

Transportation Equity Quantification and Related Issues and Challenges

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Abstract

The main purpose of this article is to explore the different challenges that planners, engineers and policy makers face in quantifying transportation equity for design and implementation purposes. The first section—quantifying equity is a critical review of the most recent literature as well as some existing tools for quantifying transportation equity. The second part—implementing equity to design identifies several different methods that attempt to integrate equity in the planning and design processes. The third section—prioritizing alternate forms of transportation presents an overview of the challenges of vehicle ownership for many disadvantaged groups and how alternate forms of transportation may be able to help alleviate this problem. The fourth section—cost deterrents to driving discusses the advantages and disadvantages of congestion pricing and other cost deterrent methods. The fifth section—barriers to addressing equity presents some of the most challenging policy, planning, design and implementation issues for integrating equity into the transportation sector. Although much stride has been made in the last few years to address the important issue of social equity in transportation, more work and action are needed to make sure all people benefit equally from a safe, efficient and sustainable transportation system.

Keywords

Transportation Equity, Quantification, Alternate Transportation, Congestion Pricing, Auto-Centered, Environment

1. Introduction

The issues of transportation equity and environmental justice are broad subjects. Transportation equity has been simply defined as fairness in mobility and accessibility for all community members. This means accessible and affordable trans-

portation for everyone in the community resulting in fair distribution of transportation resources, benefits, costs, programs and services based upon differences in income, ability and other factors affecting transportation choice and impact. Most organizations strive to achieve transportation equity and environmental justice in one form or another (California Transportation Commission, 2021). But, there is no standard process for how this can be achieved. In this article, based on existing literature, the authors have attempted to present a few topics that point to the obstacles that agencies face for quantifying and implementing transportation equity and environmental justice. These topics include quantifying equity which describes topics of horizontal equity, vertical equity, and the way Metropolitan Planning Organizations (MPOs) quantify equity. Other topics covered include progressive and regressive policies for quantifying equity and the advantages and disadvantages associated with each. In the prioritizing alternate forms of transportation, nonmotorized forms of transportation including walking and bicycling and the importance of this particular mode, along with reliable mass transit system, especially for lower income neighborhoods who cannot afford a car are discussed. The cost deterrents to driving section of this article cover how congestion pricing has been implemented in many major urban areas and what the income generated by this method has been spent. The pros and cons of congestion pricing are discussed in this section. Many legal, policy, planning, design and policy issues surrounding transportation equity and environmental justice are discussed at the end of the article.

2. Transportation Equity

While equality is an even distribution of resources, equity is adjusting the level and types of resources so that different solutions are appropriate for different groups' needs and preferences. As such, for the first time, the United States Department of Transportation (USDOT) has centered Equity as a Department-wide strategic goal via its FY 2022-2026 Strategic Plan. This is an important step to institutionalizing equity across all policies and programs, with the aim of reducing inequities within the transportation systems and the communities.

The main objectives and strategies laid out in the USDOT Strategic Plan will help support and engage people and communities to promote safe, affordable, accessible, and multimodal access to opportunities and services (such as health, education, employment, and others) while reducing transportation-related disparities, adverse community impacts, and health effects. They will also help promote USDOT as a model of diversity, equity, inclusion, and accessibility.

But, integrating Equity into transportation systems planning and design has been challenging. Research is on-going and different opinions are expressed with regards to how best to implement transportation equity. The following sections present an overview of some of the latest research detailing such challenges.

2.1. Quantifying Equity

As it is, there are a wide variety of ways in which equity is quantified with regard to design. Horizontal equity refers to the concept of considering how the costs and benefits will be shared equally throughout communities based on usage. Vertical equity considers how systems affect users differently with regard to varying levels of income, disabilities, or other special needs. The disadvantaged have historically been left behind by transportation design and have suffered the consequences as a result. Various communities have been underserved as a whole as well which only makes these disadvantages within society starker. Exactly how to quantify equity though is much more complicated than it seems however as various groups have different priorities and disproportionate power to affect the change. In addition, many organizations lack the resources required to provide a detailed analysis of equity and are forced to use only existing public resources (Litman, 2022). Many powerful groups explicitly seek to discriminate against others and use design to further existing inequities but plans which seek to benefit everyone equally or even better serve the disadvantaged may also fall victim to implicit bias or the law of unintended consequences. Therefore, more effective ways of both identifying inequity and solving it are needed which can hopefully minimize this bias and implement a more equitable and successful solution.

