Who Rides Rural Transit? A Latent Profile Analysis of Rural Demand Response Transit (DRT) Riders and Implications for Future Mobility Services

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Introduction

Background:

Demand Response Transit (DRT) services play a crucial part in supporting rural transportation, especially for individuals without private vehicle access. DRT fills a vital gap in public transit in rural and other low-density communities where fixed routes services are unavailable. Despite its importance, little research has examined who uses rural DRT services and how these riders travel. Understanding travel behavior is essential not only for optimizing current services but also for planning future mobility solutions, such as autonomous vehicles (AVs).

Problem Statement

What distinct groups of riders, based on their typical travel behavior patterns, use demand response transit in rural Tennessee?

- **Public transit provides an important mobility option, particularly for those who lack or cannot operate private vehicles.**
- **Demand Response Transportation (DRT) serves this need through a flexible and accessible option for these riders, as well as the general public.**
- **Despite extensive travel behavior research, there is a lack of analysis on DRT, specifically in rural areas.**
- **A lack of understanding DRT travel behavior in diverse rural areas can impede planning for future mobility technologies such as autonomous vehicles.**

Goals and Objectives

Goal

How can transportation planning be refocused and technologically enhanced to effectively address the unique needs of rural communities in Region 4?

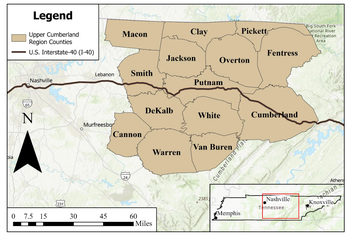
Objectives:

- **Creation of New DRT Travel Behavior Framework:** Develop a **replicable framework** to aid rural Human Resource Agencies in identifying current rider trends and **planning for future rider needs.**
- **Lay Groundwork for Future DRT User-Related Research:** Conduct **detailed literature review** of prior DRT user-related research to **understand the needs** of different demographic groups for future DRT travel in rural areas.
- **Accessible Transportation for All:** Conduct research that promotes **accessible** DRT services for all residents in **rural communities.**

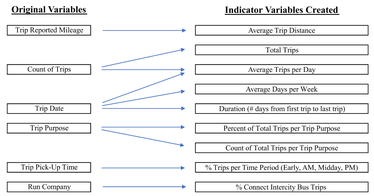
Approach and Implementation

Data Acquisition & Cleaning

Trip record data were acquired from the Upper Cumberland Human Resources Agency (UCHRA), which serves the 14-county rural Upper Cumberland region between Nashville and Knoxville. It comprises 86,361 trips taken by 2,361 riders from November 14, 2023 to September 30, 2024 (10.5 months).



UCHRA Service Area



Original and Selected Indicator Variables

Summary Statistics

Medical and Employment trips were most common; Medical and Senior Center trips were longest distance. Males took most Dialysis and Employment trips; females and older adults took most Senior Center trips.

		Trip Purpose by Trip							
		Dialysis	Employment	Medical	Senior Center	Shopping	Social/ Recreation	Other	Total
Trips	Number of trips	9,615	28,213	22,801	6,143	6,785	3,244	9,560	86,361
	Percent of total	11.1%	32.7%	26.4%	7.1%	7.9%	3.8%	11.1%	100%
	Average Trips / Day	35.1	122	85.1	29	31.6	14.9	42.5	314
Distance	Median Distance (miles)	8.5	6.5	15.2	7.6	4.4	8.2	5.8	7.8
	Mean Distance (miles)	16.4	9.2	23.6	9.5	8.6	18.6	12.1	14.5
Demographics	Male	59.7%	51.2%	39.1%	24.8%	41.1%	43.3%	39.5%	44.7%
	Female	40.3%	48.8%	60.9%	75.2%	58.9%	56.7%	60.5%	55.3%
	Younger Adults	38.0%	91.8%	41.7%	4.4%	42.1%	43.4%	59.5%	57.1%
	Older Adults	62.0%	8.2%	58.3%	95.6%	57.9%	56.6%	40.5%	42.9%
	Non-Disabled	32.2%	78.5%	66.8%	67.9%	68.2%	63.9%	69.1%	67.1%
	Disabled	67.8%	21.5%	33.2%	32.1%	31.8%	36.1%	30.9%	32.9%
	Disability- Cognitive	0.0%	16.1%	3.0%	11.9%	6.2%	7.7%	9.8%	8.8%
	Disability- Physical	64.4%	5.7%	29.7%	23.2%	25.9%	21.4%	17.7%	23.3%
	Disability- Visual	7.3%	1.2%	3.2%	0.2%	2.7%	11.8%	6.1%	3.4%

Green: Largest value, Yellow: Second largest value

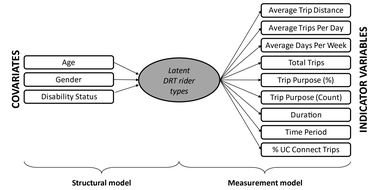
More than 9,600 Dialysis trips taken by only 92 riders; Dialysis, Employment, and Senior Center riders were regulars (large number of trips over long period of time).

