7-2022

Managing the Curb: Understanding the Impacts of On-Demand Mobility on Public Transit, Micromobility, and Pedestrians

Susan Shaheen
University of California, Berkeley

Elliot Martin
Mineta Transportation Institute

Adam Cohen
Mineta Transportation Institute

Jacquelyn Broader
Mineta Transportation Institute

Richard Davis
Mineta Transportation Institute

Project 1904 | July 2022

SJSU SAN JOSÉ STATE UNIVERSITY

MTI MINETA TRANSPORTATION INSTITUTE

Managing the Curb: Understanding the Impacts of On-Demand Mobility on Public Transit, Micromobility, and Pedestrians

Susan Shaheen
Elliot Martin
Adam Cohen
Jacquelyn Broader
Richard Davis

Mineta Transportation Institute

Founded in 1991, the Mineta Transportation Institute (MTI), an organized research and training unit in partnership with the Lucas College and Graduate School of Business at San José State University (SJSU), increases mobility for all by improving the safety, efficiency, accessibility, and convenience of our nation's transportation system. Through research, education, workforce development, and technology transfer, we help create a connected world. MTI leads the Mineta Consortium for Transportation Mobility (MCTM) funded by the U.S. Department of Transportation and the California State University Transportation Consortium (CSUTC) funded by the State of California through Senate Bill 1. MTI focuses on three primary responsibilities:

Research

MTI conducts multi-disciplinary research focused on surface transportation that contributes to effective decision making. Research areas include: active transportation; planning and policy; security and counterterrorism; sustainable transportation and land use; transit and passenger rail; transportation engineering; transportation finance; transportation technology; and workforce and labor. MTI research publications undergo expert peer review to ensure the quality of the research.

Education and Workforce

To ensure the efficient movement of people and products, we must prepare a new cohort of transportation professionals who are ready to lead a more diverse, inclusive, and equitable transportation industry. To help achieve this, MTI sponsors a suite of workforce development and education opportunities. The Institute supports educational programs offered by the Lucas Graduate School of Business: a Master of Science in Transportation Management, plus graduate certificates that include High-Speed and Intercity Rail Management and Transportation Security Management. These flexible programs offer live online classes so that working transportation professionals can pursue an advanced degree regardless of their location.

Information and Technology Transfer

MTI utilizes a diverse array of dissemination methods and media to ensure research results reach those responsible for managing change. These methods include publication, seminars, workshops, websites, social media, webinars, and other technology transfer mechanisms. Additionally, MTI promotes the availability of completed research to professional organizations and works to integrate the research findings into the graduate education program. MTI's extensive collection of transportation-related publications is integrated into San José State University's world-class Martin Luther King, Jr. Library.

Report 22-09

Managing the Curb: Understanding the Impacts of On-Demand Mobility on Public Transit, Micromobility, and Pedestrians

Susan Shaheen

Elliot Martin

Adam Cohen

Jacquelyn Broader

Richard Davis

July 2022

A publication of the
Mineta Transportation Institute
Created by Congress in 1991

College of Business
San José State University
San José, CA 95192-0219

TECHNICAL REPORT DOCUMENTATION PAGE

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
22-09		

4. Title and Subtitle	5. Report Date
Managing the Curb: Understanding the Impacts of On-Demand Mobility on Public Transit, Micromobility, and Pedestrians	July 2022
	6. Performing Organization Code
7. Authors	**8. Performing Organization Report**
Susan Shaheen 0000-0002-3350-856X Elliot Martin 0000-0001-5889-5781 Adam Cohen 0000-0002-7455-5442 Jacquelyn Broader Richard Davis	CA-MTI-1904
9. Performing Organization Name and Address	**10. Work Unit No.**
Mineta Transportation Institute College of Business San José State University San José, CA 95192-0219	**11. Contract or Grant No.** 65A0660
12. Sponsoring Agency Name and Address	**13. Type of Report and Period Covered**
California Department of Transportation 1120 N Street Sacramento CA 95814	**14. Sponsoring Agency Code**

15. Supplemental Notes

16. Abstract

In recent years, innovative mobility and shifts in travel and consumption behavior are changing how people access and use the curb. Shared mobility—the shared use of a vehicle, bicycle, scooter, or other mode—coupled with outdoor dining, curbside pick-up, and robotic delivery are creating new needs related to the planning, management, and enforcement of curb access. This study examines curb planning and management from several angles, such as safety, social equity, and multimodal connections. This research employs a multi-method approach to identify the changing needs for curb space management and how to meet these needs through new planning and implementation policies and strategies. As part of this study, the authors conducted 23 interviews. Respondents were chosen to represent public, private, and non-profit sector perspectives. Additionally, the authors employed a survey of 1,033 curb users and 241 taxi, transportation network company (TNC), and public transportation drivers. The study finds that changes in mode choice and curbside use can result in a variety of impacts on access, social equity, congestion, device management, pick-up and drop-off, and goods delivery, to name a few. The curb also has the potential to be disrupted by emerging modes, such as robotic delivery vehicles (also known as personal delivery devices) and automated vehicles. As these emerging developments continue to impact the curb, it is becoming increasingly important for policymakers to have an appropriate framework for planning and managing curb space in urban areas.

17. Key Words	18. Distribution Statement
Curb space management Shared mobility Shared micromobility Automated vehicles Last-mile delivery Outdoor dining	No restrictions. This document is available to the public through The National Technical Information Service, Springfield, VA 22161.

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price
Unclassified	Unclassified	138	

Form DOT F 1700.7 (8-72)

DOI: 10.31979/mti.2022.1904

Mineta Transportation Institute
College of Business
San José State University
San José, CA 95192-0219

Tel: (408) 924-7560
Fax: (408) 924-7565
Email: mineta-institute@sjsu.edu

transweb.sjsu.edu/research/1904

ACKNOWLEDGMENTS

This research has been generously funded by the Mineta Transportation Institute (MTI), California Department of Transportation, and the Transportation Sustainability Research Center (TSRC) of the Institute of Transportation Studies at the University of California, Berkeley. The contents of this report reflect the views of the authors and do not necessarily indicate sponsor acceptance. The authors also thank MTI staff, including Executive Director Karen Philbrick, PhD, and Deputy Executive Director Hilary Nixon, PhD.

CONTENTS

LIST OF FIGURES

LIST OF TABLES

Executive Summary

In recent years, innovative mobility and shifts in travel and consumption behavior are changing how people access and use the curb. Shared mobility—the shared use of a vehicle, bicycle, scooter, or other mode—coupled with outdoor dining, curbside pick-up, and robotic delivery are creating new needs related to the planning, management, and enforcement of curb access. This study examines curb planning and management from several angles, such as safety, social equity, and multimodal connections. This research employs a multi-method approach to identify the changing needs for curb space management and how to meet these needs through new planning and implementation policies and strategies.

As part of this study, the authors conducted 23 interviews. Respondents were chosen to represent public, private, and non-profit sector perspectives. Additionally, the authors employed a survey of 1,033 curb users and 241 taxi, transportation network company (TNC), and public transportation drivers.

The study finds that changes in mode choice and curbside use can result in a variety of impacts on access, social equity, congestion, device management, pick-up and drop-off, and goods delivery, to name a few. The curb also has the potential to be disrupted by emerging modes, such as robotic delivery vehicles (also known as personal delivery devices) and automated vehicles. As these emerging developments continue to impact the curb, it is becoming increasingly important for policymakers to have an appropriate framework for planning and managing curb space in urban areas.

Experts interviewed as part of this study indicated that if shared mobility is not properly planned, it could negatively impact curb access for all users. Increased demand for curb space could also create challenges for vulnerable populations and people with disabilities. Curb space planning and management that addresses competition among modes, uses, and users could help ensure safe and socially equitable access for all users.

The general population curbside user survey (n=1,033) administered in the San Francisco Bay Area from August 2020 to February 2021 asked questions about traveler behavior, modal interactions, wait times at the curb, safety considerations, and possible policy responses related to access and social equity. The respondents reflected the demographic makeup of the region relatively well, with slight departures in gender and educational attainment distributions. The top three modes included driving alone in a personal vehicle (71%), walking (71%), and TNCs (37%). The most commonly used public transit systems included MUNI (65%), AC Transit (36%), and SamTrans (25%). Respondents typically waited five to six minutes for MUNI and nine to ten minutes for public bus systems (e.g., AC Transit). Over half of respondents felt moderately or very safe waiting at the curb; however, their leading safety concerns included waiting at night (32%), crime (31%), and accidents (29%). When asked about the favorability of particular modal uses, respondents rated TNCs, taxis, and public transit more favorably than shared micromobility. Respondents felt that public transit is the only mode that should not pay fees to access the curb. Most respondents (70%) felt that access to the curb should be prioritized for certain vulnerable populations such as older adults (49%), persons with disabilities (47%), and pedestrians (46%). Respondents also felt that shared micromobility blocked curb space access more than other shared modes. Taken together, the results suggest that modes like courier network services, TNCs, taxis, and public transit are viewed favorably.

The driver survey (n=241), conducted in San Francisco from November to December 2020, revealed similar findings. The drivers deviated from the general population in the five demographic areas studied: income, education, age, race/ethnicity, and gender. Drivers tended to be younger, with lower education and income, predominantly male and less white than the general population. The survey asked a variety of questions including what services respondents had driven for, how many trips they typically made and where they generally began and ended, how COVID-19 impacted their rides (e.g., challenges, trip frequency and location, trip type), accidents and tickets, opinions on curb space access and management policies, and how to communicate with stakeholders. The survey revealed that respondents predominantly drove for taxi companies (79%) and Uber (33%). Currently, drivers typically complete 26 to 30 trips per day, and 29% and 25% of these trips end and start in San Francisco or Oakland, respectively. These travel patterns are similar to those that occurred prior to the COVID-19 pandemic (i.e., prior to March 2020). However, what drivers transport is changing in response to the global pandemic. Drivers increased their deliveries of food (from 62% pre-pandemic to 79% during the pandemic) and decreased passenger pick-ups and drop-offs (from 94% to 79% during this period).

Most respondents (81%) have not been involved in an accident while driving for mobility companies, but the majority (approximately 96%) had received some sort of ticket and/or citation. Drivers also provided information on a variety of challenges. Congestion, street parking, and locating the passenger were cited as the top three curb space access challenges. In general, the biggest challenge the drivers faced was congestion during pick-ups and drop-offs, but they also have concerns about safety for pedestrians and in the vehicle. The challenges they have faced have impacted drivers by causing them to avoid certain areas they drive in, serving different cities, and decreased feelings of personal safety. To address these strategies, drivers support increasing parking enforcement, dedicating zones for pick-up and drop-off, and implementing strategies for mitigating potential conflicts with other modes (e.g., pedestrians, bicyclists).

Collectively, the results of the literature review, expert interviews, user survey, and driver survey inform potential curb space strategies. Increased understanding of shared mobility's impacts can help improve curb space planning and design. Additionally, management practices (e.g., allocating locations for TNC pick-ups and drop-offs, leveraging pricing strategies) can improve curb space access and use. The MARVEL framework can support these curb space changes. The framework consists of six steps: (1) make a curb space plan, (2) allocate curb space, (3) regulate curb space access, (4) value curb space, (5) enforce curb space use, and (6) learn from curb space use. Each step of the framework and the associated strategies can help stakeholders better understand and improve curb design, access, and management.

1. Introduction

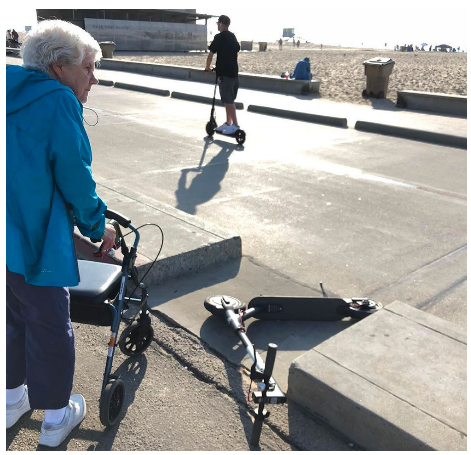
Curb space has been traditionally designed for parking private vehicles, public transit, and pedestrians. However, in recent years, a growing number of innovative mobility services are disrupting conventional curb space access and use. There is an increasing demand for passenger pick-up and drop-off, last-mile delivery, electric vehicle (EV) charging, and micromobility parking and use (e.g., bikes and scooters). Changing consumer modal preferences are also impacting other curb space users. For example, a transportation network company (TNC, also known as ridehailing and ridesourcing) driver may slow down mid-block looking for a passenger pick-up. If they are unable to find a loading zone or parking spot, a TNC driver may wait in the vehicle lane stopping vehicular traffic (Figure 1). (The services of transportation network companies or TNCs are also known as ridehailing and ridesourcing.) Or, in the case of shared micromobility, a user may drop off a scooter and park it in the middle of a curb, blocking access for pedestrians and people with disabilities (Figure 2). Table 1 provides definitions of common, innovative, and emerging shared modes that are increasingly changing how travelers interact with the curb. Additionally, the global pandemic is contributing to changing consumer preferences such as the growth of curbside pick-up, outdoor dining, and other innovations that alter the way people access and use the curb. These changes are contributing to a notable shift in how people are using and accessing the curb, and how communities are planning and managing curb space interactions.

This report is organized into seven chapters. Following the introduction, Chapter II reviews existing literature on curb space practices in North America. Next, Chapter III describes the research methods used for this report. Chapter IV then presents a summary of findings from the expert interviews. Next, in Chapter V, the report presents results from a curb space user survey. Chapter VI summarizes the findings of a shared mobility driver survey. Chapter VII presents a framework and strategies for managing the curb. The final section concludes with key takeaways and considerations for additional research.

Figure 1. TNC Blocking a Travel Lane

Source: Swan, 2019 and Inmci, 2018

Figure 2. Shared Scooter Blocking Access



Source: Swan, 2019 and Inmci, 2018

Table 1. Definitions of Common, Innovative, and Emerging Shared Modes

Modes	Definition
Bikesharing	A service that provides travelers with on-demand, short-term access to a fleet of shared bicycles, typically for a fee. Bikesharing operators typically own, maintain, and provide charging (if applicable) for the bicycle fleet.
Carpooling	The formal or informal sharing of rides between drivers and travelers with similar origin-destination pairings using vehicles of two to six passengers.
Vanpooling	The formal or informal sharing of rides between drivers and travelers with similar origin-destination pairings using vehicles of seven to 15 passengers who share the cost of a van and operating expenses and may share driving responsibility.
Carsharing	A service that provides travelers with on-demand, short-term access to a fleet of shared motor vehicles, typically through a membership, and travelers pay a fee for use. Carsharing service providers typically own and maintain the fleet and provide insurance, gasoline/charging, and parking.
Courier Network Service (CNS, or last-mile delivery)	A commercial for-hire delivery service for monetary compensation using an online application or platform (such as a website or smartphone app) to connect freight (e.g., packages, food, etc.) with couriers using their personal, rented, or leased vehicles, bicycles, or scooters.
Microtransit	A privately or publicly operated transit service that typically uses multi-passenger/pooled shuttles or vans to provide on-demand or fixed-schedule services with either dynamic or fixed routing. Microtransit vehicles have a capacity of more than six travelers.
Personal Vehicle Sharing (also known as Peer-to-Peer carsharing)	A service that provides travelers with on-demand, short-term access to a fleet of privately owned motor vehicles. Travelers pay a fee for use. Vehicle hosts and drivers broker transactions using an online-enabled application or platform (i.e., smartphone apps) provided by a personal vehicle sharing company. The company may provide resources and services to make the exchange possible (e.g., an online platform to facilitate the transaction, customer support, etc.). Personal vehicle sharing companies do not own or maintain a fleet of vehicles.
Scooter Sharing	A service that provides travelers with on-demand, short-term access to a fleet of shared scooters for a fee. Companies typically provide, own, maintain, and provide fuel/charging (if applicable) for the fleet. Scooter sharing typically includes two types of services: *(1) Standing Electric Scooter Sharing*: Uses shared scooters with a standing design with a handlebar, deck, and wheels that are propelled by an electric motor; and *(2) Moped-Style Scooter Sharing:* Uses shared scooters with a seated design, electric or gas-powered, generally having a less stringent licensing requirement than motorcycles designed to travel on public roads.

Modes	Definition
Shared Micromobility	The shared use of a bicycle, scooter, or other low-speed mode that enables users to have short-term access on an as-needed basis. Shared micromobility includes various service models and transportation modes, such as bikesharing and scooter sharing. These services models can include: *(1) Station-Based Micromobility*: A fleet of vehicles or devices that can only be picked up and dropped off at designated physical or digital stations within the operator's service area; *(2) Free-Floating Micromobility*: A fleet of vehicles or devices that can be picked up and dropped off anywhere in the operator's approved service area; and *(3) Hybrid Micromobility*: An operational model that blends characteristics of station-based and free-floating micromobility, allowing a fleet of vehicles or devices to be picked up and dropped off either at designated stations or anywhere in approved service areas.
Shared Automated Vehicles (SAVs)	Automated vehicles (AVs) that are shared among multiple users and can be summoned on-demand or can operate a fixed-route service like public transportation.
Shuttles	Shuttles offer a service typically employed using vans or buses that connect travelers from a common origin or destination to public transit, retail, hospitality, or employment centers. Human-driven shuttles are typically operated by professional drivers, and many provide complimentary services to the travelers.
Taxi Services	Taxi services provide travelers with pre-arranged and on-demand access to transportation services for compensation and pay a fee each time for usage. Travelers can typically access these rides by scheduling trips in advance by street hail or e-Hail. Street hail is done by raising a hand on the street, or standing at a taxi stand or specified loading zone. E-Hail entails dispatching a driver on-demand using a smartphone app.
Transportation Network Companies (TNCs, also known as ridehailing and ridesourcing)	A service that provides travelers with pre-arranged and on-demand rides for a fee using an online-enabled application or platform (such as smartphone apps) to connect travelers with drivers using their personal, rented, or leased vehicles. Digital applications are typically used for booking, electronic payment, and ratings.

Adapted from SAE International, 2021; Shaheen et al., 2016

2. Literature Review

The Institute of Transportation Engineers (ITE) defines the curb as the location where movement meets access, or more specifically, the strip of land between the road and nearby land uses (Institute of Transportation Engineers, 2018). Curb space planning can encourage multimodal access, reduce modal conflicts, support active transportation, aid parking and congestion management, and support public transit operations. Historically, curb space planning has focused on providing parking for private vehicles. Over the past two decades, curb management practices have undergone an evolution from auto-oriented policies that have tended to emphasize free parking and private vehicle use toward a greater focus on multimodal and active transportation. By the late 2000s and early 2010s in the U.S., the growth of shared and on-demand mobility began contributing to another shift in curb space planning and management. The curb now serves a variety of functions including movement of goods and people, public space, vehicle and device storage, and commercial opportunities (SFMTA, 2020b; Institute of Transportation Engineers, 2018).

To understand existing curb space functions, impacts, and management strategies, the authors reviewed North American and international literature, such as journal articles (where available) and reports from professional organizations and public agencies. Key findings from this review informed the expert interview protocol, survey design, and strategies for managing the curb. The authors supplemented the literature review with an Internet search focused on emerging practices and trends in response to COVID-19 and transportation technologies, such as automated vehicles and robotic delivery. However, given the evolving response to COVID-19, some curb space management practices may have been inadvertently missed or may have changed since the literature review was conducted.

This literature review is organized into two sections:

1) **Curb Space Changes:** This section summarizes the impacts of shared and innovative mobility and the COVID-19 pandemic on the curb.

2) **Curb Space Infrastructure and Design:** This section describes the role of curb space infrastructure and design, emphasizing safety and social equity.

Curb Space Changes

A growing number of modes and curb uses coupled with the impacts of the global pandemic are contributing to new approaches to curb space management. Today, the curb has to serve a variety of functions such as vehicle and device storage (including personally owned and shared vehicles and devices), outdoor dining and retail, greenspace, and other uses. The curb space impacts from shared mobility and the global pandemic are summarized in the following sections.

Shared Mobility Impacts

Shared mobility requires curb access for a variety of functions, including passenger and goods loading and unloading and device parking. However, shared mobility may also impact the environment, travel behavior, and society. An increasing body of anecdotal and empirical evidence documents the impacts of shared mobility on modal behavior. This in turn can impact how travelers' access and use the curb—although more research is needed, particularly to study contextual variables such as diverse neighborhood types and built environments (see Appendix C: Shared Mobility Impacts). Other impacts of shared mobility on curb space access and management are listed below and summarized in Table 2.

- **Congestion:** While shared mobility can provide more users with access to the curb, shared mobility can also increase demand for curb frontage and potentially induce trips that previously would have not been taken. Curb space interactions can also contribute to congestion: for example, congestion may be caused by drivers' who wait for available space in a loading zone or double park in traffic lanes to load or unload passengers or goods. In some cases, loading/unloading that blocks travel lanes and the circling of vehicles looking for proper loading zones may also contribute to increased congestion and higher vehicle miles traveled (VMT) (Erdhart et al., 2019).

- **Loading Zones:** A number of shared modes may require loading zones for passenger pick-up or drop-off and goods delivery. Demand-responsive services, such as TNCs and microtransit, may also contribute to loading zone demand. Some studies have found that dedicated loading zones have the potential to decrease cruising while searching for an available space from commercial vehicles by over 25% (Chiara and Goodchild, 2020). With the growth of curbside pick-up and last-mile delivery in response to the global pandemic, the addition of loading zones may become an increasingly important curbside management strategy (Charm et al., 2020).

- **Public Transit Operations**: Shared mobility may impact public transit operations, particularly when services block curb access for buses and light rail, which could impact safety and operational efficiency (Jiang, 2019).

- **Shared Micromobility Operations and Parking:** Bicycles and scooters may impact the curb in several ways, such as influencing where users ride and park devices. Strategies may be needed to manage the operations and parking of low-speed devices, such as designated areas for bicycle and scooter parking (e.g., corrals,[1] docks[2]) and dedicated infrastructure (e.g., bike lanes).

---

[1] Corrals are a painted or barricaded parking location for micromobility devices.
[2] Docks are street furniture into which shared micromobility devices can be inserted and locked. Some docks offer electric charging services for electric devices (e.g., e-bikes).

- **Vehicle Parking:** While shared mobility can reduce demand for private vehicle use, shared mobility also has the potential to reduce parking supply by repurposing it for other modes (e.g., shared micromobility parking, loading zones, etc.) (Shaheen et al., 2018).

Table 2. Shared Mobility Impacts on the Curb

Category	Potential Curb Space Impacts	Carpooling	Carsharing	Last-Mile Delivery	Microtransit	Shared Micromobiltiy	Shuttles	TNCs
Congestion Management	Greater curb space demand results in increased congestion in the area			X	X		X	X
	Vehicle occupancy increases and support for multimodal trips decreases congestion	X	X		X	X	X	X
	Services increase the number of curb space users	X	X	X	X	X	X	X
Loading Zones	Goods loading/unloading activity results in double parking			X				
	Services increase loading zone demand	X		X	X		X	X
	Passenger loading/unloading activity result in double parking	X		X	X		X	X
Public Transit Operations	Greater VMT and congestion cause public transit delays			X	X		X	X
	Loading/unloading of passengers or goods results in the use or blocking of public transit lanes	X		X	X		X	X
Shared Micromobility Operations and Parking	Devices require clearly defined space to operate (e.g., bike lanes)			X		X		
	Devices require dedicated space for parking, corrals, docks, or other infrastructure for storage					X		
	Improperly parked devices are a blight for the community		X			X		
Vehicle Parking	Drivers need a place to wait for their next trip (e.g., staging areas)			X	X		X	X
	Reserved parking spaces decrease operational space for other modes		X					
	Short-term parking is necessary for drivers while goods are loaded or unloaded			X				
	Vehicles require space for parking		X					

Sources: Cao et al., 2017; James et al., 2019; SFMTA, 2017; Shaheen et al., 2016; Shaheen et al., 2019; Shaheen and Cohen, 2020; and Turoń et al., 2019

Emerging Modes and Curb Space

Emerging modes such as automated vehicles, robotic delivery (sometimes also referred to as personal delivery devices or PDDs), and drone delivery will also likely impact the curb. The impacts of many of these emerging modes may be similar to the existing forms of shared mobility. For example, concerns about social equity, safety, and competition among modes, service providers, and different users are likely to be the same (Shaheen et al., Forthcoming). However, AVs could reduce the need for parking and increase curb availability for loading zones, other modes, and other uses (e.g., parklets) (Chai et al., 2020). Other emerging technologies, such as the use of precision docking (e.g., for public transit vehicles and shared AVs) could improve accessibility and safety for passengers accessing and egressing vehicles (ADA National Network, 2015).

Communities are beginning to develop strategies to prepare for these potential impacts. Some communities have defined permissible operational areas (e.g., the sidewalk and/or bike lane for personal delivery devices) and recommendations for when these devices interface with pedestrians, cyclists, and drivers (Yehezkel and Wu Troianos, 2020). Communities are also beginning to collect information on how AVs may impact the right-of-way. For example, Toronto, Canada is collecting information on the operational, safety, and equity impacts of AVs to help inform the development of emerging policy strategies (City of Toronto Interdivisional Automated Vehicles Working Group, 2019). Additionally, the Canadian Automated Vehicles Centre of Excellence (CAVCOE) is conducting AV trials in a variety of weather environments and use cases (e.g., platooned bus fleet, paratransit support) to better understand the impacts of AVs (CAVCOE, 2019).

COVID-19 Impacts

The global pandemic continues to impact modal behavior and curb use. The growth of telework/work-from-home, goods delivery, curbside pick-up, and outdoor dining is impacting curb space in a variety of ways. According to the Bureau of Transportation Statistics (2021), goods delivery increased from 38.8% in August 2020 to 58.9% in March 2021. These changing consumer patterns could be contributing to longer-term shifts in how people are accessing and using the curb. Charm et al. (2020) conducted a consumer survey of 2,006 individuals who were sampled to match the general U.S. population. The survey revealed that some retail options, such as purchases of home goods and food delivery, witnessed increases from previous years as large as 14% and 10%, respectively (Charm et al., 2020). Early indicators suggest that the pandemic may be contributing to a growth in e-commerce and delivery services that may continue after the pandemic (OECD, 2020). Table 3 summarizes the ways in which the pandemic may be impacting travel behavior and curb use.

Table 3. COVID-19 Curb Space Impacts

Decreased	Increased
Demand for TNCs which may reduce the need for passenger loading zones	Bicycle purchases and use, potentially resulting in greater demand for infrastructure (e.g., bike lanes, device storage)
E-scooter ridership and availability, possibly decreasing the number of devices parked and operating on curb space	Driving alone, which could increase congestion and demand for on-street parking
Interest in passenger AV technology potentially causing a shift to focus on other automated services (e.g., goods delivery)	E-commerce, which may grow demand for goods loading and unloading
Public transit ridership, which may lead to the redesign of curb space (e.g., allowing microtransit vehicles to access public transit loading zones during off-peak hours)	Goods and meal delivery, possibly increasing loading zone demand
Transportation and travel, possibly leading to decreased curb space demand and use	Interest in automated delivery services, potentially increasing the need for curb space management strategies that dictate how different modes can access the curb
	Tactical urbanism (i.e., low-cost, temporary changes to the built environment), potentially altering existing curb space uses
	Telework/work-from-home, possibly shifting how curb space is used (e.g., outdoor dining options instead of longer-term parking)

Source: Urbanism Next, 2020

In response to some of the travel behavior changes that have occurred during the pandemic, officials in Denver, Colorado closed 5.5 miles over eight roads to repurpose them for active modes (Figure 3). Similarly, officials in Oakland, California began closing and repurposing a total of 74 miles of streets into "Slow Streets" (sometimes referred to as "Safe Streets" or "Healthy Streets") (Figure 4). Many of these street adaptations can be implemented through low-cost, low-tech measures including traffic cones and A-frame signs communicating new uses for curb space and the right-of-way. Additional information on how different locations are shifting their curb space use in the short- and long-term in response to COVID-19 can be found at COVID Mobility Works, Complete Streets + COVID-19, and COVID-19: Local Action Tracker.

Figure 3. New Colorado Bike Lane

Source: Leyba, 2020

Figure 4. Slow Street Model

Source: National Association of City Transportation Officials, n.d.

Curb Space Infrastructure and Design

Curb infrastructure and design can help address some of the impacts of shared mobility and the pandemic on curb space management while improving safety and social equity outcomes. The following sections describe the impacts of shared mobility on safety and social equity, as well as potential ways to address these challenges through infrastructure and design.

Safety

Shared mobility can have a variety of safety impacts for curb users, including pedestrians, vehicle operators, individuals waiting for public transit, and so on. For example, Shaheen et al. (2020), Brown et al. (2020), and the Institute of Transportation Engineers (2018) identified the following cross-cutting safety challenges across multiple shared modes:

- Employer shuttles can create safety concerns during passenger loading and unloading
- Improperly parked devices can block travel lanes and cause safety concerns
- Untrained drivers, increased traffic volumes, and traffic violations (e.g., double parking) associated with TNCs can pose safety risks to other curb users
- Passenger loading in unsafe areas can impact the safety of drivers and riders
- Riders with limited experience and understanding of regulations can create safety concerns for themselves and adjacent curb space users.

The following subsections discuss safety concerns associated with TNCs, shuttles, and shared micromobility.

Transportation Network Companies and Shuttles

TNCs and shuttles can contribute to curb safety concerns, such as conflicts with active transportation (e.g., bikesharing users, pedestrians) and other vehicles (e.g., public transit buses, personal vehicles). Between April 1 and June 30, 2017, the San Francisco Police Department recorded 2,656 traffic violations within the city, of which approximately 64% (1,723 violations) were issued to Uber and Lyft drivers (Brinklow, 2017). Common violations included driving in or obstructing a public transit lane and not yielding to pedestrians (Brinklow, 2017). Similarly, Brown et al. (2020) studied five American cities and found that TNCs, taxis, and delivery and commercial vehicles accounted for 64% of traffic violations. The violations included double parking to load and unload passengers and goods, parking in "No Parking" areas, and blocking driveways. Blocking travel lanes or driveways can cause other drivers or travelers to move into less safe locations (e.g., bicyclists moving from the curb to vehicle travel lanes, or drivers veering into other lanes) (Brown et al., 2020). In San Francisco, employer shuttles have also contributed to a number of safety concerns such as double parking (i.e., stopping in the travel lane adjacent to parked vehicles) (SFMTA, 2015). The San Francisco Municipal Transportation Agency (SFMTA) has implemented a Commuter Shuttle Program to designate appropriate loading zones for employer shuttles to minimize potential conflicts with public transportation. The program currently has 125 stop locations, 14 permitted shuttle providers, specified arterials for vehicles longer than 35 feet, permit requirements, and safety education components (SFMTA, 2017; SFMTA, 2020a).

Shared Micromobility

Bike and scooter sharing may result in several safety concerns, including:

- Unsafe riding behavior from users who do not understand regulations
- High numbers of traffic violations and unsafe behaviors from users
- Improperly parked devices that block access for other curb users.

A lack of understanding of shared micromobility regulations can result in unsafe riding behavior that could impact pedestrians walking on the curb. Fang et al. (2019) completed a survey of 181 shared micromobility users and non-users and found that a high percentage of riders (43%) and non-riders (63%) did not know where devices could be ridden (e.g., sidewalk, trails). Martin et al. (2016) conducted four focus groups with bikesharing members and non-members and found that non-bikesharing users felt threatened by bikesharing users constantly switching between riding on the curb and road.

Further, shared micromobility users may not know how to safely operate devices, or they may not want to. Research on Hawaii's Biki bikesharing service found that bikesharing users were more likely than other cyclists to commit traffic violations, potentially resulting in safety concerns for riders, drivers, and pedestrians (Kim et al., 2021). Research on bikesharing safety behavior at the University of Tennessee, Knoxville identified unsafe behavior and high numbers of traffic violations from bikesharing users, including traditional and electric bicycle users (Langford et al., 2015). Both traditional and electric bicycle riders rode the wrong way about 45% of the time. Both types of bike users (pedal and e-bike) violated stop signs at controlled intersections at a similar rate with higher violation rates at faster speeds. Bicycle and e-bike riders violated signalized intersections at similar rates: approximately 70% of the time (Lanford et al., 2015). Traffic violations and unsafe rider behavior can adversely impact pedestrians and vulnerable populations such as older adults and families with young children (Fang et al., 2019).

Scooter sharing can also present numerous safety concerns if the devices are not operated correctly: scooters are generally small enough to maneuver around pedestrians, too fast for sidewalk riding, and too slow and too small for safe operation alongside motor vehicles. These characteristics may cause a scooter rider to change where they ride based on their surrounding environment, creating confusion for pedestrians and drivers (Cicchino et al., 2021). An observational study of rider behavior in Los Angeles, California showed that the presence of scooters and high traffic volumes increased the risk of interactions among scooter users, pedestrians, and drivers (Todd et al., 2019).

Shared micromobility devices can also pose safety risks if they are not properly parked. Using an observational study of 606 parked micromobility devices, Turoń et al. (2019) found that 28% of devices were not parked upright, 23% blocked the pedestrian rights-of-way, and 22% blocked private property. Other research has found that shared micromobility devices can block access to street furniture (11%), fire hydrants (6%), bus stops (3%), vehicle rights-of-way (1%), and bikesharing stations (1%) (James et al., 2019). Improperly parked devices that block access to parking spots and travel lanes may force travelers to change their travel (e.g., veer into another lane, or switch to bicycling on a sidewalk).

Regulations can also impact safety outcomes (Anderson-Hall et al., 2019). Throughout the U.S., micromobility devices are typically regulated differently, and often, there is inconsistent guidance for the speed at which devices can be operated as well as the permissible locations. Developing uniform regulations indicating where devices are allowed to be ridden and at what speeds could help reduce rider confusion and encourage compliance with policies intended to improve safety outcomes (Fang et al., 2019). For example, in Seattle, the city's department of transportation established curbspace design and management guidelines intended to facilitate walking as a safe, attractive, and viable travel mode and allow pedestrians to access their destinations, including shared modes and micromobility, public transit stops, workplaces, recreation facilities, schools, and residences. Seattle's policies instruct dockless micromobility users to park devices adjacent to landscaping and street furniture, lock devices to a bicycle rack, or park devices in designated corrals (i.e., painted areas approximately the size of a vehicle parking space designated for micromobility parking) (Seattle Department of Transportation, 2019b).

Social Equity

Although shared mobility may increase access to mobility and goods, it can also impact curb access for vulnerable populations (e.g., older adults, people with disabilities). In a survey of San Francisco residents with a disability, almost 75% of participants reported access concerns due to improperly parked micromobility devices (Ruvolo, 2020). Blocked access to the curb may also pose a challenge for accessible vehicles, such as paratransit, that may require unimpeded access to the curb as well as ramps (Figure 5) (ADA National Network, 2015).

Figure 5. Scooters Blocking a Pedestrian Path

Source: Shyrock, 2018

In addition to physical accessibility, some curb space strategies may also adversely impact social equity. For example, curb pricing strategies (e.g., dynamically priced parking fees) may disproportionately impact low-income drivers and limit their mobility options (Shaheen et al., 2019). Additionally, parking navigation tools (e.g., apps that help drivers locate and navigate to available parking spots) may be inaccessible to those without smartphones, data plans, and/or technology fluency. These apps may also prioritize driving over shared mobility, such as active and public transportation (Shahen et al., 2019). Potential equity impacts of curbside management are summarized in Table 4.

Table 4. Potential Curb Space Social Equity Impacts

Impacts	Carpooling	Carsharing	Last-Mile Delivery	Microtransit	Shared Micromobiltiy	Shuttles	TNCs
Access to buildings and curb space is blocked by improperly parked devices or vehicles					X	X	
Devices or vehicles are not designed to accommodate different physical or cognitive mobility needs	X	X	X	X	X	X	X
Drivers waiting for passengers block access to the curb and/or loading zones				X		X	X
Greater curb space demand results in increased congestion in the area			X	X		X	X
Individual mobility increases by having service gaps filled at the curb (e.g., first- and last-mile connections)	X	X		X	X	X	X
Mobility option requires English proficiency/fluency to operate	X	X	X	X	X	X	X
Service areas do not include all neighborhoods, excluding some individuals	X	X	X	X	X	X	X
Services require a smartphone, data plan, Internet connection, and/or financial service (e.g., credit card) to access them	X	X	X	X	X	X	X
Vehicles and devices can block accessible vehicles from accessing the curb and unloading passengers using a wheelchair ramp, kneeling bus (i.e., a bus that can lower its height to meet a curb), etc.	X		X		X	X	X

A number of public agencies have developed policies, programs, and boards intended to address these challenges. For example, the Seattle Department of Transportation (SDOT) established a Curb space Access Sounding Board to provide local organizations an opportunity to discuss curbside policy and access issues that affect them and their businesses, customers, visitors, employees, and other stakeholders (Seattle Department of Transportation, n.d.). The board includes a variety of stakeholder perspectives such as SDOT employees (e.g., Director, Parking Strategist) and representatives from different community and neighborhood organizations (e.g., Commute Seattle, Seattle Restaurant Alliance, Hillman City Business Association).

