MAKING NEW MOBILITY A WIN FOR PUBLIC HEALTH

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CARTEEH

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Designing mobility interventions to improve public health requires a framework that formulates strategies for the deployment of mobility to maximize the potential for cross-cutting public health impacts. Researchers developed such a framework using a combination of epidemiology and simulation modeling. A case study is presented to demonstrate how a strategic dose of mobility could improve food access for the South Baltimore community of Cherry Hill.</td></tr>
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Executive Summary

Over the next several years, as new mobility technology providers seek permission from local governments across the nation to deploy their services, policy makers will have a window of opportunity to shape deployments to improve public health. A framework is needed to formulate strategies for the deployment of these new forms of mobility that will maximize the potential for cross-cutting public health impacts. Such a framework needs to combine elements of community engagement, epidemiology, systems modeling and simulation, and data from real-world pilots and deployments. There is a crucial need to develop and validate this framework for city officials to guide decision-making related to the health impacts of new mobility.

We developed the framework using a combination of epidemiology and simulation modeling. We identified the neighborhood of Cherry Hill in South Baltimore as a candidate community for a targeted intervention, and reviewed the epidemiology of this area. Traffic simulation was used to measure the impacts of the potential intervention.

The proposed framework is capable of providing stakeholders with essential components, such as benefits to public health, as well as unintended consequences, to consider trade-offs and make decisions in policy-making processes. We demonstrated a case study of Cherry Hill for enhancing nutritious food access through a mobility intervention.

The accomplishments of this project have been presented at a national conference and during several lectures and webinars. A manuscript based on the project was submitted to *the Journal of Transport Policy* and is under review.

Acknowledgments

The project team would like to thank the residents of Cherry Hill who participated in community meetings for providing input on the strategies proposed in this report.

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Background and Introduction

> **CARTEEH QUICK FACTS**
>
> **CARTEEH** is a Tier 1 University Transportation Center, funded by the U.S. Department of Transportation's Office of the Secretary for Research and Technology.

Transportation intersects with health in a number of ways. Transportation affects individual access to health care, nutritious food, and educational or economic opportunities (1). Simultaneously, transportation-related air pollution contributes to smog and reduces air quality, which has negative impacts on health (2). Motor vehicle crashes are also a leading cause of death in the United States (3). A variety of new mobility products and services, such as rideshare, electric scooters, bicycles, and autonomous vehicles, could extend the reach of mobility options, simultaneously improving health, air quality, and safety.

Local government officials are the gatekeepers for deployment of new mobility. If city policy makers have evidence-based models for deployment of such services in a manner that optimizes social benefits, including improved air quality, they can set these conditions as prerequisites. Lacking reliable and objective evidence, most jurisdictions will not have the time and resources for analysis, and the potential for community benefit from new mobility services will be compromised.

The premise of this work is that new mobility is controllable by public policy and therefore a viable public health intervention. Our hypothesis is that strategic deployment of mobility innovations could provide health benefits related to improved access (specifically, access to nutritious foods) while maintaining or improving air quality.

Problem

Over the next several years, as technology providers seek permission from local governments across the nation to deploy their services, policy makers will have a window of opportunity to shape deployments to improve public health. A framework is needed to formulate strategies for the deployment of new mobility that will maximize the potential for cross-cutting public health impacts. Such a framework needs to combine elements of community engagement, epidemiology, systems modeling and simulation, and data from real-world pilots and deployments. There is a crucial need to develop and validate this framework for city officials to guide decision-making related to the health impacts of new mobility.

Approach

To give our work practical application, we developed and applied the framework in the context of a 12-month pilot implementation of a new mobility intervention in South Baltimore as part of the South Baltimore Go! project and demonstrated a case study. Neighborhoods selected by the South Baltimore Go! pilot were used to assess the potential impacts of the proposed subsidized traffic interventions. The case study selected Cherry Hill in South Baltimore as the study area.

