potential to interact with opportunities for populations located at each spatial unit within a region). Examples include: Z. Chen and Haynes (2017) uses a travel time threshold of 4 hours or less on high-speed rail from one municipality to another to be considered “comfortably connected”, Yenisetty and Bahadure (2020) assumes that populations living in areas where the travel distance to a public transit station is less than 1,200m is sufficient to interact with the transit system, and Shen et al. (2020) identifies regions where populations cannot access hospitals within 1 hour by car. Papers suggesting opportunity standards often employ disparity analysis through a variety of quantitative approaches such as inequality measures (e.g., Gini coefficient and Lorenz curves, poverty measures (van der Veen et al. 2020; Tiznado-Aitken, Munoz, and Hurtubia 2018)), spatial descriptive analysis, and the comparison to benchmarks (e.g., equal supply to demand of public transit in a spatial unit as done by Peungnumsai et al. (2020)) to determine which locations are spatially and horizontally (in)equitable relative to other locations in the studied region. Another branch of quantitative research conceptualizes transportation system externalities as trade-offs, maximizing transport-related benefits (i.e., time savings, emissions reductions, congestion reductions, user fares) through optimization/location-allocation methodologies e.g., (T. Feng and Zhang 2014; Fakhrmoosavi, Zockaie, and Abdelghany 2021; Zheng and Geroliminis 2020; Wismadi et al. 2014). These papers that focus primarily on **horizontal equity** and/or **spatial equity** seldom use exclusively qualitative methods.

. Whereas, papers that propose **population** standards frequently utilize other methods. Over 40% of papers that suggest **population** standards focus on **well-being** conceptualizations. These papers typically ask *what is enough to lead a satisfactory life (as related to transportation)*, and the standards that are suggested include population benchmarks for comparison such as: questionnaires and relative comparisons to physical activity per week recommendations (Adlakha and Parra 2020; Auchincloss et al. 2020; McCormack et al. 2012; H. Kim et al. 2016; Towne et al. 2016), summative per capita benchmarks (e.g., energy consumption for a ‘decent living’ is suggested in (Rao and Baer 2012), and region-relative comparisons in health-related outcomes e.g., premature mortality rates (Awuor and Melles 2019), spatial access to hospitals (R. Pereira et al. 2021), spatial access to supermarkets, active-mode-usage, and Body Mass Index (BMI) (Murphy et al. 2017). The majority of these papers use quantitative/mixed-methods to identify inequities in **wellbeing**, however, a minority do use exclusively qualitative methods to distill themes e.g. the exploration of *perceived* quality of life in (Berhe, Martinez, and Verplanke 2014).

. Papers that conceptualize *both* **population** and **opportunity** standards often conceptualize **vertical equity** and **transport-related social exclusion** (note the similar proportions in these standards in [Figure 6](#fig-fig6)). Expectedly, these papers often include a combination of methods. Questionnaires and other qualitative methods related to population standards and quantitative methods such as accessibility indices for opportunity standards are usually deployed. For instance, census data and the estimated proportion of households within some travel distance/time/availability to/of key destinations is used to identify a variety of social exclusions e.g., (Mackett, Achuthan, and Titheridge 2010; W.-H. Chen 2010; Daniels and Mulley 2011; Sun and Thakuriah 2021; Sharma and Patil 2021), transport-related social exclusion’s link to wellbeing e.g., (Delbosc and Currie 2011; Churchill and Smyth 2019), areas more likely to experience transport poverty (Allen and Farber 2019), food deserts (McKey, Kim, and Seo 2020), or transport-related energy poverty (Robinson and Mattioli 2020; Berry et al. 2016; Berry 2019).

Similar to papers that conceptualize **wellbeing**, the majority of **social-exclusion**-conceptualizing papers use quantitative/mixed-methods to identify areas, households, and/or populations at risk. They use a variety of methods to identify *where* populations at risk may be located, such as clustering methods (Mohri, Mortazavi, and Nassir 2021). The minority of papers that employs exclusively qualitative methods use surveys to understand population travel willingness/barriers e.g., (W.-H. Chen 2010; Mehdizadeh, Mamdoohi, and Nordfjaern 2017) and interviews/focus groups related to topics of unmet activity needs (Nordbakke and Schwanen 2015).

