Journal of the American Planning Association

ISSN: 0194-4363 (Print) 1939-0130 (Online) Journal homepage: https://www.tandfonline.com/loi/rjpa20

Redefining Car Access

Anne Brown

To cite this article: Anne Brown (2019): Redefining Car Access, Journal of the American Planning Association, DOI: 10.1080/01944363.2019.1603761

To link to this article: https://doi.org/10.1080/01944363.2019.1603761

Redefining Car Access

Ride-Hail Travel and Use in Los Angeles

Anne Brown

ABSTRACT

Problem, research strategy, and findings: Ride-hail services such as Uber and Lyft have the potential to redefine car access and travel, but unclear associations with the built environment and resident characteristics have undermined planners' abilities to make informed decisions. I use detailed data of 6.3 million Lyft trips in Los Angeles (CA) to examine the associations between Lyft travel, the built environment, and neighborhood socioeconomic characteristics. Although data are limited to one American city, findings present a comprehensive understanding of Lyft use across an array of built environments. I find that, far from being limited to dense urban cores, Lyft provides automobility in suburban and even rural neighborhoods. Findings suggest that unlike taxis, ride-hailing does not exclude low-income neighborhoods and communities. Instead, Lyft provides car access in neighborhoods where its closest substitute, the household car, is scarcest. Most travelers use ride-hailing to fill an occasional rather than regular travel need, but a small share of users made the most ride-hail trips. Travelers without smartphones or bank accounts, however, may be excluded from ride-hailing.

Takeaway for practice: Widespread Lyft use demonstrates that planners should anticipate ride-hailing not just in urban centers but across a wide array of built environments. Negative associations between Lyft travel and off-street parking suggest that ride-hailing can provide new modal options where parking is already constrained or where new parking restrictions are introduced. Planners should work with communities and transit agencies to adopt strategies or enter partnerships that extend ride-hail, or other technology-enabled mobility services, to travelers without smartphones or bank accounts.

Keywords: car access, equity, ride-hail, ridesource, transportation network company

Ride-hail companies—also known as ridesource and transportation network companies—such as Uber and Lyft offer an opportunity to redefine car access by connecting riders to drivers through smartphone applications. Ride-hailing in its current form is just 7 years old, yet nearly 1 in 10 Americans takes a ride-hail trip each month (Conway, Salon, & King, 2018). Ride-hailing offers broad implications for cities, travel, and planning, but a dearth of data from private companies has largely impeded efforts to understand where ride-hailing trips are made and how individual riders travel on this still-new mode. I ask and answer two questions in this study: First, what factors are associated with the spatial distribution of ride-hail services? And what factors are associated with individual ride-hail trip-making?

I begin by examining the critical role that cars play in access to opportunities in the United States and discuss how ride-hailing may represent a new chapter in automobility distinct from previously available—and often inequitable—taxi services. I then review what we know about ride-hail travel patterns and user demographics from surveys deployed across the country. I describe the unique data set used in this research: a population of 6.3 million Lyft trips taken in Los Angeles over a 3-month period in 2016. I find that ride-hail use is remarkably widespread across core urban, suburban, and even rural neighborhoods and that people living in low-income neighborhoods—far from being excluded from the service—use ride-hailing more frequently than other travelers do when all else is equal. Most travelers use ride-hailing to fill an occasional rather than regular travel need, but a small share of users made most ride-hail trips. A negative association between both income and neighborhood car ownership suggests that ride-hailing provides new automobility in neighborhoods where personal car access was previously limited. I conclude with implications for planners, who should anticipate ride-hailing across an array of built environments and work with community organizations and transit agencies to ensure access for travelers who cannot currently hail a ride due to technological or banking barriers.

DOI: 10.1080/01944363.2019.1603761

Color version available at ***tandfonline.com/rjpa***

Ride-Hailing as a New Chapter in Car Access

Car ownership in the United States is nearly universal. Ninety-two percent of U.S. households own at least one vehicle (U.S. Census Bureau, 2015a), and with good reason: Car ownership in the United States confers positive outcomes such as finding work (Sandoval, Cervero, & Landis, 2011), working more hours (Gurley & Bruce, 2005), earning higher wages (Raphael & Rice, 2002), accessing more supermarkets and healthy foods (Walker, Keane, & Burke, 2010), and moving to and staying in low-poverty neighborhoods (Dawkins, Jeon, & Pendall, 2015). But even households that do not own cars—and who have disproportionately low incomes (National Household Travel Survey [NHTS], 2017)—occasionally need to travel by car.

Ride-hailing is not the first for-hire vehicle service to provide automobility for travelers without cars: Jitneys, informal gypsy cabs, and licensed taxis have granted trip-by-trip car access for decades. Taxis in particular provide a mobility safety net for carless travelers and are disproportionately used by travelers with very high and very low incomes (NHTS, 2009; Schaller, 2015). Taxis, however, are rife with geographic inequities that create service gaps in low-income neighborhoods and communities of color (Austin & Zegras, 2012; Cohen, 2015). Taxis are not unique in producing geographical inequities in auto access: Previous research finds that car share stations are disproportionately lacking in low-income neighborhoods (Clark & Curl, 2016; Kim, 2015). Ride-hail companies, including Uber and Lyft, upend the traditional taxi model by connecting drivers to riders through smartphone applications. A number of ride-hail innovations suggest that ride-hailing could overcome shortcomings that have produced spatially uneven and inequitable taxi service. First, ride-hail companies bridge the information gap that has long plagued the taxi industry. Imperfect information in the taxi industry results in drivers clustering where they think riders will be—often hotels, airports, and downtown centers—rather than where potential riders actually are. Taxi service, as a result, often has limited service outside of city downtowns (San Francisco Municipal Transportation Agency, 2013). Ride-hail companies, by contrast, know where both riders and drivers are and can raise prices to attract drivers to underserved areas. Second, ride-hailing's rating systems, fewer pickup regulations, and dynamic passenger assignment may reduce the discrimination and economic pragmatism that have limited or eliminated taxi service in low-income neighborhoods or communities of color (Cohen, 2015; King & Saldarriaga, 2018; LaMendola, 1991; Ridley, Bayton, & Outtz, 1989).

Where Is Ride-Hailing?

Despite various innovations suggesting that ride-hailing can overcome the geographic limitations endemic in the taxi industry, reports of ride-hail geographic service equity are mixed. Media outlets report less ride-hail service and longer wait times in low-income neighborhoods and communities of color (Motavalli, 2015; Stark & Diakopoulos, 2016). Researchers find, by contrast, that ride-hail operators serve neighborhoods across income groups (Feignon & Murphy, 2018; Hughes & MacKenzie, 2016; Smart et al., 2015) and extend car access to areas neglected by taxis (Gehrke, Felix, & Reardon, 2018; Schaller, 2017).

