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Tribute to Martin Wachs
(1941–2021)

Donald Shoup, Senior Editor

When Transfers was founded in 2018, Marty Wachs and I were given the title of senior editors, which looks good but is a bit ambiguous. We never made any final decisions about articles (Mike Manville does that), so perhaps senior was just a euphemism for old. Nevertheless, Marty and I enjoyed the job of burnishing prose and enhancing the reputations of younger authors.

Since Marty's death in April, the UCLA Institute of Transportation Studies has published on its website an outpouring of praise and gratitude for his life. Marty's colleagues and former students use words like brilliant, inspirational, passionate, amazing, generous, kind, caring, ethical, witty, and cheerful to describe him.

The hundreds of tributes are almost beyond belief, though I'm sure everyone who wrote one would have preferred the opportunity to tell Marty personally how much he meant to them. By a wonderful coincidence, I had that opportunity. I talked to Marty on the telephone the day before he died. I had also, that morning, looked at a word quiz on the internet. The question was: What adjective contains the letters s, p, and n and means "possessing or expressing great sagacity"?

I guessed right — the answer was "sapient," and then looked at the synonyms provided: wise, sage, insightful, judicious, prudent, sensible, and sane. This string of words immediately made me think of Marty, and fortunately, I told him so, during our conversation that evening.

We usually don't take the opportunity to tell our friends how much we admire and respect them. I am thankful to have told Marty that this collection of words reminded me of him, and he received the compliment with his characteristic good humor.

Marty did so much in so many different fields that most of us know only a small part of everything he accomplished. The tributes flowing in help us see many facets of these accomplishments previously unknown to us. Many people may not have known, for example, that Marty was a great editor. But anyone who has read Transfers has benefited from his skill.

The transportation profession heaped on Marty every award it could give, sometimes twice. Many of these awards were for his research, which was excellent. His writing was lucid and straightforward, but often said things that had not previously occurred to anyone else.

But Marty always thought of himself first as a teacher, and he was an exceptionally gifted one. The American Collegiate Schools of Planning gave Marty its highest honor, the Distinguished Educator Award. Marty surely did more for young people than anyone else in transportation planning. He felt that he had the greatest influence through the careers of his students, and that his most important accomplishment was to help his students lead productive lives and make the world better. As one of his Ph.D. students said, "When I grow up, I want to be like Marty Wachs."

As Mae West said, you only live once, but if you do it right, once is enough. Marty did it right. Transfers is committed to carrying on with the values that he so brilliantly exemplified.

LONGER VIEW

Transportation for the Anthropocene

Mikhail Chester and Braden Allenby

We are still designing, managing, and governing transportation systems that came out of a bygone era. Our principles, technologies, and governing institutions, as well as the decisions we make, reflect modes of thinking rooted in transportation goals from the industrial age, when many of our now aging highways, railways, and ports were first developed.

But we are living in a new epoch now, one where human activity has become the dominant influence on our planet's systems — not just the climate, but all of its biological, ecological, hydrological and geological phenomena. That's why scientists call this epoch the Anthropocene, or "Time of Man." When the Anthropocene first began is debated, but there's little question that it took off in the post-World War II period. This period is defined by rapidly accelerating technological change and human activity, which is transforming the planet faster than the natural environment ever could.

It is hard to imagine any part of daily life that isn't being affected, or soon will be affected, by the changes of the Anthropocene. The human transformation of our built environment, through the mass construction of physical infrastructure, including transportation systems, and demographic changes such as urbanization, has changed the course of rivers, altered natural patterns of soil deposition and erosion, impacted plant and animal species that humans rely on for food and other products, affected the spread of diseases (as we are seeing), and contributed to changing weather patterns. These changes have created hyperconnectivity by physical and virtual means, as well as new forms of intelligence, as software increasingly manages humans' relationships with the environment and themselves. These factors, in turn, will have a profound impact on transportation systems, from shifting from physical to virtual access, to the destructive effect of unpredictable extreme weather, to changes in travel patterns due to increasing software-based control, or changes in the production and distribution of food and other resources — to name just a few possible consequences. The frequency of all such occurrences, moreover, will likely increase.

These technological, organizational, and earth system changes necessitate changes to how we plan, construct, and manage our transportation systems. Specifically, our global transportation modalities — automobiles, trains, planes, even bicycles — which developed within the last hundred years or so, now face particular challenges from emerging developments in cybertechnology, information and communications systems, artificial intelligence, and the increasing integration of computer and physical systems.

Across the globe, transportation infrastructure are now vast in scale and composed of multiple layers of old and new technology. Meanwhile, the climate is becoming less predictable, and rapid advancements in cyberinfrastructure — from GPS to ride-hailing and cloud-based routing — are redefining our conventions of communication, travel and daily commuting. Taken together, these changes mean that our world is getting increasingly complex. As the idea of the planet

as a static foundation for humans to build upon loses relevance, we need to radically alter our thinking and planning around transportation, if we are going to serve future generations.

Up until now, transportation planners have approached questions of technology, governance, and educational norms with a tacit assumption that the world's conditions, and the conditions under which we consume transportation services, would be largely stable. This assumption might have been valid during periods when technological change was slow and incremental, but it is no longer valid today. We must instead embrace instability and be willing to navigate our systems amid the complex transformations that are occurring. We have already seen numerous "once-in-a-lifetime" climate events — devastating wildfires, snowstorms, hurricanes — wreck infrastructure that was never built to withstand them because such events seemed unimaginable or too rare to drive design decisions. Cyberattacks are on the rise, with infrastructure becoming battlefields in asymmetric warfare strategies. Companies like Amazon, Google, and Tesla are shifting the notion of what transportation systems are. How people perceive access is rapidly shifting. In just a short year, COVID-19 has disrupted living patterns, and thus commuting and traffic patterns at a global scale, and few can agree on what post-pandemic transportation demand will look like. It is no longer possible to design transportation systems under the assumption of predictable technologies, or predictable travel demand and weather conditions. Instead, new transportation systems must emphasize agility, flexibility, and the knowledge that today's impossibilities may be tomorrow's reality.

An Accelerating, Uncertain, and Volatile Environment

The past century has brought a remarkable evolution in transportation technologies. This evolution has been defined, in part, by a planning approach that emphasizes rigidity. The transportation system's core technologies, such as roads, have been designed to accommodate traffic flows, and withstand weather conditions, that planners believed would be predictable over the long term. This belief in predictability, moreover, allowed the bureaucracies that plan, construct and manage our infrastructure to splinter into knowledge silos. Transportation agencies became divisions of pavement materials, traffic, and so on, which experience significant barriers to coordinate with each other. This arrangement worked for a while, but as the societal, technological and environmental conditions surrounding transportation systems have become less predictable and more systemic, these existing transportation models have become increasingly unsustainable. The attributes of the system that arose from the relative stability in the past century prevent it from adapting to instability. Siloed knowledge and practice, an emphasis on rigid technologies, and educational norms that don't reflect the growing complexity of the world around us have locked us into a particular way of planning for transportation, even as that way becomes less appropriate.

Today, the transportation landscape is changing at a dramatic pace. Over the past two decades, we've seen the maturation of electric vehicle technologies, the rise of shared mobility, and remarkable advances in vehicle autonomy. We've also seen transportation systems become more integrated with other infrastructure systems, like the energy sector (e.g., electric vehicles that provide mobility and store energy) and public health (e.g., onboard thermometers in vehicles that relay temperature data, which is valuable to health professionals evaluating the risks of local heat exposure. But to reduce these developments to purely technological advancements is too simplistic.

Climate change, ideological polarization, financial uncertainty, geopolitical conflict carried out at cyberspace speed, and disruptive new technologies have created a more complex world than the one our transportation systems were designed for. Our ability to grasp how transportation needs are changing, and how our systems will behave when tested, is diminishing. Imagine, for instance, a hurricane hitting New York City. While we can anticipate that such

a storm would cause damage and disruption to the city's transportation systems, our ability to predict the impacts precisely in terms of time, location, and severity is limited given the remarkable complexity of the systems. Emerging third-party transportation services such as Google, Uber, and Lyft are creating new markets for transportation services and now steer demand in ways transportation practitioners never planned for, and still don't fully understand. How should a transportation agency plan for demand amid a rapidly changing landscape where cloud-based services informed by private data streams (e.g., mobile phones) route an increasing number of vehicles and increasingly negotiate mobility?

Cybertechnologies such as connected devices and pervasive sensor networks open up remarkable new possibilities to improve transportation services, through wayfinding, trip planning, and new ways to pay for travel. But they also create new vulnerabilities. Consider the growing number of cyberattacks directed at physical transportation systems that are integrated with digital technology.

Scientists who subscribe to the idea that the Anthropocene represents a decided change in global evolution point to data linking exponential growth (Great Acceleration Curves) across certain human activities with alarming changes to the planet. These studies capture accelerating conditions of uncertainty and volatility. When it comes to transportation, the fundamental question is whether our systems can be responsive — and if so, how quickly — to the changing conditions in which they must remain viable. If our transportation systems ignore the implications of this new epoch, we are only hastening their obsolescence.

To respond to this increasing complexity, current technologies, organizational structures, and educational practices will have to change. We need to move away from simple notions of physical mobility to recognize how transportation technologies and functions will be increasingly intertwined with other services, and increasingly managed by software.

As a result, our definitions of transportation, many of which are rooted in today's context, are likely to be upended. The artificial separations that we've historically used to manage infrastructure (e.g., transportation, water, information and communication technology, and power as independent from each other) are becoming increasingly obsolete. In the Anthropocene, is transportation really a separate system from, say, the fiber optic cables that run under streets facilitating information connectivity and enabling virtual workspaces to exist? As we integrate solar power into our roads and electric vehicles into our transportation system, and use such vehicles as power storage assets in a smart grid, should we treat the energy system as separate or should we co-design transportation and energy infrastructure with the climate in mind? As transportation systems become more tightly interwoven with other systems, we must adapt how we design and manage them.

