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Exploring E-bikes in the Era of Electrification: Toward a More Sustainable and Equitable Transportation System

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Exploring E-bikes in the Era of Electrification: Toward a More Sustainable and Equitable Transportation System

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16. Abstract While increasing electrification is vital, additional steps are necessary to maximize its benefits in terms of reducing congestion and promoting sustainable, accessible, and equitable transportation for all. E-bikes, operating at speeds faster than pedal-only bicycles and requiring less physical effort to ride, have the potential to offer transportation alternatives to a diverse range of users. However, many individuals who could benefit from e-bikes face barriers to accessing or using this mode of transportation. In this context, the primary objective of this study is to enhance our understanding of the barriers, concerns, and needs associated with e-bikes. Recognizing that such understanding is crucial for informing relevant policies and initiatives, the research team conducted a comprehensive review of the literature and various other resources and performed a qualitative examination of e-bike uses, potential benefits, barriers, and strategies aimed at addressing these barriers. The researchers also highlighted cases relevant to marginalized population groups, particularly including people with disabilities and older adults.			
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Executive Summary

Apart from being a sustainable and active mode of transportation, bicycling quickly emerged as one of the safest transportation modes in the face of the pandemic. The popularity of bicycling has grown even more when it comes to electric-assist bicycles (e-bikes), owing to their potential to improve a person's ability to ride a bike over longer distances, on steeper grades, and/or despite physical disabilities or limitations that might otherwise be a barrier to using a bicycle. The U.S. Department of Transportation (2021) has established a strategic plan to make transportation more accessible for everyone, including an initiative to "enhance opportunities for people with disabilities to walk, roll, cycle, and use micromobility services and other innovative mobility technologies." E-bikes, sharing the same theme of providing "tiny personal mobility" but with different maneuverability, usage, and adoption patterns and rates, have the potential to play a leading role in advancing these initiatives. On the other hand, bicycling—including e-bikes—has faced significant challenges in terms of its equitable and safe access.

Despite the potential of e-bikes to improve sustainable transportation options for many (including marginalized population groups), there have not been extensive studies examining their capacity as a safe, accessible, and equitable emerging mobility or how they could be integrated into the overall transportation system. Instead, the field has been dominated by studies or discussions mostly about electric cars. While increasing electrification is vital, electrifying motorized vehicles alone will not solve transportation issues such as congestion or emissions. Effective policy and planning strategies (e.g., infrastructure planning, pricing incentives, or vehicle subsidies) are needed to ramp up the use of electric micromobility vehicles.

The use of any new mobility is associated with perceptions, attitudes, concerns, and barriers. Existing e-bike literature is limited in terms of understanding how the populations (and the public they would encounter while riding) perceive e-bikes, as well as which concerns and barriers should be addressed to fully realize the potential of this mode for specific population groups, including marginalized populations. In this context, this study aimed to explore barriers associated with the access to and use of e-bikes and provide strategies for addressing the challenges.

While the primary focus was on marginalized populations (people with disabilities and older age groups in particular), the research team acknowledged that achieving inclusive mobility necessitates a comprehensive understanding that extends beyond these subgroups. It is important to acknowledge the intersectionality of various factors such as age, ability, socioeconomic status, and geographical location, which collectively influence access to and utilization of e-bikes. Many perceptions, concerns, and obstacles related to e-bike usage are also shared among individuals with different abilities, age groups, and the general population. The perspectives of transportation planners and authorities significantly affect e-bike policy interventions and future investments, even though they may not be categorized as people with disabilities or older adults. Additionally, people on the periphery can directly influence e-bike usage. To address these aspects, the scope of this research was expanded to encompass a broader range of population groups with varying (dis)abilities and ages, as needed.

The research team reviewed the literature to understand people's e-bike perceptions and any concerns and barriers that may be delaying the adoption of e-bikes among marginalized populations in the United States. Next, expert interviews with a total of 50 micromobility stakeholders sought their experience and perspectives on e-bike benefits, potential barriers and challenges to e-bike use, and solutions to mitigate those barriers. Interviewees described e-bike benefits including increased independence and opportunity for individuals and

communities that are underserved by transportation networks; health and social benefits; reduced roadway congestion and increased environmental sustainability; and economic gains at both individual and community levels. They identified barriers to use including the costs of e-bikes compared to traditional bicycles; lack of safe bicycling facilities; difficulties with e-bike storage, charging, and repair; negative or uncertain attitudes about e-bikes; and usability issues for people with disabilities. Solutions implemented or planned by interviewees' organizations included expanding bicycling infrastructure in ways that safely accommodate powered and non-powered bicycles as well as pedestrians; improving links between e-bike networks and public transit; expanding funding to offset e-bike purchases and e-bikeshare user fees; and involving targeted communities in e-bike planning as part of overall community development. The findings addressed a wide range of strategies that businesses, local agencies, and nonprofit organizations have already implemented or are planning to overcome barriers that potential e-bike users may face. While details of these strategies varied—reflecting the uniqueness of each community, e-bikeshare program, bike library, or rebate program—several overarching recommendations emerged. These primarily included establishing partnerships, addressing accessibility, and focusing on community benefits.

To ensure that e-bikes offer a real mobility solution for all, a collaborative effort between communities, stakeholders, advocates, and various organizations is essential to address the unique transportation needs and challenges of communities, including marginalized populations. This collaboration should begin from the early stages of community planning and design, ensuring inclusive and accessible transportation for all.

Chapter 1. Introduction

Background

The year 2020 arrived with a devastating game changer, the COVID-19 pandemic, which significantly affected every aspect of individuals' lives including the way they travel. While being hit hard at the beginning, bicycling quickly emerged as one of the safest transportation modes in the face of the pandemic. Cities around the world worked to provide more space for bicyclists and temporarily closed part of their major streets to motorized vehicles (Peters, 2020). The headlines read, "bicycling is set to surge" (Sabbatini, 2020) and "COVID-19 bringing bikesharing back" (Shen, 2020). According to a survey conducted by BCG (Bert et al., 2020), apart from walking, the use of personally owned micromobility devices and bikesharing were the only modes of transportation increasing during the lockdown in the United States.

The popularity of bicycling has grown even more when it comes to electric-assist bikes (e-bikes),[1] which have the potential to improve a person's ability to ride a bike. E-bikes have been identified as a promising mode of transportation, with faster speeds, longer trip distances, and less effort required to ride, as well as providing a good alternative to car travel (Guidon et al., 2019; de Haas et al., 2021). Many different variations (e.g., tricycle, tandem, recumbent, and handcycle) are also available for riders with varying abilities and challenges (e.g., in balancing, pedaling, and seating). Adapted forms of bikes can engage people with impairments related to advanced age, physical disability, and mental disorders in cycling (Clayton et al., 2017). MacArthur et al. (2020) indicated that "e-bike options have the ability to complement existing bike share systems by offering riders, especially those with physical limitations and alternative abilities, the opportunity to make trips easier and simply access bike share and provide an easier way to navigate steep terrain."

There is no doubt that the future of bicycling relies on the ability to provide safe and accessible transportation. However, bicycling has faced significant challenges in terms of its equitable access. For example, an equitable bikeshare system requires offering bikeshare services with a protected bikeshare structure to include individuals of all abilities (NACTO, 2015). On the other hand, many bikeshare services have limited types of bikes, which may not be suitable for individuals with disabilities (Johnson, 2017). The lack of diversity in the demographic distribution of bicyclists and bikeshare users (Brown, 2017) or the geographic inequities due to central cities becoming richer and ethnically less diverse (Schmitt, 2022) have also raised various equity concerns. To address racial equity and create transportation justice, a three-year micromobility pilot program, the Equitable Commute Project, was recently launched in New York City (ECP, 2022). The program has noted the potential of e-bikes in responding to the barriers to employment and overall wellbeing across disadvantaged communities facing especially long commutes and started to subsidize an easier commute for some frontline and essential workers in the city (ECP, 2022; Williams, 2022).

