Increasing Accessibility of Driver Training Through Scholarships and Technological Intervention

Megan S. Ryerson, Ph.D. (PI) (https://orcid.org/0000-0002-8843-3286)
Xiaoxia Dong, Ph.D. (https://orcid.org/0000-0002-3907-3237)
Jasmine Siyu Wu, MCP (https://orcid.org/0000-0002-3855-4872)
Elizabeth A. Walshe, Ph.D. (https://orcid.org/0000-0002-0466-4272)
Flaura K. Winston, MD, Ph.D. (https://orcid.org/0000-0001-6632-1403)

July 31, 2025

DISCLAIMER

The contents of this report reflect the views of the authors, who are responsible for the facts and the accuracy of the information presented herein. This document is disseminated in the interest of information exchange. The report is funded, partially or entirely, under [grant number 69A3552344811 / 69A3552348316] from the U.S. Department of Transportation's University Transportation Centers Program. The U.S. Government assumes no liability for the contents or use thereof.

Technical Report Documentation Page

1. Report No. 569	2. Government Accession No.	3. Recipient's Catalog No.
4. Title and Subtitle Increasing Accessibility of Driver Training Through Scholarships and Technological Intervention: A Web-Based Decision-Support Tool for Equitable Resource Allocation in Ohio		**5. Report Date** July 31, 2025 **6. Performing Organization Code**
7. Author(s) Megan S. Ryerson, Ph.D. (PI) (https://orcid.org/0000-0002-8843-3286) Xiaoxia Dong, Ph.D. (https://orcid.org/0000-0002-3907-3237) Jasmine Siyu Wu, MCP (https://orcid.org/0000-0002-3855-4872) Elizabeth A. Walshe, Ph.D. (https://orcid.org/0000-0002-0466-4272) Flaura K. Winston, MD, Ph.D. (https://orcid.org/0000-0001-6632-1403)		**8. Performing Organization Report No.**
9. Performing Organization Name and Address Department of City and Regional Planning, University of Pennsylvania Meyerson Hall, 127, 210 N 34th St, Philadelphia, PA 19104		**10. Work Unit No.** **11. Contract or Grant No.** Federal Grant # 69A3552344811 / 69A3552348316
12. Sponsoring Agency Name and Address Safety21 University Transportation Center Carnegie Mellon University 5000 Forbes Avenue Pittsburgh, PA 15213		**13. Type of Report and Period Covered** Final Report (July 1, 2024 – June 30, 2025) **14. Sponsoring Agency Code** USDOT
15. Supplementary Notes Conducted in cooperation with the U.S. Department of Transportation, Federal Highway Administration.		

16. Abstract

Timely access to driver education is essential for safe, independent mobility among youth in the U.S., especially in states that mandate driver education for junior licensure under Graduated Driver Licensing (GDL) laws. Yet, structural and spatial barriers often delay licensure in disadvantaged communities. In Ohio, variations in financial and spatial access to certified driver training instruction create Driver Training Deserts (DTDs) that limit youth participation in the GDL system. This study describes the development and evaluation of an interactive, statewide mapping tool designed to identify DTDs and support more equitable allocation of driver education resources. We combined U.S. Census data with travel time estimates to the nearest driver training centers and created tract-level indicators of access and economic disadvantage. The tool incorporates customizable thresholds, enabling users to compare scenarios and visualize areas of compounded need. Feedback from tool users highlighted the tool's value for grantmaking efficiency, while also underscoring challenges such as the need for updated service provider data and supplemental layers. Findings illustrate how participatory design and applied geographic analysis can bridge the gap between descriptive research and operational decision-making. By offering an adaptable platform to target investments where most needed, this work demonstrates a scalable approach to addressing transportation inequities. Future development will focus on integrating dynamic data sources, expanding contextual indicators, and evaluating long-term impacts on licensure outcomes supported by grants. The methods and lessons presented here offer guidance for practitioners and researchers to apply spatial decision-support tools in other policy domains concerned with access and equity.

17. Key Words	18. Distribution Statement
Spatial decision support, mapping tool, youth mobility, Driver Training Deserts	

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price
Unclassified	Unclassified	23	

Form DOT F 1700.7 (8-72) Reproduction of completed page authorized

TABLE OF CONTENTS

1. INTRODUCTION

Timely access to driver education and training is an essential, yet often overlooked, dimension of youth mobility and transportation equity in the United States. Earning a driver's license before adulthood is not only a milestone of independence but also a prerequisite for reaching employment, education, and social opportunities, especially in states where public transit is sparse (Brown & Handy, 2015; Vaca et al., 2021). Yet, substantial disparities persist in how young people are able to meet licensure requirements. While Graduated Driver Licensing (GDL) policies have shown growing evidence in improving young drivers' safety outcomes (Chapman et al., 2014; Shell et al., 2015; Tefft et al., 2014; Walshe et al., 2022), they have also introduced complex barriers—financial, logistical, and spatial—that can delay or deter licensure among those with the fewest resources (Dong, Wu, Jensen, et al., 2023; Noble, 2005; Shults & Williams, 2013).

In Ohio, as in many parts of the country, these obstacles are compounded by the uneven geography of driver training services. Teens living in rural areas or high-poverty neighborhoods frequently face long travel distances to driver education and certified behind-the-wheel (BTW) instruction providers, a reality that adds further cost and time burdens. For families already balancing constrained budgets and work schedules, the cumulative effect of these challenges can make participation in GDL largely out of reach. Over time, such structural disadvantages not only limit young people's access to safe mobility but also reinforce broader patterns of social and economic exclusion.

Recognizing these inequities, state agencies have introduced programs designed to expand driver education capacity and reduce cost barriers for underserved communities. However, allocating funding effectively requires tools that can reliably pinpoint where need is greatest and where investments are most likely to improve outcomes. Although prior research has quantified

gaps in training access and proposed metrics to identify “Driver Training Deserts” (Ryerson et al., 2022), there remains a pressing need to operationalize these insights into accessible, practitioner-oriented platforms that can inform real-world decisions.

