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Project Title

Understanding Paratransit: Examining Time Inefficiencies and the Efficacy of Alternative Modes for Persons with Disability

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Research Needs

Based on American Community Survey (ACS) estimates, persons with disability (PWDs) represent a significant proportion of the U.S. population. Further, older adults constitute an increasing share of those with one or more disabilities. As baby boomers age, the U.S. is projected to have a higher percentage of the population with age-related disabilities including independent living disability, self-care disability, and ambulatory disability (Erickson et al. 2019; Li and Tilahun 2017; Smith et al. 2008). Within the U.S. population, 12.7% (or 40.7 million) individuals have one or more disability. One in four (or 7.4 million) U.S. persons 65 to 74 and 48.7% (or 9.8 million) over 74 have one or more disabilities (Erickson et al. 2019). Further, 5.5%

(or 17.1 million) individuals experience one or more deprivations including disability while not also being low-income (Mitra and Brucker 2017).

Research indicates that PWDs have lower access to opportunities such as employment (Grisé et al. 2018; Wong et al. 2020). Further, compared to those with a disability for $\leq$ 6 months, those with lifetime disability are less likely to make errand or shopping trips (Henly and Brucker 2019). Social exclusion remains high among PWDs, who often experience transportation disadvantage (Combs et al. 2016). Researchers show that PWDs face high levels of isolation and low life satisfaction (Bascom and Christensen 2017; Li and Tilahun 2017). This is partly due to a reliance on public transit (Bascom and Christensen 2017; Cochran 2002; Velho 2019), which remains challenging for PWDs to use effectively in most of the U.S. (e.g., Kim et al. 2020). Yet service providers may view transportation disadvantage differently than those who experience it firsthand (Shay et al. 2016).

On a national scale, the employment rate among PWDs is 37.3% for those aged 21 to 64, and 25.4% of these working individuals have an ambulatory disability (Erickson et al. 2019). Yet, there is heterogeneity in PWDs' employment rates by age, race, ethnicity, marital status, educational attainment, and sex (Sevak et al. 2015). Research shows that being employed increases social capital for PWDs (Brucker 2015), though differences in wages are evident between PWDs and non-PWDs (Wong et al. 2020). Median annual household income for PWDs is $45,500, while those having ambulatory, self-care, or independent living disability have a median annual household income around $38,900 (Erickson et al. 2019). The poverty rate among working-age PWDs is 26.1%; strong associations exist between being disabled and poverty (Brucker et al. 2015). More recently, the COVID-19 pandemic has impacted all sections of society including PWDs, who have experienced job loss early in the pandemic and have continued to seek employment as the pandemic progresses (similarly to non-PWDs) (Houtenville et al. 2021). Overall, PWDs have an employment deficit as a group even when controlling for other factors, and are more likely to be low-income. We contend that the lack of efficient, reliable travel options is partly impacting successful employment for PWDs.

Persons with disabilities are often unable or unwilling to drive an automobile, which shrinks their access to opportunities. Research confirms that those who drive modified vehicles have better mobility and access (Darcy and Burke 2018) and life satisfaction (Li and Tilahun 2017). However, driving is just one means of transportation, especially for short-distance[1] travel. In the U.S., individuals who identify as disabled rely largely on public agencies providing paratransit services, private providers, faith groups, or family and friends to get rides (Cochran 2020; Deka 2014). New mobility tools including ride-hailing and some micromobility services, though having the potential for efficient travel of PWDs, have not served this group so far (Ruvolo 2020). Researchers have explored how these new services can be useful for PWDs with appropriate changes such as storage space for mobility device and driver training (Deakin et al. 2020; Shirgaokar 2018).

Using sidewalk infrastructure also remains important for PWDs. Researchers show that PWDs who trip chain are limited by how far they can go on sidewalks (Schmöcker et al. 2008).

[1] Defined here at under a mile.

Neighborhood characteristics including negative street features (Beard et al. 2009), extensive obstacles in city centers (Bromley et al. 2007), static obstructions on sidewalks (Coppola and Marshall 2021), and limited information (Low et al. 2020) decrease effective movement for PWDs. Such challenges for mobility in individual outdoor spaces from static and dynamic obstacles can expand to whole routes (Coppolla and Marshall 2021; Inada et al. 2014). From a micro-geography perspective, getting to a transit stop or the local grocery store can be a challenge for PWDs given multiple issues with sidewalks in many cities.

In a MPC-funded study[2] under way currently by this research team, we gained insights about how PWDs travel, what barriers they face, and how extensively they plan for average daily trips (also see Shay et al. 2016; Velho 2019). As relevant to this proposal, key insights are: (a) Paratransit remains an important service for PWDs, especially those who make regular trips, and (b) PWDs report that paratransit (and transit overall) has to be "dealt with" to get to places. Overall, from the PWDs' perspective, paratransit is mostly time inefficient, and those who need it, use it, with many expressing reservations about these services. Our work suggests that there seems to be a mismatch in the structure and design of paratransit and user needs, which the current proposal seeks to examine. In essence, we are exploring the inefficiency of paratransit as a mode of travel for PWDs.

