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The COVID-19 Pandemic and Transportation Engineering

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https://doi.org/10.1061/JTEPBS.0000418

The COVID-19 pandemic has been an enormous global disruption with immense economic, environmental, and social impacts throughout the world. Only world wars and the flu pandemic of 1918 are comparable in the wide range of consequences, including fatalities, over a relatively short period of time. Unfortunately, we can expect other major disruptions to occur in the future. In this editorial, we intend to discern some lessons for the transportation engineering profession that can be learned from the current catastrophe that can help us prepare for future disruptions. We will ignore nontransportation aspects of the pandemic such as the development of treatments, tests, and vaccines.

It is clear that people around the world are experiencing significant suffering as a result of the pandemic. However, we believe that transportation engineering has a role in mitigating the negative effects of the current pandemic and future disruptive events. The intent of this editorial is to indicate areas of research that may support this goal. As in the past (Hendrickson and Rilett 2019), the *Journal of Transportation Engineering, Part A: Systems* is prepared to be a publishing venue for serious scholarly papers addressing impacts of the pandemic, new intelligent transportation system approaches, and preparation for future disruptions.

A novel aspect of the COVID-19 pandemic has been the speed of its global spread. A high percentage of infected people were asymptomatic, which led to high transmission rates and a resulting exponential growth in many cases. Air transportation critically sped up the spread of infections worldwide. Unfortunately, visual and temperature screening of passengers failed to identify all the virus carriers. Within several months of the first appearance of the novel coronavirus, it had spread to more than 170 countries and in all six populated continents (CDC 2020). Roadway and rail transportation, including mass transit and freight corridors, further spread the infection across cities and countries (Ballard 2020).

One of the first lessons transportation students learn in their introductory courses is that passenger and freight transportation is primarily a derived demand. That is, the demand for movement is directly related to participation in other economic activities (e.g., work, shopping). The COVID-19 pandemic has demonstrated this fact on a global scale. Because of individual choices, public health appeals, and stay-at-home regulatory requirements, travel volumes severely declined throughout the world as individuals practiced social distancing to avoid infection. For example, in US areas with stay-at-home orders, average daily travel distance declined from 8.0 to 1.6 km (5 to 1 mi) in late March 2020 (Glanz et al. 2020). Rather than maintaining a constant amount of time spent traveling (Ahmed and Stopher 2014), individuals severely cut back. Transport operations dependent on revenue from reliable travelvolumes experienced significant revenue declines, including fare, fuel tax, and toll revenues. Gig workers for transportation network companies and taxi drivers also experienced substantial declines in income. Conversely, the demand for transportation and logistics in certain sectors (e.g., e-commerce) has surged (McLeod 2020), albeit not nearly enough to offset the reduced transportation demand from other sectors. Understanding the complex relationships in how these decisions affected the transportation system will take many years of study. Not surprisingly, this work has already begun (MTI et al. 2020).

Activity-based travel information has also been used as an analysis tool in the pandemic. Proprietary smart phone location tracking data were made available from numerous sources on a summary basis to monitor travel. Data were reported on a daily basis and for small geographic areas. These data were also used to track individuals with exposure to the virus in countries such as China. An important research question is related to privacy issues with this tracking. It is easy to hypothesize that traditional travel diary data gathering will become obsolete because of the availability of this inexpensive location-tracking data, which will be invaluable in calibrating and validating future activity-based models. Interestingly, the advanced activity-based models used in transportation and those used in epidemiology modeling are very similar, mainly because both are interested in predicting demand on a system (e.g., use of transportation, spread of disease) based on detailed models of human interactions across space and time (Del Valle 2020). It is easy to envision multidisciplinary research related to modeling the global and national spread of a pandemic using epidemiological and transportation models.