From the Complicated to the Complex

Increasing uncertainty, rising volatility, and accelerating conditions suggest that complexity will dominate the Anthropocene. As unpredictable demand, more frequent extreme events, and disruptive technologies emerge, instability will come to define the landscapes that transportation systems function within. Furthermore, systems are poised to be managed by a greater diversity of stakeholders, including new companies and computer algorithms. Legacy technologies, governance processes, and educational norms will all require restructuring to address the rapidly shifting nature of transportation toward *cyberphysical* systems, where information can be used by many parties to affect services, and learning systems operate independently of human observation and analysis. For example, Android phones push transportation data to Google, which then uses that to power navigation apps like Google Maps and Waze.

In a more volatile future, our assumptions about long-term stability and predictability will be increasingly at odds with reality. That's why resilience efforts increasingly require new

approaches that are capable of adapting to ever-changing environments, by embracing instability and surprise. Our transportation systems are not likely to adapt quickly in response to changing environments, even if we want them to; the technologies are rigid, often decades old, and the bureaucracies that govern them show no signs of restructuring for future challenges. Given the long lead times for achieving results, we must create the conditions today for technologies, bureaucracies, and educational practices to evolve.

Transportation for the Anthropocene

When it comes to the future of transportation needs and challenges, is there anything we can know for certain? From climate change and COVID-19 to green energy sources to political leadership, geopolitical conflict targeting transportation systems, and digital communication, it's difficult to envision the changes a few decades could bring. And if we accept the premise of rapid evolution in the Anthropocene, the answer is a definite no. As we describe below, in the transportation sector, technology, governance, and education will need to progress, along with most conventions about moving people and goods from Point A to Point B. As the rigid thinking of our industrial past becomes less relevant, conceptualizing the future of transportation hinges on our ability to anticipate sustained and increasingly variable shifts while leaving room for continuous adaptation.

Agile and Flexible Technologies

The rigid frameworks that have traditionally informed transportation planning tend to result in systems that can withstand only a small range of disturbances. Going forward, the characteristics of *agility* and *flexibility* must be at the heart of what we design and build. We define agility to mean that assets can rapidly be redirected to maintain functionality in the face of uncertainty. Flexibility, on the other hand, describes a system's potential to meet demands unforeseen by its designers. Consider, for example, smart traffic lights that adjust timing based on traffic, reversible lane systems, intelligent lighting, and modular (and removal) paving systems.

Agility and flexibility are not tied to any particular mode of transportation. Instead, these terms describe a set of capabilities that are necessary for systems to adapt, including modularity, connectivity, compatibility, multifunctionality, and software-for-hardware substitution. An example of a project that incorporates both agility and flexibility is Kuala Lumpur's Stormwater Management and Road Tunnel (SMART), a hybrid structure designed to move both automobile traffic and floodwater to reduce congestion while simultaneously preventing flash floods from disrupting traffic.

Adaptive Governance

Changing how we design and build won't be enough to develop transportation for the Anthropocene. We must also question the systems of governance that surround transportation. To understand what a transportation system can and cannot do, it's necessary to better understand how its organizations function and why. Many transportation departments operate through separate divisions controlled by small leadership teams with few incentives to drive transformative change. While division directors are often imbued with considerable autonomy and authority, there are relatively few mechanisms for cross-division problem-solving when major issues arise and diverse expertise becomes critical. This is true both within transportation management structures and between transportation and other infrastructure modalities such as energy, information and communications.

This business model, which emerged with the railroads at the dawn of the 20th century and was later exported to other infrastructure, was remarkably effective for its time. It excelled in meeting fixed goals within fairly stable environments where outputs are standardized: miles of pavement maintained, vehicle miles of travel affected, or trips shifted to active transport. However, when the goals are more complex, like creating a resilient transportation

system that uses artificial intelligence and machine learning to reduce the systems' carbon footprint, while also improving social equity and providing space for AI software driven by pervasive mobile devices to manage traffic flows, our current practices are unprepared.

The sophistication of decision-making in transportation agencies must match the complexity of the environment. Most transportation agencies still operate in a top-down fashion: assessing shifting business conditions and making major decisions at the highest levels of leadership, far from the on-the-ground workers who are best equipped to sense change and fashion solutions. Industries that successfully respond to chaos do so by creating flexible leadership models. This leadership flexibility requires shifts in how we train transportation professionals, away from highly specialized technologists, toward graduates with the capabilities to work in complex social, economic and regulatory environments.

Education for Complexity

When it comes to education and job training for future transportation leaders, we must emphasize skill sets that address consensus-building, engaging with diverse stakeholders, and cybersecurity. Fundamentally, educators must recognize that the competencies needed to thrive in predictable environments are fundamentally different from those needed for complex environments. Traditional skills in transportation engineering and planning will continue to be needed (e.g., pavement design, traffic operations, integrated transportation, and land use planning, to name a few), but they may become secondary and increasingly the domain of software. The competent transportation planner or manager of the next century will also have to be able to manage complexity, where unpredictability and rapid change require a sustained focus on flexibility and adaptation.

Cyberphysical Systems and Security

Cybertechnologies are already being deployed across transportation systems, often without a comprehension of their implications as agencies embrace the efficiencies of smart infrastructure. Vehicles are now efficiently routed by Google and Apple, considering network-wide conditions that are informed by smartphones. Third-party apps deliver remarkable insight about conditions and routes of public transportation. And with thousands of onboard microprocessors, vehicles can analyze driving behavior to calibrate engine performance with onboard software now deciding how to accelerate and when to shift from gasoline use to battery consumption. For example, hybrid Lincoln cars learn your travel patterns and seamlessly switch to electric mode when the vehicle determines that you're close to home. At the same time, few players in the transportation sector have demonstrated a comprehensive understanding of the implications these technologies pose for cybersecurity. This leaves our systems vulnerable to attack.

Asymmetric warfare and sophisticated forms of attack such as ransomware, logic bombs, and cyberespionage incidents are on the rise. Recent cyberattacks on the Southeastern Pennsylvania Transportation Authority (SEPTA), the San Francisco Municipal Transportation Agency (SFMTA), and the Colorado Department of Transportation have affected operations from scheduling to payment systems to email. Modern adversaries target the whole of our society, and, in particular, our national infrastructure. Thanks to the acceleration of artificial intelligence — a set of software capabilities that have the potential to make it easier to manage complex systems — the data and connectivity revolution may steer transportation services in ways that we never planned or imagined. Transportation managers need to become cybersecurity experts or at least be able to communicate with the experts. All transportation agencies should have cross-cutting cybertechnology teams capable of securing systems, designing systems for better human interaction, and responding to cyber threats. And when it comes to the future of education for the transit field, university-level and continuing education programs must make cyber proficiencies part of the curriculum.

Complexity Leadership

Transportation organizations that have traditionally viewed themselves as mere providers of physical mobility for people and goods must now recognize that the key to their survival will be making sense of and adapting to unforeseen changes in the environment, technology, and human behavior. Improving how agencies make sense of changing environments will require a realignment of the types of information they take in and the knowledge they generate. There are many facets to this reprioritization including leveraging emerging data streams like smartphones, building climate change expertise, and generating knowledge across diverse stakeholders.

If they don't respond to these challenges, agencies will likely find themselves losing customers to new players who are better able to recognize and meet changing conditions. Already, Google's ability to make sense of urban traffic using mobile data streams gives the company a cognition advantage over most public transit providers. Although it may not be apparent to travelers, Google's algorithms are increasingly responsible for the flow of traffic in cities around the globe. Meanwhile, Amazon's investments in drone delivery are building brand new transportation infrastructure, one free of the delays due to traffic congestion and the risks of relying on uncertain public investment in the existing road system.

Because professional and bureaucratic transportation planning continues to assume fairly stable conditions, the outcomes can be catastrophic when things go wrong. For example, demand assumptions and fixed resources worked just fine for airlines until COVID-19 hit, leaving multiple companies desperate for bailouts. One thing the pandemic has made clear is how ill-prepared the transportation sector is for the kinds of systemic shocks that will be bigger and more frequent in the Anthropocene. But given our entrenched practices and power structures, we shouldn't expect a meaningful response to this new reality anytime soon. Instead, we can only brace for the inevitable disasters.

That's where *complexity leadership* comes in, the ability to change how decision-making occurs across stable and unstable times. Complexity leadership makes use of ad hoc teams that are granted the flexibility to reallocate themselves when problems emerge and disruption occurs. During periods of stability, traditional leadership structures may be appropriate, but in unstable times, adaptive leadership is critical for creating, testing, and implementing the best solutions. More and more, transportation agencies will need to respond by quickly reallocating resources and personnel as conditions shift from stable to unstable. During a weather event like the extreme cold that caused widespread power outages in Texas earlier this year, complexity leadership would have allowed agencies to form cross-disciplinary expert teams quickly, and equip them with sufficient resources and decision-making authority as they make sense of the chaos. We also need to cultivate agile and adaptive leaders who accept unpredictable change as the new normal; this is a core competency of modern military leaders.

As we come to terms with the meaning of the Anthropocene and how it relates to transportation planning and infrastructure, it appears increasingly likely that a business-as-usual approach will leave agencies unable to manage the chaos in store. However, recognizing this is an essential first step to changing things. Next, we must ask ourselves some critical questions: What *is* transportation in the future? How should we design, govern, and operate systems for an accelerating world and very uncertain future? And if we want to keep up with the times, are we willing to make a radical break from the modes of thinking that have defined transportation thus far?

Further Reading

Chester, M., & Allenby, B. (2021). *The Rightful Place of Science: Infrastructure in the Anthropocene.* ASU Center for Science, Policy and Outcomes.

Chester, M., Underwood, B. S., Allenby, B. Garcia, M. Samaras, C. Markolf, S. Sanders, K. Preston, B. & Miller, T. (2021) Infrastructure Resilience to Navigate Increasingly Uncertain and Complex Conditions in the Anthropocene. *Nature Urban Sustainability*. https://doi.org/10.1038/s42949-021-00016-y.

