



Autonomous vehicle policies with equity implications: Patterns and gaps

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ABSTRACT

Autonomous vehicles (AVs) may improve or harm social equity for disadvantaged groups. Government agencies, planning organizations, businesses, and nonprofits have drafted or published an array of AV-related policies that have equity implications. Through a review of academic and grey literature, this study pioneers a comprehensive analysis of these policies in terms of patterns, frequencies and gaps. Our analysis shows that these policies can be grouped into three categories: access and inclusion, multimodal transportation, and community wellbeing. Regarding specific policies, considerations for a shared-use model and impacts to the economy dominate the policy landscape. Helping marginalized communities, urban parking, and automating transit are also prevalent policies. However, considerations for people with low incomes and people of color are not well represented, nor are personal security issues within shared vehicles, or models for deploying AVs in rural communities. Policy-makers are beginning to plan for the potential equity impacts of AVs, but more opportunities remain for developing policies that will ensure the most equitable outcomes. This study elucidates the different types of policies with equity implications and provides planners and policymakers a base from which to draft their own policy.

Introduction

Autonomous vehicles (AVs) have the potential to either foster a more equitable future for disadvantaged groups by increasing overall transportation access or exacerbate existing gaps by creating a transportation network that is accessible only to the privileged few. These two outcomes have been referred to as the “AV heaven” and “AV hell” scenarios, respectively (Creger et al., 2019). While some might maintain that we are on the road to “AV hell,” there is still time to change course towards an “AV heaven” where AV policies improve transportation equity and help prevent the disastrous climate effects of increased Vehicle Miles Travelled (VMT) and suburban sprawl (Chase, 2014; Creger et al., 2019; Eggert, 2019).

This research aims to identify enacted, drafted or suggested AV policies with equity implications in the U.S. and any opportunities for equity that remain in existing policy. Internationally, government agencies and researchers are considering how AVs will impact social equity and deployment methods to capitalize on equity benefits. Certainly, the social, political and geographical contexts between the U.S. and other AV “hotspot” regions such as the European Union, the United Kingdom, Japan, China, Singapore, and Australia have significant differences. This is especially true regarding land use patterns,

availability and quality of transit, and typical family unit structure, all of which have implications for current and future transportation systems. However, there are some lessons to be learned from the international perspective, especially as many U.S. agencies seek to enhance multimodal transportation options and build denser cities that more closely resemble urban areas in parts of Europe, Asia, and beyond, today. The existence of international policy and policy analysis regarding AVs and social equity, explored later in this section, serves to underscore the importance of conducting a similar analysis of policy in the U.S.

In this paper, we broadly define “policy” to include not only enacted policies and regulations but also strategies, recommended courses of action and guiding principles. This is due in large part to the lack of enacted regulations and plans regarding AVs and equity in the U.S. Most of the literature and existing policies on AVs consider, assume or recommend a shared or “Mobility as a Service” model for AVs over the private ownership model that dominates car travel today (Chatman and Moran, 2019; Eppenberger and Richter, 2021; Fraedrich et al., 2015). Therefore, most AV policies discussed in this article address or promote a shared model of AVs. As we will see, the shared model is held as one of the most important equity policies for AVs by many agencies. It is worth mentioning that shared systems are not always equitable in practice, as noted by Clark and Curl (2016).

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A view into international policy development regarding AVs and equity will provide context for the state of AV policy with equity implications in the U.S. The French government has developed its own strategy for AVs, some of which has direct implications for equity including an emphasis on AVs functioning as a supplement to a multi-modal transport system and some considerations for impacts to the workforce (Republique Francaise, 2018). Similarly, the Automated and Connected Vehicles Policy Framework for Canada describes applications of automation for transit, as a potential first/last-mile solution, and the importance of preparation for workforce changes (PPSC Working Group on Automated and Connected Vehicles, 2019). The City of London, which has a number of AV trials underway, aims to leverage AV technology to complement transit and active transportation in support of its Healthy Streets and Vision Zero initiatives (Transport for London, 2019). A thorough analysis of AV policy development in Singapore notes that workforce impacts to locals may be less of a concern than elsewhere as Singapore relies heavily on contracting foreign workers as bus operators (Tan and Taeihagh, 2021). Pettigrew (2017) notes that the potential for AVs to reduce the increased risk of mortality associated with isolation for seniors aligns with the Australian Productivity Commission's stance on mitigating the negative social effects of the aging population.

In the U.S., scholars have begun exploring the connection between AV policy and equity outcomes in the abstract, but there is little research on the existence of drafted or enacted policy. While we recognize that it may be impossible to catch every policy, especially those that have only been drafted or suggested, our findings should nevertheless provide further insight into a topic that has not been thoroughly explored in the literature. Furthermore, this paper will serve as a guide for policymakers to draft their own AV policy.