Metropolitan Planning Organizations (MPOs) tend to break down equity by proximity to communities of concern, the benefits and burdens of a project, accessibility of projects, quantity of underserved people who will be served by a new project, and/or how integrated a community is into the process of designing a project. This analysis is often a points-based system using geographic and demographic data with points awarded by benefit or taken away in the event that they instead cause burdens. The community engagement access is more complex however and requires good faith input and listening on both sides, a consideration that project sponsors may be less than forthcoming about, and many organizations do not even consider. The extent, weight of, and exact variables used vary per MPO (Krapp et al., 2021).

Defining which groups are disadvantaged varies between organizations as more universal groups such as low-income populations and people of color are also sometimes supplemented by considerations of people with disabilities and elderly populations (Krapp et al., 2021; Ferenchak & Marshall, 2020; Loukaitou-Sideris & Wachs, 2018; Ogunniran & Happiness, 2019). One method for quantifying equity is by using a comparative city-based approach which can use a wide variety of cities to identify and model the extent to which various factors impact a system (Pareekh et al., 2017). Many of the models surveyed used some variation of this approach though always with different considerations and drawbacks.

While it is impossible for transportation engineers to change the political side of the equation, they can at least try to derive models which identify existing lo-

cations and areas of concern. One such proposed method is the Transit Economic Equity Index (TEEI). This particular method was developed specifically to use public data in an effort to make a practical and accessible analysis and a case study was conducted in six areas: Austin, Chicago, Houston, Lansing, New Orleans, and Seattle. Specifically, the National Historic Geographic Information System portal, Longitudinal Employer-Household Dynamics Workplace Area Characteristics data, and the Open Mobility Data portal for general transit provide specification (GTFS) feeds.

The equations developed by Lyons and Choi for Disadvantage Index and Transit Service Convenience Score choose only a few variables in order to keep the analysis simple, but as discussed elsewhere, simplifying the variables will inherently affect the usefulness (Lyons & Choi, 2021).

In addition, these were compared with calculated transit service convenience score, non-peak hour service score, and system access score to analyze the effectiveness of the existing systems in the test sites (Lyons & Choi, 2021). These methods both prove that certain existing transit systems demonstrate inequities as well as offer a path forward. The comparisons are able to identify weaknesses that could be rectified in a given system, such as Houston's in the example, while also identifying areas that could use more attention. The limits come to the fore however as the analysis is mostly focused on employment centers which do not represent the full picture of a city's infrastructure. As discussed below, access to other points by users is also a necessity for proper equity. The information is also limited by incomplete data for certain municipalities and the fact that reality is more complex than the demographic blocks chosen for modeling. The data is also blind to whether the transit is any good, just whether it is equitable between groups which pose a problem since disadvantaged communities are disproportionately affected by substandard traffic than advantaged groups which are better suited to choose alternate methods. Still, it is both useful going forward and important for indicating the intricacies and difficulties of implementing equity even with the best intentions.

The U.S. Environmental Protection Agency (EPA) maintains a tool that can help to calculate the Environmental Justice Index based on environmental indicators and demographic indexes (which is based on Person of Color and Low-Income Populations compared to national averages). This tool is able to quickly map areas and is used in project consideration to achieve greater equity in protection from environmental and health hazards (EPA, 2021, 2022a, 2022b, 2022c; DOJ, 2022). Like many other indexes, it is necessarily limited by the scope of considered variables in its attempt to simplify the issue, but it is still a valuable visual and data-oriented consideration.

Another method using GTFS data seeks to assess the gaps in a transit system. This method developed by Fan and Li could be effective in covering the issues of disadvantaged groups which do not visibly show up on demographic data. Traditionally, the analysis looks at the transit supply and dependency of each area,

calculating each using different variables. Where the supply falls short of the dependency is where a gap occurs and can be used over an area to measure the system's equity. This approach uses something similar with an emphasis on the ratio to better model the intricacies of an area and mapping in GIS to illustrate the distribution (Fan & Li, 2019).

One of the biggest strengths of GTFS data is its popularity as a standard in the industry which allows for a commonality between various applications and the efficiency in which it can be used. Its effectiveness is only increased when combined with other data sources such as demographic data. It is a complicated system that may be beyond the capabilities of many organizations and therefore, it is key to invest in developing broad use applications which can be more user-friendly for these organizations to use (Fan & Li, 2019). The Transit Gap Index offers some version of a streamlined approach to feeding in area-specific data to determine an actual model, but further steps could be done to make the process even simpler to allow it to be used in conjunction with other models. What is needed most is a nationwide system which minimizes the required input needed (especially since the accessibility of certain bits of data is scattershot depending on locale), effort time required, and required use knowledge, but such a system would require far more research, building, and better tools to obtain data for an area to be developed.

