Scientific Research Publishing

Current Urban Studies, 2022, 10, 556-574
https://www.scirp.org/journal/cus
ISSN Online: 2328-4919
ISSN Print: 2328-4900

Review of Social Equity and Environment in Urban Transportation

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How to cite this paper: Faghri, A., Boyle, P., & Lee, D. (2022). Review of Social Equity and Environment in Urban Transportation. *Current Urban Studies, 10,* 556-574.
https://doi.org/10.4236/cus.2022.104033

Received: September 19, 2022
Accepted: November 12, 2022
Published: November 15, 2022

Abstract

The purpose of this article is to present an overview of the literature regarding the current state of knowledge and practice regarding social equity and environment in the realm of urban transportation. Consisting of two sections, section 1—Transportation and the Disadvantaged explains how age, disability, economic inequity, gender identity, population density, and race affect one's ability to have access and use the transportation system. The second section—Transportation and Environmental Health covers how smog and air pollution, greenhouse gases, noise and vibration, as well as safety and security in transportation affect the disadvantaged groups explained in section 1. It is concluded that the planners, designers, engineers and policy makers need to take the needs and concerns of all citizens into consideration before a project is started.

Keywords

Social Equity, Environmental Justice, Disadvantaged Groups, Transportation Environment, Health Equity

1. Introduction

For the most part, the transportation system as a whole has been planned and designed for healthy and financially capable individuals. Although there has been a movement towards achieving Transportation Equity (seeking fairness in mobility and accessibility to meet the needs of all community members), much work remains to be done. In the United Sates, it is the official policy of the U.S. Department of Transportation (U.S. DOT) and all its suborganizations including the Federal Highway Administration, Federal Transit Administration, Federal Aviation Administration, Federal Railroad Administration and others to promote transportation equity in the planning, design and implementation of their re-

spective transport mode. Much success has been achieved and the society as a whole is benefiting from the transportation system in the U.S. What this article attempts to accomplish is to identify the areas of concern for achieving a full equitable transportation system across the urban modes. As such, the first section—Transportation and the Disadvantaged identifies groups of individuals who are still struggling with daily mobility and accessibility in urban environments. The second section of the article—Transportation and Environmental Health identifies some of the most concerning and detrimental pollutants produced by the transportation system and how the disadvantaged groups in particular are affected by them.

2. Transportation and the Disadvantaged

For a long time, there have been individuals that are disadvantaged compared to others when it comes to life in general. Access to affordable transportation is a quality-of-life factor that can create a great hindrance in an individual's life by greatly limiting their mobility. This section of the article details six types of groups that are disadvantaged regarding transportation. Those types include age, disability, economic inequity, gender identity, population density, and race.

2.1. Age

Age is a significant factor regarding transportation equity because it is a design characteristic that is considered when transportation systems are designed, modeled, and created. The perception-reaction time of the mode operator (ex: driver, bicycler, pedestrian) is greatly affected by their age. Youth and the elderly are the two focus groups regarding age and transportation inequity. Youth are most often limited in life by their guardians. They are not able to play as major role in getting their transportation needs met as most older individuals. The level of trust that a guardian has in both the transportation system(s) available and in the ability of the youth to independently use the transportation system(s) is the main factors. There are various issues that influence the travel patterns of youth including guardians' perception of safety, guardians' level of trust in transportation system accuracy, independence levels of youth, and the youth's perception of the safety of the transportation system. Overall, youth are not being the primary control factor on how and when they get where they need or want to go. Guardians are under a lot of pressure when it comes to caring for youth, in that they are expected to work full time and raise, feed, transport, etc. their youth everything they need and want to be. This creates a lot of stress on families that do not have reliable, accessible, and affordable transportation systems available to them. This issue is similar to those faced by the elderly. The elderly are at a higher risk of both security and safety issues due to the higher presence of memory-related and physical mobility issues faced by them. The elderly also face issues regarding transportation due to their locations not being near as many places they would like to or need to go if they do not own and drive personal

cars for any reason. The personal automobile is the most common form of mobility for older adults, but (the fact) that the ability to drive decreases with age and is dependent on economic resources, limit older mobility. While it does offer an alternative to driving, public transit use presents a number of challenges for older adults. Differences in travel patterns exist between older men and women, low- and high-income older adults, and urban-dwelling versus rural-dwelling older adults. Low-income, older adults, especially older women, use cars less, use public transit more and are more commonly passengers than drivers when compared with higher-income younger adults (Wachs, 2022). Regarding the elderly, factors that influence and potentially limit their mobility and travel patterns include physical health, mental capacity and health, perceptions of the safety of transportation systems, availability of public transportation close to their residence, and the proximity of their residence locations to work, shopping, and social opportunities. Furthermore, limited mobility negatively affects social relationships among older adults by reducing their opportunities to socialize and often by forcing them to rely on others for assistance in order to reach important destinations. Studies find that social and recreational activities are among older adults' least common trip purposes. Aspects of the built environment may also encourage or impede older adult mobility. One such aspect is safety: older adults face greater vulnerability to accidents and crimes than the rest of the population (Wachs, 2022). There are other options for the elderly, such as paratransit, but, this is not always the most reliable. The fact that the elderly are also often on fixed or limited incomes furthers their disadvantage regarding transportation equity.