Much of the literature stresses the importance of policymakers acting now to shape equitable outcomes and avoid the consequences of a "free market" approach to AV regulation; this is the main argument of the "heaven" and "hell" framework. Researchers are concerned that, if the social equity aspects of AV impacts are left unregulated, underserved demographics will suffer through decreased access to transportation, loss of employment opportunities, climate impacts, and more (Creger et al., 2019; Wu et al., 2021). However, AV policy has the power not only to prevent harm, but to provide benefits to disadvantaged populations. Cohen & Shirazi (2017) identified three groups for whom AV policy with equity implications could provide significant benefits: people with low incomes, the mobility challenged, and other historically disadvantaged groups. However, the impacts of existing policy and legislation, to these groups and others, is unclear. Milakis et al. (2017) organized the impacts of AVs by first order (including travel cost and choices), second order (such as land use and ownership models), and third order (including energy, economy and equity concerns). They found that while some first order benefits of AVs can be quantified, the benefits of third order impacts (such as equity) are as of yet uncertain.

Some researchers offer policy suggestions for equitable outcomes with AVs. Fleming (2018) discussed policies that specifically target low-income groups, such as adopting Shaheen et al's (2017) policy recommendations that consider Spatial, Temporal, Economic, Physiological, and Social (STEPS) barriers to accessible mobility for increasing equitable transit access, which could be adapted to shared AVs. She also emphasized the importance of expanding transit and active transportation infrastructure and services to ensure that AVs do not overtake these inexpensive and accessible modes. Fleming urged planners to implement these policies before AVs are widely deployed to provide optimal outcomes.

Other practice-oriented research engages practitioners or civilians and studies policy plans. Paddeu et al. (2020) used a participatory design process to gauge the acceptability of local shared AVs, finding that social equity - particularly in-vehicle intrapersonal security, affordability and safety - is a critical factor for participants. A focus group on AV impacts to transit with practicing planners in the Twin

Cities found that equity was a "peripheral topic" for participants despite emphasis from the researchers (Wu et al., 2020). A content analysis of 20 Regional Transportation Plans found that a strong majority planned for equity beyond environmental justice requirements, but only a minority applied this equity lens to emerging transportation technologies such as automation (Kuzio, 2019). In response to the works above, which point out the need and opportunity for bringing an equity perspective to AV policy, several planning organizations, businesses, and nonprofits have begun to publish recommendations based on their particular areas of expertise. Some state and regional government agencies have implemented AV policies that address social equity concerns. A larger cohort of agencies acknowledge potential equity outcomes of AVs without shaping them in their own policy. Therefore, while scholars have analyzed the potential equity impacts of AVs and shared vehicles, and some consideration has been given to policy with equity implications internationally and for a limited range of U.S. agency types, a focused and thorough dive into the existence, trends, and gaps of such policy in the U.S. could help bring the results of these works to the attention of policy makers and planners.

Discovering policy through keyword search

This research emphasizes equity-related AV policies that were enacted, drafted, or suggested by government agencies, planning organizations, businesses, and nonprofits. The policies are mostly presented in the grey literature, which is produced outside of traditional academic publishing and distribution channels but rather by organizations for internal use or for distribution to the public. As such, academic databases were not the most appropriate venue for this literature review as is typical for a review of research literature. Therefore, this study consisted of two literature reviews and an analysis of the results of those reviews. The first literature review was of academic papers related to the research topic, the results of which are described in the previous section. The second literature review and the bulk of the research involved a review of the grey literature - policies, reports, guidelines, playbooks, white papers, articles and more. We developed a list of keywords and used a search engine network to find policy with these keywords. This research method reflects how these documents might be accessed by the public for whom they are typically intended.

We used Google to search for AV policy documents with equity implications published by non-government organizations such as planning associations, non-profit organizations, and for-profit businesses, or drafted or enacted by government. We defined policies with equity implications as those that intend to create equitable outcomes for specific disadvantaged groups (Access & Inclusion), bolster access to non-private automobile transportation (Multimodal Transportation), and have second-order equity effects (Community Wellbeing). The reasoning behind this definition will be described in the next section.

We searched for planning organization policy by identifying key American planning organizations, and using the keywords "autonomous," "vehicle," "[name of planning organization]". We searched for state policy using the following keywords: "autonomous," "vehicle," "[state name]". If this search yielded no apparent results, we added the keyword "policy." If, again, this yielded few or no useful results we added the keyword "equity." This process was repeated for all 50 U.S. states and Washington, D.C. For local policy, we searched for policy in the top 30 largest U.S. metropolitan areas, using the keywords "autonomous," "vehicle," "[principal city of metropolitan area]". We also searched for policy in metropolitan areas known to have an association with AV technology, such as Columbus, OH (winner of the 2015 Smart City Challenge) and Tempe, AZ (one of the earliest test sites for AVs in the U.S.). Searching for policy suggestions from businesses and nonprofits required a working list of concepts within AV policy, which were then used as keywords in the search. For example, we used the keywords "autonomous," "vehicle," and then a concept such as "transit," "parking," "women," or "rural." These searches often yielded reports or

articles from nonprofits and for-profit businesses, and occasionally policy from government organizations as well.