2.2. Implementing Equity to Design

While defining and identifying equity and gaps thereof is essential, such information is useless if it is not implemented into the design. As discussed elsewhere, agreeing to the definition of equity and how to implement it is a crucial first step and one of which there is no agreement on. Progressive policy refers to design that favors lower income people while regressive favor those with a higher income level (Litman, 2022).

McCullough and Erasmus identify the four key goals of equity as:

- 1) Redistribution of resources to the most under-invested and historically disinvested communities
- 2) Redistribution of decision-making power to the most under-invested and historically disinvested communities
- 3) Achieving parity in transportation access for the most under-invested and historically disinvested communities
- 4) Assertion of dignity for people's humanity as a core value (McCullough & Erasmus, 2021).

These goals would be an example of vertical equity and would help affect more systematic change than is currently in practice. While historically transportation has both affirmed and caused inequality, the societal causes are complex. Only so much can be done strictly from the transportation side and as a result, it is essential the field be integrated into wider measures and analyses (Krapp et al., 2021). Fields such as housing, environmental justice, and labor are all important

to understanding transportation equity and are interconnected. Flexibility in spending is both essential to solving issues in equity and something that is not a reality as funding is dictated from a top-down model. Money is also needed for more than just projects, but also the expertise to implement them (McCullough & Erasmus, 2021).

The Supreme Court decision in 1896 for *Plessy v. Ferguson* enabled the Jim Crow laws of a significant portion of the 1900s which both codified numerous racial discriminations, including and very notably in the transportation sector, and further imbalances that continue to this day. These were furthered by many of the big transportation projects of the past century including the Interstate Highway System which tore apart communities through the process of redlining (National Academies of Sciences, Engineering, and Medicine, 2021).

According to Title VI of the Civil Rights Act of 1964, changes in service which have a disparate impact on populations disadvantaged by race or equality are considered to be inequitable. As a result, any agency that serves a population greater than 200,000 people and receives federal funding is required to provide an analysis of this change on equity. These changes result from routes being eliminated, transit headways being substantially reduced, or a change in fare prices. This is specifically to prevent spending from flowing more heavily to groups that are already considered advantaged (Lyons & Choi, 2021). There is no requirement by the US Department of Transportation, however, to consider equity (Krapp et al., 2021). The American Disabilities Act of 1990 implemented new policies which seek to ensure more equitable access for disabled persons. These policies are being continuously updated and mandate very strict standards in cases of new construction (Coppola et al., 2021). These policy measures are imperfect but having them on the books is essential to ensuring they are implemented. It is also essential that they are considered from an early standpoint so that they are better integrated into the design and more effective.

2.3. Prioritizing Alternate Forms of Transportation

For much of the 20th century, the main priority with regards to transportation engineering was the automobile. Auto traffic was, and still is, the driver for decisions on how to invest money and whose needs were to be met first. The issue with such a decision is that car traffic is implicitly biased towards certain groups of people. The expenses of owning and being able to use a car are substantial and as a result, lower-income people may struggle to keep up with the costs or be unable to even afford one (Litman, 2022). Lower-income persons who can purchase a vehicle (or who are left with no other option) are usually forced into purchasing older, less reliable, and more expensive to maintain cars. As a whole, those with a lower income and people of color encounter higher vehicle prices, financing costs, and insurance (National Academies of Sciences, Engineering, and Medicine, 2021). Having multiple modes available is essential for those with different needs to ensure their mobility. In fact, if one mode disappears, many

would be stranded from being able to reach their essential destinations as they lack the financial or physical access to any alternatives. There is a direct link between access to transit, especially a car, and overall life outcomes including employment, education, and health care which only seek to reaffirm and create starker class contrasts (Palm et al., 2021; National Academies of Sciences, Engineering, and Medicine, 2021).

Therefore, our bias towards supporting the auto industry is also implicitly biased against the taxpayer and those who live in the community, even discounting the safety and health concerns raised by that specific mode (which were discussed earlier) and even more complex financial and societal impacts.