This paper addresses the gap by presenting the development and user evaluation of an interactive mapping tool designed to support equitable resource allocation for driver education in Ohio. The tool integrates spatial measures of travel time with economic indicators to classify and visualize communities with compounded barriers to licensure. It also incorporates user feedback from state practitioners to enhance its usability and relevance in grant-making processes. In doing so, this work demonstrates how applied geographic analysis can be translated into actionable decision-support systems that help advance transportation equity.

2. BACKGROUND

This section situates the project within the broader context of delayed licensure, spatial inequities in access to driver education, and emerging policy responses in Ohio. It also reviews prior scholarship on decision-support tools in social policy and highlights persistent gaps in translating descriptive spatial analysis into operational planning resources. Together, these strands of evidence underscore the need for practical, equity-focused tools to guide investment decisions and support transportation safety goals.

2.1. Delayed Licensure, Driver Training Deserts, and Policy Motivations in Ohio

Obtaining a driver’s license has long been viewed as a rite of passage in the United States—a gateway to independence, employment, and participation in civic life. Yet, for many young people today, especially those in low-income, racially marginalized, or geographically isolated communities, licensure is increasingly delayed or out of reach. While often framed as a personal decision or generational shift, delayed driving licensure (DDL) more accurately reflects a web of

structural barriers: the cost of formal driver education, limited access to nearby training centers, lack of practice vehicles, and inadequate public transit alternatives. As such, licensure timing is best understood not as an individual behavior, but as a reflection of systemic inequities in access to safe and independent mobility (Brown & Handy, 2015; Vaca et al., 2021; Wu, 2025).

In recent years, researchers have begun to quantify these barriers and their consequences. Ryerson et al. (2022) introduced the concept of Driver Training Deserts (DTDs) to describe areas where residents face both high travel times to driver training centers and high rates of poverty—two factors that often co-occur and compound each other's effects. Their study, focused on the Columbus Metropolitan Statistical Area in Ohio, found that driver training centers are spatially clustered and often absent from lower-income or more rural areas. Using travel time estimates and Census tract–level poverty data, they classified neighborhoods as DTDs if they fell above the 75th percentile on both metrics in the region. The following study demonstrated that DTDs disproportionately house residents who are least likely to meet the requirements for licensure before age 18, despite often having the highest need for independent transportation (Dong, Wu, Walshe, et al., 2023).

These insights align with a broader body of research on delayed licensure and transportation equity. As others have shown, comprehensive GDL systems—while effective in reducing crash risk, as demonstrated by growing evidence (Chapman et al., 2014; Shell et al., 2015; Walshe et al., 2022)—require significant investments of time, money, and logistical support. All states in the U.S. have adopted the GDL laws and often require formal (e.g., in-class driver education and BTW training with certified instructors) and/or informal (e.g., adult-supervised practice) driver education (Walshe et al., 2024). For example, in Ohio, teens seeking licensure before age 18 must complete 24 hours of coursework and 8 hours of BTW instruction with a

certified instructor, in addition to 50 hours of adult-supervised practice (Walshe et al., 2024). These training services are often privatized and cost several hundred dollars. For families without disposable income, flexible work schedules, or access to a vehicle for practice, these requirements can be prohibitive. As a result, many youths delay licensure until age 18, when these requirements are lifted—a strategy that circumvents financial and institutional barriers but also forfeits the safety benefits associated with GDL participation (Dong, Wu, Jensen, et al., 2023; Dong, Wu, Walshe, et al., 2023; Tefft et al., 2014).

Compounding these challenges is the spatial distribution of training services. Many high-poverty neighborhoods and rural communities in Ohio lack close proximity to driver training providers, creating what Ryerson et al. (2022) described as a "geography of exclusion." In these DTDs, structural constraints and spatial disconnects converge, denying teens access to formal instruction during the developmental window when it is more effective. These gaps undermine the equity goals of GDL and suggest that safety-enhancing policies cannot succeed without corresponding investments in infrastructure and access (Dong, Wu, Walshe, et al., 2023).

Recognizing these disparities, the Ohio Governor has initiated two complementary initiatives aimed at improving access to driver education and training, administered by the Ohio Traffic Safety Office (OTSO). The Creating Opportunities for Driver Education (CODE) program provides grants to public school districts, educational service centers, career technical programs, and licensed driver training providers to start or expand driver education and training instruction programs (Ohio Traffic Safety Office, 2024). Its explicit aim is to support capacity-building in underserved areas of the state. Separately, the Drive to Succeed program offers funding to local agencies—such as health departments and police departments—which then distribute scholarships for driver education to eligible teens based on locally defined criteria (Ohio Governor Office,

2023). While CODE focuses on increasing the supply of training opportunities, Drive to Succeed addresses the demand side by reducing cost barriers for individual families.

In response to the need to prioritize resources strategically, we aim to provide the OTSO with a statewide tool that could help visualize and quantify geographic disparities in access to driver training. Building on the Ryerson et al. (2022) methodology, our team developed an interactive DTD web map for the entire state of Ohio. This tool overlays spatial measures of travel time to the nearest driver training center with economic indicators such as poverty rate, enabling users to identify high-need communities where geographic and economic barriers converge. The goal was to create a transparent, evidence-informed platform to guide driver education grant decisions and support broader planning for equitable youth mobility.

2.2. Gaps in Social Policy and Decision-Support Tool Development

Despite substantial advances in spatial analysis and public health research, tools that translate insights about inequities into actionable policy decision-support remain limited in scope, accessibility, and integration with institutional processes. In the context of driver education access specifically, most existing scholarship focuses on descriptive analysis—quantifying disparities in training availability or modeling associations with delayed licensure—without extending these insights into operational frameworks for planning or funding allocation (Brown & Handy, 2015; Ryerson et al., 2022; Vaca et al., 2021).