Once we found a policy document that contained at least one policy with equity implications, we searched for other policies with equity implications within the document. It is worth noting that of the more than 100 documents surveyed, many included dozens or hundreds of pages that were not relevant to our research topic. Therefore, only relevant sections were identified and thoroughly reviewed. Instances of policies with equity implications were recorded in a word processing document. In the case of the states, we recorded if we did not find any policy with equity implications.

Due to the emerging nature of this topic and the wide variety of actors, we likely did not find and record every existing policy with equity implications. Not every agency that has drafted or enacted such a policy has published it publicly online or made it easily searchable. Therefore, we do not claim our findings to be exhaustive. However, our preliminary research did uncover many detailed AV policies with equity implications, and together these build a robust picture of the equity landscape of AV policy within the U.S. and establish a foundation for a more comprehensive analysis in future studies. We will explore and analyze these policies in the following sections.

Classifying policy by category

Once we had examined policy documents from planning organizations and states, patterns began to emerge. We grouped the policies into three categories, each of which has three subdivisions (see Table 1). All social equity policies, by definition, have the intent of improving welfare for disadvantaged groups, whether or not this is explicitly stated. In a few cases, policies may appear to help some groups while causing harm to others, or help a group in one way but possibly harm them in a different way. In AV policy, this “harm” typically takes the form of additional individual financial cost, for example, pricing vehicle use to account for negative externalities such as pollution.

Access & Inclusion

Access & Inclusion policies are those whose specific intent is to help or mitigate harm to communities that have been historically underserved by transportation infrastructure and services, such as low-income people, racial minorities, immigrants, women, people with disabilities, seniors, teenagers, and rural residents (Wu et al., 2021). AV policies that consider such groups most often target people with disabilities and the elderly, people with low incomes, and occasionally people living in rural communities. These policies often have the effect of helping other underserved populations as well, such as women, children and teenagers, racial minorities and immigrants. These latter groups, despite historically lacking transportation access, do not have designated categories in this section because policies that target them specifically are rare or nonexistent. The groups we discuss are frequently and explicitly targeted in AV policy.

People with disabilities and seniors (who suffer age-related disabilities) will be some of the greatest beneficiaries from fully automated vehicles as their access to transportation is lower than the general

population. Certain types of disabilities, such as visual, auditory, cognitive and some ambulatory disabilities, may prevent people from driving an automobile. These disabilities may also make it difficult to use transit, ride a bicycle, or walk to a destination. Claypool et al. (2017) cite data from the Bureau of Transportation Statistics to demonstrate that “persons without disabilities utilize all forms of transportation modes more than persons with disabilities, with the exception of taxicabs and motorized personal transportation.” If AVs are designed to accommodate various disabilities, they will be a key factor in helping reduce the access gap between people with disabilities and those without.

Some AV policies intended to benefit people with disabilities concern the physical design of vehicles and how this design functions within the larger AV landscape. This is true in Seattle, whose policy “require[s] a percentage of shared automated vehicle fleet vehicles to be ADA-compliant to meet the needs of people with disabilities” (Seattle Department of Transportation, 2017). In other cases, policy intends to create additional accommodations for mobility difficulties. The National Association of City Transportation Officials (NACTO) advocates for congestion pricing within urban areas as a means to foster equity in the age of AVs. Since this approach may not be intrinsically equitable (Sparrow and Howard, 2020), NACTO suggests that “policymakers ... provide selective discount programs or exemptions” on cordon pricing, citing the example of London, UK, where “disabled drivers entering the cordoned zone pay only 10 percent of the total fee” (National Association of City Transportation Officials, 2019).

People earning low or no incomes may see increased transportation access from AVs as a result of deliberate planning that accounts for their needs and demographics. Without such planning, however, low-income people may see less transportation access through increased cost of automobile usage and diminished transit, pedestrian and cycling infrastructure. This dichotomy is one of the key issues posed by the “Heaven or Hell” framework. People with low incomes have lower access to automobiles due to the significant cost associated with purchasing and operating a car. While they may have access to other modes such as transit and cycling, it can take much longer to reach a given destination using these modes, if the destination is accessible at all (Owen and Murphy, 2018). Low-income households that do own automobiles spend a disproportionate amount of their income on transportation expenses, often to the point of being cost-burdened.