The pandemic offered a chance to see a modified form of transportation as people stayed home to a far greater extent and ridership was restricted in many areas by government decisions. The effect on transit was especially severe with ridership decreasing up to 85% and being slow to recover. These changes had a significant effect on mobility and individual cost for many of the users. The users who suffered the most were invariably people who were already disadvantaged (Palm et al., 2021). Various programs such as bike share, scooter share, open streets, and continued efforts toward Vision Zero (which seeks to eliminate traffic deaths and injuries) were implemented and/or accelerated to help combat some of these COVID-19-imposed difficulties, but their effectiveness in addressing equity is unclear (McCullough & Erasmus, 2021; Palm et al., 2021; Caspi et al., 2020). While these decisions serve a public good, they also show the criticality of public transit for serving these communities and the value that could be provided to those who did not have the option before.

One of the major difficulties in assessing the equability and extent of sidewalk infrastructure is a lack of data. Only a small number of cities offer a sufficient amount of data, and it can often be very difficult to both obtain and make usable. These standards also vary from locale to locale and make a standardized model more difficult to develop. Pedestrian level of service is historically subjective and therefore not as useful as concrete data in a thorough analysis (Coppola et al., 2021).

GIS software can be used to generate an existing sidewalk network, but to this point, the technology is still simplistic in this regard. Still, these strategies can be used to an extent to determine the extensiveness of existing systems and identify the gaps. It also offers the benefit of easy integration with demographic and city data in the program to better analyze the equability concerns. In Coppola's study area, 47.5% of road length has an available sidewalk, and of them, only 60.8% are at least four feet, 28.8% at least five feet, and 13.5% at least six feet (Coppola et al., 2021). This means that plenty of the sidewalks are insufficient to meet various recommendations and even more importantly, there exist major gaps in creating an adequate sidewalk system. While sidewalks are not required to allow for accessibility by walking, they (especially wider and better maintained sidewalks) provide both greater safety and greater encouragement for residents to use.

Encouraging walking is ideal from a cost perspective and health perspective as well as a financial perspective, but there are significant barriers in the way. Required travel distance and physical difficulties prevent certain users from using even the most walkable areas (Palm et al., 2021). The sprawling nature of the United States does walk mode no favors in many areas and is not a problem that can be built out of especially in rural areas. The research is conflicting on sidewalk availability with some saying that areas with a greater white population have more sidewalks while others find the reverse to be true (along with wider sidewalks) or even no trend at all. The data is especially hard to parse because it may point more to the characteristics of white neighborhoods being the main driving point and less because of any equability considerations. Other studies show that richer and whiter populations have far better maintained sidewalks. Despite these complexities, race is rarely even considered in sidewalk design. Cities with older buildings and younger residents tend toward greater sidewalk access, but none of these studies indicate whether correlation equals causation or if (and how much) walkability affects living choice (Coppola et al., 2021).

While bicycles afford reduced travel times and greater range in comparison to walking, they also have many of the same downsides as walking. Bikes have a much more limited range in comparison to mass transit and car traffic. It is also not an option for those without places to store their bikes whether out of lack of security or infrastructure, those with physical difficulties from disability to inability to carry groceries or children to varying degrees (Palm et al., 2021). In general, bike users tend to be white, male, younger, and well off, all groups which are served by regressive policies (Ursaki & Aultman-Hall, 2015).

Separated bike paths, intersection bike boxes, and other bicycle infrastructure has proven to increase bicycle use (Ursaki & Aultman-Hall, 2015). Support for these methods of infrastructure is growing as there exists more political pressure for design firms to consider them and the impact their developments will have on existing bicycle accessibility from the jump. This still varies from place to place, but the progress is encouraging.

One of the deterrents to bicycle use is access to one. As a result, one of the most popular ways currently to encourage bicycle use is through the use of bike-share services (Ursaki & Aultman-Hall, 2015). As indicated by the typical bike users, the prime beneficiaries of these services are environmental equity as underserved groups do not see the same benefits currently. Docking stations are placed less where they are needed due to health and income issues and more in areas that can maximize use and income. Providing financial assistance to low-income users, placing more docking stations in these areas, allowing for alternative payment options, and increased outreach are all options to combat these, but there is little indication that the companies responsible are doing this and are instead claiming funding issues. This can especially be an issue in circumstances where businesses are sponsoring the bike-share programs and have their own thoughts about placement that do not necessarily consider equity (Ursaki &

Aultman-Hall, 2015).

Users of mass transit tend to have low income, low car ownership, and younger age. In addition, those that are most reliant on transit, as seen during the current COVID-19 pandemic, are disproportionately people of color (National Academies of Sciences, Engineering, and Medicine, 2021). Increasing access to mass transit can allow for these groups to better access different jobs, participate in more activities, and maintain their needed social situations better and can eliminate the gap between those with and without cars with proper coverage (Zhang et al., 2020; Palm et al., 2021). It can also increase the overall income of those car-less in an area with proper mass transit. Lack of sufficient public transit acts as a major cause in the isolation of the poor (Fan & Li, 2019).

