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1. ACCOMPLISHMENTS

What are the major goals of the program?

The goals of the Center for Transportation, Environment, and Community Health (CTECH) are to pursue research and education innovations to support sustainable mobility of people and goods, while preserving the environment and improving community health. It leverages behavioral and economic sciences, information technology, and environmental and transportation sciences and technologies to address critical issues falling under the FAST Act's priority area of Preserving the Environment: greenhouse gas reduction, use of alternative fuels and energy technologies, environmentally responsible planning, and impacts of freight movement.

To address these challenges, the Center organizes its research activities through six thrusts: 1) Behavior, Active Transportation, and Community Health, which studies the links between travel behavior, active transportation, the built environment, and health; 2) New Transportation Technologies and Business Models, which explores how mobility-on-demand services can be used to improve environmental sustainability and human health; 3) Green Multimodal Transportation Systems, which leverages new mobility technologies to promote sustainable and health-enhancing modal integration; 4) Freight Transportation and Community Health, which explores new vehicle technologies and operation paradigms to reduce human exposure to truck exhaust; 5) Data-Driven Transportation-Health Informatics, which leverages Smart City and IoT (Internet-of-Things) technologies to develop community-based and personalized transportation-health indices for promoting healthy mobility choices; and 6) Energy, Technology and Policy Pathways, which studies the impact of different combinations of energy, technology and policy pathways on the environment and community health. The consortium, consisting of Cornell University (Cornell), University of California, Davis (UCD), University of South Florida (USF), and The University of Texas at El Paso (UTEP), aims to advance transportation sustainability in its broader human and environmental contexts through multi-level, multidisciplinary and cross-sector collaborations.

The Center leverages existing strengths of partner universities to create an innovative, multidisciplinary education program capable of training a workforce that will meet the complex challenges at the intersection of transportation, environment, and community health. Beyond the multidisciplinary curriculum designed in parallel with its research, the Center is developing programs to attract motivated undergraduates and high school students to transportation, particularly from underrepresented groups.

CTECH's research targets deliverables in the following areas:

- Advancing methods for the holistic representation of user behavior/response;
- Data-driven cyber-informatics modeling-management models/tools accounting for built environment-users and systems interactions;
- Computationally efficient algorithmic techniques for multimodal transportation systems management and community health;
- Scientific and engineering solutions for large scale integration of community health into transportation policy and planning; and
- Improved transportation-environment-community health nexus by linking fundamental scientific discovery with innovative practices.

The unique aspect of the work is that researchers focus on informing, influencing, and changing policy (i.e., legislation, regulations, programs, ordinances, and protocols) at the nexus of transportation, environment, and community health. Dissemination of research outcomes and education are critical components of technology transfer to subsequently influence policy and human behavior. The main products from our Center's research activities will be in the form of insights, knowledge, tools, and models that are instrumental to our stakeholders and practitioners as well as to policy development and

analysis. The development of technologies to license and/or commercialize can also be outcomes and is highly encouraged.

What was accomplished under these goals?

While providing critical services for the mobility, health, economic well-being, and security of communities, transportation presents challenges that also define modern society, with issues such as accessibility, air quality and energy efficiency, safety, health impacts, equity, and infrastructure vulnerability that must be confronted to sustain healthy living and economic growth. Successful solutions call for innovative cross-disciplinary research and education, and integrated technologies and approaches that meet goals in mobility alongside goals in environmental and health protection. In this reporting period, focused on FAST Act's priority area of Preserving the Environment, CTECH continued to use its fundamental research activities as the driving force to create downstream innovations, practices, and to enhance education programs for workforce development. The Center's activities are organized and the accomplishments reflected along three tracks: 1) the fundamental knowledge track comprises research activities, development of methodologies and tools, and collection and analyses of data; 2) new policy recommendations and innovative practical implications/guidelines that translate and promote research outcomes into transportation, environmental and community health practices/policies; and 3) education, outreach/engagement, and workforce development that trains students and professionals on the findings and insights of the research, as well as the tools used and lessons learned in best practices. We continued to engage stakeholders (government agencies, private industry, the public, etc.) in all of these processes to create broader impacts. Via accomplishments along these tracks, we progress towards our goal of building a unique platform for synergistic and multidisciplinary research and education at the nexus of transportation, environment, and community health, where new opportunities are explored to develop methods, tools, and technologies to support sustainable multi-modal transportation and promote healthy mobility choices.

Research projects accomplished during this reporting period cover topics such as cycling route choice in active transportation, health effects of long-term exposure to transportation PM emissions, emissions impact of congestion pricing, and association of built environment factors including transportation activities with postpartum depression and children's health. In particular, the following research projects were completed.

- Immersive, highly realistic in-lab experiments of cycling route choices
- Sustainable and Healthy Communities through Integrating Mobility Simulations in the Urban Design Process
- An Intersectoral Approach to Study Built Environment Factors Affecting Postpartum Depression in Children's Health
- 100% Biodiesel Vector Technology and Fuel Dispensing Solution
- Evaluating the Traffic and Emissions Impacts of New York City Cordon Pricing
- Pooling or not Pooling: the role of matching cost on mixed mode equilibria and VMT
- Measuring the Impact of the Large-scale Adoption of Ridesharing on the Spread of Infectious Disease
- Spatial Sustainability Assessment of Green Stormwater Infrastructure for Surface Transportation Planning, Phase III
- Understand usage patterns of e-scooter sharing and policy implications

How have the results been disseminated?

Formal research related oral presentations during the period are detailed below, followed by other dissemination activities.

> 10-26-20 Jang, S., American Public Health Association, **Establishing a baseline for community-based intervention: A needs assessment of transportation-disadvantaged older adults**, Virtual.

11-4-20 Zhang, Y., Perinatal Mental health Special Interest Group, **Development and Validation of a Machine Learning Algorithm for Risk of Postpartum Depression among Pregnant Women**, Virtual.

11-6-20 Zhang, H.M., Institute of Transportation Studies, **Traffic congestion, highway capacity, and level of service**, Davis, CA.

1-13-21 Lu, Q., University of California Pavement Research Center, **Sustainable Flexible Pavement Overlay Policy for Reduced Life-cycle Cost and Environmental Impact**, Virtual.

1-21-21 Zhang, H.M., California Department of Transportation, **Coupled morning and evening commute with ridesharing**, Virtual.

1-26-21, Mannering, F., TRB, **Assessment of Discretionary Lane-Changing Decisions using a Random Parameters Approach with Heterogeneity in Means and Variances**, Washington, DC.

1-27-21 Daziano, R.A., TRB, **How does self-assessed health status relate to preferences for cycling infrastructure? A latent class and latent variable approach**, Washington, DC.