Understanding ride-hail service geography is critical to questions of equity and fundamental planning questions about the association between ride-hail travel and the built environment. The association between ride-hailing and neighborhood resident characteristics can reveal whether ride-hailing, like taxis, excludes neighborhoods based on resident income, race, or ethnicity (Cohen, 2015; LaMendola, 1991; Ridley et al., 1989) as suggested by media outlets (Motavalli, 2015; Stark & Diakopoulos, 2016). In addition, although researchers understand associations between the built environment and other forms of car travel, the relationship between the built environment and ride-hail travel remains unclear. Better understanding this association is paramount given that planners use the built environment to shape cities and influence travel behavior.

Who Uses Ride-Hailing?

Researchers have largely used surveys to understand who uses ride-hailing and how they travel by it. A growing body of survey research presents a picture of ride-hail users who are disproportionately young and urban, although the association with age may be a cohort effect rather than an age effect (Anderson & Perrin, 2017; Clewlow & Mishra, 2017; Conway et al., 2018; Rayle, Dai, Chan, Cervero, & Shaheen, 2016; Smith, 2016). Academic research documents mixed associations between ride-hailing and income. Some research reports increasing ride-hail adoption with income and educational attainment (Clewlow & Mishra, 2017; Conway et al., 2018; Smith, 2016), whereas others find that ride-hail users have disproportionately low to middle incomes (Gehrke et al., 2018; Rayle et al., 2016). Ride-hail adopters are also disproportionately carless compared with the general population, and ride-hail use is negatively associated with personal vehicle ownership (Clewlow & Mishra, 2017; Conway et al., 2018; Gehrke et al., 2018); 35% of ride-hail users in San Francisco (CA), for example, do not own a car, compared with 19% of the city population (Rayle et al., 2016). Survey data provide one window into ride-hail travelers; no ride-hail data to date, however, have been used to examine ride-hail users, including where they live or how they travel.

Ride-hailing offers a new opportunity for automobility, but the potential planning implications of ride-hail services remain unclear. Research to date suggests that ride-hailing may provide superior access in neighborhoods previously eschewed by taxis (Hughes & MacKenzie, 2016; Smart et al., 2015), but we do not yet understand the association between the built environment, resident characteristics, and ride-hail travel. In this research, I ask two distinct research questions about ride-hail travel in Los Angeles: First, what factors are associated with the spatial distribution of ride-hail service? Second, what factors are associated with individual ride-hail trip-making? I answer these questions using a new and rich origin–destination data set of Lyft trips in Los Angeles. An improved understanding of ride-hail trips and users informs policymakers and analysts who currently seek to integrate ride-hailing into travel demand models and understand how people use it. Results likewise reveal whether drivers avoid particular neighborhoods as some media reports claim (see, for example, Motavalli [2015] and Kohler [2015]) and guide emerging regulations to ensure equitable access to ride-hail services.

Measuring Lyft Service and Use in Los Angeles

I obtained trip-level records for every Lyft trip taken to, from, or within Los Angeles County between September and November 2016. Lyft granted access to the data under a nondisclosure agreement. The data agreement prohibited data sharing but also barred Lyft editorial control over published findings. Los Angeles County is home to more than 10 million people (U.S. Census, 2016) and includes 158 cities and unincorporated places (*Los Angeles Times*, n.d.). Its neighborhoods range from remote mountain towns to sprawling suburbs and dense urban communities. Southern California's year-round temperate climate minimizes seasonal travel effects, making 3 months of ride-hail data generalizable to annual use in the county. Lyft provided the following information for each trip:

- Unique traveler identification number
- User billing zip code
- Trip origin census tract
- Trip destination census tract
- Time of day (4-h intervals: 1:00 a.m.–3:59 a.m., 4:00 a.m.–6:59 a.m., etc.)
- Weekday (yes/no)
- Trip price ($2.50 increments: $0–$2.50, $2.51–$5.00, etc.)
- Trip distance (5-mile categories: 0–5 miles, 5.01–10 miles, etc.)
- Shared ride service (Lyft Line, yes/no).

In total, 828,616 users took more than 6.3 million trips between September and November 2016 to, from, or within Los Angeles County. Ride-hail access pertains to both the neighborhoods it serves and the people who ride it. I therefore analyze ride-hail access in terms of "Lyft service" and "Lyft use." I define Lyft service as the number of Lyft trips taken over the 3-month study period per capita (jobs plus residents) that begin or end in a census tract. The neighborhood service analysis investigates factors associated with *where* trips are made—specifically, the number of trips to or from a neighborhood—but does not consider *who* makes those trips. Many trips may, for example, start or end in low-income neighborhoods filled with nightlife destinations, but these Lyft passengers may be club patrons and not residents. Distinguishing between neighborhood service and users is important for understanding who gains automobility from Lyft service and not just where trips are made. The Lyft use analysis therefore examines factors associated with individual Lyft travel. I define Lyft users as people who hailed one or more Lyfts between September and November 2016 and measure individual Lyft use as the total number of trips each user completed over the 3-month study period. I restricted the Lyft user analysis to the 571,115 individuals who lived in Los Angeles County using the steps outlined in the Technical Appendix.

I evaluate the associations between Lyft service—the number of Lyft trips that began or ended in a neighborhood per capita (jobs plus workers)—and neighborhood built environment and resident characteristics using a linear regression model that includes all trips taken in Los Angeles County between September and November 2016. Measuring Lyft service as a per capita measure accounts for different densities across Los Angeles County. I examine the association between individual Lyft use—the number of Lyft trips that an individual made over the 3-month period—and neighborhood characteristics using a negative binomial regression model. Model specification details are outlined in the Technical Appendix. Each model includes independent built environment and resident characteristic variables described in the following section.

Measuring Neighborhood Characteristics

I examine Lyft service and use in context of resident and built environment characteristics from the 2011–2015 American Community Survey. Selected variables reflect 1) household resources related to car access and 2) demographic data associated with transportation service exclusion documented by previous research. I include the share of zero-vehicle households in a neighborhood and neighborhood median income as measures of household resources; both variables are strong predictors of mode choice and travel behavior (Blumenberg & Pierce, 2012; Van Acker & Witlox, 2010). Neighborhood income and racial or ethnic composition may also be bases of service exclusion (Ong & Stoll, 2007; Spiegelman, 2016). Los Angeles remains highly segregated by race and ethnicity (Logan & Stults, 2011), and perceptions of dominant racial or ethnic groups in an area may therefore influence drivers' decisions to serve them. To reflect this possibility, I classify neighborhoods into racial and ethnic majority categories using American Community Survey data; I define neighborhoods where more than 50% of residents identified as a single race or ethnicity as "majority" Asian, Black, Hispanic, or White neighborhoods and classify neighborhoods without a clear racial or ethnic majority as "no majority." I use no majority as the baseline category in models because I hypothesize that service may vary by driver perceptions of neighborhood racial/ethnic makeups, and no majority provides a neutral baseline for these comparisons. Finally, I include the share of tract residents between the ages of 15 and 34 because previous research finds ride-hail users are disproportionately young (Clewlow & Mishra, 2017; Conway et al., 2018; Gehrke et al., 2018; Rayle et al., 2016).