2.2. Disability

Unfortunately, adults with disabilities are more than twice as likely as those without disabilities to have inadequate transportation (31 percent vs. 13 percent). Of the nearly 2 million people with disabilities in the U.S. who never leave their homes, 560,000 never leave home because of transportation difficulties (AAPD, 2016). Four major factors that lead to these unfortunate statistics are fixed-route public transit, paratransit, private transportation accessibility, and necessary compliance assessments. Fixed route public transit is often seen as a positive aspect to individuals that are able to use it regularly. Though there have been many improvements since under the Americans with Disabilities Act (ADA), there are still many improvements to be made. Currently, many issues exist with ADA requirements not being followed, examples include the announcement of stops often being unreliable due to maintenance and routine testing problems on all transit modes, and problems with the maintenance of accessibility equipment such as lifts on buses. Regarding trains, the ADA only requires that key stations be made accessible for existing rail systems. Key stations include transfer rail stations, major interchange points, stations where passenger boardings exceed average boardings, and stations serving major activity centers. In cities that have

subways, commuter rails, or other systems built before the ADA took effect, including some large East Coast systems such as Boston and New York, there are few accessible stations. Requiring only key stations to be made accessible, rather than incrementally making all existing rail stations accessible, has led to gaps in accessibility. Furthermore, it is difficult to agree on a "key" station. Any station is key to those who use it. Major issues that seem simple with rail transit systems are the existence and maintenance of elevators to ensure they are in working order and can be used by those that need them at all times. Platform accessibility can be a major hindrance and deterrent for disabled individuals looking to use rail transit systems being those issues including overly wide gaps between the train and the platform can be problematic for those that use accessibility devices. Amtrak, a major rail transit provider in the U.S., was supposed to become 100% ADA compliant within the first 20 years of the ADA passing (by July 2010), and only about 20% of stations are currently compliant. A major contributor to this issue has been the continued underfunding of Amtrak by Congress over the last 20 years. Regarding Paratransit as a transportation method available to the disabled, specific problems include restrictive eligibility criteria; unfair trip denials; tardiness or failure to show; slow service en route; inefficient and unfriendly telephone reservation systems; inaccurate information; failure to respond to complaints; lack of training for drivers; drivers' lack of respect for users; and punitive cancellation policies. Paratransit service is crucial for those individuals who rely on it to get around. Failure of paratransit to show up or to provide effective service not only causes frustration but can also cause missed health appointments and employment problems for those who need to get to work (AAPD, 2016). Paratransit was initially to be used by those that could not take advantage of and fully access fixed use public transit. Due to factors like fear and security for disabled users of fixed use public transit, Paratransit has become a method used by choice and is not only used out of necessity. The presence in today's societies of the use of private taxi and ride-sharing services is not necessarily due to those transportation options being heavily utilized by the disabled. Private transportation is an important mode of transportation that should be made available to the disabled to help increase their access to the world around them. Services like Uber or private taxis offer greater flexibility and independence to those that are able to use them being that they are available on-demand, and one can schedule rides needed in advance for even more flexibility than in the past. Instead of private transportation services being more cost-effective and reliable services than paratransit when needed, they often pose an accessibility problem for disabled individuals that look to use them. Discrimination faced by disabled individuals is still heavily present, and the ADA only requires accessibility in van-style taxis, not sedan-style taxis, which are cheaper and much more popular, and easily found in most locations. There is still much work to be done regarding the discrimination faced by disabled individuals regarding private transportation accessibility for it to become a commonly available method of transportation.

Though many improvements have been made under the ADA, enforcement of the requirements remains a major issue due to the lack of policing agencies to ensure compliance. ADA enforcement has remained complaint-driven, and that places the weight of getting a compliance issue resolved on the disabled individual that is being discriminated against and/or is unable to use the facility in question for the issue at hand. In 1998, the Federal Transit Administration (FTA) began implementing assessments in areas that had concerns regarding ADA compliance. Regrettably, such assessments were recently halted.

2.3. Economic Inequity

In general, households should look to spend only 10% of their annual income on transportation, or 45% on transportation and housing combined (Litman, 2013). This goal is far from the actual amount that households currently spend on transportation. On average, low to moderate-income households spend 42% of their total annual income on transportation, which is over 4 times the recommended limit stated above. Factors that affect transportation affordability include travel demands, land use development patterns, accessibility vs. mobility, and transportation options and costs. Travel demands and land use development patterns go hand in hand. The two factors tend to be directly related to higher transportation costs in lower-income communities. This is often due to the spread of land use concentrations correlating with uses being closer and more accessible to "more desirable" areas that are often at higher income brackets. Regarding the planning-based differences between accessibility and mobility, it can be stated that: "mobility-based planning tends to evaluate transportation affordability based on the affordability of driving. Accessibility-based planning considers additional impacts and options when evaluating affordability and so expands the scope of strategies that can be used to improve affordability" (Litman, 2022a, 2022b). These two varying perspectives lead to different approaches to transportation planning and design, which greatly influence and impact transportation equity. The costs associated with transportation include much more than the personal car and gas one can purchase (if they are able to do so).

2.4. Gender Identity

When it comes to gender identity, it can often be a forgotten group of disadvantaged individuals regarding transportation. Factors that lead to the disadvantages faced by those with varying gender identities can include: the significant lack of representation and consideration within transportation planning, the failure to include more than the two most socially popular gender options on a driver's license, the failure of institutions to provide equal access and treatment to those that identify as having "not popularly accepted" gender identities, security issue regarding the use of transportation facilities for individuals of all genders. Studies still use sex, or the biological gender, to categorize people into male and female while investigating gender differences in travel behaviors and transport

access. This ignores that the lived experiences can affect one's gender identity internally and one's behaviors and persona externally. Importantly, the difference in gender identity may also lead to quite distinct travel experiences and subjective well-being outcomes.