Even though e-bikes have the potential to improve sustainable transportation options for many (including for marginalized population groups), there have not been extensive studies looking into their potential as a safe, accessible, and equitable emerging mobility or how they could be integrated into the overall transportation system. Instead, the field has been dominated by studies or discussions mostly about electric cars. The advancements of technology over the last decade have been transformative, altering not only how we travel,

[1] For the sake of brevity, we use the term "e-bike" throughout this report to refer to a range of electric-assist bicycles (fully electric, electrically assisted, and adapted forms). Unless explicitly stated otherwise, e-bike encompasses all types of electric bicycles.

but also how we define transportation and mobility options as well as what we expect from them. Innovative technologies have entered our lives, promising a safer, greener, and more affordable future of transportation, with electrification at the heart of this transformation. As a result of the Bipartisan Infrastructure Law signed on November 15, 2021, the U.S. Departments of Energy and Transportation announced the establishment of a Joint Office of Energy and Transportation focusing on deploying electric vehicle infrastructure (The White House, 2021). While increasing electrification is vital, electrifying motorized vehicles alone will not solve transportation issues such as congestion or emissions. Effective policy and planning strategies (e.g., infrastructure planning, pricing incentives, or vehicle subsidies) are needed to ramp up the use of electric micromobility vehicles. According to Fitch (2019), there is evidence that e-bikes have the ability to replace car travel (more than conventional cycles) when given incentives, yet e-bike incentive schemes (or corresponding studies) are limited in the United States.

The Study in Context

Acknowledging the challenges and unknowns, this study contributes to the field by examining the safe use and equitable access of e-bikes as part of shared mobility services, as a first/last mile option to public transportation, or as personally owned micromobility vehicles. This focus is perhaps timelier than ever given the recent need to travel with physical distance, which might be challenging especially for marginalized populations. In addition, there are several lessons to learn from disrupting trends in electrification (including during COVID-19) as well as individuals' changing behavior, perceptions, and varying needs. The study aims to examine barriers to the access and use of e-bikes emerging as sustainable modes of transportation technologies and to identify strategies to enhance their safe and equitable access and use.

While the study's primary focus was on marginalized populations (people with disabilities and older age groups in particular), the research team acknowledged that achieving inclusive mobility necessitates a comprehensive understanding that extends beyond these subgroups. It is important to recognize the intersectionality of various factors such as age, ability, socioeconomic status, and geographical location, which collectively influence access to and utilization of e-bikes. Many perceptions, concerns, and obstacles related to e-bike usage are also shared among individuals with different abilities, age groups, and the general population. The perspectives of transportation planners and authorities significantly affect e-bike policy interventions and future investments, even though these individuals with different abilities may not be categorized as people with disabilities or older adults. Additionally, people on the periphery can directly influence e-bike usage. To address these aspects, the scope of this research was expanded to encompass a broader range of population groups with varying (dis)abilities and ages, as needed.

As part of this project, the research team first conducted a comprehensive review of the literature focusing on general perceptions toward e-bikes and various factors that influence the formation of these perceptions as well as the concerns among potential and current e-bike users and the barriers hindering the widespread adoption of e-bikes, respectively. Following the review, the research team conducted expert interviews given the importance of a collaborative effort between communities, stakeholders, advocates, and various organizations to gain a more complete understanding of the barriers that can hinder or prevent access to and use of e-bikes and identify strategies to expand e-bike use, particularly among disadvantaged populations.

- A detailed description of the literature review is available in the research paper titled, *E-bikes Toward Inclusive Mobility: A Literature Review of Perceptions, Concerns, and Barriers*, by Lee and Sener (2023).

The remainder of this report details the methods, data, and findings from the expert interviews.

Expert Interviews: Participants and Representation

Expert interviews with micromobility stakeholders in the United States were conducted to identify common barriers to accessing micromobility options and strategies for overcoming those barriers. Specifically, the interviews addressed the uses and benefits of e-bikes and similar micromobility modes; potential barriers to the access or use of e-bikes; and strategies that communities, companies, and organizations have used or considered to overcome those barriers.

Most interviews were conducted online using the Microsoft Teams conferencing platform, which also allowed the interviews to be recorded. Two interviews were conducted by telephone, and two additional interviews were not recorded due to audiovisual or other technical issues. The interviewer took extensive notes during all interviews and reviewed the video recordings to clarify the interviewees' responses as needed. Approval from the Institutional Review Board (IRB) of the Texas A&M University Human Subjects Protection Program was received before any data collection.

A total of 43 interviews involving 50 representatives of U.S. agencies, businesses, and nonprofit organizations were conducted (Table 1). Interview participants included representatives of disability and other disadvantaged communities; e-bike technology developers and manufacturers; for-profit and nonprofit bikeshare programs that are deploying e-bikes; transit agencies that are employing micromobility options; and other organizations involved in micromobility advocacy, research, or implementation. An interview guide was prepared, but questions were customized as appropriate depending on the role, background, expertise, and experience of the interviewee.

Table 1. Expert Interview Participant Representation

Organization Type	Number of Interviews	Number of Interviewees
Local government/transit agency/university transportation service	14	20
Local nonprofit/advocacy organization	11	12
National nonprofit/advocacy organization	11	11
Local/small business	2	2
National/regional business	3	3
Federal agency	1	1
University research organization	1	1
Total	***43***	***50***

Expert Interviews: Analysis Approach

The interview responses were examined qualitatively using thematic analysis—a widely used qualitative research approach for interpreting textual data and providing rich and insightful findings. Interviewee responses to each of the discussion questions were categorized and then reexamined to identify similar categories that needed to be combined for an effective analysis (for example, *first-mile/last-mile* responses were combined with *connections to transit* responses under e-bike uses). The frequency of each category of response for each question was totaled across the entire set of interviews and within each organization type (businesses, national agencies and nonprofits, local agencies, and local nonprofits) to see if there were notable differences in responses between these groups of respondents.

To analyze the interview results, the organization types were grouped as follows:

- *National and local businesses.* The businesses represented in the interviews included one nationwide bikeshare provider, one nationwide micromobility provider with a bikeshare component, one e-bike manufacturing business, one local bike shop, and one e-bike planning consultant. While each of these businesses has a slightly different role within the e-bike industry, all the interviewees provided valuable insights into e-bike economic benefits and barriers, safety and quality issues, and acceptance of e-bikes at both personal and community levels.

- *Federal agencies, national nonprofit organizations, and university research organizations.* Interviewees from federal agencies, national nonprofit organizations, and university research organizations provided useful bird's-eye perspectives on policies and practices that support or hinder bicycling and micromobility, the challenges of planning and implementing multimodal transportation systems, and strategies for accommodating the needs of people with differing abilities.

- *Local agencies.* Interviewees in the local agencies category represented local bikeshare or e-bike funding and rebate programs operated by city, county, and university campus transportation departments, transit agencies, and community planning offices. These interviewees were able to provide specific examples of e-bike uses, benefits, barriers, and solutions in their jurisdictions.

- *Local nonprofit organizations.* Similar to local agencies, several of the local nonprofit organizations represented in the interviews operate bikeshare or e-bike rebate programs, many of which offer e-bikes at reduced or no cost to qualifying applicants. A few of the bikeshare programs operated by the participating local nonprofits are exclusively recreational, and some cater specifically to people who need adaptive bikes.

Chapter 2. Use of E-bike

The e-bike uses described by interviewees varied somewhat according to how the shared e-bike program (if any) in their community was designed and currently operates. For example, some of the bikeshare organizations represented in these interviews operate bike rental, or *bike library,* services specifically for recreational purposes, which is reflected in their locations and checkout procedures. Note that business-related deliveries; transporting children, groceries, or other goods; and delivering emergency or nonprofit support services were not included as potential e-bike uses in the original interview guide but were mentioned multiple times by interviewees—further highlighting the value of qualitative research.

Figure 1 lists the e-bike uses identified in the interviews in descending order of prevalence; a detailed discussion regarding the most prevalent trip purposes follows.