2-3-21 Zhang, Y., Epic Corporation, **Putting HER in the HER: Detecting women at risk for developing postpartum**, Virtual.

3-8-21 Zhang, H.M., UC Davis 3RFM Center, **CAV platoon control to reduce energy consumption using machine learning**, Virtual.

3-9-21 Kwon, C., University of Washington, **Optimization and Learning Methods for Rebalancing Electric-Vehicle Sharing Systems**, Seattle, WA.

Qing Lu co-chaired with the International Association of Chinese Infrastructure Professionals, the 11th IACIP Annual Workshop: Resilient and Sustainable Infrastructure towards a Rapidly Changing World, held virtually January 9-16, 2021. There were 18 presentations and twelve posters focused on research and practice in transportation infrastructure with a focus on resiliency and sustainability.

On February 2, 2021, H. Michael Zhang organized a virtual event for participants from UC Davis, Sacramento State University, the City of Sacramento, California Mobility Center (non-profit), and PEM Motion (industry) to discuss opportunities to develop a live testbed for Connected and Autonomous Vehicles (CAVs) in the city of Sacramento, as well as opportunities to collaborate on CAV research.

On February 3, 2021, H. Michael Zhang participated in a virtual discussion with the California Department of Transportation about Caltrans' safety needs.

CTECH's Impacts of Transportation and Urban Systems on Health and the Environment Webinar Series hosted Visiting Professor, Department of Civil Engineering at The University of Texas at El Paso, Dr. Henry Van, on February 24, 2021. He discussed Cross Border Transportation and Environmental/Health Issues in the El Paso/Juarez Metroplex area, focusing on multifaceted, complex challenges involving very congested traffic with long wait times going from Mexico to the U.S. or vice versa. The border crossing in the El Paso/Juarez area is the same as the other major border crossings in Nogales, San Diego, and Matamoros. Critical transportation problems cause significant financial losses to major manufacturers operating in Mexico transporting products bound for the United States. Commercial and automobile traffic congestion also causes air pollution at the crossings which has become a significant health issue for people living adjacent to these border crossings.

Yiye Zhang from Weill Cornell Medicine hosted a joint workshop on health data science in the time of COVID-19 with Yokohama City University in Yokohama, Japan.

What do you plan to do during the next reporting period to accomplish the goals?
No change.

2. PARTICIPATING AND COLLABORATING ORGANIZATIONS

Listed below are organizations that CTECH has partnered with during the reporting period.

Associated Asphalt	Tampa, FL	Other – materials provided for laboratory testing
Atkinson Center for a Sustainable Future	Ithaca, NY	Collaborative Research
Bikewalk Tompkins	Ithaca, NY	In-kind Support, Other – provided mailing list to recruit participants
C2SMART	New York, NY	Collaborative Research
California Air Resources Board	Sacramento, CA	In-kind Support
California Department of Public Health	Sacramento, CA	Personnel Exchanges
California Department of Transportation (Caltrans)	Sacramento, CA	Financial Support, Collaborative Research, and Personnel exchanges
Center for Urban Transportation Research (CUTR)	Tampa, FL	Financial Support, Facilities, Collaborative Research
City of El Paso	El Paso, TX	In-kind Support, Facilities, Collaborative Research
City of El Paso Parks and Recreation Department	El Paso, TX	In-kind Support, Facilities, Other – data source, feedback
City of Ithaca	Ithaca, NY	Other – task giver, data source, feedback, potential implementer
City of St. Petersburg	St.Petersburg, FL	Collaborative Research In-kind Support, Other – feedback, potential implementer
City of Tampa, Department of Transportation and Stormwater Services	Tampa, FL	In-kind Support, Collaborative Research, Other – provide information on their green infrastructure implementation plan and policymaker advisory support
City of Temple Terrace	Tampa, FL	Other – provided stormwater GIS data for the Temple Terrace area
Cornell University – Transportation, Facilities, and Campus Services	Ithaca, NY	Other – task giver, data source, feedback, potential implementer
Downtown Ithaca Alliance	Ithaca, NY	Other – task giver, data source, feedback, potential implementer
El Paso Metropolitan Planning Organization	El Paso, TX	Collaborative Research
Englander Precision Medicine Institute	New York, NY	Collaborative Research
Environmental Defense Fund (EDF)	Washington, DC	Collaborative Research, Personnel exchanges
Florida Department of Health	Tampa, FL	Other – project contributions
Florida Department of Transportation Central Office	Tallahassee, FL	In-kind Support
Florida Department of Transportation District 7	Tampa, FL	Other – project contributions
Hillsborough Area Regional Transit Authority (HART)	Tampa, FL	In-kind Support, Other – data source, feedback
Hillsborough County MPO	Tampa, FL	In-kind Support, Collaborative Research
Hillsborough County Public Works Department	Tampa, FL	Other – provided GIS data and input on the modeling process
Joint Advisory Committee for improving the air quality in El Paso Sunland Park, and Ciudad Juárez	El Paso, TX	Personnel Exchanges, Other – data source, feedback, potential implementer
Kohn Pederson Fox Architects	New York, NY	Collaborative Research feedback, implementer
Lime	San Francisco,	

	CA	Collaborative Research, Other – data sharing agreement, participant recruitment
Lyft	San Francisco, CA	Collaborative Research, Other – data sharing agreement, participant recruitment
New York Metropolitan Transportation Council (NYMTC)	New York, NY	Collaborative Research, Other – data source,
NewYork-Presbyterian Hospital	New York, NY	Collaborative Research
Optimus Technologies	Pittsburgh, PA	Collaborative Research
Pinellas Suncoast Transit Authority (PSTA)	St.Petersburg, FL	Collaborative Research, In-kind Support, feedback, potential implementer
Qualtrics	Salt Lake City, UT	Collaborative Research
San Francisco Transportation Authority	San Francisco, CA	In-kind Support, Personnel Exchanges
Spin	San Francisco, CA	Collaborative Research, Other – data sharing agreement, participant recruitment
Superpedestrian	Cambridge, MA	Collaborative Research, Other – data sharing agreement, participant recruitment
Tampa Bay Area Regional Transit (TBARTA)	Tampa, FL	In-kind Support
Tampa Pavement Constructors/Lakeland Paving	Tampa, FL	Other – provide aggregate samples for laboratory testing
Texas A&M Transportation Institute	College Station, TX	In-kind Support
Tompkins Consolidated Area Transit (TCAT)	Ithaca, NY	Other – task giver, data source, feedback, potential implementer
Uber	San Francisco, CA	Collaborative Research, Other – data sharing agreement, participant recruitment
USF Water Institute	Tampa, FL	Other – data exchanges and technical support
Weill Cornell Medical	New York, NY	Collaborative Research
Wood PLC	Tampa, FL	Other – advice on drainage system modeling

Other collaborators or contacts with involvement in CTECH are listed or described below.

