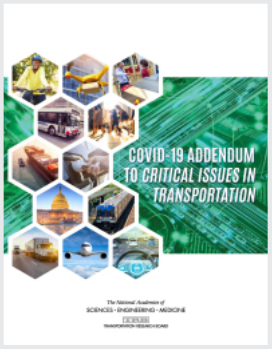

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COVID-19 ADDENDUM TO *CRITICAL ISSUES IN TRANSPORTATION*

Transportation Research Board Executive Committee

January 2021

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TRB
TRANSPORTATION RESEARCH BOARD

PREFACE

The year 2020's raging coronavirus pandemic and reckoning with long-standing racial injustice led to widespread disruption and suffering, social unrest, and renewed calls for an accounting of our fragmented public health system and troubled history of racial inequity. The crises of 2020 transcend transportation yet also raise fundamental questions for it along with other sectors of our society and economy. In this addendum to *Critical Issues in Transportation 2019*, the Transportation Research Board (TRB) Executive Committee updates all of the critical issue topic areas to address the short-term and potential long-term effects of coronavirus disease 2019 (COVID-19) on transportation. An additional addendum will be issued later in 2021 that delves much more deeply into the equity issue to probe and question transportation's role in contributing to and redressing racial injustice.

This project was approved by the Governing Board of the National Academies of Sciences, Engineering, and Medicine (the National Academies) in July 2020. Its purpose is to identify and discuss the transportation issues that have emerged or become more pronounced as a result of the COVID-19 pandemic and heightened public concern about civil rights and the persistence of racism as expressed in the reactions to the police killings of African Americans in recent years.

The TRB Executive Committee was charged with considering how the pandemic and transportation's role in reducing or abetting racial disparities in the United States are creating new priority topics for transportation research, innovation, and policy resolution.

The TRB Executive Committee is the authoring committee of this document. The Subcommittee on Planning and Policy Review guided its development and approved its content on behalf of the TRB Executive Committee. The insights and questions identified in these topics also reflect the work of other researchers and practitioners as described in the Acknowledgments section. This addendum was reviewed separately by anonymous peer reviewers according to the policies and procedures of the National Academies.

Transportation provides essential support for our economy and lifestyles and reflects our national values as well as our shortcomings and aspirations. Research that helps us understand these interconnections can help us make better choices for the future. We invite the thousands of TRB researchers and practitioners to join us in pushing the boundaries of knowledge to address the vitally important issues raised in this document.

Carlos Braceras, *Chair*, TRB Executive Committee, Utah Department of Transportation
Dr. Katherine Turnbull, *Chair*, Subcommittee on Planning and Policy Review, Texas A&M University

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Many of the research questions in the COVID-19 section derive from a virtual brainstorming session hosted by the Transportation Research Board (TRB) and the U.S. Department of Transportation in April 2020 that involved 14 transportation researchers and practitioners. The TRB Executive Committee acknowledges and appreciates the contributions of these individuals:

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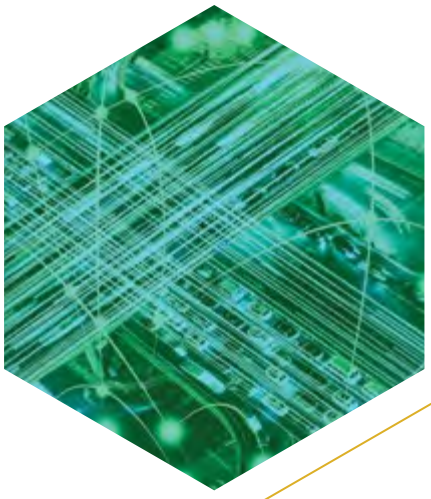
Although the reviewers listed above provided many constructive comments, they were not asked to endorse the conclusions and recommendations, nor did they see the final version of the publication before its release. The review of the publication was overseen by Robert F. Sproull (National Academy of Engineering), University of Massachusetts Amherst, and Sue McNeil, University of Delaware, Newark. They were responsible for making certain that an independent review of the publication was conducted in accordance with institutional procedures and that all review comments were carefully considered. Responsibility for the final content of the publication rests solely with the TRB Executive Committee and the institution.