Maintaining this proper mass transit system can get expensive fast however when considering the case of an area that has low density or at off-peak times (Zhang et al., 2020). In addition, a thorough mass transit system will often be placed in more well-off areas or will increase the property values of the area as the neighborhood is gentrified, forcing out those that would benefit most from it (Palm et al., 2021). Ensuring affordable housing in these areas is essential to maximizing the equity gained from these situations or they will just serve as another way to drive the poor out of their homes (National Academies of Sciences, Engineering, and Medicine, 2021).

On-demand transit takes a cue from the modern rideshare economy by using technology to allow for online request systems and mobile ride-hailing. These use existing transit, but to a more affordable and efficient degree than the car-based rideshare services. The implementation of such a method in Belleville, Canada has seen mixed success, however. While there has been increased ridership in these transit services, there were also significant issues. Some of these, such as the inability to give riders accurate arrival information and better methods to add riders who are waiting at a stop but did not hail a stop could be improved with technology, but others such as riders booking stops that they then did not use or changing arrival times based on the additions of additional passengers may be harder to deal with. It is essential for these services to create a standard level of reliability to encourage people to continue using them. As it is, wait time is highly variable and in some cases significantly more so than a simple fixed bus route (Zhang et al., 2020). Sufficient vehicles and improvements in implementation will determine just how successful and how equitable to users any ride-hailing program is.

Another option to increase equity and encourage transit use is to provide transit passes to those who are receiving public assistance such as through various social services (National Academies of Sciences, Engineering, and Medicine, 2021). Other methods for encouraging and easing costs for transit use among lower-income persons are to adjust prices based on time of day and distance, smart cards which calculate more appropriate fares per person, and free feeder transit lines. Direct subsidies have been proven to be the most effective at bene-

fitting those who rely on transit, but these are not necessarily given to those who need it most. Only 34% of the largest transit agencies target low-income riders with direct subsidies, but there is a clear value to implementing such a program and especially tailoring it to the poorest of users as the effect is substantially more noticeable with them (Darling et al., 2021).

High-speed rail has never quite taken hold in the US the way it has in other countries, but it remains an option for mass transit. While these would offer a more environmentally efficient way of moving people, they also may be socially inequitable. Their higher fares appear to drive out many more traditional lower-income and disadvantaged users. This equity is of concern since the high-speed rail is both traditionally subsidized by the public and would be a major expense to bring to the US with minimal financial return. Public data on ridership however is hard to come by and analyzing the equity as Dobruszkes et al. did requires more lateral thinking. Usage is restricted more to business trips and the few high-speed rail areas that offer lower fare trips tend to skip the very areas that could use the service (Dobruszkes et al., 2022). At most, studies seem to advocate for the proven ineffective trickle-down economics in trying to justify the usage of high-speed rail which remains out of reach for most.

Perhaps the newest micromobility alternative is the dockless e-scooter. First brought to the US in 2017, they are rapidly expanding and increasingly popular, perhaps more so than bike-share programs in many areas (Caspi et al., 2020). For example, in Baltimore, there are currently four companies (Spin, Lime, Jump, and Link) that operate scooters in the city with prices around only \$1 plus \$.25 a minute (Streicher, 2021). Anecdotally, they are a fairly common sight speeding down sidewalks, through red lights and weaving randomly across roads. Still, they offer a more affordable (with discounts for low-income residents) alternative and are much quicker than walking (Streicher, 2021). Perhaps their biggest benefit is that, unlike bike-shares, they do not require docking stations, can be left wherever, require no physical effort, and require no special equipment. Also, unlike bike-shares, they are used less as a means of commuting and more as a recreational activity (Caspi et al., 2020).

Their flexibility in where they can be left allows them to serve the city without regard to the financial viability of an area or any other concerns that bike-share companies must contend with when deciding where to place their stands. As a result, their usage skews much less white. They also tend to see more use in areas with a bike lane or near bus stops, but there is no real correlation between e-scooters and bus usage. Equitability concerns come to the fold when considering how e-scooters are redistributed by the companies as there is no direct evidence, but there are certainly signs that they redeploy them in specific markets such as colleges or downtown (Caspi et al., 2020).