This gap reflects a broader challenge in social policy research: the development of tools that not only visualize disparities but also inform resource distribution in ways that are transparent, replicable, and responsive to practitioner needs. While numerous studies have mapped spatial inequities in domains such as food access (Mohamed & Bromfield, 2017), health care services (McLafferty, 2003), and climate vulnerability (Houghton et al., 2012; Neset et al., 2016), few have

documented how such tools are embedded in real-life decision-making or how feedback from decisionmakers shapes their refinement. As a result, there is often a disconnect between analytic frameworks identifying areas of need and the institutional mechanisms that could allocate resources to address those needs.

This disconnect is further compounded by three recurring limitations in the design and deployment of decision-support systems. First, many tools prioritize static data visualization over dynamic, interactive exploration of spatial scenarios. Without the ability to filter, reclassify, or export data layers, policymakers may struggle to adapt tools to evolving programmatic goals or community contexts (Fournier et al., 2023). Second, equity considerations are frequently treated as secondary or supplementary, rather than being integrated into the core logic of tool design. Even when economic indicators are incorporated, the weighting of variables and thresholds is often opaque, limiting the transparency and trust required for public resource allocation (Ziolkowska & Reyes, 2016). Third, documentation of stakeholder engagement in tool development is sparse. Although participatory processes have been identified as essential for usability and adoption (Kwak et al., 2024; Venkatesh et al., 2016), many tools are developed without sustained input from the practitioners expected to implement them.

In the specific policy domain of driver education access and delayed licensure, this gap has real consequences. Without tools that integrate spatial and economic indicators in an actionable format, agencies risk reinforcing inequities by directing funding toward applicants with more administrative capacity rather than those serving the highest-need communities. Furthermore, the lack of documented feedback loops limits the ability to assess whether such tools are effective in guiding equitable investments.

This study addresses these gaps by combining three contributions rarely integrated in a single project: (1) a scalable methodology for defining DTDs statewide, (2) an interactive web-based platform designed explicitly for grant funding prioritization, and (3) an iterative feedback process with state policymakers and tool users to evaluate and refine the tool. By doing so, it demonstrates how translational research can bridge the divide between descriptive spatial analysis and operational policy implementation, offering lessons for the broader field of social policy and applied geography.

3. METHODS

This study applied and extended the DTD framework developed by Ryerson et al. (2022) to create a statewide, interactive mapping tool designed to inform equitable resource allocation. The methods encompass three components: (1) assembling and processing spatial and economic data; (2) defining the analytical framework and classification thresholds; and (3) developing the web-based tool architecture and interface.

3.1. Data Collection and Processing

We assembled and integrated multiple data sources to calculate the indicators and prepare the visualization layers for the tool. We obtained economic data from the 2018–2022 American Community Survey (ACS) 5-Year Estimates at the Census tract level. To compute tract-level poverty rates, we divided the population below the federal poverty threshold by the total population. This indicator served as one of the two primary criteria for identifying areas with high economic disadvantage (described further in Section 3.2: Analytical Framework and Thresholds). In addition to poverty, we generated other demographic and economic variables using the ACS estimates, including population density, median household income, the proportion of teens (ages 15–17), and the proportion of youth (ages 15–24). For geographic boundaries, we retrieved Census

tract and county shapefiles for the state of Ohio from the 2022 Census Bureau TIGER/Line Shapefiles.

To map the geographic distribution of driver training centers, we collected the names and addresses of providers from the Ohio Department of Public Safety's online portal (Ohio Department of Public Safety (DPS), n.d.) as of December 2023. We geocoded each address using the Google Maps Platform APIs. This dataset included both public high schools offering BTW training and private driver training centers. As of December 2023, there were 354 centers categorized as "Teen Driving Schools" by the Department of Public Safety, representing a decline from 431 centers reported in December 2021.

For travel time estimation, we used the ***R5r*** package, an open-source R interface for multimodal routing on detailed street networks (Pereira et al., 2021) . We generated realistic estimates of driving time using the 2023 OpenStreetMap (OSM) street network and current traffic conditions. Across the entire state of Ohio, we created 1 km × 1 km grid cells to capture spatial variation in access. We computed the shortest driving time from each grid cell to the nearest active driver training center and then aggregated these results to the tract level by calculating mean and maximum travel times (as described in Ryerson et al., 2022). This approach improved the spatial precision of accessibility estimates compared to using a single tract centroid, especially in large or irregularly shaped tracts. We focused on driving times as the primary measure of physical access to driver training, given the limited availability of public transportation and walkable connections in Ohio. As discussed in Ryerson et al. (2022), we found that only a small number of centrally located grid cells offered public transit travel times under 60 minutes. The majority of grid cells either exceeded this threshold or lacked public transportation connections altogether.

Throughout all stages of spatial data processing, we projected datasets to the WGS 84/UTM Zone 17N coordinate reference system (EPSG:32617) to ensure consistency in measurement and visualization. We aggregated all indicators to the Census tract level, which served as the primary unit of analysis for identifying DTDs and presenting results in the web-based mapping interface.

3.2. Analytical Framework and Thresholds

Consistent with Ryerson et al. (2022), we operationalized the concept of DTDs by identifying census tracts that simultaneously exhibit high poverty and limited geographic access to driver training. While the original approach applied the 75th percentile cutoff to both dimensions, we adapted the framework to improve interpretability and flexibility in a statewide policy context. Specifically, after consulting with experts in the field and practitioners in Ohio, we set the poverty criterion at the 75th percentile of tract-level poverty rates across Ohio (≥22.9%), which we rounded to ≥20% to facilitate clearer communication with tool users and policymakers. This threshold ensured consistent identification of economically disadvantaged areas across diverse communities.

To address variation in travel patterns and planning needs, the tool incorporated three travel time thresholds to define limited access to training:

- Group 1: Mean travel time to the nearest driving school ≥75th percentile (10.9 minutes, rounded to 10 minutes).
- Group 2: Mean travel time ≥90th percentile (15.4 minutes, rounded to 15 minutes).
- Group 3: Mean travel time ≥95th percentile (18.9 minutes, rounded to 20 minutes).

This approach identified 267 tracts (Group 1), 95 tracts (Group 2), and 51 tracts (Group 3) statewide. Figure 1 shows the distribution of DTDs under three travel time thresholds.