2.5. Population Density

The varying types of populations and societies in the U.S. have different factors that create disadvantages regarding transportation equity. The three community types explored in this article are rural, suburban, and urban.

A significant lack of funding to rural communities means that public transit in general, let alone accessible transportation, is often in very short supply. At least 12 million individuals living in rural communities, or 41% of the rural population, live in counties with no public transportation (AAPD, 2016). The greater reach of rural communities' leaves individuals residing there with further distances to travel and fewer options and means of doing that greater amount of travel that is necessary. Minimal and often nonexistent public transit modes lead to an even greater level of disadvantage for individuals in rural areas. Suburban areas face similar issues to those in rural areas on a smaller scale. Locations are more spread out than in urban communities, and there is often a lack of public transit modes available for regular use. For the elderly and the disabled, services like Paratransit remaining reliable and consistent is a major downfall of available transportation options for those that rely on it. Though locations are typically located closer together in urban communities, the importance of accessibility regarding transportation modes is still very important. Safety and security are key factors for individuals that reside in urban areas, especially since those individuals often end up spending more on transportation, in general, than other communities.

2.6. Race

Race is a type of disadvantaged category that is often a topic of conversation, though real change does not often occur. On average, 20% of African American households live without a personal car. For Latinx households, that statistic is a bit lower at 14%, and Asian households account for 13% of households that live without a personal vehicle (BCP Organization, 2019). Almost all transit authorities have a statement on racial justice and/or equity on their websites, but, the problem of racial inequity in transportation in all areas/systems, still exists. The fact that those at the top are most often far from diverse themselves leaves out the representation of minority groups that face disadvantages on a daily basis. The California Transportation Commission's website states that "The California Transportation Commission recognizes that throughout California's history, improvements to the State's transportation system have disproportionately benefited some population groups and burdened others. The Commission condemns all forms of racism and is actively working to promote equitable out-

comes through our programs, policies, and practices." If transit and transportation authorities feel so strongly, there should be knowledge of how much more work is to be done.

3. Transportation and Environmental Health

This section focuses on transportation planning and design and its relationship with human and environmental health. The broader topics covered include the effect of critical pollutants produced by the transportation sector on disadvantaged groups, noise, vibration, and light pollution, and safety hazards caused by and not effectively or adequately addressed by the transportation sector. These subsections will concentrate on these human and environmental health challenges, specifically the impact on the disadvantaged community members described in the previous section of this article.

A comprehensive life cycle assessment of transportation infrastructure waste generation is outside of the scope of this article; however, a simplified version of the life cycle assessment will follow. This life cycle assessment comes from different references and covers different countries, including a case study of five transportation infrastructure projects from Bosnia, Pakistan, and China (Zhang et al., 2021).

3.1. Smog and Air Pollution

Smog and air pollution are a byproduct of the transportation sector from the planning stage to the end of life for most modes of transportation. The transportation modes of most interest in this segment are those bound to the roadway, such as cars, trucks, and motorcycles. Specifically, those that are tradition-gas-powered vehicles, as electrical-powered vehicles do not constitute a large enough portion of drivers using the roadways at this time and do not produce pollutants. Though the transportation sector is not the only contributor to smog, it is one of the most significant contributors. Smog conditions occur by increasing concentrations of CO, NO_x, SO_2, O_3, and fine particles in the atmosphere produced by emitting sources such as transportation. These pollutants are trapped in the lower atmosphere by inversion, where smog clouds form near the ground. This phenomenon means that these pollutants, which can have detrimental effects on human health, are contained within the layer of the atmosphere people breathe. Different types of smog are either created mainly through the burning of fossil fuels or the emission of fossil fuels, primarily from the transportation sector, starting a chain of events and reactions that create smog (Nemes et al., 2014).

Air pollution and smog can have significant effects on human health. Strong oxidants, such as ozone, can damage the lungs and irritate the lining, which, if the lungs sustain permanent damage, can cause increased stress on the heart. Several other health effects include decreased immune system function and increased fatigue. These effects disproportionately affect the disadvantaged, who

may have underlying health conditions that could worsen, such as lung or heart conditions, and may lack proper transportation to health facilities or financial support to protect themselves from the health effects of smog and air pollution. Air pollution affects human health even before becoming a problem such as smog. The emissions directly emitted by motor vehicles also have an impact on local populations. This form of air pollution is typically overlooked by policy-makers and, therefore, transportation planners, despite these pollutants being one of the major causes of larger-scale problems such as smog. This type of air pollution is a function of traffic densities and populous' proximity to roadways, approximately within 650 feet (200 meters) of a major arterial (Winer, 2008). In places of high population density, it is often difficult or impossible to be a safe distance from these major roadways. Therefore, residents of high population density areas bear a disproportionate amount of the transportation sector's air pollution than more rural areas. A California Department of Health Services study found that non-white children were three to four times more likely to live in areas with higher traffic density than white children (Winer, 2008). While multiple studies have exposed the correlation between the proximity of emissions from the transportation sector and minority communities, it is difficult to directly measure the disproportionate exposure to air pollution as air pollution monitoring technology is sparingly available or monitored in the United States. Less than 20% of counties have regulatory-grade devices to monitor small particulates. This lack of ability to appropriately monitor means many neighborhoods within a region lack appropriate representation of air pollutant concentrations. This representation problem has led to the Environmental Protection Agency (EPA) deeming areas are within the regulatory standards for air pollution concentrations despite some of these communities within the region experiencing pollution levels above the standards (Fowlie et al., 2020). Low-income neighborhoods are also predisposed to being close to major roadways and the air pollution inherent in such a position. Researchers at UCLA and others are conducting studies to quantify the health effects of proximity to traffic, specifically, if there is a correlation between those experiencing economic inequity in their search for affordable housing and locations of high traffic density. This correlation leads to disproportionate vehicular air pollution impacts on low-income populations. An initial review of the UCLA study discovers that, despite not necessarily benefiting from the major roadway within proximity, minority and high poverty neighborhoods experienced twice the traffic density as the rest of the southern California region (Winer, 2008). This study demonstrates the disproportionate burden of traffic air pollution caused by high traffic density on low-income communities. Children and the elderly are especially vulnerable to air pollution caused by the transportation sector. CO, for example, one of the pollutant components that can lead to smog, can cause congestive heart failure in the elderly and adverse birth effects such as low birth weight or premature births (Haryanto, 2008). The elderly can also show a decline in lung function

