First Mile to Health: Improving Healthcare Access in North Carolina

Center of Excellence for Mobility and Congestion - Theme 3
NCDOT Research Project TCE2020-02

August 2023

Authors

Dr. Kai Monast
Dr. Noreen McDonald
Dr. John Park
Dr. Burcu Adivar
Dr. Trung Tran

NC STATE UNIVERSITY
ITRE
Institute for Transportation Research and Education

RESEARCH & DEVELOPMENT

Technical Report Documentation Page

1. Report No. FHWA/NC/TCE2020-02 (P3)	2. Government Accession No.	3. Recipient's Catalog No.
4. Title and Subtitle First Mile to Health: Improving Healthcare Access in North Carolina		5. Report Date August 2023
		6. Performing Organization Code
7. Author(s) Dr. Kai Monast, Dr. Noreen McDonald, Dr. John Park, Dr. Burcu Adivar, and Dr. Trung Tran		8. Performing Organization Report No.
9. Performing Organization Name and Address North Carolina State University Institute for Transportation Research and Education Campus Box 8601, Raleigh, NC 27695-8601		10. Work Unit No. (TRAIS) 11. Contract or Grant No.
12. Sponsoring Agency Name and Address North Carolina Department of Transportation Research and Development 1549 Mail Service Center Raleigh, NC 27699-1549		13. Type of Report and Period Covered 2/1/2020 – 2/28/2023 14. Sponsoring Agency Code TCE2020-02 (P3)
Supplementary Notes:		

16. Abstract

The purpose of this research was to document the initial experiences of coordinated public transportation providers in North Carolina during the first phase of Medicaid Transformation where the NC Department of Health and Human Services (DHHS) introduced Prepaid Health Plans (PHPs) and private, for-profit Medicaid transportation brokers. Prior to Medicaid Transformation, coordinated public transportation was often the provider of choice for Medicaid non-emergency medical transportation (NEMT) that originated from the county-based Division of Social Services (DSS). The volume of NEMT trips and revenues formed the financial and service foundation of many of the other community-based mobility programs supported by the transit systems.

17. Key Words Mobility as a service, healthcare access, Medicaid transformation	18. Distribution Statement		
19. Security Classif. (of this report) Unclassified	20. Security Classif. (of this page) Unclassified	21. No. of Pages 102	22. Price

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

Contents

Medicaid Transformation and Non-Emergency Medical Transportation in North Carolina:

Initial Experiences for Coordinated Public Transportation

Dr. Kai Monast
North Carolina State University (NCSU)
Institute for Transportation Research and Education (ITRE)
kcmonast@ncsu.edu

Jeremy Scott, NCSU/ITRE jscott@ncsu.edu
Jonah Freedman, NCSU/ITRE jfreedm@ncsu.edu
Tim Brock, NCSU/ITRE tbrock2@ncsu.edu
Waugh Wright (NCSU/ITRE), waugh.wright@ncsu.edu

September 13, 2022

Purpose

The purpose of this research is to document the initial experiences of coordinated public transportation providers in North Carolina during the first phase of Medicaid Transformation where the NC Department of Health and Human Services (DHHS) introduced Prepaid Health Plans (PHPs) and private, for-profit Medicaid transportation brokers. Prior to Medicaid Transformation, coordinated public transportation was often the provider of choice for Medicaid non-emergency medical transportation (NEMT) that originated from the county-based Division of Social Services (DSS). The volume of NEMT trips and revenues formed the financial and service foundation of many of the other community-based mobility programs supported by the transit systems.

With such a substantial change in the NEMT service structure, the public transportation industry in North Carolina was concerned that the introduction of private for-profit transportation brokers would reduce NEMT trip volumes and associated revenues. These reductions would impact not only NEMT services, but also other community mobility programs.

This research documents the initial experiences of Medicaid Transformation in North Carolina from the public transportation perspective using a case study approach that combines data from multiple sources and survey responses. The specific research questions addressed in this paper concerning the impact of Medicaid Transformation on coordinated public transportation are:

1. Will public transit be able to contract with private brokers?
2. Will public transit be offered trips from private brokers?
3. Are all transit systems experiencing the same impacts on trip volumes?
4. Are per trip invoices comparable between DSS and private brokers?
5. Do private brokers pay fully and on-time?
6. Do the private brokers offer trips that public transportation systems can accept?
7. Are public transit systems offered trips first by private brokers?
8. What comments did the transit systems enter into the survey?