The built environment, like traveler characteristics, influences travel behavior and mode choice. Researchers measure the built environment in many ways, often summed up as the "5 Ds," which are associated with mode choice and car travel: density, design, diversity, distance to transit, and destination accessibility (Ewing & Cervero, 2010). I tested combinations of density and composite built environment metrics and selected the final model specifications based on model fit criteria. Final models include six density metrics. Population and employment density from the U.S. Environmental Protection Agency's Smart Location Database (U.S. Environmental Protection Agency, 2014) reflect the concentration of people and jobs in a neighborhood. Smart Location Database road network density measures design, with higher network densities indicating dense urban grids and lower densities revealing fewer or more circuitous suburban and rural roads. A measure of transit stop density (stops per square mile) derived from the Bureau of Transportation Statistics' (2017) *National Transit Map* database captures distance to transit and general transit accessibility in a neighborhood. On-street and off-street parking space counts obtained from Chester, Fraser, Matute, Flower, and Pendyala (2015) reflect the substantial role that parking plays in driving behavior (Shoup, 2011; Weinberger, 2012; Weinberger, Seaman, & Johnson, 2009). Finally, I include a measure of activity diversity to distinguish between areas that have similar activity densities but that generate or attract travelers differently (Ortúzar & Willumsen, 2011). Specifically, I measure neighborhood activity diversity as the number of jobs per square mile in the "Arts, Entertainment, and Recreation" and "Accommodation and Food Services" sectors in the Longitudinal Employer-Housing Dynamics program (U.S. Census Bureau, 2015b) because ride-hail surveys reveal that socializing, leisure, and entertainment are the most common reasons that people ride-hail (Clewlow & Mishra, 2017; Lyft, 2018a; Rayle et al., 2016).

Data Limitations

The Lyft data used in this research are unique compared with data previously available to researchers and present a complete picture of Lyft travel over a 3-month period; they nevertheless have limitations. The user analysis likely underestimates the total number of Lyft riders because it excludes 1) travelers who rode Lyft with friends or family but did not hail Lyft themselves and 2) users who have Lyft accounts but did not make a trip during the study period. Lyft trips are divorced from rider demographic or economic data such as a rider's race, ethnicity, or income. Researchers have administered surveys to obtain such data in the past (Clewlow & Mishra, 2017; Gehrke et al., 2018; Henao, 2017; Rayle et al., 2016). I therefore describe Lyft users as "living in a low-income neighborhood" rather than having a low income because their income cannot be known based on the neighborhood in which they live. Compared with survey samples, these data are more robust because they provide a population of trips. Findings therefore provide both a foundation for future research and a critical resource for policymakers to better understand how and where Lyft travel fits into the transportation landscape.

Results

Ride-hailing offers an opportunity to redefine car access, but the potential links to local characteristics and equity implications of ride-hail services remain unclear.

Trip-level data from Los Angeles reveal associations between two measures of Lyft travel (trips per capita and number of trips per user), the local built environment, and neighborhood resident characteristics. The figures in the body of this article highlight key findings; Tables A-1 and A-2 in the Technical Appendix show full model results of the associations between Lyft travel, the built environment, and resident characteristics, which underpin the discussion presented here.

Lyft Provides Service in Neighborhoods Previously Excluded by Taxis

Table 1 shows descriptive statistics of Lyft service and Lyft use on average and across neighborhoods of different densities, incomes, and racial/ethnic majorities. Because resident and built environment characteristics—such as income and density—are often correlated, the bulk of findings I discuss in the remainder of this study reflects model results to distinguish meaningful from spurious associations.

I find that—contrary to media reports of service exclusion (Kohler, 2015; Motavalli, 2015)—Lyft served nearly every corner of Los Angeles County, with more trips taken in the densest neighborhoods. Figure 1 shows that Lyft served census tracts home to 99.8% of the Los Angeles County population; only outlying rural areas were not served by at least one Lyft trip. The maps show what cities have not previously known beyond anecdote: where ride-hail trips and users are. The maps showing the geographic extent of Lyft service complement the concrete statistical analyses I present later. Lyft trip-making and use across a wide range of built environments suggest that planning for ride-hailing should occur not only in core urban settings but also in suburban and rural environments.

Previous research and media reports reveal that taxis avoid communities of color, particularly Black neighborhoods (Cohen, 2015; LaMendola, 1991; Ridley et al., 1989). Lyft, by contrast, provides *more* trips per capita in majority Black neighborhoods compared with neighborhoods with no racial majority, and there was *no difference* in per capita trips between majority Black and majority White neighborhoods, after controlling for neighborhood income and built environment. Majority White neighborhoods are positively associated with Lyft service, controlling for the built environment, whereas majority Asian and Hispanic neighborhoods are associated with significantly less service. Fewer trips in majority Asian and Hispanic neighborhoods may relate to a number of factors, which I discuss at length in later sections of this study.

Ride-hailing is also strongly associated with the share of the population between 15 and 34 years old. For every 10% increase in the share of the population between age 15 and 34, Lyft service is predicted to rise about 25%. More Lyft travel in neighborhoods home to young adults may reflect youths' increased ride-hail adoption, as documented by previous researchers (Clewlow & Mishra, 2017; Conway et al., 2018; Gehrke et al., 2018; Rayle et al., 2016), or could represent barriers that older adults face in accessing ride-hail services (Shirgaokar, 2018).

In addition to resident characteristics, built environment variables are associated with Lyft service, but the associations are relatively weak by comparison. Figure 2 shows that although Lyft is a form of car travel, its spatial distribution more closely resembles that of transit than car trips. Nearly half (46%) of Lyft trips were made in the densest neighborhoods, more than two times the share of car trips (20%) and just slightly less than the share of transit trips (50%; California Department of Transportation, 2012). Trip distance, price, and sharing also occur on a gradient across density, with the cheapest, shortest, and most shared trips made in high-density neighborhoods. Trips are more than twice as long on average in low-density neighborhoods[1] than in high-density neighborhoods (6.9 versus 15.0 miles) and nearly twice as expensive ($9.03 versus $17.80). Some of these differences can be attributed to the variation in ride-splitting—in which riders traveling between different origins and destinations share a single Lyft Line (now rebranded Lyft Shared) trip—across different densities. About one-third of trips (33%) in high-density neighborhoods were made on shared Lyft Lines compared with about one-fifth (21%) of trips in low-density areas.

Tables A-1 and A-2 in the Technical Appendix show that Lyft trips per capita—the number of Lyft trips beginning and ending in a neighborhood per job and resident in that neighborhood over the 3-month study period—are generally higher in urban areas with a dense road network, many jobs and people, and robust transit. Transit stop density has the strongest association with Lyft trips in a neighborhood: A 10% increase in the number of transit stops per square mile is associated with about a 2.5% increase in Lyft trips traveling to or from a neighborhood.