2.4. Cost Deterrents to Driving

Beyond encouraging the usage of and providing access to other forms of trans-

portation, cost deterrents can be deployed to discourage people from driving. These can tip the scales in a mode choice decision for drivers to the more equitable forms of transit. Congestion pricing is a system that has been instituted around the world, including in North American cities such as Vancouver, Seattle, and New York City. At its best, this system can reduce vehicle miles traveled, congestion, and greenhouse gas emissions while also increasing the amount of money that can be generated and put back into the system for maintaining and investing in new transportation improvements (Cohen D'Agostino et al., 2020), (Axsen & Wolinetz, 2020). That last issue is not always maintained (such as in Singapore and Gothenburg), but it is perhaps the most essential to maintaining equity for low-income users (Cohen D'Agostino et al., 2020). Transparency in spending this money is also key for inspiring confidence in toll structures (Weinreich, 2021). This system can very easily lead to inequities, however. While discounts for those using electric vehicles are encouraging from an environmental standpoint, those who can afford such vehicles tend to be well off. As a result, the people who can better afford to contribute to the system are forced to contribute less. These discounts and exemptions can reduce the effectiveness of the changes in reducing congestion and in generating income that could be reinvested and can lead to unintentional consequences such as encouraging more people to use more expensive and no less polluting rideshare services that may be exempt. Likewise, lower-income users can sometimes struggle to pay the fees without always having an option to take an alternative. Like other measures, CP pricing tends to raise the housing costs inside the city which can again price out low-income residents and force them to commute further and pay more in the very costs that drove them out (Cohen D'Agostino et al., 2020).

Implementing discounts for transit use and subsidizing bike-share and car-share (through the program) and allowing for exemptions for disabled users and off-peak hour usage can better benefit low-income users while maintaining the integrity of the system. Variable fees are more equitable as they target more frequent drivers who tend to be higher income and more. There also needs to be a consideration on where users are coming from as the system can be set up, such as in Gothenburg, where drivers coming from the direction of lower-income areas are forced to pay more on average (Cohen D'Agostino et al., 2020). These systems are also rarely popular with users regardless of efficacy which makes implementing them a struggle. Maintaining the system can be just as hard as changes in government can lead to changes in implementation and additional fights, while the pandemic led to mass changes in the systems (usually disabling them). It also allows for the process to become political and affect the amount of money going to more equitable measures instead of just benefiting the rich. Proper communication is needed as well as a trial period to build confidence in the system (Axsen & Wolinetz, 2020). In addition, the most effective or efficient systems tend to be the least equitable, but as of yet, there are not enough studies on CP pricing with regard to equity or reliability (Cohen D'Agostino et al., 2020),

(Fakhrmoosavi et al., 2021).

Vehicle Kilometers Traveled/Vehicle Miles Traveled (VKT/VMT), fuel, and carbon taxing can make for an even larger impact on greenhouse gas emissions than strictly congestion pricing. Fuel and carbon taxes increase the price per unit of fuel while VKT/VMT pricing charges per distance traveled. Besides being more effective, they are also easier to implement as they do not require any new infrastructure to be constructed. However, these are likely to be less popular among freight users as they are more negatively impacted. A combination of approaches however has the greatest reduction and can allow for more nuanced and equitable solutions while keeping the solutions and pricing simple tend to help with acceptance (Axsen & Wolinetz, 2020). Optimizing the price of each of the modes becomes more crucial to equity the more congested a road (Ortega et al., 2021).

Low traffic areas are an option that has gained new prominence due to the COVID-19 pandemic, but they have existed before primarily in Europe. These roads restrict or remove motor traffic from certain roads allowing for greater use by bikes, pedestrians, and or as usable space. These can be temporary (as in the case of many which were instituted in 2020 during the height of the pandemic) or more permanent fixtures. Like other solutions proposed here, they tend to more affluent regions, but other research indicates that these differences and any negative effects are minimally inequitable. A case study in London indicated that the areas implementing them at first were based less on equity than ease of install, but over time, more diverse neighborhoods started to adopt them in greater proportion (Aldred et al., 2021). This study can prove helpful for both proving that this can be an effective method for improving the health and safety benefits that come with limiting traffic in certain regions and that equity is possible with both a considered approach and continued applications over time.

2.5. Barriers to Addressing Equity

Now that we are learning new ways to identify and address equity, logic would dictate that this is a problem that can be fixed. Addressing equity is not as easy as that for many reasons, however. Many studies and proposed solutions are focused less on fixing historical issues and instead are focused more on ensuring that the issues do not get worse (Krapp et al., 2021). As currently practiced, equity is primarily a concern for individual projects and routes and is not considered for the system as a whole. In fact, considering the system as a whole is disadvantageous to planners as it only opens up a project to more questions about equity and requires much more effort (Lyons & Choi, 2021). State DOTs may be constrained based on how their funding is tied directly to certain types of infrastructure which prevents them from providing the most equitable solution (Krapp et al., 2021).