CARTEEH	College Station, TX	Partner (UTEP)
Cornell-Unibo Center for Vehicle Intelligence	New York, NY	H. Oliver Gao is Co-PI of Cornell-Unibo Center
John Swanson	The Villages, FL	Donor – Biodiesel Project

H. Michael Zhang is collaborating on ridesharing research with Maged Dessouky, Dean's Professor and Chair, Daniel J. Epstein Department of Industrial and Systems Engineering, and Jong-Shi Pang, Epstein Family Chair and Professor of Industrial and Systems Engineering, Viterbi School of Engineering. Both are from the University of Southern California in Los Angeles, California. The idea for the project came out of a previous CTECH project.

Michael Kleeman is collaborating with Dr. Peggy Reynolds, an epidemiologist in the Department of Epidemiology and Biostatistics at the University of California, San Francisco. Her research focuses on environmental risk factors for cancer.

3. OUTPUTS

Noise is considered by the World Health Organization as a harmful environmental pollutant and has adverse psychosocial and physiologic effects on public health. Transportation is the major source of environmental noise, particularly in urban areas. With multifaceted impacts on health, road traffic noise originates from several major contributors including engine and exhaust noises, aerodynamic noise, and tire-pavement noise. The tire-pavement noise becomes dominant in the road traffic noise when vehicle speed exceeds certain values. With the increasing use of electric vehicles that do not produce engine or exhaust noise, the proportion of tire-pavement noise in the traffic noise on roads is expected to be higher in the future. Reducing the tire-pavement noise, therefore, will play a more important role in health promotion for the public living along highways and streets.

Qing Lu's project, *Analysis and Design of Pavement Surface Mixtures for Traffic Noise Reduction* at USF analyzed the relationship between design variables and acoustic performance of asphalt mixture and develops design recommendations for porous asphalt mixtures that consider noise reduction at the tire-pavement interface in addition to conventional functions (e.g., high skid resistance and permeability). Potential adjustments to existing designs of porous asphalt mixture are investigated for improving acoustic performance of pavement surface.

Outputs from the study include a semi-empirical model developed by combining a theoretical microstructural model of acoustic absorption of porous media and statistical models that relate the calibrated model parameters to design variables of porous asphalt mixtures. The parameters of the theoretical model are calibrated with acoustic absorption data measured by an impedance tube test on specimens of porous asphalt mixtures of varying design parameters. It was found that the microstructural model with calibrated parameters may reproduce laboratory measurements. The relationship between mixture design variables and mixture acoustic absorption may be estimated using the semi-empirical model. Also, several aggregate gradation related variables affect the acoustic absorption of porous asphalt mixtures, such as nominal maximum aggregate size (NMAS) and percentage passing a certain sieve size (e.g., 2.36 mm). Statistical models were also developed for the relationship between gradation related variables (e.g., NMAS) and tire-pavement noise measured from the field, using data assembled from multiple sources. It is recommended that the design of porous asphalt mixture consider increasing mixture porosity and reducing NMAS under the condition that other pavement surface functions (e.g., skid resistance and durability) are not negatively impacted.

The developed models and analysis results can provide pavement agencies with a better understanding of the relationship between mixture design and acoustic performance of pavement surfaces and provide insights in designing pavement surfaces that contribute to lower tire-pavement noise.

At UC Davis, Fraser Shilling, Michael Zhang and Graduate Student researcher, Shenyang Chen collaborated on a project entitled *Sea Level Rise Resilient Transportation Systems in Coastal Communities.* Global sea-level rise (SLR) is occurring now due to climate change from global warming. More and more studies expect a further acceleration of rising seas shortly, which increases the flooding risks in coastal communities. Flooded road systems will result in the disruption of critical routes, potentially reducing emergency access and egress and pushing travelers to detour, which causes extra vehicle miles traveled and delays. Because of the near-term and long-term threats of sea-level rise to the coastal infrastructure, urban transportation planning has introduced projected future sea level as a key factor. While a recent study projected the traffic delays for the entire San Francisco Bay Area, none have been dedicated to a specific network.

They deployed a simulation-based analysis of flooding's impact on a microscopic traffic network. They selected two typical sites to build the network in the SUMO mobility simulator, the Suisun City

waterfront area, and the City of San Rafael. Both networks are expected to suffer from the rising sea levels. The first is an isolated zone where the major impacts are on local trips. The second, on the other hand, contains critical corridors where flooding can cause massive rerouting of through traffic. Besides understanding and predicting the traffic flow pattern with partially flooded streets, their work also examines the alternatives that maintain the functionality of infrastructure and guarantee evacuation accessibility.

As outputs, they created multiple SLR scenarios for each site of where streets would be expected to flood. In each scenario, the flooded streets are either updated with a lower speed limit or totally closed, depending on the flood depth. Then trip demand and route choice are updated based on the updated network topology. The simulation results are highlighted in three aspects, which are the key indices of SLR impact on mobility: 1) trips removed; 2) increased delay; and 3) increased average trip distance. Then by looking into a network with different SLR levels, we can identify the critical routes and intersections that can significantly undermine performance if inundated, potentially affecting emergency access and long-term use.

The findings of critical routes and intersections will offer specific advice to the project manager with efficient enhancement plans, either by raising up the elevation of infrastructure or expanding the road capacity of alternative routes.

Publications

Journal publications

1) Han, X., Yu, Y., Gao, Z., Zhang, H.M., The value of pre-trip information on departure time and route choice in the morning commute under stochastic bottleneck capacity, *Transportation Research Part B: Methodological*, Under Review.
2) Hou, Z. Wu, K., Zhang, H.M., Investigating the Health Effect of the Bike-sharing Program in New York City, *Transportation Research Part D: Transport and Environment*, Under Review.
3) Ma, R., Zhang, H.M., The Morning Commute Problem with Ridesharing Travelers and Downtown Congestion in Monocentric City Networks, *Transportation Research Part B: Methodological*, Under Review.
4) Balusu, S., Mannering, F., Pinjari, A., Hazard-based duration analysis of the time between motorcyclists' initial training and their first crash, *Analytical Methods in Accident Research*, 2020, Volume 28, Page 100143, DOI: 10.1016/j.amar.2020.100143.
5) Islam, M., Mannering, F., The role of gender and temporal instability in driver-injury severities in crashes caused by speeds too fast for conditions, *Accident Analysis and Prevention*, 2021, Volume 153, Page 106039, DOI: 10.1016/j.aap.2021.106039.
6) Li, Q., Li, X., Mannering, F., An assessment of discretionary lane changing decisions using a random parameters approach with heterogeneity in means and variances, *Transportation Research Record*, 2021, Volume 2675, Pages 1-9, DOI: 10.1177/0361198121992364.