About the Researchers

As this research is a case study that combines quantitative and qualitative data, it is important to declare the expertise and perspectives of the researchers. The Institute for Transportation Research and Education (ITRE) staff responsible for this paper are under contract to the North Carolina Department of Transportation (NCDOT) to provide technical assistance, technological support, and data analysis concerning the public transportation industry. This particular work is based on a Transportation Center of Excellence research project also sponsored by NCDOT, but it draws upon historic knowledge associated with the NCDOT technical assistance contract. The researchers have been involved with North Carolina's Medicaid Transformation since its inception in 2015 and have attempted to assist transit systems through the years-long transition. All attempts have been made to be impartial and convey the facts, but the research is intentionally designed represent the perspective of the public transportation industry in North Carolina.

Medicaid Non-Emergency Medical Transportation

Transportation to medical appointments and services is an essential feature of Medicaid, particularly for transportation disadvantaged populations, including low-income, seniors, non-White, and women (*1, 2, 3*). Nationally, state Medicaid programs spend around $3 billion on NEMT annually; although this is small fraction of total Medicaid spending, there has been movement in the past decades to reduce these costs (*4*). The Deficit Reduction ACT (DRA) of 2005 led to an increase in states employing NEMT brokerages to meet these needs (*1*).

As every state runs its Medicaid program independently, there is a wide range of NEMT systems as well. In 2014, a national survey of state NEMT services found 7 different NEMT models: in-house management; managed care organization (MCO), statewide broker, regional broker, in-house management and MCO, in-house management and regional broker, and MCO and statewide broker (*1*). Most of the statewide brokers are for-profit companies, often working in multiple states, while regional brokers are a mix of for-profit companies and local agencies (public transportation, human services, etc.) (*1*). State Medicaid programs tend to negotiate a pre-set limit on much money private NEMT brokers will receive, a practice intended to encourage them to bring down their costs and schedule their trips as efficiently as possible, although overall costs may not be lessened (*5*).

Coordinated Public Transportation Prior to Medicaid Transformation

All 100 counties in North Carolina have some form of coordinated service for both the general public and human services agency passengers *(7)*. Coordinated transportation systems are umbrella organizations that provide service to multiple human services agencies and, in many cases, the general public. By coordinating their efforts, human services agencies share the expense of capital and operating costs and therefore reduce the cost of individual trips *(8)*. Coordination also makes federal Section 5311 funds available to subsidize capital and operating costs in non-urbanized areas *(9)*.

Section 5311 funds were designed to combine federal transportation money previously split into different programs and to improve general public transportation in rural areas *(7)*. Accessing these funds was a primary impetus for developing coordinated community transportation systems and serving the general public. North Carolina receives more than $30 million in Section 5311 funds every year.

Before these services were coordinated in the early 1980's, human services transportation was provided by individual agencies operating separate fleets of vehicles for serving senior centers, nutrition sites, Medicaid customers, and other federally funded program recipients. Although only suggested for federal Section 5311 funding, locally coordinated human service transportation plans are a requirement for being eligible to receive federal Section 5310 Elderly and Persons with Disabilities funds, so all 50 states plus the District of Columbia have coordination plans (*10, 11*). FTA, 2022; National Center for Mobility Management, 2022).

According to the annual transit financial and service dataset, the NC Operating Statistics, Medicaid is the largest funder of human services agency transportation in the coordinated transportation model in North Carolina. As locally generated revenue, Medicaid funds serve as local matches for other federal and state funding programs. In Fiscal Year 2019, prior to the Covid-19 pandemic, 61 of the 80 (76%) coordinated public transportation systems provided Medicaid NEMT, serving almost 1.3 million trips, or 23% of the total trips provided. Medicaid contracts resulted in $21.5 million in revenues which was 21% of the total

state, federal and local revenues for coordinated transportation providers. Table 1 shows the FY19 Medicaid statistics for the public transportation providers that served Medicaid trips. An average of 25% of their total revenue is derived from Medicaid services, with a minimum of 2% and a maximum of 68%. Medicaid revenue accounts for 42% of local revenue earned, which is important because local revenues are often used as local matches to federal and state grants. One transit system reported 96% of its local revenue was derived from Medicaid. The transit system average for the percent of Medicaid trips is 26%, with an agency minimum of less than 1% and maximum of 81%.

Table 1. Medicaid Statistics in FY19 for Transit Systems Providing NEMT (n=61)

Medicaid Revenue Percentage of Total Revenue (Federal + State + Local)	
Average	25%
Minimum	2%
Maximum	68%
Medicaid Revenue Percentage of Local Revenue	
Average	42%
Minimum	4%
Maximum	96%
Medicaid Trip Percentage of Total Trips	
Average	26%
Minimum	0.2%
Maximum	81%

Figure 1 displays the same data as Table 1, but as histograms with dashed lines indicating mean values.