TRB staff member Stephen Godwin drafted this document under the guidance of the Subcommittee on Planning and Policy Review and Karen Febey managed the peer-review process.



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COVID-19 ADDENDUM TO *CRITICAL ISSUES IN TRANSPORTATION*

Introduction

In early 2020, the United States experienced a rapidly unfolding global pandemic that travelers infected with coronavirus disease 2019 (COVID-19) helped spread worldwide within weeks of its outbreak. By late December, more than 19 million Americans had tested positive for COVID-19 and more than 332,000 had died. In the early months of the COVID-19 pandemic, hospitals in hotspots were overwhelmed. At the same time, medical professionals in many parts of the country were critically short of personal protective equipment (PPE)[1] due, in part, to vulnerabilities in the supply chain. Widespread PPE shortages increased infection risk for essential workers of all kinds as well as the public. By late March 2020, large swaths of the country were under stay-at-home orders. Business closures resulted in unemployment levels unseen since the Great Depression. By May 2020, one in four American workers—more than 40 million people—had filed for unemployment.[2]

Fear of exposure, social distancing, the absence of an effective vaccine, and economic shutdowns resulted in unprecedented declines in travel across all modes of transportation in the first half of 2020. Road and highway travel declined 40 percent, though indicators of vehicle miles of travel (VMT) show that travel was about 90 percent recovered by July 2020 and remained so through early November 2020.[3] Airline travel declined more than 90 percent[4] and rail transit trips dropped by 70 to 90 percent.[5] Travel on other travel modes also dropped off sharply and cruise ship operations were suspended. By mid-year, the country began to slowly reopen. However, the United States experienced a resurgence of infections in multiple states during the summer and a more accelerated one in the fall amid growing fears of a protracted economic recovery due to widespread unemployment and bankruptcies[6] and economic growth hampered by continued mandates for social distancing.[7]

Some changes in behavior that took hold during the pandemic, including the greatly expanded

use of remote technologies for teleworking and increased home goods delivery, reinforced trends already under way and identified in *Critical Issues in Transportation 2019*.[8] However, the magnitude and potential permanence of these changes raise many new and unanticipated questions about future travel demand and modal preferences. The COVID-19 pandemic also exposed the transportation system's strengths and fragilities as the backbone of the nation's supply chain and lifeline for essential services.

Research will play a critical role in determining how transportation influences the spread of and recovery from the pandemic, how the transportation system can respond to critical stresses from events such as COVID-19, and how the economic conditions and changes in behavior that endure after the pandemic will influence transportation and telework.[9] This 2021 addendum focuses on the recovery and expected aftermath over the next several years. Research can make valuable contributions to resolving near-term problems, but its role will be especially important for understanding and addressing challenges and fundamental changes, including uncertainty, that may occur in transportation in the ensuing years. However, this addendum also emphasizes the value of capturing lessons learned during the pandemic, not just in the United States, but globally, before memories fade and crucial data are lost. Although several topics are interrelated and cross-cutting, important policy and research questions and issues are sketched out below in the order of critical issues topics discussed in the 2019 edition.

Transformational Technologies and Services

Information and Communication Technologies

The impact of information and communications technologies (ICT) as a substitute for travel for work, entertainment, medical care, and socializing has been unfolding for decades,[10] and telework enabled by ICT was already replacing traveling to work for about 5 percent of workers.[11] However, the widespread adoption of web conferencing platforms allowed 42 percent of the workforce to telework by June 2020,[12] and many organizations' managers have discussed making telework a permanent option.[13] Will this experience accelerate the previously growing trend of working from home?[14] How much of the workforce will actually continue to do their work remotely and how often? How will employer policies change regarding working from home and other travel demand management strategies? What will be the effect of remote working on non-work trips? Will more people attend meetings, conferences, medical appointments, and family and social gatherings remotely and substitute trips to the movies with upgraded digital subscriptions? Will the sharp growth in deliveries of take-out meals,[15] groceries,[16] and other goods continue after the pandemic has passed? What are the ramifications for travel behavior, mode choice, provision of infrastructure, and private carriers whose business models depend on business travel?[17]