Books or other non-periodical, one-time publications

Nothing to report.

Other publications, conference papers, and presentations

1) Rossetti, T., Daziano, R.A., How does self-assessed health status relate to preferences for cycling infrastructure? A latent class and latent variable approach, TRB 100th Annual Meeting – A Virtual Event, January 24-28 2021.
2) Cheu, R.L., Rincones, R., Ruiz, E., Impacts of COVID-19 on Transportation Engineering Education and Research in the United States, TRB 100th Annual Meeting – A Virtual Event, January 24-28 2021.
3) Luo, Q., Gee, M., Piccoli, B., Work, D., Samaranayake, S., Managing Public Transit during a Pandemic: The Trade-Off between Safety and Mobility, SSRN, 2021, DOI: 10.2139/ssrn.3757210.
4) Zalesak, M., Samaranayake, S., SEIR-Campus: Modeling Infectious Diseases on University Campuses, DeepAI, 2020.

Policy Papers

1) Baghestani, A., Tayarani, M., Allahviranloo, M., Gao, H.O., Equity Dimensions, Environmental Justice, and Health Impacts of New York City Cordon Pricing, *Transportation Research Part D: Transport and Environment*, Under Review.
2) Nadafianshahamabadi, R., Roy, A., Thompson, T., Gao, H.O., Disparities in Exposure to Different Vehicle Types Emissions: Evidence from A Hyper-Local Integrated Transportation, Emission, And Dispersion Modeling System, *Environmental Research Letters,* Submitted.
3) von Grafenstein, L., Gao, H.O., Infrastructure Policy and Public Health: Evidence from OECD Countries, *Science of the Total Environment*, Accepted.

Website(s) or other Internet site(s)

Websites http://ctech.cee.cornell.edu/, https://urbano.io/, and https://www.hbuddy.org/ are continuously being updated.

The Healthy Buddy Program (HBP) is being replicated at University of Texas at Austin (UTA) for Spanish speaking, older adults. The website (https://www.hbuddy.org/) and all of the program materials were translated to Spanish, keeping the same method that has been used for the English Version of the HBP. 20 participants at UTA and USF used the tool.

The computer code and outputs for Fitch and Handy's model, described below under *New methodologies, technologies, or techniques*, and in more detail in the *Outcomes* section below, are at https://github.com/bicyclingplus/micromobility-VMT-sim.

The computer codes for Kwon's proposed hybrid simulation model, described below under *New methodologies, technologies, or techniques*, and in more detail in the *Impacts* section, are shared at https://github.com/diwas07/ride_hailing_disease_spread.

New methodologies, technologies, or techniques

Changhyun Kwon at USF developed a novel hybrid simulation model to estimate disease exposure resulting from the use of ridesharing services. A compartmental model was used for macro-level disease transmission among an urban population, including both documented and undocumented cases, while an agent-based model was used to track micro-level disease transmission through ridesharing services specifically.

One cause of extra travel costs in the transportation system is uncertainty, and this adverse effect can be mitigated by providing information. The Zhang Research Group at UC Davis developed a new method to assess the impact of pre-trip information in the morning commute when the congested bottleneck's capacity is stochastic. This method bypasses the tedious derivations of the conventional approach for this type of problem and provided a much simpler way to obtain the commuting cost of individual commuters and the system. Using this method, they found that providing fully/partially accurate pre-trip information can always reduce the expected travel costs in contrast to no information. When information provided is not one hundred percent accurate, providing pre-trip information still reduces travel costs compared with providing no pre-trip information, when the expected travel costs increase monotonically with the decrease of information accuracy. Furthermore, the more accurate the information provided is, the lower the extra travel costs are. These theoretical results are supplemented by case studies that show examples of benefit gains of providing pre-trip information.

Ricardo Daziano at Cornell tested cycling stimuli delivery over two platforms: head mounted displays (HMD), and large screen displays. The head mounted display provided a more realistic experience due to its ability to replicate real time interaction of the virtual environment, however, the misalignment of user and bike easily induced motion sickness. On the other hand, the large screen displays reduced motion

sickness and were easily adaptable, however it was limited in truly testing the hypotheses given that it does not provide a 360 experience.

Michael Kleeman at UC Davis developed techniques to improve the spatial resolution of emissions inventories for mobile, area, and point sources in California to support twelve years of analysis using chemical transport models that can predict resulting air pollution fields.

Dillon Fitch at UC Davis built a simulation model to analyze the options for data collection which includes the organization of local and public data and computer code. The model encourages considering design and power analysis for transportation research and communicates the expected VMT (and thus emissions) reductions from micromobility services. The next phase of this research will include other benefits/costs such as safety and physical activity to provide a more exhaustive look at the public health impacts associated with micromobility services.

Inventions, patents, and/or licenses

Yiye Zhang's Group at Weill Cornell Medicine (WCM) developed a machine learning model applied to electronic health records (EHRs) to predict the risk of postpartum depression (PPD). The most predictive EHRs of PPD included medical history, active clinical diagnosis, healthcare service utilization, and social determinants of health. An extension of the study retrospectively evaluated the trajectories of clinical events during pregnancy, and the trajectory patterns' association with the built environment while adjusting for clinical cofounders. They found that higher rates of PPD were associated with neighborhoods with homogeneous land use, lower walkability, and lower accessibility to retail stores after adjusting for age, neighborhood average education level, marital status, and income inequality. The machine learning model consists of over 30 clinically interpretable variables most predictive of PPD. Extracted from electronic health records (Epic), this model is intended to serve as an innovative tool to provide tacit clinical decision support without requiring additional workflow burden of the care team. Model output – individualized risk scores and risk factors – will be used to screen for the risk of PPD among pregnant women and to connect high risk women to mental health intervention as primary prevention. Their published research has a provisional patent filed, won the Biomedical Business Plan Challenge in 2019, and led to a startup company, Iris OB Health. Currently, they are under pilot implementation at WCM OBGYN and Psychiatry practices to conduct a 12-month study. They will be evaluating clinician acceptability of the tool and individualized patient's PPD risk prediction while also studying user experience and interface (UI/UX) designs that would optimize the delivery of machine learning outputs in clinical settings. Their implementation partners include WCM Architecture for Research Computing in Health (ARCH), Cornell Tech, and NewYork-Presbyterian IT Transformation. They also constructed a list of variables representing social determinants of health including built environment across the states of New York, New Jersey, Connecticut, and Pennsylvania.

A provisional patent application was filed by Qing Lu in December 2020 and the title of the invention is "Development and Evaluation of Porous Pavement Surface Mixtures with Bio-based Epoxy Asphalt Binder", which resulted from the Year 3 CTECH project of the same title.