Chester, M., Miller, T., & Munoz-Erickson, T. (2020). Infrastructure Governance for the Anthropocene. *Elementa, 8*(1), pp.1-14. https://doi.org/10.1525/elementa.2020.078.

Chester, M. & Allenby, B. (2020). Toward Adaptive Infrastructure: The Fifth Discipline. *Sustainable and Resilient Infrastructure*, pp.1-5. https://doi.org/10.1080/23789689.2020.1762045.

Chester, M., & Allenby, B. (2018). Toward Adaptive Infrastructure: Flexibility and Agility in a Non-stationarity Age. *Sustainable and Resilient Infrastructure*, 3(1), pp. 1-19. https://doi.org/10.1080/23789689.2017.1416846.

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Cycling Toward Mobility Justice in Latino Immigrant Communities

Jesus M. Barajas

Bicycling boomed in the early 2000s, and cities both led and responded to this trend. Cities adopted sustainable transportation goals and made infrastructure investments that improved bicycle safety. As the number of cyclists increased, so did their diversity. A 2013 analysis by the League of American Bicyclists and the Sierra Club showed that, between 2001 and 2009, cycling grew much more among people of color: the share of all trips made by bicycle doubled among Black Americans, grew 80% among Asians, and increased 50% among Latinos, compared to just 22% for whites.

This growth of cyclists of color was not uniformly sustained over the following years, however. Cycling continued to grow among Asian populations, doubling from 0.7% of trips in 2009 to 1.4% in 2017. But the growth did not persist among Black and Latino populations. Cycling among Black people halved from 1% of trips in 2009 to 0.5% in 2017. In the Latino population, cycling decreased by a quarter from nearly 1% of trips in 2009 to 0.7% in 2017, ending up about flat over the 16-year period from 2001.

Why the sudden change? No racial or ethnic group is a monolith. This article takes a closer look at cycling *within* the Latino community, which may help explain why the growth in Latino cycling stalled.
Here is a potentially telling statistic: Between 2001 and 2017, cycling trips to work for U.S.-born Latinos increased by 54%, but *decreased* by 67% for foreign-born Latinos, with accelerated rates of change for both groups since 2009. Similarly, cycling trips for any purpose increased by 9% among U.S.-born Latinos between 2001 and 2017 but *decreased* by 28% for Latino immigrants, again with sharper declines for both groups since 2009.

What these statistics suggest is the potentially large role that identity — in this case, immigrant identity — plays in travel behavior. Identity is a complex concept, involving both how people see themselves and how society sees them. While identity by itself cannot cause travel differences, it often has powerful associations with social status, economic outcomes, and personal safety, all of which do help shape travel.

If transportation planners and policymakers fail to recognize how identity can influence travel, they will miss important opportunities to help people meet their travel needs. Planners tend to focus on outcomes that are easier to measure and are at the core of their expertise, such as minimizing travel time and costs, reducing crashes, and increasing accessibility. This focus leads to interventions in the built environment, like bike lanes or traffic calming (such as speed bumps or bollards), which can increase the likelihood of people bicycling.

But planners often miss the critical influence that social ties, culture, and experience also have on people's travel decisions. When they first arrive in the U.S., immigrants often rely on their social networks to get around, and these

networks shape the transportation modes that they choose. Cultural narratives, such as taboos and prohibitions for women around cycling, or travel habits from their home countries, may also inform immigrant views on cycling. This sort of information is not readily apparent from simple demographic categories in census data or general travel surveys, so planners rarely factor it into transportation decision-making. Failure to consider these details can inadvertently create conditions for mobility injustice — even if cities provide infrastructure and investment in immigrant neighborhoods, they may still not meet the needs of immigrant communities.

To understand how some of these less tangible factors might explain cycling trends, and what they imply for mobility justice, I conducted a mixed-methods study of how Latinos travel in the San Francisco Bay Area. Together with a team of students, I conducted surveys in English and Spanish of 769 people, both immigrants and U.S.-born, Latino and otherwise, at 44 sites across the Bay Area, including transit stations, bus stops, public plazas, and ethnic businesses.

The survey intentionally emphasized Latino immigrants and people whose incomes were lower than the typical household in the Bay Area. Only about a third of respondents had access to a working vehicle and about a third lived in households earning less than $25,000 per year. Immigrants earned even less, with almost half earning less than $25,000.

I used the survey to examine the difference in factors that might influence cycling for immigrants and non-immigrants. The key survey question asked whether a person had bicycled for any reason other than to exercise in the previous week. The questionnaire also collected data on three important categories that I expected to be influential in their decision: individual characteristics, social relationships, and perceptions of bicycling. Individual characteristics included country of origin, race/ethnicity, income, and educational attainment. I measured social relationships via the number of cyclists a person knew, their employment status, whether they lived with roommates, and whether they lived in an immigrant enclave. Finally, I measured

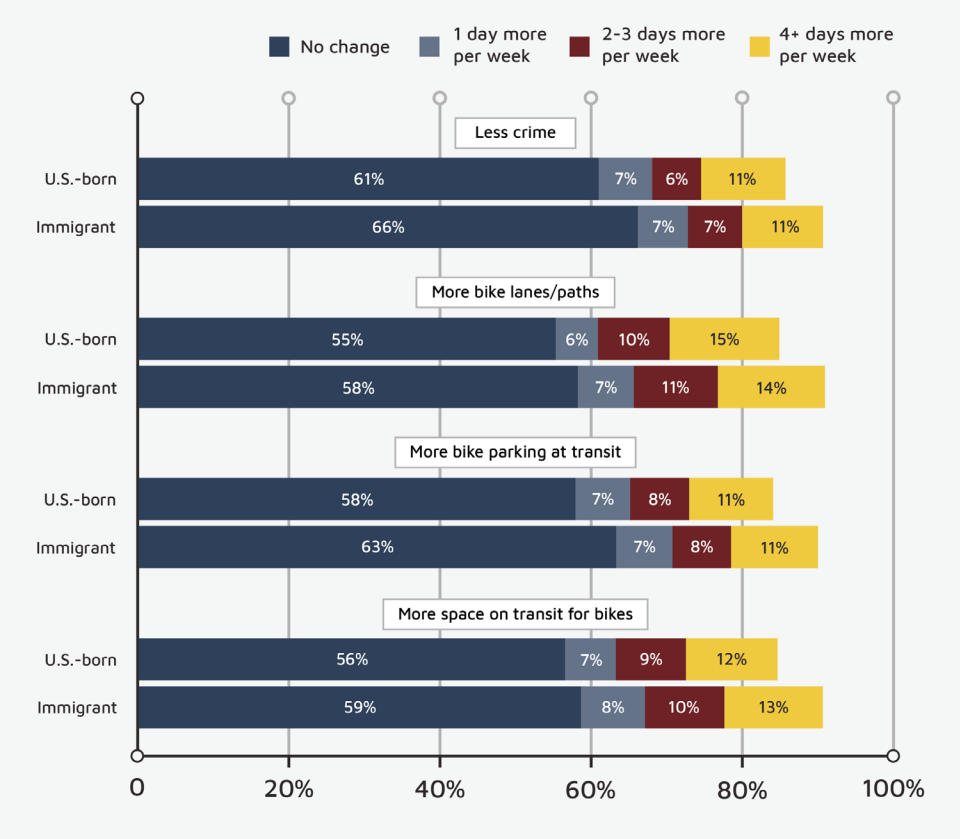

Figure 1. Change in the frequency of cycling more if barriers were removed

perceptions of bicycling by asking respondents if they thought that characteristics of their urban environment made cycling more or less difficult. To measure convenience and safety, for example, I asked respondents if they would have cycled more if their neighborhood had better bike lanes and paths, or if there were less crime around their destinations. I also asked if they bicycled to save time or money and if they used their bikes in combination with public transit. I supplemented the survey data with information on land use, transportation infrastructure, and bicycle crashes near survey respondents' homes to learn how "bike-friendly" characteristics in their neighborhoods shaped their responses.

Additionally, I conducted 23 in-depth interviews with Latino immigrants who had ridden a bike at some point in their lives. For the most part, survey respondents and interview respondents did not overlap. A few survey participants agreed to be interviewed, but I was more successful in recruiting interviewees with the help of community-based organizations and social service agencies. In the interviews, I asked people about their perceptions of their neighborhoods, why they did or didn't bicycle, and how they would compare their cycling experiences — for example, in safety, ease, and convenience — to those of other people they knew.

When combined, these methods provided deeper insight than a survey or interview alone — and much more insight than census or other standard travel data — into why immigrants would choose to ride a bike.

Understanding cycling choices

Most of the people in my survey were not regular cyclists. About one in five respondents had ridden a bicycle in the previous week, with no difference between immigrants and U.S-born Latinos. Perhaps because cycling was uncommon, I found few differences in the ways that immigrants and non-immigrants perceived neighborhood cycling conditions, cycling convenience, or cycling ease (Figures 1-3). More than half of both groups said they would not bicycle more often even if there were less crime in their neighborhoods, more bike lanes along their travel routes, more bike parking at transit, or more space on transit for bikes. Immigrants were slightly more likely to bicycle instead of drive if they could, but most did not.