Paratransit is expensive to provide as a service for agencies in the U.S. (Kim et al. 2020; Menninger and Werly 2014). Researchers have studied the topology and operational features of paratransit services (du Preez et al. 2019; Lu et al. 2014). However, the heterogeneity of demand for paratransit seems to be under examined, to the best of our knowledge. The Regional Transportation District (RTD), which provides transit services to the Denver Metropolitan Region, runs a paratransit service called Access-a-Ride. As the summary figures in **Table 1** show, Access-a-Ride has much higher operating costs per boarding, though RTD is compensated[3] through subsidies at a slightly higher level relative to other classes of transit services. On the one hand, fare revenue per boarding on paratransit is much higher than other services suggesting inequities across transit modes. On the other hand, the low number of boardings per hour indicates either inefficiency of supply or much lower demand[4] compared to other transit modes within RTD.

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[2] MPC 614 – Learning from the Travel Experiences of Persons with Disabilities: Investigating Navigation Challenges Posed by Infrastructure (https://www.mountain-plains.org/research/downloads/2020-mpc-614.pdf)

[3] RTD gets 67% of the operating costs paid for through local funds, 10% through federal assistance, while the remaining comes from fares (or is directly generated). On capital expenditures, there is a 1:2 split between federal:local funding sources. For more details, see https://www7.fta.dot.gov/sites/fta.dot.gov/files/transit_agency_profile_doc/2019/80006.pdf

[4] According to 2019 *American Community Survey* 5-year estimates (Table ID S1810), 379,477 of 3,878,523 (or 10%) of Boulder, CO + Denver-Aurora-Lakewood, CO Metro Area + Colorado Springs, CO population has one or more disability. Note these three geographies represent a large portion of RTD's service area.

Table 1: Metrics for costs, boardings, revenues on RTD (2019 – pre-COVID-19)

Class of service	Operating costs per boarding	Subsidy per boarding	Percent covered via subsidy	Fare revenue per boarding	Boardings per hour
Access-a-Ride (/paratransit)	$ 53.12	$ 48.44	91%	$ 4.69	1.45
CBD local bus	$ 6.20	$ 5.04	81%	$ 1.16	30.90
Urban local bus	$ 6.20	$ 5.09	82%	$ 1.12	29.09
Suburban local bus	$ 8.84	$ 7.67	87%	$ 1.16	19.51
Rail	$ 12.60	$ 10.52	83%	$ 2.08	126.53

Our MPC-funded research so far[2] and the aggregate metrics from RTD suggest that access-a-ride may not be an effective or equitable option for many PWDs. However, it could be an important avenue for access to many destinations including education, healthcare, food, and employment for many PWDs.

Research Objectives

We have four specific objectives in this study:

1. Examine differences in travel time between paratransit and comparable automobile[5] modes across tours undertaken by RTD vehicles picking up and dropping off multiple patrons.
2. Study correlates at the traffic analysis zone (TAZ) level where land use, street network, and other spatial vectors can impact efficiency in a heterogeneous but systematic manner.
3. Investigate how those who receive deep subsidies (e.g., Medicaid) leading to free travel on paratransit experience travel time efficiencies relative to those who pay in cash or purchase tickets.
4. Study how government agency decisions regarding infrastructure spending, focusing on the American with Disabilities Act, limit efficient service provisions.

Our research suggests that paratransit is needed but likely not an effective means of travel for PWDs. Our data show demand (n=1,069,013) for Access-a-ride through RTD for a period of 2.5 years starting January 1, 2019 and ending June 30, 2021. Each origin-destination (OD) pair has the following attributes: customer id, sex, age, start and end time for trip (yyyy:mm:dd hh:mm:ss), latitude and longitude for each pick up and drop off (at high accuracy up to 13 decimal places), cost of trip to customer, and type of fare payment. We have also joined weather and land use attributes to the primary table, and calculated factors including land use diversity at the traffic analysis zone level.

[5] We use automobile trips as a comparative not because we are proposing that all these trips be supplied by car, but because auto travel is the norm in city-regions like Denver. Many travelers internalize the benefits of auto travel whereas PWDs are likely not getting these time budget savings. From a policy perspective, our agenda is to see if automobile-like systems (e.g., sedan-based ride-sharing running in spatial hotspots and certain times) may be more efficient than the current form of paratransit.