Other products, such as data or databases, physical collections, audio or video products, application software or NetWare, analytical models, educational aids, courses or curricula, instruments, equipment, or research material

- Alex Travis is leading two New York State (NYS) public educational initiatives, the NY State Citizen Public Health Leader training and the NYS Public Health Corps certification program. The goal of the first is to have one Leader in every neighborhood and community, up to 100,000 citizens. Leaders will be health literate, will have foundational knowledge related to pressing public health issues, and will have skills to connect and communicate with peers, allies, and key social resources. Presently, they will be able to take an active role in helping their communities

prevent and rebuild from the effects of COVID-19. Over the longer term, this cadre of Leaders will be part of an informed network that can be mobilized to share information, and plan for prevention, detection, and response, in the event of public health emergencies. The second, a 60-hour professional certificate program, was designed to strengthen NYS's workforce dedicated to public health and preparedness. Special emphasis will be on the social and environmental determinants of health and will enable the Fellows to see linkages between topics that have previously been thought of as separate, neither linked to each other nor to public health. For example, exposure to air pollution and other racial/ethnic/social/economic inequities that combine to create disparities in severity of disease and worsened outcomes. H. Oliver Gao contributed instructional content to both programs, supporting Cornell's effort in these initiatives that dovetail with CTECH's efforts and that will add to the public's understanding of how transportation impacts community health.

- H. Michael Zhang and researcher, Rafee Musabbir, advised a group of undergraduate Electrical and Computer Engineering students on their senior project design on modeling vehicle/pedestrian interactions using machine learning approaches for autonomous driving.
- In Cornell's course entitled 'Uncertainty Analysis in Engineering', 151 students in the class worked with the cycling dataset which was used to exemplify the application of statistical concept for policy relevant studies.
- Francis Vanek completed the first run of a Cornell engineering course entitled 'Sustainable Transportation Systems Design' including several new recorded video lectures on sustainable transportation systems engineering.
- Dr. Vanek also incorporated consideration of diversity and inclusion in rebuilding the end-of-life expressway infrastructure in major U.S. cities such as New Orleans, LA and Syracuse, NY. This effort increased the understanding of how the presence of urban expressway infrastructure negatively impacts disadvantaged urban communities, and how it might be redesigned in the future. Participating students will hopefully take those ideas forward and apply them as practitioners in the field.
- Qiong Zhang, in collaboration with Xiaofan Xu, a former Ph.D. student who worked on the Spatial Sustainability Assessment of Green Stormwater Infrastructure for Surface Transportation Planning project, developed an educational case study. It introduces green infrastructure to stormwater management and transportation planning into the course 'Introduction to Environmental Engineering' offered at Florida Polytechnic University in the Spring of 2021.
- Qing Lu incorporated environment and health impacts when teaching about the design of pavement at USF.
- The Samaranayake Group developed the SEIR-Campus: Modeling Infectious Diseases on University Campuses, a Python library for agent-based simulation of infectious diseases on university campuses.
- Qiong Zhang's graduate student improved the SWMM hydrologic model with the data of a fine road network for the city of Tampa, Florida to study the effect of road transportation on the surface runoff. She also calibrated the modified SWMM model using the monitored outfall flow data and station-based rainfall data.
- Ricardo Daziano created a stated preference cycling dataset instrumented bike for immersive experiments.
- Qing Lu developed a semi-empirical model for the acoustic absorption of porous asphalt mixture based on a (theoretical) microstructure acoustic model of porous media and (empirical) statistical models that relate microstructure model parameters to asphalt mixture design parameters. A data set of asphalt mixture design and acoustic performance was assembled by combining data collected from the literature and data from laboratory experiments.
- Xiaopeng Li brought up a physical informed neural network-based tire-road friction estimation method. By utilizing existing on-vehicle sensing technology, including wheel speed sensors and

high-definition GPS with integrated Inertia Measurement Unit (IMU), their method could achieve quick and accurate tire-road friction estimation. Comparing to existing studies, their model would dynamically calibrate the model parameters related to tire condition (e.g., tire pressure and tire wear), and thus would provide a more accurate result. In the expected scenario, with a more capable vehicle equipped with these sensing technologies running on the road, by using an extended Kalman filter data fusion algorithm, they can further improve the accuracy of the estimation. Figure 1 shows the message flow for the overall estimation procedure in a single vehicle.

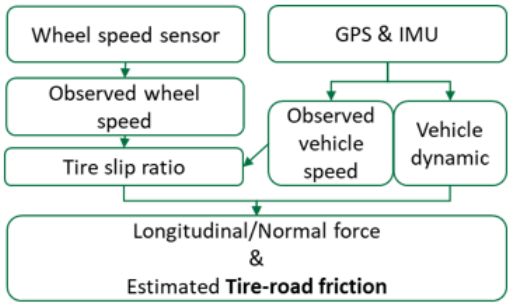

Figure 1 Estimation flowchart

- The Cheu Research Group collected 92 responses from a survey distributed to 700 transportation faculty members in 300 plus accredited civil engineering programs in the United States, on the Impacts of COVID-19 on Transportation Education and Research. The shared information could potentially impact faculty in universities across the country in making transportation engineering education more accessible and lessoning the negative impacts of COVID-19 on transportation research. The resulting TRB paper will be a valuable resource for university administrators to device policies to prepare for future pandemics.

***T2 Plan Output One* – commercialization of research outputs - number of researchers involved in startups – goal of 1 annually.**

Yiye Zhang and Jyotishman Pathak, along with their colleagues at Weill Cornell Medicine, Alison Hermann, and Rochelle Joly, are involved in the startup, Iris OB Health. The newly formed company applies a patent-pending, risk stratification algorithm to clinical data in order to identify and offer appropriate treatment to women at risk of developing postpartum depression.

***T2 Plan Output Two* – commercialization of research outputs - number of patents filed – goal of 4 annually.**

Two provisional patent applications were filed. The first, Using Electronic Health Records and Machine Learning to Predict Postpartum Depression (8781-02-US), and the second, Development and Evaluation of Porous Pavement Surface Mixtures with Bio-based Epoxy Asphalt Binder (63128393). More information is above under *Inventions, patents, and/or licenses*.

4. OUTCOMES

The rise in bicycling and bike share services in North American cities is a sign of latent demand for bicycling. The more recent rise in dock-less bike and scooter shares (micromobility services) indicates the latent demand for "micro" transportation options could be substantial. Given that substitution of bicycling, scootering, and other small vehicle travel for car travel will help cities reach numerous planning goals (e.g., accessibility, emissions, climate, health, equity, etc.), there is a clear need for

understanding the implications of these mobility services. This is especially true in states like California where the rise in micromobility services also represents a growing workforce and capital investment. While micromobility services have the potential to decrease car travel and thus many negative externalities associated with car travel, the extent to which these services decrease car travel is currently uncertain. Similarly, how micromobility services support transit is largely uncertain. How these services might be leveraged to improve equitable access to everyday activities is also an important question many cities currently face. Quantifying the magnitude of micromobility service effects on travel behavior is an important first step for cities and regions to understand the role these services should play as mobility options.