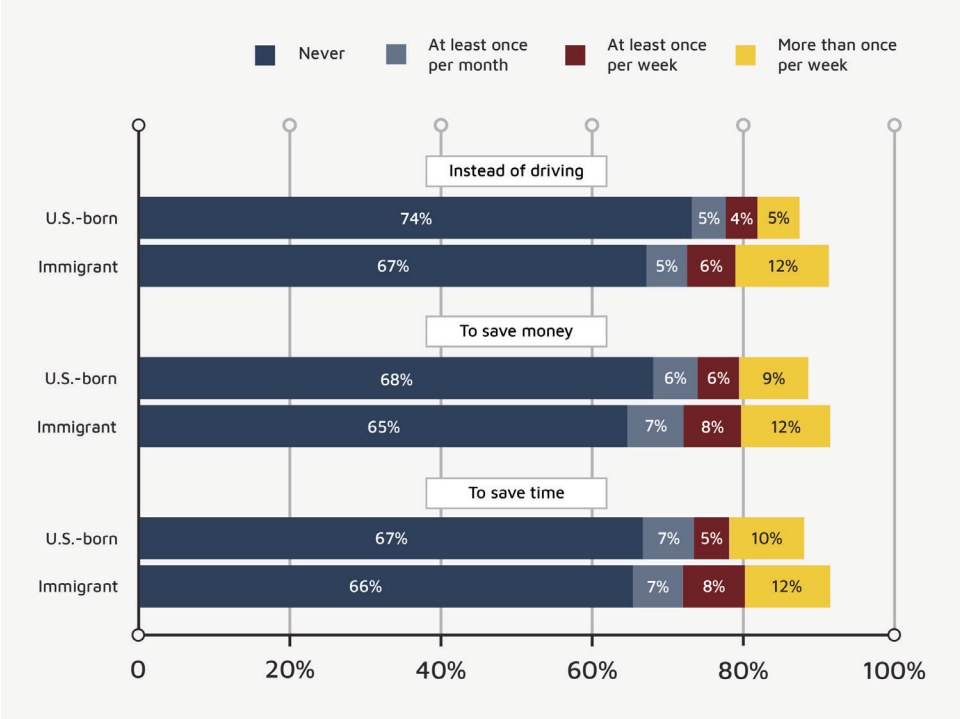

Figure 2. Frequency of cycling instead of driving to save time or money

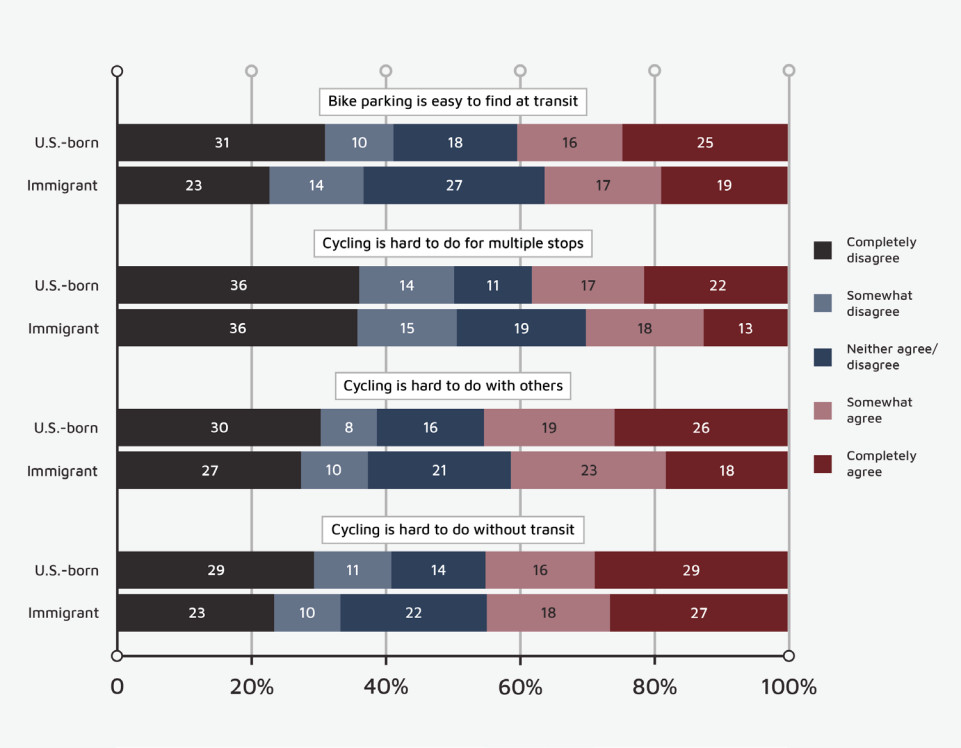

Figure 3. Perceptions of bicycling

About a quarter of both groups cycled to save time or money at least once a month, suggesting that some of the respondents were infrequent cyclists. Of those who responded, most did not report that bike parking, cycling with others, making multiple stops, or using bikes and transit were major barriers to bike use.

Why weren't there differences in how the two groups perceived cycling conditions? Probably the biggest reason, again, was that the vast majority of survey respondents, both immigrant and U.S.-born, weren't cyclists. About 80% had not ridden a bicycle in the previous week, and their responses indicate that they did not think the characteristics we asked about would encourage them to ride.

Additionally, the respondents tended to live in places with similar built environments — all had dense street networks, comparable accessibility, and roughly equivalent bicycle and transit infrastructure. Since there wasn't much difference in how much people bicycled or the conditions where they lived, it isn't too surprising that strong patterns didn't emerge. Indeed, when I examined the built environment characteristics near respondents' homes as control variables, the only significant predictor of cycling was the number of road intersections per square kilometer.

Immigrants and non-immigrants did, however, display other differences in how they thought about cycling. First, respondents' social relationships — also known as their social environments — mattered in different ways within and across the two groups. I considered employment status as part of the social environment because of how strongly social networks play a role in job acquisition for immigrants. Compared to unemployed immigrants, immigrants who were employed were more likely to know other people who used a bicycle regularly. That in turn was a strong predictor of whether or not they rode a bicycle themselves. Among non-immigrants, there was no association between employment status and knowing other cyclists, but cycling predicted knowing other cyclists.

Second, whether or not someone was a cyclist influenced their perceptions of the environment. In other words, if they had bicycled in the previous week, then they were more likely to view neighborhood conditions for cycling

favorably and to view cycling as convenient. This relationship between cycling and perceptions of convenience was stronger for immigrants than for U.S.-born respondents.

Third, other transportation modes affected cycling behaviors differently between immigrants and non-immigrants. This was most evident with walking. For those born in the U.S., more walking trips increased the likelihood of cycling, suggesting some *reinforcing effects* of sustainable travel modes. For immigrants, however, more walking meant they were less likely to bicycle. They were also less likely to get to transit by bicycle. This may mean that cycling is more likely used as a *substitute* for other travel modes among immigrants; when they can travel by something other than a bicycle, they will. Other studies have shown that the longer immigrants live in the United States, the more likely they are to give up other forms of transportation and start driving; many low-income immigrants follow this pattern in order to get and keep jobs.

Immigrants' cycling experiences

My interviews with Latino immigrants confirmed some of the patterns contained in the survey data. Everyone we interviewed described how relationships with friends, family, and immigrant-serving community organizations influenced their impressions of cycling. Strong social ties and involvement in cycling communities were critical entry points to a regular cycling habit. In particular, organized social rides were low-pressure and low-stakes ways to build up bike-riding skills and connect novices to experienced cyclists. For example, a mother of two who lived in San Francisco's Mission District spoke about how such events influenced her children's experiences on bikes:

> *My son first got a bike and later, one good thing that happened is that here in [this cycling organization], they began to organize rides with different people from the community where we could go out to places together. This really helped my son gain confidence.*

Peer pressure also seemed to play the primary role in introducing people to cycling and motivating them to bicycle. In many cases, the experiences were affirming — visiting bicycle fairs or seeing friends and family post their adventures on social media made people want to join them. But not all such encounters were encouraging. A young man from Guatemala had given up cycling as his primary mode of transportation after his friends' experiences frightened him away:

> *Yes, most of my friends have bicycles and the others have cars. They say it's difficult, that it makes them late and they come back late at night and there are bad people on the street — they rob them, they hit them.*

Another person we interviewed talked about how she had always wanted to ride a bike to save money on transportation, but her brother talked her out of it, saying as she put it, "There isn't much of a culture where drivers respect bicycles and it's very dangerous."

These social networks were also critical for providing resources, mobility, and access that low-income immigrants could otherwise not afford. For example, some community organizations run bicycle "kitchens" where community members could use the space as a bicycle workshop, and where some interviewees learned bike repair skills and donated their time to fix up and keep used bicycles. One interviewee shared that the director of the cycling organization he belonged to had given him a free broken bike, and he used the bike kitchen to repair it, which gave him a reliable means of transportation. These resources filled critical needs as safe and educational spaces — one interviewee shared that he and his friends were kicked out of another bike kitchen because they were Latino young adults in a primarily white space.

For some immigrant respondents, transportation habits and negative ideas held over from both their home countries and their new country needed to be overcome before they could adopt

cycling as a regular mode of transportation. Some immigrants didn't see themselves reflected in the kinds of people who were cycling — cyclists were "90% white" in one interviewee's estimation — a fact they attributed to a lack of cycling habit stemming from the lack of investment in cycling infrastructure in their home countries. Others, especially women, talked about how their cultural narratives discouraged them from cycling. A Mexican woman described the "ancestral taboos from I don't know how many hundreds of years ago" that would discourage women from riding horses and bicycles, and how that reticence to ride is difficult to overcome. Yet others talked about domestic narratives — how achieving success in America meant owning a car and leaving bicycles behind as "a hobby or simply for fun," as one interviewee told us.

Our interviewees also described relevant neighborhood characteristics that added detail to our survey findings. Traffic safety and protection from vehicle crashes were the most important factors in deciding to bike or not for many interviewees. Some interviewees wanted more people to start cycling so there was safety in numbers, while many wanted to see infrastructure improvements first, like separated bike lanes, slower traffic, and better pavement quality. These interviews also revealed gender differences in cycling. Men tended to characterize cycling conditions in more positive terms than women, even when describing the same corridor.

For other interviewees, violence and personal security were the main factors that influenced bicycling. Many low-income immigrants have no choice but to live in violent neighborhoods where housing costs are lower. As one interviewee described it:

> *I don't go out after 7 at night. I don't walk on the street for anything. I know another person who bikes. He tells me the same thing, the same — that it's dangerous, it's dangerous but we have to use our bikes.*

The neighborhood context was another factor weighing into immigrants' travel decisions. For newly arrived immigrants who spoke little English, learning to navigate their surroundings on a bicycle was joyful, because, unlike being stuck on a transit vehicle, they were free to move about as they wished. But cycling was also challenging because there were no directional signs in Spanish. The intersection of language ability and immigrant status could be particularly threatening for those without documentation to live in the United States and who lack understanding of traffic laws, rules, and norms. "Whatever small error you commit will become a bigger complication for you and your family," one interviewee explained. He was sensitive to giving police an excuse to stop undocumented immigrants like him for traffic infractions that could end in deportation.