Automating vehicles will not eliminate financial barriers to access, but many social equity policies for AVs aim to reduce individual AV costs (such as sharing policies that distribute costs over multiple passengers) or increase the accessibility and quality of inexpensive, non-car modes such as buses and walking. If these types of policies are applied, low-income households (particularly those with no vehicle access) should see great improvements in transportation accessibility without suffering commensurate increases in cost. One imperative consideration is, as suggested by Transpogroup (2018), to “provide multiple ways for accessing AV services, including subscriptions, cell phones, [and] cash.” The Minnesota Department of Transportation (MnDOT) (2019) and Mid-America Regional Council (2018) also have considerations for the unbanked in their AV policy development. The Delaware Department of Transportation notes that if AVs are more fuel-efficient than non-automated vehicles, the regressive gasoline tax would effectively force non-AV users to subsidize AV users, despite the former group traveling fewer vehicle miles (Barnes and Turkel, 2017). Policies that implement usage-based fees may help prevent lower income groups from subsidizing higher income AV owners.

People living in rural communities face distinct transportation challenges that may be ameliorated by the introduction of AVs. In rural areas, destinations are often not within comfortable walking or biking distance. Transit is inaccessible, infrequent or non-existent. Therefore, rural residents must have access to a vehicle to reach employment, retail, and social gatherings. Those without vehicle access or the ability to drive - including children, teenagers and seniors - have very little

Table 1
AV Equity Policy Classification.

Access & Inclusion	People with disabilities & seniors Low-income people Rural communities
Multimodal Transportation	Shared Transit Active transportation
Community Wellbeing	Safety & security Job loss impact mitigation Sustainability & land use

mobility whatsoever. However, despite the apparent necessity of having a car in a rural community relative to urban areas, travelling in that car is also more dangerous: accidents are more deadly on rural roads (National Highway Traffic Safety Administration, 2020). Since many crashes in rural areas can be attributed to driver behavior such as speeding or alcohol use, AVs could address these types of crashes.

While AVs can expand transportation access and make traveling by car safer for people living in rural areas, governing agencies will need to make significant investments in their communities to realize these benefits. Several agencies, including the Florida Metropolitan Planning Organization (Smith et al., 2018) and Washington State Department of Transportation (2018), have policies encouraging agencies to implement automated shuttles within rural areas.

Multimodal transportation

Multimodal Transportation policies are those that bolster and expand access to non-private AV means of transportation. These include transit, active transportation modes such as walking and cycling, and shared AVs. These policies are considered equity policies because most underserved groups are disproportionately more likely to use non-car transportation modes. For example, more than 20% of households earning less than \$20,000 per year in the U.S. do not own a vehicle. In zero-car households, transit is used for almost a quarter of trips, and almost 45% of trips are non-motorized (Renne and Bennett, 2014). People experiencing poverty use transit at about three times the rate of people with higher incomes, and make twice as many walking and biking trips (Federal Highway Administration, 2014). Therefore, these policies create more equitable access and outcomes for these groups.

One possible consequence of AVs is that government officials divert funds from transit and active transportation projects and funnel them into AVs and their infrastructure. This could cause transit service to drop precipitously and sidewalks and bike lanes to crumble. Those who rely on these modes would be left stranded while advantaged groups see greater mobility with AVs, widening the transportation access gap. Already, transit projects in Columbus, OH and Pinellas County, FL have been denied funding with the reasoning that transit would be obsolete once AVs dominate transportation (Barnes and Turkel, 2017). By contrast, some agencies reorient their priorities to protect and provide options for vulnerable road users. Seattle writes that “our streets should prioritize access for people, amplifying the role and value of walking, biking, and transit in Seattle” (Seattle Department of Transportation, 2017). This hierarchy reverses the trend of prioritizing private automobile access and use above all else in the U.S. In Europe, discourse on AV technology is much more likely to center on its application for transit than smaller vehicles (Azad et al., 2019).

Some policies promote the use of shared AVs over privately owned or operated AVs. As we will demonstrate in the following section, these policies are the most commonly discussed among policy documents and often stated as the most important piece of policy in an individual document. They tend to be guiding principles for AV policy strategy rather than specific regulations. The lines between these and policies that apply automation to transit tend to blur, especially with regards to automated shuttles or “microtransit.” Promoting shared AV trips - even trips that are shared among a handful of individuals - may be the key to providing users the most flexibility while minimizing the congestion and resource-intensive use wrought by single-occupancy vehicles. The American Planning Association views shared vehicles as so essential that it identifies the promotion of shared-use AVs as its overarching, “Key Planning Principle” in its AV policy guide (American Planning Association, 2018). A significant number of local and state governments have adopted this principle in their planning, including, but not limited to, Hawaii (Ulupono Initiative, 2020), Minnesota (Minnesota Department of Transportation Office of Connected and Automated Vehicles, 2019), Washington (Washington State Department of Transportation, 2018), and Kansas City (Mid-America Regional Council, 2018).