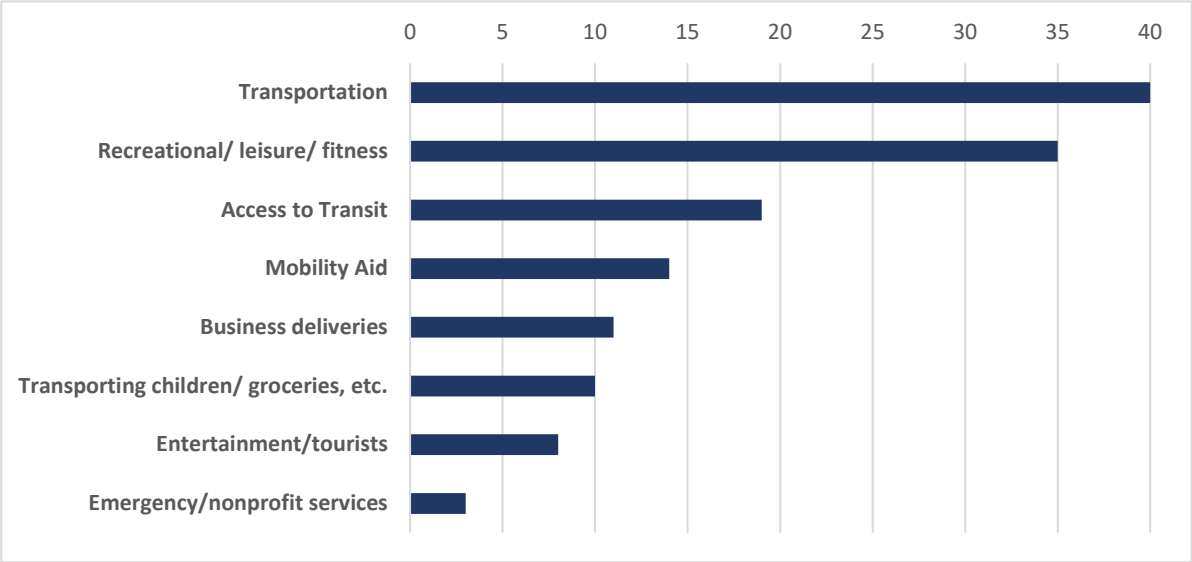

Figure 1. E-bike uses identified in expert interviews.

Transportation

Commuting to work or school, running errands, and meeting other daily transportation needs comprised the most frequently described use of e-bikes in the interview responses. One interviewee highlighted an interesting observation upon the launch of their shared e-bike program in Worcester, Massachusetts, in August 2022:

> "*The biggest percentage of trips at the start of the shared e-bike program in August was recreational. In the second month (September), we started to see work trips and shopping trips increasing. By October and November, the largest percentage was work-related. The average length of a trip is 3.89 miles*."

It appears that initially, people primarily used the shared e-bike program for recreational purposes, perhaps indicating a hesitancy to rely on a new mode of transportation for essential tasks like commuting to work. However, as the program continued, there was a noticeable shift toward work-related trips, which might suggest that once individuals experienced the convenience and reliability of e-bikes for other purposes, they

were more inclined to use them for commuting as well. Further research will be critical for delving deeper into these evolving trends as new modes are introduced into the transportation ecosystem.

It is possible that reducing access barriers / making a new mode available was something people wouldn't immediately rely on for travel as important as getting to work, but once they tried it for another purpose, felt it was reliable. Additional research will be essential in deep mining such evolving trends.

The COVID-19 pandemic had a significant impact on the way people use e-bikes. When the pandemic first hit in early 2020, essential workers began using e-bikes and other micromobility options in response to reduced transit services and contagion concerns. According to one interviewee who works in Montgomery County, Maryland, this shift was evident in the longer trips recorded in the ride data, which were primarily taken by people in disadvantaged neighborhoods who lacked access to other transportation modes:

> "*Based on geography, 40–50 percent of trips are in and out of designated equity emphasis areas of the city, meaning that people in disadvantaged neighborhoods are taking those trips*."

Recreation, Leisure, and Fitness

The second most frequently reported use of e-bikes described by interviewees was for recreational, leisure, and fitness activities, with trips to tourist and entertainment destinations mentioned as common uses in some locations. This trend is reflected in the increased use of e-mountain bikes on recreational trails, providing an opportunity for people to enjoy nature and engage in physical activity. One of the interviewees from Boise, Idaho, confirmed this phenomenon:

> "*We have an extensive network of recreational trails, and more e-mountain bikes are showing up on the trails*."

In some cities, e-bikes are also becoming popular for accessing civic centers, arenas, and arts and entertainment districts. The interviewees emphasized the increased use of e-bikes at such places during events. This shift likely indicates a broader trend toward using micromobility options for short trips, which are often more convenient and cost-effective than traditional modes of transportation.

Access to Transit

One of the significant reported benefits of e-bikes was their ability to provide access or connections to transit, allowing individuals to make short trips or take trips during off-hours. First-mile/last-mile access to transit was identified in nearly half of the interviews as a current or planned aspect of e-bike transportation in a community. Moreover, e-bikes were acknowledged as "*filling a need that wasn't met by other transportation modes*," especially in disadvantaged neighborhoods.

Mobility Aids

E-bikes were called out specifically as mobility aids for people with disabilities, health issues, or limited strength or stamina. Several interviewees mentioned the significant benefits of the electric motor assist to older adults, whether they are just starting to ride or have been riding for years. One bike shop owner described his experience with older adults:

"*I'm dealing with a lot of people who are first-time purchasers. A lot of them are 50 and above; partly because they have the money to buy e-bikes. If they're new to biking, they're more likely to get an e-bike because it's easier with the hills. They use them largely for recreation and fitness; often one partner is into biking and the other is wanting to join but needs help keeping up*."

Business Deliveries

E-cargo bikes were described several times in the interviews as gaining in popularity and use, despite being more expensive and requiring more roadway space than traditional e-bikes. However, even standard e-bikes without the additional cargo capacity are being used for business and personal deliveries in some communities. A representative of one local transportation agency confirmed this phenomenon:

"*When we introduced e-bikes [to the bikeshare program], we had people start using them for DoorDash and other deliveries, which they'd never used the regular bikes for*."

Another interviewee from a major city commented on the use of e-bikes for a wider variety of purposes:

"*A lot of people who biked as a child are discovering that these new e-bikes are really convenient. E-bikes make bike lanes useful to a wider segment of the population, help people who can't afford or don't want a car, and expands what people think you can do with a bike like getting groceries or carrying their kid*."

Chapter 3. E-bike Benefits

The themes that emerged from descriptions of e-bike benefits and opportunities in the interviews overlapped considerably across interviewee organizational types and across the varying populations or stakeholders they serve. Here, the research team distinguished e-bike benefits for individual users from the broader community and economic benefits attributable to e-bikes.

User Benefits

Increased Independence, Access, and Participation through Mobility

Unsurprisingly, *mobility* was a frequent term used in describing the benefits of e-bikes to individual users; however, this term carried slightly different meanings depending on the user group. For people who use shared or privately owned e-bikes for commuting and daily errands, mobility is described as independence stemming from access to transportation that is not tied to transit schedules and service hours or to having a driver's license and/or a car. One interviewee commented,

> "*E-bikes are a big mobility option for people; they can take trips without using a personal vehicle but faster than transit for work, errands, and other destinations. Some people have reported being able to sell their family's second car in favor of buying an e-bike*."

Another interviewee mentioned how popular e-bikes are becoming with younger teenagers who like the independence they provide. Mobility as a means for independence was mentioned most frequently by interviewees from national nonprofit organizations.

For e-bike users in disadvantaged neighborhoods, the mobility offered by e-bikes additionally helps to provide equitable access to jobs, resources, and other opportunities. The cost of using a shared e-bike is typically less than the cost of car-based micromobility providers. Free or vastly discounted e-bikeshare passes, offered in many communities to individuals whose income levels qualify them for other public assistance programs, are aimed at improving this access and equity. In Detroit, Michigan, the bikeshare program also works directly with local workforce development efforts to help people commute to jobs. An e-bike library in Oakland, California, is one of several *clean mobility* projects in the state designed to reduce transportation costs for people in disadvantaged communities while improving air quality; one of the project's funding requirements ensures that the library serves the disadvantaged communities at least 80 percent of the time. Mobility as a means for access was identified most frequently by interviewees from local agencies (many of whom are directly involved in the programs that help to facilitate that access) and by those representing national nonprofit organizations.