We developed the framework using a combination of epidemiology and simulation modeling. We then validated the effectiveness of the framework using the real-world data generated through the South Baltimore Go! pilot project. We had the following aims:

1. **Identify new mobility deployment scenarios that will improve health outcomes.** We conducted a series of roundtables with community members, policy officials, public health experts, and industry representatives to design deployment scenarios that align mobility concepts with improving road safety, air quality, and access to healthy food.

2. **Simulate new mobility deployment scenarios and assess impacts on health outcomes.** We used existing epidemiological data from the South Baltimore area including those related to safety, food access, and air quality. We combined transportation models with simulation techniques to project the anticipated effects of new mobility interventions as part of the South Baltimore Go! project on a range of public health outcomes. Roadway and infrastructure characteristics, police-reported crashes, food access, and air quality information were included in the simulation models.
3. **Validate the simulation models using real-world data from the South Baltimore Go! pilot project.** We evaluated the validity of the models developed in the second aim using data generated through the South Baltimore Go! pilot project. Validity was assessed in terms of the feasibility of implementing the intervention and on the potential scalability of the intervention concept.

Methodology

We began by conducting roundtable discussions with community leaders and city officials from the South Baltimore area. Each roundtable had 12 to 15 participants who represented thought leaders from the local community, as well as policy and public health constituents. We also included representatives of new mobility providers. Our goal was to identify scenarios for deployment that would maximize public health impact and minimize unintended consequences. The discussion guides for the roundtables were submitted to the Johns Hopkins School of Public Health Institutional Review Board for approval prior to going into the field.

Municipalities in the United States routinely use coarse-grained transportation models such as the Integrated Transport and Health Impact Model to forecast the public health effects of project-level transportation plans and policies (4–6).

More recent methods known as activity-based models have been proposed that capture travel dynamics and population impacts at finer spatial and temporal resolutions based on activity patterns on individuals at a micro-level (7). For the proposed work, such models using detailed demographic information of our target populations would be needed to assess health impacts (8).

We used the SUMO traffic simulation software (9), which has the capability of integrating with Google's online representations of roadways that include details of traffic lanes and signals at intersections (10). Figure 1 shows a snapshot of a typical scenario. A suite of simulations were conducted to assess the primary health impacts of interest in the proposed work: road safety, air quality, and food access.

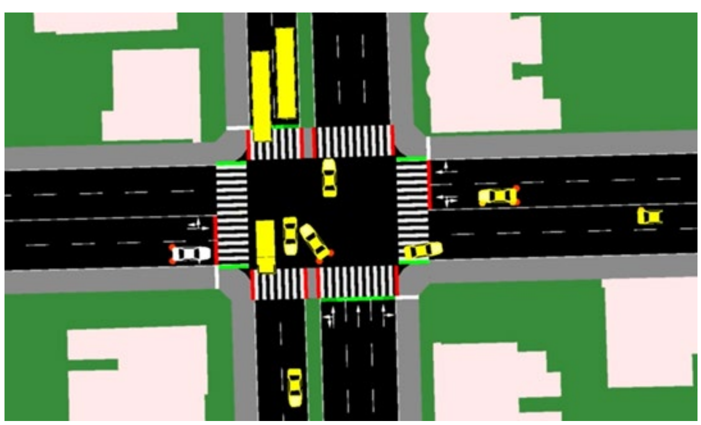


Figure 1. Screenshot from the SUMO traffic simulation software that shows road user intersection behavior.

To assess accessibility and quantify improvement of autonomous vehicle (AV) deployment strategies, the accessibility analysis index was adopted. The accessibility index takes parameters, such as the travel time, number of accessible destinations, weight of destinations, and population, into consideration and estimates the average opportunity accessibility for grocery stores for each unit, such as a block group. The equation of for the accessibility index adopted in this project is as follows:

$$A_i = \frac{\sum_j w_j D_j}{POP_i}$$

where i is the index number of travelers, j is the index number of accessible destinations, A_i is the accessibility index of the traveler, POP_i is the population of the block group that the traveler belongs to, D_j is the indicator for the accessible destination, and w_j is the weighted value of the destination determined by travel time. This equation is modified from Dharmadhikari and Lee's accessibility function (11). The weighted value is acquired from the travel time decay curves (12).