Automation

Technology companies have been developing robots, drones, and small automated vehicles for last-mile and remote delivery to customers that had been focused on pilot tests and niche markets. Use of these technologies increased during the pandemic and initial recovery.[18] Automated operation of taxis and public transit might be one way to reduce the risk of spreading infections, as would contactless payment for transit and tolling.

Will interest in avoiding person-to-person contact during the pandemic stimulate greater demand afterward for these technologies?

The pandemic might well motivate faster automation of workplaces that require people to work in close proximity, especially in warehouses already actively automating, but how would that extend to movement of people and goods? In the short term, on-road automated vehicle testing was greatly reduced during the pandemic.[19] Over the longer run, the continued development and rollout of automated vehicles appears consistent with the assessment made in the 2019 edition.

Serving a Growing and Shifting Population

Are there broad, lasting changes in the location of economic activity and residences due to the pandemic that might shift future demand for personal travel? (Freight impacts are discussed in the Goods Movement section.) Key questions are (a) whether companies and residents will decide that the risks of pandemics and benefits of telework outweigh the agglomeration benefits[20] of large cities and metropolitan areas and (b) what ramifications these decisions will have for these areas.[21] These are long-run issues whose consequences attributable to the pandemic cannot be easily isolated from other trends. Even before the pandemic struck, New York City, Los Angeles, and other large metropolitan areas were losing population, while other large but less densely developed metros, such as Phoenix and Houston, were gaining.[22] Within metropolitan areas, key interrelated questions are whether the:

- pandemic accelerates the national trend in declining public transit usage in a persistent fashion;
- use of public transit alternatives suggested by the Centers for Disease Control and Prevention (CDC) during the pandemic (trips by single occupant vehicles [SOVs], walking, and cycling[23]) shifts demand afterward on a sustained basis; and
- technologies enabling telework, as well as more permissive employer policies that enable telework and other travel substitutes, will motivate more workers to move farther away from the location of their workplaces, in some cases moving completely away from the metropolitan areas in which their offices are located.

The pandemic has had a major short-term impact on business and leisure travel. What will be the long-term impact on these types of travel as well as on their destinations? For example, the pandemic induced a sharp increase in the purchase and use of recreational vehicles for tourism.[24] Will that demand persist over time? How will destination choices change and what effects will that have on businesses, regions, and states dependent on tourism and air travel?

Energy and Sustainability

In the short term, a decrease in the demand for transportation led to decreases in emissions and energy consumption during the pandemic. However, as the economy recovers and physical distancing requirements are eased, will rebounding and growing SOV trips increase congestion and

emissions? To what extent will increases in SOV travel be offset by increased cycling, walking, use of micromobility modes (including shared bikes and scooters), and possible additional repurposing of streets to better accommodate pedestrians, bicyclists, and high occupancy modes? Over the longer term, if the pandemic hastens ongoing demographic shifts away from large metros toward smaller ones and Sunbelt metros of all sizes,[25] more energy consumption and emissions would be expected because origins and destinations are farther apart in less densely developed areas that have less public transit. However, might these effects be offset somewhat by fewer work trips by teleworkers, less traffic congestion (or shifts in congestion times), and broader travel substitutes through ICT? The substantial reduction in air travel during the pandemic is expected to reduce short-term greenhouse gas (GHG) emissions from this energy-intensive mode while encouraging travel by personal automobile. Will these effects be sustained and what are the net effects on GHG emissions for the short and long term?