Other public agencies, such as SFMTA, are using different approaches to address concerns about curb space equitycurb space. SFMTA identified social equity as a core component of the agency's Curb Management Strategy. This plan emphasizes accessibility and proposes a number of policy actions. Key policies proposed include maximizing loading zone accessibility (e.g., adding curb ramps, evaluating the street grade), establishing paratransit loading zones, replacing flag stops (i.e., where public transit vehicles are adjacent to parked cars) with bus zones, and developing guidelines to identify locations where bus zones are needed (SFMTA, 2020b). SFMTA is also using mobility services, such as carsharing, to ensure on-street parking spaces are available to users other than single private-vehicle owners (SFMTA, 2017). Other agencies encourage social equity by requiring service areas to cover entire neighborhoods or cities and rebalancing fleets when vehicles or devices cause curb space or parking disruptions that can adversely impact access (Shaheen et al., 2019).

Key Takeaways

Shared mobility can result in a variety of curb space impacts, such as increasing demand for the curb and competition for curb access among more users, modes, and functions. The global pandemic is also impacting the curb by reducing demand for commuting and increasing demand for other services and curb space uses (e.g., curbside pick-up and outdoor dining). These impacts can be addressed through curb space infrastructure and design changes. Curb space infrastructure can also help address safety concerns, such as those from TNCs and shared micromobility, and improve equity outcomes.

3. Methodology

In this study, the authors employed a multi-method approach to developing a curb space management framework. This approach employed three key steps.

1. Expert Interviews. The authors conducted 23 expert interviews from September 2019 to September 2020 to better understand the need for and role of curb space management, opportunities and challenges from the public and private sector perspectives, and issues related to the COVID-19 pandemic. The research team developed an expert interview protocol for subject matter experts and senior-level officials involved in curb space management, policy, and planning. The experts represented academia, non-profit organizations, public and private sectors, community-based organizations, and shared mobility service providers (including carsharing, shared micromobility, microtransit/shuttles, TNCs, and AVs). Each of the interviews lasted approximately one hour. Twenty of the expert interviews were conducted prior to the outbreak of the COVID-19 pandemic (between Fall 2019 and Spring 2020), and in Fall 2020, the authors conducted an additional three expert interviews. These latter interviews focused on the impacts of COVID-19 on curb space access with public transportation officials in the San Francisco Bay Area. A complete list of participating organizations can be found in Appendix A: List of Interviewees. A copy of the expert interview protocol is included in Appendix B.

   As with any qualitative research, the insights from the experts may not be entirely unbiased. To attempt to mitigate potential bias, experts were asked standard questions, and an effort was made to interview multiple experts (n=23). Additionally, all interview responses were aggregated for the analysis to ensure the objectivity of the final results.

2. User Surveys. To better understand how people use the transportation modes at the curb, a general population survey was deployed to people within the San Francisco Bay Area between August 2020 and February 2021. About 80% of the sample lived within San Francisco and Oakland. The survey contained questions about respondent demographics, home and work location, use of different transportation modes, travel impacts related to the COVID-19 pandemic, and questions related to how people engaged with travel modes at the curb. The response to these questions helped inform the behavioral side of the research: understanding how people interact with the curb when engaging with public transit and other modes within an urban environment.

   The survey sample size included 1,033 respondents. The survey design was intended to align with the American Community Survey distributions of several demographic attributes of the populations within San Francisco and Oakland, including age, gender, race/ethnicity, income, and education. The survey data collection was gradual: quotas were filled over time to ensure alignment with the population as closely as possible. This gradual process enabled a better match to the population and the match to the population distributions was exact. Certain demographic cohorts are harder to acquire than others, and toward the end of recruitment, the process can become tailored to achieving specific demographic quotas. For example, if quotas remain open for respondents of high income and young age, but closed for most other categories, then qualifying respondents for the remaining period of recruitment must simultaneously meet both attributes. Ultimately, demographic quotas needed to be relaxed by some margin to achieve a sufficient sample size. Hence, the final sample population exhibits some misalignment from the general population.

Despite the insights the user survey provided, it faced some limitations. First, participation was voluntary, which can skew participation toward users who were interested in the research topic. Additionally, the information was self-reported, so respondents may have exaggerated or underreported their use of certain modes and/or may have failed to properly recall the travel details covered in the survey. Lastly, the participation was limited to the San Francisco Bay Area, and the results may not be generalizable to other areas.

3. Driver Surveys. In late 2020, a survey was distributed to drivers of TNCs, taxis, microtransit, and other courier delivery services. The survey was distributed to subscribers of the Rideshare Guy's3 newsletter. An initial invitation was sent in late November 2020, and a single reminder message was sent about one month later in December 2020. A total of 241 respondents completed the survey. The survey asked questions about the services for which the respondents drove and their experiences in delivering transportation services before and during the COVID-19 pandemic. The survey also asked questions about the specifics for drop-offs and pick-ups and associated challenges, days and hours of driving, and the time-dependent difficulties of accessing the curb. Among other questions, the survey also asked drivers' opinions about principles and priorities with respect to accessing the curb, as well as policies for improved curb management. Finally, the survey solicited the demographic data of survey respondents.

   The driver survey faced the same limitations as the user survey. Survey participation was voluntary, potentially skewing the results to those who are interested in this topic. The information provided by the drivers was self-reported, which may have resulted in some inaccuracies. Additionally, the drivers served the San Francisco Bay Area, so their perspectives, the opportunities and challenges faced, their preferred strategies, and other findings may not be applicable to other locations.

[3] The Rideshare Guy is a blog that helps educate TNC and delivery drivers.

4. Expert Interviews

A total of twenty-three expert interviews were conducted between September 2019 and September 2020 to understand a variety of stakeholder perspectives on shared mobility, public transportation, vulnerable populations, and curb space management. The questions covered a variety of topic areas including the impacts of shared and emerging mobility on best practices for curb space management, the role of data and metrics to monitor curb space performance, and long-range views of curb space planning. This chapter reviews the findings of these expert interviews and is organized into five sections:

1. Shared Mobility Curb Space Impacts
2. Curb Space Management Policies and Practices
3. Data and Curb Space Management
4. Potential Curb Space Management for Automated Vehicles
5. Long-Range Curb Space Planning.

Shared Mobility Curb Space Impacts

Experts were first asked about their perceptions regarding interactions between shared mobility and public transportation at the curb. This section summarizes the expert insights on TNC, shared micromobility, and public transportation curb space interactions.

TNCs and Curb Space Impacts

The experts interviewed discussed a variety of impacts of TNCs on rights-of-way access and public transportation, such as increased traffic congestion in urban areas and curb space availability. Public sector experts generally believed that TNCs contributed to traffic congestion by loading at bus stops or in a traffic lane. This was especially common during high-traffic events, such as state fairs and sporting events. One expert discussed a study conducted by SFMTA which found that TNCs accounted for approximately half of the increase in congestion in the region between 2010 and 2018, negatively impacting public transit operations. TNCs and public transit often share a common challenge: gaining access to a loading area away from moving traffic that is safe for riders and drivers. However, public sector experts noted that TNCs benefitted from designated curb space for safe and legal passenger loading at or near public transit stops in downtown areas.

Shared Micromobility and Curb Space Impacts

Experts reported a number of impacts from shared micromobility on curb space access. Public sector and academic experts discussed how dockless micromobility introduced challenges regarding where dockless devices should be parked and/or ridden (e.g., on the curb, or in bike or traffic lanes). Several experts also expressed concerns for the safety of vulnerable populations (e.g., people with visual disabilities, older adults) who may be at risk when fast-moving scooters and bikes are ridden on sidewalks. While some public sector experts voiced concerns that improperly parked dockless devices could block ADA access on sidewalks and at bus stops (Figure 6), they also believed that corrals (e.g., painted or geofenced parking locations) and docking stations could reduce the frequency of parking concerns (Figure 7).

Figure 6. Improperly Parked LimeBikes in Dallas

Source: McFarland, 2018

Figure 7. Shared Micromobility Corrals (Left) and Docks (Right)

Source: District Department of Transportation, 2019b and Gauqelin, 2019

Curb Space Management Policies and Practices

Experts were asked about best practices for managing curb space between shared modes and public transit. The experts generally agreed on four best practices: (1) creating designated space for shared modes; (2) pricing curb space access; (3) enforcing proper use of the curb; and (4) providing signage, markings, and in-app messaging to enhance communication about curb space management. The following subsections describe these strategies in greater detail.

Designated Space for Shared Modes

Many of the strategies experts discussed involved reallocating existing curb space for shared mobility, such as repurposing parking for shared micromobility. Generally, experts agreed that curb space access should prioritize higher-occupancy modes (e.g., public transit, publicly funded microtransit) and active transportation (e.g., walking, bicycling). The next priority should be shared vehicles and rides (e.g., TNCs, carpooling, carsharing), and the last priority should be the parking or loading/unloading of private vehicles. However, the experts noted that specific priorities may vary based on nearby land uses. For example, a block with a high number of restaurants, bars, and hotels may prioritize loading zones for taxis and TNCs. Several experts mentioned that some communities have adopted transportation plans that promote public transit and shared mobility over single-occupant vehicles, but curb space policies have been slow to adapt to these changes.

Public and private sector experts both expressed support for increasing the availability of TNC loading zones to reduce the potential for conflicts in travel lanes. Experts identified three areas for designated shared mobility zones: (1) public transit hubs, (2) downtown/nightlife/peak traffic areas, and (3) dense urban areas. Additionally, several public sector experts highlighted the potential to reduce congestion by converting parking to loading zones in entertainment districts. One public sector expert described a local business association that started a TNC loading zone pilot in a nighttime entertainment district because TNCs had been attributed to increased traffic congestion and interference with nearby bus stops. However, this expert did not have data to determine whether the pilot had succeeded. One of the experts described a 2017 demonstration by Washington, D.C.'s Department of Transportation piloting Pick-Up/Drop-Off (PUDO) zones in areas of the city that experienced congestion due to competition for curb space and travel lanes. In PUDO zones, parking spaces were repurposed for loading zones during certain times of the day. The purple lines in Figure 8 depict the PUDO Zone in the DuPont Circle neighborhood where parking spaces became loading zones from Thursday evening to Sunday morning.

Figure 8. Area Map for Washington, D.C.'s Nightlife Parking Demonstration (2017)

Source: Shared-Use Mobility Center, 2017

The experts interviewed said these zones can help decrease congestion because passengers generally prefer to be picked up and dropped off very close to their origins and destinations and are reluctant to walk to a nearby unfamiliar street, particularly at night. Curbside loading areas could also be shared between public transit and shared mobility operators and subdivided based on frequency of use. These areas could have overlapping segments that multiple modes share during periods of peak congestion. Several experts also noted the length of loading zones should be much longer than the length of the vehicle to ensure drivers pull up to the curb rather than stop in the traffic lane. Coordinating with shared mobility service providers (e.g., TNCs) to help identify designated locations at rail stations and other areas can help prevent conflicts with other modes. Additionally, public and private sector experts noted that curb space could be allocated at bus stops or transit centers for microtransit or TNCs, supporting late-night connectivity to fixed-route public transit.

One public sector expert said that converting parking to loading could also help manage delivery services (e.g., UberEats, Doordash) during peak demand hours. The expert explained that restaurant patrons and delivery drivers are competing for scarce curbside access, contributing to a growing number of conflicts in the time of COVID-19. Some experts suggested that designating "food hub areas" (i.e., locations where different restaurants consolidated their to-go orders for couriers to pick up) could help resolve conflicts during peak demand, although this concept has not yet been tested.

Several public and private sector experts believed that some on-street parking dedicated to privately owned vehicles could be repurposed exclusively for shared mobility. For example, one expert said that designating 230 parking spaces for carsharing in New York City (out of an inventory of approximately three million parking spaces) represented an easy way for the public sector to support shared use of the curb and promote shared mobility. According to the expert, the vehicles parked on the street were among some of the highest utilized vehicles in the city's carsharing fleet.

Most experts agreed that expanding infrastructure for micromobility, such as protected bicycle lanes and boulevards, could serve the dual purpose of enhancing safety and minimizing curbside conflicts. For example, one expert noted that many locations in the United States are building more sidewalks (particularly in suburban areas), and this may be an important strategy for enhancing access and safety for pedestrians, micromobility users, and drivers.

Some experts believe that shared micromobility policies need to be tailored to land use, urban density, and transit connectivity. According to one expert, dockless micromobility is better suited to suburban areas (e.g., a user ends a trip by locking the bike to a streetlight or a public bike rack) while station-based micromobility may be more appropriate in dense downtown areas with more pedestrian and vehicular activity. Experts supported the addition of stations for dockless devices (Figure 9) and/or parking policies that require dockless devices to be parked in docking stations at transit hubs.

Figure 9. LA Metro's Proposed Dockless Scooter Parking Station

Source: Metro Presentation, 2019

Pricing

Generally, experts supported some type of curb space pricing, such as parking permits or access fees, to help manage demand and promote shared mobility. Private sector experts emphasized that curb space pricing that incentivizes higher-occupancy modes (e.g., cheaper tolls) should be applied to all personally owned vehicles and TNCs. Several public sector experts mentioned San Francisco's dynamic parking pricing pilot, SFpark. By adjusting prices with demand for on-street parking, SFpark used a market mechanism to promote the availability of parking throughout the day. Experts also discussed the need for the public sector to overcome misperceptions that have prevented communities from repurposing parking for shared uses and public spaces. For example, many communities view metered parking as sacrosanct because of its importance in generating revenue for local governments. However, not all communities share this view. One expert gave an example of a recent initiative in Vancouver, Canada, where carsharing vehicles receive two free hours of metered parking. In this particular case, Vancouver prioritized curb space access for shared mobility above the revenue potential the parking space could generate.

Enforcement

Experts also proposed strategies focused on enforcing curb space policies. Experts believed that effective enforcement has three components: (1) rider education, (2) driver education, and (3) penalties for infractions. A period of educating drivers, passengers, and/or micromobility users about policy changes should precede fines or more severe measures, such as towing. One public sector expert found that, in most instances, a conversation with a traffic officer at the curbside was sufficient to help drivers understand important curbside policy changes. Experts also agreed that clear enforcement policies, such as citations, administrative fees, permit suspension or revocation for vehicles/devices, and impounding promoted compliance with curbside policies. Several experts thought enforcement was a deterrent for improper behavior. Areas that generate a lot of enforcement revenue should be closely evaluated for issues, such as unclear signage and poor lane markings that could contribute to systemic curb space violations.

Several experts supported incentive-based policies to encourage regulatory compliance (e.g., providing a fleet operator an incentive for ensuring timely device parking and fleet rebalancing). For example, an operator would have a minimum required time to correct parking violations and rebalance micromobility fleets. However, if the operator exceeded the minimum times required to correct these violations, they could be eligible for some type of incentive (e.g., an increase in fleet size).

Signage, Markings, and In-App Messaging

Experts agreed that distinct signage, markings, and in-app messaging promoted safe curbside access for shared modes (see Figure 10). Several public sector experts believed that real-time Global Position System (GPS) data could be effective in determining whether a vehicle or micromobility device was stopped or parked in generally the right area, and it could improve parking compliance by preventing a trip from ending in a defined geographic area (the principle behind geofencing). However, one private sector expert regarded geofencing as a best practice for designating loading locations at airports, transit centers, sports stadiums, concert venues, and other high-traffic areas. This expert noted that geofencing could effectively restrict pick-up areas, but drop-off was often the result of a conversation between passenger and driver. Other private sector experts did not specify geofencing as a best practice.

One public transit agency interviewed used brochures, how-to videos, and instructions posted on the agency website to instruct drivers and passengers to use designated TNC pick-up and drop-off zones rather than bus areas. This agency also used bright yellow signs, distinct from their standard signage, to indicate new loading zones that might be unfamiliar to drivers or passengers.

Additionally, one expert highlighted the need for TNCs and transit agencies to coordinate on using consistent and current digital maps because an agency may change their curb space in response to construction and maintenance. This would help provide curb space users with accurate information and support increased compliance with regulations requiring parking and loading in designated areas.

Figure 10. Signage for TNC Pick-up at Los Angeles International Airport

Source: Fallon, 2018

Data and Curb Space Management

Curb space demand data may be used to help manage curb space and develop policies. Experts interviewed said that public agencies should establish clear curb space priorities and request appropriate data to monitor key performance metrics. Operations data provided by shared mobility service providers, particularly time-of-day and geographic location, could be exchanged for curb space access. Similarly, sharing data interdepartmentally within agencies can also improve curb space management. A centralized repository could help to track key data points, such as locations with a high-volume of safety incidents which could be used to help inform curb space planning and management decision-making.

Experts noted some difficulties with data sharing, such as in the case of a service provider that shares data in a format that is difficult to comprehend without some type of formal training. For example, one expert discussed receiving data from a TNC that used Coordinated Universal Time (UTC) and street addresses without city names, making the data set unusable. Additionally, experts noted that some service providers share data in a PDF document rather than a spreadsheet, making the data difficult to analyze. One expert recommended SharedStreet's CurbLR, an open data standard for describing curb space attributes and use, as a potential tool for data sharing between the public and private sectors (visualized in Figure 11). Another expert suggested third-party platforms that help analyze curb space data (e.g., Remix, Populus, etc.).

Figure 11. CurbLR Curb Policy in a Standardized Digital Format on CurbLR

Source: Shared Streets, n.d.

Potential Curb Space Management for Automated Vehicles

Experts with experience planning for automated vehicles (AVs) were asked about potential strategies for managing curb space access in an automated vehicle future. These experts stated that AVs present an opportunity to implement curb space pricing that could encourage higher-occupancy modes and micromobility. However, experts also noted that AVs and robotic delivery could exacerbate curb space congestion. Experts identified several strategies for managing curb space in an automated vehicle future:

1. Curb Space Management vis-à-vis Land Use Planning:

    a. Manage the curb by encouraging compact growth that prioritizes public transit, shared mobility, and active transportation.

    b. Plan to repurpose parking lots and garages for other community priorities, such as infill development and public spaces.

2. Curb Space Design:

    a. Identify potential origin and destination curb segments that would be appealing to the public and long enough to stage a loading zone.

    b. Anticipate allocating more curb space for passenger loading zones than conventional curbside parking spaces.

    c. Implement digital maps of curb space locations, responsible agencies, and modal assignments to assist in designing AV routes, including origins, destinations, and designated loading zones.

    d. Adapt geofencing policies used for TNCs to an AV context.

e. Implement pricing to promote public transportation as a more desirable alternative to AVs.

f. Monitor AV paratransit pilots currently underway for guidance on ADA access for automated vehicle deployments.

g. Share information with partner agencies about developments in curb space management pilots.

Long-Range Curb Space Management

The interviews concluded by asking experts about their long-term vision for curb space management. The visions they shared included the following.

- Just-in-Time Curb Space Access: Public agencies may develop a reservation system for flexible “on-demand” or “just-in-time” parking and loading zone access. Curb space allocations change periodically throughout the day depending on demand (e.g., freight in the early morning and late at night, bus stops during commute hours, parklets at midday).

- Comprehensive Curb Space Planning: Cities could perform holistic evaluations of how curb space is used and develop best practice plans for curb space management to ensure shared, multimodal access for all.

- Data-Driven Curb Space Management Policy: Standardized and interoperable data across intelligent transportation infrastructure (e.g., sensors and connected technologies) could enable data-driven, dynamic, and real-time curb space management strategies.

- Curb Space as a Service (CaaS): A variety of curbside services could be consolidated on a single digital platform shared by public and private sectors.

Key Takeaways

The experts interviewed stated that if shared modes are not properly planned, they could negatively impact curb space access by increasing demand for a finite public resource. However, designating curb space for different modes (e.g., loading zones for TNCs and goods delivery, protected bike lanes for shared micromobility devices to operate in) can help address increased demand and competition between modes. Curb space management can also be improved through pricing strategies that incentivize shared, active, and high-occupancy modes. Further, enforcement can improve curb space management: this can be achieved through rider and driver education efforts and penalties for infractions. Signage, markings, and in-app messaging that clearly define who can access the curb, when, and for what purpose can address curb space safety concerns. Additionally, data sharing between the public and private sectors can support curb space planning and management efforts, although there may be difficulties with data sharing from private operators due to privacy and proprietary information concerns. As AVs develop, their impacts may need to be managed through land use practices and curb space design. The experts provided four long-range plans that include these management strategies and work to include the impacts of emerging modes. The long-range plans provided include just-in-time curb space access, comprehensive curb space planning, data-driven curb space management, and curb space as a service.

5. Curb User Survey

To better understand how people use transportation modes at the curb, a general population survey was deployed to people within the San Francisco Bay Area between August 2020 and February 2021. About 80% of the sample lived within San Francisco and Oakland. The survey asked about different topics including respondent demographics, home and work location, use of different transportation modes, COVID-19 pandemic travel impacts, and engagement with travel modes at the curb. The responses to these questions helped inform a behavioral understanding of how people interact with the curb when taking public transit and other modes. This chapter includes the following two sections:

1. Survey Demographics: Demographic information on the survey respondents and comparison to the 2019 U.S. Census American Community Survey (ACS)

2. Curb Space User Findings: Information about curb space interactions including modal use, wait times, frequency, safety concerns, and public transit connections.

Survey Demographics

The survey sample size was 1,033 respondents. The survey as well as its administration was designed to collect a sample that would align with the American Community Survey distributions of several demographic attributes of the populations within San Francisco and Oakland. The ACS statistics of San Francisco and Oakland were combined to produce the population distribution to be compared to the survey sample. Table 5 shows a summary of demographic distributions for the sample and the population. Overall, the survey sample aligned well with the population, but some differences exist. For example, the gender split showed a departure in the sample from the population. The male to female split was 45% to 55% in the survey, while the split within the population was 50% to 50%.

Table 5. Demographics of Survey Respondents and Population

Characteristics	Survey*	Population of San Francisco and Oakland
Income	**N=1,033**	**N=534,264****
Less than $10,000	74 (7%)	24,946 (5%)
$10,000 to $14,999	57 (6%)	28,418 (5%)
$15,000 to $24,999	47 (5%)	29,189 (5%)
$25,000 to $34,999	62 (6%)	27,271 (5%)
$35,000 to $49,999	86 (8%)	35,714 (7%)
$50,000 to $74,999	140 (14%)	59,058 (11%)
$75,000 to $99,999	107 (10%)	46,814 (9%)
$100,000 to $149,999	209 (20%)	82,964 (16%)
$150,000 to $199,999	107 (10%)	60,405 (11%)
$200,000 or more	144 (14%)	139,485 (26%)
Education	**N=1,029**	N=1,016,499***
Less than high school	44 (4%)	125,908 (12%)
High school/GED	136 (13%)	136,429 (13%)
Some college	225 (22%)	133,645 (13%)
Associate's degree	81 (8%)	51,278 (5%)
Bachelor's degree	316 (31%)	333,684 (33%)
Graduate or professional degree	227 (22%)	235,555 (23%)
Age	**N=1,026**	N=1,109,952†
18 to 19	52 (5%)	22,394 (2%)
20 to 24	160 (16%)	71,059 (6%)
25 to 34	181 (18%)	287,790 (26%)
35 to 44	238 (23%)	214,786 (19%)
45 to 54	164 (16%)	167,314 (15%)
55 to 64	108 (11%)	145,250 (13%)
65 to 74	98 (10%)	115,212 (10%)
75 to 84	22 (2%)	58,689 (5%)
85 or older	3 (0%)	27,458 (2%)
Race/Ethnicity	**N=1,033**	N=1,314,593††
White	400 (39%)	477,852 (36%)
Asian	314 (30%)	365,857 (28%)
Black	120 (12%)	151,724 (12%)
Hispanic/Latino	157 (15%)	250,420 (19%)

Characteristics	Survey*	Population of San Francisco and Oakland
Other	42 (4%)	68,740 (5%)
Gender	**N=1,029**	N=1,109,952†
Male	462 (45%)	551,633 (50%)
Female	567 (55%)	558,319 (50%)

*The survey N value varies because respondents could choose to skip certain questions.
**The population N value for the income level applies to the population of households as reported by the U.S. Census.
***The population N value for education applies to educational attainment for individuals over 25 years of age as reported by the U.S. Census.
†The N value for gender and age applies to the total population aged 18 and older.
†† Population for race/ethnicity is the total population of San Francisco and Oakland.

The income distribution shows that the survey sample aligned well with the population distribution for all income categories at $50,000 and below. At the upper end of the distribution, the survey sample had a higher relative representation within the $100,000 to $150,000 bracket. The sample underrepresents income levels of $200,000 or more. The distribution of educational attainment for the sample matched the general population rather well. Notably, upper educational levels and high school/GED attainment of the sample matched the population very closely. One category where there was some difference was "Some college." This difference was, in part, due to the way the survey sample categorized students, which included respondents who were studying for a degree but had not yet attained it. Overall, the education distribution of the survey sample matched the population relatively well.

With respect to age, the distribution of the survey sample aligned with the population well within the middle age brackets. The sample slightly overrepresented younger populations, likely due to a greater inclusion of students (as noted in the educational distribution), and the sample slightly underrepresented adults over the age of 75. The distributions of race/ethnicity aligned well across five main categories, including white, Asian, Black, Hispanic/Latino, and Other. The biggest difference between the representation of the sample and the population was within 4% across all cohorts. Thus, the sample exhibited relatively fair representation by race/ethnicity at these high-level categories.

In addition to asking about demographic background, the survey also asked about disability status through three basic questions. Respondents were asked if they use a wheelchair (9%), have other disabilities that require specialized accommodations for transportation (13%), and require transportation vehicles and infrastructure that is ADA compliant (wheelchair or scooter) to get around (10%). By comparison, an issue brief by the U.S. Bureau of Transportation Statistics reported that 24.6 million Americans had a travel-limiting disability in 2017 (Brumbaugh, 2018). The U.S. population over 18 that year was 248 million, and thus persons with travel-limiting disabilities accounted for 9.9% of the U.S. population over 18. Overall, the share of respondents reporting some type of travel-limiting disability was larger than that found in the general population, but not significantly so.

Curb Space User Survey Findings

The survey asked respondents about their travel choices. This included questions on the modes that respondents had used in the last 18 months, as well as more specific questions about the frequency of use of those modes and specific public transit services. The questions provided background on the types of modes that the sample population were familiar with and used. Figure 12 shows the high-level profile of modes used by respondents. As expected, the distribution shows a relatively high use of driving alone. However, while driving alone (along with walking) is the most commonly selected mode used, its frequency is actually lower than in the broader Bay Area. For example, the 2018 American Community Survey reported that about 93% of people within the broader San Francisco-Oakland Metropolitan Statistical Area had access to at least one car. Other modes with notable usage included Uber/Lyft, public bus, BART, and personal bicycle. Overall, the modes of use represented within Figure 12 suggest a semi-urban population that, relative to the broader U.S. population, has high exposure to public transportation and non-motorized modes and is less reliant on the personal automobile.

Figure 12. Modes Used by Respondents

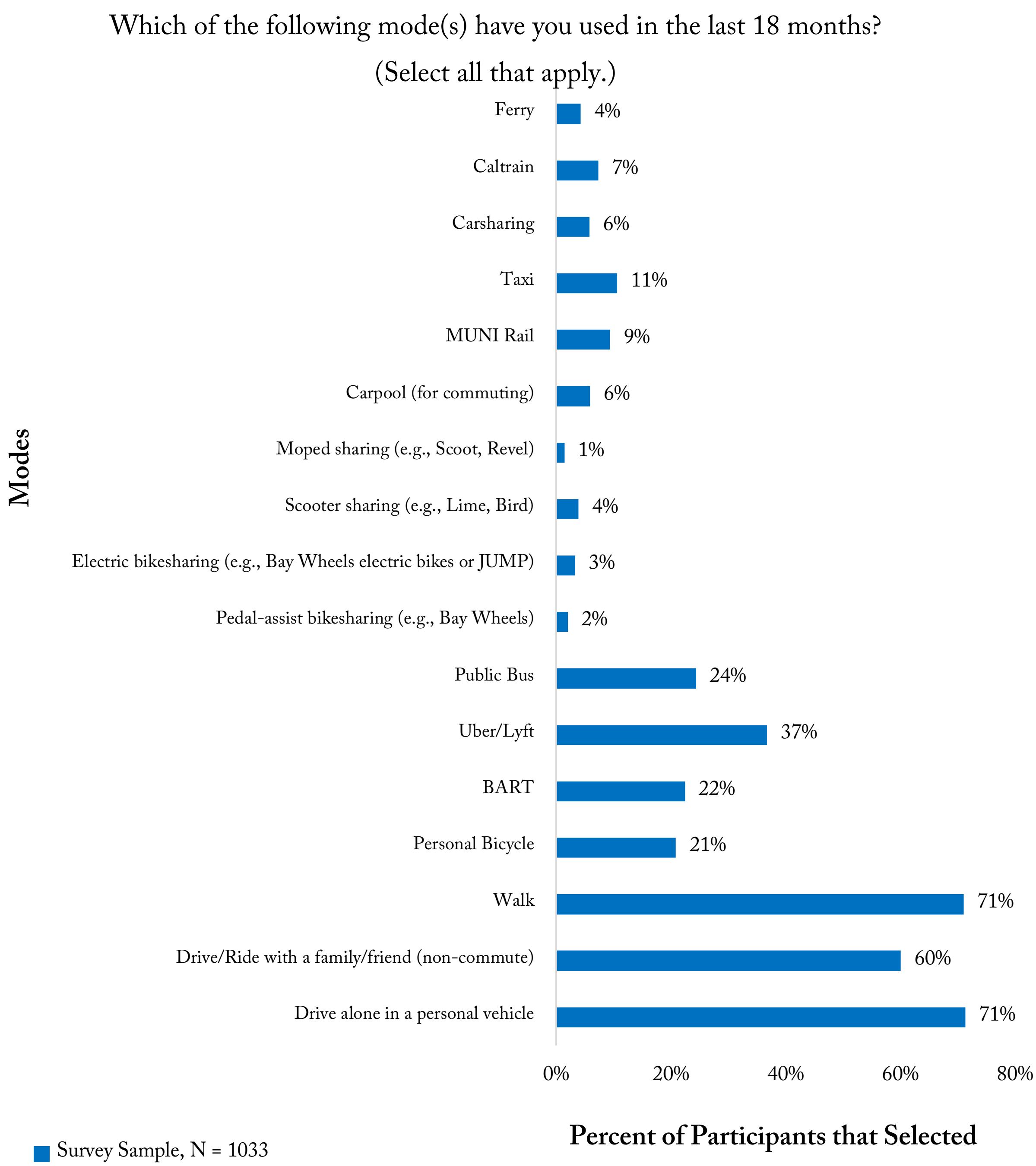
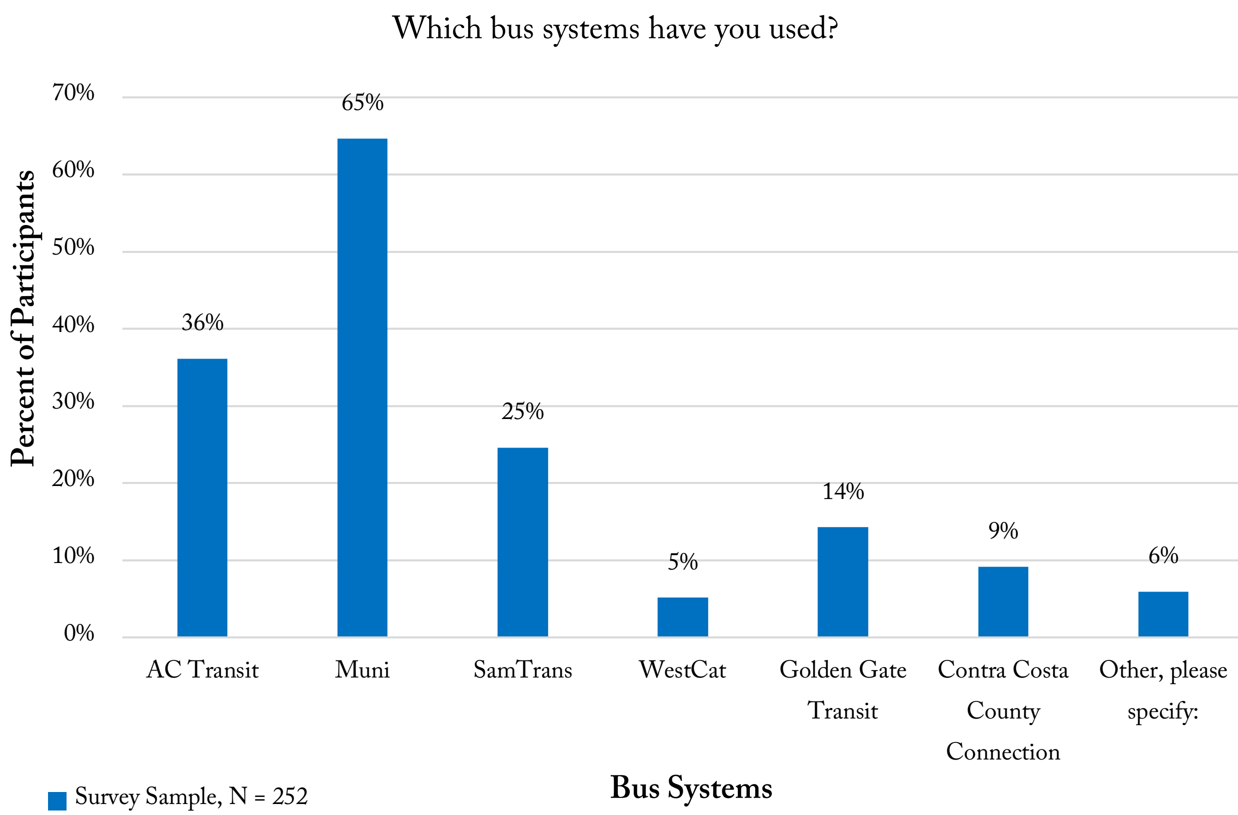


Figure 13 shows responses to the next question asked of respondents who use public bus. The question provides context on the regional public bus systems with which respondents are familiar. Figure 13 shows that the most urban systems (MUNI and AC Transit) dominate use among bus users, with Sam Trans coming in a close third. Responses are given as a percent of bus users and therefore add up to greater than 100%. The data give a representation of the relative use and exposure to different bus systems among respondents.