Dillon Fitch and Susan Handy's goal for their project entitled *North American Micromobility Panel* at UC Davis was to quantify the effects of micromobility services on travel mode use and travel distance which in turn can be used to estimate the downstream effects on emissions as well as safety and health more broadly. Because the goal is to examine micromobility services during "normal" travel conditions, the COVID-19 pandemic has caused a delay and led to the restructuring of this project into two phases (Phase 1: study simulation, Phase 2: data collection and analysis). Phase 1 is a simulation study to help design the data collection methods. While this project has many objectives, they chose to focus Phase 1 on estimating VMT reduction from micromobility use. While the model from Phase 1 will help inform Phase 2, it will not solely determine the parameters of Phase 2. Phase 2 will include new data collection (via GPS travel diary and surveys) and analysis. Because Phase 2 is still underway, we only report the outcomes from Phase 1 below.

Study-specific outcomes include:
(1) Simulations of the study by varying the number of cities did not show a clear trend, suggesting that the number of cities is not a strong factor in expected observance of a decrease in VMT from micromobility use. The number of cities is important for a variety of other study goals not addressed in this model (e.g., generalizability), and so city selection will rest on other procedures beyond the model including the ability and available time of the micromobility service providers.
(2) Because of large person-level variation, micromobility trip frequency and distance strongly influence the chance of observing a VMT reduction, while variation in mode substitution at the city level is relatively small, making it less influential. Trip distances are shorter for scooters compared to bikes (by our estimate, 75% less) making it more difficult to observe a VMT reduction from regular scooter users in comparison to bike users. This suggests the need to sample a subset of micromobility users ("super" users) to ensure the study is statistically powered to observe a VMT reduction for both scooters and bikes. Random selection of users based on recent trips suggests a sample with approximately two micromobility trips per week and an estimated power of observing a VMT reduction of only 0.6. In comparison, a sample of users with seven trips per week result in a power of observing a VMT reduction of nearly 0.8.
(3) GPS diary duration increases power to a strong extent (approximately 10 percentage points per week) suggesting longer panels should be selected if budget allows. When examining the tradeoff between increasing sample size and increasing panel duration, results suggest sample size is more important for increasing power. However, the costs of increasing sample size compared to panel duration are much greater due to survey incentives, such that a balance between the two is needed. Our results suggest that 2000 users with a four-week panel provide enough power for the "super" user (n=500 scooter, 500 bike) effect. The lesser power for the "normal" users (n=500 scooter, 500 bike) may not be easily remedied with the current study budget.
(4) In general, the model simulations suggest that this study has a good chance of observing a VMT reduction associated with micromobility use of the users who frequently use micromobility services. For more "normal" infrequent users, the study may be more inconclusive. VMT reduction is only one primary outcome of this study. While this was the focus of our simulation model because of the widespread social implications (e.g., emissions reductions), other outcomes such as changes to safety exposure, physical activity, and transit use are expected, although the powers of observing their effects are unknown.

More generally, this simulation model provides a basis for other studies on a wide variety of other travel behaviors to conduct detailed analysis of potential designs for survey and GPS diary data collection. Simulation models as preparation for an empirical study is a practice that is lacking in the field of travel behavior and social science more broadly, although commonly discussed in the statistical and experimental design literature as an important first step toward building a strong empirical study. By sharing a computational model that leverages a wide variety of data sources and strings together the effects of a series of behavioral models though a copula, we hope other researchers in transportation and beyond can learn how to apply this technique to help design more efficacious studies.

Additional outcomes include:

- Carpooling is often promoted as a mode to reduce traffic congestion and vehicle miles traveled in road networks. The recently completed project entitled *Pooling or not Pooling: the role of matching cost on mixed mode equilibria and VMT* developed a game-based mode-choice model for the morning commute involving carpooling supported by a ridesharing platform. In the model, commuters travel from homes in the suburbs (Origin) to downtown offices (Destination) either driving alone or carpooling. A ridesharing platform provides ride-matching services to carpoolers. Carpoolers riding in one vehicle can equally share the shareable travel costs among them, but will be charged matching fees by the ridesharing platform. It was assumed that all commuters attempt to minimize the average generalized costs, and derive evolutionary stable states (ESS) and social optimum (SO) state by using replicator dynamics and by minimizing the average generalized costs, respectively. Under ESS and SO states, the effects of high-occupancy-vehicles (HOV) lanes and matching fees on commuters' mode choices and the ridesharing platform's profits were analyzed. The findings showed that the platforms profit-seeking behavior may increase congestion on general-purpose (GP) lanes and may reduce the efficiency of the overall system. Congestion on GP lanes is more likely to increase when the ration of HOV capacity to freeway capacity is high, the proportion of shareable travel costs in generalized costs is low, inconvenience costs joining carpools is high, and the platform is profit-seeking. The results of this model showed that ridesharing platforms need to be regulated and HOV capacity needs to be carefully allocated in order for carpooling to benefit everyone.
- The Daziano Group findings showed that people with stated good physical health tend to have preference parameters similar to those of experienced cyclists. This result means that the provision of cycling infrastructure with the purpose of attracting non-cyclists also has the potential of attracting those with worse health outcomes. This result suggests a double benefit coming from car use reduction and lower health pending.
- Qiong Zhang's study showed that Green Stormwater Infrastructure (GSI) as an alternative stormwater management strategy could provide significant benefits such as energy savings and environmental impact reduction, especially when implemented on a large scale (e.g., watersheds). Also, some features of the road transportation system like its low terrain and high impervious rate are key factors to determine the location and type of candidate GSI. Additionally, the density of GSI at a smaller scale such as the zip code area is critical for optimal GSI implementation. The spatial optimization model for GSI implementation, the methods for identifying the existing and candidate GSI, and the hydrological model integrated with GSI, can provide the decision support for improving and optimizing the stormwater management system in surface transportation planning.
- Xiaopeng Li performed a field experiment with their testbed and the tire-road estimation was based on a simple linear model. As shown in Figure 2, during the experiment, 0.3-0.6 tire-road friction coefficients were observed which proved the effectiveness of their method. They continue to work on the model to improve its accuracy. They configured the USF runway Friction tester, which could measure the pavement friction factor to serve as a ground truth. They will use this

friction tester and their automated testbed to collect some friction data in the same spot to train and validate their algorithm.