. The largest group of papers that suggest **Infrastructure** standards conceptualize **Rights**. Recall, **Infrastructure**-standards suggesting papers represents 37% of all papers and **Rights-**conceptualization is represented two times more than any other conceptualization type. These papers often focus on populations with mobility impairments and non-car users’ inequities in their ability to access the transportation systems. Methods vary, but focus equally on audits of existing infrastructure relative to best-practice universal design principles (Odeck, Hagen, and Fearnley 2010; Larkins, Dunning, and Ridout 2011; Jiménez-Espada and González-Escobar 2021; Perez-delHoyo et al. 2021) and qualitative methods that interview and survey users about their perceived access to transport systems e.g., (Marquez, Poveda, and Vega 2019; Iderlina Mateo-Babiano, Kumar, and Mejia 2017; Fürst and Vogelauer 2013; Velho et al. 2016; J. Park et al. 2017; Lim et al. 2021; Stjernborg 2019) and experiment the suitability of existing best practice standards e.g., (Daamen, de Boer, and de Kloe 2008; Velho et al. 2016; Bharathy and D’Souza 2018).

More broadly, papers that suggest **Infrastructure** standards are often multi-dimensional, and extend beyond **Rights** conceptualizations. They often suggest **Opportunity** and **Population** standards as well and often apply **Vertical**, **Horizontal** and **Spatial** equity lenses as well. These multi-dimensional papers can refer to established guidelines and suggest composite indices e.g., Rachele et al. (2017) combines transport network properties such as street connectivity, cul-de-sac length, street block length, traffic volume, public transport stops and service frequency inputs to define an indicator of transport design that is supportive of walkability and access to public transport. Other works include assessing the quality of infrastructure (Xu et al. 2017), the severity and frequency of accidents on the system (Benevenuto and Caulfield 2020; Appleyard, Ferrell, and Taecker 2017), user-groups (particularly disadvantaged groups in the case of vertical equity conceptualizations) (Prasertsubpakij and Nitivattananon 2012) as part of the multi-criteria indicators. Another branch of literature explicitly focuses on affordability or other barriers to the transport system, and suggests improvements to the infrastructure such that all groups (especially the most disadvantaged) can sufficiently interact with the system e.g., (Basu and Alves 2019; Song, Kirschen, and Taylor 2019; Welch 2013), dabbling into conceptualizations of **transport-related social exclusion** e.g., (Kent and Karner 2019) and **sufficientarian/capabilities** conceptualizations e.g., (N. Smith, Hirsch, and Davis 2012).

. Though papers that conceptualize **Environmental +** standards are not common in the literature review (4% of all papers), they most frequently occur in papers focused on **Inequitable externalities**. These papers often use traffic-related air pollution, noise pollution, green-space, urban design elements, urban air temperature, health related outcome, and physical activity guidelines to quantify transport-related externalities. Methods used are almost all quantitative or mixed-methods, and the identification in inequalities is spatial clustering, the use of Gini coefficient (T. Feng and Zhang 2014), comparisons to established environmental thresholds or health guidelines (Agost-Felip, Rua, and Kouidmi 2021, 2021; Kruize et al. 2007; Iungman et al. 2021; Apparicio et al. 2021; Khomenko et al. 2020; Mueller et al. 2018), creation of composite multi-dimensional indices (Agost-Felip, Rua, and Kouidmi 2021; Miranda and da Silva 2012; Corazza et al. 2020), and/or in addition to spatial analysis (Jephcote and Chen 2013; Carrier et al. 2014).

See Table XX for detailed examples of papers conceptualizations and standards across each equity dimension.

# Discussion and ways forward (identifying gaps and possible agenda for the future)

We discuss trends in how the literature has conceptualized and used standards (the “How”) to evaluate the “What” of transportation equity, the equity dimensions. These trends are context-specific: they concern the “When” and “Where” (differences across publication year, across case studies continent, and between urban and rural contexts) and the “Who” (differences in the focus on the population sub-groups, transport modes, destinations of interest) as discussed in the preceding sections following the four equity dimensions that structure this review (mobility/accessibility, traffic-related pollution, human-health related, and traffic safety).

A summary of what we found in the literature:

* the “When” and “Where”:
  + most studies focus on case studies in north american and europe
  + south american/africa papers have key differences in focus compared to global north: they are more focused on affordability-as-a-barrier, tensions in infrastructure dev vs. service prioritization, data availability limitations
* the “Who”:
  + low income most popular
  + (dis)abilities are exclusive focused population category in many studies; other ‘vulnerabilities’ are typically composite (aside from income, which is part of both exclusive-focus and composite vulnerabilities)
  + transit, with cycling and walking becoming more popular
  + cars are seldom the focus, and if they are, it is as a comparison to transit and/or focus on their negative externalities
  + destinations of interest are mostly employment and healthcare; other destinations are less studied. The many ‘destination’ however, is the trip itself – the experience, the infrastrucutre, the mode-service, a bundle of trips taken a month to all locations, etc.
* the “What” and “How”:
  + accessibility/mobility -> opportunity standards are typically travel impedance standards, and affordability thresholds (e.g., more than 10% of monthly income should not be spent on transport (Rivas, Serebrisky, and Suárez-Alemán 2018) to work and/or other necessary destinations). Oftentimes spatial equity, disparity analysis is operationalized. Infrastructure standards are also suggested -> oftentime Rights conceptualizations, i.e. access for all.
  + transport-related environmental externalities -> pollution/noise standards are suggested, often using WHO guidelines or local neighbourhood averages as a comparision.
  + health -> health standards, the reliance on population transport health literature such as physical activity guideline recommendation per week or excess mortality burden.
  + safety -> the use of engineering standards and best practice
  + cross-dimensional -> measures such as urban livability, etc. a more holistic conceptualization of transport equity

## The need for explicit conceptualizations and grounded standards

Some conceptualizations are implicit. Some standards seem arbitrary. Despite the need for and importance of setting more standards, some proposals seem arbitrary. For example, XXXX proposes 20 ferries per day to avoid social exclusion. Justifications for this number is lacking. It is unclear if 10 or 30 ferries would make a difference in a specific quality-of-life outcome or if that number is tied to funding/resource constraints. We need standards linked to grounded outcomes.

Relative measures are used: context, temporal, and group-specific. E.g. a certain group should have more access in certain situations. Context-matters, but this presents a challenge in policy planning.

Equity is not justice. Some studies conflate the two. Justice should not be mixed up with equity. More justice work is needed, e.g., Restorative justice – repairing harm is missing from the discussion

## Methods and data limitations

On the methodological side, more mixed methods are needed in transport equity research. Conceptualizations and standards are usually discussed from purely qualitative or quantitative approaches, a missed opportunity to combine the strengths of both approaches, whether by deep diving into some particular experiences or perceptions through qualitative methods or tailoring more meaningful quantitative analysis after qualitative explorations. For instance, Xie and Spinney (2018) finds through interviews and go-alongs with women cyclists that the standard Cycling Level of Service (CLS) tools used by engineers to plan cycling infrastructure misses the critical gendered perspective. Further, Somenahalli and Taylor (2007) surveys older adults to understand their mobility issues, revealing factors that are unseen in standard daily travel surveys.

Furthermore, this is plenty of disparity analysis, without engaging explicitly with equity conceptualizations. For example, within the mobility/accessibility dimension, metrics of accessibility (usually 15 to 60 minutes) are used to show differences among areas and groups but with scarce policy and practice implications of those results. Aiming at specific goals and standards tied to conceptualizations is the ideal case. When these analyses engage with metrics that may be tied to conceptualizations (like Gini coefficient or Theil index), they fall short in assessing if the result’s good or bad e.g., (Mijares, Suzuki, and Yai 2013). If a Gini coefficient of 0 means that all people have the same access to public transport stops, what does it mean a 0.2, 0.3, or 0.4? Is this good or bad news for decision-makers? Are new policies needed to reduce that number to a certain threshold, orienting future interventions? These questions usually remain unanswered despite its importance. These measurements can also bring some challenges and pitfalls, as recently summarized by Karner, Pereira, and Farber (2023).

What are the sources of data and what are the motivations for some categories? POI databases typically include education, health and aggregated categories for leisure and community. Within ‘community’ are organizations, government services, visiting friends/family – very broad, grandma’s house is not there, social networks rarely incorporated. Childcare, typically daycare or facilities – domestic work, mobilities of care, mobility interdependence, are unrepresented relative to the presence of work destinations. Transport systems’ focus is more than just to work or as a source of economic development, though in underdeveloped regions, transport systems as a force of economic development e.g., high-speed rail (Z. Chen and Haynes 2017; Monzon, Ortega, and Lopez 2013; H. Kim and Sultana 2015).

Data availability matters, especially when operationalizing emerging theories (i.e., sufficientariansm (van der Veen et al. 2020)):

* Leisure destinations (e.g., green space, parks, recreation) are less studied in this context.
* Some categories are missing all together – mobilities of care.
* Issue of data availability

## Evaluate interventions and policies

There is a need to evaluate more equity interventions or policies. In our review, only 19 out of 155 studies assess specific projects with an equity lens . Examples include mode-shift from driving to active school travel (Mammen et al. 2014), transit fare restructures (Hickey, Lu, and Reddy 2010) and spatial analysis of Low Traffic Neighborhoods (Aldred et al. 2021). This is a key step towards transport justice; assessing the effects of policies on different dimensions and populations groups and evaluating if a specific context is moving towards equitable standards over time.