Policies that support transit in the context of AVs revolve around securing funding for transit, applying automation to transit, or building out transit infrastructure. NACTO takes a strong stance on transit and automation by urging policymakers to improve transit *now* in preparation for AVs. Among its recommendations are to “Redesign Bus Networks for Improved Travel Time and Reliability,” “Ensure Fleet Vehicles and Station Infrastructure is Wired for Technology,” and “Streamline Payment and Transfers” (National Association of City Transportation Officials, 2019). The Association of Bay Area Governments (Metropolitan Transportation Commission Association of Bay Area Governments, 2018) may follow this lead; the Californian agency lists “double down on high-capacity bus and rail corridors” as well as “innovate suburban transit with autonomous, on-demand microtransit” as priorities. The Los Angeles Department of Transportation plans to apply automation technologies to its entire public transit system (Hand, 2016).

Policies that support active transportation and its infrastructure prioritize pedestrians, cyclists, and other vulnerable road users. One major opportunity may be to convert on-street parking to sidewalks or cycling lanes (or even bus-only lanes). California addresses this in a “complete and livable streets” policy, planning to “prioritize people rather than vehicles” and “provide quality public space by taking advantage of shared AVs’ reduced need for parking and right-of-way space” (California Multi-Agency Workgroup, 2018). NACTO addresses interaction between AVs and pedestrians by requiring AVs detect people (rather than requiring pedestrians to carry sensors), suggesting more mid-block crossings, and earmarking funds from congestion pricing to build transit and active transportation (National Association of City Transportation Officials, 2019).

Community Wellbeing

Community Wellbeing policies do not relate directly to the needs of disadvantaged groups or to transportation access but are designed to mitigate potential harm to the greater community. We consider them equity policies because disadvantaged groups are likely to be disproportionately harmed - physically or economically - without them. They include safety and security, job loss impact mitigation and sustainability and land use. Their apparently indirect relationship to equity merits explanation.

General safety requirements can address equity issues for vulnerable populations who may have security concerns or be subject to harassment such as women (Gardner et al., 2017), transgender and gender non-conforming people (Lubitow et al., 2020), and racial minorities (Lee and Scott, 2016; Reny and Barreto, 2020). Consequently, ensuring security within shared AVs will be paramount for these groups who may fear harassment or assault when entering a shared vehicle with a stranger. Ensuring security mechanisms are incorporated into AV policy and design will be vital to creating equitable access for these groups.

Curiously, the issue of security within shared vehicles is absent from the policies we reviewed, with the exception of some research regarding the acceptability of shared AVs (Paddeu et al., 2020) and an article published by the design company Teague (Siripanch, 2020). The article acknowledges the opportunity for harassment and assault present in unsupervised vehicles shared by a small number of individuals. It provides a number of solutions to prevent or address verbal and physical harassment, including installing cameras, providing discreet voice commands or seat controls to alert authorities of an emergency, and programming vehicles to drop off riders at a “safe space” rather than the user’s residence to avoid sharing that information with other passengers. Transpogroup (2018) suggests hiring “attendants” to maintain security within shared vehicles (incidentally, this policy could also help to mitigate job loss issues).

As for job loss impact mitigation, People of Color are more likely to hold driving jobs, and the wages are often higher than median income for racial and ethnic majority groups including Blacks and Hispanics (Center for Global Policy Solutions, 2017). As a result, these

communities are at a greater risk of unemployment and lower income with the proliferation of AVs. Certain policies may help temper the negative effects of this economic upheaval. This is a primary equity concern for a number of state and local agencies. The [Center for Global Policy Solutions \(2017\)](#) report analyzes which groups nationally are vulnerable to the elimination of the driving industry and makes policy suggestions to help mitigate its impact. The state of Oregon performed a similar analysis on state level data ([Task Force on Autonomous Vehicles, 2019](#)). Many of the policies involve creating a cushion during unemployment, such as bolstering unemployment insurance, expanding Medicaid eligibility for displaced workers, and instituting a progressive basic income program at the federal level. Other policies from this report regard education and retraining. Policies from government agencies such as the Association of Bay Area Governments ([Metropolitan Transportation Commission Association of Bay Area Governments, 2018](#)), Kansas City ([Mid-America Regional Council, 2018](#)), the [Centralina Council of Governments \(2019\)](#), and [WSDOT \(2018\)](#) support some form of education or retraining. The Global Policy Solutions report also provides a compelling case for transitioning bus driving roles to security attendants: “City bus drivers preserve order and safety on buses, provide information, ensure payment... School bus drivers have specific responsibilities related to the safety of the children they supervise. For these reasons, it may not be desirable or necessary to replace bus drivers, completely at least, even if the buses were fully autonomous” ([Center for Global Policy Solutions, 2017](#)).