Another relevant neighborhood factor was gentrification. Although the jury is still out on the empirical link between gentrification and cycling, many interviewees believed there was a tight connection between the two. One interviewee living in the Mission District described the tension between planning and demographic changes in her neighborhood:

> *My neighborhood is more accessible [than my old neighborhood] because Valencia Street [a main thoroughfare] has a bicycle route along the whole street but — these contradictions are very hard. Now that they have put more bike lanes in the neighborhood, the families and children that need them aren't here anymore. It is super unjust.*

Seeking mobility justice

My findings support the idea that Latino immigrant experiences, such as home country travel habits and precarious social position in the U.S., social networks, and neighborhood conditions influence their perceptions of and the desire to use a bicycle. In immigrants' own words, being an immigrant shapes how others see them when they travel, as belonging or out-of-place, and this, in turn, shapes how they see themselves and their environments. These findings highlight the need to practice

transportation planning with a mobility justice framework in mind.

Mobility justice, as expressed by the Untokening Network, calls for planners and transportation professionals to recognize that "identity influences vulnerability." As the network explains, those who live under the specter of any number of *-isms* — racism, sexism, nativism — will have different transportation needs and will require outside-the-box solutions to ensure they can move about safely and freely. Based on the findings in this study, these needs might require transportation agencies to prioritize investments in community cycling groups to strengthen social networks while also investing in infrastructure, incorporating both as central pillars of an equitable bike plan. These investments could support community events like group rides or bicycle festivals, learn-to-ride skills clinics, know-your-rights workshops, and cooperative repair spaces for community members — all examples of initiatives that immigrant community groups have established on their own. Or it might mean pairing crime reduction and cycling safety efforts in ways that don't subject already-vulnerable groups to additional policing — a thornier problem to solve.

While one study can't give us the precise reasons for every shift in cycling trends I reported earlier, a mobility justice perspective allows us to ask better questions. Some of the questions relevant for immigrant groups — like how social capital leads to transportation resources — might need to be explored in a different way for U.S.-born cyclists. Other questions may be more salient for different racial groups: Among Black Americans, for example, understanding the role of policing in deterring cycling might rightly take center stage. In any case, closely examining how intersecting identities influence transportation decision-making and developing interventions that acknowledge and account for those identities is a needed first step in developing plans based on equity.

This article is adapted from Barajas, J. M. (2019). Perceptions, people, and places: Influences on cycling for Latino immigrants and implications for equity. Journal of Planning Education and Research*, and Barajas, J. M. (2020). Supplemental infrastructure: How community networks and immigrant identity influence cycling.* Transportation, 47*, 1251–1274.*

Further Reading

Blumenberg, E. (2009). Moving in and Moving Around: Immigrants, Travel Behavior, and Implications for Transport Policy. *Transportation Letters: The International Journal of Transportation Research, 1*, 169–180. https://doi.org/10.3328/TL.2009.01.02.169-180

Sheller, M. (2018). *Mobility justice: The politics of movement in the age of extremes*. Verso.

Untokening Collective. (2017). *Untokening 1.0—Principles of Mobility Justice*. http://www.untokening.org/updates/2017/11/11/untokening-10-principles-of-mobility-justice

Author Bio

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Rich versus Poor, Near versus Far from Transit: Who Travels More?

Marlon G. Boarnet, Andrew Eisenlohr, Raphael Bostic, Seva Rodnyansky, Evgeny Burinskiy, Hue-Tam Jamme, and Raul Santiago-Bartolomei

Transit-oriented development, also known as TOD, is a planning paradigm that favors dense mixed-use neighborhoods with storefronts and apartments clustered close to transit stations. TOD prioritizes pedestrian-friendly design and public transit, with streets built for people rather than cars. TOD is an increasingly popular strategy in American cities among planners who believe it can advance two important goals: an environmental goal of reducing greenhouse gas emissions, and a social policy goal of increasing access to opportunities for residents.

The idea behind the environmental goal is that people who live near transit will drive less and ride transit more, thereby mitigating the effects of climate change and air pollution. The idea behind the social policy goal is that access to public transit is especially valuable to low-income households, who are less likely to own personal vehicles. Building more housing near transit can boost access to jobs, schools, health care, and a range of other opportunities. Equity advocates often view TOD neighborhoods as ideal settings for affordable housing. Rightfully so, we believe.

These two policy goals are distinct. The environmental goal of reduced greenhouse gas emissions hinges on driving less, while the equity goal of access hinges on TODs being affordable to the low-income people who depend on transit. Can we accomplish both goals? Can TODs reduce emissions and enhance affordability? Or are the tradeoffs between the two large enough to force us to choose one over the other?

If you're unsure of the answer, you're not alone. Planners have not been alert to the ways that emissions reduction and affordable housing goals can be in tension with one another, and as a result, relatively little research examines how they interact.

To help fill this gap, we developed a research program to answer two questions. First, who would reduce their driving more if they moved closer to transit, high- or low-income households? Second, who would ride public transit more if they moved into a TOD?

There is no direct way to answer these questions because no detailed data sets let researchers observe people as they move in and out of different neighborhoods. So we took a different approach and answered these questions using California Household Travel Survey data from four metropolitan areas: Los Angeles, Sacramento, San Diego, and San Francisco. Our goal was to compare the travel

behavior of people in TODs to people outside them and to compare the travel behavior of people of different incomes within TODs themselves. (For most of our analysis, we defined "TOD residents" as those living within a half-mile of a rail station, and we defined "non-TOD residents" as those living farther away). By examining the differences between groups, and controlling statistically for a wide variety of other characteristics (e.g., race, education, employment status, household size, and so on), we could estimate what would happen, on average, if higher- or lower-income households had moved.

We developed a regression model that predicts a household's daily vehicle miles traveled (VMT — a common measure of driving). This model incorporates an array of information, including whether the household lives in a TOD or not, its income, and other factors like the number of personal vehicles owned, the number of persons in the household, and the number of employed persons in the household — all of which likely affect household travel patterns. We then aggregated the model's household-level predictions.

Richer TOD Residents Contribute More to Driving Reduction

Table 1 shows our first set of comparisons: the average vehicle miles traveled by income and by TOD residence.

Table 1 has three primary findings. First, households with higher incomes drive more, regardless of where they live. Second, controlling for income, TOD residents always drive less than non-TOD residents. Third, the difference in vehicle miles traveled between TOD and non-TOD households widens as income rises.

For example, among households earning less than $25,000, TOD residents drive 15 fewer miles per day than non-TOD residents (17.7 miles versus 32.7 miles). That gap gets smaller for households earning between $25,000 and $50,000; TOD households drive 11.1 fewer miles than their non-TOD counterparts. As incomes rise above $50,000, however, the gap widens, to a difference of 18.5 miles at incomes above $100,000.

Annual Household Income	**Average VMT:** *TOD Households*	**Average VMT:** *Non-TOD Households*	**Difference in Average VMT** *TOD minus Non-TOD Households**
$0-$25,000	17.7	32.7	-15.0
$25,000-$50,000	31.9	43.0	-11.1
$50,000-$100,000	36.4	53.2	-16.8
$100,000+	43.7	62.2	-18.5
All Incomes	**33.9**	**52.4**	**-18.5**

**Note: All differences in averages are significant at the 95% confidence level*

Table 1. Daily Vehicle Miles Traveled, by Income and TOD versus non-TOD Residence

If the only goal of TOD were to reduce driving and hence reduce air pollution and greenhouse gas emissions, then this finding might suggest that planners should build TODs primarily for high-income households. After all, each high-income household represents a larger reduction in driving. Pursuing such a policy, however, would contradict the goal of prioritizing affordable housing near rail transit, and might even clash with many people's conceptions of basic fairness. This contradiction would be particularly notable if, as we suspect, lower-income people in TODs rely on transit more.

Poorer TOD Residents Take More Transit

Table 2 shows our comparisons of transit use broken down by income and by TOD versus non-TOD residence.

We see, first, that the lowest-income households use public transit more frequently than other households, regardless of location in a TOD. The relationship between transit use and income is more ambiguous than that between income and driving — it is not the case that more income always means less transit use — but on average, non-TOD households with incomes below $25,000 take twice as many transit trips as households with incomes of $100,000 or more. Within TODs, the gap is smaller, but the poorest households still take 30% more trips than the richest. Second, at every income level, TOD residents take substantially more daily transit trips than non-TOD households, with the largest increase occurring at the lowest income level. Thus, these findings suggest that if we want TODs to increase transit use and the accessibility benefits that TOD brings, we should prioritize the lowest-income residents for TOD residence. This conclusion, of course, is in direct tension with the finding we reported above — that TOD's environmental goals will best be met by prioritizing the most rather than the least affluent.

Linear Distance – VMT Results

The results in Table 1 suggest that households living in TODs drive less than households outside them, but provide little further detail. Those results, for example, do not distinguish

Annual Household Income	**Average Transit Trips:** *TOD Households*	**Average Transit Trips:** *Non-TOD Households*	**Difference in Average Transit Trips** *TOD minus Non-TOD Households**
$0-$25,000	0.89	0.51	0.38
$25,000-$50,000	0.54	0.32	0.22
$50,000-$100,000	0.57	0.22	0.35
$100,000+	0.59	0.26	0.33
All Incomes	**0.64**	**0.29**	**0.35**

Table 2. Daily Transit Trips, by Income and TOD versus non-TOD Residence

**Note: All differences in averages are significant at the 95% confidence level*

between people who live just outside a TOD and people living 10 miles from one, even though we might expect that the former drives less (and uses transit more) than the latter. To address this question, we used an additional "linear" model to examine how driving behavior changes with distance from a rail station. We used these results to calculate the difference in average vehicle miles traveled for those living 1 mile from a rail station versus those living zero miles from rail, 2 miles versus 1 mile, and so forth. We made these calculations for the same income categories as above.