Finally, interviewees used the term *mobility* to describe how e-bikes enable people with disabilities or limited stamina to participate in recreation and exercise and to increase their own independence. One interviewee summed up the accessibility advantages of e-bikes as follows:

> "*E-bikes are adaptive bicycles. All bikeshare should be electric. Standard-design e-bikes can get you to serving 95 percent of people, then you can look for ways to accommodate the other 5 percent; for instance, recumbent bikes can be electrified*."

Some people with disabilities may be additionally disadvantaged economically; for these individuals, access to jobs and resources offered by e-bikes can be significant. A representative of an organization that works on behalf of people with disabilities described the potential for benefit:

> "*For the folks that we work with, vehicles are not affordable or are otherwise inaccessible. E-bikes give them a wider range of mobility and the ability to not have to rely on rides from others*."

Mobility as a means of participation for people with disabilities was identified most frequently by national nonprofit organizations, including organizations that advocate for the needs of people with disabilities.

"The Bike Ride without the Sweat"

The lower physical effort that is needed to ride an e-bike was mentioned frequently, sometimes in the context of a city's challenging topography or climate but always in comparison to the exertion involved in riding a pedal-only bicycle. The lower exertion level allows people to take trips that might otherwise be physically impossible to manage (i.e., a route with a steep hill to climb). Significantly, it also means that e-bike riders can arrive at their destinations not looking and feeling like they have been strenuously exercising—in other words, "*without the sweat*."

Longer and Faster Trips

E-bikes' higher average speeds mean that riders can travel longer distances in a shorter span of time compared to pedal-only bicycles and often in less time than taking transit. This effectively extends the range that a rider may be willing to travel for work, errands, or appointments. Several interviewees described how e-bikes have increased the distances that people are willing to travel by bicycle in their communities; while the stated distances vary (and may be influenced by the local topography, built environment, and/or climate), the theme of this expanding trip radius was echoed by interviewees in multiple cities. A representative from a national nonprofit organization that works with cities to implement bicycle and pedestrian programs speculated about this trend:

> "*Most people are willing to ride about 2 miles or 10 minutes to get to a destination, which is not far enough in most cities. E-bikes extend that range—by how much we don't know exactly, but even if you extend the range from 2 to 3 miles, you're going to capture some more market*."

A university researcher found that young bicycle riders' ranges for commuting and leisure trips expanded from 5 miles using pedal bikes to 10 miles using e-bikes.

Greater Inclusivity

Interviewees commented on the ways in which e-bikes have expanded the populations of riders in their communities, specifically for people whose age, gender, fitness level, or perceptions about who can or should be a cyclist may have otherwise discouraged them from trying to ride a bicycle. A representative of a city bikeshare program noted that

> "*E-bikes have opened up who can ride bikes. [They help to fight the] perception that bikes are for the more privileged populations (well-off, fit, male, white)*."

Another interviewee, representing a national nonprofit organization that advocates for mobility options, emphasized how e-bikes make bicycling less physically intimidating:

> "*More people are willing to try to bike, especially seniors. People who had the time and the need for short rides or recreational riding but were worried about their physical ability to do it have found e-bikes to be a great gateway*."

Improved Health and Fitness

Even though the physical effort needed to ride is lower compared to an entirely human-powered bicycle, riding an e-bike provides exercise and social/recreational opportunities. The lower-intensity exercise offered by e-bikes can be particularly helpful to older riders, to people who are recovering from an injury, and to people who are new to exercise.

Several interviewees noted that e-bike use increased sharply during the COVID-19 pandemic lockdowns as people searched for ways to be active while remaining socially distant; however, even after most pandemic restrictions eased, e-bike recreational use has remained popular. A representative of a national bicycling advocacy organization commented on this trend:

> "*E-bikes have been shown to keep people riding, and there are multiple health benefits to a recreational and travel mode that people want to use. There was a fall in Peloton stationary-bike users after the pandemic, but we haven't seen that decline in e-bike use*."

Community and Economic Benefits

Enhanced Sustainability

The most frequently identified community-level benefits of e-bikes in the interviews included the increases in the use of alternate transportation modes and the corresponding decreases (realized or potential) in traffic congestion and vehicle emissions. An interviewee from Seattle, Washington, noted that e-bikes are an important contributor to the City's goal of increasing the proportion of nonsingle-vehicle trips to 60 percent by 2030. Another interviewee from Santa Barbara, California, provided an environmental policy–related argument for e-bikes and alternate modes:

> "*Environmental review benchmarks have moved from traffic congestion metrics to vehicle miles traveled (VMT). E-bikes don't count toward VMT. If you don't like traffic congestion, then support active transportation*."

Interviewees in some cities also credited e-bikes with reducing parking demand in dense urban areas. An interviewee from a large eastern city sees the potential for e-bike trips to relieve demand on the city's overcrowded transit system. In addition to the decreased congestion attributable to the increased alternate mode use, several interviewees commented on the mobility and safety benefits of alternate transportation modes becoming more visible in their communities as more people use them. A representative of a local bicycling advocacy organization noted the following:

"*E-bikes and bikeshare has helped us to accelerate our ability to advocate for continued expansion of infrastructure that is friendly to alternate modes, which leads to more people biking—kind of a positive feedback loop*."

Boosted Business

Interviewees identified several different benefits of e-bikes related to business and employment opportunities. Interviewees representing local bikeshare programs (for-profit or nonprofit) observed that e-bikes, once introduced into a bikeshare fleet, were consistently used more often than pedal-only bikes and tended to increase overall bikeshare use. E-bikeshare programs were associated with increased revenue for local businesses in some cities, including bike-related businesses and local restaurants and entertainment venues. Finally, several interviewees from national nonprofit organizations commented on the new employment opportunities—from e-bike repair to delivery services—that e-bikes help make possible.

Chapter 4. E-bike Barriers

The literature review highlighted several concerns and barriers associated with the use of e-bikes. Significant concerns about e-bikes included safety, security, social stigma imposed on electric assistance, and loss of disability benefits. Along with these concerns, lack of knowledge, misperceptions, limited access, high purchase costs, and inadequate infrastructure were identified as major deterrents to adopting e-bikes.

Using the insights obtained from the literature review, the interview questions were designed to deeply dive into the aforementioned barriers as well as other barriers identified through interviews. Interviewees described a variety of barriers and challenges to e-bike use. The most frequently raised issues had to do with safety, cost, access/availability, logistics surrounding e-bike support infrastructure, unique impediments for people with disabilities and older adults, and awareness and misperceptions of e-bikes among potential users and the surrounding community.

Unsafe Bicycling Environment

Insufficient bicycling facilities and threats from motor vehicle traffic were identified by the largest number of interviewees as significant barriers to e-bike use in their communities. Reported issues included cities or neighborhoods with few or no bicycle facilities, bicycle lanes on busy roads with insufficient separation or protection from surrounding traffic, and bicycle lanes and trails that are too narrow for e-bikes to share with slower-moving pedal cycles and pedestrians. An interviewee representing a national nonprofit organization that assists cities with micromobility planning described how inadequate bicycle infrastructure discourages cycling in many cities:

> "*You can't message someone into feeling safe on a bike at the edge of a 45-mph roadway, with a stripe of paint separating them from the cars speeding by. People point to empty bike lanes saying 'No one's riding, why should we build a wider bike lane?' Well, no one's riding in it because it isn't safe the way it is*."

Several interviewees emphasized that the lack of a safe environment in which to ride is particularly discouraging to e-bike users who are new to biking. Additionally, areas where people are underserved by other modes (and where e-bikes have the most potential to expand transportation options and availability) also tend to be underserved by bike infrastructure. A lack of safe spaces for e-bikes (and bicycles in general) therefore undercuts some of the major benefits related to access and inclusivity that e-biking otherwise promotes.