Resilience and Security

Existing resilience plans did not anticipate a pandemic on the scale of COVID-19. Most resilience plans were based on a localized or a regional disruptive event that impacts infrastructure, not on a global event that shuts down large parts of the economy and travel. Some of the most concerning short-term issues were lack of adequate PPE stockpiles and reliance on long, global supply chains (see the Goods Movement section). There were also many lessons learned involving transportation that should be studied and incorporated into future plans.[26] (Intergovernmental issues are covered in the Governance section.) Needed documentation and development include:

- Scenario planning that incorporates large-scale pandemics and other large-scale crises;
- Understanding of the role of travel policies and bans in reducing disease spread;
- Keeping transportation systems operating for essential workers and food delivery to grocery stores and vulnerable populations;
- Responding to concurrent disasters such as tornadoes, hurricanes, flooding, and wildfires when transportation staff are sheltering at home;
- Protecting essential workers in the field during disaster response that places them at risk of infection; and
- Making needed modifications to crisis management and emergency response plans.

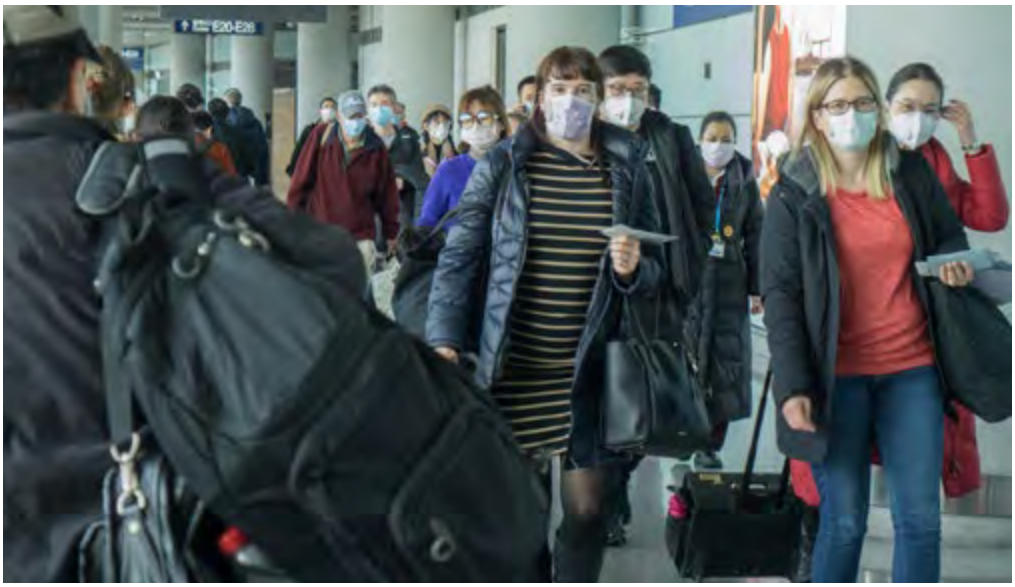
Safety and Public Health

Key public health issues arising from the pandemic include the risk of becoming infected during travel (for travelers and transportation workers) and how that can be mitigated through technology and operating practices.[27] CDC guidance in June 2020 stated that COVID-19 is mainly spread from person to person through respiratory droplets. The World Health Organization guidance in July 2020 recognized the possibility of transmission through smaller aerosols that can linger in the air longer and over greater distances.[28] As a result, extended passenger queueing and improved ventilation, filtration, partitioning, and air treatment systems for vehicles, vessels, rail cars, airports, and other transfer points may become more important for protecting transport operators and passengers. Such changes have broad implications for the design of stations, vehicles, international border crossings, and vessels. However, implementing these changes on a large scale would be a long-term effort.

Near-term questions for transportation services, vehicles, and stations during pandemics focus on whether mask wearing should be mandated; the enforceability of mask-wearing requirements; disinfection strategies; health screening (temperatures); social distancing; the merits of contactless payment; and the role of public transit for the movement of essential workers, including public health workers, amid pandemics. Research is needed to better understand the risks of becoming infected while traveling by shared modes such as public transit, shared micromobility, airplanes, vessels, and ridehailing and microtransit, and how protection and mitigation measures would change these risks. Understanding best practices in mitigating disease spread during transportation and how experience varies across urban, suburban, and rural areas in the United States, as well as worldwide, would be invaluable. Such research would have to take overall public health measures and rates of community infection into account in assessing the merits of transportation-specific public health measures, when comparing regions of the United States, and in drawing lessons from other countries.