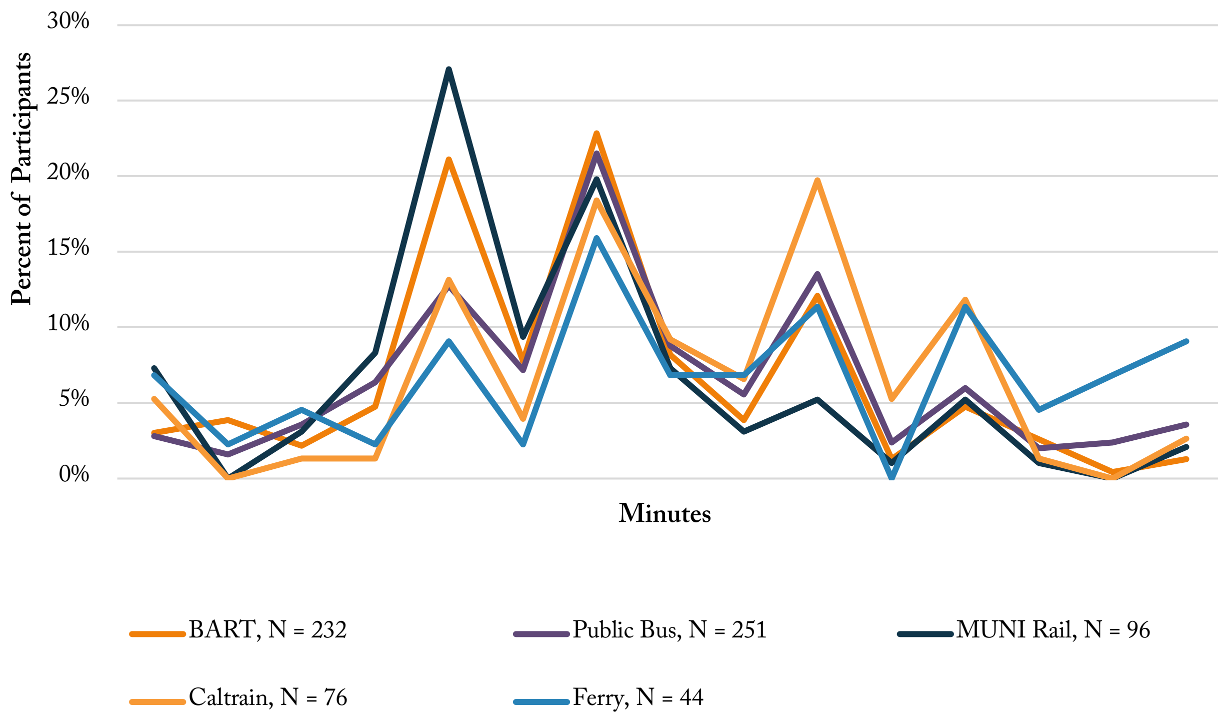
Figure 13. Bus Systems Used by Respondents



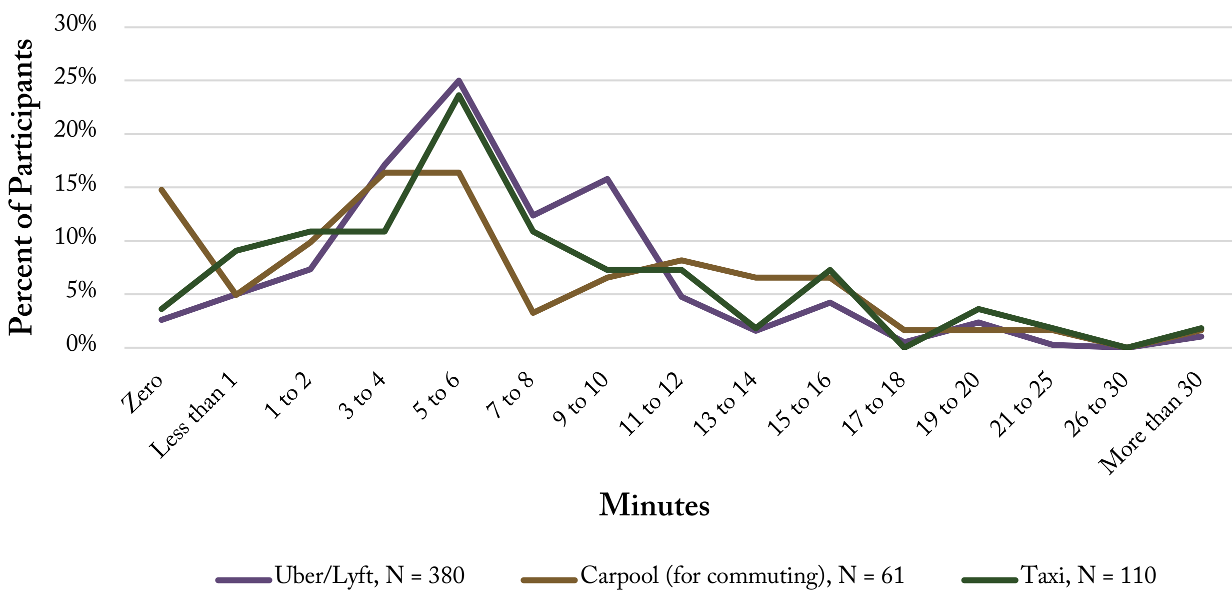
The survey asked several questions about interactions people had with the curb and the modes that they connected with at the curb. One of the questions asked participants about their average wait time at the curb. Figure 14 shows the profile of reported wait times for major public transit modes (e.g., rail, bus, ferry) and for personal vehicle modes (e.g., Uber/Lyft, carpools for commuting, and taxis). A comparison of the distributions shows some distinctions. The distribution of wait times for the public transit modes had a multi-peak distribution extending out to 15 minutes. The distribution for the personal vehicle modes also exhibited multiple peaks, but it revealed a dominant peak at the five-minute mark and a wider distribution across intermediate values. Overall, the comparison of distributions suggests that curbside users consider wait times on average to be shorter for personal vehicle modes. This result is not surprising, and it is consistent with expectations given the wide range of headways present within the more traditional public transit modes. Still, the results show that personal vehicle modes that are hailed or used in otherwise pooled circumstances deliver curbside wait times that are, on average, lower than those of the more traditional public transportation modes.

Figure 14. Average Reported Wait Times at the Curb

On average, how long have you WAITED (in minutes) at the curb for the following modes to meet you?

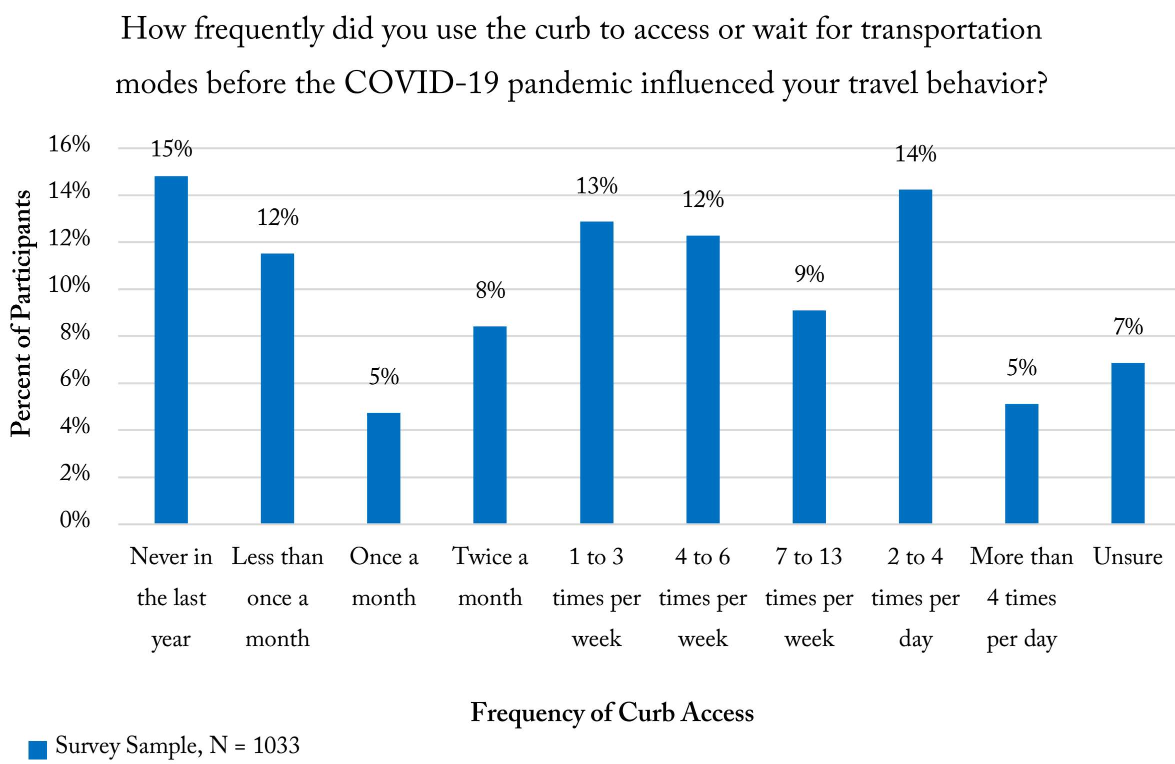


On average, how long have you WAITED (in minutes) at the curb for the following modes to meet you?



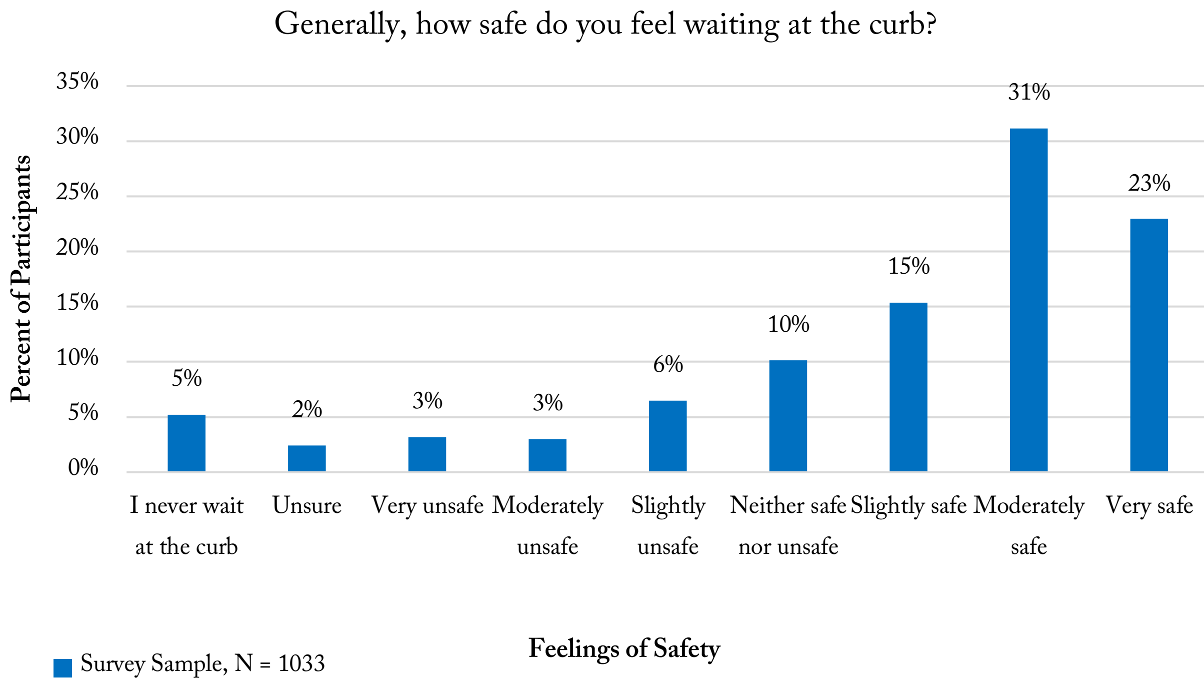
As with frequency of mode use, the survey probed how frequently respondents used the curb to access or wait for public transit modes. Figure 15 shows the distribution across all survey responses regarding their frequency of curb use. The results illustrate that, before COVID-19, about 32% of respondents used the curb to wait for or to access transportation modes once a month or less. Another 33% used it somewhere between twice a month and 6 times per week, while 28% were very frequent curb users for transportation access, accessing the curb seven or more times per week. The remaining 7% of respondents were unsure.

Figure 15. Frequency of Curb Access



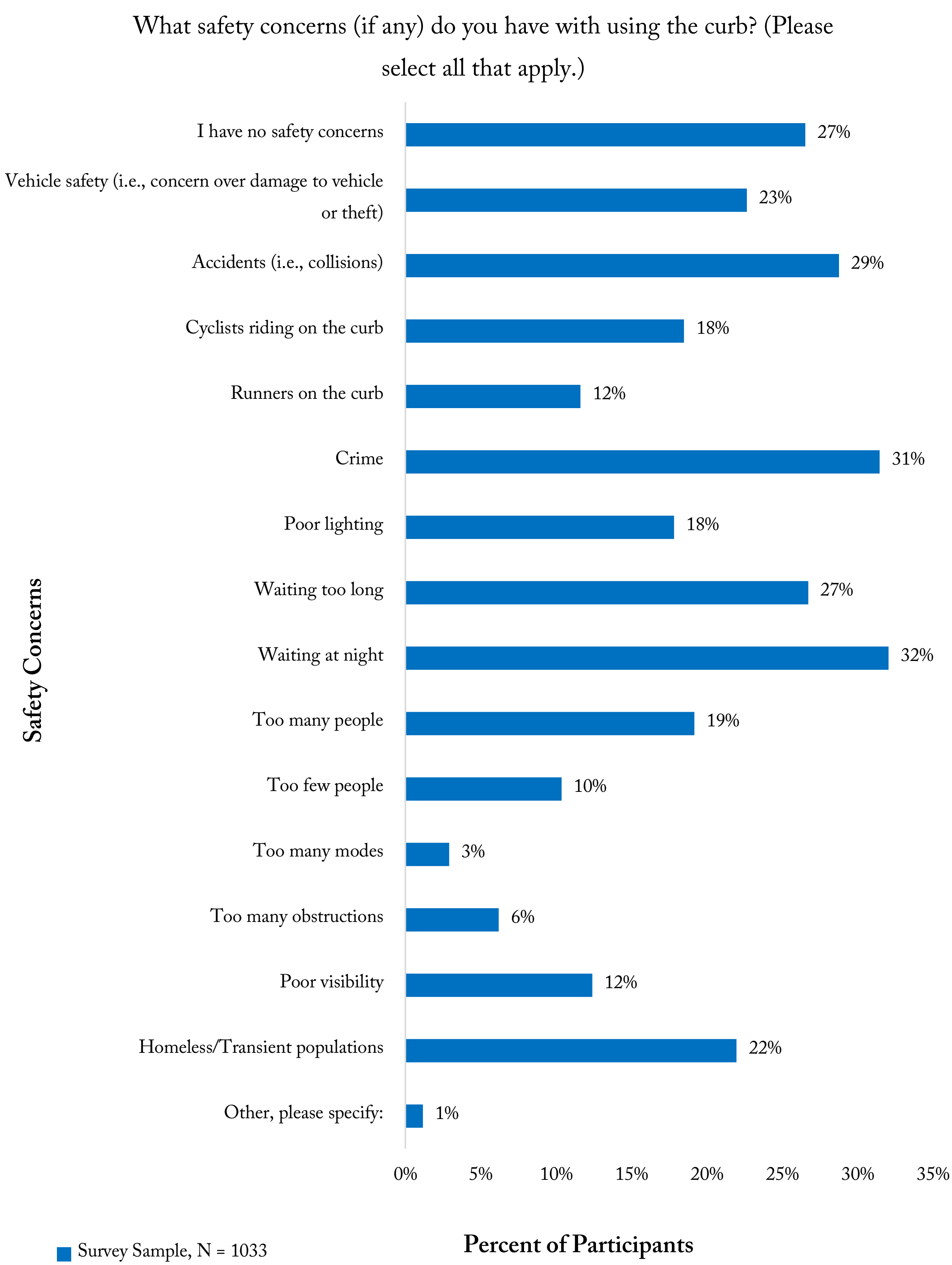
The survey also asked questions about respondents' perceptions of safety about waiting at the curb. Most respondents reported feeling safe waiting at the curb. Figure 16 shows the distribution of responses: over half of respondents felt "moderately safe" (31%) or "very safe" (23%). However, the seven-point scale reveals some trepidation within the long tail of the distribution toward unsafety. The remaining half felt "slightly safe" (15%) to "very unsafe" (3%). Only 2% of respondents were unsure how to respond to this question.

Figure 16. Safety of Waiting at the Curb



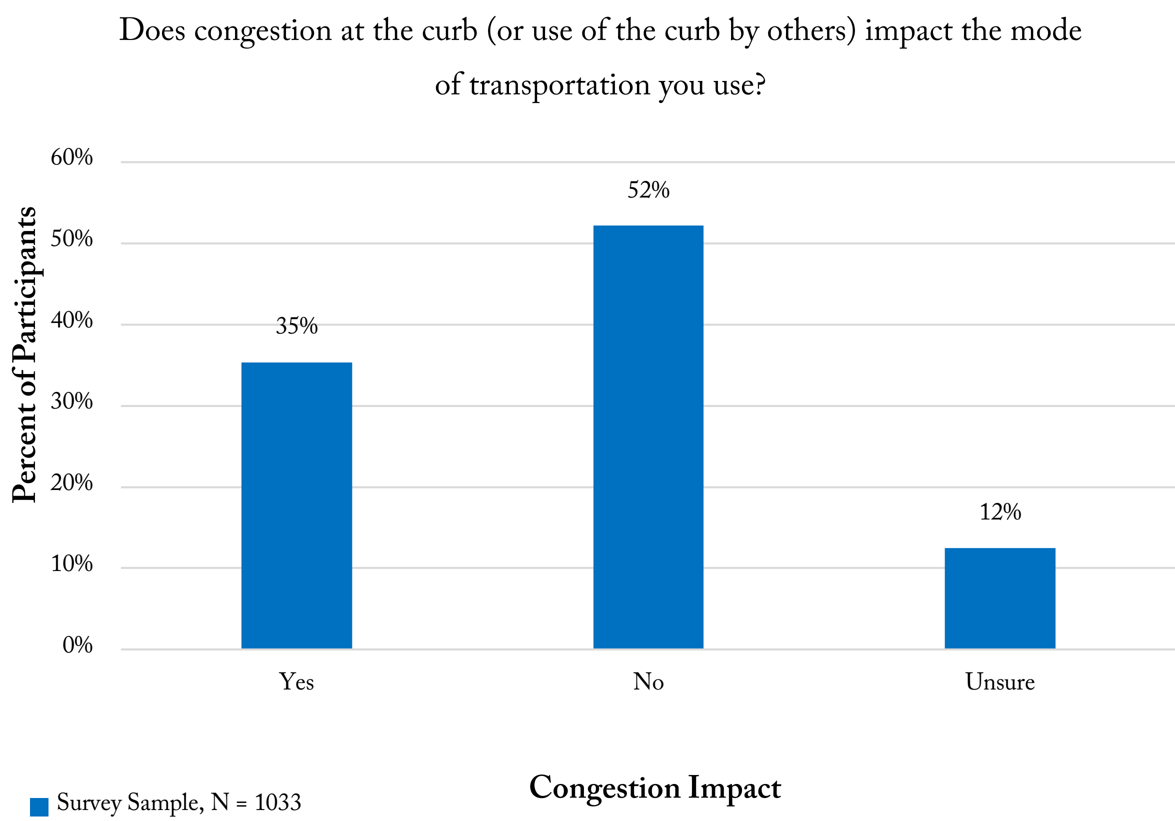
In a follow-up to this question, respondents were asked what safety concerns (if any) they had while using the curb. Figure 17 shows the distribution of responses, which illustrates that the most common concerns (perhaps not surprisingly) were related to "waiting at night" (32%) and "crime" (31%). Other commonly selected concerns were "accidents (e.g., collisions)" (29%), "vehicle safety (i.e., concern over damage to vehicle or theft)" (23%), and "homeless/transient populations" (22%). Notably, about a quarter (27%) of respondents reported having no safety concerns. Also revealing was the fact that "too many modes" (3%) and "too many obstructions" (6%) were the most infrequently selected responses. The distribution ultimately speaks to common issues that are of concern with respect to the curb. Among possible mitigation measures may include better pedestrian scale lighting, which can be a deterrent to crime and other unsolicited interactions.

Figure 17. Safety Concerns Using the Curb



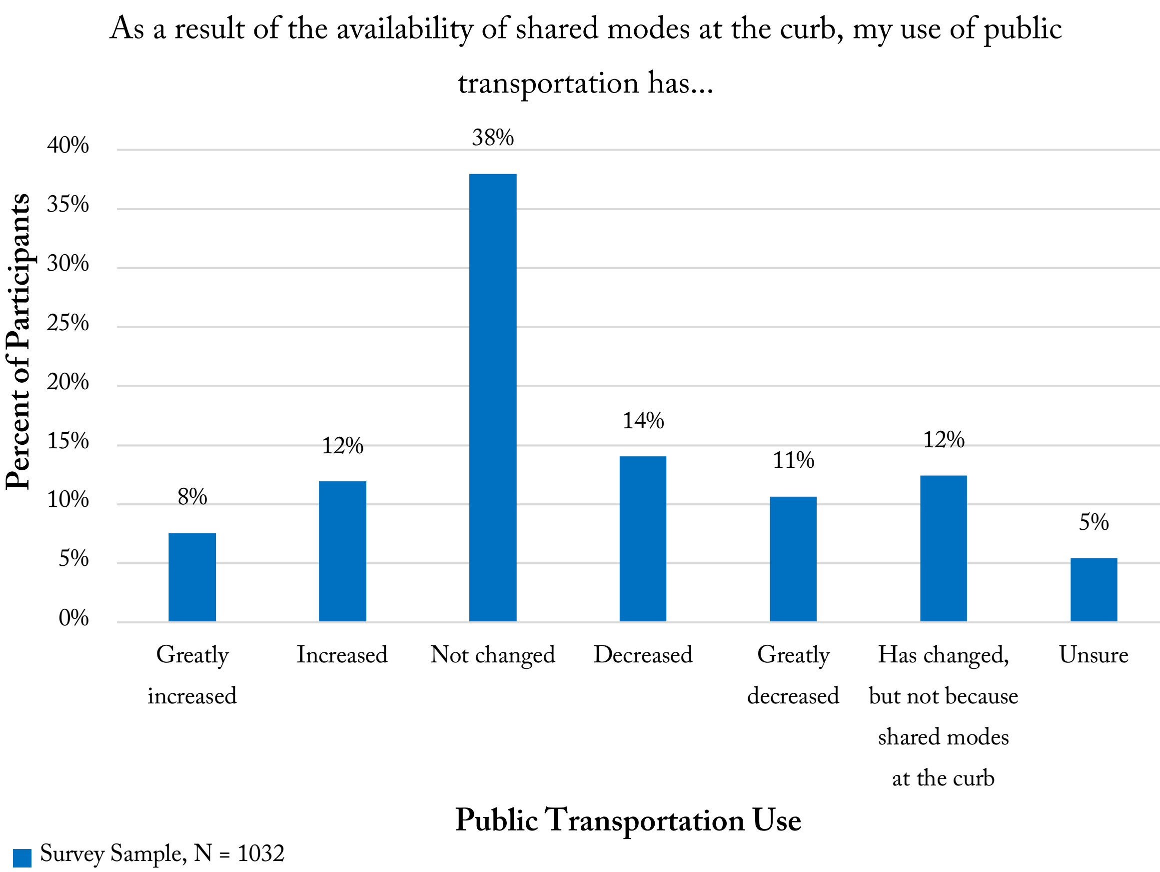
Respondents were also asked whether congestion at the curb impacts their use of specific transportation modes. The results, shown in Figure 18, suggest that over half of respondents do not feel that congestion at the curb impacts their use of transportation modes. At the same time, a sizable minority (35% of respondents) reported that congestion did impact their mode choice. This result suggests that there is more work to be done with respect to addressing congestion issues at the curb.

Figure 18. Congestion at the Curb and Mode Impact



The survey asked whether the availability of shared modes at the curb influenced respondents' use of public transportation. Figure 19 shows the distribution of the responses: note that about 20% of respondents reported an increase in the use of public transportation due to the presence of shared mobility, and about 25% of respondents reported that their use of public transportation has decreased as a result. The result speaks to the capacity of shared modes to facilitate connections to public transit or provide substitutions to it.

Figure 19. Shared Mobility at the Curb and Public Transit

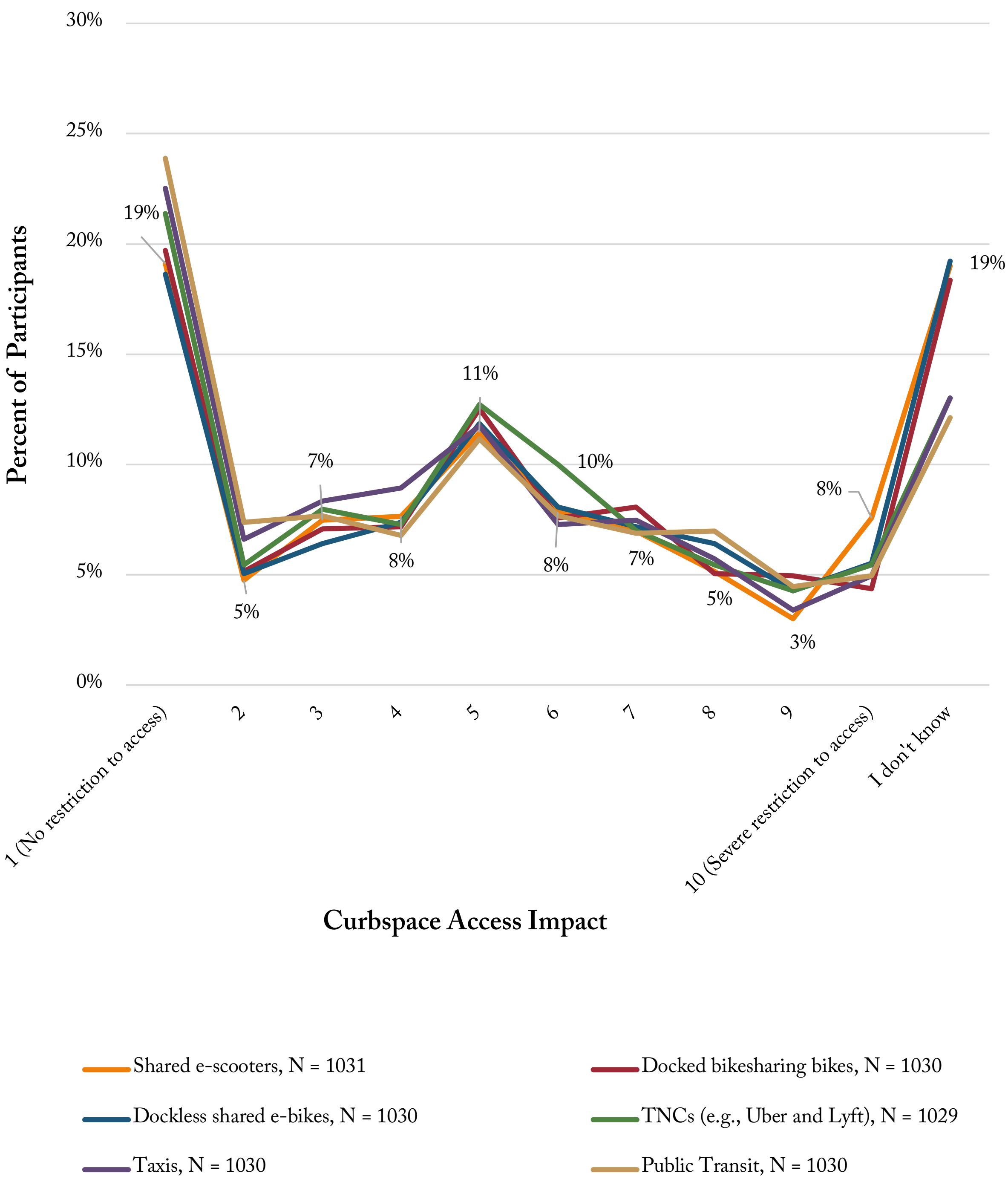


The survey asked respondents to indicate the degree to which curbside modes impacted their access to the curb in San Francisco. Respondents were asked to indicate their answer on a scale from one to 10, where 1 meant no and 10 meant severe restriction to access. Figure 20 shows the distribution of responses across six curbside modes. The graph can be interpreted by considering the fact the responses within each mode to add up to 100%. The profiles of user access to the curb can be compared across modes. For example, if one mode receives 20% at a given value of the scale, indicating highly restrictive, and another mode receives 25% at the same value, then we can conclude that the mode with 25% was "voted" to be relatively more restrictive to curb access than the mode receiving 20%. These comparisons can be made across modes and across the scale.

The profile of responses represented in Figure 20 is interesting in that there is very little distinction across the plotted modes. Remarkably, the profile of each mode follows the same general pattern, with about 20% to 25% of respondents reporting that the presence of any given mode presents no curb access restriction. Between 12% to 19% of respondents reported that they did not know whether a given mode was restricting their access to the curb. Taking these responses together, between 62% to 64% of respondents reported that these modes (shared e-scooters, docked and dockless bikesharing, TNCs, taxis, and public buses) do restrict their access to the curb to some degree. However, the fact that no single mode departs significantly from the profile is indicative of an interesting collective sentiment that there are no specific modes that impact curb access in especially significant ways. Across the scale, the profile only separates notably for TNCs at the score of six on the scale, where this value received 10% of the responses for TNCs, but only about 8% for the other modes. Another small separation is noted at the value of 10 (severe restriction), where e-scooters receive a score of 10 by 8% of respondents. In contrast, only about 5% respondents considered all other modes to be severely restrictive to their curb access. Most other modes Overall, the results from the profiles within Figure 20 suggest that a majority of respondents felt that curbside modes do, in some ways, interfere with their access to the curb. The percentages in Figure 20 denote the average impact percent for each mode. Remarkably, no mode stands out as being uniquely problematic.

Figure 20. Impact to Curb Access by Modes

Please indicate the degree to which the following modes are impacting your access of the curb in San Francisco on a scale of 1 to 10, where 1 is "No restriction to access," and 10 is "Severe restriction to access."



In a similar manner, an additional question probed how favorably (or unfavorably) the respondents viewed specific curbside modes. Respondents were asked this question as users of all modes, not as a user of any specific mode of interest. Figure 21 and Figure 22 provide the profiles of responses. Figure 21 shows the favorability profile for the curbside shared mobility modes of shared e-scooters, docked bikesharing bikes, and dockless shared e-bikes. The percentages in Figure 21 represent the average of each favorability score. Figure 22 shows the profile of favorability for TNCs, taxis, and public transit. The general shape of the top and bottom plots is different, with those of TNCs, taxis, and public transit receiving higher overall favorability ratings. An average of 57% of respondents rated the shared micromobility modes on the unfavorable side of the scale at five or less. However, the TNC/taxi/public transit modes received unfavorable ratings from an average of 41% of respondents. On the favorable side of the scale (six and up), shared micromobility modes received favorable ratings from 32% of respondents, with the remainder (an average of 11%) reporting that they did not know. In contrast, the TNC/taxi/transit modes received general favorability ratings on average from 55% of respondents, with between 4% to 6% reporting that they did not know. When combined with the findings conveyed earlier, the results suggest that while there was general agreement on the amount of restriction each mode places on access to the curb, there is disagreement with respect to the favorability of individual modes. The results suggest that the automotive or motorized modes of TNCs, taxis, and public transit are on average viewed more favorably than micromobility modes.

Figure 21. Favorability of Curbside Modes

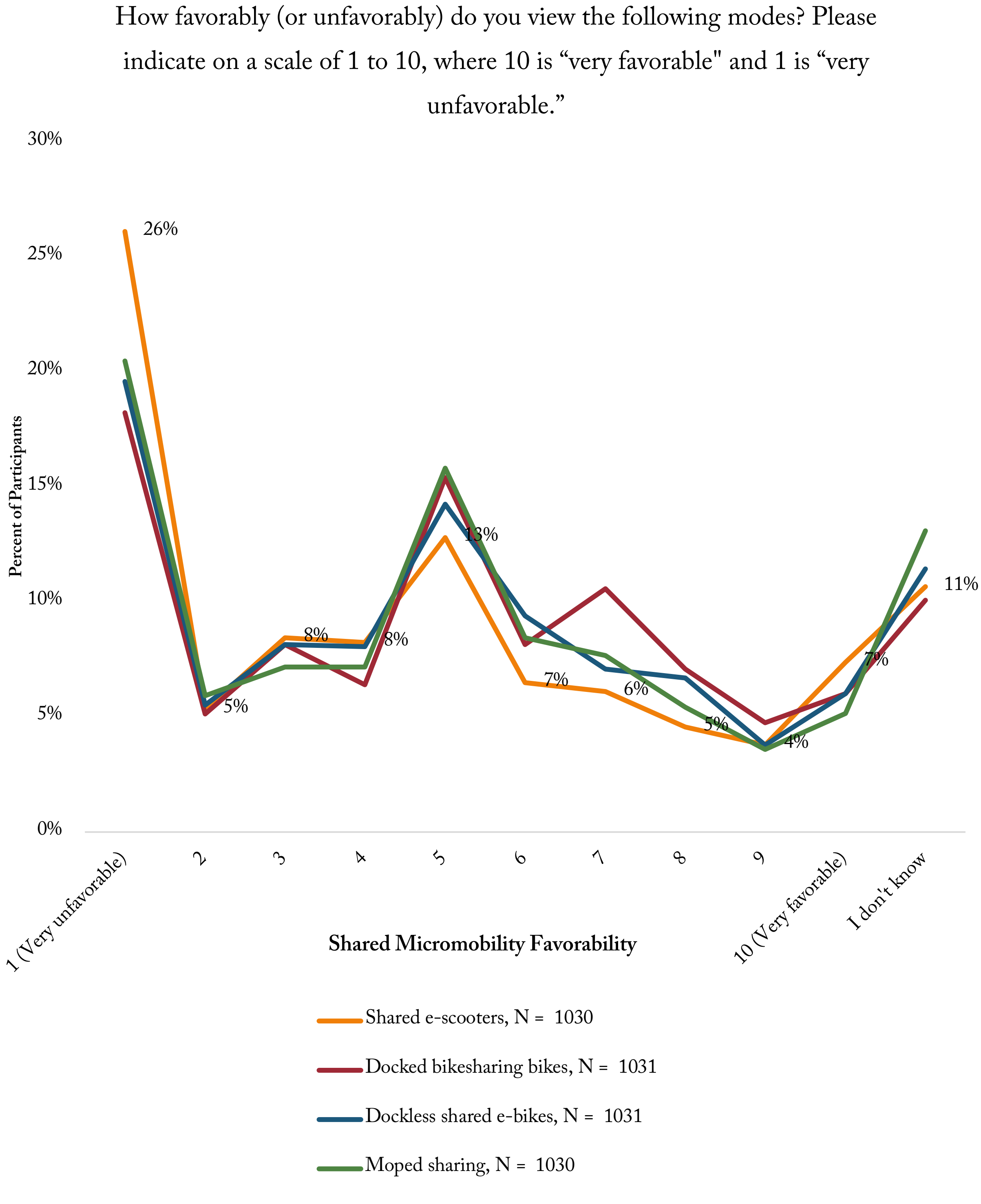
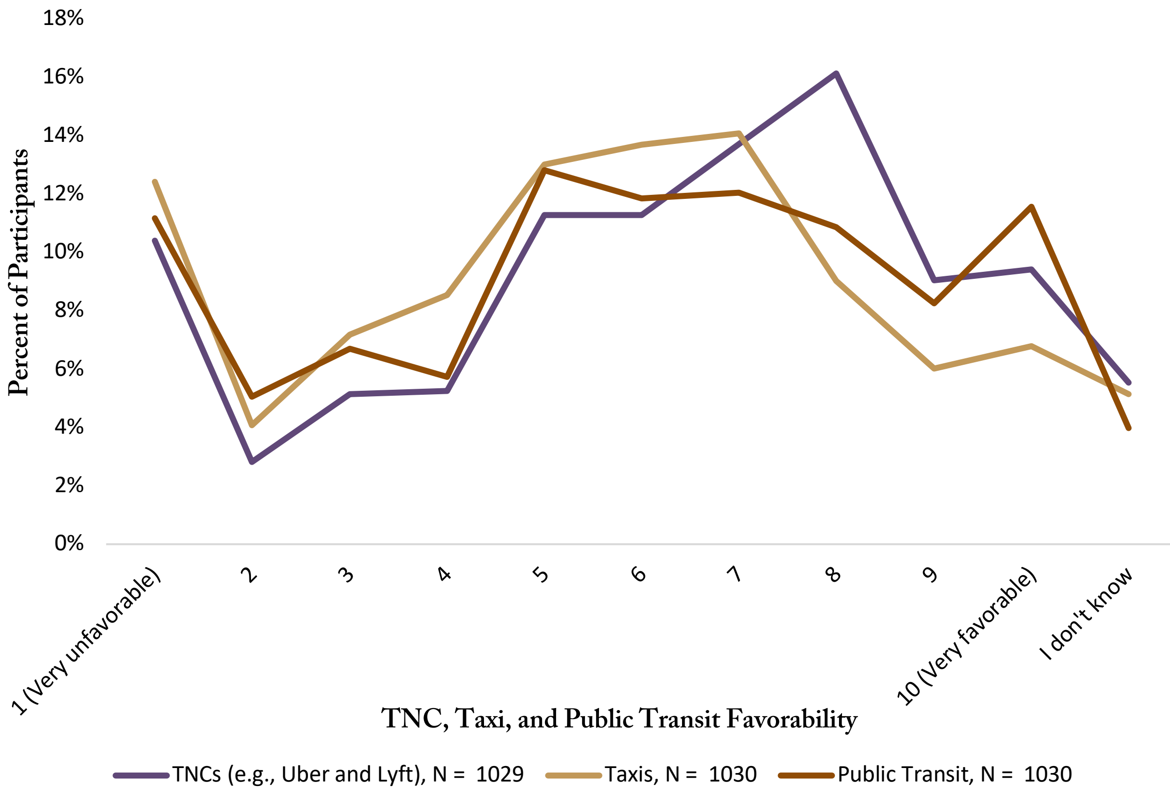


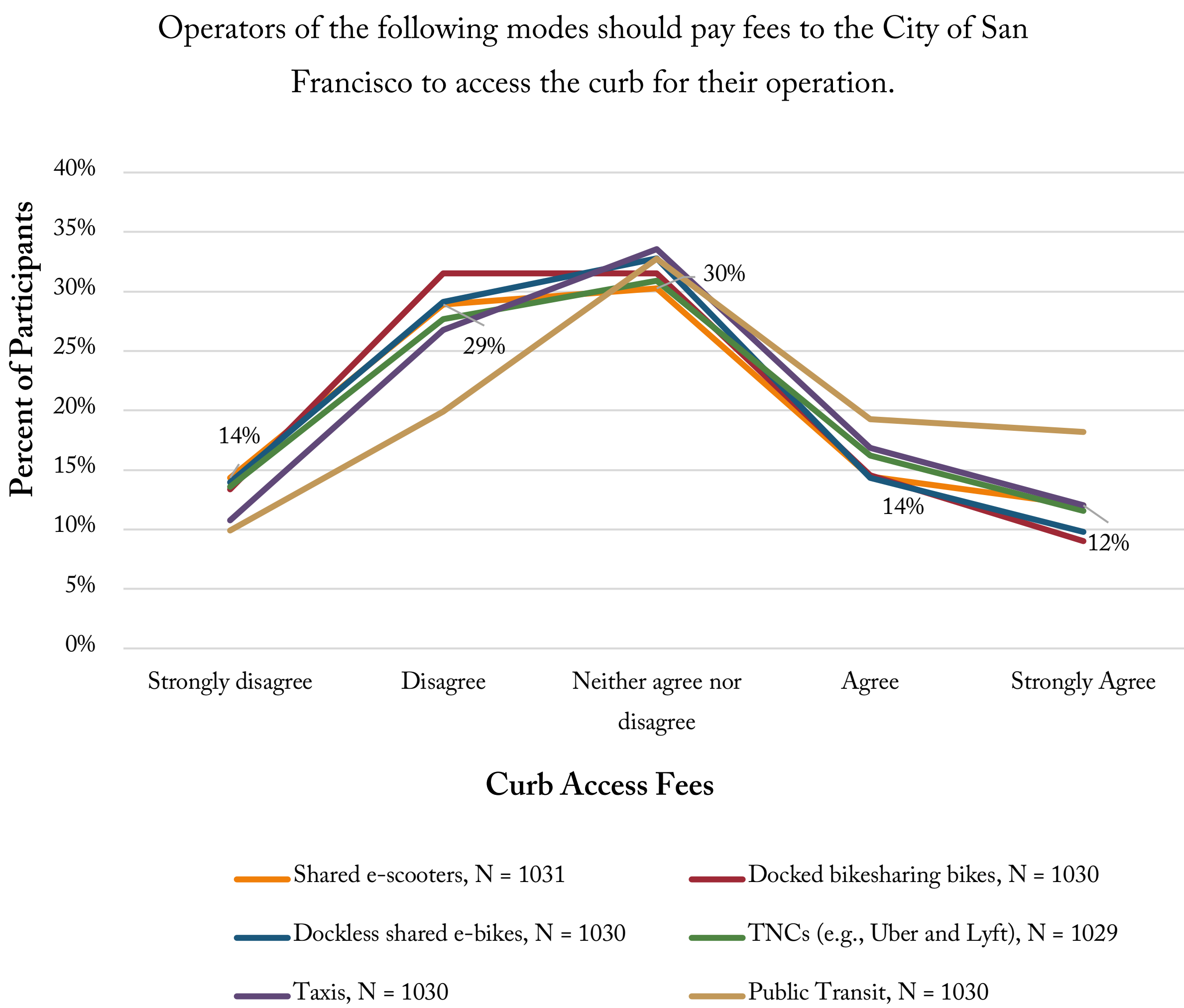
Figure 22. Favorability of TNCs, Taxis, and Public Transit Modes

How favorably (or unfavorably) do you view the following modes? Please indicate on a scale of 1 to 10, where 10 is “very favorable" and 1 is “very unfavorable.”