With the data generated by the South Baltimore Go! pilot project, we could assess the validity of the simulation models developed in the second aim. The case study was examined to validate the feasibility of the intervention in achieving public health objectives at the micro-level. Scalability was examined to identify potential barriers to widespread deployment. Selection of specific outcome measures and sampling designs for the validations was determined by the nature of the mobility interventions used in the South Baltimore Go! pilot project. Validation measures were designed to reflect the community needs expressed in the roundtables.

Results

We conducted detailed epidemiological modeling and travel simulation modeling to inform the work of the planned mobility intervention in South Baltimore. Our work identified the neighborhood of Cherry Hill as a candidate community for a targeted intervention (Figure 2 shows one example of the spatial epidemiology). These findings were presented to the South Baltimore Go! Pilot Project Advisory Committee over the course of the past quarter. Our results informed the advisory group decision to conduct an initial pilot intervention focused on increasing grocery access for Cherry Hill residents using subsidized ridesharing trips. After several rounds of discussion, we selected the two intervention strategies:

- **AV rideshare.** AVs operate as ridesharing services like Uber and Lyft.
- **Loop shuttle.** AVs operate as shuttles traveling on loop routes to facilitate existing public buses by helping residents move to bus stops faster.

We demonstrated the improvements and impacts of these two strategies on nutritious food access in Cherry Hill neighborhoods.

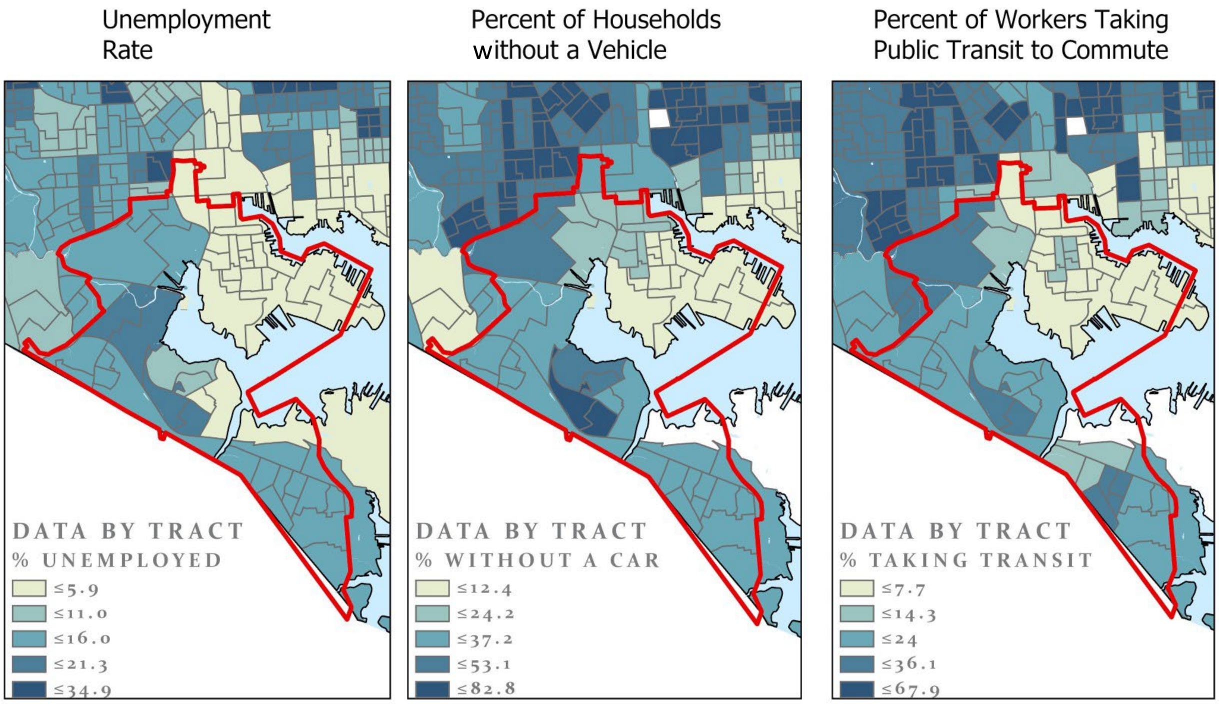


Figure 2. Population characteristics in South Baltimore area by census tract.