Given that lack of transportation is often a constraint on access to timely health care, the growth and increased acceptance of telehealth services raise a different set of questions about their longer-run implications.[29] Will this be an avenue to better care for mobility-limited segments of the population and those distant from health care services? To what extent does the digital and income divide in general, and uneven broadband access in particular, impede the adoption of telehealth services for the very segments that could most benefit from them?

Although the health risks of COVID-19 have been more prominent than those from traffic safety



during 2020, traffic safety trends have also been troubling. Data from the first half of 2020 indicate that, although the number of traffic fatalities declined due to travel reductions, the rate of fatalities apparently increased sharply from 1.1 to 1.25 deaths per 100 million vehicle miles.[30] These increases are attributed to increased speeding, reduced use of safety belts, increased driving under the influence of drugs and alcohol, and reduced enforcement.[31] During past economic downturns, both the number and rate of traffic deaths declined, raising questions about why experience during the pandemic-induced economic downturn of 2020 is so different and what policies and strategies could address the heighted traffic safety risks. For example, is the increase due to high-risk drivers resisting stay-at-home guidance and pandemic-induced increases in drug and alcohol consumption? If so, what countermeasures would be effective in mitigating these risks?

Equity

The pandemic is having a disproportionate impact on the health of low-income groups, minorities, people with certain medical conditions, and older adults.[32,33,34] Transportation research needs to document (a) the impact the pandemic is having on vulnerable public transit–dependent populations and low-income workers, including farm and food-processing workers who depend on employer-provided vans and buses and (b) the effects that the expected slow recovery from the economic recession and prolonged unemployment may have on auto ownership, travel patterns, and new job locations among vulnerable groups, especially outside of center cities where automobiles are essential for access to employment, shopping, and health care. Research also needs to document best practices and new ways of providing transportation services for vulnerable populations without automobiles to access health care, including wellness check-ups, during the pandemic recovery and afterward. Such baseline information is needed to design and plan for appropriate public policy responses and prepare for future disasters and pandemics.

Large-scale shifts to telework have also raised a number of social equity questions, including about gender inequities in managing children at home while also working; unequal access to the Internet for at-home work and remote learning/education across income groups and in areas lacking broadband; and workers' and families' lack of adequate digital devices for remote work, education, and medical and other services.

Many essential employees are dependent on public transit systems to get to work even while transit systems are severely cutting back on services. These public transit–dependent employees are often minority and/or lower-income employees who were disproportionately impacted by service reductions. As agencies are now shifting to recovery plans and developing return-to-work strategies, what factors should be considered for supporting vulnerable communities during the transition and post-COVID-19? What service changes should transportation agencies consider to support vulnerable populations post-COVID-19, so that services improve, perhaps even to levels that exceed pre-COVID-19 standard services? These and other issues related to the pandemic are addressed in more detail in the companion addendum to *Critical Issues in Transportation 2019* that focuses on racial equity.

Governance

The multiple and sometimes fragmented lines of governmental authority in the United States have their advantages in a pluralistic democracy rooted in a suspicion of concentrated power, but their limitations were made manifest in the inconsistent federal, state, and local responses to the pandemic. The causes and consequences of these limitations are far broader than transportation, but transportation research could examine sources of failures and successes in transportation's role in emergency response across levels of government. For example, how effective were the different approaches taken by federal, state, and local transportation authorities in providing a coordinated response to the pandemic? What lessons and best practices can be learned from these experiences to improve emergency response plans and governance during a future major disruption? What lessons can be learned regarding communication among the various agencies involved in managing the response to a major disruption? How effective were collaborations, coordination, and communication among transportation organizations, including among private organizations and between the public and private sectors? How can coordination among local agencies, states, and nations during a large-scale disruption be improved based on lessons learned from the experience with COVID-19? What essential roles and activities are practiced most effectively at each level of government? What can the United States learn from best practices adopted abroad in developing and implementing transportation measures across all levels of government?