Research Methods

Our analytical methods will include tracing tour paths for each set of vehicle ID and trip ID using sequences of OD pairs using the shortest[6] routes. We will rely on the attributes in the original RTD dataset along with other geospatial information to showcase differences in travel patterns (demand) across various socio-demographic cohorts (Abbasi et al. 2021) since the evidence (Erickson et al. 2019) suggests that these factors play an important role in life outcomes. If our ongoing work[2] suggests that time inefficiency is one of the many variables making paratransit the last option for PWDs' movement in the region, the current proposal seeks to generalize these findings using a robust regional dataset.

When running travel time comparisons across paratransit and the counterfactual (automobile) trip, we will rely on basic bivariate tests such as a t-test of difference in means, as well as ordinary least square regression to identify how statistically significant the differences are across various predictor factors including attributes of the traveler, trip, and weather. Upon constructing tours, we will analyze travel time across at the tour level using similar methods. We will also collapse number of trip starts across various time horizons (e.g., early am peak, late am peak, etc.) at the TAZ level. We will use count models built on poisson and negative binomial specifications to estimate correlates of total demand at the TAZ level. When investigating mode of payment across those with deep subsidies (i.e., trip is paid for) versus those who purchase tickets or pay cash, we will rely on a multinomial logit specification (with multilevel factors to control for temporal and spatial aspects, if necessary), to estimate if subsidies are systematically connected to demand. Lastly, using the information and insights generated in this work, in combination of our findings from MPC-614, we will design a survey aimed at planners and engineers working at local, regional, state, and federal agencies. We will also rely on phone-based interviews to understand how those who design, build, maintain, and fund infrastructure are constrained when thinking of ADA standards. This last project is aimed to connect MPC 614 to the current project.

Expected Outcomes

Our project is designed to develop an understanding of how paratransit data reveals inefficiencies in supplying the travel needs of PWDs. Our analysis will have the following likely outcomes. (1) An understanding of gender- and mode-of-payment-based inequity for travel time on paratransit. (2) Tour-based inefficiencies that reveal issues with supply of service. (3) Location-based pressures that are related to land use and infrastructure at the TAZ level. (4) Pressures that public agencies face in supplying efficient services for PWDs. The practical impacts of our research should be useful for planners and engineers working in transit agencies or consulting firms.

Relevance to Strategic Goals

This proposal falls under the Livable Communities strategic goal of the FAST ACT. Our project is aimed at making communities livable through easier movement, especially for the mobility-impaired population, using better transportation services including paratransit. This proposal

[6] The subject matter expert at RTD confirms that this is a good approximation of actual routes taken by Access-a-Ride vehicles.

links to previous MPC projects #579 and #615 by examining how location-specific infrastructure impacts PWDs' paratransit demand. This proposal also connects directly with MPC project #614 that investigated the infrastructure challenges of persons with disabilities.

Educational Benefits

The project is designed to support research assistant/s who will be working with the PIs towards Master's theses or final/capstone projects in Urban & Regional Planning and Civil Engineering. The PIs have identified specific students who will be taking on research roles on this project. These individuals will be mentored by the PIs and will gain skills that will enable them to be successful in the transportation industry. One student, for example, is currently working on this project and is aiming to defend a thesis during this project's tenure. Engagement with this project will help such students to grow in their careers.

Technology Transfer

The research products will be aimed at academic, practitioner, and advocacy audiences. The reports and papers (in pre-print manuscript form) generated through this study will be shared in the public domain on webpages at CU Denver or in other web locations. The hope is that this knowledge will enable our public partner, Regional Transportation District (RTD), to generate efficiencies in organizing travel for PWDs. Academic versions of this work will be published in Q1 transportation journals. We will strive to include subject matter experts on thesis/project committees so that the research team can develop synergies with public agencies to enable research to inform practice (and vice versa).

Work Plan

The proposed scope of work is designed to be completed in one year. Since the dataset is already available to the researchers, the team will spend some time creating tours by relying on vehicle IDs and run IDs. Once the tour-level data are assembled, we will start analysis on a series of papers looking at tour-level travel time inefficiency, trip frequency at the TAZ level, and mode-of-payment differences across the sample. To understand how public-sector decisions impact PWD-related infrastructure, the researchers will focus on a survey and interviews with government actors across the US, particularly those whose work intersects with ADA. The final month will be spent tying these various products into a report. We will be publishing these results as academic papers.

Task	Timeline
Data assembly	Months 1-2
Tour-based analysis	Months 2-7
Spatial Analysis	Months 3-8
Mode-of-payment analysis	Months 4-9
Understanding public sector decision making in relationship to ADA	Months 3-11
Finalizing report	Months 11-12

Project Cost

Total Project Cost:	$200,000
MPC Funds Requested:	$100,000
Matching Funds:	$100,000
Source of Matching Funds:	University of Colorado Denver

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