According to our findings and surveys, the traffic conditions in Cherry Hill are not ideal. Many residents have no access to a car, so they rely heavily on public transit. However, only two bus lines travel through the residential area of Cherry Hill. This results in low accessibility to grocery stores, representing healthy food, for the residents of Cherry Hill. Figure 3 shows a feature map of Cherry Hill.

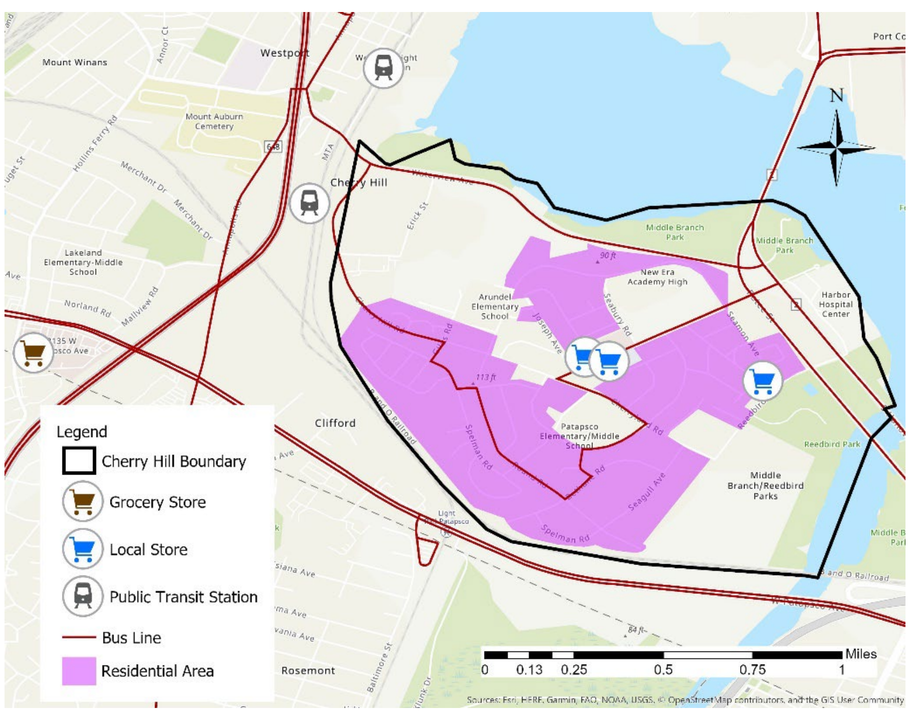
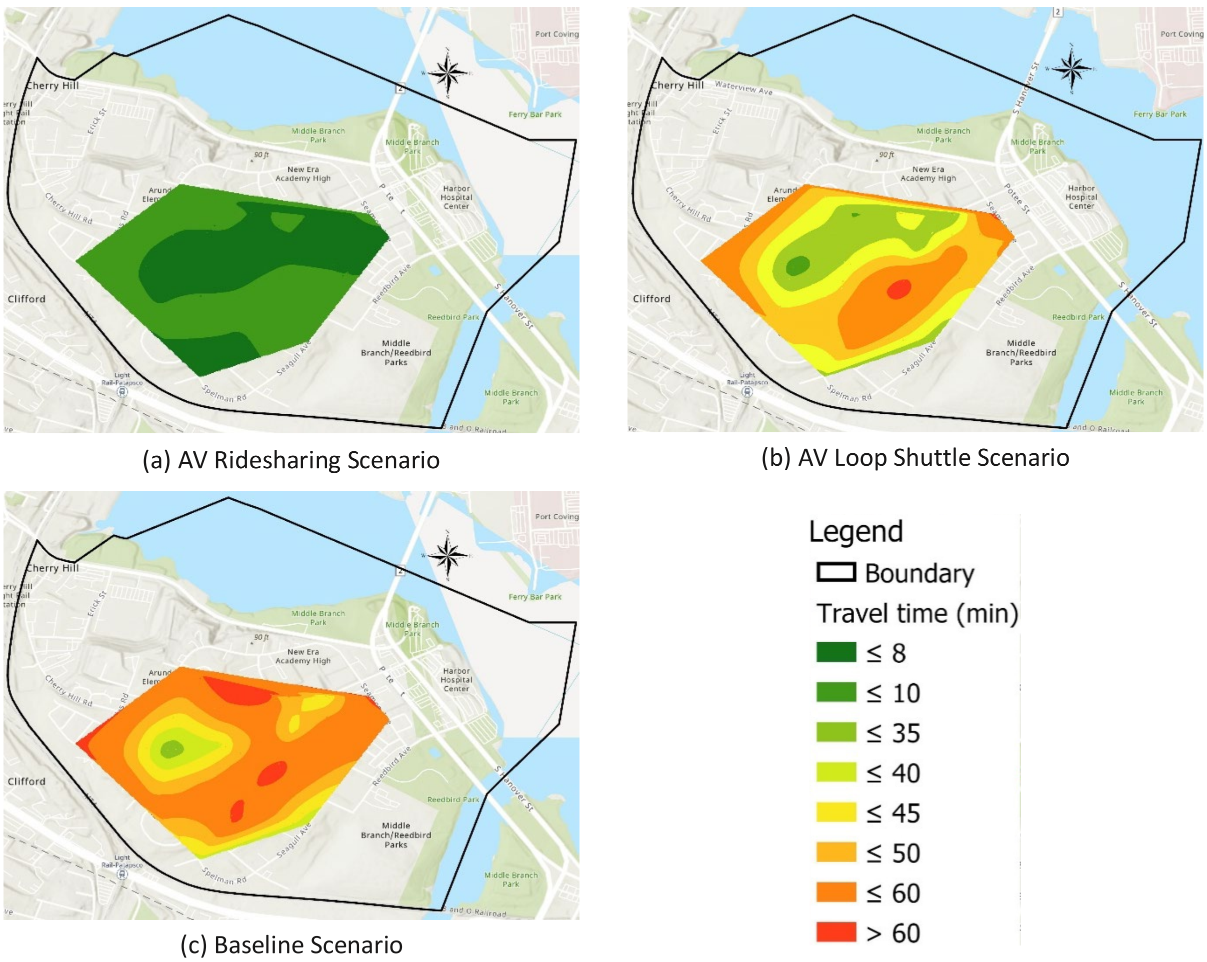