System Performance and Asset Management

Transportation infrastructure capacity designs and capital plans are driven by expectations about peak demand and shifts in peak periods; thus, questions about whether the pandemic results in sustained reductions in peak-period travel have broad implications for current and expected system performance. During the short term, the focus is normally on how well transportation agencies and companies manage excess demand relative to capacity, but during the early months of the pandemic, the focus across modes was on the reverse. When demand plunged, airlines, airports, public transit agencies, shared mobility operators, motor carriers, railroads, ship operators, and seaports were all forced to make hard and unprecedented changes to scale down facilities, reduce staff to minimal levels, and disinfect facilities and vehicles, aircraft, and vessels while also coping with reduced funding for operations as revenues plummeted. Traffic signals timed to manage flows based on average traffic resulted in many delays for motorists and other road users at intersections with little cross traffic. What best policies and practices have emerged from this experience? Will more jurisdictions, for example, adopt adaptive traffic management and signaling systems? With transportation facilities of all kinds suddenly vastly underutilized, an opportunity emerged to make concerted progress in rehabilitating them with minimized disruptions to passengers and traffic. What are the lessons learned from this experience that can be applied in the future? With major reductions in revenues to transportation agencies and industries, what best practices emerged for maintaining a state of good repair in a severely constrained fiscal environment?

Over the long term, will changes in personal and freight travel demand affect pending decisions about, and long-range plans for, system capacity?

Funding and Finance

Transportation agencies and private companies alike depend on a vast array of user fees and charges that declined in proportion with reduced demand. As demand and revenues recover, companies and agencies have the added problem of how to fund operations while also providing for social distancing and the additional costs of disinfecting facilities and vehicles. If there are signs of a protracted economic recovery, research will be needed to understand the ability of public agencies and private industry to deliver services and capital programs, as well as their ability to pay off revenue bonds, both short and long term. For private carriers of all kinds, the loss of revenues and potential bankruptcies raise questions about short- and long-run industry consolidation and the role and nature of public funding and debt forgiveness for sustaining transportation companies and employment until demand rebounds. There may be long-term changes in revenues to public agencies and private companies, particularly from certain

types of user fees and taxes. How will such changes in revenues affect the amount of service that can be provided? What policy tradeoffs need to be considered in cutting services due to reduced revenues to ensure that vulnerable populations are not severely impacted and that cuts occur in an equitable manner?

In the wake of the pandemic, the federal government and the states offered extraordinary assistance to public transportation agencies and private transportation carriers alike. What were the effects on public agencies and private companies of financial rescue and recovery packages passed by the U.S. Congress and state-specific efforts to aid in transportation project delivery? In addition to generous loans to private companies adversely affected by the global pandemic, the extraordinary grants to airlines, transit agencies, and Amtrak in the federal Coronavirus Aid, Relief, and Economic Security (CARES) Act of 2020 could be justified by Congress based on the essential nature of these modes and the highly unusual emergency conditions caused by the pandemic. Even so, the unusual public-sector financial support for commercial airline companies raises a question about longer-term implications for an industry that has traditionally relied almost exclusively on private-sector funding.