We show the results in Figure 1, low- and high-income households both drive less when they live closer to rail, but the size of that reduction is larger for higher-income households. For instance, those earning at least $100,000 who live zero miles from a rail station (i.e., a person in an apartment atop the transit stop) drive about 7 miles less per day than households earning the same amount who live a mile from a rail station. For households earning less than $25,000, moving from one mile to directly atop a rail station reduces driving by about 5 miles per day. High-income households reduce their driving to a greater extent for all 1-mile changes in distance to rail up to 5 miles from a rail station. (This pattern mirrors the figures shown in Table 1: the highest-income households drive most, and as a result also reduce driving the most.)

For households of any income level, the driving impact of living near rail declines sharply after 4 miles. This finding is consistent with other transportation research, which shows that rail transit produces the greatest effect for people living within 1 mile of a station.

Meeting Both Goals

How can we put the findings above, some of them in tension with each other, together to inform TOD policy? On the one hand, TODs could most effectively meet the goals of reduced driving and reduced greenhouse gas emissions by attracting high-income households. It is these households that drive the most, and the biggest reductions in driving will, unsurprisingly, come from people who would have driven the most if they lived elsewhere. On the other hand, low-income households are more likely to use the transit TOD proximity offers, and likely benefit the

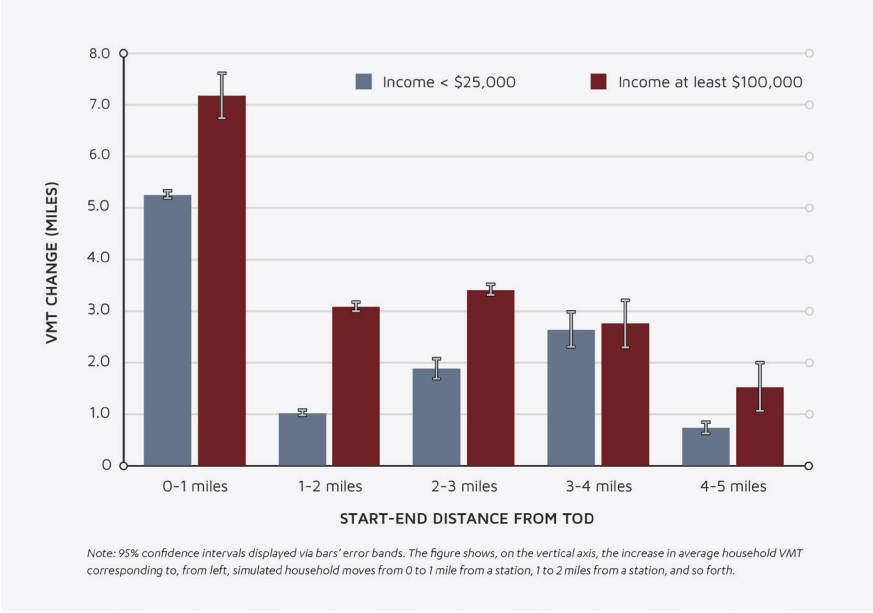

Figure 1. Increase in VMT based on 1-mile increases in residential distance to nearest rail station (specified as "starting distance-end distance"), lowest-income versus highest-income households

most from increased access to jobs and other opportunities that transit provides.

In principle, nothing stops cities from attaining both goals. If cities create dense mixed-income neighborhoods, with ample supplies of both affordable and market-rate units that house a broad range of income groups, they can attain both their environmental and equity goals.

In practice, however, many cities don't reach this happy medium. Zoning policies in many cities constrain the amount of housing that can be built near rail, and this artificial constraint puts TOD's environmental and equity goals in conflict. Housing scarcity produces competition between the high-income households that reduce driving and the low-income households that rely on transit the most.

Since this problem is an artifact of poor zoning policy, it can be solved by changing the zoning. When TOD neighborhoods are upzoned, increasing the overall housing supply, it becomes easier to do both — to attract a mix of incomes that can robustly address both environmental and equity goals. This is not a new idea (Dan Chatman and his colleagues at UC Berkeley have made the same argument), but it is a good one. "Doing both" — building units in TODs that can attract high-income households while providing affordable housing — should be pursued through a combination of vigorous upzoning, substantial increases in affordable housing funding, and serious local involvement to ensure that planning caters first to long-term neighborhood residents, rather than newer residents. A focus on planning for long-time residents while also preparing for growth is particularly important in locations at risk of gentrification.

The seeming tension between environmental and equity objectives in TODs can be resolved by being more ambitious, not less: by building more, involving more stakeholders and more effectively funding affordable units. If cities commit to this approach, their TODs can achieve multiple goals. They can reduce greenhouse gas emissions, promote housing equity and transit access, and help advance or maintain affordability.

The views expressed herein are those of the authors and do not necessarily reflect those of the Board of Governors of the Federal Reserve System or other System officials.

Further Reading

Boarnet, M. G., Bostic, R. W., Rodnyansky, S., Burinskiy, E., Eisenlohr, A., Jamme, H. T., & Santiago-Bartolomei, R. (2020). Do high income households reduce driving more when living near rail transit?. *Transportation research part D: transport and environment, 80*, 102244.

Chatman, D. G., Xu, R., Park, J., & Spevack, A. (2019). Does transit-oriented gentrification increase driving?. *Journal of Planning Education and Research, 39*(4), 482-495.

Boarnet, M. G., Bostic, R. W., Williams, D., Santiago-Bartolomei, R., Rodnyansky, S., & Eisenlohr, A. (2017). *Building affordable housing in transit-oriented developments: Impacts on driving and policy approaches.* National Center for Sustainable Transportation. https://www.metrans.org/assets/research/Affordable-Housing-Policy-Brief-Boarnet_v2-1.pdf

Bostic, R. W., Boarnet, M. G., Rodnyansky, S., Santiago-Bartolomei, R., & Leslie, C. (2016). *Developing affordable housing guidelines near rail transit in Los Angeles.* METRANS Transportation Center. https://dot.ca.gov/-/media/dot-media/programs/research-innovation-system-information/documents/f0016794-ca17-2939-finalreport.pdf

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Distracted Driving is Hazardous Driving

Karl Kim and Eric Yamashita

Every year, thousands of people are killed or injured in motor vehicle crashes that involve distracted drivers — often, people using their cell phones, tablets, e-readers, gaming consoles and other mobile devices while driving. According to the National Highway Traffic Safety Administration (NHTSA), distracted driving takes the lives of about 3,000 people each year, and injures another 400,000. One out of every four vehicle collisions in the United States is caused by texting and driving. About 13% of all fatal crashes involving distracted driving also feature some sort of cell phone use, according to the National Safety Council. Studies using driving simulators, instrumented vehicles (vehicles with sensors and real-time recording of driver behavior), and crash data have demonstrated that texting, dialing, reading, and checking email are serious safety threats that lead to crashes and death.

While none of this is news, the problem persists. According to the federal government's National Occupant Protection Use Survey, or NOPUS, conducted by NHTSA, talking on mobile phones while driving declined by 1.8% from 2009 to 2018, but the use of phones and other hand-held devices for texting and browsing social media increased. The survey also found that mobile phone use is highest among younger drivers (ages 16–24) and female drivers. Another NHTSA survey on distracted driving attitudes and behaviors found that 28% of drivers "always" or "almost always" answered their phones while driving and 58% said they would continue to drive while talking on the phone. In a third study by ZenDrive Research, which analyzed 3 million drivers who collectively took 570 million trips (adding up to 5.6 billion miles) over three months, the data showed that drivers use their phones on more than 80% of trips. Actual device use, moreover, might be higher than some studies report, because of the so-called "lie factor" in traffic safety research where drivers tend not to admit to illegal or socially unacceptable behaviors.

State Laws on Device Use While Driving

What can be done to combat distracted driving? Many states have passed laws on using cell phones and texting while driving, as summarized in Figure 1. The most common intervention is a ban on texting while driving. Forty-seven states and three territories have such bans, and some existing evidence suggests they are effective. In these states, for example, rates of texting among high school-aged drivers are lower today than before the bans were implemented. Eighteen states and one territory go further and ban hand-held use entirely for drivers, while another four states have limited bans on hand-held use. In many states, however, there are no restrictions on using hand-held devices, beyond prohibitions on texting.

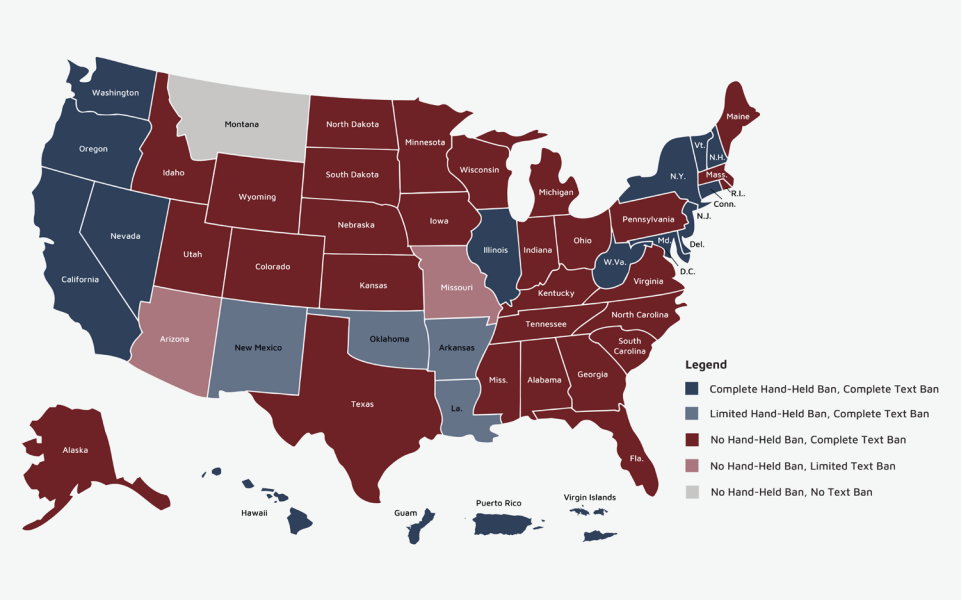
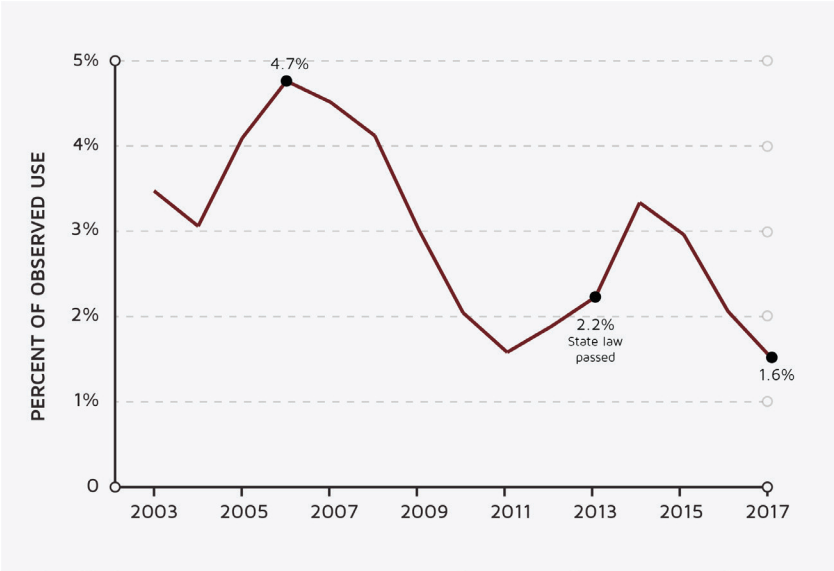