due to long-term exposure to traffic particulates. In general, air pollution and smog affect the respiratory system and, therefore, cardiovascular functions; both systems are developing or sensitive in children and the elderly, respectively (Inchaouh & Tahiri, 2017).

3.2. Greenhouse Gases (GHG)

Regardless of opinion on the cause of climate change, there is a consensus that it is occurring. Climate change correlates with an increase in greenhouse gas emissions, and one of the most significant contributors to greenhouse gases is transportation. Nearly 15% of global greenhouse gas emissions and more than 20% of energy-related CO_2 attribute to transportation (Alhindawi et al., 2020).

Some direct effects of climate change are changes in water quality and quantity in regions, decreased air quality and increased exposure to air pollution, ecosystem alterations and destruction, alteration of ocean ecosystems and temperature increase leading to an increase in toxins and decrease in food quality, and increase in extreme weather conditions. Diseases associated with climate change affect human health, including water-borne diseases, air-borne diseases, food-borne diseases, and vector-borne diseases, which transmit to humans from insects. Climate change has also shown evidence of increasing degradation of infrastructure and increased mental health problems in the human population. The following explanation of how climate change affects those who are disadvantaged due to their age is described by the United States Environmental Protection Agency (EPA). Both the elderly and children are at higher risk of the effects of increased greenhouse gases, of which the transportation sector largely contributes.

The elderly are especially vulnerable because of the added impact of the aging process, including muscle and bone loss and limited mobility. As temperatures increase, those sensitive to heat, such as the elderly, are more susceptible to congestive heart failure, chronic health conditions, other adverse health effects, and even death. The elderly are also strongly affected by extreme weather events, which will become more common due to increased greenhouse gases. Evidence demonstrates that the elderly make up a disproportionate number of fatalities in extreme weather conditions, particularly those related to flooding. During Hurricane Katrina, nearly half of the recorded fatalities were those over the age of 75 and, for Superstorm Sandy, almost half of all fatalities were over 65 years of age (Alhindawi et al., 2020). Extreme weather events also typically cause interruptions in transportation systems and make it challenging to transport elderly patients that struggle for transportation during normal weather conditions. This transportation issue makes getting the elderly to any medical attention they need or helping them evacuate far more complex. The elderly are also more prone to requiring electrical medical equipment or elevators, which can leave people without the electrical medical equipment they rely on in the event of a power outage during an extreme weather event and further exaggerates the transportation issue by making it difficult to get medical attention needed in a multistory

building if the elevators lose function.

An increase in temperatures leads to poorer air quality, longer seasons of aeroallergens, and increased intensity and frequency of wildfires. These events all contribute to increased pollution, dust, smoke, and the number of patients in hospitals, including the elderly. The elderly commonly suffer from respiratory conditions such as asthma and chronic obstructive pulmonary disorder (COPD), of which poor air quality exaggerates and can worsen the situation. Increased hospital visits can also lead to overcrowding and limit the availability of that resource to this vulnerable group.

An increase in temperature leads to a greater chance of vector-borne diseases because diseases carrying insects such as ticks and mosquitoes can expand their range and increase their seasons. Health effects such as Lyme disease, West Nile, and St. Louis encephalitis viruses can increase in elderly populations who already have a weakened immune system. Elderly populations are also at high risk of gastrointestinal illnesses, which can come from contaminated water. The occurrence of polluted waters will increase with climate change.

The EPA has found that children are also vulnerable to the effects of climate change due to several reasons. Firstly, children are especially at risk as they are going through the process of developing physically and mentally into adults. An example of this risk is that children develop their lungs fully during adolescence and are therefore more sensitive to respiratory ailments. As mentioned before in this report, climate change can prolong the pollen season and trigger asthma and allergies during this critical development stage.

Often neglected is the mental health aspect of climate change. As children are developing physically, they are also developing mentally and emotionally. The possibility of injuries or death during an extreme weather event or possibly if a loved one becomes ill prematurely due to contaminated water or other human health effects of climate change may evolve into depression or anxiety.

The EPA has established a summary of the specific impacts of climate change that would affect children at particular ages. The EPA found that newborns may have a high probability of being born premature or low birth weight when the birthing parent experiences higher temperatures, lower air quality, or contaminated water during pregnancy. Infants and toddlers cannot adequately regulate their body temperature and have more sensitive immune systems. These characteristics make them highly vulnerable to poor air quality, possibly causing asthma episodes, contaminated water or food, which can cause diarrhea, and heat-related illnesses.