Figure 3. Feature map of Cherry Hill in South Baltimore.

With detailed simulation modeling, we aimed to understanding two issues:

1. The impact of projected interventions in Cherry Hill in South Baltimore.
2. The COVID-19 impacts on transportation, air quality, and health.

Related to the first issue, we defined the baseline scenario as residents traveling by public buses. For AV simulation scenarios, AVs were added to the baseline scenario according to the previously described deployment strategies. The purpose of these scenarios was to assess improvements in accessibility to the closest grocery store to Cherry Hill. Figure 4 shows the estimated travel times. Figure 4(c) shows the simulated traveling time of residents in the baseline scenario, Figure 4(a) displays the estimated result of the AV ridesharing scenario, and Figure 4(b) shows the simulation result of the AV loop shuttle scenario.



(a) AV Ridesharing Scenario

(b) AV Loop Shuttle Scenario

(c) Baseline Scenario

Figure 4. Simulation results of traveling time to the closest grocery store for residents in Cherry Hill.

In addition to travel time estimation, we aggregated the simulation results to the accessibility index calculation. The accessibility index of each resident was computed, and the average of these indices was considered as the accessibility index for the scenario. We rescaled all accessibility indices of the scenarios, with the baseline scenario as 1, to compare the improvement of our intervention strategies. Table 1 summaries the resulting accessibility indices.