	Trip Purpose by Rider							
	Dialysis	Employment	Medical	Senior Center	Shopping	Social/ Recreation	Other	Total
Total Number Trips	9,615	28,213	22,801	6,143	6,785	3,244	9,560	86,361
Distinct Riders	92	434	1,831	103	473	392	827	2,361
Median Age (years)	68	41	66	73	65	63	61	64
Median Trips / Rider / Month	20	13	2	10	2	2	2	3
Mean Trips / Rider / Month	17.3	14.7	3.5	13.1	3.9	3.5	4.3	6
Mean Duration / Rider (days)	173	120	127	130	112	71.8	86.7	113

Green: Largest value, Yellow: Second largest value

Latent Profile Analysis

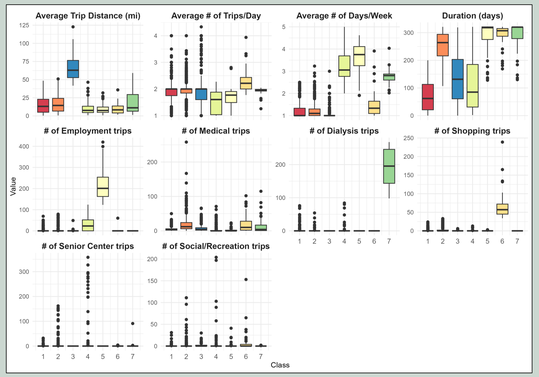
- Latent Profile Analysis (LPA) was used to identify "latent", or underlying, UCHRA DRT rider types from a set of indicator variables selected from the trip record dataset.
- LPA is unique from other clustering algorithms as it calculates the probability that a rider will be in each of the possible rider types.
- After the set of finalized rider types were identified, demographic data were included as covariates to further describe the characteristics of riders in each type.
- This analysis ran nine models with a variety of variables for a range of 2-to-10 rider types per model.



Latent Profile Analysis Model

Outcomes and Impact

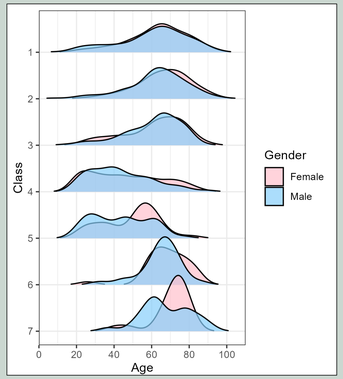
Rider Class Boxplots



Typical Rural DRT Rider Classes

Class	Name	n	% trips	Description	AV Suitability	AV Reasoning
1	Infrequent Riders	908	38%	Less than 20 trips, 2 month duration	Unlikely	Short-term duration, infrequent
2	Medical Movers	737	31%	2 trips/day, long duration	Unlikely	Variable destinations
3	Long-Distance Travelers	304	13%	50+ mi/trip, varying trip purpose	Unlikely	Currently use intercity bus, so less efficient
4	Three-Day Riders	229	10%	3+ days/wk, varying duration	Unlikely	Variable destinations, purposes
5	Commuters	82	3%	3-4 days/wk, short distance, long duration	**Likely**	**Regular and frequent travel**
6	Market & Medical Trippers	57	2%	2-3 trips/day, 1-2 days/wk, long duration	**Maybe**	**Regular travel, but many older adults/persons with disability**
7	Dedicated Dialysis Riders	44	2%	2-3 days/wk, 5-30 miles distance, long duration	Unlikely	Require driver assistance after treatment

Rider Class Age Distribution



Conclusions and Future Work

Conclusions

- **Seven latent classes of rural DRT riders were identified, each with distinct travel characteristics.**
  - Largest groups were Infrequent Riders (38%) and Medical Movers (31%).
  - Median age was near 60-70 years old, but Commuters and Three-Day Riders were younger (≈ 45 years old).
  - Dedicated Dialysis Riders made up 2% of all riders, but took some of the most trips per rider.
- **Frequent, routine travelers – particularly Commuters – are the most likely candidates for early AV adoption.**

Recommendations:

- **Coordinate services with dialysis centers to improve efficiency, as 92 riders took 9,615 dialysis trips over 10.5 months.**
  - Align treatment times for riders near each other.
  - Shift treatment schedules closer to transit agency operating hours.
  - Adjust treatment start/end to align with off-peak transit demand hours.
- **A user-centric approach is critical if/when AVs are introduced to rural areas and DRT fleets.**
  - Introduce AV technology in rural DRT fleets first to Commuters.
  - Older and mobility impaired riders will likely continue preferring or requiring a human-operated DRT vehicle.

References and Publications

Background:

- This paper is currently under review. Email mdavi238@vols.utk.edu to be notified when the paper is published.
- Our prior work on rural DRT **trip purpose trends** (Day of Week, Hour of Day, Trip Distance) in the Upper Cumberland region can be found at the QR code below:

Transportation Research Board (TRB) Annual Meeting, Jan 11-15, 2026