Children also demonstrate different activity-based behaviors than most adults. Children commonly will spend more time outdoors and be further exposed to the effects of increased greenhouse gases than many adults. One example is that children, when swimming, typically swallow far more water than an adult does swimming. If the water is contaminated, the child is more likely to be diagnosed with a stomach or diarrheal illness.

More often than the elderly, children require a caregiver, but, similarly to the elderly, during, for example, an extreme weather event, children could become separated from their caregiver, or the caregiver may not be able to reach the child (EPA, 2021).

Those with disabilities are typically disproportionately impacted in terms of injury or death during extreme weather events. During Hurricane Katrina, for example, over 10% of the total deaths occurred in nursing homes where most had medical conditions and disabilities (EPA, 2021). Those with a disability may experience limited communication, cognitive function, or physical function. Therefore, people with disabilities may not react promptly to an evacuation or, given the transportation problem mentioned before, may not be able to evacuate at all. And, as mentioned with the elderly population, if someone with a disability requires electrical medical equipment, in the event of a power outage, which would become more common, the resident would be without the equipment they rely upon. The EPA provides another example from Hurricane Katrina where there was a lack of appropriate amount of wheelchair-accessible transportation, a lack of proper supply of needed medications, a lack of required medical equipment, and a lack of evacuation shelters that provided for the needs of those with disabilities.

The transportation sector in the United States accounts for most of the air pollution in urban areas (Welch, 2017). Electric cars do not generate these pollutants. More recently, there has been a push to introduce and popularize electric vehicles to reduce or eradicate the greenhouse gas pollution produced by transportation. Though there has been a success in incorporating electric vehicles, the affordability and versatility of electrified transportation are still not appropriate so that all communities can benefit from the pollution-free mode. Low-income citizens may not be able to afford a new electrical vehicle or not charge their car at home, and electric vehicles may not be as common to purchase as a used vehicle at the rate that traditional gas-powered cars are. The current route society seems to be taking to combat the harmful effects of greenhouse gases by changing out the gas-powered modes that produce them with electrical-powered counterparts will leave out a portion of society that is often more affected by those harmful effects in the first place.

Economic inequity disproportionately affects those with low income that cannot afford infrastructure that can sustain the effects of climate change or cannot afford the consequences of such developments. For example, low-income communities in California have inadequate water infrastructure. The current impacts of climate change have caused these communities to be disproportionately vulnerable to drought (Tuller, 2018). This deficient water infrastructure in low-income neighborhoods is likely familiar nationwide. As water becomes more contaminated due to increased greenhouse gas, those communities may experience more polluted water coming from the facet in wetter climates.

Another example is that those with limited income may struggle to afford air

conditioning or heat during extreme temperatures. An increase in greenhouse gases brings about more extreme temperatures and weather. Damage sustained by extreme climate events may not be possible to fix for those with lower incomes. Economic inequality increases with climate change; low-income communities will feel the effects of climate change sooner than others and will disproportionately suffer.

Population density affects the volume of greenhouse gases emitted by transportation. A denser population has the advantage of possibly reducing gas-emission vehicle usage by encouraging other modes such as walking or biking, such as in New York City. However, many cities similar to Los Angeles do not have a robust high-density city center and are more uniformly distributed (Porter et al., 2013). Greenhouse gases will be denser in these areas. In this case, the automobile is the preferred mode of transportation and results in more slow or idle traffic than a design like New York City intended to encourage little or no traffic. Slow or idle traffic will continue to produce greenhouse gases with no benefit of efficient travel.

On the other side of the spectrum, rural areas create more open space, resulting in residents traveling further to get to their destinations. Though it is less likely that greenhouse gases will become dense in rural areas because of the larger open space, they still introduce pollutants into the atmosphere.

For both high and low population densities, the impact of increased greenhouse gases on infrastructure is among the most noticeable. Though more apparent in high-density populations due to the spatial concentration of infrastructure systems, the interdependencies of these systems make a more significant impact when affected by greenhouse gases over time or instantaneously in the case of an extreme weather event. Though there are impacts from climate change on all types of infrastructure systems, this report will further examine the effects of climate change on transportation infrastructure. Impacts on transportation infrastructure by climate change are predominantly by more frequent maintenance, increased traffic congestion, required expansion of emergency transportation systems, and other economic costs associated with those who need a fully functional transportation network (Aroke et al., 2021). Though rural and urban communities will experience transportation infrastructure failures, high-density communities will experience a more significant economic loss due to the higher congestion of the infrastructure systems.

The transportation sector, as noted before, is one of the most significant contributors to greenhouse gas emissions and, therefore, climate change. Transportation planners need to acknowledge that over half of the major contributing countries to greenhouse gases are also the least vulnerable to the impacts of climate change (Althor et al., 2016). Despite being one of the top three contributors to emissions worldwide, the United States is not as vulnerable to the impacts of climate change (Crippa et al., 2021). This exporting of harm disproportionately affects countries that are not equally contributing to the problem. This article

will not argue the unacceptability of this situation given the complexity of defending and the near impossibility of finding a solution for countries polluting the planet's atmosphere that they all share. However, this situation should be, at a minimum, recognized in the transportation planning process as 29% of greenhouse gas emissions in 2019 were contributed by the transportation sector in the United States (EPA, 2021).