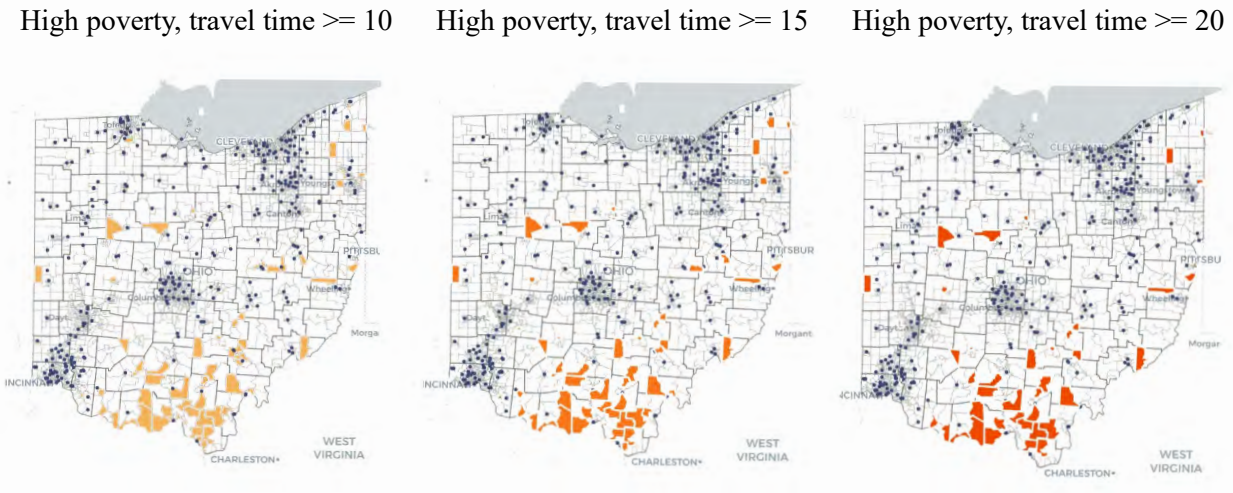

Figure 1. Ohio Driver Training Deserts (DTDs) are defined by above-average poverty rates and various travel times to the nearest driving schools.

This multi-threshold design allows users to compare different access scenarios without requiring computational recalculation. By selecting among preloaded definitions, decisionmakers can explore how alternative cutoff values affect the classification and spatial distribution of DTDs. This approach balances methodological rigor with practical usability in real-time grant review and planning processes.

3.3. Tool Development and Presentation

We developed the DTD map tool as an interactive web-based application built entirely in R. The workflow relied on the ***Leaflet*** package (Cheng et al., 2024), which rendered dynamic maps saved as standalone HTML files for distribution or website hosting. This approach allowed us to create a flexible, portable resource that required no specialized software installation or server maintenance. Because all data processing and threshold classification occurred offline in R, the final HTML output required no database connection or backend server, supporting easy distribution and use.

The interface was designed to be accessible for non-technical users, emphasizing clear visualization, intuitive navigation, and multiple options for exploring different scenarios. Users can toggle among three DTD definitions reflecting alternative thresholds of mean travel time to the nearest driving school (≥10 minutes, ≥15 minutes, and ≥20 minutes) combined with a poverty rate of at least 20%. Figure 2 shows the statewide overview with tracts meeting the Group 1 criteria highlighted.

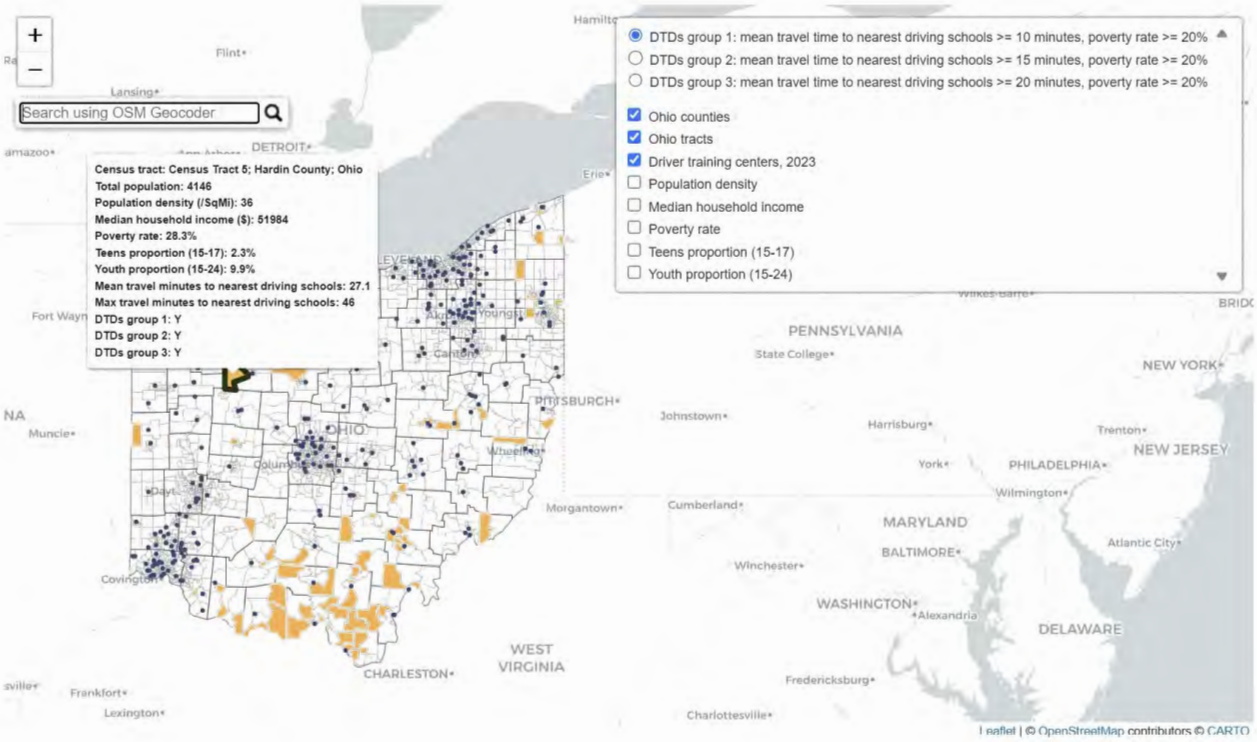

Figure 2. Statewide overview of the Driver Training Deserts web tool showing tracts meeting Group 1 criteria (mean travel time ≥10 minutes, poverty rate ≥20%) highlighted in orange. Driver training center locations are indicated by points. The pop-up label displays detailed tract-level economic and access indicators.