## Links between standards and outcomes

A more robust assessment of the implications of equity standards on life outcomes is still pending. Estimating the benefits of increased mobility or accessibility, or reducing affordability burdens and transport externalities needs to be associated with outcomes like life and neighborhood satisfaction, subjective well-being, mental and physical health, social capital, among others.

# Concluding remarks

* TBD

# Appendix

The following are additional details.

#### The search strategy:

|  |
| --- |
| Figure 7: 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 7](#fig-A1) 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 7](#fig-A1) for the full list) and equity conceptualizations (e.g., “Justice” OR “equity” - see purple text in [Figure 7](#fig-A1) for the full list).
* **Context**: the included studies should also be limited to publications that include equity 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 7](#fig-A1) 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 equity standards and equity 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 7](#fig-A1) 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 as concepts contained within are frequently published in a more developed form in journals.

#### Example of the data extraction template:

A close-up of a document

Description automatically generated

|  |
| --- |
| Figure 8: The data extraction template with associated defintions. |
|  |

### Sample of select papers summarized by their, equity dimension, case study continent, conceptualizations and standards

| Dimension | Continent | Conceptualization | Standard |
| --- | --- | --- | --- |
| Equity dimension 1: **mobility and accessibilty** | (Rivas, Serebrisky, and Suárez-Alemán 2018) - 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 **transportation-related** **affordability**, especially for the most economically vulnerable (**vertical equity**). | **Population standards**: 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. |
| (Bharathy and D’Souza 2018) - 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. | **Infrastructure standard**: 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. |
| (Ryan and Pereira 2021) - 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). | **Population** and **Opportunity standards**. 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 public 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. |
| (Wismadi et al. 2014) - 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. | Opportunity standards: 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 |
| (Zheng and Geroliminis 2020) - 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. | Infrastructure standard: suggest that a toll-pricing scheme based on individuals travel value-of-time (lower income people have a lower VOT) is equitable. |
| Equity dimension 2: **environmental pollution** | (Carrier et al. 2014) - 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 | **Infrastructure standards**: 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) |
| (Jephcote and Chen 2013) - 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. | **Infrastructure standard**: 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. |
| Equity dimension 3: **health** | (Adlakha and Parra 2020) - 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 neighborhoods with low-walkability and socio-economic status (**vertical equity**). | **Population standards**: All people should get 150 min of moderate activity a week or 75 min of vigorous physical activity per week. |
| (Saving Mothers et al. 2019) - 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. | **Opportunity standard**: 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). |
| (Iungman et al. 2021) - 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**). | **Environmental+ standards**: 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 °C. |
| (Mehdizadeh, Mamdoohi, and Nordfjaern 2017) - 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. | **Opportunity** and **Population standards**: 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. |
| (Murphy et al. 2017) - 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**). | **Opportunity** and **Population standards**: 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. |
| Equity dimension 4: **transport-related safety** | (Ferenchak and Marshall 2019) - 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**. | **Infrastructure** and **Population standards**: 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). |
| (Zhe et al. 2008) - Asia (Tokyo, Takamatsu, and Tokushima | Evaluates the observed safety of shared use pedestrian and bicycle paths from the perspective of **well-being**. | **Infrastructure standard**: 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. |
| **Multi-equity dimensions** | (Alderton et al. 2019) - 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. | **Opportunity standards** are suggested: 1) Green space: % of residents living < 400 m from public open space, a large park (> 1.5ha), and/or local park, 2) Public 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 |
| (Berhe, Martinez, and Verplanke 2014) - Africa (Mekelle, Ethiopia) -**Mobility/ accessibility** and **health** | 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. | **Opportunity standards**: 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). |
| (Agost-Felip, Rua, and Kouidmi 2021) - Europe (Castellon, Spain) - **Mobility/ accessibility**, **safety**, and **health** | Conceptualizes equity through age-friendly urban spaces that reduce (and eliminate) conditions for **transportation-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. | **Opportunity standards**: 1) Access to facilities needed for old age health. Minimum distance thresholds from the geometric center of neighborhood 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 public 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. |
| (Mateo-Babiano 2016) - Asian (Manila, Philippine) - **Mobility/ accessibility** and **safety** | 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) | **Infrastructure**, **Opportunity**, and **Population standards**: percieved pedestrian perception on protection, ease, equitable access, mobility, identity, and enjoyment must be met. |

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