3.3. Noise, Vibration, and Light Pollution

Noise, vibration, and light pollution are all aspects associated with transportation networks. Noise pollution is considered an adverse or unwanted sound. In transportation, noise pollution generates from several or all modes. Some of the most recognizable may be airports, highways, and trains or railways. Some health effects provided by Environment Pollution and Climate change associated with noise pollution are cardiovascular disease, endocrine effects, cognitive disablement, sleep disturbance, and annoyance. For cardiovascular disease, the most common impact from noise pollution is hypertension. This impact is attributed mainly to vehicular noise only because there are limited studies for other modes of transportation, demonstrating a need for such research. Sleep disturbances can have long-term health impacts on individuals and can drastically affect their quality of life. Annoyance thresholds cannot be standardized and are different per person. Annoyance can have detrimental mental and physical health effects, impacting a person's quality of life (Ruggiero, 2016).

Vibration pollution is present in several modes of transportation, but commonly known sources of severe vibration are traffic-induced, such as proximity to highways, and railways. Reviewing innovations that society seems to be projecting towards, such as pollution-free electric cars, solve only some concerns with the transportation sector. Many new innovations do not relieve any vibration pollution from the transportation sector, or some innovations exaggerate the situation. Electric vehicles may be more environmentally friendly and silent but do not remove vibrations caused by the moving vehicle. Faster and higher capacity transit improves the economy but does not remove vibration caused by the rail system (Yoon & Pyo, 2019). Effects of vibration by transportation systems are often ignored or underwhelmed by other concerns such as noise pollution. This lack of knowledge is unacceptable as vibrations can compromise structural integrity and have adverse health effects. The oscillations caused by traffic-induced vibrations create added stress on structures leading to integrity and safety concerns, including nonessential damages, such as cracking (Agent & Deen, 1975). Health effects on humans are both physical and mental. Vibrations from transportation can physically cause involuntary motion as the body experiences oscillations that cause the vibration. Cognitive effects include changes in attitude, impacted work performance, and increased fatigue. Vibrations can also cause minor damages, such as material possessions in high places in a resident's home falling and breaking. Annoyance is also present typically with residents

that are exposed long-term to transportation-related vibrations. Annoyance can cause several health problems, as has been reported previously in this paper.

Light pollution is a result of artificial light at night. Light pollution impacts the natural cycles of surrounding organisms. The most prevalent impacts are hormonal and circadian or sleep-wake cycle disruption (Thonen et al., 2022). Light pollution from the transportation sector typically comes from equipment and devices such as streetlights or maintenance lights and related facilities such as ports or airports. Not only are there health impacts of light pollution on both humans and other organisms, but there are also cultural impacts, such as the limited visibility of stars typically observed in areas of high light pollution (Wyek, 2019). Like vibration pollution, light pollution has little research, especially the role of transportation infrastructure in its intensity. This lack of study should demonstrate the need for transportation planners to acknowledge the health and ecosystem effects of light pollution that projects will have on the surroundings.

There is a multitude of evidence that many transportation infrastructure projects in the past and present are adjacent to minority communities despite these communities often demonstrating their disapproval. The notion of a new highway is usually that it will improve a community because the network connects businesses and residents to faster travel routes. This concept was not the case in Nashville, Tennessee. Overton Park in Memphis, Tennessee, and the predominantly Black community in Nashville were planned for removal to pave the way for the Interstate Highway System. Despite both cases making it to court and receiving similar media coverage, the courts ruled in favor of the avoidance of the park; however, the road continued as planned through Nashville despite similar protests by the Black community (Mohl, 2014).

Inglewood, Los Angeles, is near the Los Angeles International Airport. Airports are a substantial source of noise and light pollution. The community consists of 46.4% Black, 46% Latino, 4% White, 2.5% other, and 1.1% Asian residents (Asemanfar et al., 2018). Inglewood is also a lower-income community as classified by the County of Los Angeles Department of Health Services. These low-income or minority communities not only experience health impacts from noise, vibration, and light pollution but economic ones as well. Aircraft noise pollution has consistently damaged residential property values (Aliyu et al., 2016).

3.4. Safety

Safety in transportation is a vast topic. Typically, the goal in transportation is to increase safety, such as with traffic signals or road signs. Safety in transportation would mean the built environment offers a limited risk of injury, danger, or damages to oneself or property. Considering the scope of the topic, the following will be local examples from the state of Delaware and the surrounding region of how transportation planners and designers have failed or exceeded in keeping disadvantaged groups safe.

The elderly and those with disabilities disproportionately lack access to proper transportation. These populations typically rely on public transit agencies for travel. Even if they are in proximity of public transit, non-driving groups require safe, complete streets. Complete streets provide equal support to all modes of transportation instead of typical street design, favoring automobiles.

Millsboro, Delaware, is a small town with a substantial and growing population of elderly. As the population of residents and elderly flourish, so do transportation safety concerns. The AAA Foundation of Traffic Safety found that seniors live seven to ten years over when safe to drive (Betz, 2021). The town of Millsboro addresses the growing elderly population in the drafted 2020 Comprehensive Plan (AECOM, 2020). The plan, if implemented, incorporates complete streets making access to other transportation services safer. The reason for this example is to show how the town of Millsboro initially failed its residents in the original transportation infrastructure as it disproportionately limited accessibility to the elderly. Due to an influx of elderly, the town of Millsboro has begun to implement proper transportation planning and equitable design.