Goods Movement

As with any retraction in the economy, freight movements declined as the pandemic's effects were felt, but a 25 percent decline in cargo movements was particularly sharp for railroads and maritime ports.[35] By April 2020, 75 percent

of seaports worldwide were reporting reduced vessel calls, a figure that had improved only 5 percentage points by mid-July.[36] Demand effects varied considerably across the domestic trucking industry, with those segments serving manufacturing declining sharply and those serving essential retail establishments, especially grocery stores, experiencing increased demand.[37] In the short term, the pandemic wreaked havoc on supply chains and revealed critical weaknesses in stockpiling strategies in logistics systems that minimize inventory and depend heavily on Asian sources.[38] As opposed to problems associated with stockpiling and the need to move goods from distant sources, how well did transportation carriers meet the heightened demand to transport available PPE and critical medical supplies? With decreased traffic congestion, vehicle speeds increased. What can be learned about freight efficiency improvements with changes in freight operations and reduced congestion? What avoidable logjams occurred as demand recovered? What prudent practices are needed to be better prepared for future supply chain disruptions? How can the robustness and resiliency of the supply chain be improved?

Over the longer term, questions arise about whether

- logistics and transportation providers will be prepared for and able to distribute vaccines quickly and effectively, given that the earliest successful vaccine candidate requires maintenance of deepfreeze conditions (–70 degrees C/–94 degrees F) before being given to patients;[39]
- companies will shorten supply chains and distribution patterns, including re-shoring and near-shoring more manufacturing;
- changes in consumer preferences for shopping will shift toward greater reliance on home delivery and the implications that will have for the local infrastructure (including curb management) required to support such demand; and
- the preexisting trend of closures of brick-and-mortar stores and shopping malls will be accelerated and impact the logistics and demand for infrastructure.

Institutional and Workforce Capacity

As the pandemic unfolded and disrupted the economy, millions of transportation workers were idled while some, such as truck drivers and mariners, were overly stressed by long and extended duty hours as they provided essential services. Front-line public transit, intercity rail, and airline workers were exposed to infection while interacting with the public. Many employers reduced staff through furloughs, layoffs, and early retirements, with unclear prospects about future staffing levels. What lessons have been learned from these experiences that can be applied in future disasters? What additional long-term measures need to be adopted to protect the health of front-line transportation workers? What will be the long-term impact on transportation worker employment levels? How would increased future teleworking affect team synergy, organizational loyalty, worker productivity, and innovation? Many workforces shifted to electronic documents to reduce human-to-human contact in document transfers to good effect in the freight industry. What other innovations were adopted that can be incorporated into ongoing operations? How will operational changes impact the workforce needed moving forward (e.g., expanded skill sets)? What institutional vulnerabilities were exposed during the pandemic, and what lessons can be learned from these experiences? For example, as reliance on ICT and information technologies systems generally has grown during the pandemic, has this enhanced the importance of cybersecurity for transportations systems and agencies?

Research and Innovation

As policy makers and health professionals tried to gauge the effectiveness of stay-at-home measures, a vast array of recently developed travel data and algorithms[40] were made available and became useful indicators of how much and how effectively the public was practicing social distancing. Many questions arise about the data derived from smartphone usage, including privacy, consent, representativeness,[41] and archiving. Also of great interest is faster and more frequent data collection with greater geographic precision than in the past. Researchers would like to use these and other new data sources, as well as data science, to inform crisis management decisions and risk models and their future applications in transportation system modeling and planning.[42] Scenario planning and modeling can also assist in addressing uncertainty and preparing for the future. It is critical to conduct user surveys and collect longitudinal data regarding changes in travel behavior during and after the recovery from the pandemic. In doing so, policy and programmatic decisions can be informed by accurate information about changing demand for personal and freight travel and the broader implications these changes have for society, the economy, and the environment. Given the disproportionate effects of the pandemic on minorities and recent immigrant populations, such surveys need to account appropriately for the cultures and first languages of these groups.

Science can provide great value to society during a crisis by informing policy decisions in real time, addressing gaps in knowledge on strategic issues, and taking advantage of unique circumstances to analyze natural experiments, but doing so requires adaptation of established approaches.[43] The urgency of understanding and managing the effects of the pandemic ushered in the accelerated allocation of funding for research, the research itself, accelerated peer review, and, sometimes, public sharing of results by authors before peer review. An evaluation of this experience would determine innovations worth incorporating into research management during emergencies on an ongoing basis, appropriate standards for peer review during crises, and assistance in reimagining the research enterprise more broadly.