Figure 1. Summary map of state laws on device use while driving

In 2013, Hawaii passed a law banning the use of hand-held cell phones while driving. The University of Hawaii has collected data on hand-held device use by drivers since 2003. The university collects these data by observing actual vehicles and trying to discern if a driver is using a device. This method is not directly comparable to the self-reported survey data we mentioned above (there is a big difference between a driver admitting to using a device at some point during a trip, and an observer happening to see that use occur), and the estimates of use are as a consequence much lower. Figure 2 shows those estimates, for cell phone use while driving, from 2003 to 2017. Device use appears to have fluctuated over time, between a high of 4.7% in 2006 to a low of 1.6% in 2017.

To better understand the nature and extent of device use while driving, we recently conducted a nationwide survey, where respondents were asked several questions about their use of hand-held devices while driving. We sent our survey to more than 5,000 email addresses across the U.S., to people interested in transportation topics, traffic safety, public policy, risk management, and education. We also distributed it through social media platforms, including Facebook, Twitter, and LinkedIn, to reach a broad national audience. The group we

Figure 2. Observed cell phone use while driving, Hawaii, 2003-2017



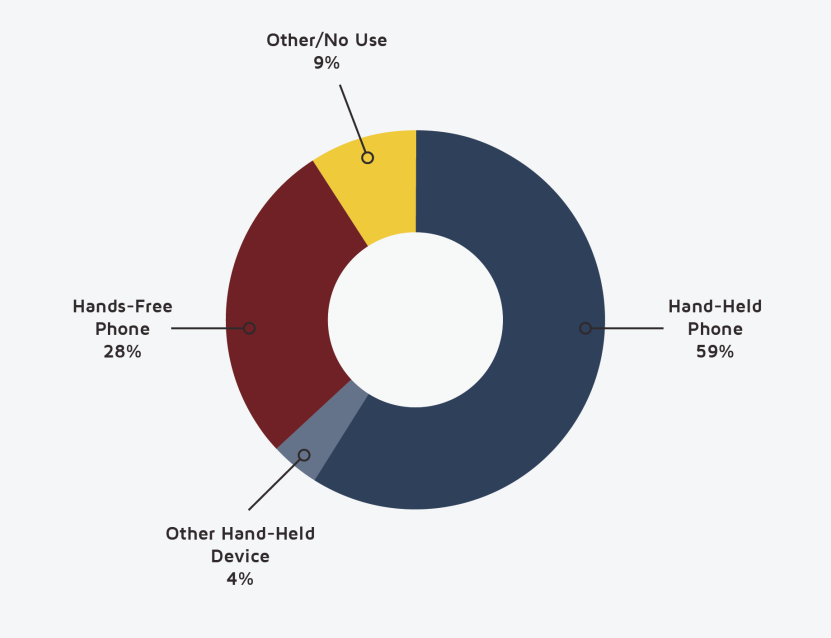


Figure 3. Device use reported in survey

targeted, because they work in fields related to transportation, safety and risk, is obviously different from the larger driving population, so our results are not directly comparable to NOPUS. It is possible, however, that our sample might be more aware than the general public of the hazards associated with device use, which suggests that our findings may understate the actual prevalence of device use in the population.

There were a total of 337 respondents across 43 states, plus Washington, D.C., and Puerto Rico (all except Vermont, West Virginia, Arkansas, Wisconsin, North Dakota, Montana, and Idaho). Half the respondents identified as male, and just under half (46%) as female (the rest did not indicate gender). The survey included respondents across different age groups and socioeconomic backgrounds, and who drive various types of vehicles (car, van, pickup truck).

In the survey, 63% of respondents reported generally using a hand-held device — which included phones, tablets and other devices — while driving, and 59% reported using a cell phone specifically. Twenty-eight percent reported using a hands-free phone, while 4% reported using other types of hand-held devices (see Figure 3). Recall again that these self-reported rates may well be underestimated.

We also found that young and middle-aged drivers use hand-held devices more than older adults. Fifty-seven percent of drivers 25 years and younger use hand-held devices while driving, similar to the 60% rate of use for those 26 to 64 years of age. Just 38% of those over 65, however, reported using a device while driving. About a third of young drivers (18- to 25-year-olds) and older adults (over 65 years old) use hands-free communication devices, 36%, and 33%, respectively (see Figure 4).

Our study also found more males (59%) use hand-held devices than females (57%), which differs from other published research, such as NOPUS.

Respondents from states that ban text messaging or hand-held device use were, compared to respondents in other places, less likely to report such use.

Nevertheless, even in states with bans or restrictions, 52% of respondents admitted to using a hand-held phone while driving. Even in states with bans on text messaging while driving, 46% of the drivers in the study admitted to engaging in that activity. States with bans on text messaging have the highest use of hands-free devices.

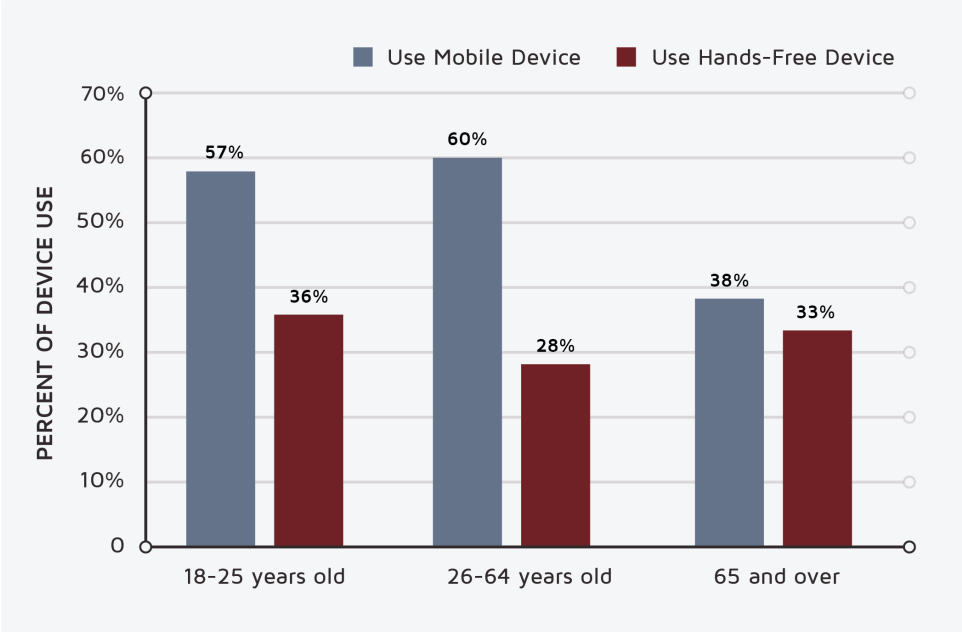


Figure 4. Mobile device use while driving by age groups

Device Use

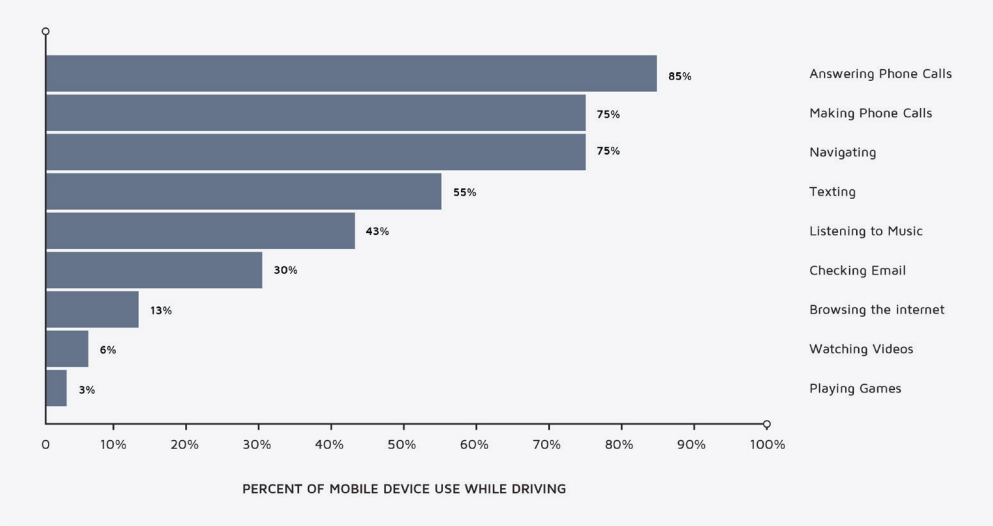
Of the 206 respondents using devices while driving, the most frequent uses were answering or making phone calls, navigating, texting, listening to music, checking email, browsing the internet, watching videos, and playing games as shown in Figure 5.