Children too are highly susceptible to the dangers of transportation infrastructure. Children tend not to have a proper grasp of risk assessment and lack adequate motor skills to act safely in the presence of roadways or other transportation networks. Seeing as children are unique users of transportation given their curious nature and sometimes rebellious one, they are unpredictable. A good question for transportation planners to consider for equity's sake is what age range a transportation system needs to support. A survey conducted in Denver, Colorado, found parents were more willing to agree to their child biking on the street the older they were, age ranging from pre-kindergarten to 8th graders (Ferenchak & Marshall, 2020). In Millsboro's case, the town needed to focus more on the elderly, but children can be more difficult. The Colorado study found that parents were unwilling to agree to their child biking younger than 3rd grade and, therefore, too young to design for; however, planning for an 8th grader made be too old (Ferenchak & Marshall, 2020). Age should be a meaningful consideration when planning for future transportation systems. Delaware has consistently ranked as one of the top states in the nation for bike friendliness. The state continuously works to remain top rated in bike-friendly roadways by developing more secure connected networks that can benefit all Delawareans, including children, by creating the Blueprint for a Bicycle-Friendly Delaware, among other initiatives (DelDOT, 2018).

Those with disabilities can require public transportation or taxi/rideshare services to travel. Without safe and reliable transportation, those with disabilities will disproportionately lack equal access to employment, health care, or other public services. This lack of excess unreasonably diminishes and impacts an individual's quality of life and safety. Recently, there was a lawsuit filed against the City of Baltimore for inadequate curb ramps and sidewalks (Roads & Bridges, 2021). Without curb ramps, it is unsafe and can sometimes be impossible for

someone with a disability to use the transportation infrastructure or reach a public transportation system. Unkempt sideways pose dangers to those with disabilities who will have trouble crossing or may not be able to cross at all. In 2019, Baltimore found that only about 1.3% of the 37,806 curb ramps surveyed complied with Americans with Disabilities Act (ADA) standards (Roads & Bridges, 2021). The establishment of the ADA was in 1990, 31 years before this lawsuit claiming the city had and continues to fail to comply. Residents should not have to sue to receive equitable transportation designs. Transportation planners now follow ADA regulations, but existing infrastructure needs consideration in plans that currently do not meet ADA standards so that those with disabilities can use the roadways safely.

Gender identity appears to have grown in discussion in recent years regarding the transportation industry. With the introduction of rideshare apps and now semi-autonomous vehicles, there has been a push for carpooling. Carpooling reduces the number of cars on the road, reducing congestion and reducing pollutants related to vehicles. However, with the introduction of ridesharing apps, such as Uber and Lyft, there have been reports of drivers assaulting women passengers. An Uber driver received seven to twenty years in state prison in West Chester, Pennsylvania, for assaulting a woman passenger (Rellahan, 2021). As a result of the uptake in attacks, new apps have hit the market that provides women-only services. These new apps have, unfortunately, brought about controversy. As the companies only hire woman drivers, many have claimed employment discrimination based on sex. Uber and Lyft claim to provide safe rides yet attacks on women continue. There are disproportionate impacts on riders' safety for individuals who rely on this transportation mode depending on gender identity. More information on unnecessary effects on woman passengers for ridesharing is in the report by Cristina Medina (Medina, 2017).

4. Conclusion

Transportation, mobility and accessibility for the disadvantaged groups need to be identified and properly incorporated in the planning, design and implementation processes of the urban transportation system. This article identified six groups of disadvantaged individuals who may find the current state of urban transportation system challenging to use for their essential mobility and accessibility needs. The groups include the elderly, youth, disabled individuals, and those with economic inequity. The issues of gender identity, population density and race were also discussed as they relate to urban transportation. As such, the detrimental and harmful environmental impacts of transportation including smog and air pollution, greenhouse gasses, noise, vibration, light pollution, as well as safety and security were identified. The disproportionate impact of how these harmful environmental pollutants affect the disadvantaged groups was also presented in this paper. With the impending increase of automation and carpooling in the transportation system, transportation planners should consider other cul-

tural and systemic consequences. Discrimination based on skin, sexuality, gender, income, age, or disability occurs in transportation, intentionally or accidentally. Transportation planning and design need to account for all users to make a properly safe environment by improving past infrastructure that does not meet the users' needs or creating new and enhanced systems that show a sense of equity.

Acknowledgements

The authors express sincere gratitude to all professional members of the State of Delaware Department of Transportation who graciously assisted with the conducting of this project.

Conflicts of Interest

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

References

Agent, K., & Deen, R. (1975). *Relationships between Roadway Geometrics and Accidents*. Transportation Research Board, National Research Council.

Alhindawi, R., Nahleh, Y., Kumar, A., & Shiwakoti, N. (2020). Projection of Greenhouse Gas Emissions for the Road Transport Sector Based on Multivariate Regression and the Double Exponential Smoothing Model. *Sustainability, 12,* Article 9152. https://doi.org/10.3390/su12219152

Aliyu, A. et al. (2016). Influence of Aircraft Noise on Residential Property Values: Evidence from Current Literature. *Proceedings of the Academic Conference of Nightingale Publications & Research International on Sustainable Development, 2,* 1-20.

Althor, G., Watson, J., & Fuller, R. A. (2016). Global Mismatch between Greenhouse Gas Emissions and the Burden of Climate Change. *Scientific Reports, 6,* Article No. 20281. https://doi.org/10.1038/srep20281

American Association of People with Disabilities (AAPD) (2016). *Equity in Transportation for People with Disabilities*. The Leadership Conference Education Fund.

Architecture, Engineering, Construction, Operations and Management (AECOM) (2020). *Town of Millsboro, Delaware Comprehensive Plan*. The Truly Probusiness Profamily Town.