Finally, sustainability and land use policies may seem the least removed from direct equity considerations. However, because low-income people and racial minorities are disproportionately impacted by environmental degradation and zoning policies, leveraging AVs to enable a more sustainable energy use and denser land uses will create more equitable outcomes for these groups. Policies that focus on sustainability and energy use are relevant in an environmental justice context, while land use policies tend to support policy goals from the Multimodal Transportation section. One significant concern is that the ease of use of AV technology will cause VMT to explode. If vehicles continue to be fueled by gasoline, this would greatly increase GHG emissions. The negative effects of GHG emissions are felt by all but most closely by poor people and People of Color - not only within the U.S., but globally ([Levy and Patz, 2015](#)). Incentivizing, prioritizing or even mandating alternative energy sources - such as electricity - for AVs is a priority for many agencies. Both Seattle ([Seattle Department of Transportation, 2017](#)) and the Association of Bay Area Governments ([Metropolitan Transportation Commission Association of Bay Area Governments, 2018](#)) have mandated that AVs be fully electric. Other agencies, like the Louisville Metro Government ([Louisville Metro Government, undated](#)), are taking inventory of existing EV charging infrastructure and making plans to expand it. Land use-related policies to prepare for AVs are more varied. NACTO ([National Association of City Transportation Officials, 2019](#)) offers a number of strategies related to land use in urban areas, including zoning for higher density, converting on-street parking spaces to a variety of uses, and flexible management of the curbside. The Association of Bay Area Governments ([Metropolitan Transportation Commission Association of Bay Area Governments, 2018](#)), preparing against the potential for urban sprawl from AVs, plans to “retain or strengthen urban growth boundaries to control greenfield development.” Reducing parking minimums or implementing parking maximums is also a popular strategy.

Other concerns

There are some common AV policies that we do not consider to have equity implications. For example, it is common for state policy to address primarily safety concerns of AVs, such as regulating how and to which extent the technology must avoid crashes. While it is true that some are at higher risk for injury and death in crashes than others (for example people living in rural communities, as mentioned previously),

because safety is a universal requirement for the operation of AVs and rarely takes an equity lens, we do not consider safety requirements on their own to be equity policy. Notable exceptions to this rule include the need for AV crash tests to include the bodies of women and children, and not just adult males (as has been the historical standard) ([Anderson et al., 2016](#)), and the need for AV technology to be able to recognize and yield properly to people with varying skin tones, body shapes and mobility aids ([Wilson et al., 2019](#)). Another somewhat common example was any policy concerned with data privacy, because, again, these types of policies apply broadly to most everyone. There are exceptions, here, too - one policy specified that AVs not collect health-related data such as age or ability status and then apply that information to trolley problem calculations (for example, in a scenario where a crash with a pedestrian is unavoidable, veering the AV to injure an older or disabled passenger to avoid harming a younger, able-bodied pedestrian) ([National Council on Disability, 2015](#)). We did not consider any regulations to allow testing of AVs within a state or municipality as equity policy, either.

Policy frequencies and opportunities for development

While each agency or organization has taken a different approach to AV policymaking, certain policies are featured in many AV policy documents. As shown in [Table 2](#), the most frequently employed policies span the categories we have identified. Policies for employing a shared-use model for AVs top the list. Many agencies are also considering how to enable a smooth transition for workers who lose their jobs to automation. Considerations for parking are also popular - both in the sense of parking policy and ensuring new parking structures are convertible to other uses in the future. Policy documents also frequently state automating transit and an intent to use AVs to either help or prevent harm to historically marginalized communities.

Having reviewed much of the existing AV equity policy, we found some significant gaps that policymakers must address to ensure success and equitable outcomes for an automation-based transportation network. First, more agencies would benefit from a guiding policy framework, several of which have already been developed. One potential framework is “FAVES” - Fleets of Automated Vehicles that are Electric and Shared. By necessarily tying AVs to shared mobility and electric energy, policymakers can prevent a drastic increase in VMT and associated emissions. The City of Portland, OR (undated) has adopted this framework as its overarching policy principle. Hawaii has created a similar but unique framework known as A2CES: Accessible, Automated, Connected, Electric and Shared ([Ulupono Initiative, 2020](#)). This approach is more thorough than FAVES with the addition of the Accessible and Connected components. A2CES even adds an equity dimension that is missing from FAVES; Hawaii defines “Accessible” in this context as “vehicles and services [which] allow for all to travel without regard to disability or socioeconomic circumstances” ([Ulupono Initiative, 2020](#)). While lacking a catchy acronym, MnDOT has taken another approach to examining the interplay among aspects of AVs. The agency identified 7 goals (“Equity and Accessibility” among them) and connected each of its strategies back to these goals ([Minnesota Department of Transportation Office of Connected and Automated Vehicles, 2019](#)). By building an overarching framework where objectives interplay to achieve equitable outcomes, policymakers can create a whole policy that is greater than the sum of its parts.