Determining the ideal mode choice of a population is incredibly difficult as the only effective way to determine the usage of alternative transportation modes

is to have an extensive system in place. It is only then that users can make their choices known (Pareekh et al., 2017). It can be hard to tell if, for example, bikes or transit are not being used because of insufficient facilities or because the population would rather drive. Since many of these transportation projects are huge investments and one project usually means that another project(s) is left behind due to limited funding, a seemingly equitable solution could prove ineffective, counterproductive, or a missed opportunity.

It is also difficult to get any group of people to agree with just how equity should look and how much it should be prioritized in comparison to other issues (Krapp et al., 2021). Equity lacks a clear and consensus definition which can make it difficult to identify tangible goals for a project. Even the acknowledgment of their being historical or present inequities is a controversial subject and one which features a shifting discourse in relation to ongoing events (McCullough & Erasmus, 2021). Addressing equity can also run up against legal complexities such as tribal governments and various interest groups (National Academies of Sciences, Engineering, and Medicine, 2021).

As private business takes over many mobility services, the opportunity by the government to implement equitable versions for the public good is undercut by businesses that only care about their share price and economic concerns (Ditmore & Miller, 2021). Various private companies such as Uber and Lyft have used legal loopholes in order to dodge responsibilities with accessibility which shows how equity is viewed as a burden by businesses in a capitalist economy (Wang et al., 2021). Their rise has coincided with a decrease in transit ridership (Steiner et al., 2021). Dealing with this is a concern as there is a large contingent who views private industry driving with minimal regulation to be the ideal. There have been efforts to use partnerships between transit agencies and these companies to reach disadvantaged groups and makeup budget shortfalls, but there are significant challenges to this and the very real concern that they are merely replacing cheaper forms of transit and driving them out (Steiner et al., 2021).

Equity can also be mutually exclusive in regard to the type of equity. For example, a program that seeks to promote the use of more environmentally sustainable vehicles and modes may instead succeed in giving additional benefits to already advantaged populations (Cohen D'Agostino et al., 2020). There are concerns that focus on accessibility may come at the expense of mobility (and vice versa) while even the current concept of accessibility is a very limited one (Krapp et al., 2021). As it is, so many of the equity considerations (such as car-sharing and bike-sharing) which may target reducing dependence on vehicle transport have proven to be inequitable when it comes to underserved groups (Ursaki & Aultman-Hall, 2015). Therefore, it is important to balance many forms of equity solutions in order to help combat our issues. There is no simple solution or singular focus that can fix equity issues. It is a difficult and complex process that needs continued support, research, and evaluation.

The ongoing pandemic has also further exposed both issues involving equity

and in implementing it now and going forward. During the early stages of the pandemic, public transit usage was decimated and those left using it tended towards the most disadvantaged who were unable to seek any alternatives. While encouraging the use of public transportation is a key to the implementation of equity, during a public health crisis it also puts these already disadvantaged groups at a greater risk of exposure (Palm et al., 2021).

Smaller organizations lack the staff and ability to properly assess what is an extremely complicated issue with wide-ranging implications. Certain variables can be subjective, particularly when reaching out to the community or for some of the more qualitative measures (Krapp et al., 2021). While better data is coming out all the time, it is also heavily reliant on data collection which requires sensitive handling of user privacy (Cohen D'Agostino et al., 2020). These privacy concerns are a major public issue and developing an adequate solution for these in an environmentally sustainable way is essential. As stated previously, modeling traffic and transit can be difficult as so many trips are not simple Point A to Point B or regular employment traffic. To properly analyze the mobility of a network, non-recurring traffic and complex origin-destinations need to be considered. This data can be difficult to accurately gauge and often requires community input and thorough consideration in order to minimize accessibility gaps.

While many organizations presently award a project point for geographic proximity to disadvantaged areas, they do not always consider the ability of these areas to use their new improvements (Krapp et al., 2021). Also, the points method does not fully reflect the complexities of different communities. Two communities may be historically underserved or disadvantaged, but they may be so in different ways depending on the nature of that community. Weighting needs to be more strongly considered by organizations, but again this allows subjectivity to creep in. In addition, not every group can be graphically charted in the way income and race often can with disabled people, in particular, is generally spaced out through all populations (Krapp et al., 2021). The existing points-based structure also makes equity more of a checklist instead of an integrated problem that needs to be solved. Outreach, especially when it is done from a token method cannot be the only effort made by a team in design (McCullough & Erasmus, 2021).