Safety and Enforcement

Fifty-one percent of survey respondents reported they felt unsafe or very unsafe riding with a driver using a hand-held device, yet 60% of respondents felt that it was unlikely that a motorist would be stopped and cited for using a hand-held device while driving — only 5% of drivers reported actually receiving a ticket. Seventy-seven percent of the respondents agreed there should be stricter enforcement.

Our survey included a question about crash involvement. Among the 323 respondents who answered this question, 15% had been in a crash within the past three years. Of those, 60% reported currently using hand-held devices while driving. Among respondents who were not in any crashes, 57% admitted to using a device while driving. While there is a slight association between self-reported crashes and device use

Figure 5. Frequent uses of mobile devices while driving



while driving, no one admitted to using a device at the time of the crash.

Overall, the survey respondents supported increased police enforcement of laws prohibiting hand-held device use while driving. However, detecting device use in vehicles is difficult. State law enforcement personnel need increased training to spot, record, and cite device use by drivers. To enhance enforcement, states would need to increase penalties, and provide further education on the hazards of distracted driving.

Nevertheless, technology may provide some solutions. For example, researchers at the University of Hawaii are developing methods to automate the detection of hand-held device use by drivers while driving. High-resolution cameras, artificial intelligence software libraries, and machine vision technologies are used to study hand-held device use by drivers.

Reducing Distracted Driving

To prevent crashes and improve road safety, states need to more properly address the hazards associated with distracted driving. Doing this will require better research into how drivers perceive the risks and benefits of using hand-held or hands-free devices while driving — including social or work-related pressures to make calls or send texts. Manufacturers of hand-held devices and communications and Internet service providers share responsibility for educating drivers about the increased risks of crashes due to driving and texting or talking. Research is also needed on the development and evaluation of innovative strategies to help drivers avoid device use while driving.

One such strategy is expanded support training and education to reduce risky behaviors. Between April 2010 and April 2011, NHTSA conducted a demonstration project in Hartford, Connecticut, and Syracuse, New York, using high-visibility enforcement to discourage the use of hand-held cell phones. The enforcement campaign resulted in a drop in observed cell phone use from 6.8% to 2.9% in Hartford and from 3.7% to 2.5% in Syracuse. Dialing and texting rates dropped from 3.9% to 1.1% in Hartford and from 2.8% to 1.9% in Syracuse.

Strategies to reduce device use while driving should target all potential distractions from devices to car technologies. For example, heads-up information from mobile phones on dash-mounted displays to support navigation and other tasks can reduce the risks of distracted driving crashes. Bluetooth and other communications technologies in vehicles can reduce the need for hand-held devices, but may also divert attention from driving and the roadway environment, causing distraction. Better integration of these technologies with warning and collision avoidance systems to inform drivers who are veering off course can also help reduce crashes. Blocking technologies — pre-installed on the device or added as software — to prevent calls or texts from moving vehicles may further reduce crash risk.

Through a collaborative approach combining research, education, training, and partnerships between safety advocates, transportation agencies, law enforcement, industry, and device manufacturers, we can all reduce distracted driving and improve traffic safety.

This article is adapted from Kim, K., Ghimire, J., Pant, P., and Yamashita, E. (2019). Self-reported handheld device use while driving. Accident Analysis and Prevention, 125*, 106-115.*

Further Reading

Insurance Institute for Highway Safety, 2017. Distracted driving: Cellphones and texting. Highway Loss Data Institute, http://www.iihs.org/iihs/topics/laws/cellphonelaws.

Lipovac, K., eri , M., Te i , M., Andri , Z., Mari , B., 2017. Mobile phone use while driving-literary review. Transportation research part F: traffic psychology and behaviour 47, 132-142.

NHTSA, 2011. National distracted driving telephone survey finds most drivers answer the calls, hold the phone, and continue to drive. In: NHTSA ed. Traffic Tech: Technology Transfer

Series. U.S. Department of Transportation, Washington DC.

Zendrive Research, n.d. Largest distracted driving behavior study. In: Budnick, N. ed. distracted-driving. zendrive.com, http://blog.zendrive.com/distracted-driving/.

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OPINION

A Prescription for Equitable Access

Katherine Chen

During a year when COVID-19 illness and prevention dominated conversations about health care, the pandemic also made it more difficult for many Americans to go to the doctor for non-COVID-19 care.

In June 2020, more than one in three Americans reported that they had delayed or not received necessary medical care within the past month because of the pandemic. By late March 2021, that figure had improved only slightly, to nearly one in four. The reasons for this delayed or missed care are many, but transportation is one of them.

During the pandemic, trips to the doctor's office, like all travel, became more complicated. Stay-at-home orders, cuts to public transit service, and suspension of some shared-ride programs — not to mention concerns about contracting or spreading COVID-19 — deprived people of their usual ways of moving around. Even when people could travel for health care, many found they had no place to go. Many community clinics temporarily reduced their hours and canceled most in-person visits and non-emergency procedures. Moreover, many people who lost their jobs also lost their health insurance or had to switch to lower-cost plans that covered fewer services at fewer locations.

Although it's difficult to assign transportation a precise share of the blame for the pandemic's disruption of medical care, it is clear that transportation played a role. As we emerge from a year of isolation and uncertainty, we have reason to fear that COVID-19's impact on transportation has widened health disparities that existed well before the pandemic began.

Black, Latinx, and low-income communities have long contended with higher rates of chronic health conditions that require in-person care — such as heart failure, end-stage kidney disease, and prostate or cervical cancer — as well as greater difficulty reaching that care. One study estimated that Black and Latinx patients, compared to white patients, were about twice as likely to have delayed seeking health care specifically because of transportation problems. A big part of the problem is that driving, whether to the doctor's office or anywhere else, is often a privilege of the healthy. In general, the most medically vulnerable patients not only seek health care more often, but also — because of their worse health and lower socioeconomic position — more often rely on public transit, rides from others, or programs like paratransit and Medicaid's Non-Emergency Medical Transportation service, or NEMT, to access that frequent care. Patients with end-stage kidney disease, for example, typically take three to four round trips each week to undergo hemodialysis, a life-sustaining process that filters their blood to remove toxins and excess fluids. About three-quarters of these patients rely on transportation programs or rides from others to get to dialysis.

The COVID-19 pandemic has likely made it even harder for these disadvantaged groups to get health care when they need it. A CDC report from June 2020 found that Black and Latinx adults were 33% and 53% more likely than white adults to have delayed or avoided any

medical care due to concerns about COVID-19. Differences in car access may, again, explain at least part of this disparity. Low-income people and people of color are more likely to rely on modes of travel — such as public transit and carpooling — that make social distancing difficult, and that (in the case of transit) have seen service reduced during the pandemic. In these situations, seeking medical care is more likely to involve tough decisions about whether the benefit of the visit is worth the risk of the trip.

Can technology help address these challenges? Health systems have been able to replace many clinic visits with telehealth (care delivered via phone or video call), which eliminates the need to travel. However, disparities in access to technology and broadband internet mean that telemedicine programs have been less effective at reaching lower-income populations and communities of color. Many tests and treatments, moreover, still require in-person care. There is no way to get hemodialysis over Zoom.

To keep patients healthy and allow them access to needed in-person care, policymakers must ensure continued political and financial support for transportation programs. Maintaining transportation services during the current downturn in transit ridership is important not just for connecting patients to care, but also for reducing crowding and minimizing COVID-19 transmission risk for transit operators and passengers. This ongoing investment will also keep transportation services viable in the long term, especially once people start seeking out the care they have delayed as a result of the pandemic.

Still, the striking pre-pandemic inequities in transportation to health care remind us that sustaining existing transit programs, while necessary, is not sufficient for achieving access to health care for all. The political, economic, and social forces — including structural racism — entangled at the root of disparities in transportation and health mean that transportation leaders would be wise to seek outside help. Progress toward equitable access to health care during and after the pandemic will likely require multiple levels of collaboration among transit agencies, transportation service providers, health care systems, health insurers, and communities.

First, transportation programs should work with local health systems to streamline enrollment in services like paratransit and other non-emergency medical transportation. Because patients who miss care due to transportation problems often return later with more serious health conditions, many health systems have already begun to implement screening tools that ask patients if they need transportation assistance. If they do, social workers or case managers then help patients apply for relevant transportation assistance programs. These screening protocols are helpful because applying to the programs is often confusing and difficult, sometimes requiring in-person interviews with the patient and/or added paperwork from patients' doctors. A still-better reform, however, would be to simplify these cumbersome processes; doing so can decrease delays in care, and thus reduce both avoidable suffering and expense.

Second, policymakers should consider making it easier for Medicaid programs to contract with ride-hailing companies to offer NEMT rides on-demand. Several states have already taken this step in response to stories of patients who missed vital care because of a late ride or other problems with conventional transit services. The more flexible rides offered through these partnerships could offer better service and might also accommodate more social distancing than public transit.

Third, transportation leaders should support efforts by other sectors to help deliver health care, including COVID-19 vaccines, where patients live, shop, and work. For example, policies to increase access to telehealth and mobile clinics in transportation-disadvantaged communities can improve access to certain routine health services while freeing up transportation resources to help the sickest patients get the in-person care they need.

Finally, both transportation and health care providers must partner with patients from the communities most marginalized by both industries. With population health on the line,

we cannot afford blunders like prioritizing drivers in the design of mass COVID-19 testing sites in cities where many people don't own cars. To design better systems that serve a range of health care and transportation needs, we must work harder to include, listen to, and learn from people from historically oppressed communities at all levels of decision-making.

One year into the pandemic, as rollout of the COVID-19 vaccine offers a glimpse of a post-pandemic world, transportation and health care practitioners face a critical moment to act together, across disciplines, to advance equity in health and transportation.

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