Second, there are opportunities within some of the equity categories we have identified as well. They relate to ensuring access for low income and rural communities, as well as ensuring interpersonal security within shared vehicles. More thoughtful consideration of the specific impacts on low-income individuals and households is necessary. This group stands to lose the most if equitable outcomes are not planned for. Transit and non-motorized infrastructure are critical, as well as progressive and usage-based pricing mechanisms. A number of agencies and organizations have identified this latter strategy as a priority, including government agencies like the state of Delaware, Hawaii, Florida MPO, and

Table 2
AV Policies by number of references.¹

Rank	Category	Sub category	Policy	(min) # references
1	Multimodal Transportation	Shared Mobility	Encouraging, incentivizing or mandating shared, multi-passenger model over private ownership/SOV model	16
2	Community Wellbeing	Workforce	Develop and provide retraining opportunities for jobs lost to automation	10
3	Access & Inclusion	All	Avoid harm/help marginalized communities throughout AV deployment	8
3	Community Wellbeing	Sustainability/Land Use	Reconsider parking policies; institute parking maximums/remove parking minimums	8
3	Community Wellbeing	Sustainability/Land Use	Parking structure conversion	8
3	Multimodal Transportation	Transit	Apply automation technology to transit	8
7	Access & Inclusion	All	Involve and center community representatives in decision making processes	7
7	Multimodal Transportation	Shared Mobility	Implement AV technology on shuttles or microtransit for first/last mile solution	7
9	Community Wellbeing	Workforce	Identify and analyze sectors that will be impacted by automation	6
9	Community Wellbeing	Sustainability/Land Use	Build out EV charging infrastructure	6
9	Community Wellbeing	Sustainability/Land Use	Create policy incentivizing, prioritizing or mandating alternative energy sources for AVs/transit	6
9	Community Wellbeing	Sustainability/Land Use	Develop new funding strategies for road infrastructure	6
9	Access & Inclusion	People with disabilities/seniors	Leverage AVs to increase mobility for people with disabilities, older adults and families with children	6
14	Access & Inclusion	Low Income Communities	Institute usage-based fees	5
14	Multimodal Transportation	Transit	Improve transit service today to ensure that transit is a viable mode alongside AVs	5
14	Multimodal Transportation	Complete Streets	Prioritizing movement of peds/cyclists over vehicles in urban areas	5

¹ The phrasing of the policies we use in this section is a general paraphrase of the idea or intention behind the policy type. The vocabulary and minor elements of the execution varies from agency to agency for each policy. The number of references for each of these policies refers to confirmed instances of the policy

within a document according to this research. We use the caveat ‘minimum’ to reference that these policies may have been published elsewhere but were missed in this research due to the limits of the methodology.

the City of Portland; NACTO dedicates 12 pages to the topic of pricing in its AV policy guide (Barnes and Turkel, 2017; City of Portland Oregon, undated; National Association of City Transportation Officials, 2019; Smith et al., 2018; Ulupono Initiative, 2020). Perhaps less obvious but critically important are land use considerations - building up housing and job supply near transit lines. Many organizations and agencies have at least one of these policies, but for this group more than any other it is critical that all of these policies operate in tandem to produce the greatest benefit. For example, piloting AV shuttles in low income communities, as is planned by San Francisco, CA and Tempe, AZ, may help ensure access among these communities but could backfire in building trust should something go wrong (City of Tempe Arizona, 2018; Metropolitan Transportation Commission Association of Bay Area Governments, 2018). If enacted, this policy should be paired with involving and centering community members in the decision making process.

Most agencies and organizations developing AV policy are considering primarily urban, rather than rural, areas. Planning for rural areas should consider that fleets of shared AVs may not be the right solution for very low density communities, due to the high potential for unoccupied AVs traveling long distances between trips. Future research should determine which ownership models, in combination with transit/shuttle infrastructure, will function for these communities. However, local rural jurisdictions may not have funding for such research. Therefore, state governments (perhaps in partnership with universities) should be responsible for working with rural community members and studying ownership models to determine how to best apply sharing principles to rural locations. Because AVs may greatly increase access to economic opportunities, the economic divide between rural and urban populations has the potential to widen if the two area types do not have comparable access to AVs. Many rural areas even now lack access to the internet and other connectivity infrastructure (Neef, 2018). This must be built out so that by the time AV technology is mainstream, rural communities have adequate access.