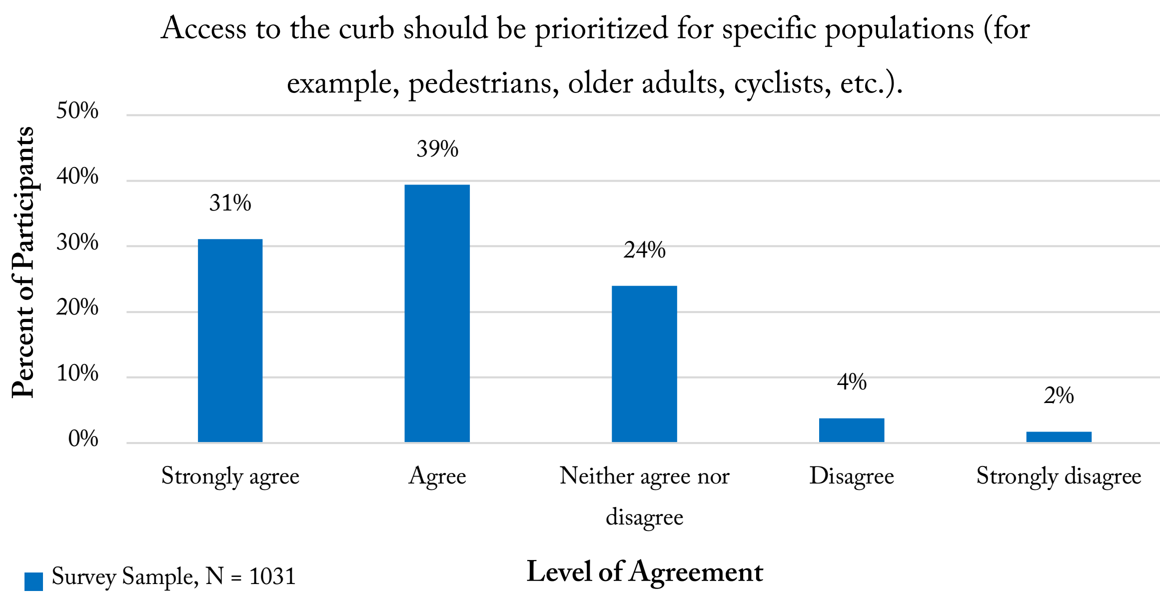
The survey also asked questions about general policies and priorities that could be applied to curb space regulation. The questions asked about whether operators should pay fees to access the curb, whether access should be prioritized for specific populations, and if so, which populations should be prioritized for access. Figure 23 shows the distribution of responses to the Likert scale question asking whether operators should pay fees to the City of San Francisco to access the curb for their operation. The results of the responses were mixed between agreement and disagreement. However, here, too, the respondents disagreed across the modes. On average, more respondents disagreed that operators should have to pay fees for curb access. Across all modes, an average of 48% of respondents disagreed that operators should pay fees. An average of 32% of respondents neither agreed nor disagreed, and an average of 34% agreed. Respondents had a modest departure from these averages for public transit, but the difference was large enough to flip the balance of agreement. The results show that 30% of respondents disagreed that public transit agencies should pay fees for access to the curb, 33% neither agreed nor disagreed, and 37% agreed with the statement.

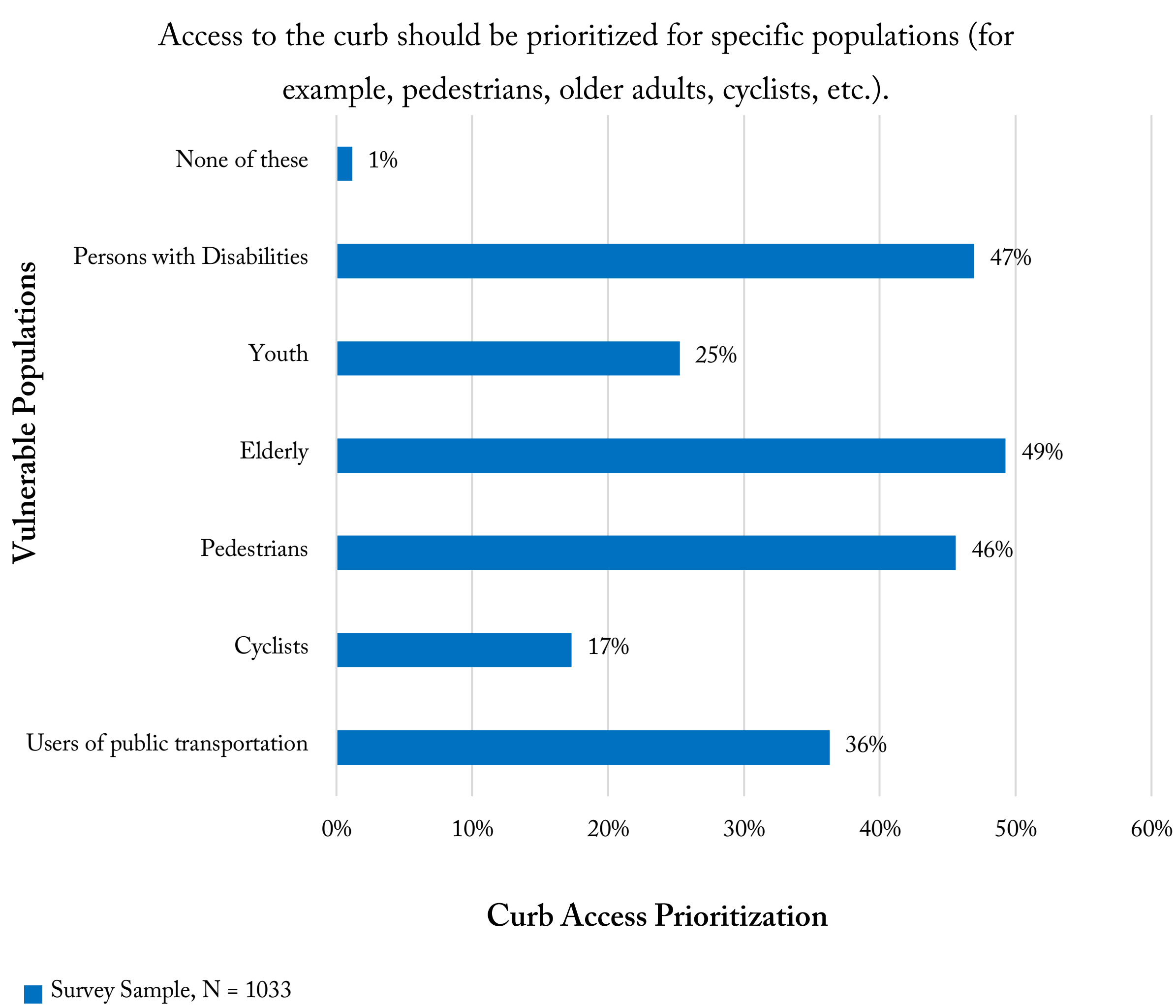
Figure 23. Payment of Fees to Access the Curb



Respondents were asked whether access to the curb should be prioritized for certain populations. The responses followed a Likert scale, and about 70% of respondents indicated that they agreed that access should be prioritized for certain populations. The 70% of respondents were asked in a follow-up question which groups should be prioritized among: (1) persons with disabilities, (2) youth, (3) older adults, (4) pedestrians, (5) cyclists, and (6) public transportation users. Figure 24 represents the results from both questions. Respondents reported that access to the curb should be given in the following order: older adults (49%), persons with disabilities (47%), and pedestrians (46%). Responses also included a distant fourth priority of users of public transportation (36%), followed by youth (25%), and finally cyclists (17%). Overall, the results suggest that respondents felt groups typically considered most vulnerable within the transportation system should receive prioritized access to the curb. These results, while not surprising, reinforce policy positions that have been generally advance by municipalities and transit agencies when designing curbspace or setting policies.

Figure 24. Access to the Curb Prioritization





Curb User Survey: Key Takeaways

The curbside user survey was a general population survey that targeted San Francisco and Oakland as well as smaller surrounding Bay Area cities. The survey contained questions about traveler interactions with modes that use the curb as a major point of interaction and evaluated user responses to curb wait times, safety considerations, curb access restrictions by mode, general mode favorability, responses to possible policies related to curb access fees, and access prioritization for specific populations. Many of the leading responses with respect to safety were not surprising. A majority of respondents felt safe waiting at the curb, while respondents cited waiting at night, crime, and accidents as the leading safety concerns associated with the curb.

Some of the more interesting findings stemmed from what the survey did not show. For example, the survey showed little to no departure among different shared mobility and public transit modes with respect to their rated degree of restricting access to the curb. Respondents considered shared micromobility to restrict access to the curb, along with TNCs, taxis, and public transit to various degrees, but there was little difference noted across the different modes. When asked about favorability, respondents rated TNCs, taxis, and public transit more favorably than shared micromobility on average. Yet public transit was the only mode where more respondents than not felt that an exemption to curb access fees should be in place. Collectively, most respondents felt that access to the curb should be prioritized for certain vulnerable populations including older adults, persons with disabilities, and pedestrians. Taken together, the results suggest that modes like TNCs, taxis, and public transit are viewed favorably and are not restricting access to the curb by degrees that are out of step with restrictions imposed by other modes. Shared micromobility modes were also not reported to impose exceptional access restrictions to the curb (at least no more than other curbside modes), but they were not viewed as favorably as the automotive modes. These and related findings may provide some perspective on the degree to which the general population rates and responds to curbside issues and modes. The findings can offer guidance on user mode preferences, key concerns, and issues that are not a concern with respect to curbside access among the general population. Notably, respondents offered higher favorability to motorized 4-wheeled modes (e.g. TNCs, taxis, and public transit) than shared two-wheeled modes. However, there were only small distinctions across modes with respect to how they impacted ease of access. To this point, although very little distinction across modes was found, a fair share of respondents still considered all the modes to be generally restrictive to their access to the curb, as an average of 23% reported a value of 7 or higher (as noted in Figure 20). This indicates that despite the lack of distinction across modes, there are still issues with conflict. One possible and logical remedy to this is the development of dedicated zones of use by mode, where both users and operators of a given mode can expect to encounter it. This organization may reduce conflicts at the curb, particularly those newer modes (e.g. TNCs and share micromobility) that have imposed their operations over existing urban infrastructure. In the section that follows, we explore curbside interactions and challenges from the perspective of the operator through a survey of drivers delivering curbside services.

6. Driver Survey

The research team also distributed a survey to drivers of TNCs, taxis, microtransit, and other courier/delivery services in late 2020. The survey was disseminated to subscribers of Rideshare Guy's newsletter. An initial invitation was sent in late November 2020, and a single reminder message was sent about one month later in December 2020. A total of 241 respondents completed the survey. The survey collected demographic information about the respondents; the survey also asked questions about the services for which the respondents drove and their experiences in delivering transportation services before and during the COVID-19 pandemic. The instrument included questions about the specifics for drop-offs and pick-ups and associated challenges, days of driving and hours of driving, and the time-dependent difficulties of accessing the curb. Additionally, the survey asked drivers for their opinions on principles and priorities with respect to curb access and management policies. In the section that follows, the results of key findings from the driver survey are summarized.

Survey Demographics

The survey asked questions about the demographics of drivers to evaluate their attributes relative to the population. As with the curb user survey, the distribution of the driver survey demographics was compared to the overall population of San Francisco and Oakland. Table 6 shows the comparisons. Relative to the curbside user population, which was collected so as to align with the distribution of population demographics, the demographics of the driver survey respondents departed even more considerably from the population as reported in the US Census American Community Survey. This departure occurred for all five of the evaluated demographic characteristics. The starkest departure is perhaps the gender balance, which was overwhelming tilted toward men (85%) relative to the perfect 50/50 balance of the population. With respect to household income, drivers generally had lower incomes than the overall population, with the most common income category being $35,000 to $49,999 (24%). While not reflective of the average income in the population, the most common income category in San Francisco and Oakland population was $200,000 or more (26%).

Regarding age, driver respondents were generally younger than the general population. A majority of drivers (55%) were between the ages of 25 to 34. Roughly 95% of respondents were under the age of 45. However, 45% of the population is between the ages of 18 and 45. The most common level of educational attainment among the driver respondents was "High school/GED" (33%) followed by "Some college" (32%). "Some college" included respondents who were actively students in a two-year or four-year college. Within the population, a majority of individuals over the age of 25 have a bachelor's degree or higher. Finally, with respect to race/ethnicity, the sample distributions showed a slight underrepresentation of white people (28% versus 36%), significant underrepresentation of Asian people (6% versus 28%), significant overrepresentation of Black people (33% versus 12%), and significant underrepresentation of Hispanic/Latino people (4% versus 19%) compared to the population as a whole. Finally, the "Other" category had a significant representation of Native American or Alaskan Native people (18% of all responses), with the remainder of respondents falling within the category of “two or more races.” Broadly, the demographic profile of driver survey respondents presents a population that is significantly different from the general population of the region served. Drivers are found to be younger, with lower education lower income, predominantly male, and less white, Asian, and Hispanic/Latino than the general population.

Table 6. Driver Survey Demographic Distribution

Characteristics	Survey*	Population of San Francisco and Oakland
Income	**N=237**	**N=534,264****
Less than $10,000	2 (1%)	24,946 (5%)
$10,000 to $14,999	18 (8%)	28,418 (5%)
$15,000 to $24,999	21 (9%)	29,189 (5%)
$25,000 to $34,999	38 (16%)	27,271 (5%)
$35,000 to $49,999	57 (24%)	35,714 (7%)
$50,000 to $74,999	25 (11%)	59,058 (11%)
$75,000 to $99,999	43 (18%)	46,814 (9%)
$100,000 to $149,999	16 (4%)	82,964 (16%)
$150,000 to $199,999	9 (4%)	60,405 (11%)
$200,000 or more	8 (3%)	139,485 (26%)
Education	**N=238**	**N=1,016,499*****
Less than high school	16 (7%)	125,908 (12%)
High school/GED	78 (33%)	136,429 (13%)
Some college	75 (32%)	133,645 (13%)
Associate's degree	29 (12%)	51,278 (5%)
Bachelor's degree	37 (16%)	333,684 (33%)
Graduate or professional degree	3 (1%)	235,555 (23%)
Age	**N=240**	**N=1,109,952†**
18 to 19	0 (0%)	22,394 (2%)
20 to 24	8 (3%)	71,059 (6%)
25 to 34	132 (55%)	287,790 (26%)
35 to 44	87 (36%)	214,786 (19%)
45 to 54	12 (5%)	167,314 (15%)
55 to 64	1 (0%)	145,250 (13%)
65 to 74	0 (0%)	115,212 (10%)
75 to 84	0 (0%)	58,689 (5%)
More than 85	0 (0%)	27,458 (2%)
Race/Ethnicity	N=239	N=1,314,593††
White	66 (28%)	477,852 (36%)
Asian	15 (6%)	365,857 (28%)
Black	80 (33%)	151,724 (12%)

Characteristics	Survey*	Population of San Francisco and Oakland
Income	**N=237**	**N=534,264****
Hispanic/Latino	9 (4%)	250,420 (19%)
Other	69 (29%)	68,740 (5%)
Gender	N=240	N=1,109,952†
Male	203 (85%)	551,633 (50%)
Female	37 (15%)	558,319 (50%)

*The survey N value varies because respondents could choose to skip certain questions.
**The population N value for the income level applies to the population of households as reported by the U.S. Census.
***The population N value for education applies to educational attainment for individuals over 25 years of age as reported by the U.S. Census.
†The N value for gender and age applies to the total population aged 18 and older.
†† Population for race/ethnicity is the total population of San Francisco and Oakland.

Driver Survey Findings

The driver survey asked a series of questions regarding the services respondents drove for, travel patterns while providing passenger or package delivery services, challenges and concerns regarding curb access, and perspectives on curbside policies and priorities.

The results from the question asking drivers what services they drove for, shown in Figure 25, reveal that most of the survey respondents drove for taxi services, followed by Uber, microtransit, UberEats, and Lyft. Other CNSs such as Postmates, GrubHub, and Ziro had representation around 2% to 5% of respondents. Note that respondents could select "all that apply" and so the percentages add up to greater than 100%.

Figure 25. Services the Driver Survey Respondents Drive For

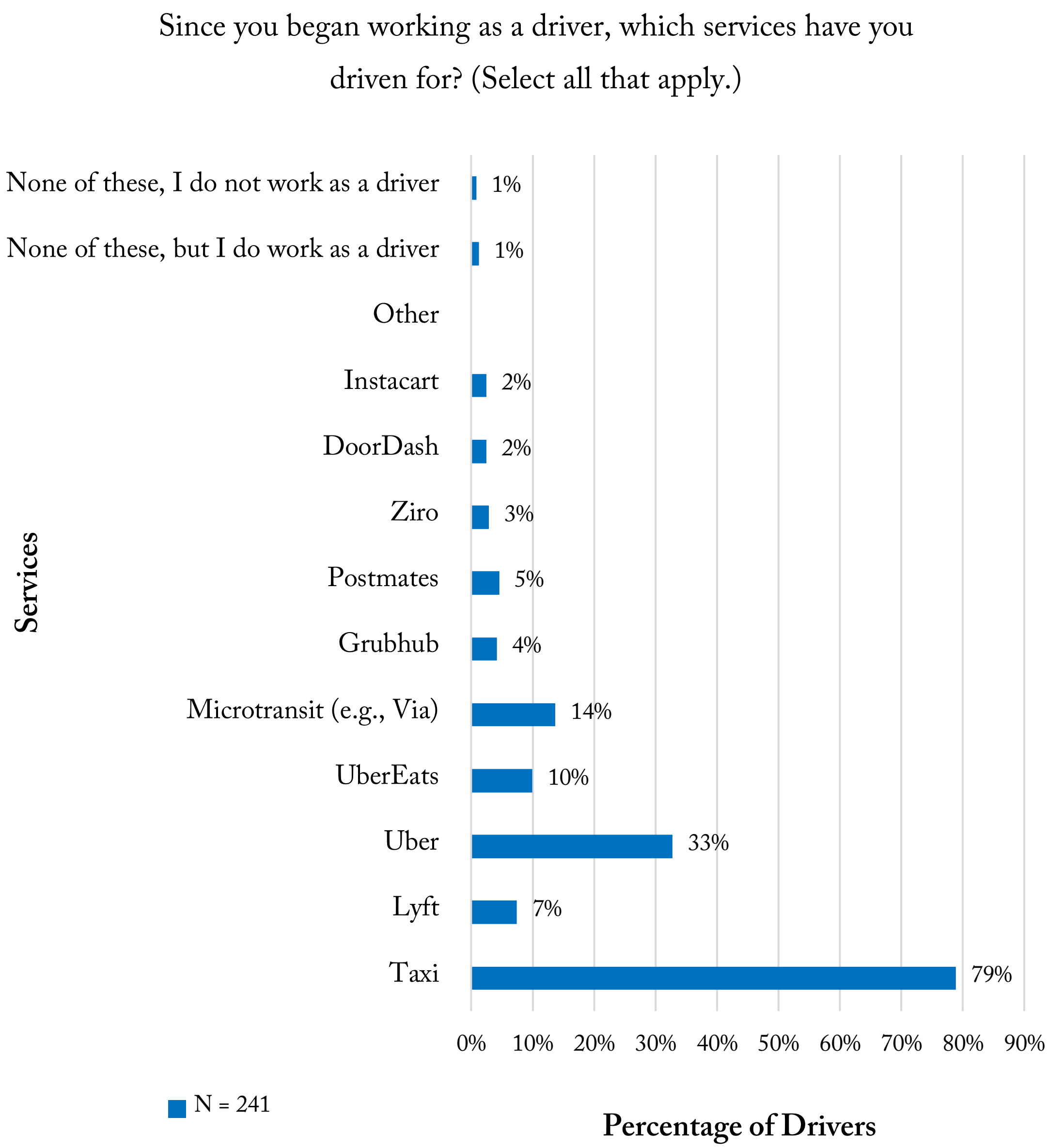
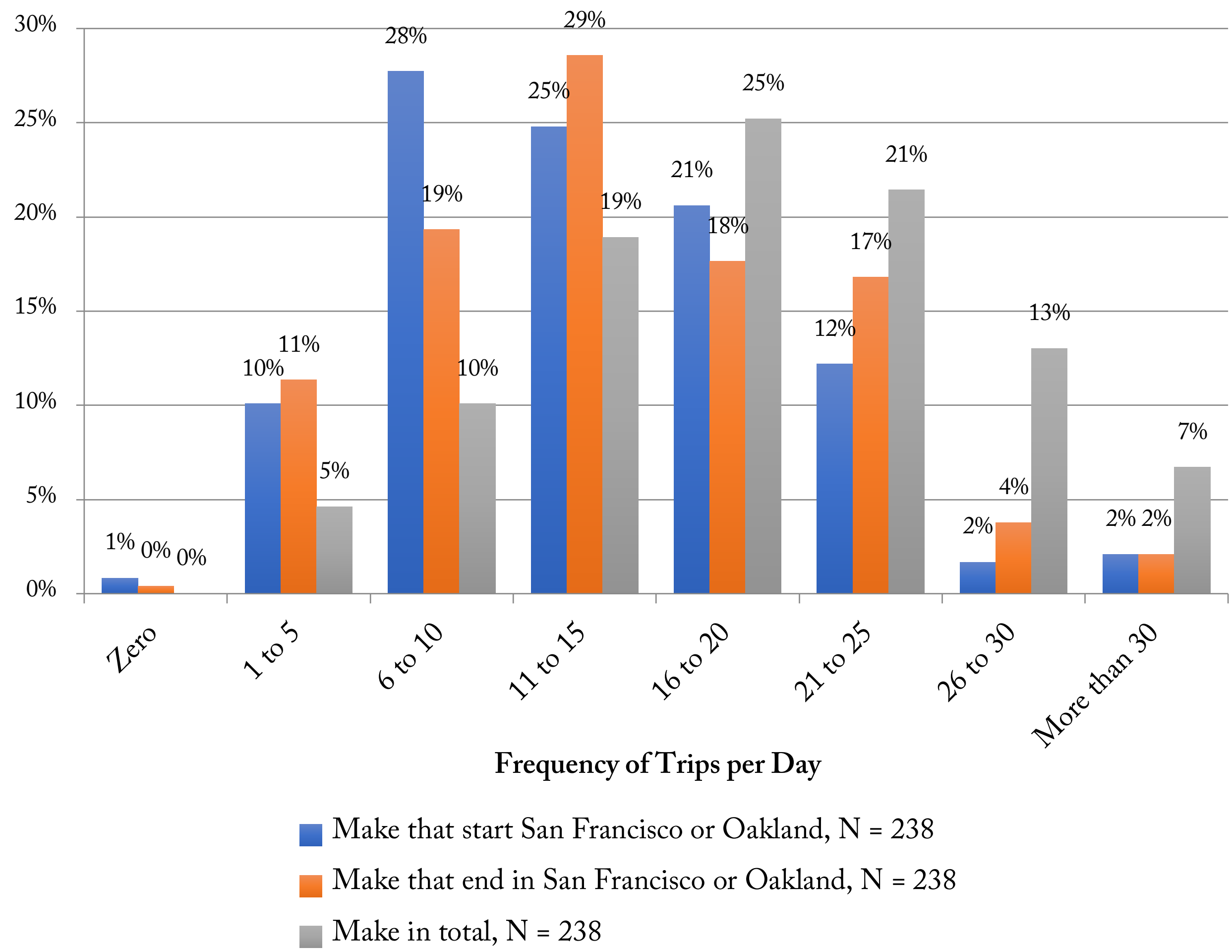


Figure 26 shows the results of the questions on trip making frequency and activity that started and ended within San Francisco and Oakland.

Figure 26. Trip Making Frequency

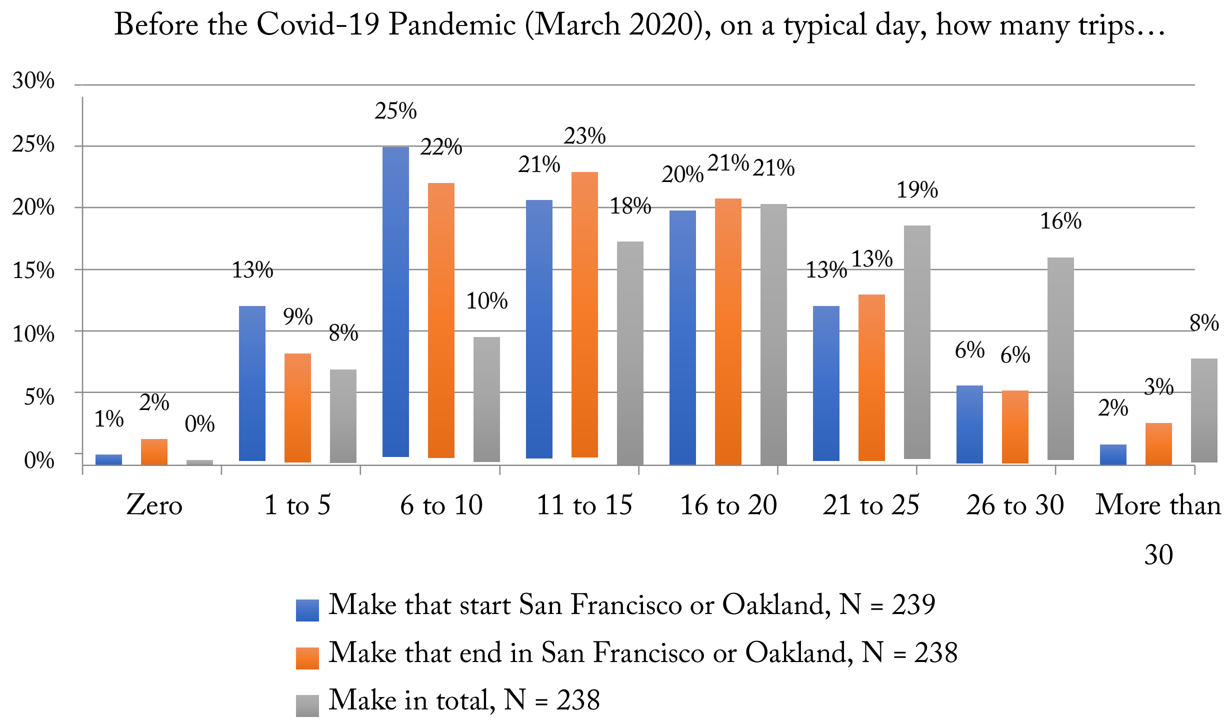
Currently, on a typical day, how many trips…



The responses show that most trips made by drivers started and/or ended in San Francisco and Oakland. The responses show a higher representation of categories representing anywhere between 16 to 30 trips per day within the "Make in total" response, relative to those trips that started and/or ended in San Francisco and Oakland. This is naturally due to this category as constituting an approximate sum of trips that may start or end within either city. The distribution of responses does suggest the cities are more often a destination versus an origin. This is evident from the fact that slightly more trips end within San Francisco and Oakland compared to those that start within the cities. The results also reveal a relatively dispersed distribution of trip frequencies across the different trip categories. This suggests—perhaps not surprisingly given the self-employed nature of the occupation—that different drivers provided their services at different frequencies.

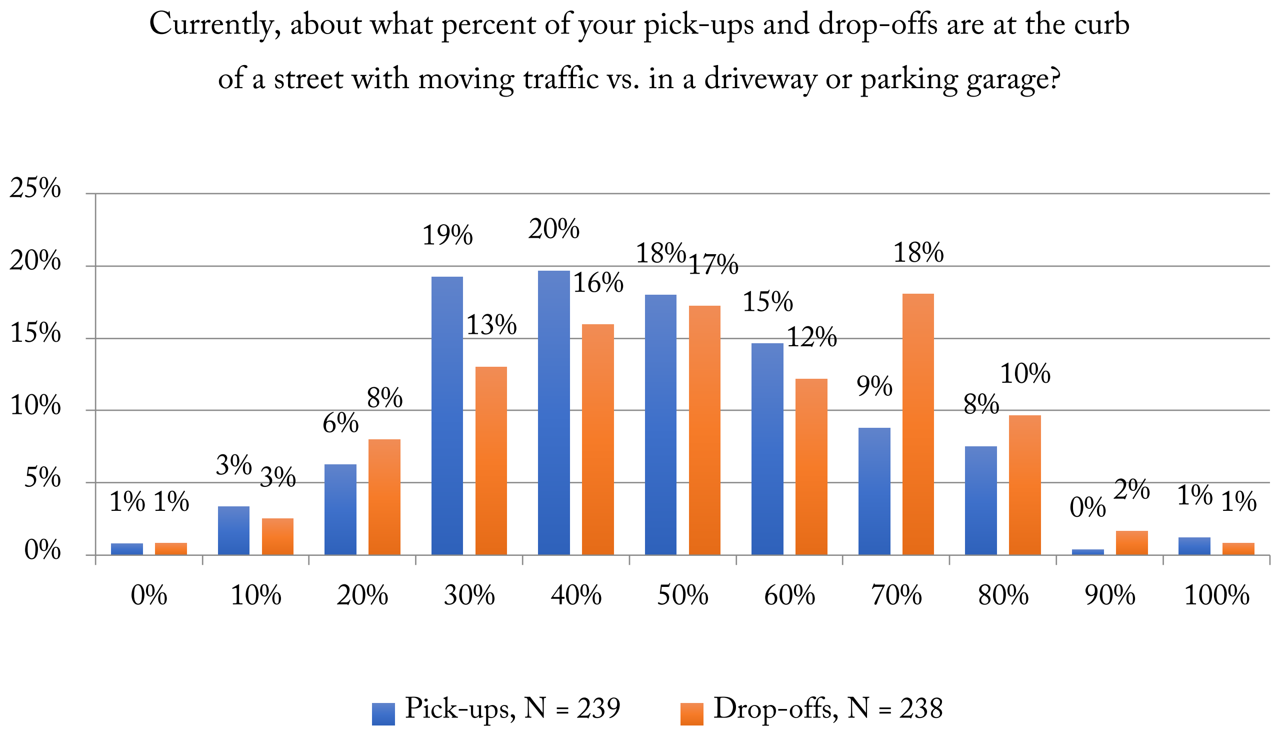
Because the survey was administered during the COVID-19 pandemic, it asked questions about trip frequency before the pandemic. The results, shown in Figure 27, suggest that the frequency of service provision declined following the onset of the pandemic, but not significantly so. This is most prominently shown by comparing the "Make in total" response across Figure 27 and Figure 26. The category of 26 to 30 trips per day had a 16% share of responses before the pandemic and 13% at the time of the survey. This slightly rightward shift suggests that survey respondents did not perceive a major change in their frequency of trip making (by November 2020).

Figure 27. Trip Making Frequency Prior to the COVID-19 Pandemic



Driver survey respondents were asked what percent of pick-ups and drop-offs took place at the curb versus off-street in a driveway or a parking garage. Figure 28 shows the results. The comparative distributions show that drop-offs in moving traffic happened more often than pick-ups. That is, drivers reported that it was more common for them to drop off passengers than to pick them up in moving traffic. The difference in reported frequency is not significant, but it is evident with a comparison of the higher-frequency categories. For example, about 30% of drivers reported that they had drop-offs within moving traffic at least 70% of the time. In contrast, about 18% of drivers reported that they had pick-ups within moving traffic at least 70% of the time. The general balance of these distributions shows that drop-offs in traffic occur more often than pick-ups in traffic.

Figure 28. Curb Pick-Ups and Drop-Offs with Moving Traffic



The survey asked respondents what or whom they transport within their vehicle. The question was framed in the context of services provided before the COVID-19 pandemic and at the time of response. Figure 29 shows the distribution of responses, where the options available to transport included: (1) people, (2) food, (3) packages, (4) other, and (5) none. The results show that before the pandemic, drivers predominantly transported passengers, followed by packages, food, and other items. At the time of the survey, the distribution was distributed equally across people and food. In fact, the percentage of drivers delivering packages declined slightly during the pandemic.