In addition to the main DTD classifications, the tool provides several optional overlay layers displaying Census tract-level economic characteristics, including poverty rate, median household income, population density, and the proportion of teens and youth. Users can activate

these layers individually to explore contextual factors that may influence access needs. For example, Figure 3 illustrates the median household income overlay, demonstrating how the tool supports a more holistic understanding of community characteristics.

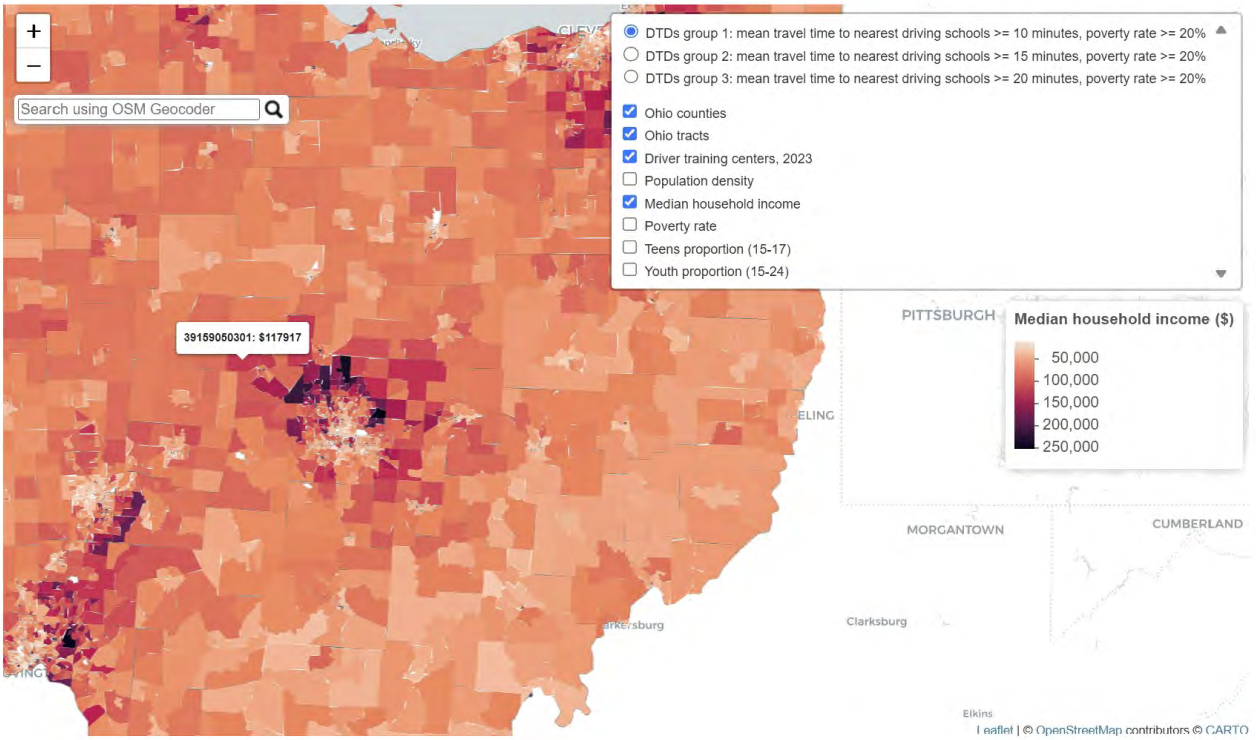

Figure 3. Median household income overlay demonstrating the ability to visualize additional demographic and economic context alongside DTD classifications. The choropleth shading supports equity-focused grant decision-making.

To improve interpretability, we used custom color palettes and highlight options that visually distinguished different DTD groups and background demographic layers. Hover actions dynamically display tract-level labels with detailed information, including poverty rates, demographic indicators, and mean travel times. The tool also integrates an interactive search function, enabling users to locate specific addresses or tracts by typing keywords in the search bar. Figure 4 demonstrates this feature along with an example pop-up displaying detailed attributes for a selected driver training center.