Even in cities that have well-established bicycle facilities, existing lanes and trails may not be wide enough to allow for separation or safe spacing between e-bikes, pedal cycles, and pedestrians or to accommodate larger e-bikes such as e-cargo bikes or adaptive bikes. One interviewee addressed this aspect of e-bike safety:

> "*E-bikes are emphasizing the lack of space for midspeed modes like bikes and scooters—they're not appropriate for sidewalks, but there may not be other spaces for them on the transportation network. The lack of dedicated, safer space for the riders of these modes will exacerbate the tension between cyclists and pedestrians*."

A related safety issue that several interviewees raised was harassment of e-bike riders, whether by law enforcement or other road users. This was identified as a barrier, particularly for individuals in the Black, Indigenous, and People of Color (BIPOC) community, with instances of unequal enforcement of traffic laws

contributing to an unsafe bicycling environment for those affected. Examples of unequal enforcement raised by interviewees included BIPOC individuals being more likely than White individuals to be ticketed for riding on sidewalks and to be cited for speeding on an e-bike.

Prohibitive Costs with Limited Funding Assistance

The costs of e-bikes compared to traditional pedal-only bicycles were a frequently identified barrier for people purchasing their own e-bikes, for riders participating in bikeshare, and for bikeshare operators who have added e-bikes to their fleets.

The higher purchase price of an e-bike was identified as a significant barrier for people interested in owning one; while a few e-bike models retail for $1,000 or less, they are more likely to develop mechanical problems and have a shorter usable life. Most e-bikes cost $2,000 or more (as of late 2022/early 2023); e-cargo bikes are even more expensive. Personally owned e-bikes also come with ongoing costs for maintenance, repairs, and battery replacement. In addition, few bike shops are currently equipped to service e-bikes, which can result in additional costs if the bike needs to be transported elsewhere. Unlike electric car purchases that qualify for federal subsidies and rebates, e-bike purchases were not included in any federal-level purchase incentive programs at the time these interviews were conducted; state-level and local purchase incentives were available in a minority of U.S. states. Even in locations where e-bike purchase rebates are offered, purchasers typically need to pay the full cost of the e-bike upfront before receiving a portion of it back as a rebate; the people who most need the discount to afford the purchase may not be able to pay full price, even temporarily.

Higher costs were also identified as a potential barrier to using shared e-bikes. Some bikeshare programs charge higher rates for the use of e-bikes compared to the rates for pedal-only bikes. While most of the programs represented or described by interviewees provide low- or no-cost subscriptions for people with low incomes, these programs do not cover all of the riders who might find higher bikeshare costs to be a barrier to use. Additionally, some programs designed for lower-income users have gaps in coverage that could hinder their use for some types of trips. For example, a bikeshare program in one California city offers low-income users unlimited one-hour e-bike rides for an annual cost of $25, but there is currently no mechanism to provide low-cost rides that last more than an hour. And finally, for individuals with severely limited incomes, even a low cost to ride shared e-bikes may be problematic.

Costs are also an ongoing issue for bikeshare providers. Like individual e-bike purchasers, bikeshare programs must consider the initial purchase price of e-bikes that are also robust enough to stand up to shared use, the staff time needed to ensure that the e-bikes are charged (or to swap out batteries if no charging facilities are available in the field), and the cost and staffing needed for ongoing maintenance and repairs. E-bikes are also more likely to be stolen due to their higher value. Like individual e-bike purchasers, bikeshare providers do not have many options for funding sources to support these higher capital and operating costs.

Limited E-bikeshare Program Access/Availability

The most frequently mentioned constraint on e-bikeshare program access and availability to everyone who might want to use it was, unsurprisingly, the total number of e-bikes in a shared fleet. Besides budgetary limitations, factors including supply chain limitations and local caps on fleet sizes can limit the number of shared e-bikes in a community.

The locations of bikeshare stations and lending libraries will influence which neighborhoods have convenient access to a shared e-bike. As a bikeshare director from a regional transit authority explained:

> "*Our pilot bikeshare program was operated as a hub-to-hub system, with hubs located at transit stations. Because we had only 50 bikes for the pilot, we tried to constrain the service area to the downtown and the neighborhood just north of downtown. People who used the bikes were encouraged to return them to a transit station hub; if they returned a bike somewhere other than a transit station, it was a $2 penalty. If bikes were taken outside the service area, it was a $25 penalty. The service area restrictions, having only 50 bikes, and the rules of engagement for using them were all limiting factors*."

Finally, a bikeshare program's strategies and capacity for distributing/balancing shared bikes across its service area will affect availability in any given location. Issues around e-bike storage, parking, and charging (discussed next) also affect geographic availability within a community.

Wide-Ranging Logistical Challenges

Logistical challenges relate to both the lack of peripheral or support infrastructure to safely and securely store and charge e-bikes and any technical issues or impediments that may arise when participating in an e-bikeshare program (i.e., setting up a user account, researching a bike, processing a payment, etc.)

Inadequate Storage and Charging Infrastructure

The lack of safe, secure storage for e-bikes is a particular problem for people who have their own e-bike, especially if they live in apartment buildings or other multifamily housing. Many apartment complexes prohibit bringing e-bikes indoors for storing or charging due to fire safety concerns (and the added weight of e-bikes can make them difficult or impossible to bring indoors even if permitted). Few residential or public spaces are equipped with secure storage or e-bike charging facilities. E-bikes that are left outside are likely to be stolen. An interviewee representing a nationwide bikeshare provider described additional emerging challenges related to micromobility vehicle parking and storage:

> "*Some cities are instituting new regulations around e-bike and e-scooter parking, such as requirements to lock the bike/scooter to a rack, or requirements for bikes to be parked in designated corrals. While this is well-intentioned, a difficulty is that those requirements and the infrastructure deployed to implement them don't always match what is needed in terms of parking density and coverage*."

E-bikeshare programs alleviate many of these storage and charging issues for users, but—as described earlier—the associated costs to address these issues make up a significant portion of a bikeshare program's operating budget. An interviewee representing an e-bikeshare program in Virginia elaborated on this challenge:

> "*Swapping out batteries is a challenge and occupies a lot of the team's time. Right now, we have no facilities for in-field charging. If 10 percent of our stations had charging capacity, that might eliminate the need for the battery swapping*."

Technical Challenges

Most e-bikeshare programs use a smartphone app for setting up user accounts, checking out or reserving a bike, and making and receiving payments; users link a credit card or bank account with the app to pay for their

use of shared bikes. For some users, one or more aspects of this app-based system can be a barrier to use. Some older adults are not comfortable with app-based technology (and/or may not own a smartphone).

While more people of all income levels own smartphones, some individuals with lower incomes may not be able to afford the monthly data service plan for the phone that would allow them to use an app for e-bikeshare, and some may not have an email address for the two-factor authentication procedures that many apps require for security. Individuals who are unbanked do not have a bank account or credit card to link to for payment.

Other Unique Impediments Related to Accessibility

Riders with disabilities, limited strength, or other physical limitations may need design features that standard e-bike models do not have. This can be particularly problematic in a bikeshare scenario because there are likely to be very few (if any) adaptive e-bikes in a fleet.

The heavier weight of e-bikes compared to nonpowered bikes may also pose problems for some users, especially those with strength or balance problems. One interviewee who works with a local bike lending library noted several unique challenges for older populations:

> "*We learned pretty quickly the importance of having a very stable style of e-bike to serve our older adults; the bike should also be a step-through design without a high bar*."