The impact on freight transportation has already been noticeable. Supply chains were significantly disrupted, starting with the closure of factories in parts of China in January 2020. Shortages of personal protection equipment, sanitizers, medical ventilators, and toilet paper, for example, quickly developed. Nevertheless, essential food and supplies continued to be moved, and production of goods subject to shortage soared. Movement of freight was aided by reductions in traffic congestion on major roadways (Shaver 2020). Over the past 20 years, the logistics industry has adopted a just-in-time approach for many products, which has reduced the need for warehousing. This approach has significantly affected the movement of freight across the globe and across individual countries and is usually seen in positive terms; however, the lack of warehousing of critical medical equipment has negatively impacted the ability of many countries to fight the pandemic. It has become apparent that stockpiling of significant amounts of emergency-related equipment and products may become more typical and supply chains may become more domestic. Again, the effect of these decisions would be fruitful topics of study for transportation engineering professionals.

With the short-term and significant decline in freight and passenger travel, there have been resulting improvements in air quality and declines in petroleum use throughout the world (Sommer 2020). With respect to COVID-19, which primarily attacks the respiratory system, it appears that people who live in areas with poor air quality are more susceptible to the disease (Friedman 2020; Sutter 2020). This correlation reinforces the idea that

transportation is a major driver of environmental and health impacts. It is easy to hypothesize that reducing emissions will reduce global warming and lead to healthier populations that will be better able to withstand the next pandemic. Reducing the negative environmental impact of transportation will continue to be an important research topic in the years to come.

For the past 20 years, a great deal of research has been performed about making our transportation systems resilient, reliable, and sustainable. The driving forces behind this research were natural events, such as earthquakes, floods, and hurricanes, that became natural disasters because our infrastructure was not designed for a broad range of operating conditions. Much of this research was on understanding and strengthening the connections between transportation systems and other civil engineering lifelines including communication, power, and water.

Unlike natural disasters and wars, the pandemic did not affect the physical infrastructure of transportation. Rather, it directly affected the human aspect of the transportation system. The pandemic has demonstrated the importance of understanding the connection between the transportation system and its users. For example, stay-at-home orders have reduced travel and increased the use of telecommunications. It is clear that transportation engineers must prepare for a wider variety of potential disruptions than may have been considered in the past, and they must understand the different potential effects on the transportation system. Undoubtedly, the pandemic will broaden definitions of what constitutes a resilient, reliable, and sustainable transportation system.

The COVID-19 pandemic has dramatically illustrated the need for preparation for future disruptions. With respect to natural disasters, our transportation system has served a two-fold purpose: evacuating citizens away from affected areas while simultaneously allowing first responders to access these same areas. Similarly, the current pandemic requires that essential services be maintained. For example, while travel on public transportation significantly declined, it was still needed for essential workers, and operating agencies must be prepared to continue such services. Protection for operators of public transportation and other shared-ride vehicles should be enhanced and possibly redesigned to allow for greater physical distancing. In addition, the freight and logistics systems, which are vital for maintaining critical lifelines including food, water, communications and power during a pandemic, clearly signal the need for additional research on connected and automated vehicles that, in turn, will have long-term effects on our transportation system.

The COVID-19 pandemic also has illustrated the complementariness of the transportation and public health systems. Transportation helped spread the virus, but also ensured that essential supplies were available. Over the past 20 years, there has been increased cooperation between transportation engineers and medical public health professionals on research related to reducing crashes and improving emergency preparedness for natural disasters. Multidisciplinary research between transportation engineers and public health researchers should increase in the future.

The long-term travel impacts of the pandemic are still uncertain as we write. Will stay-at-home telecommunications become more common relative to personal travel? Will crowding in public transportation and shared ride modes become permanently less appealing because of the fear of infections? How will public sector agencies keep their essential employees safe? Will the development of connected and automated vehicles be accelerated? Will e-commerce use climb substantially? These are all productive research questions for transportation engineering professionals.

Acknowledgments

Financial support from the Mobility21 National University Transportation Center and the Mid-America University Transportation Center, both of which are sponsored by the US Department of Transportation as well as the Hillman Foundation for the Traffic 21 Institute at Carnegie Mellon, is gratefully acknowledged.

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