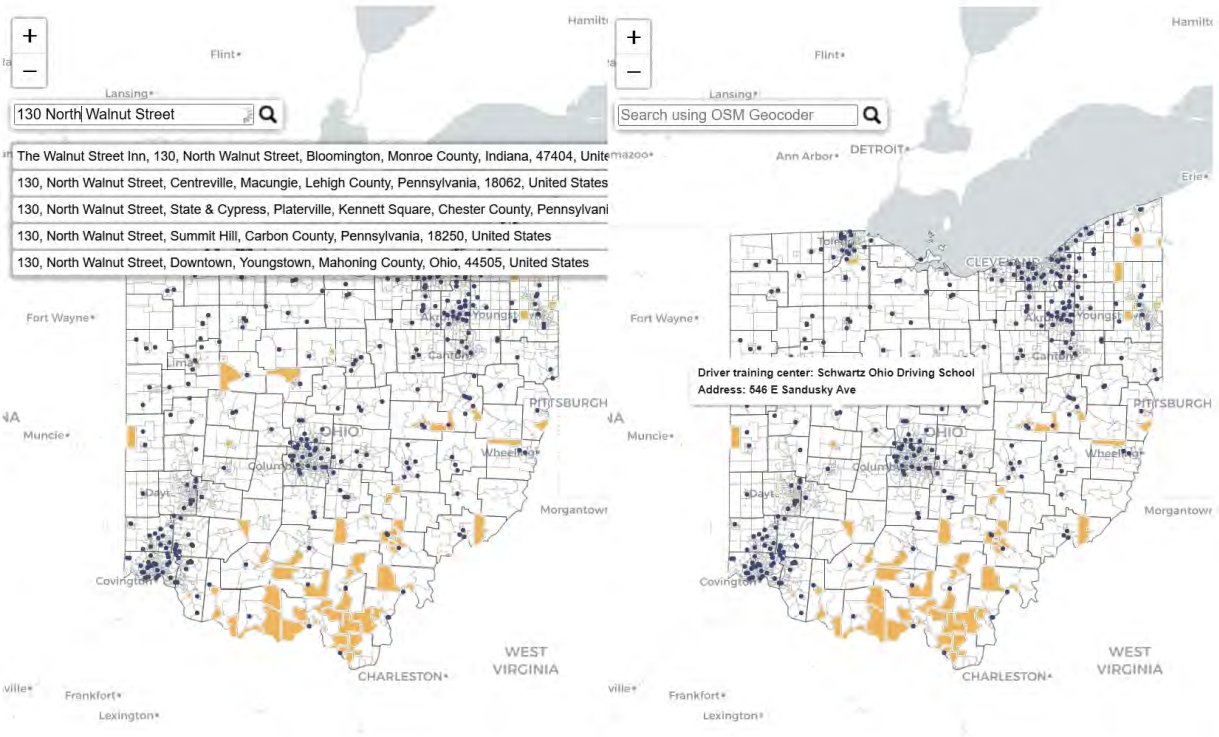

Figure 4. Example of the search functionality and interactive labeling. Users can locate addresses or tracts and view detailed data on training access and demographics.

Overall, the DTD map tool was designed as both a reference resource and an exploratory platform, enabling decision makers to validate grant applications, identify high-need areas, and better understand the spatial distribution of disadvantage and training access across Ohio.

4. FEEDBACK FROM TOOL USERS

To evaluate the utility, usability, and limitations of the Ohio DTD web tool, we conducted a series of semi-structured interviews and written feedback exchanges with staff from the OTSO between January and March 2025. These discussions focused on the tool's role in supporting grant decision-making, its perceived accuracy and relevance, and opportunities for future enhancements. Table 1 summarizes the main topic areas and guiding questions explored during these conversations.

Table 1. Summary of Discussion Topics and Example Insights from Policymaker Feedback

Topic Area	Key Questions Discussed	Examples of Insights
Usage and Context	In what ways did you use the DTD web tool?	Primarily for CODE grant review; not used for Drive to Succeed.
Data Accuracy and Relevance	How accurate did you find the data? What improvements are needed?	Some provider locations disagree with actual service providing areas; recommended more frequent updates.
Desired Enhancements	What features or data would you like to see added?	Junior licensure rates, service catchment zones, and overlays of demographic/safety indicators requested.
Decision-Making Impact	How did the tool support making decisions about funding priorities or workflow?	Improved efficiency and transparency; easier to justify funding allocations.

OTSO staff primarily viewed the DTD web tool as a supportive resource for reviewing applications in the CODE Grant Program. This program aims to expand the driver training capacity in underserved areas by providing grants to establish or grow BTW instruction. Staff noted that the tool's visualization of poverty rates and travel time to the nearest driving school, displayed as separate layers, helped identify neighborhoods with varying levels of barriers to accessing driver education. By enabling comparisons of economic and demographic conditions across census tracts, the DTD tool provided additional confirmation of areas most in need of investment. OTSO used this information to support decisions about how to allocate resources strategically and prioritize applicants proposing programs in high-need communities.

Despite these benefits, users highlighted several limitations. A consistent concern involved the accuracy of the provider's location data. The dataset retrieved from the Ohio Department of Public Safety reflects only registered enterprise addresses, typically classroom sites, without any indication of the actual BTW service areas. OTSO officials observed that approximately 70% of students now complete the classroom portion of driver education online, and many physical training school locations have closed as a result. With fewer registered enterprise sites, the DTD map tool struggled to capture the full scope of BTW service availability. This discrepancy between business registration addresses and real-world service coverage created uncertainty about whether the mapped access accurately reflected current conditions of BTW training. This shortcoming, however, can be addressed; participants emphasized that frequent and validated updates to provider's location data would be essential to maintain the tool's relevance over time.

OTSO staff also identified several enhancements that would increase the tool's value for decision-making. They recommended integrating tract-level data on junior licensure rates and average age at first licensure to complement poverty and access measures, thereby providing a more complete picture of youth mobility needs. Additionally, they expressed interest in collecting information on BTW service catchment areas to better account for provider's reach beyond the registered addresses. Finally, staff proposed adding overlays of related demographic or safety indicators, such as youth population density or crash incidence, to support more holistic and data-informed resource allocation.

Overall, OTSO staff reported that the tool improved the efficiency and transparency of the grantmaking process. The ability to export tract-level data and visualize high-need communities was particularly valuable. At the same time, they emphasized that the tool's effectiveness depends on ongoing data updates. This feedback highlights both the promise and the challenges of

integrating spatial decision-support tools into operational policy processes, underscoring the importance of iterative refinement and sustained collaboration with end-users. More broadly, it illustrates how pairing spatial analysis with responsive, practitioner-informed design can help ensure that decision-support tools translate research into meaningful policy impact.

5. DISCUSSION

This study demonstrates how a scalable DTD framework can be operationalized through an interactive mapping platform to support more equitable resource allocation. By combining measures of poverty and travel time, the tool reveals substantial geographic disparities in access to driver education and training across Ohio. The integration of multiple travel time thresholds enables policymakers to explore alternative definitions of limited access without requiring additional data processing. Feedback from the tool users suggests that the tool improved the efficiency of grantmaking decisions, while also highlighting the critical importance of maintaining accurate and current data on training provider locations.