Figure 29. What or Whom Drivers Transport

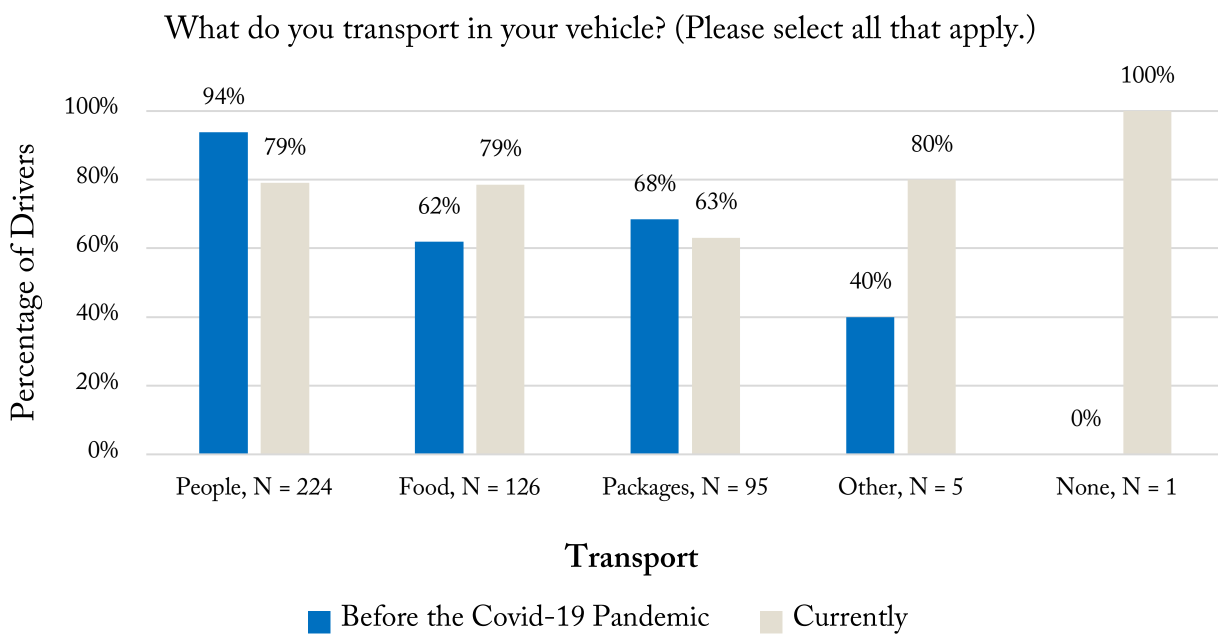


Figure 30. Ease of Pick-Up and Drop-Off by Trip Purpose

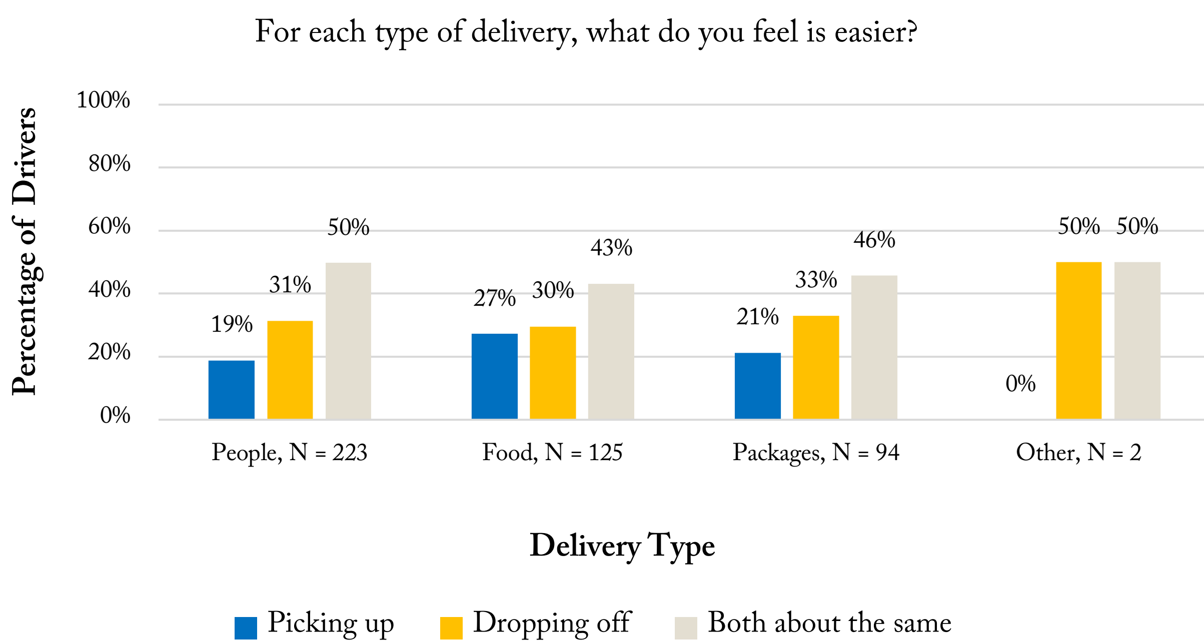
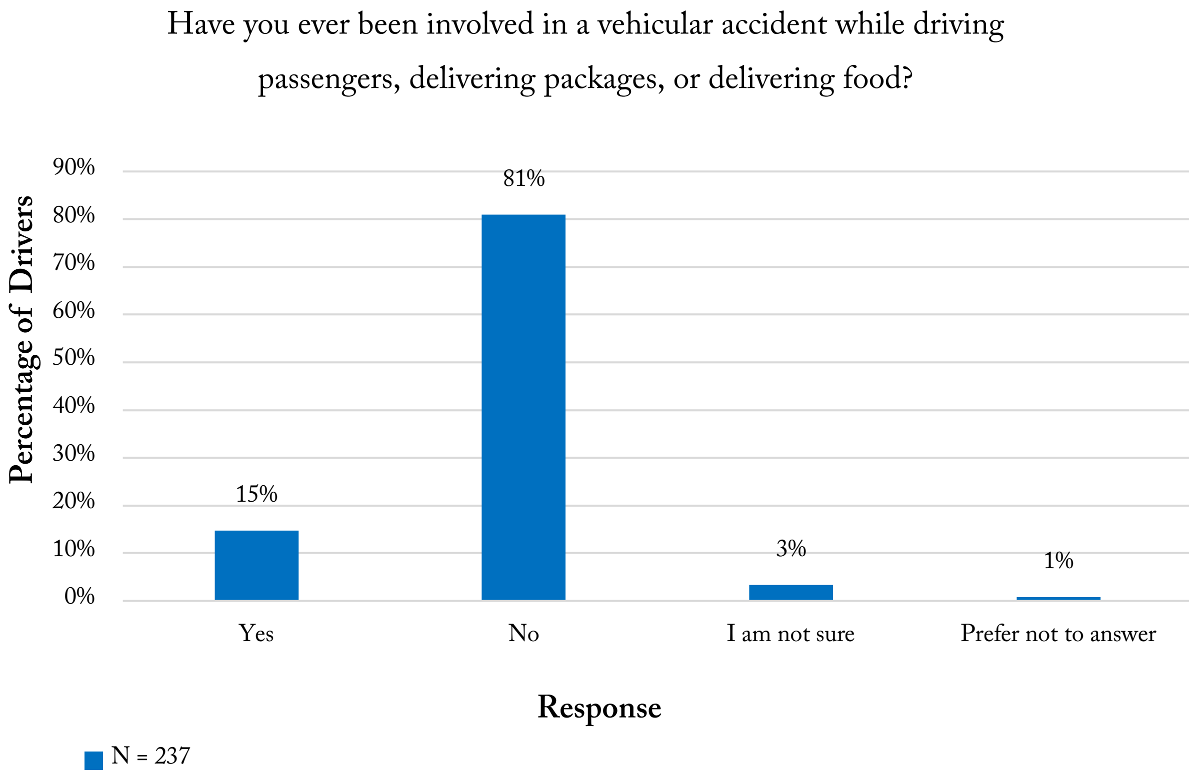


Figure 31. Daily Exclusivity of Trip Purpose

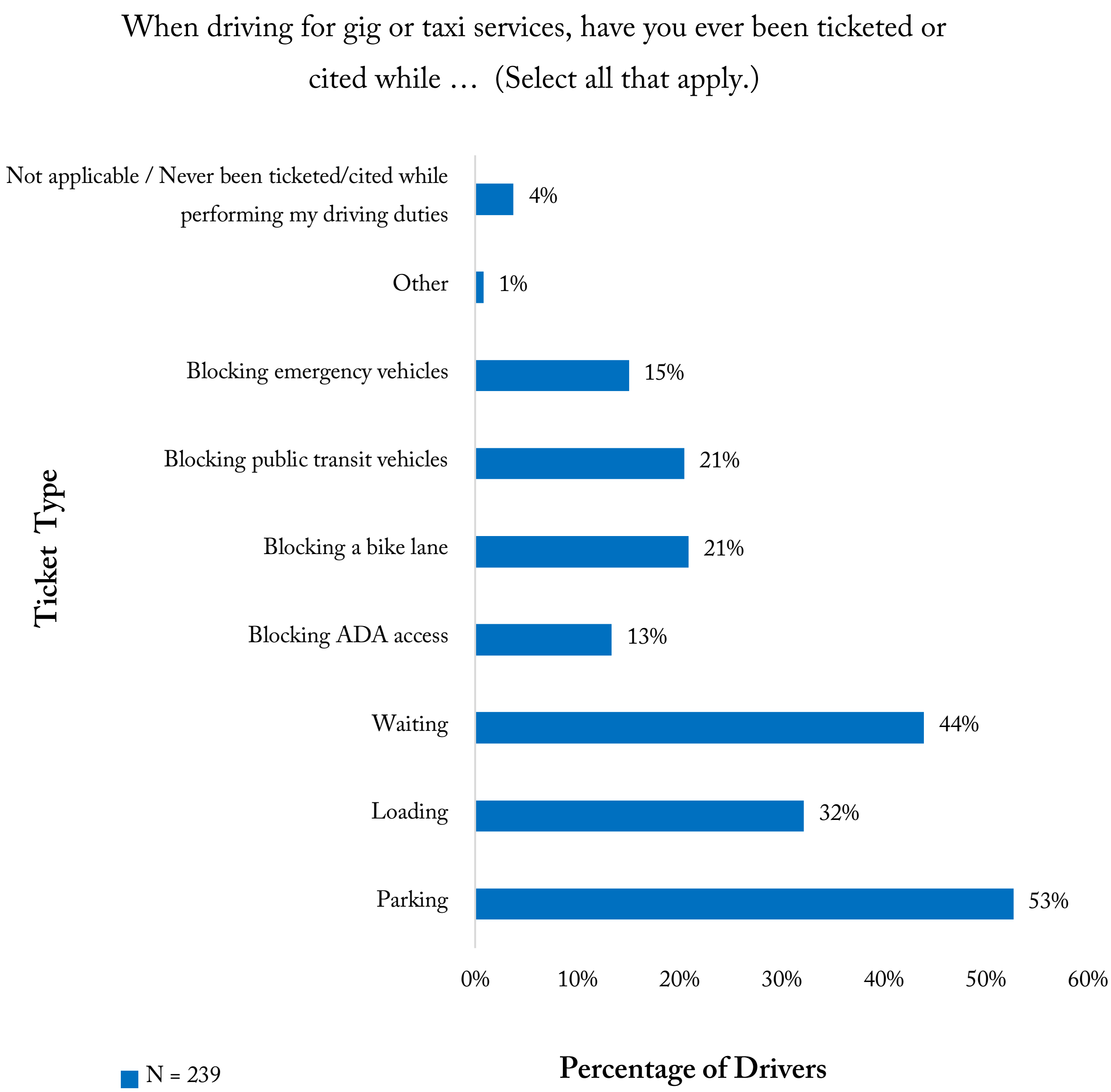
The next set of questions explored how drivers responded to certain challenges associated with the profession. To begin, drivers were asked whether they had ever been in an accident while driving for the delivery of passengers, packages, or food. Figure 32 shows the distribution of responses. A minority (15%) reported having a vehicular accident while driving.

Figure 32. Accident Occurrences while Driving



Drivers faced other challenges, including receiving citations while driving for gig services. Respondents were asked whether they had been ticketed, as well as why they were ticketed while driving professionally. The responses are shown in Figure 33, and they reveal that the most common reasons drivers had received citations included parking (53%), waiting (44%), and loading (32%). Other common citations included blocking something, such as a transit vehicle or bike lane (21% each), an emergency vehicle (15%), or ADA access (13%). Remarkably, only 4% of driver respondents reported that they had never been ticketed performing the service(s).

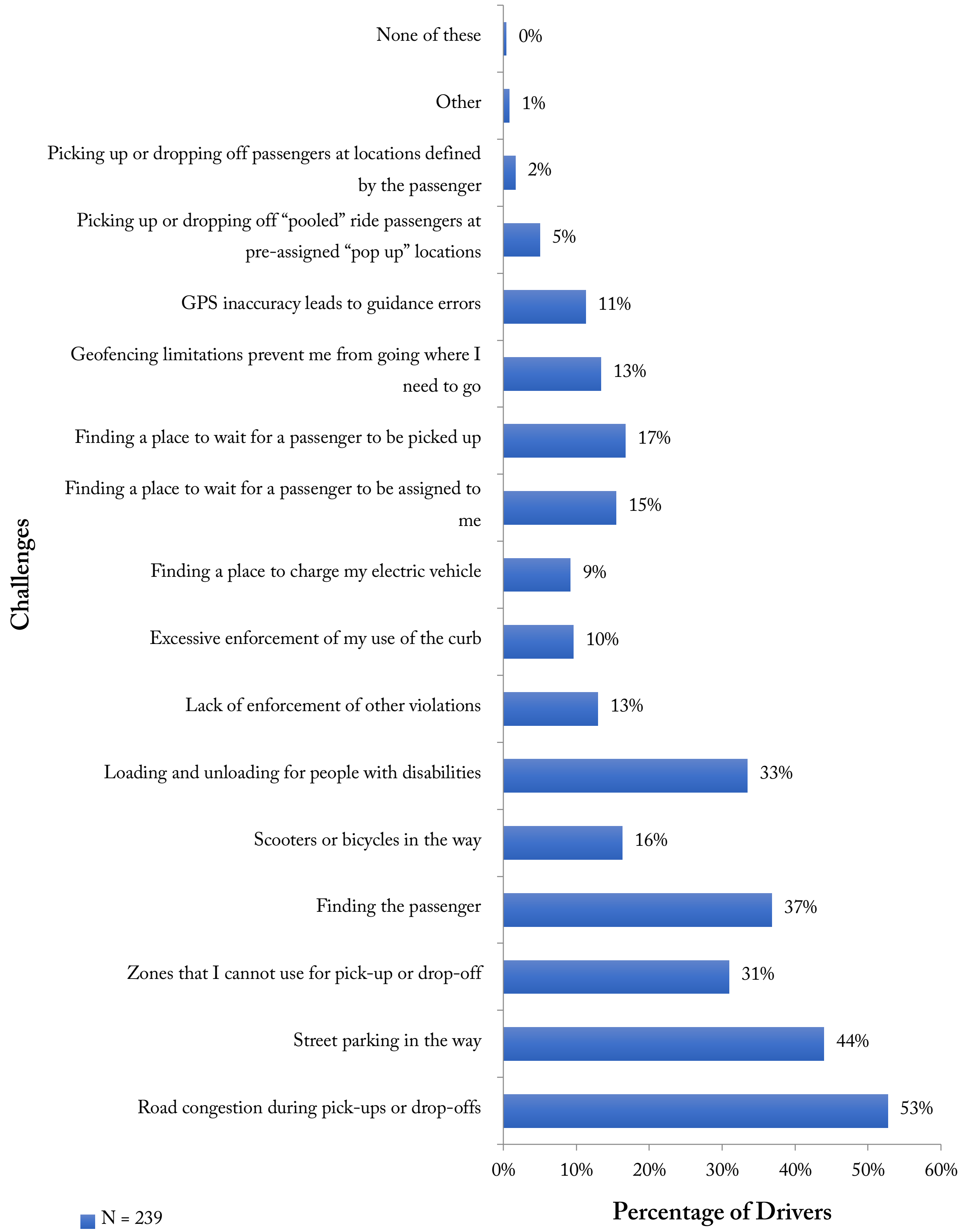
Figure 33. Tickets and Citations while Driving for Gig or Taxi Services



Driver survey respondents were asked about the specific challenges that they faced when trying to access the curb or loading zones. The results are shown in Figure 34. The most common challenge reported was road congestion (53%). Other leading responses included "street parking in the way" (44%), "finding the passenger" (37%), "loading and unloading for people with disabilities" (33%), and "zones that I cannot use for pick-up or drop-off" (31%). Notably, 9% of respondents reported that finding an electrical vehicle charging location was a challenge.

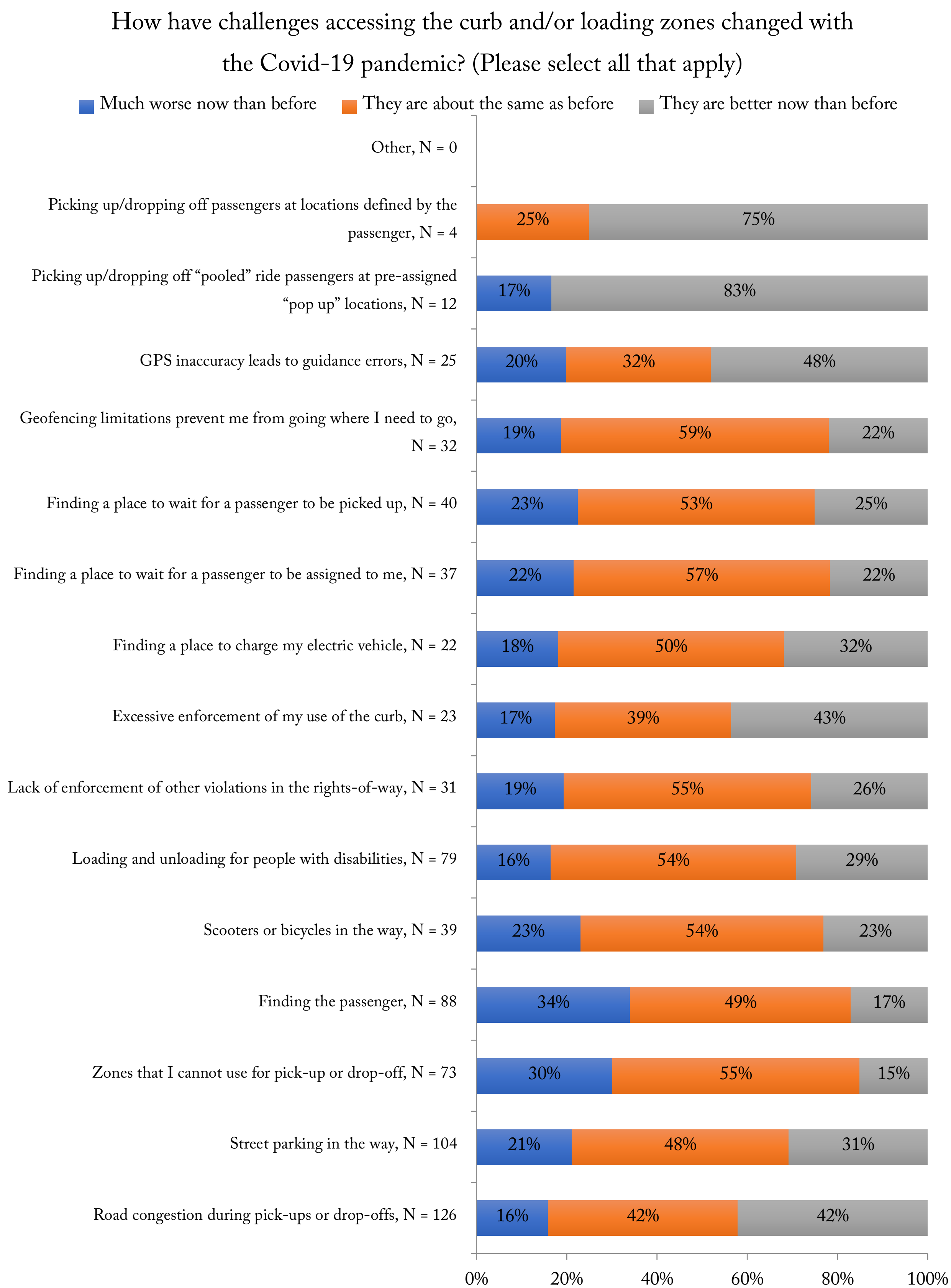
Figure 34. Challenges Accessing the Curb and Loading Zones

What challenges do you have accessing the curb and/or loading zones? (Please select all that apply.)



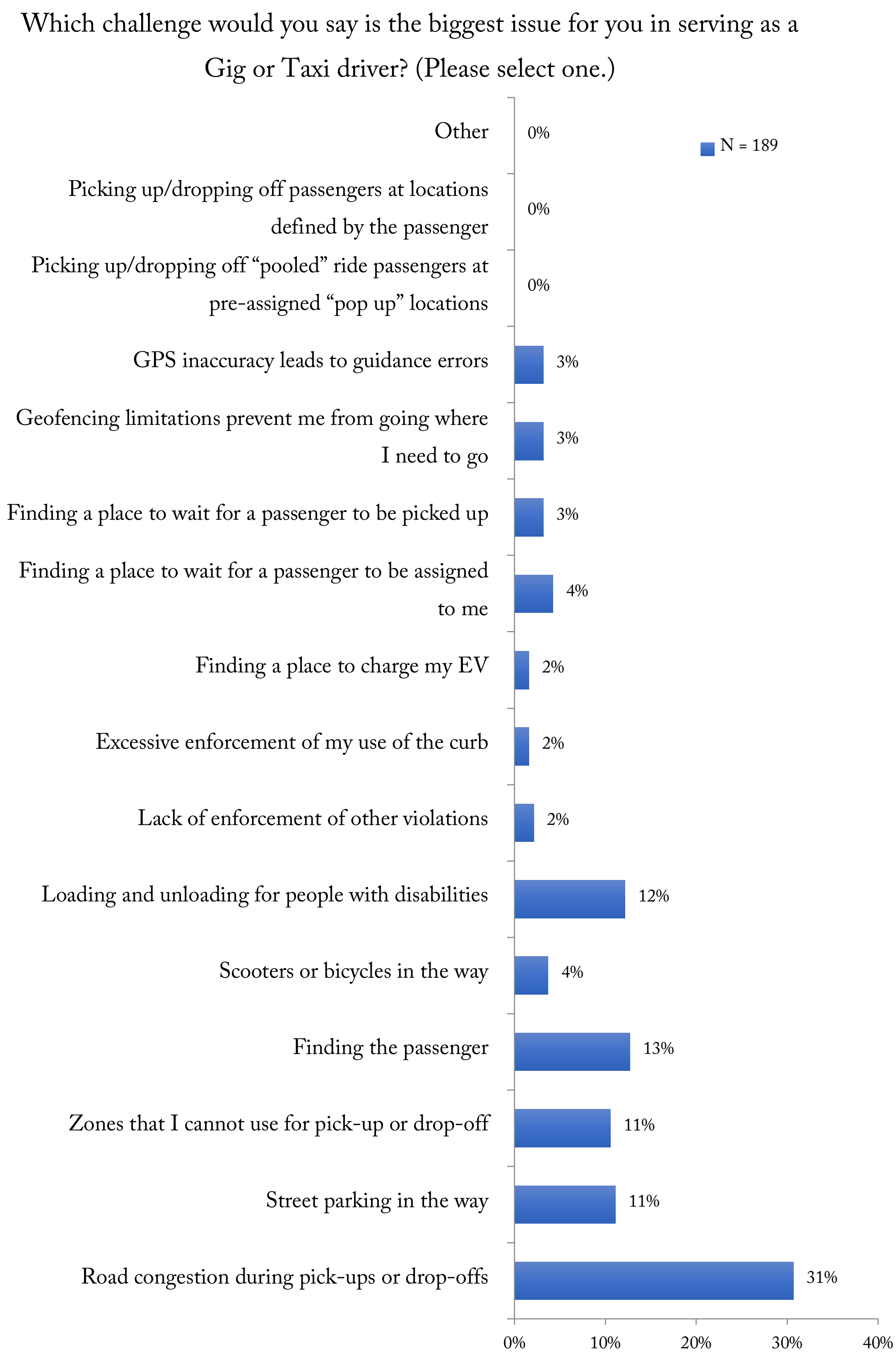
Building on the previous question, respondents were asked whether the challenges identified had gotten better or worse as a result of the pandemic. Figure 35 shows a mix of responses. In most cases, a majority of respondents suggested that the pandemic left such challenges "about the same as before." However, for those picking a side (better or worse), respondents generally said that challenges were "better now than before," meaning the pandemic had actually improved the situation related to the specific challenge. This response was notably the case with congestion-related challenges, and also with certain enforcement difficulties. The challenge of "finding the passenger" was the challenge most notably exacerbated by the pandemic.

Figure 35. Change in Challenges as a Result of the Pandemic



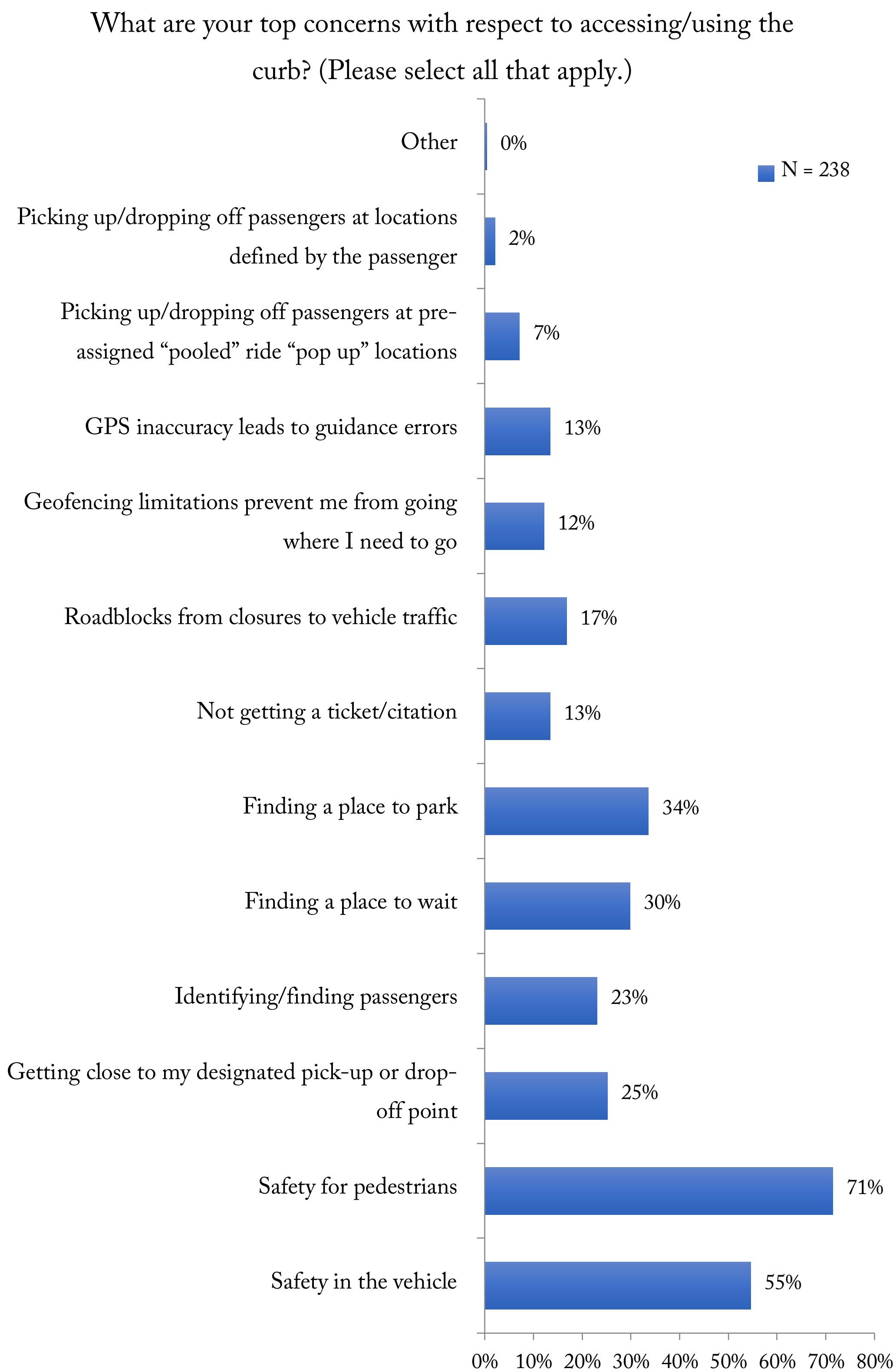
Respondents were also asked what their biggest challenge was as a gig driver, and only one response was allowed. Figure 36 shows that respondents selected road congestion during pick-ups and drop-offs (31%) as the biggest challenge. A distant second biggest challenge was finding the passenger (13%). Overall, the biggest challenges selected by respondents mostly pointed to issues related to the pick-up or drop-off of the passenger, loading zones, parking in the way of traffic, or specific challenges associated with loading and unloading persons with disabilities.

Figure 36. Biggest Challenge as a Gig Driver



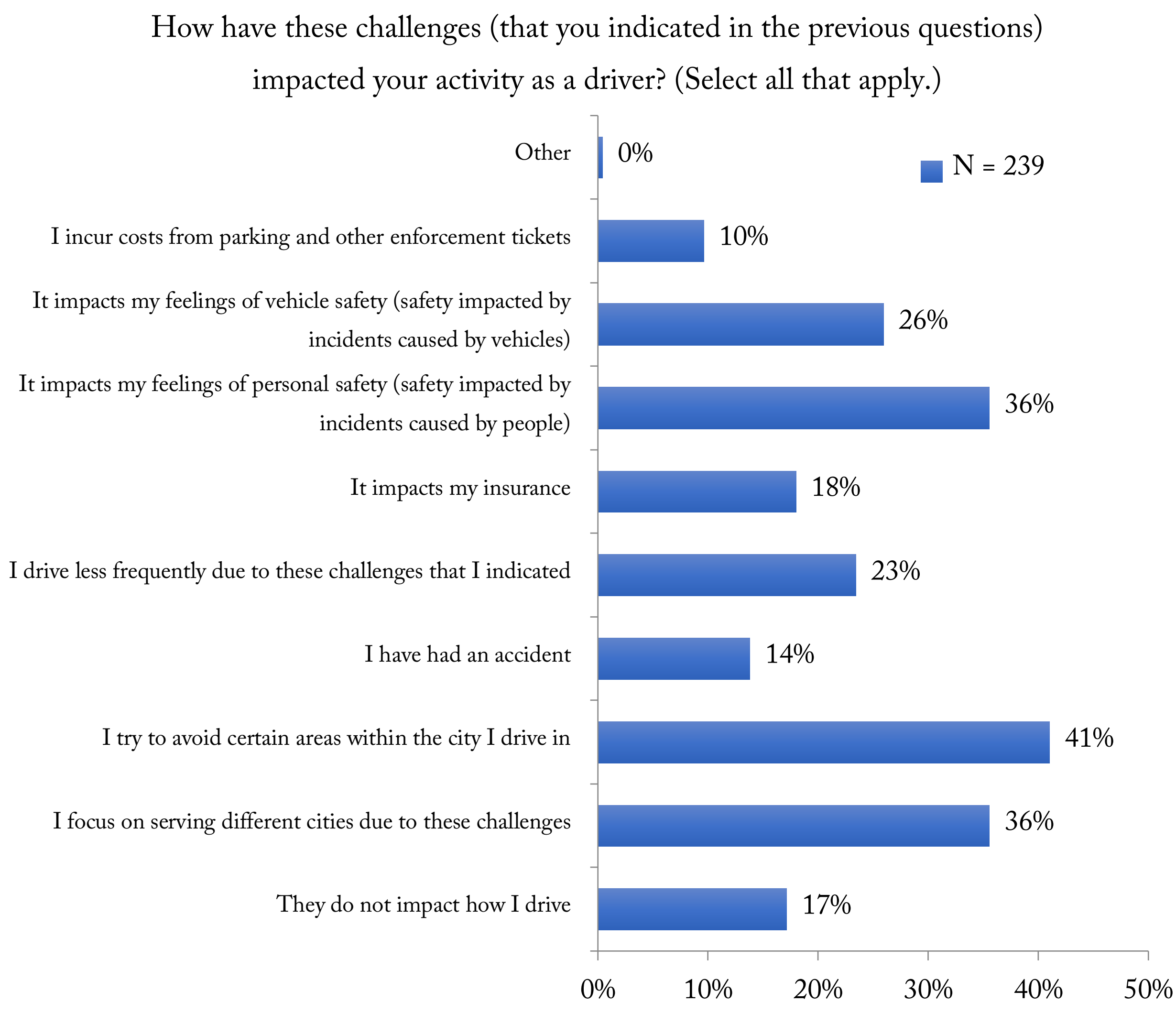
Respondents were asked what their top concerns were with respect to accessing the curb. The responses, shown in Figure 37, show that safety for passengers (71%) and the vehicle (55%) were the overwhelming top concerns considered. The next tier of concerns pertained to finding a place to park (34%) and to wait (31%).

Figure 37. Top Curb Access Concerns



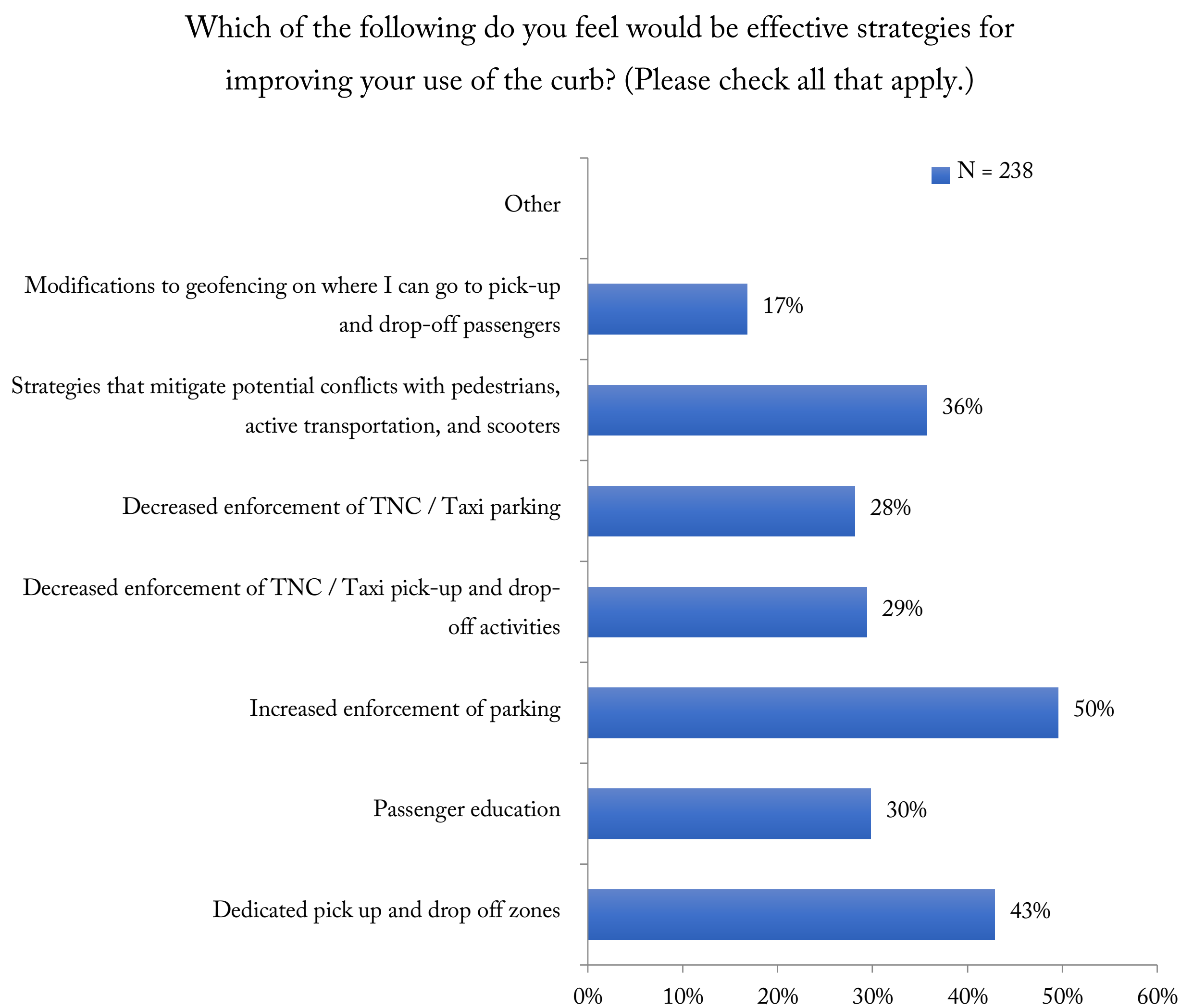
The results in Figure 37 suggest that there is considerable stress on the driver with respect to safety, and the responses suggest that some of the most stressful situations relate to the pick-up of passengers, where passenger identification and traffic and parking management happen simultaneously. The survey followed up by asking how these challenges impacted the respondent's activities as a driver. The results are shown in Figure 38. Notably, the leading responses suggest that challenges faced by drivers impact the locations in the city served (41%) and which cities they serve (36%). Equal to this latter impact is the impact to drivers' personal feelings of safety (36%), followed by feelings about vehicle safety (26%) and how frequently respondents drive (23%).

Figure 38. Impacts of Challenges on Driving Activity



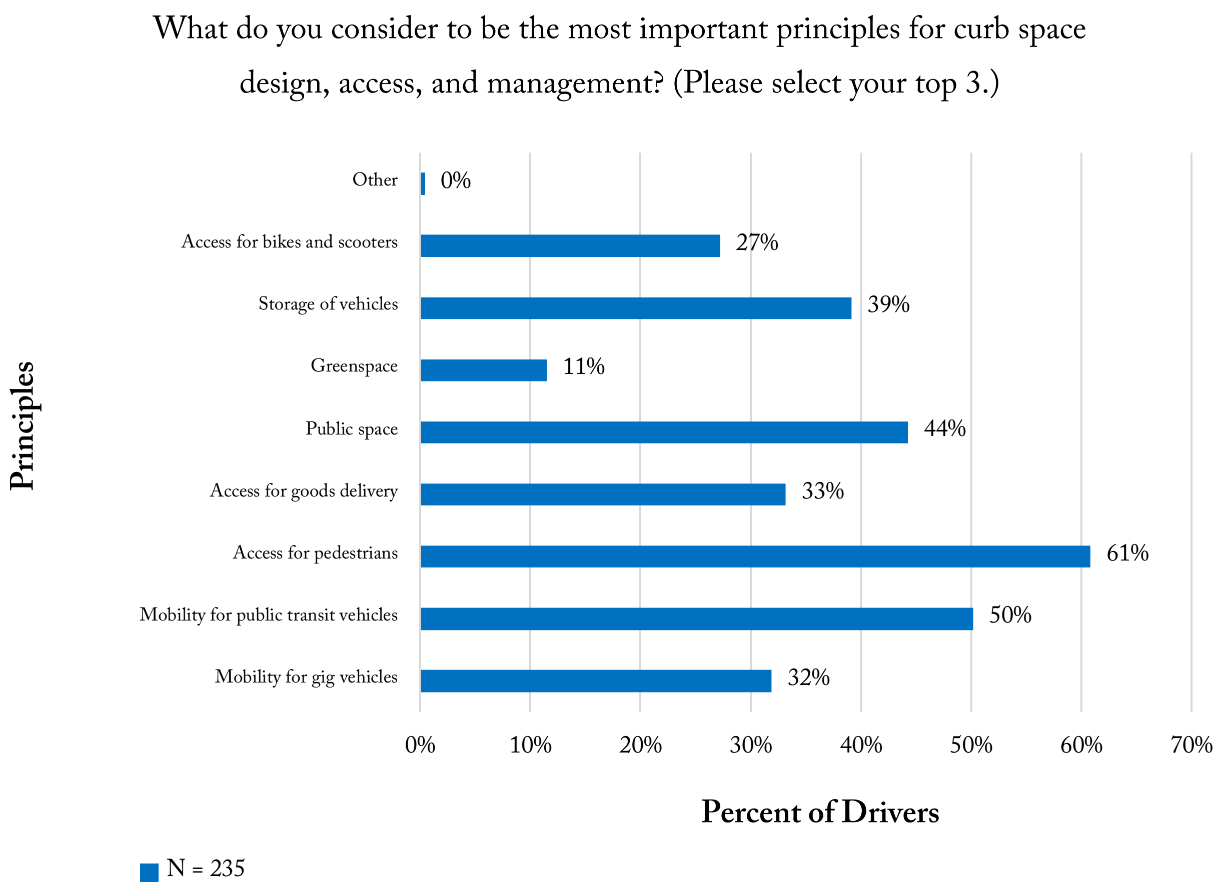
The survey asked questions about the strategies drivers felt would be effective for improving their curb use. The responses are presented in Figure 39. The two leading responses are greater enforcement for parking (50%) and dedicated pick-up and drop-off zones (43%). These two measures are consistent with addressing the challenges noted in Figure 38. Drivers are facing considerable pressure with respect to finding passengers and staging their vehicles within moving traffic. The stress stemming from these situations would be improved by the availability of zones in which drivers could safely wait for passengers to find them. The request for greater enforcement of parking, which can be a problem for drivers, also speaks to this policy. Drivers simply need locations that they can pull into in order to safely find and wait for passengers. Drivers also noted a need to mitigate conflicts with pedestrians and users of other active transportation modes (such as bikes and scooters) (36%). While drivers preferred greater enforcement of parking, about half as many would also prefer reduced enforcement of TNC-/taxi-related parking and other activities.