Off-street parking density, in contrast to other density variables, is negatively associated with Lyft trips, controlling for other neighborhood factors. A 10% increase in off-street parking density is associated with a 1.4% decrease in Lyft trips per capita. With off-street parking density positively associated with residential, job, and road network densities, fewer Lyft trips in such areas may reflect users' decisions to ride-hail where parking is

Table 1

Lyft trips and users across neighborhood characteristics and descriptive statistics.

	Trips				Users				
	No. trips per capita[a]	Mean trip distance (miles)	Mean trip price ($)	Mean % line	No. users per capita[b]	No. trips per user	Mean trip distance (miles)	Mean trip price ($)	Mean % line
Neighborhood density[c]									
Low	0.49	14.97	17.80	20.9	0.059	6.93	10.36	13.12	16.5
Medium	0.75	8.22	10.57	27.1	0.041	8.66	8.73	11.21	19.8
High	1.46	6.90	9.02	32.9	0.062	10.45	7.87	10.23	23.7
Neighborhood income[d]									
Low (≤$38,319)	1.01	8.60	10.73	34.4	0.048	10.50	7.70	9.98	27.4
Middle ($38,320–$76,364)	0.81	9.60	12.01	26.2	0.049	9.00	8.70	11.13	20.0
High (≥$76,365)	0.83	10.40	13.00	21.8	0.057	7.70	9.60	12.38	15.8
Neighborhood racial/ethnic majority									
Asian	0.82	8.95	11.56	24.51	0.042	7.45	9.51	12.21	20.27
Black	1.00	7.47	9.59	38.61	0.049	10.23	8.45	10.79	25.85
Hispanic	0.60	8.81	11.08	29.93	0.038	9.08	8.28	10.59	23.62
White	1.27	10.04	12.41	24.51	0.082	9.03	9.04	11.69	17.40
No majority	0.96	10.98	13.60	23.09	0.046	9.08	8.73	11.23	20.14
Average	0.86	9.55	11.96	27.0	0.050	9.0	8.70	11.19	20.6

Notes:
a. Number of Lyft trips taken over the 3-month study period per capita (jobs plus residents).
b. Number of Lyft users who took at least one trip between September and November 2018 per neighborhood job plus resident.
c. Densities reflect activity (population plus jobs) density. Low is the bottom quartile of neighborhoods, medium is the middle 50%, and high is the top quartile.
d. Income groups defined by quartile, with middle representing the middle 50% of neighborhood median incomes: low, ≤$38,319; middle, $38,320–$76,364; high, ≥$76,365.

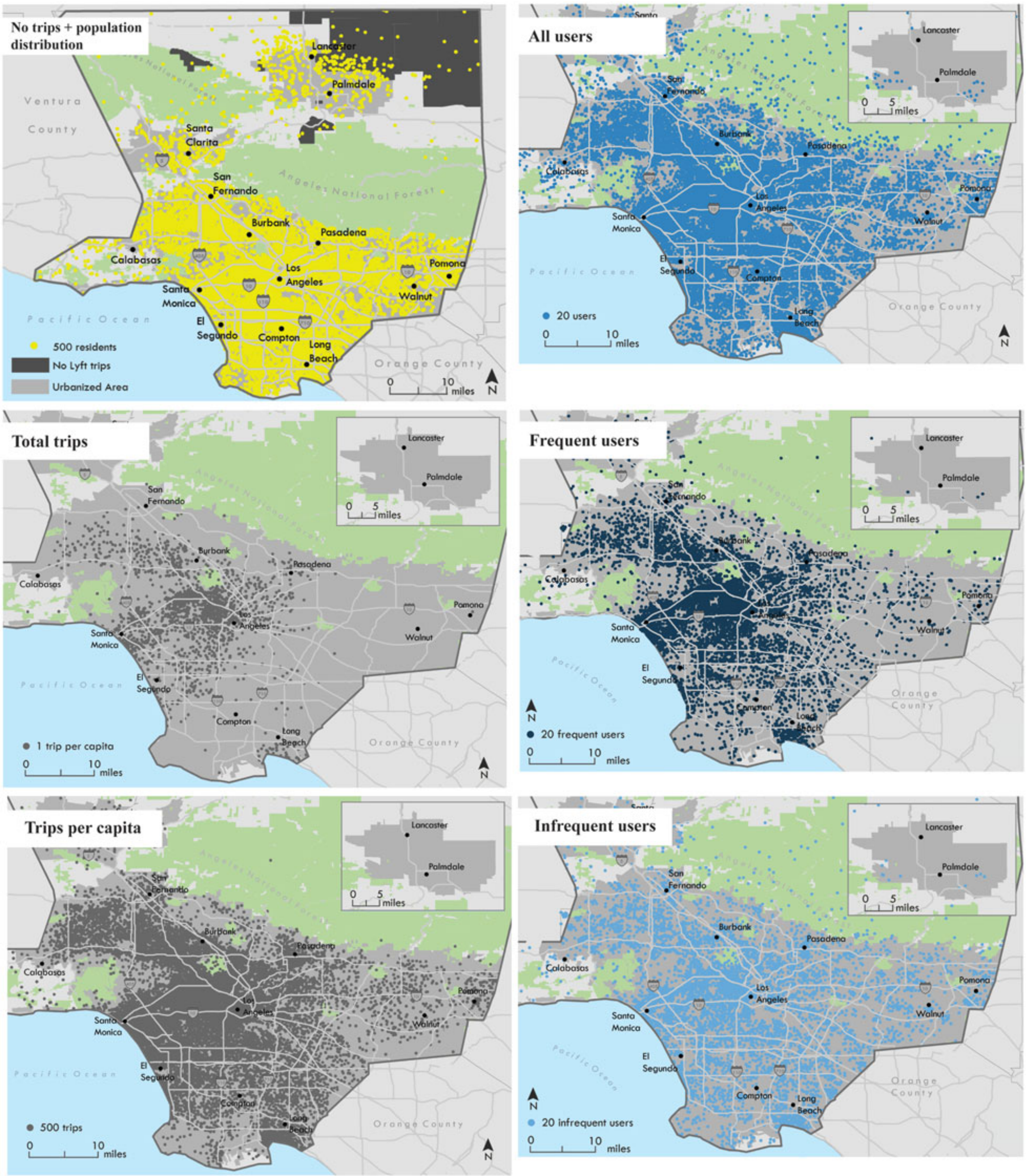

Figure 1. Spatial distribution of Lyft trips and users in Los Angeles County. Frequency indicates trip quartile. Frequent users are the top 25% of users and made nine or more trips in 3 months. Infrequent users are in the bottom 25% and made just one trip in 3 months.

expensive or scarce (Clewlow & Mishra, 2017; Gehrke et al., 2018; Henao, 2017).