Table 1. Relative Accessibility Indices of All AV Scenarios Compared to the Baseline Scenario

Strategy	Scenario	Relative Accessibility
AV rideshare	Baseline	1
	25% AV trips	1.40
	50% AV trips	1.97
	75% AV trips	2.76
	100% AV trips	3.52
AV loop shuttle	Baseline	1
	Route 1	1.24
	Route 2	1.17
	Route 3	1.11
	All routes	1.28

The simulation results show a significant improvement in travel time. AV operations could reduce the traveling time for the residents of Cherry Hill to go from their houses to the closest grocery store. While the AV rideshare strategy reduces travel time and increases accessibility much more than the AV loop shuttle strategy does, the AV rideshare strategy has the limitations of high demand and costs. Therefore, for better scalability and sustainability, the AV loop shuttle strategy is more appropriate.

For simulation of vehicle emission, we designed different illustrative scenarios related to the COVID-19 issue. The simulation scenarios were based on when the public transit services in Maryland were adjusted in 2021 due to COVID-19 impacts. The modification scenarios are simulated within the Cherry Hill area to estimate changes in gas emission. Table 2 shows the results of the demonstration.

Table 2. Gas Emission of Simulation Scenarios in Cherry Hill

Gas Emission	Baseline	Scenario 1 Less Travelers	Scenario 2 Less Traveler & Less Public Transit
Resident trips	40% driving 60% public bus	24% driving 36% public bus	Reduced trips & 20% change of bus services
CO	1.54 kg/hr	0.91 kg/hr	0.83 kg/hr
CO_2	180.41 kg/hr	134.38 kg/hr	147.24 kg/hr
PM_x	40.55 g/hr	31.17 g/hr	34.31 g/hr

Conclusions and Recommendations

Our case study demonstrated the application of the proposed framework on designing traffic policies. Simulation scenarios can provide information and insights for the candidate traffic policies. Moreover, the potential improvements for public health and unexpected outcomes estimated in the simulation give stakeholders essential components to consider tradeoffs and make decisions in policy-making processes.

Outputs, Outcomes, and Impacts

The outputs are the developed novel applications of the SUMO software.

The outcomes are the proposed framework for traffic policy making.

Research Outputs, Outcomes, and Impacts

This research produced the following outputs, outcomes, and impacts:

- **Peer-reviewed publications:** Chang, C.H., Michael, J.P., Mueller, J.M., Duffy, F.S., Ehsani, J.P., Golub, M., and Igusa T. Integrated Policy Development Framework for Assured Autonomous Vehicles: Case Study of Healthy Food Accessibility. *Transport Policy* (under review).
- **Presentations at conferences:** Chang, C.-H. *Evaluation of Potential Autonomous Vehicle Deployment Strategies to Improve Health-Food Accessibility.* Second Transportation, Air Quality, and Health Symposium, 2021.
- **Online graduate course:** Transportation, Policy and Health 305.630.01.
- **Graduate Seminar at Civil and Systems Engineering, Johns Hopkins University:** Ehsani, J., and Michael, J., October 6, 2022.
- **Webinar:** *COVID-19 Impacts on Transportation, Air Quality, and Health.* November 9, 2020.

Technology Transfer Outputs, Outcomes, and Impacts

This research produced the following technology transfer outputs, outcomes, and impacts:

- Simulated data of travel time estimation and accessibility indices for Cherry Hill neighborhoods.
- Scenarios about potential AV deployments for the SUMO software.
- Videos and figures of work accomplishment.

Education and Workforce Development Outputs, Outcomes, and Impacts

This project involved three doctoral students and numerous masters-level students. Principal investigator Johnathon Ehsani supervised Michelle Duren from the Department of Health Policy and Management at the Bloomberg School of Public Health. Co-investigator Takeru Igusa supervised Chia-Hsiu Chang and Matthew Golub from the Department of Civil Engineering from the Whiting School of Engineering. All doctoral students were involved in all aspects of this project and were able to use the data generated from this CARTEEH project as a case study for academic courses for which they received credit.

In addition, the investigators presented the study findings in a number of academic and professional settings including public seminars, webinars, and conferences as part of the dissemination of the research findings.

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