Security within shared driverless AVs is perhaps the most overlooked equity issue in AV planning and inadequate security may limit the size of the shared mobility. Security will be critical to providing true access to populations that are vulnerable to harassment and assault - including women, trans and nonbinary people, and racial and religious minorities. If security within vehicles is not ensured, these groups may avoid shared AVs altogether. Because the individuals from these groups make up the majority of the U.S. population, their nonparticipation (or even relatively low participation) in shared AVs could prevent a critical mass user base of shared AVs from forming, causing the entire system to collapse. As mentioned in the previous section, Teague appears to be the only entity to have given serious consideration to security for vulnerable populations within shared, driverless AVs. While Teague’s discussion of AV security veers more into the realm of vehicle and system design rather than policy, these design guidelines could function as a sketch for governments or car companies hoping to minimize crime - and maximize user base - within shared vehicles.

Finally, exceedingly few policies explicitly address race, despite the fact that race is a major factor in one’s level of transportation access. The Global Policy Solutions report does a thorough analysis on how Blacks, Hispanics and Native Americans will be disproportionately harmed by the loss of driving jobs, and suggests targeted employment strategies tailored to these groups, including “job placement and training and coaching, wage subsidies, and the direct creation of jobs by the government” (Center for Global Policy Solutions, 2017). Beyond the labor market, one concern about shared AVs is that programs will pilot in wealthier, Whiter neighborhoods, creating a significant (although potentially temporary) gap in mobility between these and lower-income

neighborhoods with a higher proportion of People of Color. All agencies should consider making the advancement of racial justice a priority in its AV and transportation plans, as did Seattle in its New Mobility Playbook (Seattle Department of Transportation, 2017). Because People of Color are disproportionately impacted by carbon emissions, sustainability initiatives such as electric energy sources should be incorporated into plans to address racial disparities with AVs.

Conclusions

The AV revolution will require significant social equity policy to increase access for disadvantaged groups. Some organizations have begun to create such policy; many others have not. Scholars studying AV policy have stressed the link between AVs and equitable outcomes, but few have examined the current AV equity policy landscape and its implications for future policymaking. Transportation planners, policymakers and government officials have the power to shape the first transportation revolution of this millennium. Their actions now may guide outcomes for years to come. Developing an understanding of the existing AV equity policy and its gaps is a critical step to creating well-informed plans to increase access for all with this emerging transportation technology.

This paper has demonstrated that existing AV equity policy falls under the categories of Access & Inclusion, Multimodal Transportation and Community Wellbeing, and that certain policies are more frequently employed. The results show that a shared model for AVs is the most commonly enacted AV policy with equity implications. In fact, many if not most other AV policies with equity implications found in this research hinge on a shared model rather than the private ownership that dominates automobile travel today. Preparing for and responding to economic changes is also a priority for many agencies. Policies such as “avoiding harm to marginalized communities” and “leveraging AVs to increase mobility for people with disabilities” are not particularly actionable but may serve as guiding principles. Policymakers are also considering key issues such as urban parking, applying automation to transit, and electrification.

The results have also elucidated some gaps in AV equity policy. Some agencies have begun to consider how policies interplay but most have yet to develop a framework to guide their policy development. Moreover, policies considering certain groups who suffer mobility obstacles including people with low incomes and People of Color are nearly absent from the body of AV policy as a whole. The issues of sustainable and equitable operation of AVs in rural communities and in-vehicle interpersonal security also require greater consideration from policymakers.

As a result of this analysis, we offer the following recommendations for planners and policymakers looking to implement AV equity policy within their jurisdiction. First, since planning organizations, businesses and nonprofits act as thought leaders (as they are not limited by the need for approval from a voting base), policymakers looking to start their AV policy framework should first look to these organizations to “dream big.” However, since government organizations tend to be constrained by what is politically feasible, policymakers should also review actions by other governments to see what policy has actually been enacted. Second, policies should be adapted to the unique needs of the agency - consider local (or state, etc.) demographics, land use, transportation network, infrastructure, and economy. What works well for San Francisco, CA may not be the right approach for a small midwestern town. This is much more salient at the local level but may also hold true, to a certain extent, at the state level. Lastly, many policies may only provide marginal benefits at best or detrimental at worst, if not paired or grouped with complementary policies. Policymakers should remain keenly aware that policies are not created in a vacuum and may have unintended consequences, and that creating an overarching policy framework is an effective way to ensure policies support and enhance one another.

CRedit authorship contribution statement

Katie Emory: Data curation, Formal analysis, Writing – original draft, Writing – review & editing. **Frank Douma:** Funding acquisition, Conceptualization, Methodology, Writing – review & editing. **Jason Cao:** Funding acquisition, Conceptualization, Writing – review & editing.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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