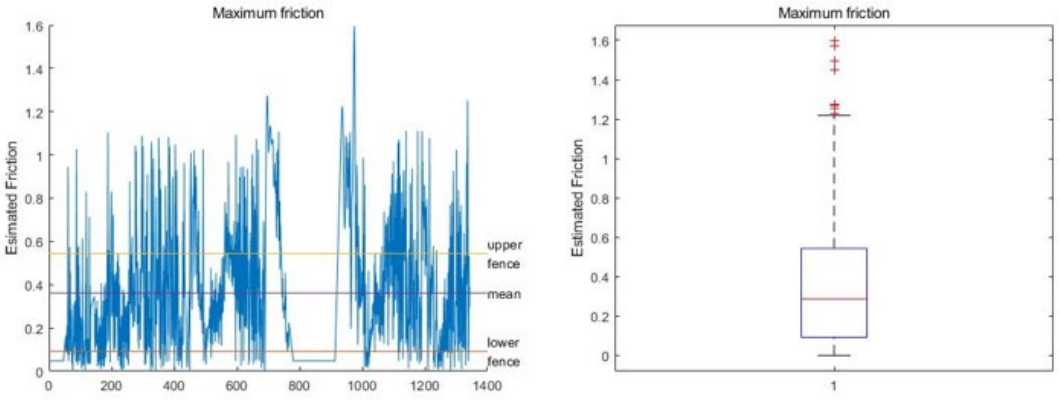

Figure 2 Field experiment result

<u>T2 Plan Outcome One</u> – cited works – Number of reports in media – goal of 8 annually.

The Zhang Group's postpartum depression risk prediction model produced interest in the use of machine learning and electronic health record data to conduct primary prevention of postpartum depression. Their study was named as the "Editor's Choice" in Journal of Affective Disorders, and they have presented the model at Epic Corporation, one of the largest electronic health record vendors in the U.S.

Ruey (Kelvin) Cheu was recognized in the El Paso Herald-Post as one of 16 current UTEP faculty members to be among the world's most cited researchers and those who are among the top 2% within their specialty areas (http://elpasoheraldpost.com/utep-researchers-join-list-of-top-researchers-in-the-world/).

An article about the jointly supported (CUTR and CTECH) Healthy Buddy Program's shift to assist seniors get vaccinated was written about in *The Oracle*, USF Tampa's student run newspaper http://www.usforacle.com/2021/04/06/healthy-buddy-program-changes-its-focus-to-help-seniors-get-vaccinated/.

<u>T2 Plan Outcome Two</u> – cited works – Number of citations/requests of reports, papers, and research briefs – goal of 100 annually.

The following paper published in *Sustainability*, which resulted from Qiong Zhang's CTECH research, had four citations

Xu, X., Schreiber, D.S.P., Lu, Q., Zhang, Q., A GIS-Based Framework creating Green Stormwater Infrastructure Inventory Relevant to Surface Transportation Planning, *Sustainability*, Volume 10, Page 4710, 2018, DOI: 10.3390/su10124710.

Cited by Bottero et al. 2019 "Strategic assessment and economic evaluation: the case study of Yanzhou Island (China)", Rodak et al. 2019 "Urban stormwater characterization, control, and treatment", Adib and Wu 2020 "Fostering Community-Engaged Green Stormwater Infrastructure Through the Use of Participatory Geographic Information Systems (PGIS)", Omitaomu et al. 2021"Planning green infrastructure placement based on projected precipitation data".

5. IMPACTS

Publications and research results from the recently completed project, *Evaluating the Traffic and Emissions Impacts of New York City Cordon Pricing* have been communicated to relevant NYC agencies such as NYC DOT and MTA. Congestion pricing is one important travel demand management strategy. Despite the successful implementation in a few case studies around the world, political barriers have hindered their implementation in the U.S. Results from this study have important implications and impacts in quantifying the environmental/health aspects of congestion pricing in NYC, which would be the first metropolitan area in the U.S. to implement cordon pricing. Findings from this research study, including the establishment of an integrated modeling framework, enables decision makers to precisely estimate traffic and emission impacts of cordon pricing plans. The modeling framework is also transferable to other metropolitan areas, to evaluate their pricing strategies as well as other travel demand management strategies.

Changhyun Kwon, Tapas K. Das, and Miguel Reina Ortiz at USF collaborated on the project *Measuring the Impact of the Large-scale Adoption of Ridesharing on the Spread of Infectious Disease*, which evaluated the role of ridesharing on the spread of infectious diseases during an outbreak using a hybrid compartmental/agent-based modeling approach. This project also compared potential control measures for disease spread in ridesharing: isolating documented infected drivers, disinfecting vehicles, proper precaution and hygiene, and combinations of different control measures. The effectiveness of the control measures was evaluated. A novel hybrid simulation model was developed to estimate disease exposure resulting from the use of ridesharing services. A compartmental model was used for macro-level disease transmission among an urban population, including both documented and undocumented cases, while an agent-based model was used to track micro-level disease transmission through ridesharing services specifically. Key simulation parameters were identified from the case of the COVID-19 outbreak in the Tampa Bay area for numerical experiments. Subsequently, several scenarios resulting from studying various values of key parameters were simulated to assess the level of significance of these parameters. Finally, they simulated the application of different outbreak control measures in ridesharing and analyzed their impact on disease transmission. Results from the study led to the following findings that have important timely implications/impacts:

1. When almost all the documented infected individuals in the city are isolated, only undocumented infected individuals are responsible for the spread of disease. Owing to this fact, the fraction of exposed cases that become infected largely determines the severity of disease progression in the city, as well as the role that ridesharing plays during the outbreak. When only a small fraction of infected cases is identified and isolated, there is an overall increase in both ridesharing exposure as well as the total number of infected cases in the city as compared to the situation when a large fraction of infected cases is identified and isolated.
2. The probabilities of passenger-to-passenger (P2P) and driver-to-passenger (D2P) exposure significantly affect the ridesharing service's role in disease spread. Even though the decrease in both P2P and D2P exposure probability decreases the ridesharing service's role in disease progression, a small change in P2P exposure probability results in a pronounced change in infected cases as compared to a small change in D2P exposure probability. Even with a small penetration, ridesharing service can drastically exacerbate the progression of disease in the city.
3. Different control measures can be implemented at the ridesharing level to diminish the ridesharing exposure to the disease. 100% isolation of documented drivers reduces the D2P exposure but still does not create much difference in overall ridesharing exposure. Another control measure is disinfecting vehicles after each ride, which eliminates the P2P exposure and hence drastically reduces the ridesharing exposure. Similarly, proper precaution and hygiene from both driver and passenger brings down the chance of both P2P and D2P exposure and eventually lowers the total ridesharing exposure.