My findings suggest the types of activities in a neighborhood, not just the number of activities, are associated with Lyft travel. Specifically, my analysis reveals the number of workers per square mile in food, arts, and recreation is positively associated with Lyft service. Results conform to surveys of ride-hail users, which show that social and leisure activities are the most common ride-hail trip purpose (Clewlow & Mishra, 2017;

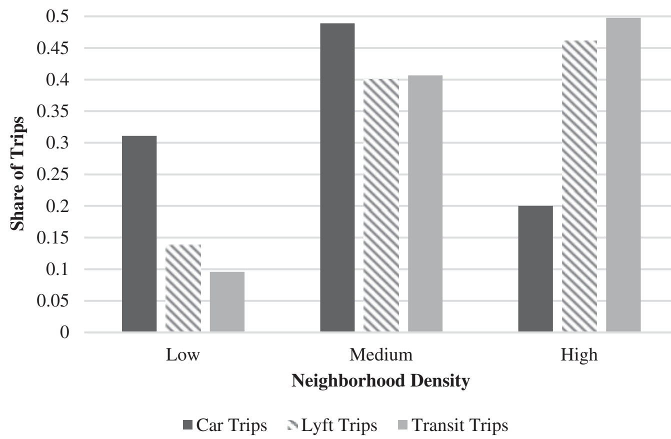

Figure 2. Share of car, transit, and Lyft trips in low-, medium-, and high-density neighborhoods. Sources: California Department of Transportation (2012) and Lyft (2016).

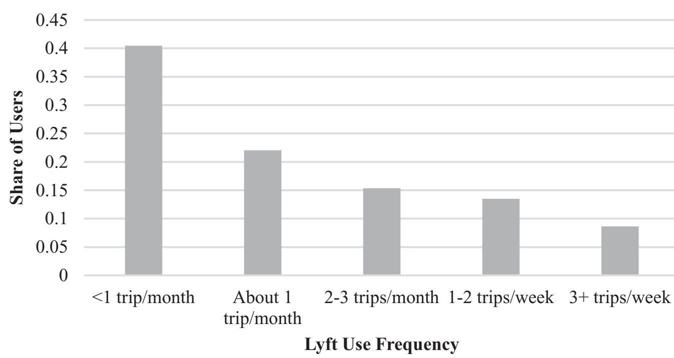

Figure 3. Distribution of Lyft use frequency. Source: Lyft (2016).

Feignon & Murphy, 2018; Gehrke et al., 2018; Henao, 2017; Rayle et al., 2016).

Ride-Hailing Users in Los Angeles

Lyft users, like Lyft trips, are spread throughout Los Angeles County (see Figure 1). Most Lyft users ride with Lyft only occasionally; Figure 3 shows that 40% of users took less than one Lyft trip per month, whereas about one-fifth (22%) made one or more Lyft trip per week. These findings suggest that for some travelers, Lyft may be a staple mode, but most travelers ride Lyft only occasionally to fill modal gaps or trip-specific needs. These findings are consistent with both national and California survey data (Circella, 2018; Clewlow & Mishra, 2017; Conway et al., 2018). Similar to transit, where a small fraction of riders make the most trips (Manville, Taylor, & Blumenberg, 2018), Lyft use is highly asymmetrical. Ten percent of Lyft users made more than half (52%) of Lyft trips; the top 5% of riders made one-third (36%) of all trips.

The association between the built environment extends beyond neighborhood-level Lyft service to how frequently users hail Lyft. Associations between individual Lyft use and the built environment are broadly similar to those described above (see Table A-1 in the Technical Appendix). Travelers who live in dense neighborhoods take more Lyft trips per person controlling for socioeconomic variables, an association echoed by 2017 NHTS data (Conway et al., 2018).

Previous research finds that ride-hail adoption rises with income (Clewlow & Mishra, 2017; Conway et al., 2018), but no research has found conclusive differences in trip frequency by income. I find that although a *larger share* of users live in high-income neighborhoods (neighborhoods in the top median household income quartile; 27%) than in low-income neighborhoods (neighborhoods in the bottom median household income quartile; 24%), travelers living in low-income neighborhoods *make more trips*—about one more trip per month—than users living in high-income neighborhoods, controlling for residential location. In other words, although more people who live in high-income

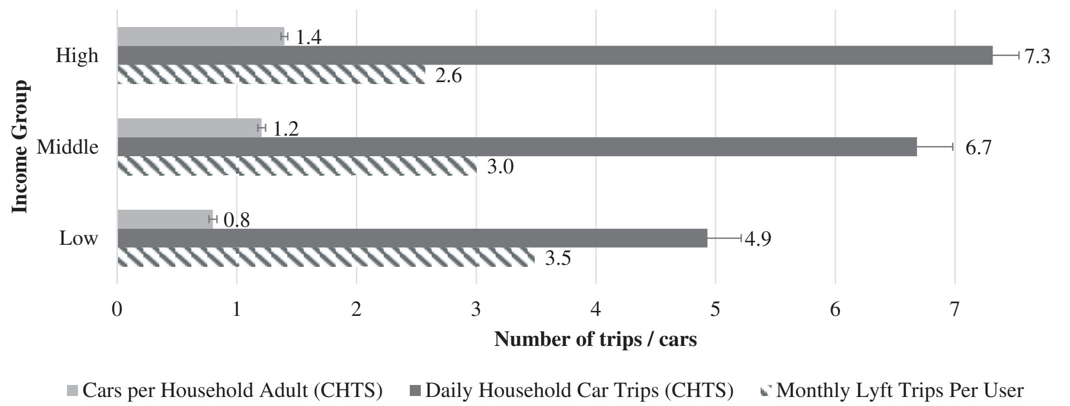

Figure 4. Number of Lyft trips versus car trips and ownership across incomes. Error bars indicate 95% confidence intervals. Sources: California Department of Transportation (2012) and Lyft (2016).

neighborhoods have tried Lyft, they do not hail Lyft as frequently as people living in low-income neighborhoods. Differing adoption by neighborhood income suggests that ride-hailing may serve different roles in automobility across income groups.

The association between neighborhood income and Lyft use is relatively weak when separated from car ownership, which is the strongest positive predictor of individual Lyft use; every 10% increase in the share of neighborhood households without a car is associated with a 7% increase in the number of Lyft trips that a user makes. Household vehicle ownership is also strongly associated with Lyft service to a neighborhood: every 10% increase in the share of households without a car is associated with between a 22% and 30% increase in Lyft trips in a neighborhood.

The associations between zero-car households, income, and Lyft trip-making are inverse to the one typically observed in travel survey data. Figure 4 shows that in Los Angeles, low-income households make just two-thirds the number of car trips and own about half as many cars per adult compared with households in high-income households (California Department of Transportation, 2012). Low-income households have relatively low personal auto access and appear to buoy limited personal automobility with higher Lyft use: Travelers living in low-income neighborhoods make 36% more Lyft trips per month than those living in high-income neighborhoods.