This project advances the literature on spatial equity and applied decision-support tools in several ways. First, it extends the original DTD framework (Ryerson et al., 2022) from a metropolitan case study to a comprehensive statewide application, demonstrating that such methods are adaptable to diverse geographies and policy contexts. Second, it illustrates how interactive web-based tools can move beyond static visualization to support real-world operational decisions, a dimension often missing in previous studies of spatial inequity (Fournier et al., 2023). Finally, the iterative development process anchored in practitioner feedback underscores the value of co-design in creating tools that are both methodologically rigorous and practically usable (Kwak et al., 2024; Venkatesh et al., 2016). Together, these contributions show how translational research can bridge the gap between descriptive spatial analysis and actionable policy implementation.

For policymakers and transportation safety officials, this study underscores the potential of interactive mapping tools to make inequities visible and to guide more targeted investments in youth mobility infrastructure. By integrating economic indicators and travel time thresholds into an intuitive interface, the DTD tool helps decision-makers prioritize funding in a data-informed and evidence-informed manner. However, sustained impact depends on several conditions: regular updates to underlying data sources, clear documentation of assumptions and limitations, and the provision of training materials to build user confidence. In this context, spatial tools should be viewed not as static products but as evolving resources that require ongoing collaboration between researchers, practitioners, and community stakeholders.

Several limitations warrant consideration. First, the analysis relied on registered addresses for driver training providers, which do not always correspond to the actual locations where BTW training instruction occurs. OTSO staff noted that the growing prevalence of online coursework and the closure of physical classrooms complicate efforts to accurately measure access. Second, the tool focuses exclusively on driving times as the primary indicator of access, omitting other important factors such as vehicle availability, household transportation costs, or public transit options. Third, while the approach and platform are broadly transferable, their applicability varies in states with different licensure requirements, funding structures, or spatial configurations of training services.

Future work could explore several directions to enhance the utility and impact of this approach. Creating supplementary resources, such as recorded demonstrations, step-by-step guides, or live training sessions, will help build user confidence and support broader adoption among practitioners. Additional layers, including vehicle ownership rates, crash incidence, or measures of transit accessibility, could provide a more comprehensive picture of mobility

challenges. Finally, longitudinal studies assessing whether investments guided by this tool lead to measurable improvements in licensure rates, transportation access, or safety outcomes would offer valuable insights into the effectiveness of data-informed grantmaking strategies.

6. CONCLUSION

This study demonstrates how applied spatial analysis and practitioner-informed design can advance more equitable approaches to transportation policy. By developing and implementing an interactive mapping tool to identify DTDs across Ohio, we further illustrated how combining poverty indicators with travel time measures can make structural barriers to licensure visible and actionable. Feedback from practitioners suggests that the tool improved the efficiency of grantmaking decisions, while also highlighting critical areas for continued development, such as data validation and user support.

The experience of creating this platform underscores that decision-support tools are not static products but evolving resources shaped by iterative refinement and sustained collaboration. As agencies grapple with the challenges of reducing delayed licensure and ensuring safe, independent mobility for all youth, tools like the Ohio DTD map can play a vital role in targeting investments where they are most needed.

Future efforts should build on this foundation by expanding contextual indicators and evaluating long-term outcomes of funding decisions informed by spatial analysis. In doing so, researchers and practitioners can work together to ensure that innovations in geographic information systems translate into meaningful improvements in transportation equity and public health.

7. ACKNOWLEDGE

The authors gratefully acknowledge the Ohio Traffic Safety Office (OTSO) for their partnership and invaluable contributions to this project. We thank the OTSO staff for sharing their insights, providing feedback on the development and refinement of the Driver Training Deserts (DTDs) map tool, and supporting efforts to improve equitable access to driver education across Ohio.

8. CONTRIBUTIONS

The authors confirm contribution to the paper as follows: study conception and design: Jasmine Siyu Wu, Xiaoxia Dong, Elizabeth A. Walshe, Flaura K. Winston, Megan S. Ryerson; data collection and analysis: Jasmine Siyu Wu; interpretation of results: Jasmine Siyu Wu, Xiaoxia Dong, Elizabeth A. Walshe, Flaura K. Winston, Megan S. Ryerson; draft manuscript preparation: Jasmine Siyu Wu, Xiaoxia Dong, Elizabeth A. Walshe, Megan S. Ryerson. All authors reviewed the results and approved the final version of the manuscript.

11. REFERENCES

Brown, R. E., & Handy, S. L. (2015). Factors Associated with High School Students' Delayed Acquisition of a Driver's License: Insights from Three Northern California Schools. *Transportation Research Record*, *2495*(1), 1–13. https://doi.org/10.3141/2495-01

Chapman, E. A., Masten, S. V., & Browning, K. K. (2014). Crash and traffic violation rates before and after licensure for novice California drivers subject to different driver licensing requirements. *Journal of Safety Research*, *50*, 125–138. https://doi.org/10.1016/j.jsr.2014.05.005

Cheng, J., Schloerke, B., Karambelkar, B., Xie, Y., Wickham, H., Russell, K., Johnson, K., library), V. A. (Leaflet, library), C. (Leaflet, library), L. contributors (Leaflet, plugin), B. C. (leaflet-measure, plugin), J. D. (Leaflet T., plugin), B. B. (Leaflet M., plugin), N. A.