Figure 39. Drivers' Selected Curb Strategies



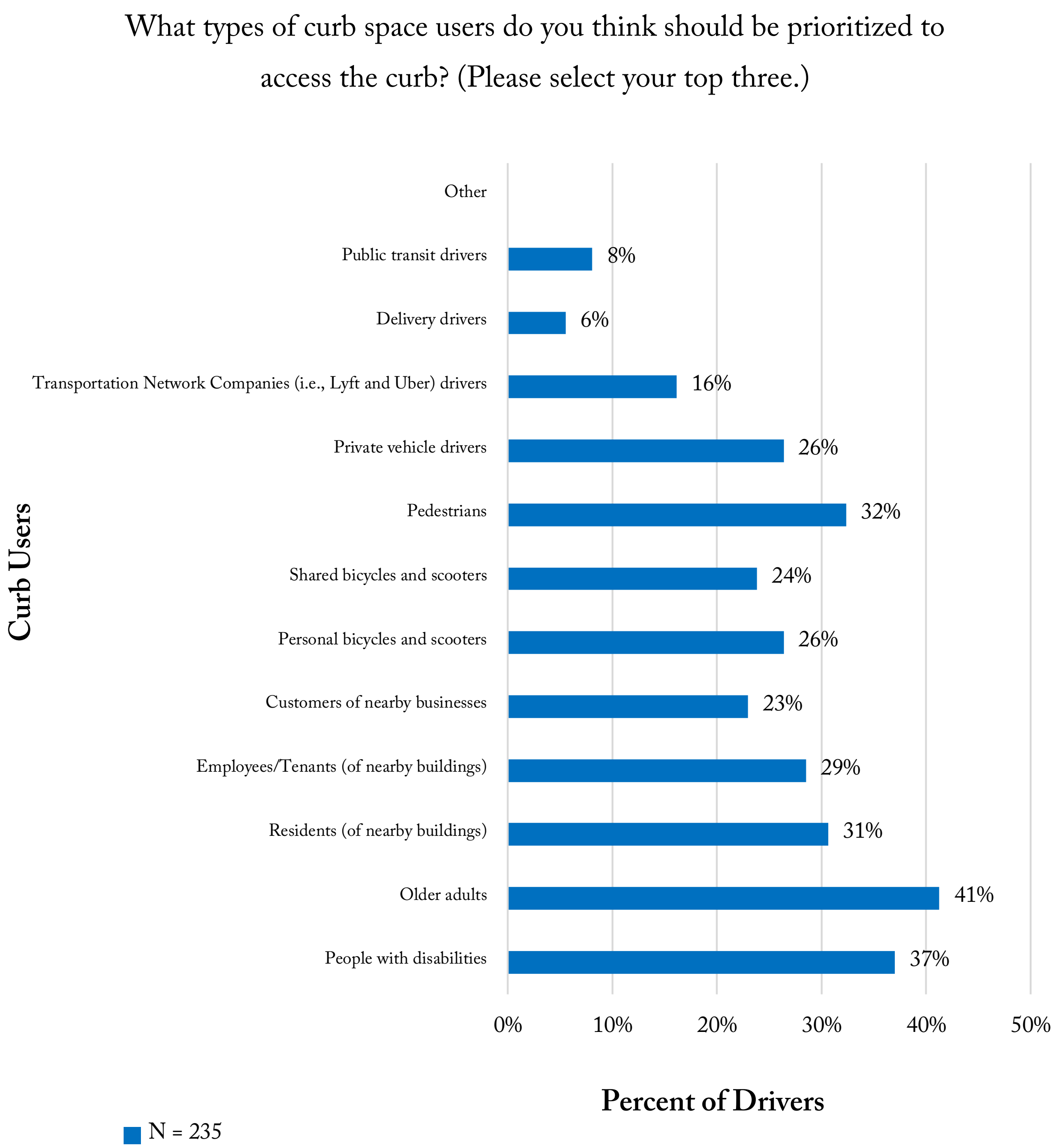
Drivers were asked what principles they felt would be most important with respect to curb design, access, and management; they were asked to select their top three. Figure 40 shows that the leading principles selected by drivers include access for pedestrians (61%), mobility for public transit vehicles (50%), public space (44%), and vehicle storage (39%). Collectively, these design principles suggest that improvements need to be made for the safer and more fluid interaction between vehicles and pedestrians.

Figure 40. Drivers' Selected Strategies for Curb Space Design, Access, and Management



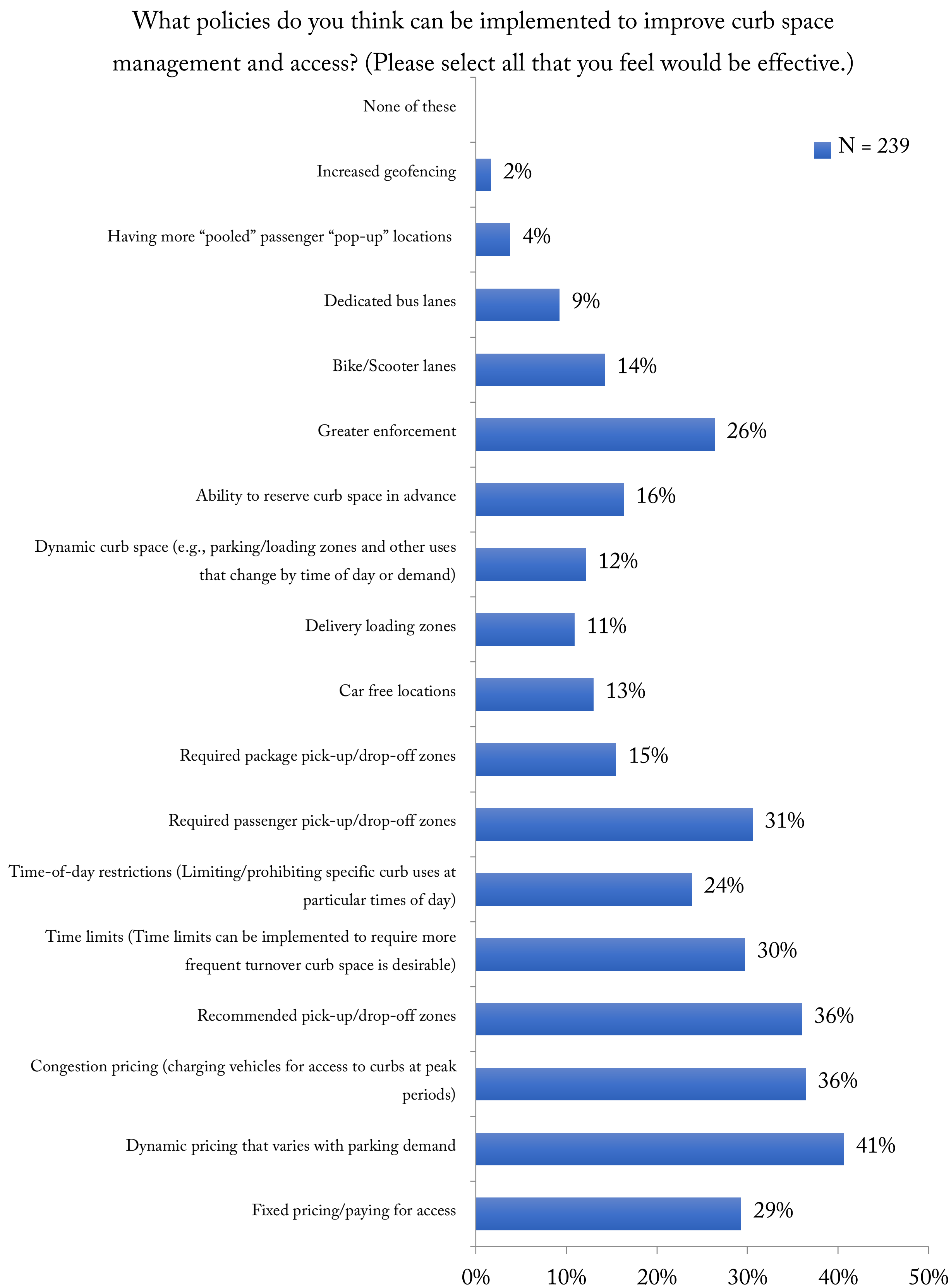
Drivers were also asked what types of users they felt should be prioritized for curb access; they were asked to select their top three. Figure 41 shows that the curb space users who drivers feel should be most prioritized include older adults (41%), persons with disabilities (37%), and pedestrians (32%). Local residents (31%) and local employees (29%) were close behind, occupying fourth and fifth place. In general, drivers most often selected groups that are commonly supported in public policy principles. These findings again speak to the need to develop curb space designs that can enable a more coordinated interaction between vehicles and people. This need is further supported by data presented in Figure 39, which shows that drivers favored increased enforcement for parking, dedicated pick up and drop off zones and broader strategies to mitigate conflicts across modes.

Figure 41. Drivers' Selected User Prioritization



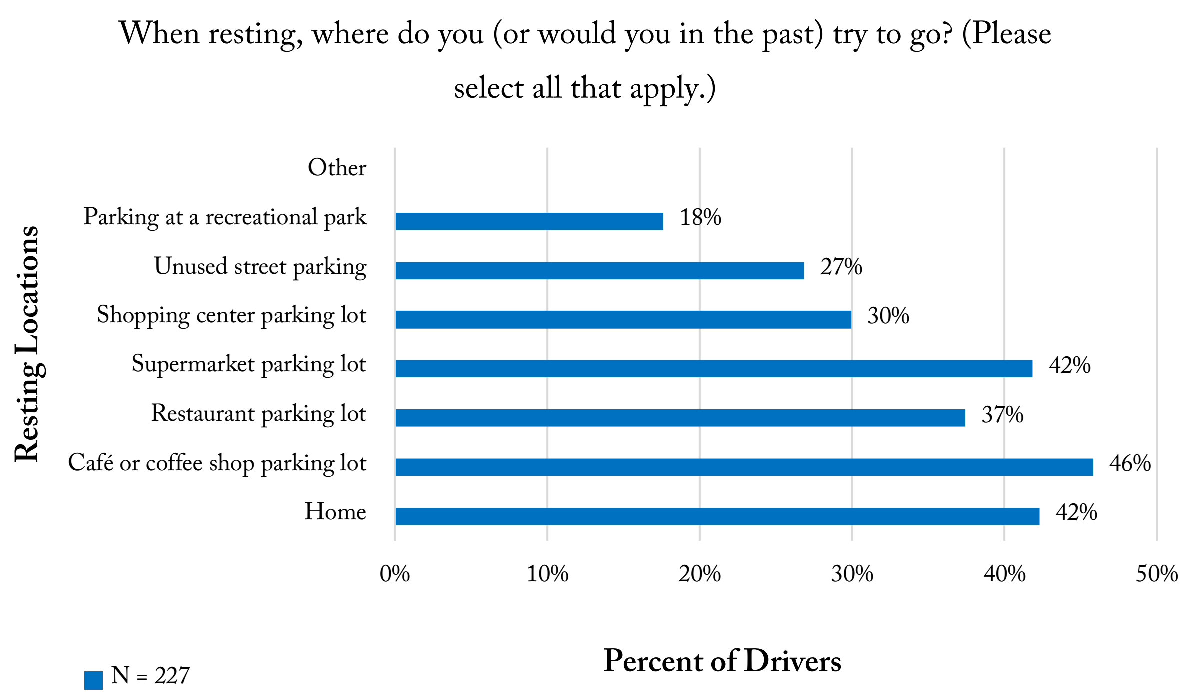
Additionally, drivers were asked about policies that they felt would be effective to improve curb space management and access. The responses, shown in Figure 42, reveal a preference for pricing parking (41%) and congestion management (36%). Additionally, recommended pick-up and drop-off zones (36%) received equivalent support. Other popular responses included requiring pick-up and drop-off zones (31%), paying for access (29%), and restricting access by time of day (24%). Paying for access may not be paying for parking per se, but paying to use the zones, which is different. Personal vehicles could potentially use the zone if access to curbside zones is completely unregulated. If there is no pricing for access, it is possible that such zones will become overused or subject to congestion. Note however, a minority of respondents favored these strategies. While it is important to note that no responses yielded a majority, the leading responses by drivers revealed some acceptance of space and time management at the curb as well as pricing for access. These measures represent potential pathways to improving access to the curb and the outcomes of interactions at the curb with the existing infrastructure design overlayed with information technology. Information technology, such as geofencing of zonal access, may be necessary to facilitate curb management. Real-time information on where passengers are accessing and egressing modes at the curb may also help with demand management and congestion.

Figure 42. Curb Management Strategies



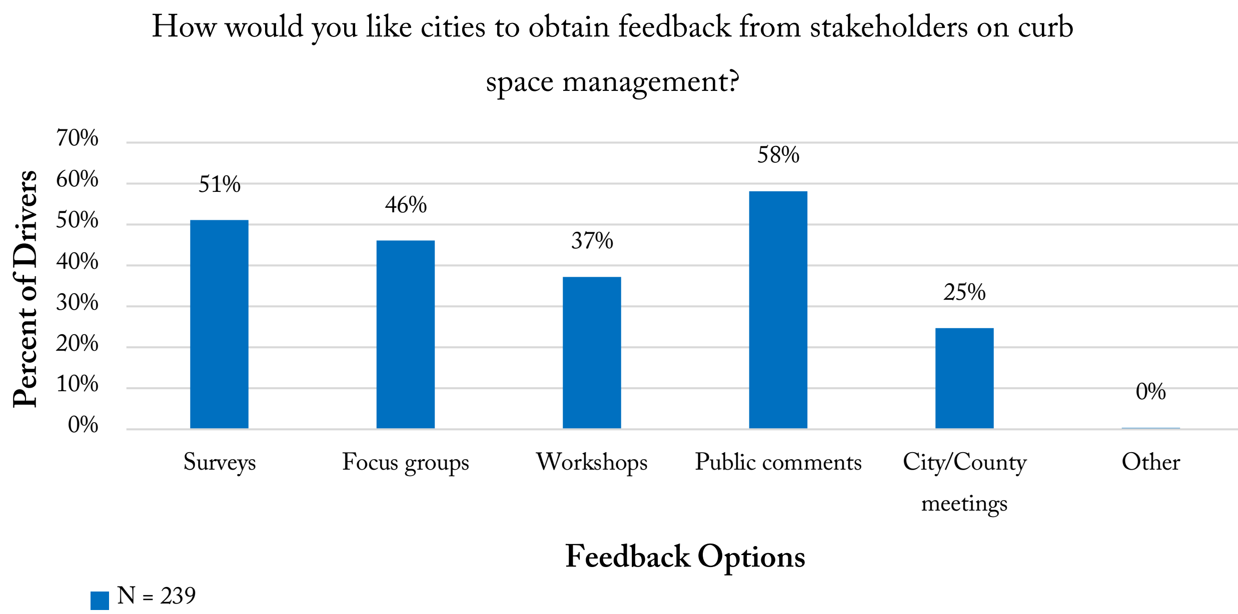
Drivers were asked about where they try to find places to rest. Responses within Figure 43 show that many drivers seek out parking lots at coffee shops (46%), supermarkets (42%), restaurants (37%), and shopping centers (30%). A large minority of drivers also reported that they go home (42%) to rest, suggesting that they are delivering services close enough to home to rest there. The results of Figure 43 emphasize a known problem: that drivers of gig services have no dedicated locations to use for rest. Using unoccupied space within the parking lots of supermarkets and shopping centers, as drivers are doing, may be an efficient approach to addressing this need. But the fact that shopping parking lots are used also shows that a series of an impromptu strategies are created out of necessity with no organization. While these driver innovations make use of existing infrastructure to address day to day problems, their ad-hoc nature can create problems. For example, the use of shopping parking lots can reduce parking availability for other commercial purposes. In addition, parking in vacant lots raises safety concerns for people using the lot for its intended purpose as well as the driver. Furthermore, parking to rest the driver is a good opportunity to charge an electric car, but if the infrastructure used to rest vehicles is not coordinated with fueling infrastructure, then there is a perpetual lost opportunity to support electric vehicles operating within the confines of TNC and taxi services. Hence, the improvised strategies developed by drivers can create new challenges and missed opportunities, reinforcing the need for better organization of driver infrastructure to facilitate drivers' performance of services.

Figure 43. Where Drivers Rest



Finally, Figure 44 shows the distribution of responses to the question of how drivers would prefer to give feedback to cities. Among the options listed, drivers most commonly selected public comments (58%) and surveys (51%). A minority expressed preferences for focus groups (46%), workshops (37%), and finally, city/county meetings (25%). These and other forums may serve as conduits for obtaining additional feedback and ideas from drivers.

Figure 44. Feedback Delivery Preferences



Driver Survey: Key Takeaways

The results of the driver survey reveal a number of challenges facing drivers as they aim to perform their services delivering people, food, and packages. Drivers generally do not represent the population that they serve: they typically have lower incomes and levels of educational attainment, are younger, more male, and exhibit significant departures from the general race/ethnicity make-up of the cities served. Most respondents drove taxi and TNC vehicles, and a majority of respondents transported food and packages in addition to people. Drivers cited several challenges associated with service delivery. Most of the challenges pertained to safety-related issues. The combination of survey responses suggests that drivers face tense and often stressful situations when navigating traffic, looking for passengers, dropping off passengers, and finding safe areas to transition passengers to and from the vehicle. The collection of challenges suggests that curb space, as it exists, needs to be improved: for example, by the provision of simple access points for taxi, TNC, and package/food delivery drivers to use to transport passengers and delivery packages. Drivers need dedicated locations that are widely distributed where they can pick-up/drop-off passengers or goods without interfering with traffic, endangering the passenger, or damaging their vehicle. Dedicated pick-up and drop-off spaces would enable these general objectives.

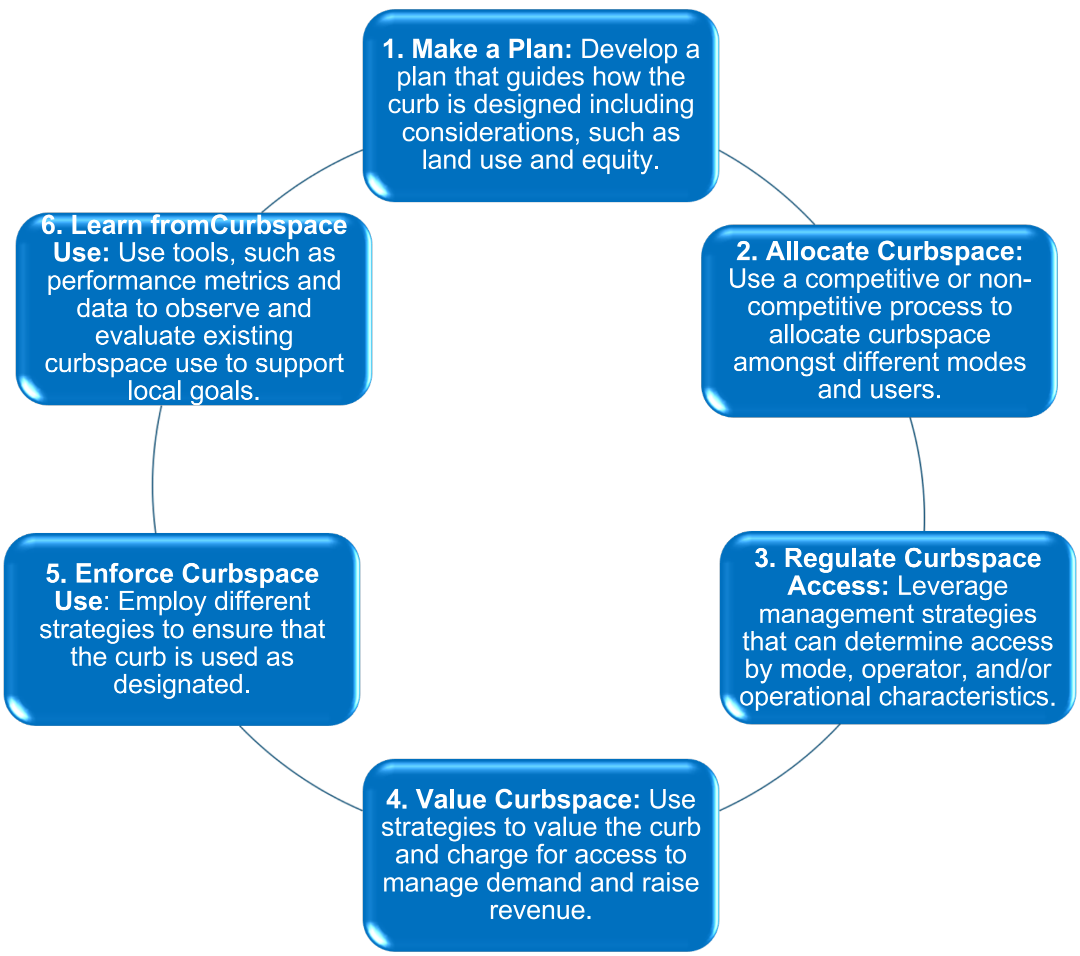
Also notable was a fairly sized minority endorsing pricing approaches as a means for managing space and time at the curb. A large minority of drivers reported that dynamic pricing and congestion pricing could be viable approaches to improved management of the curb. These policies may enable more available space at street parking locations and a lower flow of traffic on roads where drivers deliver their services. Drivers noted that the challenges they encounter force them to change their behavior and alter the areas and even cities that they serve. These concerns extend beyond the simple interaction between them and the passenger, but to the broader street-scape ecosystem. The survey results suggest that drivers encounter an environment that is generally not organized for the delivery of their service. The curb was designed with a different era in mind and without consideration for how drivers and/or service providers use it today. The results from this survey and other work may advance insights on how to improve the curb environment through infrastructure improvements and new policies.

7. Framework for Managing the Curb

A framework for managing the curb can help public agencies better to understand existing curb space use and pursue the most effective ways to repurpose the curb to achieve their goals. This chapter provides a framework and recommended practices for curb space management, including planning, allocating, regulating, valuing, enforcing, and evaluating curbside access.

To synthesize the curb space planning, management, and redesign processes, this report proposes a MARVEL Curb space Management Framework. The MARVEL framework includes six steps: (1) Make a Plan, (2) Allocate Curb space, (3) Regulate Curb space Access, (4) Value Curb space, (5) Enforce Curb space Use, and (6) Learn from Curb space Use. These steps are summarized in Figure 45. The framework was developed through information gathered from the literature review and expert interviews.

Figure 45. MARVEL Framework



The goal of this framework is to provide public agencies with the tools they need to prioritize social equity and access while mitigating the potential adverse impacts and disruptions associated with curb use changes. The following sections provide further information on each step of the MARVEL framework.

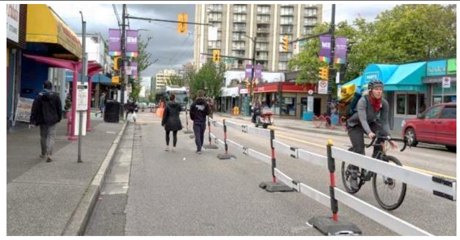
Make a Curb Space Plan

Curb management begins with developing a curb space plan that helps to prioritize and manage the curb. As curb space plans are developed, they can be informed by considerations such as the following.

- **Accessibility:** Access to a variety of different modes for users with varying ranges in age, size, mobility, and mental capabilities.
- **Emerging Mobility:** Integration of emerging modes and/or services (e.g., AVs, light electric vehicles, etc.).
- **Environmental Impacts:** Impacts to the environment including increased greenhouse gas emissions, noise and light pollution, and other criteria emissions.
- **Social Equity:** Physical, digital, and financial accessibility by all users, regardless of age, gender, race, ethnicity, income, ability, or other characteristic/identity.
- **Land Use:** Impacts to and from surrounding land uses (e.g., retail opportunities, public transit stops).
- **Managing Multiple Modes:** Accommodations for different modes and their respective needs (e.g., device storage for shared micromobility, loading zone for TNCs) to develop an integrated, multimodal plan.
- **Stakeholder Engagement:** Outreach methods to engage with community members, transportation professionals, and other stakeholders to help ensure the curb space plan meets existing needs. Strategies to engage stakeholders can be found in Appendix D: Stakeholder Engagement Methods.

Curb space planning may follow different planning approaches and policy goals, including those summarized in Table 7.

Table 7. Planning Approaches and Policy Goals

	Planning Approaches and Policy Goals	Image	Curb Application Examples
Slow Streets	Reduce traffic volume and speed to support active transportation by closing off a network of streets with low to moderate speeds (i.e., under 40 miles per hour) and no intersection obstructions to vehicle traffic and/or lowering traffic speeds		• Identify slow streets through temporary signage • Install permanent changes (e.g., speed bumps) • Use digital maps to illustrate networks of slow streets
Complete Streets	Focus on integrating various transportation modes, services, and infrastructure by leveraging rights-of-way planning, design, operations, and maintenance decisions to support accessible, safe, comfortable, and convenient travel for individuals of all ages and abilities		Use infrastructure and design elements to enhance public spaces including: • Public seating, • Bicycle racks, • Public transit shelters, • Loading zones, and • Pedestrian-friendly intersections
Universal Design	Increase mobility and curb access for the widest range of users by designing according to the seven principles of universal design: (1) Equitable use, (2) Flexibility in use, (3) Simple and intuitive use, (4) Perceptible information, (5) Tolerance for error, (6) Low physical effort, and (7) Size and space for approach and use		• Reduce potential barriers (e.g., uneven curbs) • Include tactile signage to indicate crosswalks and other pedestrian accommodations • Offer flexible seating that can be rearranged to accommodate different group sizes and needs • Maintain well-lit and consistent lighting • Provide curb cuts and audible crossing cues to facilitate easier street crossings

	Planning Approaches and Policy Goals	Image	Curb Application Examples
Vision Zero	Increase pedestrian safety and decrease traffic fatalities and injuries by increasing safe, healthy, and equitable mobility for all by employing the nine components of a vision zero commitment: (1) Political commitment, (2) Multi-disciplinary leadership, (3) Actionable plans, (4) Social equity considerations, (5) Cooperation and collaboration, (6) Systems-based approach, (7) Data-driven efforts, (8) Community engagement, and (9) Process transparency		• Implement raised curbs to separate pedestrians from vehicle traffic • Add protections to bike lanes to distinguish them and separate different traffic speeds • Insert traffic cams to monitor traffic speeds in an area and identify points of congestion • Implement designs in a variety of communities • Gather data and community feedback to inform plans and design changes

Source: National Association of City Transportation Officials, 2013; City of Vancouver, 2020; Smart Growth America, 2020; Arambula, 2018; Budds, 2019; Toole Design, n.d.; Vision Zero Network, 2018; Transport for London, 2018

Data and Curb Space Planning

Data can support curb space planning by helping decision-makers to: (1) identify locations to reallocate parking for other mobility services, (2) inform agencies how to adapt management strategies to better meet local goals, and (3) support enforcement tools. For example, data can help public agencies understand how the curb is used, providing information such as variations across different users, modes, use cases, and needs (Hutchings and Perry, 2021). Curb space data typically include:

1. **Asset Data:** Information on physical modes, such as the number of devices or vehicles in a fleet. Examples of curb asset data specifications include Coord's curb search API, Inrix's Road Rules, and SharedStreet's CurbLR (Baskin, 2019); and

2. **Journey Data:** Data on trip attributes, such as origin and travel time.

Standards can allow data to more easily be shared and used by various stakeholders. Data standards for shared mobility that could aid in understanding curb space access, use, and performance include:

- **General Bikeshare Feed Specification (GBFS):** A data format that provides real-time, operational bikesharing data but excludes historical data and personally identifying information.

- **General Transit Feed Specification (GTFS):** A data format typology that public agencies can use to publish public transit schedules and geographic information to make the data accessible to a wide variety of software programs.

- **Mobility Data Specification (MDS):** A data standard and application programming interface (API) that can be used by cities to gather, analyze, and compare real-time and historical data from shared mobility providers. MDS includes data such as mobility trips and routes, location and status of vehicles/equipment (e.g., available, in-use, out-of-service), and service provider coverage areas.

Additional information on data standards, common data sharing challenges, and potential strategies can be found in Caltrans' Shared Mobility Policy Playbook and the USDOT's Mobility on Demand Planning and Implementation guide.

Allocate Curb Space

After curb space plans have been developed, the curb can be allocated to enable access for different modes, services, and users. This process can be done through competitive or non-competitive processes. Table 8 and Table 9 summarize a variety of competitive and non-competitive curb space allocation strategies, including their respective advantages and disadvantages.

Table 8. Competitive Curb Space Allocation Strategies

Strategy	Description	Advantages and Disadvantages	Example
Auction	A public policy whereby requests for rights-of-way are granted to the highest bidder	**Advantages:** Raises money for municipal coffers and establishes market rate pricing for public rights-of-way **Disadvantages:** Creates equity issues when operators with greater financial resources can outbid operators with fewer financial resources; potentially passes costs onto the consumer	A variety of smartphone apps have been developed to allow people to auction off available parking spaces. In 2011, Parking Auction debuted in New York City's Manhattan Upper West Side (Barry, 2011). In 2014, Monkey Parking was available in San Francisco, California, as well as Rome, Italy (Levy, 2014).
First-Come, First-Serve	A public policy where requests for public rights-of-way by private operators are attended to in the order in which they arrive	**Advantages:** Does not require more sophisticated policies to be developed, particularly when there is only one requester **Disadvantages:** Potentially gives preferential treatment to market incumbents and/or results in difficulties gaining access for new entrants if those resources are taken by an earlier requester	In 2021, Raleigh, North Carolina offered permits for the private use of public space (e.g., for curbside dining or newspaper stand construction), including parking stalls and the curb through a first-come, first-serve process during the application process between June 1 and 30 (Raleigh, 2021).
Request for Proposals (RFPs)	A solicitation, often through a bidding process, by a public agency or government interested in procuring a shared mobility service	**Advantages:** Gives public agencies and local governments greatest control to select the service characteristics and requirements they desire **Disadvantages:** Potentially consumes time and other resources and is susceptible to litigation if not properly executed	Denver, Colorado released an RFP for a shared micromobility operator to operate in the city. The RFP required applicants to meet a variety of qualifications including service characteristics and community engagement mechanisms (City and County of Denver, 2020).

Sources: Cohen and Shaheen, 2016; Institute of Transportation Engineers, 2018; San Francisco Municipal Transportation Agency, 2020; Schaller Consulting, 2018

Unlike competitive processes, non-competitive approaches can foster a more collaborative environment. Table 9 describes non-competitive curb space allocation processes and their respective advantages and disadvantages.

Table 9. Non-Competitive Allocation Strategies

Strategy	Description	Advantages and Disadvantages	Example
Collaborative Approaches	A public policy employing a collaborative process, such as negotiation or mediation, in an attempt to reach a mutually beneficial outcome	**Advantages:** Brings all stakeholders together to possibly obtain a mutually beneficial outcome **Disadvantages:** Potentially results in difficulties if not all parties are willing to have an open dialogue	The Seattle Department of Transportation has a "Curb space Access Sounding Board" that allows stakeholders (e.g., residents, mobility service providers) to offer insight on current and planned curb use (Seattle Department of Transportation, 2019a).
Equal Distribution	A public policy whereby every stakeholder receives an equal share of the public rights-of-way	**Advantages:** Promotes a perception of fairness **Disadvantages:** Possibly results in difficulties in allocating space between large and small mobility service providers	In Santa Clara, California, the shared micromobility permit regulations allow a total of 3,000 devices (1,000 bicycles and 2,000 scooters) to be available from a variety of operators in the city. The number of devices per operator are equally distributed (City of Santa Clara, 2019).
Lotteries	A public policy whereby requests for rights-of-way are selected by random drawing	**Advantages:** Has a perception of fairness **Disadvantages:** Excludes other potentially mitigating factors that may warrant preferential treatment	In San Diego, the Metropolitan Transit System issues taxi medallions by lottery to drivers meeting minimum experience requirements.
Permits	Permits are granted based on an applicant's ability to meet a predetermined qualification	**Advantages:** Supports agency goals and is relatively transparent **Disadvantages:** Possibly requires agencies to increase requirement stringency if too many applicants qualify	San Diego, California allows select shared micromobility operators who meet permitting requirements to deploy fleets in the city (San Diego, 2021).
Preferential Treatment	A public policy that gives preferential treatment to a specific mobility operator for a particular reason	**Advantages:** Allows a public agency to incentivize certain behaviors or characteristics **Disadvantages:** Requires careful planning and legal review to ensure policy is fairly implemented	The Oakland Department of Transportation selected Revel as the local shared moped operator due to its ability to meet localized needs and willingness to conduct education and outreach campaigns (Newland, 2020).
Real Estate Agreements	Agreements made with real estate developers to exchange building requirements for mobility options	**Advantages:** Creates developments that offer more mobility options **Disadvantages:** Requires an extended period of time to alter permitting processes	The Bay Area Rapid Transit (BART) District has real estate agreements with carsharing companies, which allocate carsharing parking and govern issues (e.g., indemnification, signage, rights-of-way maintenance). A similar model could be employed to manage curb space access (Shaheen et al., 2016).

Sources: Cohen and Shaheen, 2016; Institute of Transportation Engineers, 2018; San Francisco Municipal Transportation Agency, 2020; Schaller Consulting, 2018

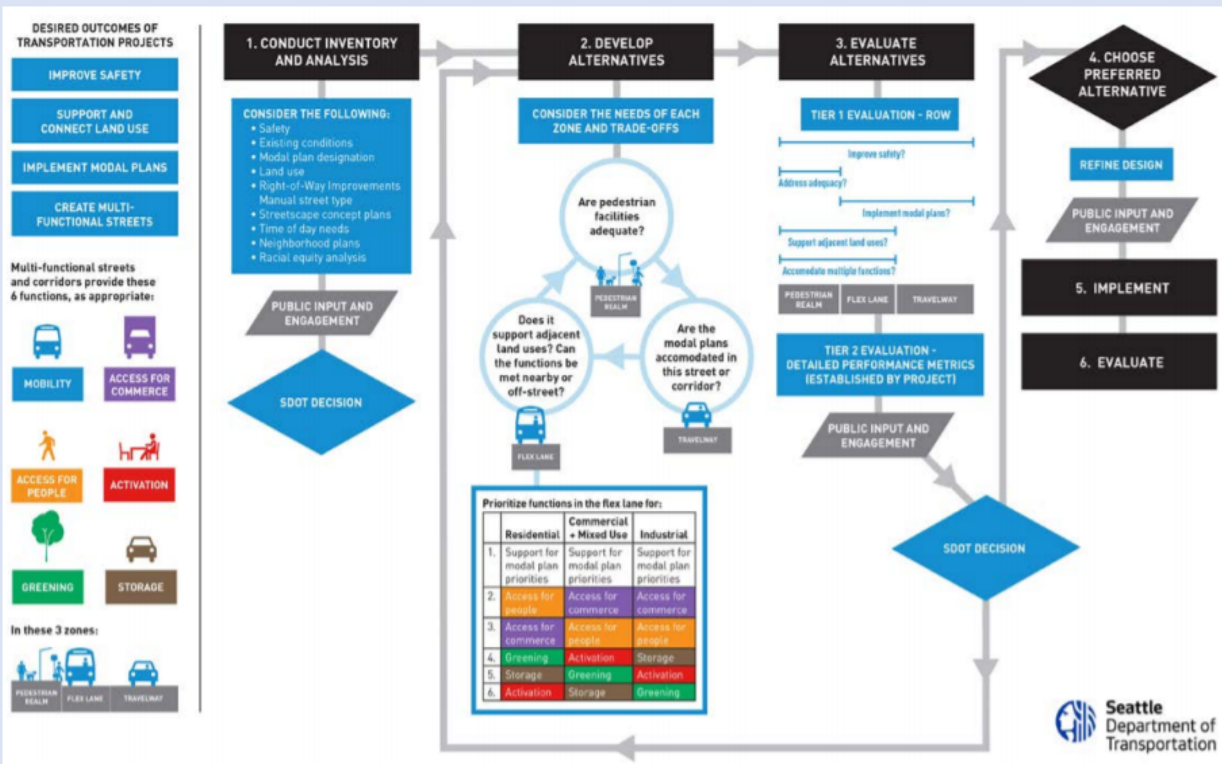
Seattle, Washington's Curbspace Allocation Framework

Seattle's Department of Transportation developed a framework to allocate curbspace. The framework consists of six steps:

1. **Conduct Inventory and Analysis:** Determine curbspace availability and the needs that need to be met;
2. **Develop Alternatives:** Build out a list of options including considerations for existing facilities, various modes, equity impacts, and surrounding land uses;
3. **Evaluate Alternatives:** Consider the different alternatives by examining the impacts to the pedestrian realm, curbspace, and travel lanes, and then gain public insight;
4. **Choose Preferred Alternative:** Select the desired option and conduct public outreach;
5. **Implement:** Bring the plan into reality; and
6. **Evaluate:** Examine the performance of the plan and potential future changes.