Lack of Awareness and Frequent Misperceptions

Finally, interviewees described several barriers related to the lack of awareness and misperceptions of e-bikes among individual users and within communities. Many of these issues can be summarized with the question, "*Are e-bikes really for me (us)?*"

Individuals who have never ridden bicycles before (or have not ridden since childhood) may be wary of trying e-bikes for the first time; people who already know how to ride a bicycle may still need instruction and reassurance about the unfamiliar aspects of e-bike technology. An interviewee representing a bikeshare program in Wisconsin said some people who express curiosity about trying an e-bike "*feel that they don't know how to use it or that they don't want to look silly trying to figure it out*." Other new-rider concerns described by interviewees included discomfort with the higher e-bike speeds compared to pedal cycles, uncertainty about their stability on a heavier-weight bike, fear of riding close to traffic, and concern about the fire hazard of e-bike batteries. People with disabilities may not be aware of adaptive e-bike designs (e.g., electrically assisted recumbent bikes or handcycles) that could make e-bikes a viable option for them.

The bicycling community sometimes stigmatizes e-bikes as not being *legitimate* bikes. Some older adults who are experienced cyclists express reluctance to try an e-bike because they see it—as one interviewee described—as "*a threshold in the aging process that they don't want to cross*."

Community-level perceptions of e-bikes have become barriers to expanding e-bike use in some cities. Interviewees described some communities' negative prior experiences with poorly run bikeshare or scooter share programs and/or reckless and aggressive riding behaviors, which have fueled distrust of shared mobility, electrically powered devices, or both.

Individuals living in communities that are socioeconomically disadvantaged may distrust the introduction of new transportation modes and infrastructure (e.g., the installation of e-bikeshare stations/docks) in their neighborhoods. An interviewee from a local agency in San Francisco, California, described this concern:

> "*There are questions about bikes and gentrification in the city that can make people distrustful and unwilling to try out bikeshare. 'Who is this for? Is it serving our community, or someone else?' Neighborhoods who have a history of disinvestment are particularly sensitive to this*."

Chapter 5. Strategies for Addressing E-bike Barriers

Interviewees offered numerous examples of strategies that have been implemented or are planned to address the identified barriers to e-bike use. The strategies that were mentioned most frequently in the interviews are described according to the barriers that they are intended to address.

Addressing Safety Barriers

Strategies identified by interviewees for addressing safety-related barriers to e-bike use focus on infrastructure improvements to better protect e-bike riders and other vulnerable road users and policy changes and educational efforts to reduce harassment of e-bike users under existing law.

Rethink and Expand Bicycling Infrastructure

The most frequently recommended strategy for improving the safety of e-bike riders (as well as other vulnerable road users)—expanding bicycle/pedestrian/micromobility infrastructure in a community—was also recognized by interviewees as the most challenging to implement. In addition to increasing the number of roadway miles and the connectivity of bike-pedestrian lanes and trails, interviewees emphasized the need to physically separate those facilities from motor vehicle traffic and to provide adequate space or separation to allow e-bikes (and e-scooters, where applicable), pedal cycles, and pedestrians to coexist safely. An interviewee from a national nonprofit transportation research organization described two example scenarios for reconsidering bike-pedestrian facilities for micromobility:

> *"If you're going to put a separated bike lane on a normal arterial, maybe there's a regular bike lane and an e-bike lane. A lot of older adults like to bike on trails; consider the capacity of trails and make them 14–16 feet or wider*."

An interviewee from Seattle, Washington, described another consideration for the future of micromobility-friendly infrastructure:

> "*On a city planning level, we need to be thinking whom we're designing our roadways for now, versus whom we designed for in the past. A lot of existing bike lanes are very narrow and do not accommodate larger vehicles like e-cargo or family bikes. There's not enough room for a parent to ride alongside their child. There's not enough room for a faster-moving bike to pass a slower one. There are not many midblock locations where someone with a cargo bike could load and unload children or packages. These are all features that should be included in future developments to make the facilities usable by a wider variety of people*."

Interviewees identified several examples of cities that are redesigning infrastructure to improve safety: Seattle, Washington, is implementing trails with separate bicycle and pedestrian paths (Seattle Department of Transportation, 2017); Houston, Texas, is implementing 150 miles of traffic-separated, connected bike trails (Knapp, 2019); and Kansas City, Missouri, installed 20 miles of protected bicycle facilities over the past two years, with another 10 miles planned for the coming year (Bike KC, 2023).

Funding sources that communities have used to build bicycling and micromobility infrastructure—as identified by interviewees—included California's Active Transportation Fund, the Federal Transportation Improvement

Fund, Safe Routes to School, state-level clean energy and emissions reduction grants, and local traffic calming grants. An interviewee from a national bicycle-advocacy organization cited the success of the Final Mile partnership (https://finalmile.peopleforbikes.org/), which has been working to accelerate the construction of new bike lanes and bikeways in the cities of Austin, Texas; Pittsburgh, Pennsylvania; Providence, Rhode Island; New Orleans, Louisiana; and Denver, Colorado. At the federal level, the 2021 Infrastructure Investment and Jobs Act (IIJA) includes funding for expanding and connecting bicycle infrastructure in local communities (Mills, 2021).

Examine Laws Affecting E-bike Riders

Harassment of e-bike riders, by law enforcement or other road users, was identified by some interviewees as a safety-related barrier to e-bike use, particularly among people in the BIPOC community. Strategies for mitigating this barrier target the root causes for harassment of e-bike riders identified by interviewees, such as unclear or inconsistent rules about where e-bikes can travel, inadequate bicycling facilities, and unequal enforcement targeting marginalized groups.

An interviewee in Denver, Colorado, described how inadequate bicycling infrastructure can lead to riding behaviors that can make a rider more vulnerable to harassment:

> "*In the downtown, there have been a lot of complaints about sidewalk riding. Some of the riders who are new to e-bikes are still trying to get comfortable riding near traffic. You can't enforce rules (like no riding on the sidewalk) if you haven't provided the infrastructure to make the legal choice safe and convenient*."

Providing more and better infrastructure that can accommodate micromobility modes safely alongside other cycling and pedestrian travel was repeatedly identified in the interviews as an important strategy for mitigating both the traffic safety problem and the risk of harassment.

Other recommendations for minimizing conflicts and potential harassment included evaluating traffic laws that affect e-bikes and micromobility, eliminating laws that force people using micromobility modes into high-risk situations, and making laws as consistent as possible across a given region. An interviewee from Montgomery County, Maryland, provided an example to demonstrate:

> "*We had an instance where a cyclist crossed over a county boundary riding on the sidewalk, and was arrested and ticketed because one county allowed riding on the sidewalk and the other didn't. Making these laws more consistent will improve community-wide understanding and safety*."

Finally, continued education and awareness efforts are needed to address problems of unequal enforcement targeting people of color. One interviewee noted efforts by the Portland Bureau of Transportation to raise awareness about racial profiling and other forms of unequal treatment among bikeshare users in Portland, Oregon, as one example.

Addressing Cost Barriers

The interviews highlighted two different sets of strategies to mitigate cost barriers to e-bike use. The first set of strategies targets e-bikeshare users; the second set targets e-bike purchases for personal use.

Expand E-bikeshare Access Passes

The most frequently described strategy for increasing the number of e-bikeshare users was to heavily discount the cost of e-bikeshare for individuals with lower incomes. Most of the e-bikeshare programs operated by local agencies and nonprofit organizations represented in the interviews already use this strategy, offering discounted or free (in some cases) access to e-bikeshare to individuals who qualify on the basis of income and/or their eligibility for other financial assistance programs (e.g., Temporary Assistance for Needy Families[TANF], Supplemental Nutrition Assistance Program [SNAP], Federal Student Aid, or Medicaid). Funding to provide these discounts to eligible riders comes from a variety of sources. The American Rescue Plan and the Bipartisan Infrastructure Law provided funding to bikeshare programs in multiple communities that enabled e-bike purchases for bikeshare fleets as well as discounted fees for eligible riders (Bublr Bikes, 2022; White, 2022; North American Bikeshare and Scooter Share Association, 2024). Other e-bikeshare funding programs mentioned by interviewees included grants from the California Air Resources Board (2023) and from nonprofit organizations such as the American Heart Association (Herbert, 2022). E-bikeshare fee waivers and reductions for lower-income e-bikeshare customers were also funded in some programs by "full-price" e-bikeshare users. One interviewee described this strategy:

> "*A collaborative approach is key. The cost burden needs to be shared between the provider and the community. Rates for other bikeshare members and for casual, one-time users may need to be a little higher to subsidize the discounted rates for underserved communities*."