People living in low-income neighborhoods also made shorter, cheaper, and more shared trips than those living in higher-income neighborhoods when controlling for other neighborhood characteristics (see Technical Appendix Table A-3). Accounting for other neighborhood characteristics, users living in low-income neighborhoods took more than one-quarter (27%) of trips on shared Lyft Line compared with one-fifth (20%) and one-sixth (16%) of trips by users living in middle- and high-income neighborhoods, respectively. Higher rates of sharing among travelers living in low-income neighborhoods may reflect the lower prices of shared trips. A 5-mile trip on Lyft Line, for example, is about $2 less than a nonshared Lyft ($9 versus $7), controlling for time of day and day of the week.

Extending Equitable Access to Cars

Ride-hailing may provide a new way for travelers to gain car access, but unclear associations with the built environment and resident characteristics have undermined planners' abilities to make informed decisions in this new mobility ecosystem. I explore two questions in this research to fill this gap in understanding: First, what factors are associated with the spatial distribution of ride-hail service? Second, what factors are associated with individual ride-hail trip-making?

I find that, contrary to media reports of ride-hail service exclusion (Kohler, 2015; Motavalli, 2015), Lyft served nearly every corner of Los Angeles County in a 3-month period, and trips per capita were in fact higher in low-income and majority Black neighborhoods historically eschewed by taxis and some car share programs. Lyft travel was associated with higher densities—echoing city fears of heightened congestion on already congested city streets—but its near-ubiquitous presence across space suggests that planners should incorporate ride-hail strategies across a wide array of built environments. Planning for ride-hailing should not occur in a vacuum but rather should consider the broader suite of available modes, which continue to meet the bulk of daily travel demand alongside occasional ride-hail use. Negative associations between Lyft travel and off-street parking suggest that ride-hail can provide a new travel option where parking is already constrained or where new parking restrictions—such as reduced parking requirements or pricing—are introduced.

Negative associations between Lyft use and neighborhood income and car ownership suggest that in many neighborhoods, Lyft extends car access where personal automobility, and likely taxi access, was previously limited; given the myriad positive outcomes associated with car ownership, ride-hailing therefore presents a mobility boon to travelers who may previously have been isolated from opportunities (Dawkins et al., 2015; Gurley & Bruce, 2005; Sandoval et al., 2011; Walker et al., 2010).

Associations between neighborhood age and racial/ethnic composition, however, also reveal that ride-hail access may still be uneven across travelers. Fewer trips in majority Asian and Hispanic neighborhoods, controlling for built environment characteristics, may relate to one of four factors. First, higher Lyft service in majority Black and majority White neighborhoods may be partly due to the geographical location of these neighborhoods, which are more centralized within Los Angeles County than majority Asian and Hispanic neighborhoods.

Second, differences in Lyft use may reflect how households use existing personal vehicles. Asian and Hispanic drivers in Los Angeles carpool more than either White or Black travelers, suggesting that car access is achieved, at least to some extent, by households pooling together limited auto resources (California Department of Transportation, 2012). Cars in majority Asian neighborhoods may also be more plentiful than a simple zero-car household measure would suggest. Rates of carlessness in majority Asian neighborhoods are about the same as those in other neighborhoods (8.5%), but more than one-quarter of households in majority Asian neighborhoods have *more than three cars*, compared with 20% of households living in other neighborhoods.

Third, reduced ride-hail trips and trip-making in majority Hispanic neighborhoods may represent technological barriers to ride-hail services such as less access to smartphones. Households in which only Spanish is spoken also have far lower rates of smartphone ownership (47%) compared with households in which Spanish is not the only spoken language (68%; Federal Deposit Insurance Corporation [FDIC], 2016). Even when smartphones are present in the household, the data plan required may be ephemeral. Forty-four percent of smartphone users lost service at some point due to financial constraints; low-income, Black, and Latino users are all twice as likely to have canceled or lost service at some point compared with higher income and White users (Smith, McGeeney, Duggan, Raine, & Keeter, 2015). Lack of smartphone access, however, may be a barrier to broader populations. The positive association between Lyft use and young neighborhood residents, for example, could echo survey research that finds that younger adults adopt ride-hailing at higher rates (Clewlow & Mishra, 2017; Conway et al., 2018; Gehrke et al., 2018; Henao, 2017; Rayle et al., 2016), or it could reveal technological barriers that impede use by seniors, who own smartphones at relatively low rates and are more distrustful of paying for services online (FDIC, 2016; Shirgaokar, 2018). Bridging the technological divide to ensure ride-hail access for those without—or without reliable access to—smartphones could therefore extend the automobility that these services provide. Private companies are already offering services to smartphone-less residents to ride-hail services; companies such as GoGoGrandparent, RideWith24, and GreatCall allow riders to use landlines and speak with operators to hail a ride. Community–ride-hail partnerships may provide another solution: Lyft Concierge, for example, partners Lyft with local organizations and businesses, which can hail rides for customers (Lyft, 2018b). Lyft Concierge began in health care but could be extended to senior or affordable housing developments, community centers, or public libraries to increase ride-hail access points for any traveler without a smartphone.

A final explanation of lower Lyft use in majority Hispanic neighborhoods presents another imperative for policy action: Unbanked households are often excluded from cashless transportation platforms. National reports of banking status find that 16% of Hispanic households are unbanked compared with just 3% of White households, and that the share of unbanked households rises sharply among immigrant and undocumented populations (FDIC, 2016). Uber and Lyft currently allow riders to pay with prepaid cards, but 12% of nonusers still report not being able to pay cash as the largest barrier to ride-hailing (SharesPost, 2018). Overcoming banking barriers is paramount, particularly as transit agencies seek to partner with ride-hail companies to improve station access (Federal Transit Administration, 2018). Planners should consider two opportunities that existing transit fare card technologies could leverage or streamline payment across modes and extend ride-hail access to unbanked travelers. First, ride-hail payment systems may be directly linked with fare cards, allowing travelers to pay for trips using fare card balances; Sound Transit Agency in Seattle (WA) is pursuing this strategy as part of its Mobility on Demand sandbox pilot (Federal Transit Administration, 2018). Alternatively, agencies could adopt electronic fare payment systems that offer banking features that eliminate the need to coordinate payment systems across organizations. An example of this strategy, although it is being phased out, is the Ventra card in Chicago (IL), which offered a MasterCard debit feature. The card could be loaded with cash at fare machines and had a debit card number that travelers could use to pay for ride-hail or other shared services. Bike share systems also offer lessons for extending access to cash-only travelers by providing locations where residents can pay cash for discounted passes at select locations or visit partnered community development credit unions (Citi Bike, 2019; Ford GoBike, 2019). Future research is needed to test the efficacy of these interventions in extending ride-hail access, as well as comparing how—or whether—travel patterns differ between ride-hail companies.

Ride-hailing offers ample opportunities to redefine car access and enhance mobility in neighborhoods ranging from urban to rural, with the potential to boost automobility for those who need it most. The challenge for planners is to harness this opportunity to ensure that its promise is shared by all—not just some—travelers.