In general, the sense is given that equity may be a growing field of consideration and analysis, the issue remains academic in too many cases and has not made enough of an impact on actual analysis. In addition, the quantity of the equity analysis that is being written can be overwhelming to consider and makes the design process significantly more complicated because just how equitable a design is considered is a moving target. This “performative equity work” ties into the earlier point that equity in current efforts toward equity are not made towards fixing any issues in transportation (McCullough & Erasmus, 2021). Any changes must also deal with justified suspicions from underserved communities

which have decades and centuries of experience in dealing with discrimination, false promises, and tokenism. There is widespread racism in the power structures making these decisions which complicates the intentions of those that mean well. Certain groups are barely considered, such as Native Americans, if at all ([National Academies of Sciences, Engineering, and Medicine, 2021](#)).

In addition, the efforts of equity efforts will always be undermined by the efforts of the police who have their own idea of how to create “safety” and undercut efforts to improve equitable transportation for BIPOC communities in all forms of transportation. They and the communities who loudly or quietly support their efforts are an obstacle to be overcome in design as they will disproportionately target, incarcerate, and murder BIPOC citizens ([McCullough & Erasmus 2021](#); [National Academies of Sciences, Engineering, and Medicine, 2021](#)).

In the aftermath of the year 2020, where equity was pushed to the forefront of many Americans’ minds, many agencies have hired equity experts. These experts must also include those from marginalized groups whose voices provide valuable insight and are essential for achieving equity ([McCullough & Erasmus, 2021](#)). Anecdotally, agencies such as MDOT have engaged with studies that seek to analyze this issue and how to move forward, but many of these are early on and not necessarily run by anyone from said marginalized groups. Nor is there any clear indication of how such studies would be used practically in implementation to design.

During the pandemic, new efforts were implemented to benefit equity in terms of mode of transportation, but this was not always done with consideration of other forms of equity which were regarded merely as an impediment to the implementation of these alternatives ([McCullough & Erasmus, 2021](#)). Most of the current attempts to expand micromobility services that seek to provide greater equity and move away from car transit are applied inequitably to the low-income and BIPOC communities which need them the most ([National Academies of Sciences, Engineering, and Medicine, 2021](#)). These communities are left behind and technological gates, technologies that could theoretically help disabled persons but are too often left unconsidered, are put up which prevent many from using them ([Wang et al., 2021](#)). This can even be done by design as transit groups and services which are specifically targeting a higher-income clientele ([National Academies of Sciences, Engineering, and Medicine, 2021](#)).

The current model which regularly implements a policy and then tries to retroactively figure out why disadvantaged communities do not take advantage of these changes is counterproductive and only reaffirms inequities. The most effective policies are those which start out considering equity and carry it throughout the design. There is little evidence that reaching out to affected communities as part of the transportation planning process has made any impact on environmental equity or justice. It exists merely as a procedural process ([National Academies of Sciences, Engineering, and Medicine, 2021](#)). Despite the policies on the books relating to disabilities, governments and cities are consistently failing to meet these standards in various regards which have led to numerous court

cases (Wang et al., 2021).

3. Conclusions and Recommendations

While there currently exists much in the way of research, there is a lot that remains to be done. The authors have identified a number of gaps in the literature which could stand for more and continuing research in the area of transportation equity. Data such as that on the extensiveness of sidewalk coverage and impact studies such as the impact of demographic factors on said coverage are essential for identifying points of inequity and how to best solve them. Most importantly, however, is to develop a method for streamlining the equity determination process to allow organizations to have access to the fruits of all this research and apply it without excessive human resources, time, and/or knowledge base. Tools such as GTFS and GIS can be used to aggregate this information and to present it in a more user-friendly form, but that jump needs to be made. Equity research is important, but evidence points to it being more of a talking point than a thoughtfully considered action item.

There is so much more we can do to fight inequity, but it is a constant fight without an easy or proven effective solution or even a consensus on the topic. Many factors affecting the issue include age, income inequality, population density, and race, and it is our responsibility to ensure that each group is serviced to the best of our abilities and not left behind in favor of other groups. Equity affects us all from our ability to be healthy to our ability to live a positive life. The best we can do as engineers and planners are to advocate for it always and do our part to consider and research the topic before applying it to design.

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Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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