Expand and Prioritize E-bike Purchase Subsidies

At the time the interviews were conducted in late 2022 and early 2023, no programs subsidizing e-bike purchases existed at the federal level. Interviewees described a few state and local programs that offer rebates or other financial support for people purchasing e-bikes. In Colorado, the City of Denver's rebate program was repeatedly credited as one of the most successful programs; its two-tier structure offers higher purchase subsidies to e-bike purchasers with lower incomes (City and County of Denver, 2022). Utility companies in Vermont sponsor e-bike subsidies for e-bikes that will be used for transportation and that are purchased at shops in or near the state. The Vermont State Employees Credit Union also supports e-bike purchases with low-cost loans, and the VBike bicycle advocacy group offers guidance to potential e-bike buyers regarding purchases and financial aid programs (VBike, 2022). In Massachusetts, a $1 million bond was passed in 2022 that allows the State to provide rebates of up to 30 percent of an e-bike purchase cost (MassBike, 2022). Hawaii's state legislature adopted a bill during the most recent legislative session that offers e-bike credits; as of late 2022, the State was making arrangements with a third-party vendor to provide e-bike purchase rebates (Hawaii Department of Transportation, 2023).

As recommended by interviewees, strategies for expanding e-bike subsidies most frequently focused on designing programs to better assist lower-income people most in need of the transportation options that an e-bike provides but least able to afford the purchase. One interviewee suggested that, in addition to scaling purchase subsidies by income level, extra funds could be allocated to supply the necessary equipment (e.g., bike lights and helmets) and to subsidize repair services. Leasing programs for e-bikes (currently offered as a workplace benefit in some European countries) and workplace e-bike servicing (currently offered by employers including Google and Facebook) were also suggested as strategies that could boost e-bike use as a transportation mode.

Addressing E-bikeshare Program Access/Availability Barriers

Recommended strategies for increasing access to e-bikeshare programs included linking e-bike pickups and drop-offs to transit routes and existing community hubs and expanding bikeshare facilities into neighborhoods that are most in need of transportation options.

Link to Community Hubs and Services

In communities with public transit systems, placing stations along the major transit routes was a frequently suggested strategy for increasing first-mile/last-mile trips. In Boise, Idaho, bikeshare stations are being built along three premium bus routes. Similarly, in Montgomery County, Maryland, 10 bikeshare stations have been built at bus rapid transit (BRT) facilities, with more bikeshare stations planned along additional BRT corridors. The Capital Metro transit system in Austin, Texas, partners with BCycle to provide integrated transit and bikeshare services.

Interviewees also recommended locating shared e-bikes at other places where people are likely to go for services or as part of their daily routines, such as libraries, post offices, community centers, and areas with high residential density. Texas A&M University in College Station, Texas, provides bicycle racks (serving regular bikes, e-bikes, and other micromobility devices) outside campus residential and public buildings; the number of racks in each location is based on building occupancy numbers. The university's transportation office is pursuing a grant to provide e-vehicle charging stations near two major student housing areas and to add e-bike storage lockers in a central campus location.

Expand Services in Marginalized Communities

One obvious step to expand e-bike use in lower-income and other marginalized communities is to install e-bike stations and support infrastructure directly in these locales, as funding allows. Precinct 1 in Harris County, Texas, which encompasses one of the densest and poorest areas of Houston, partnered with Houston BCycle in 2020 to construct 30 bikeshare stations across the precinct. The original agreement included the purchase of 320 conventional bicycles; Precinct 1 has also secured funding for 100 e-bikes to be added to the bikeshare program. Denver, Colorado, has designated some lower-income and otherwise disadvantaged areas within the city and surrounding county as *opportunity zones*. The city's two bikeshare providers are required to deploy a certain percentage of e-bikes in opportunity zones; trips that start and end within an opportunity zone are discounted. Additionally, these bikeshare providers committed to distributing *5280* passes (named for the number of feet in a mile and in reference to first-mile/last-mile trips) to low-income individuals. These passes allow for a certain number of free unlocks of an e-bike.

Addressing Logistical Barriers

Logistical challenges relate to both inadequate e-bike storage and charging infrastructure and e-bikeshare system technical challenges. Recommended strategies for providing secure storage and charging facilities for e-bikes included supportive transportation and land use policy advocacy and partnerships with others on multiuse facilities. Recommended strategies for offering alternative reservation, checkout, or billing mechanisms for e-bikeshare systems that do not require a smartphone included in-person reservation options, key fobs for bike checkouts, and dedicated debit cards for unbanked people.

Include E-bike Support Infrastructure in Transportation/Land Use Policy

Interviewees discussed policy changes that are needed in many communities to expand the availability of safe e-bike storage and charging, particularly in dense urban areas. For example, New York, New York, recently converted some roadside parking spaces to secure e-bike storage facilities in the public right-of-way. Changing local policies to allow e-bike storage and charging facilities in apartments or public buildings is an important step in improving e-bike access and use in urban areas; this change must also include measures for preventing and mitigating potential fires from bicycle batteries.

Partner on Mobility Interests

Examples of existing partnerships identified by interviewees included partnerships with transit that allow for e-bike parking and lock boxes at transit stations and partnerships with existing secure storage facilities. A couple of interviewees expressed hopes that similar partnerships can be formed for the development of multimodal charging facilities that can serve the needs of electric cars, e-bikes, and other micromobility vehicles.

Provide Alternatives to Smartphone-Based Bikeshare Systems

A representative from a national bikeshare company described several options for accommodating potential e-bikeshare users who face barriers with app-based systems, including establishing payment accounts directly within the e-bikeshare system that do not require a credit card or bank account access, introducing alternative technologies (e.g., key fobs) for unlocking a bike, and initiating a phone-in customer service center. Biketown in Portland, Oregon, provides cards with radio frequency identification (RFID) technology for unlocking and checking out bikes and partners with the City and with a banking organization to create payment accounts for unbanked customers. Additional recommendations from interviewees included in-person customer service options and landline help desks to assist people who are uncomfortable with or cannot access app-based technologies.

Addressing Accessibility Barriers

Interviewees described several strategies for expanding the availability of adaptive e-bikes for people with disabilities or older populations. One strategy included purchasing or custom-engineering electrically powered versions of conventional adaptive bicycle designs, such as adult tricycles, bicycles with low stepover frames, recumbent bicycles, buddy bikes (tandem bicycles with rear-seat steering), and other tandem bicycles. Additional recommendations included equipping e-bikes with baskets or buckets to hold a rider's service animal, with wayfinding technology, and/or with audible alerts to warn visually disabled people of hazards or obstacles. A representative of a local transit agency that operates bikeshare services expressed a desire to better serve people who would benefit from an adaptive e-bike:

> "*Serving people with disabilities is something we have thought about for a while. We would like to create a bike library and offer unusual bikes like trikes, recumbent, tandems, and cargo bikes for checkout on a weekly or monthly basis*."

Addressing Awareness/Perception Barriers

Interviewees described their efforts to improve awareness and acceptance of e-bikes among prospective riders and within communities (including disadvantaged populations) and emphasized the interrelationship between public awareness and acceptance and e-bike policy.

Opportunity, experience, and education were identified as key elements of e-bike awareness and acceptance for prospective riders. One interviewee commented,

> "*All you have to do is put someone on an e-bike, and they start to smile. People don't really understand what an electric bike does, and when they ride one, they're super excited*."

Many of the bikeshare programs represented in the interviews bring e-bikes to public events, provide classes and workshops, and hold group rides to develop the confidence of new riders and to build communities around bikeshare. Some of the represented organizations offer specialized training for older adults and for people with disabilities, including education about adaptive e-bike designs.