(Leaflet M., plugin), L. V. (Leaflet awesome-markers, plugin), D. M. (Leaflet E., plugin), K. A. (Proj4Leaflet, plugin), R. K. (leaflet-locationfilter, plugin), M. (leaflet-omnivore, … PBC. (2024). *leaflet: Create Interactive Web Maps with the JavaScript "Leaflet" Library* (Version 2.2.2) [Computer software]. https://cran.r-project.org/web/packages/leaflet/index.html

Dong, X., Wu, J. S., Jensen, S. T., Walshe, E. A., Winston, F. K., & Ryerson, M. S. (2023). Financial status and travel time to driving schools as barriers to obtaining a young driver license in a state with comprehensive young driver licensing policy. *Accident Analysis & Prevention*, *191*, 107198. https://doi.org/10.1016/j.aap.2023.107198

Dong, X., Wu, J. S., Walshe, E. A., Winston, F. K., & Ryerson, M. S. (2023). Residing in a Driver Training Desert leads to Delayed Licensure: Investigating the Relationship between Accessibility to Driver Training and Young Driver's Licensure. *Findings*. https://doi.org/10.32866/001c.85096

Fournier, E. D., Federico, F., Cudd, R., & Pincetl, S. (2023). Building an interactive web mapping tool to support distributed energy resource planning using public participation GIS. *Applied Geography*, *152*, 102877. https://doi.org/10.1016/j.apgeog.2023.102877

Houghton, A., Prudent, N., Scott, J. E., Wade, R., & Luber, G. (2012). Climate change-related vulnerabilities and local environmental public health tracking through GEMSS: A web-based visualization tool. *Applied Geography*, *33*, 36–44. https://doi.org/10.1016/j.apgeog.2011.07.014

Kwak, Y., Chen, S., & Deal, B. (2024). Transitioning complex socioeconomic modeling to informed and visualized decision-making: A tightly coupled planning support system. *Applied Geography*, *169*, 103332. https://doi.org/10.1016/j.apgeog.2024.103332

McLafferty, S. L. (2003). GIS and Health Care. *Annual Review of Public Health*, *24*(1), 25–42. https://doi.org/10.1146/annurev.publhealth.24.012902.141012

Mohamed, M., & Bromfield, N. F. (2017). Attitudes, driving behavior, and accident involvement among young male drivers in Saudi Arabia. *Transportation Research Part F: Traffic Psychology and Behaviour*, *47*, 59–71. https://doi.org/10.1016/j.trf.2017.04.009

Neset, T.-S., Opach, T., Lion, P., Lilja, A., & Johansson, J. (2016). Map-Based Web Tools Supporting Climate Change Adaptation. *The Professional Geographer*, *68*(1), 103–114. https://doi.org/10.1080/00330124.2015.1033670

Noble, B. (2005). Why are some young people choosing not to drive? *PROCEEDINGS OF ETC 2005, STRASBOURG, FRANCE 18-20 SEPTEMBER 2005 - TRANSPORT POLICY AND OPERATIONS - EUROPEAN POLICY AND RESEARCH - ACCESS TO TRANSPORT AND FUTURE ISSUES*. https://trid.trb.org/view/846325

Ohio Department of Public Safety (DPS). (n.d.). *Find a Driving School*. Retrieved May 30, 2022, from https://services.dps.ohio.gov/DETS/public/schools

Ohio Governor Office. (2023, March 16). *Governor DeWine Announces Teen Driver Safety Scholarship Awards*. Governor of Ohio. https://governor.ohio.gov/media/news-and-media/governor-dewine-announces-teen-driver-safety-scholarship-awards-03162023

Ohio Traffic Safety Office. (2024). *Creating Opportunities for Driver Education (CODE)*. https://otso.ohio.gov/grants/driver-training-grants/code

Pereira, R. H. M., Saraiva, M., Herszenhut, D., Braga, C. K. V., & Conway, M. W. (2021). r5r: Rapid Realistic Routing on Multimodal Transport Networks with R^5 in R. *Findings*. https://doi.org/10.32866/001c.21262

Ryerson, M., Davidson, J., Wu, J. S., Feiglin, I., & Winston, F. (2022). Identifying community-level disparities in access to driver education and training: Toward a definition of driver training deserts. *Traffic Injury Prevention*, *23*(sup1), S14–S19. https://doi.org/10.1080/15389588.2022.2125305

Shell, D. F., Newman, I. M., Córdova-Cazar, A. L., & Heese, J. M. (2015). Driver education and teen crashes and traffic violations in the first two years of driving in a graduated licensing system. *Accident Analysis & Prevention*, *82*, 45–52. https://doi.org/10.1016/j.aap.2015.05.011

Shults, R. A., & Williams, A. F. (2013). Trends in driver licensing status and driving among high school seniors in the United States, 1996–2010. *Journal of Safety Research*, *46*, 167–170. https://doi.org/10.1016/j.jsr.2013.04.003

Tefft, B. C., Williams, A. F., & Grabowski, J. G. (2014). Driver licensing and reasons for delaying licensure among young adults ages 18-20, United States, 2012. *Injury Epidemiology*, *1*(1), 4. https://doi.org/10.1186/2197-1714-1-4

Vaca, F. E., Li, K., Tewahade, S., Fell, J. C., Haynie, D. L., Simons-Morton, B. G., & Romano, E. (2021). Factors Contributing to Delay in Driving Licensure Among U.S. High School Students and Young Adults. *Journal of Adolescent Health*, *68*(1), 191–198. https://doi.org/10.1016/j.jadohealth.2020.05.003

Venkatesh, V., Thong, J. Y. L., & Xu, X. (2016). *Unified Theory of Acceptance and Use of Technology: A Synthesis and the Road Ahead* (SSRN Scholarly Paper 2800121). Social Science Research Network. https://papers.ssrn.com/abstract=2800121

Walshe, E. A., Romer, D., Nagaard, N., & Winston, F. K. (2024). *Licensed to Drive but are they Prepared to be Safe? Young Driver Training Requirements Vary Widely by State*.

Walshe, E. A., Romer, D., Wyner, A. J., Cheng, S., Elliott, M. R., Zhang, R., Gonzalez, A. K., Oppenheimer, N., & Winston, F. K. (2022). Licensing Examination and Crash Outcomes Postlicensure in Young Drivers. *JAMA Network Open*, *5*(4), e228780. https://doi.org/10.1001/jamanetworkopen.2022.8780

Wu, J. S. (2025). *Driving Delayed: Public Health and Planning Perspectives on Adolescent Mobility Access.*

Ziolkowska, J. R., & Reyes, R. (2016). Geospatial analysis of desalination in the US – An interactive tool for socio-economic evaluations and decision support. *Applied Geography*, *71*, 115–122. https://doi.org/10.1016/j.apgeog.2016.04.013