4. The overall effectiveness of this control measure depends on the efficiency of the precautions and hygiene practices adopted by both parties. However, when each of the above-mentioned control measures is put in practice, rideshare still contributes to a considerable number of exposures, and this increases the number of infected cases in the city. Nevertheless, the combination of all the proposed control measures eliminates the P2P exposure and remarkably reduces the D2P exposure. This helps to make ridesharing service almost a safe mode of transportation even during an infectious disease outbreak in urban settings.

Additional impacts include:

- H. Michael Zhang's research results showed that under certain conditions, profit-seeking ridesharing platforms/companies can exploit the HOV lanes to make a larger profit while harming the efficiency of the overall system. This will be useful to regulators and state DOTs in their regulation of ridesharing platforms/companies and in their provision of HOV lanes.
- Ricardo Daziano's research provides evidence that supports a double benefit from policies that promote cycling among the inexperienced: these not only have the potential benefit of producing a shift towards more sustainable modes of transportation, but also promotes more physical exercise among the population that is less physically fit. This double benefit has the potential to reduce public health spending, as well as to decrease future spending to counter the effects of climate change.
- Qiong Zhang made the SWMM-based model and the optimization model available to the City of Tampa Transportation and Stormwater Services to test its usefulness. The hydrology and sustainability assessment results can advance the knowledge of the benefits of green stormwater infrastructure implemented at the system-level. Ultimately, the environmental and human health impacts will be alleviated through improved stormwater management.
- Xioapeng Li's work toward more accurate tire-road friction estimation can benefit both the vehicle side and the infrastructure side. For the vehicle side, safety is the most concerning issue. Previous studies have revealed that drivers overestimating pavement friction is highly corelated with high accident rates, which would cause a sever safety hazard and high economic loss. Meanwhile, the effectiveness of vehicle stability systems such as the Traction Control Systems (TCS) and the Anti-lock Braking System (ABS) relies much on the tire-road friction estimation. With accurate tire-road friction estimation, vehicle safety and performance of the vehicle stability system can be further improved. For the infrastructure side, the state highway department puts millions of dollars every year into maintaining the highway infrastructure, including the pavement. There is a Maintenance Rating Program (MRP) which is an evaluation system conducting visual and mechanical evaluations of the highway maintenance conditions to schedule and prioritize routine maintenance activities toward providing uniform conditions that meet predetermined objectives. The MRP is mostly conducted manually by infrastructure workers, which is expensive and has low efficiency. By incorporating Li's accurate tire-road estimation method into this procedure, the efficacy of MPR can be improved, and time and resources saved.

<u>T2 Plan Impact One</u> –impact on practice – number of research recommendations implemented – goal of 7 annually.

Qing Lu's efforts have increased the scientific knowledge in the field of acoustic performance of asphalt mixture and design variables. A microstructural model of porous asphalt mixture for sound absorption was adapted and applied to the design of asphalt surface mixtures for improved noise performance of pavement for use in the existing design procedures of porous asphalt mixtures to allow noise performance as one of the design objectives.

<u>T2 Plan Impact Two</u> –software applications – number of algorithms, codes, software used by researchers – goal of 7 annually.

Jizheng Liu, from the Beijing Institute of Technology, contacted the Zhang Research Group at UC Davis about the data and algorithms developed from a CTECH project that minimizes the fuel consumption of Connected Autonomous Vehicle platoons going through intersections. Data and codes were shared with them for use in their research.

R package gmni for the estimation of discrete choice models was either downloaded or updated by 100 individuals.

Weill Cornell Medicine researchers and practitioners used the newly developed model detailed above under *Inventions, patents, and/or licenses*.

6. CHANGES/PROBLEMS

Across all four partner institutions, there were continued delays in acquiring data, an inability to recruit for surveys and/or engage public participants, lower response rates to online surveys, and less outreach due to the COVID-19 circumstances. Field and laboratory work continue to be hindered due to full or partial shutdowns of college campus research capabilities. Reduced funding and/or students relocating back to their home cities rather than staying on campus challenged some research groups. Inefficiencies working from home also continues to negatively affect productivity.

The opportunities for in-person collaborations and to participate in conferences, meetings, or events remain limited. Also, there is an inability to organize student related professional opportunities/events.

On the positive side, new projects related to COVID-19 and air quality have begun. In another situation, delayed data collection led researchers to construct a new simulation model to improve the collection methods and techniques.

7. SPECIAL REPORTING REQUIREMENTS

CTECH Specific Metric: Overarching goals of the Center include the development of a metric for community health that incorporates mobility and health indicators; mobility on-demand models including environmental sustainability indicators; large-scale models to promote environmental sustainability, community health, and environmental justice.

During this reporting period, for example, researchers Mohammad Tayarani and Oliver Gao at Cornell integrated the large-scale travel demand model of New York City with EPA's MOVES model to quantify emissions impacts of different congestion pricing scenarios in downtown Manhattan for the evaluation and promotion of community health and environmental justice in important transportation policies. Congestion pricing is one of the strategies aimed at curbing traffic demand and relieving traffic congestion. London, Singapore, and Stockholm have implemented this strategy, not only to reduce congestion, but also to reduce the concentration of traffic-related pollutions, and overall improve the quality of the air. However, despite recent attention to the contribution and effectiveness of congestion pricing, there is little evidence in the literature on the impacts of pricing on changing the origin-destination (OD) matrices for different modes. Therefore, a comprehensive, continuous, and precise analysis is necessary to simulate the outcome of the pricing policy in terms of demand variation, network performance, and traffic emissions.

This ex-ante study was aimed at analyzing how pricing strategies in New York City impact transportation demand, network assignment, and traffic emissions by studying the public reaction to cordon pricing through changes in their activity patterns. They studied cordon-pricing by implementing a dynamic

feedback loop in an activity-based travel demand model of the New York metro area. Applying the activity-based model can address the growing complexity in travel patterns and enable a more credible analysis of responses to policies that are generally influential in transport planning and policy-making. Such models, which are more sensitive to scenarios, could potentially allow for a variety of activity patterns such as mode and destination choices simultaneously. Manhattan, as the second-largest central business district (CBD) in the world and first in the U.S. based on the number of trip attractions and job opportunities, is selected as the case study. The New York Best Practice Model (NYBPM) and the Post Processing Software for Air Quality (PPS-AQ) are employed to analyze the cordon pricing impacts on trip generation, OD trip matrices, network performance measures, and vehicle emissions. More specific outcomes from the study include: 1) a non-linear pattern regarding the pricing charges was observed in changes in both traffic congestion and vehicle emission; 2) a significant reduction in taxi trips across NYC that was shifted mostly to transit system; and 3) besides the changes in the travel mode preferences, a change in trip distributing due to the charging schemes was also noticed.