Partner with Community Organizations

Working with established organizations in a community is a key outreach strategy for any e-bikeshare program or e-bike advocacy group, but this partnership becomes even more important when introducing e-bikes or other micromobility programs to disadvantaged communities. As one interviewee noted,

> "*How you approach groups matters. It matters what the message is, and who the messenger is. If I don't feel like the messenger can connect to my lived experience, the message will be less relevant. You don't want some person who looks like a rich bike racer telling a mom with a job and kids that she should be biking more*."

Partnering with local community organizations and services is also key to understanding the needs and challenges facing the community's residents before implementing a program. An interviewee who has worked in national advocacy organizations and city transportation agencies elaborated on this issue*:*

> "*BIPOC and other marginalized communities are often resistant to new things due to a long history of mistrust and programs that were 'planned for' instead of 'planned with.' The first time you visit a community shouldn't be when you're putting a station there. Involve them in the planning, and find out what they need, what the barriers are, what are their priorities, and what are they excited about. Bikeshare can be a good, affordable option for getting to work—do they need better work access? You need to meet people where they are—you need to reach not only bike enthusiasts but people who do not have bikes in their everyday lives*."

Recommended strategies for community engagement and needs assessment included conducting focus groups with members of community organizations, organizing local transportation advocacy coalitions, and hiring people from the targeted communities to help with program planning and implementation.

Chapter 6. Conclusions

The U.S. Department of Transportation (2021) has established a strategic plan to make transportation more accessible for everyone, including an initiative to "enhance opportunities for people with disabilities to walk, roll, cycle, and use micromobility services and other innovative mobility technologies." During the past few years, micromobility has shown promise for filling some of the gaps in community transportation systems. Micromobility vehicles and shared services have the potential to be particularly beneficial to members of two populations who often lack other options for daily transportation and active recreation: (1) people with mobility limitations related to age, disability, or health issues, and (2) people living in disadvantaged situations due to income, race, ethnicity, or other socioeconomic factors. E-bikes, sharing the same theme of providing "tiny personal mobility" but with different maneuverability, usage, and adoption patterns and rates can play a leading role in advancing these initiatives.

Use of any new mobility is associated with perceptions, attitudes, concerns, and barriers, and existing e-bike literature is limited in terms of understanding how the marginalized populations (and the public they would encounter while riding) perceive e-bikes, as well as which concerns and barriers should be addressed to fully realize the potential of this mode for these groups. Acknowledging that such understanding is crucial to inform relevant policy and initiatives, the research team reviewed the collective knowledge from the literature and various other resources. To ensure that e-bikes are a real mobility solution for all, a collaborative effort between communities, stakeholders, advocates, and various organizations is essential to address the unique transportation needs and challenges of communities, including marginalized populations. This collaboration should begin from the early stages of community planning and design, ensuring inclusive and accessible transportation for all.

This study highlighted the benefits that have already been realized by individuals and communities through the availability and use of e-bikes and the further potential that e-bikes and similar micromobility modes may have to improve personal mobility and health, reduce traffic congestion, and mitigate climate change by reducing vehicle emissions. Interviewees collectively identified dozens of benefits, barriers, and mitigation strategies pertaining to expanding the use of e-bikes in transportation and recreation. The themes that emerged from the analysis are listed in Table 2 and described below.

Table 2. E-bike Benefits, Barriers, and Mitigation Strategies – Themes from Expert Interviews

Organization Type	Topic Area	Theme
Businesses National agencies/ nonprofits Local agencies Local nonprofits	Benefits	Increased independence, access, and participation through mobility. "*The bike ride without the sweat*." Longer and faster trips. Greater inclusivity. Improved health and fitness. Enhanced sustainability. Boosted business.
	Barriers	Unsafe bicycling environments. Prohibitive costs and limited funding assistance. Limited e-bikeshare program access/availability. Wide-ranging logistical challenges related to e-bike storage/charging and technical issues. Unique impediments for people with disabilities and older populations. Lack of awareness and frequent misperceptions.

Organization Type	Topic Area	Theme
	Strategies	Rethink and expand bicycling infrastructure. Examine laws affecting e-bike riders. Expand e-bikeshare access passes. Expand and prioritize e-bike purchase subsidies. Link to community hubs and services. Expand service in marginalized communities. Include e-bike support infrastructure in transportation/land use policy. Partner on mobility interests. Provide alternatives to smartphone-based bikeshare systems. Conduct e-bike demonstrations, group rides, and training. Partner with community organizations.

The findings addressed a wide range of strategies that businesses, local agencies, and nonprofit organizations have already implemented or are planning to overcome barriers that potential e-bike users may face. While details of these strategies varied—reflecting the uniqueness of each community, e-bikeshare program, bike library, or rebate program—several overarching recommendations emerged, including the following:

- *Establish partnerships—partnerships are key.* Examples included public transit partnerships to adjust fares or provide facilities, community service organization partnerships to serve the needs of disabled and disadvantaged populations, library and community center partnerships to provide e-bike libraries, and public-private partnerships with bikeshare providers and bike shops to moderate costs. Interviewees repeatedly expressed the need for and benefits of partnerships in expanding the opportunities and support for e-bike use in a community.

- *Address accessibility.* Many accessibility barriers can be addressed directly by local e-bikeshare programs (e.g., by acquiring adaptive bikes for people with disabilities, providing alternative payment and checkout procedures, etc.). To effectively identify and prioritize accessibility barriers, the targeted communities must be involved in the process. The importance of partnerships was again emphasized in many of the interviewee recommendations for improving the accessibility and inclusivity of e-bikeshare programs—working through established advocacy and service groups to learn what each community needs.

- *Focus on community benefits.* The identified barriers to e-bike use emphasize the need for safer roadway infrastructure for all alternative transportation modes; for expanded funding for e-bikeshare programs and e-bike ownership (e.g., subsidies); and for policy decisions that support e-bike travel, storage, and charging needs. Overcoming these barriers requires the involvement of political decision-makers but also, fundamentally, the support of the community in which e-bikes operate. As one interviewee stated,

  > "*Often, city leaders don't have an accurate picture of what residents actually want from transportation. [Our organization] does a lot of surveys to find out this information, and we have never found a city with less than 60 percent support for building more bike trails around a community. There's support even among people who don't ride themselves—they want it for their kids, for their neighbors. This cuts across political affiliations; in some cities, there is 70–80 percent support. But this support is soft; it only exists to the degree that it doesn't inconvenience their own travel decisions. When you introduce things that remove control from people's daily schedules—like reduced downtown parking or less space for personal car travel—that support erodes. E-bike or not,*

the message is not about promoting bicycle use per se but about increasing alternatives and access. E-bikes give people some control back because they can ride farther and access more opportunities."

Continued outreach and education to community leadership, law enforcement, and road users will be key in normalizing e-bikes as a transportation mode.

This study significantly contributes to a critical yet often overlooked area, shedding light on important insights and advancing our understanding in this field. The expert interviews offered a range of perspectives from individuals involved in providing, funding, selling, or advocating e-bikes and micromobility in communities. What the interviews did not directly reveal are the perspectives of current or potential e-bike riders.

Building upon the insights obtained in this study, as a next step, researchers are currently in the process of elaborating on these findings through direct engagement with potential or current e-bike users, especially focusing on older adults (aged 65+) and adults with disabilities. This approach will also help validate findings on barriers and challenges and explore effective approaches for addressing them. The lack of national policy and funding mechanisms to support e-bike purchases, e-bikeshare programs, and adequate infrastructure provisions indicates a need for more research to quantify the benefits of e-bikes and similar micromobility modes to community mobility, economic, air quality, and congestion metrics. Further research is also needed to better understand the benefits and barriers associated with specialized e-bikes, including e-cargo bikes and adaptive e-bike designs for people with disabilities.

While this study solely focused on e-bikes as a significant but often overlooked *mobility enabler*, as new micromobility options continue to emerge, it is essential to carefully examine them within the context of fostering an inclusive transportation ecosystem. This entails recognizing and addressing differences, barriers, and solutions related to access and usage. Future research should aim to explore these evolving micromobility options and their potential contribution to creating a more inclusive and sustainable transportation system.

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