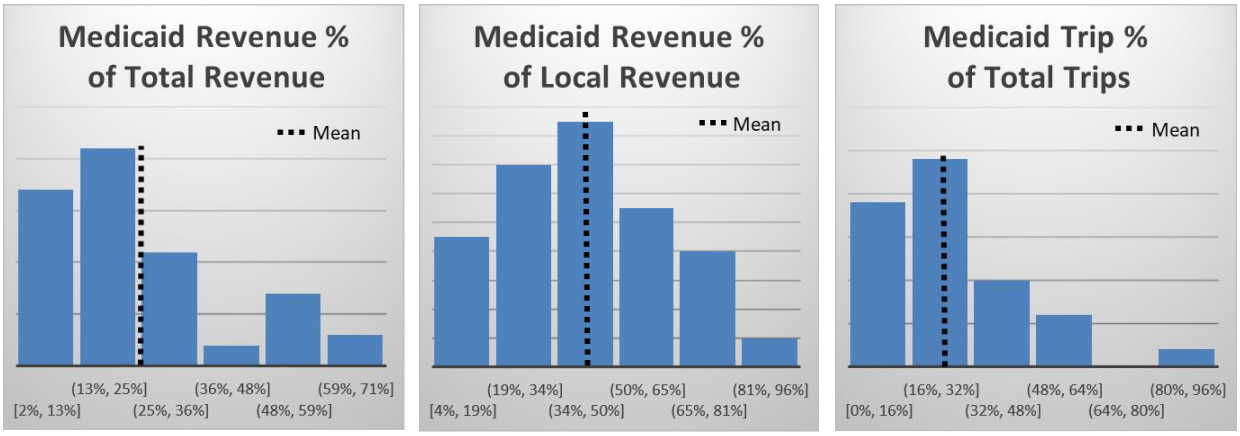


Figure 1. Histograms of Medicaid Statistics in FY19 for Transit Systems Providing NEMT (n=61)

Providing Medicaid transportation tends to be more expensive than most human services agency contracts because of the service characteristics (*7*). Nutrition trips, for instance, typically involve providing regularly scheduled service to customers to the nearest nutrition sites and going to the same destination

at the same time. Thus, it is easy to group nutrition trips to provide more efficient and cost-effective service. On the other hand, Medicaid trips are more difficult to group because they tend to less-predictable, have both origins and destinations dispersed throughout the service area, and have times dispersed throughout the day.

Medicaid Transformation in North Carolina

In 2015, the North Carolina State Legislature enacted Medicaid Transformation with Session Law 2015-245 *(12)*. On July 1, 2021, the North Carolina Department of Health and Human Services (NC DHHS) implemented the first phase of Medicaid Transformation which transitioned 1.6 million people from fee-for-service to NC Medicaid Managed Care *(13)*, representing about 15% of the Medicaid non-emergency medical transportation (NEMT) trips. This transition introduced Prepaid Health Plans (PHPs) which are pre-determined per person rates intended to cover both health care needs and NEMT necessary to access those health care needs. The PHPs are administered by health insurance companies that utilize private, for-profit transportation brokers to distribute Medicaid trips to transportation providers. Previously, county Division of Social Services (DSS) agencies served as the sole transportation broker and the county-based coordinated public transportation providers were often the selected provider of these services. Phase 2 is the launch of Tailored Plans which will expand to include most of the remaining Medicaid beneficiaries and is expected to begin in December 2022 *(14)*, which is when DSS will cease being an NEMT transportation broker.

NC DHHS issued contracts to five PHPs across the state as shown in Figure 2 *(15)*. Four PHPs serve the entire state and one, Carolina Complete Health, is limited to regions 3, 4, and 5.