Aroke, O., Esmaeili, B., & Kim, S. C. (2021). Impact of Climate Change on Transportation Infrastructure: Comparing Perception Differences between the U.S. Public and the Department of Transportation Professionals. *Sustainability, 13,* Article 11927. https://doi.org/10.3390/su132111927

Asemanfar, K., Enriquez, C. et al. (2018). *Assessing Community Health in Inglewood* (pp. 1-59). University of California, Los Angeles (UCLA) Environmental Science Practicum.

Betz, M. (October 2021). *Dr. Marian Betz on How to Talk with an Older Adult about Stopping Driving*. National Institute of Health (NIH) News in Health, A Monthly Newsletter from the NIH, Part of the U.S. Department of Health and Human Services.

Brake the Cycle of Poverty Organization (BCP Organization) (May 2019). *Access to Affordable Transportation—Transportation Equity*.

Crippa, M., Guizzardi, D. et al. (2021). *GHG Emissions of All World Countries*. Joint Research Center (JRC) Science for Policy Report, European Commission.

DelDOT Bike Plan (April 2018). *Blueprint for a Bicycle-Friendly Delaware. A Statewide Policy Plan*. State of Delaware Department of Transportation.

EPA (2021). *Sources of Greenhouse Gas Emissions*. United States Environmental Protection Agency, Greenhouse Gas Emissions.

Ferenchak, N., & Marshall, W. (2020). Validation of Bicycle Level of Traffic Stress and Perceived Safety for Children. *Transportation Research Record: Journal of the Transportation Research Board, 2674,* 397-406. https://doi.org/10.1177/0361198120909833

Fowlie, M., Walker, R., & Wooley, D. (October 2020). *Climate Policy, Environmental Justice, and Local Air Pollution*. The Brookings Economic Studies Program.

Haryanto, B. (2008). Air Pollution Exposures from Transportation and Health Impacts in Jakarta. In *The Workshop: Near-Roadway and on-Road Exposures to Air Pollution: Risk Communication and Decision Making* (pp. 1-9). Asian Institute of Technology.

Inchaouh, M., & Tahiri, M. (2017). Air Pollution Due to Road Transportation in Morocco: Evolution and Impacts. *Journal of Multidisciplinary Engineering Science and Technology, 4,* 7547-7552.

Litman, T. (2013). *Transportation Affordability: Evaluation and Improvement Strategies*. Victoria Transport Policy Institute.

Litman, T. (2022a). *Evaluating Accessibility for Transport Planning. Measuring People's Ability to Reach Desired Services and Activities*. Victoria Transport Policy Institute.

Litman, T. (2022b). *Evaluating Transportation Equity. Guidance for Incorporating Distributional Impacts in Transport Planning*. Victoria Transport Policy Institute.

Medina, C. (2017). Women-Only Ridesharing in America: Rising Sexual Assault Rates Demand an Exception to Anti-Discrimination Laws. *Loyola of Los Angeles Law Review, 50,* Article 4.

Mohl, R. A. (2014). Citizen Activism and Freeway Revolts in Memphis and Nashville: The Road to Litigation. *Journal of Urban History, 40,* 870-893. https://doi.org/10.1177/0096144214533296

Nemes, A., Kovacs, H., & Palotas, A. B. (2014). Equipment for Diluting Air Pollution. In *Proceedings of the 2014 International Conference on Computer, Communications and Information Technology*. Atlantis Press. https://doi.org/10.2991/ccit-14.2014.77

Porter, C. D., Brown, A., Dunphy, R. T., & Vimmerstedt, L. (2013). *Effects of the Built Environment on Transportation: Energy Use, Greenhouse Gas Emissions, and Other Factors*. Transportation Energy Futures Series, United States Department of Energy (DOE). https://doi.org/10.2172/1069163

Rellahan, M. P. (August 25, 2021). *Uber Driver Sentenced for Raping Female Passenger*. Dailylocal.com.

Roads and Bridges (June 14, 2021). *Lawsuit Filed Against City of Baltimore Over Accessibility of Curb Ramps, Sidewalks*.

Ruggiero, A. (2016). Noise Pollution: What the Scientific Community Can Do? *Environmental Pollution and Climate Change, 1,* 1-2.

Thonen, J., Ripper, D., & Duke, E. (2022). *Artificial Light at Night: State of the Science* (pp. 1-18). International Dark-Sky Association.

Tuller, D. (2018). Confronting the Effects of Climate Change on Health in California. *Health Affairs, 37,* 1354-1357. https://doi.org/10.1377/hlthaff.2018.0942

Wachs, M. (August 2022). *Transportation for the Elderly: Changing Lifestyles, Changing*

Needs. University of California Press.

Welch, D. (2017). *Electrified Transportation for All: How Electrification Can Benefit Low-Income Communities*. Center for Energy and Climate Solutions.

Winer, A. (2008). *Air Quality in Southern California—Time for a Paradigm Shift*. University of California Los Angeles (UCLA), Institute of the Environment and Sustainability.

Wyek, S. (March 2019). *Light Pollution in Switzerland. An Analysis of Regions and Natural Habitats*. Swiss Federal Institute of Technology Zurich, Department of Environmental Systems Science.

Yoon, J. Y., & Pyo, S. (2019). A Review of the Mitigation Measures for Reducing Railway Rolling Noise from an Infrastructure Point of View. *International Journal of Railway, 12,* 1-9. https://doi.org/10.7782/IJR.2019.12.1.001

Zhang, J. et al. (2021). Environmental Life Cycle Impact Assessment of Transportation Infrastructure: A Multi-Case Study in International Perspective. *International Journal of Sustainable Transportation,* 1-12. https://doi.org/10.1080/15568318.2021.1959684