ABOUT THE AUTHOR

ANNE BROWN (abrown33@uoregon.edu) is an assistant professor in the School of Planning, Public Policy, and Management at the University of Oregon.

ORCID

Anne Brown http://orcid.org/0000-0001-5009-8331

RESEARCH SUPPORT

This research was supported by UCLA Institute of Transportation Services and UCLA Graduate Division.

SUPPLEMENTAL MATERIAL

Supplemental data for this article can be found on the publisher's website.

NOTE

1. Low-density neighborhoods are those in the bottom quartile of neighborhood activity density (residents plus workers) in Los Angeles County. High-density neighborhoods are those in the top activity density quartile.

REFERENCES

Anderson, M., & Perrin, A. (2017). *Tech adoption climbs among older adults*. Pew Research Center. Retrieved from http://www.pewinternet.org/2017/05/17/tech-adoption-climbs-among-older-adults/

Austin, D., & Zegras, P. (2012). Taxicabs as public transportation in Boston, Massachusetts. *Transportation Research Record: Journal of the Transportation Research Board*, *2277*(1), 65–74. doi:10.3141/2277-08

Blumenberg, E., & Pierce, G. (2012). Automobile ownership and travel by the poor: Evidence from the 2009 National Household Travel Survey. *Transportation Research Record: Journal of the Transportation Research Board*, *2320*(1), 28–36. doi:10.3141/2320-04

Bureau of Transportation Statistics. (2017). *The national transit map*. Washington, DC: U.S. Department of Transportation. Retrieved from https://www.bts.gov/content/national-transit-map

California Department of Transportation. (2012). *California household travel survey*. Retrieved from http://www.dot.ca.gov/hq/tpp/offices/omsp/statewide_travel_analysis/chts.html

Chester, M., Fraser, A., Matute, J., Flower, C., & Pendyala, R. (2015). Parking infrastructure: A constraint on or opportunity for urban redevelopment? A study of Los Angeles County parking supply and growth. *Journal of the American Planning Association*, *81*(4), 268–286. doi:10.1080/01944363.2015.1092879

Circella, G. (2018). *Impacts of new mobility services on the use of other travel modes in California*. Davis, CA: National Center for Sustainable Transportation. Retrieved from https://ncst.ucdavis.edu/wp-content/uploads/2017/12/NCST_Webinar_Ride-hailing_January_2018_V1_LP.pdf

Citi Bike. (2019). *Reduced fare bike share*. Retrieved from https://www.citibikenyc.com/pricing/reducedfare

Clark, J., & Curl, A. (2016). Bicycle and car share schemes as inclusive modes of travel? A socio-spatial analysis in Glasgow, UK. *Social Inclusion*, *4*(3), 83–89. doi:10.17645/si.v4i3.510

Clewlow, R. R., & Mishra, G. S. (2017). *Disruptive transportation: The adoption, utilization, and impacts of ride-hailing in the United States*. Davis: UC Davis Institute of Transportation Studies. Retrieved from https://itspubs.ucdavis.edu/wp-content/themes/ucdavis/pubs/download_pdf.php?id=2752

Cohen, M. (2015, November 17). Underserved and under the spotlight. *South Side Weekly*. Retrieved from https://southsideweekly.com/underserved-and-under-the-spotlight/

Conway, M., Salon, D., & King, D. (2018). Trends in taxi use and the advent of ride-hailing, 1995–2017: Evidence from the US National Household Travel Survey. *Urban Science*, *2*(3), 79. doi:10.3390/urbansci2030079

Dawkins, C., Jeon, J. S., & Pendall, R. (2015). Vehicle access and exposure to neighborhood poverty: Evidence from the moving to opportunity program. *Journal of Regional Science*, *55*(5), 687–707. doi:10.1111/jors.12198

Ewing, R., & Cervero, R. (2010). Travel and the built environment: A meta-analysis. *Journal of the American Planning Association*, *76*(3), 265–294. doi:10.1080/01944361003766766

Federal Deposit Insurance Corporation (FDIC). (2016). *2015 FDIC national survey of unbanked and underbanked households*. Retrieved from https://www.economicinclusion.gov/surveys/2015household/documents/2015_FDIC_Unbanked_HH_Survey_Report.pdf

Federal Transit Administration. (2018). *Mobility on demand (MOD) sandbox program*. Retrieved from https://www.transit.dot.gov/research-innovation/mobility-demand-mod-sandbox-program.html

Feignon, S., & Murphy, C. (2018). *Broadening understanding of the interplay between public transit, shared mobility, and personal automobiles* (Transportation Cooperative Research Program). Washington, DC: Transportation Research Board. doi:10.17226/24996

Ford GoBike. (2019). *Bike share for all*. Retrieved from https://www.fordgobike.com/pricing/bikeshareforall

Gehrke, S. R., Felix, A., & Reardon, T. (2018). *Fare choices: A Survey of ride-hailing passengers in metro*. Retrieved from https://www.mapc.org/farechoices/

Gurley, T., & Bruce, D. (2005). The effects of car access on employment outcomes for welfare recipients. *Journal of Urban Economics*, *58*(2), 250–272. doi:10.1016/j.jue.2005.05.002

Henao, A. (2017). *Impacts of ridesource—Lyft and Uber—on transportation including VMT, mode replacement, parking, and travel behavior* (Doctoral dissertation). University of Colorado, Denver. Retrieved from http://digital.auraria.edu/content/AA/00/00/60/55/00001/Henao_ucdenver_0765D_10823.pdf

Hughes, R., & MacKenzie, D. (2016). Transportation network company wait times in greater Seattle, and relationship to socioeconomic indicators. *Journal of Transport Geography*, *56*, 36–44. doi:10.1016/j.jtrangeo.2016.08.014

Kim, K. (2015). Can carsharing meet the mobility needs for the low-income neighborhoods? Lessons from carsharing usage patterns in New York City. *Transportation Research Part A*, *77*, 249–260. doi:10.1016/j.tra.2015.04.020

King, D., & Saldarriaga, J. (2018). Spatial regulation of taxicab services: Measuring empty travel in New York City. *Journal of Transport and Land Use*, *11*(1), 181–194. doi:10.5198/jtlu.2018.1063

Kohler, E. (2015, August 6). A year later, Lyft continues to redline in Minneapolis. *The Deets*. Retrieved from http://www.thedeets.com/2015/08/06/a-year-later-lyft-continues-to-redline-in-minneapolis/

LaMendola, B. (1991, March 16). Cab drivers won't risk safety for fares in high-crime areas. *Sun Sentinel*. Retrieved from http://articles.sun-sentinel.com/1991-03-16/news/9101130914_1_public-service-cab-drivers-yellow-cab

Logan, J. R., & Stults, B. (2011). *The persistence of segregation in the metropolis: New findings from the 2010 census* (census brief prepared for project US2010). Retrieved from https://s4.ad.brown.edu/Projects/Diversity/Data/Report/report2.pdf

Los Angeles Times. (n.d.). Mapping LA neighborhoods. *Los Angeles Times*. Retrieved from http://maps.latimes.com/neighborhoods/

Lyft. (2016). Trip-level data. Los Angeles County, September to November.