This process is shown in Figure 46.

Figure 46. Seattle's Curbspace Allocation Framework



Source: Seattle Department of Transportation, 2019b

Regulate Curb Space Access

A variety of strategies can be implemented to help guide the use of the curb, minimize modal conflicts, enhance safety, and improve access and equity for an array of modes and users. Management strategies may be mode-specific or applied to multiple modes. Strategies can also address non-transportation uses of the curb, such as outdoor dining and public space (e.g., parklets). This section discusses curb space management in four categories:

1. **Multimodal Management:** Strategies that can be applied to a variety of modes and services;
2. **Device Management and Parking:** Targeted strategies that manage the access, operation, and/or storage of devices (e.g., shared micromobility, robotic delivery, etc.);
3. **Loading Zones:** Strategies that help manage the pick-up/drop-off and/or delivery of passengers and goods; and
4. **Vehicle Parking:** Policies that help manage parking supply, price parking, and/or dedicate space for shared vehicles (e.g., carsharing).

These strategies are summarized in Table 10 through Table 16.

Table 10. Multimodal Management Strategies

Strategy	Description	Example
Assigning Access by Time of Day	Designate curb use based on the time of day	In 2019, the City of Boston implemented the Pick-Up/Drop-Off (PU/DO) pilot. The city designated four pre-existing parking spots (two per block in the pilot area) as loading zones from 5 pm to 8 am. Signage detailed requirements of using the spaces including the fact that drivers must remain in the car and vehicles could only stay in the spot for up to five minutes. Uber and Lyft also implemented a geofence in the area that directed drivers and passengers to these locations. The pilot increased curb use (i.e., vehicles per hour) by 350%, decreased parking citations by 8% (improving congestion and pedestrian sightlines), and reduced passenger pick-ups and drop-offs in travel lanes by 38% (City of Boston, 2020).
Extending the Curb	Provide sidewalk extensions into the traffic or parking lane (i.e., bulb outs) to increase visibility for pedestrians, slow vehicle speeds, shorten crossing distances, and provide space for other amenities (e.g., bicycle racks, wayfinding signs)	The Chicago Department of Transportation implemented curb extensions on sections of the city's busiest bike routes to improve bicyclist and pedestrian safety (Bloom, 2019).
Geofencing Service Areas	Apply a virtual perimeter onto a real-world geographic area to limit transportation services in the region (e.g., shared micromobility, TNCs)	In Seattle, the University of Washington's Urban Freight Lab tested geofencing with Uber and Lyft. Geofenced perimeters were implemented in the city's busiest neighborhoods to guide riders and drivers to designated loading zones (Schlosser, 2019). The pilot found that that designated stops and geofences decreased the number of drivers stopping in the travel lane, reduced the loading time by 42 seconds, and increased passenger satisfaction by 5% (Schlosser, 2019).
Implementing Flex Zones	Accommodate different curb space uses by implementing zones whose function can vary (e.g., by time of day)	San Diego, California's regional plan included guidelines for implementing curb space use that varies by the time of day. For example, sections of the curb will be used for deliveries in the morning and outdoor dining in the evening (San Diego Forward, 2021).
Locating Vehicle Staging Areas	Designate areas for vehicles to wait for TNCs, courier services, and other shared modes to reduce congestion in an area	Due to the increased demand in goods delivery from the COVID-19 pandemic, communities throughout the U.S. have designated curb sections as goods loading zones. Raleigh, North Carolina designated about one hundred locations as pick-up zones, typically replacing on-street parking (City of Raleigh, 2020).
Mandating Fleet Caps	Use caps to limit the number of vehicles or devices that can be deployed in a category (e.g., EVs in carsharing fleets, dockless scooters in scooter sharing fleets) or by operator	St. Louis, Missouri allowed shared micromobility companies to begin with a fleet of 750 devices. The operators could then increase their fleet size by 350 devices per month until they reach the cap at 2,500 devices (City of St. Louis, n.d.)
Offering Living Previews	Temporarily install a proposed project (e.g., curb space redesign) to offer community members the opportunity to	As part of the SMFTA's curb space redesign, the agency conducted living previews to gain public insight. The previews included features, such as wider sidewalks,

Strategy	Description	Example
	provide insights on the potential project	greenery, furnishings, protected bike lanes, and loading zones (SFMTA, 2017).
Providing Landscaping and Other Amenities	Green the curb through landscaping, parklets, and other amenities such as benches and public art	In California, the City of West Hollywood developed a parklet program that consisted of selecting a parklet location, designing and developing the parklet, gaining public insight on the design, and maintaining the parklet (City of West Hollywood, 2018).
Requiring Fleet Permits	Leverage permits that determine the requirements that must be met in order to operate (e.g., distribution of devices in lower-income neighborhoods)	In Oakland, the city approved of a carsharing program. Permits were granted to carsharing operators who met the requirements (e.g., membership-based, free-floating). The permits allowed carsharing operators to waive certain parking time limits, pre-pay parking fees, request signage, and change their service area (City of Oakland, 2019).

Curb space management strategies can also focus on managing small devices such as bicycles, scooters, and personal delivery devices (i.e., robotic delivery vehicles). These strategies, which may influence where devices can be used or parked, are summarized in Table 11.

Table 11. Device Management Strategies

Strategy		Description	Example
Operational Strategies	**Adding Protected Bike Lanes**	Separate low-speed and active modes (e.g., bicycles and scooters) from vehicle traffic through dedicated infrastructure, such as bicycle lanes	San Jose, California conducted public outreach to develop a network of bike lanes (City of San Jose, 2020).
	Creating Permissible Operational Areas	Designate areas where devices can be operated (e.g., only in neighborhoods away from dense downtown regions)	In 2020, the Pennsylvania Department of Transportation enacted Senate Bill 1199 (Personal Delivery Devices), which classified and regulated robotic delivery devices. Included in the regulations are permissible operational areas (i.e., in pedestrian areas or low-speed roads) (Pennsylvania Department of Transportation, 2020).
Parking Strategies	**Implementing Parking Corrals**	Designate rights-of-way sections (e.g., via painted markings, barricades) to serve as corrals to organize dockless devices	In August 2018, Santa Monica, California implemented corrals (nineteen and four on the street and sidewalk, respectively) for shared scooter parking (Linton, 2018). The corrals occupy available curb space or locations previously marked as red (i.e., no stopping) zones (City of Santa Monica, 2019).
	Installing Charging Device Stations	Install stations that can be used to charge and/or park multiple micromobility devices	In 2019, GetCharged Inc, a micromobility company, partnered with parking operators and private property owners throughout Atlanta, Georgia to add more than 250 micromobility charging, docking, and service stations (Karon, 2019).
	Designating Device Parking Areas	Identify areas to park devices so they remain organized and do not obstruct the right-of-way	Since 2016, officials in Portland, Oregon have required bikesharing service users to park bicycles at marked docking stations or public bicycle racks (Portland Bureau of Transportation, 2020).

With the growth in for-hire vehicles for passenger trips and goods delivery, dedicated space for loading zones may be able to reduce conflicts and mitigate curbside congestion, such as congestion caused by drivers who double park waiting for their next pick-up, drop-off, or delivery.

Table 12 provides examples of management strategies for loading zones.

Table 12. Loading Zone Strategies

Strategy	Description	Example
Consolidating Last-Mile Deliveries	Create a hub where packages from multiple delivery firms can be consolidated and then delivered in small low emission vehicles to decrease congestion at loading zones and from vehicles loading and unloading goods	In Seattle, the University of Washington's Urban Freight Lab opened a delivery hub to address last-mile delivery challenges (e.g., congestion from loading and unloading, environmental impacts) by completing last-mile deliveries in smaller more maneuverable vehicles compared to larger delivery trucks and vans. The delivery hub partners with companies that specialize in electric cargo tricycles, electric parcel carriers that can connect to e-bikes or be hand-pushed, route optimization technology, and neighborhood hub infrastructure designs (Schubert, 2021).
Designating Commuter Shuttle Loading Zones	Develop plans to clearly define what type of vehicles are allowed to access public transit loading zones (including when, where, and for how long)	The SFMTA developed a plan to manage the 450 shuttles from more than seven companies that operate in the city. The shuttles offer direct service from San Francisco to the San Francisco Peninsula, Silicon Valley, and nearby rail services. The plan included a network of 125 designated shuttle zones, required permits, mandated phasing in of new vehicles, safety trainings, and enforcement measures (SFMTA, 2017).
Developing and Expanding Loading Zones	Convert existing curb frontage to loading zones and/or increase the length of loading zones to allow more vehicles to access the curb	Seattle, Washington implemented passenger loading zones (PLZs) in high-traffic areas to decrease congestion and address safety concerns resulting from a lack of TNC pick-up and drop-off locations (Goodchild et al., 2019). The city also expanded loading zones, and approximately 47% of commercial vehicle and 30% of passenger loading zones are now 20 to 40 feet long (Miller, 2020). Longer loading zones may be particularly important for larger commercial vehicles that require a ramp for loading and unloading.
Implementing Pick-Up and Drop-Off Zones	Develop regulations to determine which modes can access loading zones, access may vary by time of day, day of the week, vehicle occupancy, vehicle type (e.g., electric), mode (e.g., personal vehicle versus a TNC), etc.	In 2017, Washington, D.C. piloted "Pick-up/Drop-off" (PUDO) zones in areas of the city with high volumes of nightlife. The zones help address safety and congestion concerns from passenger loading activities from TNCs. The zones prohibit parking from 10 pm to 7 am and are enforced via towing. There are now 20 PUDO locations in the city (District Department of Transportation, 2019a).
Reserving Loading Zones	Offer or require vehicles (e.g., TNCs, goods delivery vehicles) to reserve curb space to pick-up or drop-off riders or goods	From August to October 2019, Washington, D.C. piloted a system that required goods delivery, taxis, and TNC drivers to reserve specific time slots to access certain curb space types. Washington used the platform curbFlow, which allowed drivers to reserve a loading zone spot up to 30 minutes in advance (Short, 2019).

Strategies can also be used to manage parking access at the curb. Parking strategies may also involve the repurposing, relocating, or pricing of parking in an effort to manage vehicle demand or to shift users to other modes. These strategies are described in Table 13.

Table 13. Vehicle Parking Strategies

Strategy	Description	Example
Dedicating Vehicle Parking for Carsharing	Reallocate the curb to provide parking spaces for carsharing	In 2018, Williamsburg, New York began a two-year carsharing pilot that included the allocation of 230 on-street and 80 off-street parking spaces for carsharing vehicles (Pesantez, 2020).
Using Parking Lanes to Protect Low-Speed and Vulnerable Users	Strategically allocate vehicle parking space to separate slower modes (e.g., pedestrians, bicyclists) from higher-speed modes (e.g., vehicle traffic)	In 2019, Cambridge, Massachusetts passed the "Cycling Safety Ordinance," which required all street projects to upgrade to the safest bicycling infrastructure. The city is working on developing a 20-mile network of protected bike lanes (Schmitt, 2019).
Implementing Electric Vehicle Parking	Provide EV charging at parking locations (e.g., next to the curb) to support EV adoption	The City of Los Angeles mounted EV chargers to over 130 streetlights throughout the city. Parking in front of the chargers is free, but the chargers typically cost $1 to $2 per hour to use (Berman, 2019).
Using Demand-Based Pricing	Adjust parking prices based on demand (e.g., higher prices during higher periods of demand, such as the weekends)	Between August 2013 and February 2014, San Francisco, California conducted a demand-based parking pricing pilot: Sfpark. Studies employing the pilot data estimated that the first two years of Sfpark helped to manage supply more reliably and reduced parking search time by 50% (Millard-Ball et al., 2019).

Curbspace for Outdoor Dining and Curbside Pick-Up

In response to increased demand for goods delivery and outdoor dining due to the COVID-19 pandemic, a number of public agencies are repurposing the curb for these increasingly popular uses. The Los Angeles County Department of Public Works developed an outdoor dining program for restaurants with six different permit options for outdoor dining and curbside pick-up. Table 14 summarizes these permitting approaches and their respective costs and requirements.

Table 14. Los Angeles Department of Public Works Outdoor Dining Permit

Permit Type	Location	Cost	Placement Requirements
Alley and Road Closures	Public alley or closed street	Varies	Participating restaurants can locate outdoor dining options on public alleys or streets maintained by the Department of Public Works. The facilities used must be protected by traffic controls (e.g., signs).
Offsite Outdoor Dining	Off-site private parking lot or walkway	$234	Offsite outdoor dining facilities must be approved by a valid planning commission authoring the use of the infrastructure.
Onsite Outdoor Dining	On-site private parking lot or walkway	$234	Onsite outdoor dining can be located on a pre-existing on-site walkway or parking facility.
Parklet	On-street parking area	Varies	Parklets can be placed along a two-lane road maintained by the Department of Public Works with a posted speed of under 25 miles per hour. Parklets must be at least as large as two parallel or four diagonal parking spaces and protected by traffic safety barriers. The parklets must also abide by ADA requirements.
Food Pick-Up Zone	Designated curbspace	Free	These zones may be located in commercial or business districts; at least 15 feet from a fire hydrant; and not in a location currently designated as a loading, no stopping, or accessible parking zone. The maximum wait time allowed at these locations is 15 minutes.

Source: Los Angeles Department of Public Works, 2020

A variety of strategies can be implemented in response to the pandemic, including:

Curbside Pick-Ups: Public agencies can repurpose the curb for curbside pick-ups from restaurants and retailers. Twenty-two agencies in the United States have implemented this strategy (e.g., Austin, TX; St. Paul, MN).

Outdoor Permits: Restaurants, retailers, and other businesses can apply for permits to move their operations outdoors; nine agencies in the U.S. have offered outdoor permits (i.e., Boston, MA; Chicago, IL; Cincinnati, OH; Las Vegas, NV; Oakland, CA; Pittsburgh, PA; San Francisco, CA; South Charleston, WV; Winter Haven, FL).

Parking Fees: Public agencies can suspend the collection of fees for on-street parking spaces to encourage social distancing and support local businesses. In the U.S., 22 agencies have suspended parking fee collection (e.g., Madison, WI; San Jose, CA).

Parklets: The curb can be redesigned to serve as a parklet and public space; two U.S. agencies have developed parklets (i.e., Dallas, TX; Winter Haven, FL).

Temporary Loading Zones: Short-term loading zones can be developed to facilitate more efficient goods loading and unloading, and 40 U.S. agencies have implemented these (e.g., Charleston, SC; Long Beach, CA).

Additional information on emerging strategies be found at the following resources: (1) COVID Mobility Works, (2) Complete Streets + COVID-19, and (3) COVID-19: Local Action Tracker.

Value Curb Space

Public agencies may consider valuing the public rights-of-way and charging users fees to access and/or use the curb to help manage demand and raise revenue. Communities throughout the U.S. have leveraged various curb space valuation methods. For example, Portland, Oregon charges a $0.25 tax per scooter ride. The funds are then placed in a "New Mobility Account" that pays for program administration, enforcement, infrastructure improvements, and access enhancements for underserved communities (City of Portland, 2019). Other cities (e.g., Chicago, Illinois; St. Louis, Missouri) charge an application fee (typically $250 to $500) per operator. Some cities (e.g., Seattle, Washington) leverage established permits and permit review fees. Other cities may charge an annual fee per device (typically $10 to $50) or block of devices. For example, Aurora, Colorado charges $2,500 for the first 500 bicycles, $5,000 for the first 1,000 bicycles, $7,500 for the first 2,000 bicycles, or $10,000 for fleets with more than 2,000 bicycles. Other fees that cities have leveraged include fees per docking station, performance bonds (to protect the public entity if the shared micromobility company goes out of business or fails to meet certain terms under a contractual agreement), and escrow payments per device (or per block of devices). When valuing the curb, public agencies may need to consider the following items.

- Access for different types of curb users
- Variations in demand based on the time of day
- Existing and potential competition between modes
- Multimodal access for a variety of modes and service providers
- Social equity (e.g., ADA access, impact to low-income users)
- Market rate cost for off-street parking and/or foregone meter/permit revenue (if applicable)
- Cost recovery of program administration (e.g., staffing, signage).

Areas with higher curb space demand (e.g., central business districts with a lot of demand for passenger loading and goods delivery) may have a higher valuation or price in order to manage demand more effectively. A variety of pricing strategies can be used to help manage access, as described in Table 15.

Table 15. Curb Pricing Strategies and Objectives

Pricing Strategy	Description	Objective	Example
Congestion	Fee for parking/loading in a select area during high-demand hours (e.g., 6 AM to 9 AM)	Support trips taken at different hours of the day, on different routes, and using different modes to reduce anticipated congestion	In 2020, San Francisco's mayor sent a letter to the SFMTA asking them to consider a curb plan that included congestion pricing to address growing curb access competition (Office of the Mayor, 2020).
Dynamic	Fees that fluctuate based on demand for access (i.e., fees decrease as parking availability increases)	Help control and match parking supply and demand	SMFTA has street parking zones that are subject to special event pricing during events where more than 10,000 attendees are expected. During special events, the meters have time limits ranging from zero (i.e., no parking) to four hours and cost of $8 per hour (SFMTA, 2018).
Flat rate	Fixed fee used for access to and/or parking at a particular on-street space	Raise revenue for infrastructure maintenance, transportation expansion, and other projects	Durham, North Carolina increased its curbside parking prices from $1.50 to $1.75 per hour. The change is expected to help raise revenue for agency operational costs and transportation services (City of Durham, 2020).
Temporal	Fee for accessing an area (e.g., road section, curb) during times of increased activity (e.g., sporting events)	Use pricing mechanisms to address event-based congestion and support the use of alternative routes	The Seattle DOT implemented a curb pricing structure that varied rates by time of day (e.g., $0.50 per hour in the morning and $1.00 per hour in the afternoon). The goal of the new program is to make one to two spaces per block available (Zimbabwe, 2020).
Zone	Fees paid for parking or loading within a demarcated zone (e.g., central business district), but exiting the zone does not change the fee	Reduce congestion in highly trafficked areas	San Francisco Municipal Transportation Agency priced spots for participating carsharing vehicles by zone. The zones varied by density with Zone 1 including the city's dense downtown district and each subsequent zone encompassing progressively lower-density areas. Per-month parking spaces cost $225 in Zone 1, $150 in Zone 2, and $50 in Zone 3 (San Francisco Municipal Transportation Agency, 2017).

Adapted from: Shaheen et al., Forthcoming

Enforce Curb Space use

Some public agencies have ordinances and other enabling legislation that permit parking authorities and law enforcement officers to enforce curb policies. Some common enforcement strategies are discussed below.

- **Geofenced Perimeters:** Agencies can apply virtual perimeters and zones to real geographic locations to manage modes and support pedestrian safety and accessibility. Prior to implementation, geofenced areas may need to be considered to ensure equitable geography (i.e., ensuring certain neighborhoods are not excluded).

- **Impounding:** Devices or vehicles that are improperly parked can be removed and stored in public agency and/or company lots. Impounding allows obstructions to be quickly removed, but it may require manual reporting and removal, and vehicle and device storage may be limited.

- **Fines:** Fees or tickets can be imposed on devices or vehicles that are improperly parked or operated in non-permissible areas. These measures can act as a revenue source for agencies that can help finance other enforcement tools. However, fines may require manual monitoring to implement.

Learn from Curb Space Use

Monitoring and evaluating the curb can help with management practices (e.g., understanding who is using the curb and at what times of day, identifying congested areas, etc.). This information can be used for future curb space planning, management, and policies (e.g., identifying community priorities, designing streets, etc.) (Smith et al., 2015). Additionally, evaluating the curb can shed light on equity issues (e.g., accessibility challenges of older adults navigating around shared mobility and other curb space uses). Insights into curb space use and user behavior can also help identify management and enforcement strategies that may be most effective. New resources, such as technology platforms, can help with curb space monitoring by providing public agencies with the ability to evaluate available curb sections based on various characteristics (e.g., number of parking incidents, presence of barriers) (Smyth, 2020). Additionally, monitoring and evaluating the curb can be aided through performance metrics and data collection.

Curb Performance Metrics

Traditionally, curb performance has been measured in terms of parking availability for personally owned vehicles. However, increased competition for the curb from a variety of modes, new technologies, and changing planning priorities are causing public agencies to develop new metrics for evaluating curb performance. Table 16 identifies some performance metrics that could be used to monitor and evaluate curb access and use.

Table 16. Curb Performance Metrics

Impact Category	Description	Metrics
Bikeability	Analysis of supportive biking infrastructure and potential safety risks	Number of bike parking stations Number of bicyclists on a block per hour
Curb Productivity	Measurement of how productive a segment of the curb is based on its designated use (e.g., loading zone)	Number of passengers loading on a bus at a public transit stop Number of deliveries made
Economic Vitality	Analysis of changes in economic activity in the area	Number of commercial vacancies Number of users
Equity	Identification of accessibility and equity barriers by different demographic groups	Number of accessible vehicles or devices available Number of available payment options (e.g., cash, credit card) for various modes Number of languages on signage
Parking Demand	Evaluation of the current and desired parking amount	Number of available parking spaces per day Parking requests
Parking Efficiency	Measurement of how efficiently parking in an area is used	Duration of time vehicles are parked Number of vehicles double parked
Passenger Loading Activity	Quantitative measurement of the number and type of passenger loading activities taking place at the curb	Number of passengers loading Number of passengers unloading Number of passenger vehicles per loading zone
Passenger Loading Demand	Evaluation of the number of vehicles that need curb access and the length of time the curb is needed	Curb length Number of vehicles trying to access the curb
Passenger Loading Impact	Description of how passenger loading activity impacts travel conditions or other modes	Number of cars forced to go around by a vehicle loading or unloading Number of minutes traffic flow was delayed
Public Transit Reliability	Evaluation of the impact of curb changes on public transit service	Average travel speeds Ridership rates Public transit schedule adherence
Safety	Evaluation of how design changes have impacted safety	Number of accidents reported over time Number of police citations for traffic violations

Source: Fehr & Peers, 2019; Fehr & Peers, 2020; Goodchild et al., 2019; Howell et al., 2019; Seattle Department of Transportation, 2019a

MARVEL Framework: A Case Study of Portland, Oregon

Table 16 reiterates the steps of the MARVEL framework and each step is accompanied by an example from Portland, Oregon's recent transportation plan.

Case Study: Portland Bureau of Transportation's Central City in Motion

In 2018, Portland, Oregon approved the $36-million *Central City in Motion* plan. The plan proposal included presentations, community and stakeholder testimony, and supplemental analysis (Maus, 2018). *Central City in Motion* focuses on planning, prioritizing, and implementing transportation projects in Portland's core area to increase transportation system efficiency and travel time reliability. The projects improve infrastructure for pedestrians, bicyclists, and public transit operations. These changes are critical since Portland has the seventeenth-highest pedestrian fatality rate per 100,000 people in the country (Henderson Law Firm, 2021). The plan also helps accommodate Portland's anticipated population growth (Population Research Center, 2020; Sawyer, 2020). Figure 47 illustrates a rendering of one of the *Central City in Motion* projects.

Figure 47. Central City in Motion Rendering

Source: Portland Bureau of Transportation, n.d.

Table 17. Curb Space Management Plans

	Description	Example
1. Make a Curb Space Plan	Curb space management plans may be based on broader transportation goals and answer curb space use questions. Table 7 provides different policy approaches that can inform curb space management plans.	*Central City in Motion* focuses on addressing a variety of transportation challenges, improving the overall network, and determining where capital investments should be made. The plan is centered around four core values: (1) prioritize safety, (2) enable efficiency, (3) promote social equity, and (4) improve sustainability.
2. Allocate Curb Space	Curb allocation is typically accomplished through various informal and formal processes. Table 8 and Table 9 describe competitive and non-competitive allocation strategies.	PBOT's transportation plan includes dedicating more than nine miles for public transit prioritization, creating one hundred safe intersections, and developing/improving more than 30 miles of bike-friendly streets. Project locations were determined through a review of historic data, an evaluation of future goals, and public outreach efforts.
3. Regulate Curb Space Access	Due to curb limitations, public agencies may need to manage access based on mode, occupancy, operator, etc. Table 10 through Table 13 provide examples of potential management strategies. Potential restrictions will need to be flexibly designed so they can integrate emerging modes. The "Emerging Modes and Curb space" subsection of the Literature Review offers potential impacts of emerging modes.	In order to accomplish the plan goals, some restrictions must be implemented (e.g., limiting the availability of private vehicle parking, allocating space exclusively for high-occupancy modes).
4. Value Curb Space	Curbs may need to be valued to support allocation approaches and management strategies. Table 15 provides information on pricing strategies.	In Portland, funding is derived predominantly from federal and state grants, rather than curb pricing. However, to continue funding and maintaining improvements, the transportation plan has measures in place to secure funding from public transit ridership (predicted to increase due to service improvements) and development fees levied where applicable.
5. Enforce Curb Space Use	Enforcing curb access is critical to ensuring the efficiency of plans and helping support regional goals.	While PBOT's plan currently does not have defined enforcement metrics, curb use will likely be monitored by existing agencies including the city's Rights-of-Way Enforcement Program and departments within the PBOT.
6. Learn from Curb Space Use	Impact studies and other analysis methods can help document and gain understanding regarding the transportation, environmental, economic, and social equity impacts of curb space management plans. Table 16 offers potential curb space performance metrics.	An analysis conducted on previous Portland data helped inform *Central City in Motion*. As projects are completed, an analysis with similar data sets will be used to determine whether the changes have helped the city reach its goals.

Adapted from: Cohen and Shaheen, 2016; Portland Bureau of Transportation, 2020

Key Takeaways

Curb space management can be achieved through frameworks that guide the planning, allocation, management, valuation, enforcement, and evaluation of the curb. The MARVEL framework works to support these activities by clearly defining and providing strategies for six steps of curb space management.

1. **Make a Curb Space Plan:** This plan may be informed by considerations (e.g., accessibility, equity) and planning approaches (e.g., Complete Streets, Vision Zero). Shared and standardized data can help inform curb space plans by providing information on which modes are used where.

2. **Allocate Curb Space:** Curb space can be allocated through competitive (e.g., auctions, first-come first-serve) and non-competitive (e.g., collaborative approaches, lotteries) approaches.

3. **Regulate Curb Space Access:** Regulations to limit access and use can be applied to curb space. These regulations and strategies may focus on multimodal management (e.g., fleet permits, flex zones), device management (e.g., bike lanes, parking corrals), loading zones (e.g., commuter shuttle loading zones, reservation systems), and/or vehicle parking (e.g., carsharing parking, EV parking).

4. **Value Curb Space:** Valuing rights-of-way can help pass curb management costs to users and raise revenue. Common strategies include congestion/temporal, dynamic, flat rate, and zone pricing.

5. **Enforce Curb Space Use:** Enforcement measures can help ensure the curb is used as designated.

6. **Learn from Curb Space Use**: Curb space use can be monitored and evaluated to determine whether improvements and changes are needed. Evaluations can leverage performance metrics (e.g., productivity, transit reliability, equity).

8. Conclusion

Emerging innovations in mobility and consumption, as well as travel behavior changes, are changing how people access and use the curb. The global pandemic is also changing how the curb is used: it is being repurposed for curbside pick-up, outdoor dining, and retail uses. This study employed a multi-method approach to understand the efficacy of potential strategies to address changing curb space needs. Expert interviews with individuals from the public, private, and non-profit sectors provided insights on curb space impacts and possible management techniques (e.g., designating space for different modes, leveraging pricing strategies, enforcing use, installing signage, sharing data). Additionally, a survey of curb users (n=1,033) in the San Francisco Bay Area offered key insights on curb wait times, safety considerations, modal preferences, and potential strategies for supporting different modes and curb users. A survey of taxi and TNC drivers (n=241) shed light on challenges (e.g., curb space access, navigation, passenger identification) and potential strategies to address them (e.g., geofencing changes, passenger education).

The research shows that shared mobility (e.g., TNCs and shared micromobility) can negatively impact the curb if these modes are not properly planned for and integrated into curb space policies. For example, shared mobility may increase demand for (and hence congestion at) the curb and may also impact public transit operations. According to the experts interviewed, TNCs can increase congestion in urban areas, while shared micromobility may negatively impact vulnerable populations by blocking access to curbs and ramps. The experts recommended curb space management policies such as designating space for shared modes (e.g., converting parking spaces to loading zones), implementing pricing strategies (e.g., lower tolls for higher occupancy vehicles, free parking for shared modes), and conducting rider and driver education and outreach. Sharing data (e.g., geographic location of devices and vehicles, safety incident information) and planning for emerging modes (e.g., AVs) can help communities prepare for new modes.

Key findings of the curb user survey in the San Francisco Bay Area include:

- **Demographics:** Survey respondents generally reflected the population of the San Francisco Bay Area well, with very slight deviations.

- **Curb Space Use:** Respondents used the curb to access various shared mobility modes. The survey revealed modal preferences and safety concerns, including:

    - **Modal Preferences:** The sample generally viewed public transit, taxis, and TNCs more favorably than shared micromobility.

    - **Curb Access by Mode:** Regarding modal access, the respondents perceived little to no difference between various shared modes blocking access to the curb.

  - **Safety:** Curb users generally felt safe waiting at the curb but were concerned about a variety of sociological factors such as waiting at night, crime, and accidents.

- **Improvements:** Survey responses shed light on various curb space improvements.

  - **Access Fees:** The respondents indicated that public transit is the only shared mode that should not have to pay curb space access fees.

  - **Curb Space Prioritization:** Respondents said that curb space access should be prioritized for vulnerable populations (e.g., people with disabilities, older adults) and pedestrians.

Additionally, the survey of taxi and TNC drivers identified the following key findings:

- **Demographics:** The drivers surveyed generally do not reflect the population they serve and typically have lower incomes and levels of educational attainment, and are younger, male, and depart from the racial/ethnic makeup of the locations they serve.

- **Services:** Most of the respondents drove taxi and TNC vehicles and transported passengers and goods.

- **Challenges:** Drivers often face potentially dangerous situations and challenges.

  - **Street Design:** Street design generally does not consider the needs of innovative and emerging modes (e.g., loading zones for TNC passengers), potentially causing and exacerbating navigational challenges and safety concerns.

  - **Safety:** Navigating traffic, looking for and dropping off passengers, and finding safe locations to load and unload passengers can be difficult. These challenges may result in safety concerns for both riders and passengers.

- **Improvements:** The driver survey suggests that curb space access could be improved by implementing the following.

  - **Access Points:** Drivers believe that creating access points for shared mobility would improve curb space use. Ideally, these locations would not interfere with traffic and would support passenger and vehicle safety.

  - **Pricing Strategies:** A minority of respondents supported dynamic and congestion pricing strategies to manage access to and time at the curb.

In the future, curb space planning and management may need to consider emerging and automated modes, such as AVs and robotic delivery. The curb may need to be designed to prioritize shared modes, repurpose sections for changing needs (e.g., the provision of charging infrastructure for electric vehicles and devices), and provide ADA and paratransit access. Stakeholders may also need to provide mode use information through digital maps and other means of data sharing. Additionally, future planning considerations may need to consider additional curb space uses, such as outdoor dining, retail, and goods delivery and pick-ups.

These findings informed the development of the six-step MARVEL framework. The framework can assist with curb space planning and management to integrate various modes and enhance mobility and equity. The framework consists of the following steps:

1. **Make a Plan:** Develop a plan that guides how the curb is designed, including considerations such as land use and equity.

2. **Allocate Curb Space:** Use a competitive or non-competitive process to allocate curb space amongst different modes and users.

3. **Regulate Curb Space Access:** Leverage management strategies that can determine access by mode, operator, and/or operational characteristics.

4. **Value Curb Space:** Use strategies to value the curb and charge for access to manage demand and raise revenue.

5. **Enforce Curb Space Use:** Employ different strategies to ensure that the curb is used as designated.

6. **Learn from Curb Space Use:** Use tools, such as performance metrics and data, to observe and evaluate existing curb space use to support local goals.

Further research is needed to understand how the design and use of the curb may be impacted by the long-term consequences of the global pandemic and vehicle automation.

Appendix A: List of Interviewees

Table 18. List of Interviewees

	Organization	Location	Affiliation
Academic	University of Maryland	College Park, MD	National Center for Smart Growth
	University of Texas at San Antonio	San Antonio, TX	Department of Urban and Regional Planning
	University of Georgia	Athens, GA	School of City and Regional Planning
Non-Profit	North American Bikeshare Association	Portland, ME	Executive Board
Private	Lyft	New York City, NY	TNC Policy
	Spin Bikes	Seattle, WA	Government Partnerships
	Uber/Jump Bikes	San Francisco, CA	TNC Policy
	Uber/Jump Bikes	Washington, DC	Micromobility Policy
	Via Transportation	New York City, NY	Policy
	Zipcar	Washington, DC	Policy
Public	Alameda County Transit (AC Transit)	Alameda County (Oakland), CA	Service Planning
	Bay Area Rapid Transit (BART)	San Francisco Bay Area, CA	Transit and Curb Management
	Dallas Area Rapid Transit (DART)	Dallas, TX	Planning and Development
	Chicago Department of Transportation	Chicago, IL	Citywide Services
	District Department of Transportation	Washington, DC	Parking and Ground Transportation
	Golden Gate Transit	San Francisco, CA	Service Planning
	Pierce County Transit Agency	Tacoma, WA	Projects/Sales
	Pinellas Suncoast Transit Authority	St. Petersburg, FL	Planning
	Oakland Mayor's Office	Oakland, CA	Mobility and Interagency Relations

	Organization	Location	Affiliation
	San Francisco County Transportation Authority (SFCTA)	San Francisco, CA	Executive Board
	San Francisco Metropolitan Transportation Authority	San Francisco, CA	Sustainable Streets, Parking and Curb Management Group
	San Jose Department of Transportation	San Jose, CA	Automated Vehicles Program
	San Mateo County Transit (SamTrans)	San Mateo County, CA	Service Planning

Appendix B: Expert Interview Protocol

The purpose of these interviews is to provide a policy context for the research. We would like to know how various transport providers, policymakers, and other interest groups view the introduction of shared mobility, particularly TNCs and shared micromobility, and what they see as the most important policy issues for integrating shared and innovative modes with curb space.

Introduction

1. Identify name, position, and organization of interviewee.
2. How many incidents has your organization experienced related to curb space issues?
3. Overall, how would you describe the relationship between different modes at the curb?

Impacts from Shared Mobility and COVID-19

1. How has shared mobility impacted curb space access? What issues has it raised (e.g., operational delays, safety incidents in bus lanes, blocked or impeded ADA access at pick-up/drop-off areas)?
    a. Have these incidents been increasing or decreasing in recent years? Have the types of incidents changed over time?
    b. How has your organization manage these issues from a safety and risk management perspective?
    c. Are there data/studies that your organization can share related to these issues?
2. How has shared mobility's impacts on transit changed in light of COVID? Have any new issues have emerged?
3. Has an increased demand for goods delivery and take-out/pick-up impacted operations (e.g., a pattern of delivery drivers travelling or temporarily stopping in the bus lane)?

Mitigating Curb Space Access Impacts

1. What types of policies or practices do you think would be effective to help mitigate curb space access impacts from shared modes on public transit?
    a. Are there example policies or practices from other stakeholders that your organization has studied?

b. In your view, are there any curb space management policy gaps or practices that you wish were being addressed by the city/cities where you operate?

c. Are there any policies that Caltrans could support or change?

2. What types of policies or practices has your organization implemented in response to COVID-19-related impacts? Any lessons learned?

3. Has the city/cities where you operate implemented any curb space management practices to reduce conflicts during COVID-19 recovery? Are there any policies or practices that you think are needed?