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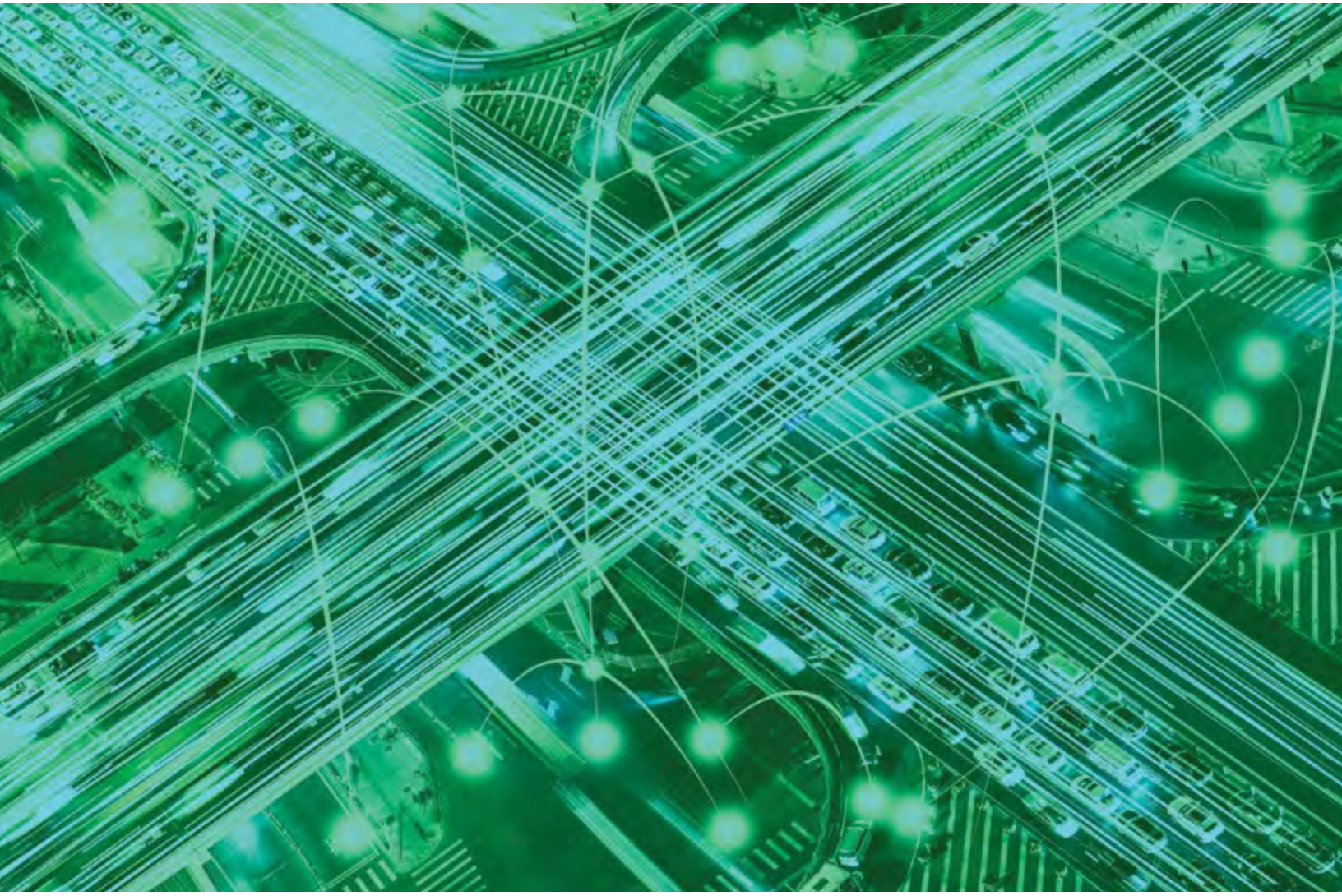

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