Lyft. (2018a). *2018 economic impact report*. Retrieved from https://take.lyft.com/economic-impact/

Lyft. (2018b). *Request rides for anyone with Lyft Concierge*. Retrieved from https://blog.lyft.com/posts/2018/1/16/remotely-request-rides-for-anyone-with-lyft-concierge

Manville, M., Taylor, B. D., & Blumenberg, E. (2018). *Falling transit ridership: California and Southern California*. UCLA Institute of Transportation Studies. Retrieved from https://www.scag.ca.gov/Documents/ITS_SCAG_Transit_Ridership.pdf

Motavalli, J. (2015, July 21). Do Uber and Lyft redline low-income communities? *Car Talk*. Retrieved from http://www.cartalk.com/blogs/do-uber-and-lyft-redline-low-income-communities

National Household Travel Survey. (2009). *2009 National Household Travel Survey*. Retrieved from http://nhts.ornl.gov

National Household Travel Survey. (2017). *2017 National Household Travel Survey*. Retrieved from http://nhts.ornl.gov

Ong, P. M., & Stoll, M. A. (2007). Redlining or risk? A spatial analysis of auto insurance rates in Los Angeles. *Journal of Policy Analysis and Management*, *26*(4), 811–830. doi:10.1002/pam.20287

Ortúzar, J., & Willumsen, L. G. (2011). *Modelling transport*. West Sussex, UK: John Wiley & Sons.

Raphael, S., & Rice, L. (2002). Car ownership, employment, and earnings. *Journal of Urban Economics*, *52*(1), 109–130. doi:10.1016/S0094-1190(02)00017-7

Rayle, L., Dai, D., Chan, N., Cervero, R., & Shaheen, S. (2016). Just a better taxi? A survey-based comparison of taxis, transit, and ridesourcing services in San Francisco. *Transport Policy*, *45*, 168–178. doi:10.1016/j.tranpol.2015.10.004

Ridley, S., Bayton, J. A., & Outtz, J. H. (1989). *Taxi service in the District of Columbia: Is it influenced by patron's race and destination?* Washington, DC: Lawyer's Committee for Civil Rights Under the Law.

San Francisco Municipal Transportation Agency. (2013). *Taxi user surveys: Best practices studies of taxi regulation*. Retrieved from https://www.sfmta.com/sites/default/files/Draft%20SF%20UserSurvey%2055%20WEB%20version04042013.pdf

Sandoval, J. O., Cervero, R., & Landis, J. (2011). The transition from welfare-to-work: How cars and human capital facilitate employment for welfare recipients. *Applied Geography*, *31*(1), 352–362. doi:10.1016/j.apgeog.2010.07.008

Schaller, B. (2015). *Between public and private mobility examining the rise of technology-enabled transportation services: Taxi, sedan, and limousine industries and regulations*. Special Report 319. Washington, DC: Transportation Research Board. doi:10.17226/21875

Schaller, B. (2017). *Unsustainable? The growth of app-based ride services and traffic, travel and the future of New York City*. Schaller Consulting. Retrieved from http://schallerconsult.com/rideservices/unsustainable.htm

SharesPost. (2018). 2017 year-end ridesharing report. *SharesPost*. Retrieved from https://sharespost.com/insights/research-reports/2017-year-end-ridesharing-report-preview/

Shirgaokar, M. (2018). Expanding seniors' mobility through phone apps: Potential responses from the private and public sectors. *Journal of Planning Education and Research*. Advance online publication. doi:10.1016/0739456X18769133

Shoup, D. C. (2011). *The high cost of free parking*. Chicago, IL: Planners Press. doi:10.1177/0739456X970170010

Smart, R., Rowe, B., Hawken, A., Kleiman, M., Mladenovic, N., Gehred, P., & Manning, C. (2015). *Faster and cheaper: How ride-sourcing fills a gap in low-income Los Angeles neighborhoods*. Los Angeles, CA: BOTEC Analysis Corporation. Retrieved from https://nyuscholars.nyu.edu/en/publications/faster-and-cheaper-how-ride-sourcing-fills-a-gap-in-low-income-lo

Smith, A. (2016). *Shared, collaborative, and on demand: The new digital economy*. Pew Research Center. Retrieved from http://www.pewinternet.org/2016/05/19/the-new-digital-economy/

Smith, A., McGeeney, K., Duggan, M., Raine, L., & Keeter, S. (2015). *U.S. smartphone use in 2015*. Pew Research Center. Retrieved from http://www.pewinternet.org/2015/04/01/us-smartphone-use-in-2015/

Spiegelman, E. (2016, April 12). Regulating the quality (and equality of taxi, Uber and Lyft service by algorithm. *Medium*. Retrieved from https://medium.com/@taxicomisionado/regulating-the-quality-and-equality-of-taxi-uber-and-lyft-service-by-algorithm-ebd28438c9ac

Stark, J., & Diakopoulos, N. (2016, March 10). Uber seems to offer better service in areas with more white people. That raises some tough questions. *Washington Post*. Retrieved from https://www.washingtonpost.com/news/wonk/wp/2016/03/10/uber-seems-to-offer-better-service-in-areas-with-more-white-people-that-raises-some-tough-questions/?utm_term=.ca785b83f684

U.S. Census. (2016). *Table pepannres: Annual estimates of the resident population: 2016 population estimates for Los Angles County, California*. Retrieved from https://factfinder.census.gov/

U.S. Census Bureau (2015a). *2011–2015 5-year American Community Survey*. Retrieved from https://factfinder.census.gov

U.S. Census Bureau. (2015b). *Longitudinal employer-household dynamics*. Retrieved from lehd.ces.census.gov/data/

U.S. Environmental Protection Agency. (2014). *Smart location database*. Retrieved from http://www2.epa.gov/smart-growth/smart-location-mapping

Van Acker, V., & Witlox, F. (2010). Car ownership as a mediating variable in car travel behaviour research using a structural equation modelling approach to identify its dual relationship. *Journal of Transport Geography*, *18*(1), 65–74. doi:10.1016/j.jtrangeo.2009.05.006

Walker, R. E., Keane, C. R., & Burke, J. G. (2010). Disparities and access to healthy food in the United States: A review of food deserts literature. *Health & Place*, *16*(5), 876–884. doi:10.1016/j.healthplace.2010.04.013

Weinberger, R. (2012). Death by a thousand curb-cuts: Evidence on the effect of minimum parking requirements on the choice to drive. *Transport Policy*, *20*, 93–102. doi:10.1016/j.tranpol.2011.08.002

Weinberger, R., Seaman, M., & Johnson, C. (2009). Residential off-street parking impacts on car ownership, vehicle miles traveled, and related carbon emissions: New York City case study. *Transportation Research Record: Journal of the Transportation Research Board*, *2118*(1), 24–30. doi:10.3141/2118-04