Monitoring and Enforcement for Shared Modes

1. Have you needed to curtail a shared mobility service operating in your service area? If so, how did the city (or cities) where you operate respond (e.g., impound dockless micromobility, fine an operator)?

2. What curb management practices or policies do you support for monitoring and enforcing regulations for shared modes (e.g., ticketing, reducing fleet caps)?

Metrics and Data for Shared Mobility Integration

1. What are some metrics you would recommend for measuring access and enforcement at the curb?

2. What types of data sources do you think can be used to or are needed to assess these metrics?

Long-Term Vision

1. What is your long-term vision with respect to curb space management supporting public transit and shared mobility integration?

Shared Automated Vehicles (Optional)

2. In what ways do you think the introduction of automated public transit will change the way curb space is used or managed?

Conclusion

1. Is there anything else you would like to share that we haven't discussed?

2. Is it alright for us to contact you again if we have any follow-up questions?

Appendix C: Shared Mobility Impacts

Table 19. Shared Mobility Impacts

Mode	Environmental	Travel Behavior	Social
Carpooling	Decreases GHG and fuel by increasing vehicle occupancy Reduces fossil fuel consumption by reducing congestion	Reduces the use of personal vehicles for single- or low-occupancy vehicle trips Decreases public transit trips Reduces the use of personal vehicles and need for parking	Reduces negative transportation-related environmental impacts for low-income and minority households Increases accessibility and economic opportunity for low-income and minority households Possibly enhances accessibility and economic opportunity
Carsharing	Reduces GHG emissions by decreasing vehicle ownership and encouraging active and higher occupancy (e.g., public transit) modes	Increases use of active modes (e.g., to connect to shared vehicle) Unclear impacts on public transit – may replace public transit trips with vehicle trips or may increase public transit use through reduction of vehicle ownership Possibly reduces personal vehicle ownership and use	Increases access to and reliability of transportation services, particularly for individuals with typical commute schedules (e.g., 9 am and 5 pm)
Courier Network Services (CNS) and Last-mile Delivery	Changes GHG emissions based on the use of vehicles or trips (e.g., reduction of trips walking to the grocery store in exchange for increases in grocery delivery)	Increases the use of vehicles and active modes to complete deliveries	Increases access to goods, services, and economic opportunities Potentially increases to pollutant exposure in areas where goods delivery trips are typically made (e.g., fulfillment centers)
Microtransit	Improves GHG emissions by increasing vehicle occupancy and using more efficient, dynamic trip routing systems	Increases use of active transportation modes (e.g., walking to and from microtransit stops) Increases public transit use by filling service gaps (e.g., first- and last-mile connections) May reduce vehicle use for selecting trip types (e.g., commutes)	Offers an additional mode and/or improved service for lower-density areas or vulnerable populations (e.g., people with disabilities)
Shared Micromobility	Reduces negative environmental impacts by decreasing VMT	Increases public transit use by filling service gaps Replaces short distance trips (i.e., under 3 miles) previously completed by other modes (e.g., public transit, taxi)	Potentially increases access to transit by filling service gaps Possibly excludes some users due to costs Excludes people with disabilities due to a lack of inclusive devices

Mode	Environmental	Travel Behavior	Social
			Blocks access by not removing improperly parked devices
Transportation Network Companies (TNCs)	Increases GHG emissions and/or VMT from induced trips; may substitute some trips from private vehicles and public transportation	Impacts may vary by surrounding built environment and land uses and public transit service (e.g., increase connectivity to public transit in higher-density areas, decrease ridership in low-density areas)	Increases access to public transit by addressing first- and last-mile gaps Excludes some populations by being inaccessible, unaffordable, or having limited service areas

Appendix D: Stakeholder Engagement Methods

Table 20. Stakeholder Engagement Methods

Feedback Method	Description	Example
Complete Focus Groups	Host focus groups (ideally with eight to 10 participants and under two hours) to uncover the public's opinion on complex projects, controversial issues, etc.	In 2016, EMC Research, a market and opinion research service, conducted focus groups for Caltrain. Focus group participants were asked questions regarding their attitude, perception, satisfaction, and assessment of efficiency of Caltrain's service (EMC Research, 2016).
Collect Submissions for Insights	Leverage processes (e.g., RFPs) to collect community insight and potential ideas	In 2017, the Canadian Transportation Agency invited submissions regarding its potential rate setting system, specifically on whether costs should be aggregated or disaggregated, the appropriate approach to determine what should be charged, and strategies to improve transparency (Tougas, 2017).
Conduct Open Houses	Hold open houses in person, virtually, or a mix of both to provide community members with project updates and a forum for interacting with agency officials	The Napa Valley Transportation Authority hosted an open house to allow community members to review the agency's draft update to the Countywide Bicycle Plan. Staff members led discussions on the recommendations and community members could ask questions and provide comments (Sestito, 2018).
Develop Community Investment Teams	Bring together parties with a vested interest in the success of projects to allow them to help design the project, identify critical needs, and establish a clear scope and evaluation method	Pierce Transit, in Washington, created a Community Investment Team composed of a variety of partner organizations (e.g., chambers of commerce, colleges, retailers, hospitals, senior centers). The partners helped guide and offer insight into different transportation projects and demonstrations (Pierce Transit, n.d.).
Distribute Informational Material	Provide the community with information on projects, services, changes, etc. through a distribution of material (e.g., paper flyers, emailed newsletters, advertisements) with information on how they can offer their insights	The San Diego Metropolitan Transit System's "Choose Transit" campaign encouraged ridership in 18- to 50-year-old non-riders and received an AdWheel Award in 2019. The campaign used videos, social media, and partners at 80 different organizations and saw over 150 million paid advertising and 3.5 million media impressions (i.e., interactions with media content) (May, 2020).
Host Public Meetings	Open Board of Commissioner (or the equivalent governing body) meetings to the public and include an opportunity for public comments	The San Francisco Metropolitan Transportation Commission held board meetings for its different services and departments (e.g., tolls, transit fare card) which were open to the public. During the pandemic, community members could join the meetings remotely and a forum to make comments was available (Metropolitan Transportation Commission, 2021).
Leverage Social Media	Use social media sites (e.g., Facebook, Twitter) to provide information to and interact with the public	TransLink, a transportation agency in British Columbia, Canada, used social medial to listen and learn from customers, build partnerships, create awareness, and improve customer service. Since 2013, TransLink has witnessed increases in social media engagement and

Feedback Method	Description	Example
		ridership by 1,385% and 7.5%, respectively (Hootsuite, n.d.).
Place Booths at Community Events	Staff tables or booths at community events and public gathering spaces to provide an opportunity for community members to offer feedback	The San Diego Metropolitan Transit System exchanged free advertising for community events inside and outside of the transit vehicles for the ability to place informational booths at the events (Conrad et al., 2014).
Provide Websites for Public Input	Maintain a website that acts as a comprehensive information resource with the option for community members to provide feedback	The Chicago Transit Authority (CTA) updated its website to improve the user interface, increase information availability, and streamline customer service. Part of the update included welcoming feedback, which was then followed up by CTA employees (Mader, 2018).
Send App- or Text-Based Updates	Provide information via agency apps or opt-in telephone lists where recipients can respond with additional comments or concerns	The Massachusetts Bay Transportation Authority (MBTA) endorsed the Transit App as the predominant source of information about public transit services. The app offered notifications, integrated other services (e.g., TNCs, bikesharing), and offered an option to allow travelers to interact with MBTA (Enwemeka, 2016).
Use Customer Surveys	Conduct surveys in print, by telephone, in person, and/or online to collect public opinion on different issues	The Southern Nevada Regional Transportation Commission implemented onboard Wi-Fi surveys to gather real-time feedback on passengers' rides. This helped to inform system-wide changes (Comfort, 2020).

Pierce Transit, n.d.

Abbreviations and Acronyms

ACS	American Community Survey
AAPOR	American Association for Public Opinion Research
EPA	Environmental Protection Agency
MPG	Miles Per Gallon
RDD	Random Digit Dialing

Bibliography

ADA National Network. *A Planning Guide for Making Temporary Events Accessible to People with Disabilities*. 2015. https://adata.org/guide/planning-guide-making-temporary-events-accessible-people-disabilities#Curb%20Ramps

Anderson-Hall, K., K. Bordenkircher, R. O'Neil, and C. Scott Smith. Governing Micro-Mobility: A Nationwide Assessment of Electric Scooter Regulations. 2019.

Arambula, C. *A Complete Street Design with Designated Spaces for Bike Users, Cars, Pedestrians and Transit*. 2018. https://www.strongtowns.org/journal/2018/2/22/time-to-get-rid-of-the-complete-streets-or-bust-mindset

Barry, K. "App lets drivers auction public parking spaces." *Wired*, 2011. https://www.wired.com/2011/08/app-lets-drivers-auction-public-parking-spaces/ (accessed January 10, 2021).

Baskin, J. "Curb analytics: A new way to see your city's curbs." May 15, 2019. https://www.coord.com/blog/curb-analytics-a-new-way-to-see-city-curbs

Berman, B. "LA adds hundreds of EV chargers to streetlights, giving renters a place to plug in." *Electrek*, November 14, 2019. https://electrek.co/2019/11/13/la-adds-hundreds-of-ev-chargers-to-streetlights-giving-renters-a-place-to-plug-in/

Bloom, M. "New painted bike lanes, curb extensions installed to make Milwaukee Avenue safer for cyclists, pedestrians." *Block Club Chicago*, October 28, 2019. https://blockclubchicago.org/2019/10/28/new-painted-bike-lanes-curb-extensions-installed-to-make-milwaukee-avenue-safer-for-cyclists/

Brinklow, A. "Lyft, Uber commit 64 percent of downtown SF traffic violations." *Curbed SF*, September 26, 2017.

Brown, A., N. J. Klein, C. Thigpen, and N. Williams. "Impeding Access: The Frequency and Characteristics of Improper Scooter, Bike, and Car Parking." *Transportation Research Interdisciplinary Perspectives 4* (2020): 100099. https://doi.org/10.1016/j.trip.2020.100099

Brumbaugh, S. "Travel Patterns of American Adults with Disabilities." Issue Brief. US Department of Transportation, Bureau of Transportation Statistics. September 2018. https://www.bts.gov/sites/bts.dot.gov/files/docs/explore-topics-and-geography/topics/passenger-travel/222466/travel-patterns-american-adults-disabilities-11-26-19.pdf

Budds, D. "Why inclusive cities start with safe streets." *Curbed*, August 28, 2019. https://archive.curbed.com/2019/8/28/20835301/universal-streets-accessible-street-design

Bureau of Transportation Statistics. *Effects of COVID-19 on Travel Behavior*. 2021. https://www.bts.gov/browse-statistical-products-and-data/COVID-related/effects-COVID-19-travel-behavior

Cao, Y., Z. Yang, and Z. Y. Zuo. "The Effect of Curb Parking on Road Capacity and Traffic Safety." *European Transport Research Review* 9, no. 1 (2017): 4. https://doi.org/10.1007/s12544-016-0219-3

CAVCOE. *Best Practices for Automated Vehicle Trials in North America Municipalities*. 2019. https://www.toronto.ca/wp-content/uploads/2019/10/9014-TS_CAVCOE_City_Tor_AV_Trials_final_rpt.pdf

Chai, H., C. Rodier, J. Song, M. Zhang, and M. Jaller. *The Impacts of Automated Vehicles on Center City Parking Demand*, 41. 2020.

Charm, T., B. Coggins, K. Robinson, and J. Wilkie. "The great consumer shift: Ten charts that show how US shopping behavior is changing." *McKinsey and Company*, August 4, 2020. https://www.mckinsey.com/business-functions/marketing-and-sales/our-insights/the-great-consumer-shift-ten-charts-that-show-how-us-shopping-behavior-is-changing

Chiara, G., and A. Goodchild. "Do Commercial Vehicles Cruise for Parking? Empirical Evidence from Seattle." *Transport Policy* 97 (2020): 26–36. https://doi.org/10.1016/j.tranpol.2020.06.013

Cicchino, J. B., P. E. Kulie, and M. L. McCarthy. "Severity of E-Scooter Rider Injuries Associated with Trip Characteristics." *Journal of Safety Research* 76 (2021): 256–261. https://doi.org/10.1016/j.jsr.2020.12.016

City and County of Denver. *Denver Transportation & Infrastructure: Request for Qualifications Shared Micromobility*. 2020. https://www.denvergov.org/content/dam/denvergov/Portals/743/documents/RFQ-shared-micromobility-final.pdf

City of Boston. *Pick-up and Drop-off Zone Pilot launched in the Fenway*. Boston.Gov, 2020. https://www.boston.gov/news/pick-and-drop-zone-pilot-launched-fenway

City of Durham. *Park Durham Updates*. 2020. https://www.parkdurham.org/DocumentCenter/View/283/Revised-Customer-Letter-Update---October-5-2020_FINAL

City of Oakland. *Free-Floating Zone Parking Permit (FFZPP) and Master Residential Parking Permit (MRPP) Terms and Conditions*. 2019. https://cao-94612.s3.amazonaws.com/documents/FFZP-MRPP-Terms-and-Conditions-2019_Final.pdf

City of Portland. *2018 E-Scooter Findings Report*. 2018. https://www.portlandoregon.gov/transportation/article/709719

City of Raleigh. *City Sets Up Temporary Curbside Pick-up Zones*. November 2020. https://raleighnc.gov/news/2020-11-04-city-sets-temporary-curbside-pick-up-zones

City of San Jose. *San Jose Better Bike Plan 2025*. 2020. https://www.bikesanjose.com/draftplan

City of Santa Clara. *Shared Mobility Permit Administrative Regulations*. 2019. https://www.santaclaraca.gov/home/showdocument?id=64441

City of Santa Monica. *City of Santa Monica Shared Mobility Device Pilot Program User Survey Results Conducted*. 2019. https://www.smgov.net/uploadedFiles/Departments/PCD/Transportation/SharedMobility_UserSurveySummary_20190509_FINAL.PDF

City of St. Louis. *City of St. Louis Bike Share—Frequently Asked Questions* [22]. Stlouis-Mo.Gov. https://www.stlouis-mo.gov/government/departments/street/traffic/bicycling/st-louis-dockless-bike-share-faq.cfm (accessed June 28, 2021).

City of Toronto Interdivisional Automated Vehicles Working Group. *Automated Vehicles Tactical Plan*, 176. 2019.

City of Vancouver. (2020). *Temporarily widened sidewalk on Davie Street*. https://dailyhive.com/vancouver/vancouver-slow-streets-coronavirus

City of West Hollywood. *Parklet Program*. City of West Hollywood, 2018. https://www.weho.org/city-government/city-departments/planning-and-development-services/long-range-planning/pilot-projects/parklet-program

Cohen, A., and S. Shaheen. *Planning for Shared Mobility*. 2019.

Comfort, P. *Transit Trend to Watch: Adopting Customer Centricity to Improve Ridership*. January 6, 2020. //www.trapezegroup.com/blog-entry/2020-customer-experience-trends

Conrad, K., R. Schupp, A. Teevan, and A. Strumolo. "Giving back to the community." *Mass Transit*, December 19, 2014. https://www.masstransitmag.com/bus/article/12020836/giving-back-to-the-community

District Department of Transportation. (2019a). *Nightlife to Network: Piloting "PUDO" Zones in the District of Columbia*. 2019. https://www.mwcog.org/file.aspx?&A=yYbU3EZwmtxjvWT4dgbXJfF0DgHnNG9pARmCAddAZsI%3D

District Department of Transportation. (2019b). The District is looking to better manage dockless scooters with designated drop-off points. 2019.

EMC Research. *Caltrain Customer Experience Focus Group Report*. 2016. https://www.caltrain.com/Assets/_MarketDevelopment/pdf/Caltrain+Customer+Experience+Focus+Group+2016.pdf (accessed March 16, 2021).

Enwemeka, Z. "The MBTA says this is the best transit app for Greater Boston riders." September 2016. https://www.wbur.org/bostonomix/2016/09/06/mbta-best-transit-app

Erdhart, G. D., S. Roy, D. Cooper, B. Sana, M. Chen, and J. Castiglione. "Do Transportation Network Companies Decrease or Increase Congestion?" *Science Advances* (2019): 12.

Fallon, P. "Rendering of e-scooter parking dock in a North Hollywood Station parking space." 2018. https://www.fastcompany.com/90270831/why-its-impossible-to-find-your-lyft-or-uber-at-the-airport?partner=rss

Fang, K., A. Agrawal, A. and Hooper. *How and Where Should I Ride this Thing? "Rules of the Road" for Personal Transportation Devices*. 2019. https://scholarworks.sjsu.edu/cgi/viewcontent.cgi?article=1264andcontext=mti_publications

Fehr & Peers. *Cincinnati Curb Study*. 2019. https://issuu.com/fehrandpeers/docs/cinc_strategic_transit_study_final

Fehr & Peers. *San Francisco Curb Study*. 2020. https://www.fehrandpeers.com/curbs-of-the-future/

Goodchild, A., D. MacKenzie, A. Ranjbari, J. Machado, and G. D. Chiara. *Curb Allocation Change Project*. 2019.

Henderson Taylor Law Firm. Pedestrian Accidents on the Rise in Oregon. *Henderson Taylor Law Firm*, January 21, 2021. https://hlf-law.com/pedestrian-accidents-on-the-rise-in-oregon/

Hootsuite. *How One Social Media Campaign Increased TransLink's Brand Sentiment—Social Media Marketing and Management Dashboard*. Hootsuite. https://www.hootsuite.com/resources/how-one-social-media-campaign-increased-translinks-brand-sentiment (accessed March 16, 2021).

Howell, A., N. Larco, R. Lewis, and B. Steckler. *New Mobility in the Right-of-Way*. University of Oregon: Urbanism Next Center, 2019. http://carbonneutralcities.org/wp-content/uploads/2019/03/4.New-Mobility-in-the-Right-of-Way_March-2019.pdf

Hutchings, K., and C. Perry. "Ensuring curb equity: Parking & mobility magazine feature article." *IPMI*, July 3, 2021. https://www.parking-mobility.org/2021/07/03/ensuring-curb-equity/

Inmci. "Scooters blocking wheelchair access to sidewalks." *Wheelchair Travel*, December 16, 2018. https://wheelchairtravel.org/electric-scooters-blocking-wheelchair-access-sidewalks/

Institute of Transportation Engineers. (2018). *Curbside Management Practitioners Guide*. 50.

James, O., J. Swiderski, J. Hicks, D. Teoman, and R. Buehler. *Pedestrians and E-Scooters: An Initial Look at E-Scooter Parking and Perceptions by Riders and Non-Riders*. 2019. https://www.mdpi.com/2071-1050/11/20/5591/pdf

Jiang, J. "More Americans are using ride-hailing apps." Pew Research Center, January 4, 2019. https://www.pewresearch.org/fact-tank/2019/01/04/more-americans-are-using-ride-hailing-apps/

Karon. "Coming soon to Atlanta: Dockless vehicles are getting, uh, docks." *Curbed Atlanta*, June 6, 2019. https://atlanta.curbed.com/2019/6/6/18654840/atlanta-dockless-vehicles-getting-docks

Kim, K., J. Ghimire, P. Pant, and E. Yamashita. "Bikeshare and Safety: Risk Assessment and Management." *Transportation Research Interdisciplinary Perspectives* 9 (2021): 100276. https://doi.org/10.1016/j.trip.2020.100276

Langford, B. C., J. Chen, and C. R. Cherry. "Risky Riding: Naturalistic Methods Comparing Safety Behavior from Conventional Bicycle Riders and Electric Bicycle Riders." *Accident Analysis and Prevention* 82 (2015): 220–226.

Levy, K. "Now there's an app that lets you auction off your parking spot." *Business Insider*, May 5, 2014. https://www.businessinsider.com/now-theres-an-app-that-lets-you-auction-off-your-parking-spot-2014-5

Leyba, J. "A cyclist rides in the bike lane on South Broadway in Denver." 2020. https://www.denverpost.com/2020/01/24/denver-bike-lanes-125-miles-editorial/

Linton, J. "Santa Monica installs in-street e-scooter parking corrals." *Streetsblog Los Angeles*, November 8, 2018. https://la.streetsblog.org/2018/11/08/santa-monica-installs-in-street-e-scooter-parking-corrals/

Los Angeles Department of Public Works. *Outdoor Dining*. 2020. https://pw.lacounty.gov/outdoor-dining/

Mader, S. “Chicago Transit’s website redesign offers blueprint for improving rider experience.” *Mobility Lab*, December 12, 2018. https://mobilitylab.org/2018/12/12/chicago-transits-digital-redesign-offers-blueprint-for-improving-rider-experience/

Martin, E., A. Cohen, J. Botha, and S. Shaheen. *Bikesharing and Bicycle Safety*, 93. 2016.

Maus. “Central City in Motion plan adopted by Portland city council with 3-0 vote.” *BikePortland.Org*, November 16, 2018. https://bikeportland.org/2018/11/15/central-city-in-motion-passes-council-with-unanimous-support-292183

May, E. “Transit marketing campaigns we love.” Trapeze, October 29, 2020. //www.trapezegroup.com/blog-entry/transit-marketing-campaigns

McFarland, M. “Dallas’s rush into bikeshare turns controversial.” 2018. https://money.cnn.com/2018/02/05/technology/dallas-bikeshare-limebike-ofo/index.html

Metro Presentation. “Rendering of e-scooter parking dock in a North Hollywood Station parking space.” 2019. https://la.streetsblog.org/2019/04/18/metro-considering-e-scooter-parking-rules-for-stations/

Metropolitan Transportation Commission. *Meetings*. Metropolitan Transportation Commission, March 2021. https://mtc.ca.gov/whats-happening/meetings

Millard-Ball, A. “The Autonomous Vehicle Parking Problem.” *Transport Policy* 75 (2019): 99–108. https://doi.org/10.1016/j.tranpol.2019.01.003

Miller, D. *Comparing Loading Zones*. 2020. https://www.coord.com/blog/comparing-loading-zones

National Association of City Transportation Officials. *Urban Street Design Guide*. 2013. https://islandpress.org/books/urban-street-design-guide

National Association of City Transportation Officials. *Blueprint for Autonomous Urbanism: Second Edition by NACTO* |. 2019. https://www.blurb.com/b/9645870-blueprint-for-autonomous-urbanism-second-edition

National Association of City Transportation Officials. *Slow Streets*. https://nacto.org/publication/streets-for-pandemic-response-recovery/emerging-street-strategies/slow-streets/

Newland, P. *OakDOT and Revel Launch Shared E-Moped Service*. City of Oakland, January 10, 2020. https://www.oaklandca.gov/news/2020/oakdot-and-revel-launch-shared-e-moped-service

OECD. "E-commerce in the times of COVID-19." 2020. https://read.oecd-ilibrary.org/view/?ref=137_137212-t0fjgnerdbandtitle=E-commerce-in-the-time-of-COVID-19

Office of the Mayor. *Mayor London Breed Calls for Proposals for Congestion Pricing, Sunday & Weekend Meters*. Office of the Mayor (San Francisco), February 18, 2020. https://sfmayor.org/article/mayor-london-breed-calls-proposals-congestion-pricing-sunday-weekend-meters

Pennsylvania Department of Transportation. *Personal Delivery Devices*. https://www.penndot.gov:443/Doing-Business/PDD/Pages/default.aspx (accessed May 11, 2021).

Pesantez, N. *City Reserving Dozens of Parking Spots in Williamsburg for Citywide Car-Sharing Pilot*. 2020. https://greenpointpost.com/city-reserving-dozens-of-parking-spots-in-williamsburg-for-citywide-car-sharing-pilot (accessed January 8, 2021).

Pierce Transit. *Public Participation Plan*. https://www.piercetransit.org/public-participation-plan/ (accessed March 16, 2021).

Population Research Center. *PSU's Population Research Center Releases Preliminary Oregon Population Estimates*. November 16, 2020. https://www.pdx.edu/news/psus-population-research-center-releases-preliminary-oregon-population-estimates-0

Portland Bureau of Transportation. *Better Naito Forever*. Portland.Gov. https://www.portland.gov/transportation/pbot-projects/ccim/construction/better-naito-forever (accessed July 8, 2021).

Portland Bureau of Transportation. *Transportation for Everyone: Central City in Motion Implementation Plan*. 2020. https://www.portlandoregon.gov/transportation/71158#:~:text=Central%20City%20in%20Motion%20is%20Portland's%20plan%20for%20strategic%20investments,times%20for%20businesses%20and%20residents.

Raleigh. *Permits for Private Use of Public Spaces*. January 12, 2021. https://raleighnc.gov/private-use-public-space-permits

Ruvolo, M. Access Denied? Perceptions of New Mobility Services Among Disabled People in San Francisco. 2020. https://escholarship.org/uc/item/12k769c5

SAE International. *JA3163: Taxonomy of On-Demand and Shared Mobility: Ground, Aviation, and Marine*. 2021. https://www.sae.org/standards/content/ja3163_202106/

San Diego. *Authorized Shared Mobility Device Operators*. 2021. https://www.sandiego.gov/bicycling/bicycle-and-scooter-sharing/company-contacts

San Diego Forward. *2021 Regional Plan: Curb Management*. 2021. https://sdforward.com/docs/default-source/2021-library/5335-rp-policyonepagers-05curbmanagement_final_en.pdf?sfvrsn=2eb3fe65_2

Sawyer, B. "Data Bank: Oregon population still grew in 2020 but at a slower pace per preliminary data from PSU's Population Research Center." *Portland Business Journal*, December 4, 2020. https://www.bizjournals.com/portland/news/2020/12/04/population-still-grew-in-2020.html

Schaller Consulting. Making the Most of the Curb: Managing Passenger and Parcel Pick-up and Drop-off on Congested City Streets. 2018. http://www.schallerconsult.com/rideservices/makingmostofcurb.pdf

Schlosser, K. "As Uber and Lyft pick-ups and drop-offs clog traffic, new study calls load zones a move in right direction." *GeekWire*, September 9, 2019. https://www.geekwire.com/2019/uber-lyft-pick-ups-drop-offs-clog-traffic-new-study-calls-load-zones-move-right-direction/

Schmitt, A. "Cambridge Becomes First U.S. City to make protected bike lanes mandatory." *Streetsblog USA*, April 9, 2019. https://usa.streetsblog.org/2019/04/09/cambridge-becomes-first-u-s-city-to-make-protected-bike-lanes-mandatory/

Schubert, C. "Experimental zero-emissions last-mile delivery hub launches in Seattle as a test for urban logistics." *GeekWire*, June 17, 2021. https://www.geekwire.com/2021/experimental-zero-emissions-last-mile-delivery-hub-launches-seattle-test-urban-logistics/

Seattle Department of Transportation. (n.d.). *Flex Zone/Curb Use Priorities in Seattle—Transportation*. https://www.seattle.gov/transportation/projects-and-programs/programs/parking-program/parking-regulations/flex-zone/curb-use-priorities-in-seattle (accessed November 18, 2020).

Seattle Department of Transportation. (2019a). *Curbside Management Team 2019 Annual Report*. 2019.

Seattle Department of Transportation. (2019b). *Seattle Curb Space Allocation Framework*. 2019.

Sestito, M. "NVTA to host open house to discuss draft Napa County bicycle plan." *Napa Valley Register*, June 2018. https://napavalleyregister.com/star/news/local/nvta-to-host-open-house-to-discuss-draft-napa-county-bicycle-plan/article_82cb77a7-9411-5c95-a6f1-21f790a29461.html

SFMTA. *Commuter Shuttle Pilot Program*. 2015. https://www.sfmta.com/sites/default/files/projects/2015/Evaluation%20Report%20-%20Oct%205%202015.pdf

SFMTA. *On-Street Car Sharing Pilot Program*. 2017. https://www.sfmta.com/sites/default/files/projects/2017/Carshare_eval_final.pdf

SFMTA. (2020a). *Commuter Shuttle Program Permits 2020—2021*. SFMTA (San Francisco Municipal Transportation Agency), September 4, 2020. https://www.sfmta.com/reports/commuter-shuttle-program-permits-2020-2021

SFMTA. (2020b). *Curb Management Strategy*. 2020. https://www.sfmta.com/sites/default/files/reports-and-documents/2020/02/curb_management_strategy_report.pdf

Shaheen, S., and A. Cohen. *Micromobility Policy Toolkit: Docked and Dockless Bike and Scooter Sharing*. Institute of Transportation Studies, Berkeley, 2019. https://escholarship.org/uc/item/00k897b5

Shaheen, S., A. Cohen, and A. Bayen. *The Societal Value of Carpooling: The Environmental and Economic Value of Sharing a Ride*. Institute of Transportation Studies, Berkeley, 2018. https://escholarship.org/uc/item/7jx6z631

Shaheen, S., A. Cohen, and J. Broader. Mobility on Demand and Automated Driving Systems: A Framework for Public-Sector Assessment Report. Forthcoming.

Shaheen, S., A. Cohen, J. Broader, R. Davis, L. Brown, R. Neelakantan, and D. Gopalakrishna. *Mobility on Demand Planning and Implementation: Current Practices, Innovations, and Emerging Mobility Futures*. 2020. https://escholarship.org/uc/item/3hc6m2vj

Shaheen, S., A. Cohen, M. Dowd, and R. Davis. *A Framework for Integrating Transportation into Smart Cities*. Mineta Transportation Institute, 2019. https://doi.org/10.31979/mti.2019.1705

Shaheen, S., A. Cohen, and I. Zohdy. *Shared Mobility Current Practices and Guiding Principles*. Federal Highway Administration, 2016.

Shared-use Mobility Center. *DDOT Nightlife Parking Demonstration Area*. 2017. https://learn.sharedusemobilitycenter.org/overview/nightlife-parking-demonstration-passenger-loading-zone-washington-dc-2017/

Short, A. "Garçon! D.C. requires curb reservations for deliveries." *Streetsblog USA*, November 14, 2019. https://usa.streetsblog.org/2019/11/14/garcon-d-c-requires-curb-reservations-for-deliveries/

Shyrock, E. Another day in paradise...on my way to work this morning the sidewalks were blocked by Bird scooters in not one, but three!, places. Totally unacceptable!! I called 311 to file a report and called out both the City of Austin and Bird Scooters on social media. Folks need to realize not everyone has the privilege of being able to walk around these obstacles to continue on their way to work, school or play! 2018. https://www.kxan.com/news/local/austin/scooters-blocked-her-path-her-post-led-to-a-new-program/

Smart Growth America. *National Complete Streets Coalition*. Smart Growth America. https://smartgrowthamerica.org/program/national-complete-streets-coalition/ (accessed July 8, 2021).

Smith, C., J.-S. Oh, and C. Lei. *Exploring the Equity Dimensions of US Bicycle Sharing Systems.* 2015. https://doi.org/10.13140/RG.2.2.30941.72163

Smyth, S. *Digital Curb Challenge Cities Selected!* 2020. https://www.coord.com/blog/digital-curb-challenge-cities-selected

Swan, R. "Traffic fatalities soaring despite effort to make city streets safer." 2019. https://www.sfchronicle.com/bayarea/article/SF-sets-sights-on-no-street-fatalities-but-13857436.php#photo-17465689

Todd, J., D. Krauss, J. Zimmermann, and A. Dunning. "Behavior of electric scooter operators in naturalistic environments." Technical Paper 2019-01–1007. 2019. https://doi.org/10.4271/2019-01-1007

Toole Design. (n.d.). Clear signage, tactile paving, and pedestrian islands make Jackson Street a safe street design. The tactile paving is oriented perpendicular to the street and spans the width of the crosswalk. Furthermore, the planting buffer between the road and the bike lane increase the safety for bikers and pedestrians alike, while adding greenery to the street. https://www.asla.org/universalstreets.aspx (accessed July 8, 2021).

Tougas, F. *Canadian Transportation Agency Closes Submissions on Regulatory Costing Model Consultation*. McMillan LLP, March 2017. https://mcmillan.ca/insights/canadian-transportation-agency-closes-submissions-on-regulatory-costing-model-consultation/

Transport for London. *London's Vision Zero Action Plan moves forward the Mayor's Transport Strategy*. 2018. https://visionzeronetwork.org/lessons-from-londons-inspired-vision-zero-action-plan/

Turoń, K., P. Czech, and J. Tóth. "Safety and Security Aspects in Shared Mobility Systems." *Scientific Journal of Silesian University of Technology: Series Transport* 104 (2019): 169–175. https://doi.org/10.20858/sjsutst.2019.104.15

Urbanism Next Center. *COVID-19—Impacts on Cities and Suburbs: Impacts to the Urbanism Next Framework*. 2020. https://assets-global.website-files.com/5d9f83b8b237fa6c07d5d69d/5f74a09153a98284228146a3_COVID-Paper_3_Framework-Impacts-pages.pdf

US Census American Community Survey 2018 5-Year Estimates. San Francisco and Oakland. US Census, Department of Commerce, 2020.

Vision Zero Network. *A Primer on Vision Zero*. 2018. https://visionzeronetwork.org/wp-content/uploads/2018/05/What-is-VZ_FINAL.pdf

Yehezkel, A., and A. Wu Troianos. "Legal considerations before deploying autonomous delivery robots." *The Spoon*, February 23, 2020. https://thespoon.tech/legal-considerations-before-delploying-autonomous-delivery-robots/

Zimbabwe, S. *2020 Rate Changes—Transportation*. Seattle Government, October 2020. https://www.seattle.gov/transportation/projects-and-programs/programs/parking-program/paid-parking-information/2020-rate-changes

About the Authors

Susan Shaheen was among the first to observe, research, and write about the changing dynamics in shared mobility and the likely scenarios through which automated vehicles will gain prominence. She is a Professor in Civil and Environmental Engineering at the University of California, Berkeley. She also co-directs the Transportation Sustainability Research Center (TSRC) of the Institute of Transportation Studies (ITS) Berkeley. She has authored 84 journal articles, over 160 reports and proceedings articles, 34 book chapters, and co-edited three books. She has advised over 30 Master's and PhD students and mentored 150 undergraduate students. She has received international and national awards, including the 2017 Roy W. Crum award from the Transportation Research Board (TRB) for her distinguished achievements in transportation research. From January 2021 to January 2022, she served as Chair of TRB's Executive Committee and Vice Chair from 2020 to 2021. Professor Shaheen was the chair of the Emerging and Innovative Public Transport and Technologies Committee of TRB, and she was the founding chair of subcommittee for Shared-Use Vehicle Public Transport Systems of TRB. At present, she is and an Associate Editor for Transportation Research, Part A; Travel Behaviour and Society; and the Transportation Research Record. She is a member of the World Conference on Transportation Research Society (WCTRS) Steering Committee and Mobile Source Technical Review Subcommittee to the U.S. Environmental Protection Agency's Clean Air Act Advisory Committee. She also served two terms on the ITS Program Advisory Committee to the U.S. Department of Transportation and a Desk Editor for Transport Policy from 2016 to 2021.

Elliot Martin conducts research in shared-use mobility, public and freight transportation, transportation energy, and life-cycle assessment. He has conducted advanced research that measures the impact of shared mobility systems on greenhouse gas emissions, modal shift, and household vehicle holdings. He has led a major research-deployment project on truck parking availability within California, analyzed data from urban parking systems, and supported research in advanced- and alternative-fuel vehicles. He specializes in research instrument design and applies statistical approaches to the analysis of freight movement, sensor performance, vehicle activity data, and travel behavior surveys. Elliot earned a PhD in transportation engineering following a dual Masters in transportation and city planning, all at UC Berkeley. He completed his undergraduate degree at Johns Hopkins University. He previously was an assistant economist at the Federal Reserve Bank of Richmond.

Adam Cohen has over 17 years of experience as a researcher with the Transportation Sustainability Research Center at the University of California, Berkeley, and 13 years of experience as a researcher with the Mineta Transportation Institute of San Jose State University. Adam co-chairs TRB's standing subcommittee on the Equity of Innovative Mobility Services and Technologies AP020(3). He currently serves as Vice Chairman of SAE International's Shared and Digital Mobility Committee and is the co-sponsor of SAE JA3163 which establishes standard terms and definitions for shared and on-demand mobility. Previously, Adam worked for the

Department of Homeland Security (DHS) and the Information Technology and Telecommunications Laboratory (ITTL) at the Georgia Tech Research Institute (GTRI).

Jacquelyn Broader is a researcher with the University of California, Berkeley's Transportation Sustainability Research Center. Her research focuses on various topics including integrating emerging on-demand modes into communities, evaluating different state and federally funded projects for accessibility and equity opportunities and challenges, understanding the potential role of the sharing economy in evacuations, and doing feasibility studies of innovative transportation strategies (e.g., mileage-based user fees/road use charges). Jacquelyn has 13 publications, three of which are peer-reviewed. Jacquelyn earned a degree in Urban Studies from the University of California, Berkeley as well as minors in Disability Studies and Sustainable Design. She also serves on the Advisory Board of Self-eSTEM, a non-profit organization focused on creating a pipeline of women from underserved communities into science, technology, engineering, math (STEM) industries.

Richard Davis has a BA in Screenwriting with a minor in Computer Science at Loyola Marymount University in Los Angeles. Richard graduated with a Master's in Urban Planning at San Jose State University. Richard believes in a future where cities are profoundly oriented towards human connection and built according to biophilic design principles.