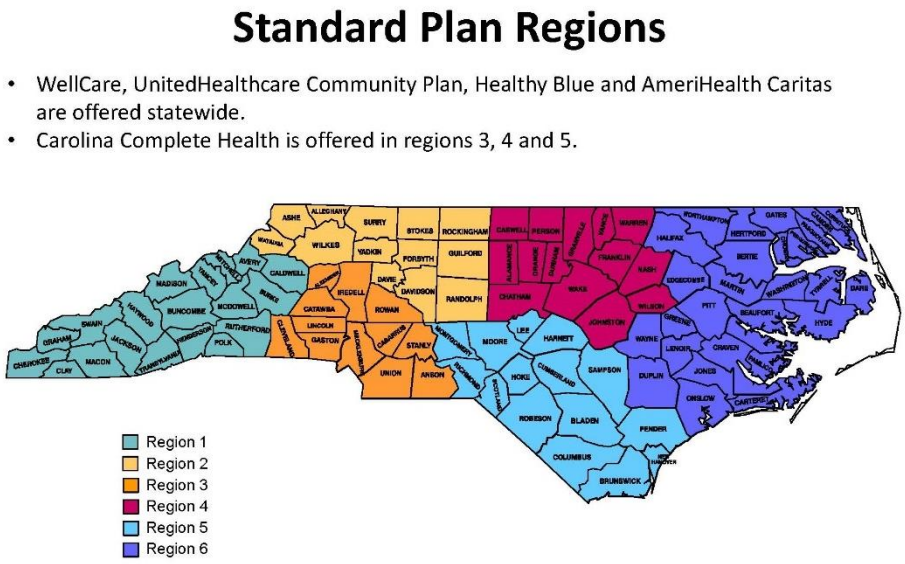


Figure 2. Prepaid Healthcare Plan (PHP) Regions

Three private NEMT brokers were introduced to the transit systems during the planning stage, ModivCare (then Logisticare), OneCall, and National MedTrans. National MedTrans exited the market after contract negotiations and software integration discussions had begun but prior to implementation because it was acquired by the company that became ModivCare *(16)*. During the study time period, three of the statewide PHPs and the regional PHP contracted with ModivCare and one statewide PHP (WellCare) contracted with OneCall to be the transportation broker *(17)*. As of May 2022, OneCall exited the market and was replaced with MTM. During the initial phase, county-based DSS agencies continue to be the transportation broker for the majority of NEMT trips but phase 2 will eliminate DSS as an NEMT broker.

Public Transportation Concerns Prior to Medicaid Transformation

Prior to the implementation of NC Medicaid Transformation, public transportation providers were concerned the introduction of PHPs and private, for-profit transportation brokers would require significant changes in how NEMT is provided and possibly threaten the coordinated model. This section explores some of the major concerns which led to the development of a survey to track the trips, reimbursements, and comments monthly after the transition. The concerns, taken from a white paper written by the research team in 2018 (7), include:

- **Service Policies:** PHPs were expected to establish stringent service policies. To be able to coordinate trips among multiple agencies, many coordinated transportation systems require at least a one-day advance reservation. PHPs may reduce the reservation period or require real-time, on-demand service. Reducing the advance reservation period could decrease efficiency and increase costs. The PHP could refuse to reimburse providers for no shows and late arrivals.

- **Cost Reimbursement:** Coordinated transportation providers bill human services agencies for services a number of different ways; most using shared miles or hours (total service/revenue miles/hours times the rate, divided by the number of passengers), which is effective for recouping all expenses. The PHPs' proposed billing model was expected to establish the reimbursement amounts before the trip is carried, based on the distance between origin and destination. Coordinated providers would need to understand how changes in the cost reimbursement structure impact other services. Transportation providers also needed to be able to determine, on a trip-by-trip basis, whether the reimbursement amount adequately covered costs – a calculation based on the ability to group service, deadhead miles/time, and other service requirements. If the coordinated transportation provider is not judicious in only providing service where the reimbursement amount meets or exceeds the cost, then private for-profit Medicaid transportation will be subsidized by other human services agencies, grant programs or local funds, reducing funds available for non-Medicaid passengers to access needed services.

- **Coordinated Providers Excluded from Medicaid Service:** If the coordinated transportation system is not selected to participate in Medicaid NEMT or cannot agree upon acceptable terms, the service being provided to the community will change. Public transportation providers with high levels of NEMT trips will be forced to restructure their service delivery models to constrain costs and increase efficiency. Their technology applications will also need to be re-evaluated to determine whether they are adequate for supporting these new service structures. Also, it is likely

that the loss of Medicaid transportation will result in many coordinated providers being over-capitalized with vehicles and possibly technology, at least until new services are established.

- **Cross-Jurisdictional Service:** Regardless of which organizations provide Medicaid NEMT in the future, it is likely that future Medicaid transportation providers will be required to operate beyond the traditional service area boundaries that currently exist. Rather than dealing with a single transportation agency for each service area, the PHP or its broker will likely assign trips to the most cost-effective provider – which could be an operator from a different service area.

Data

The first phase of Medicaid Transformation began on July 1, 2021. The survey period spans from July 1, 2021 to December 31, 2021. The data are compiled from a transit agency survey, transit agency operating statistics, and directly from the largest private transportation broker (ModivCare). Survey results were combined with corresponding monthly public transportation service statistics for the study period and for prior years using the NC Operating Statistics of the respondents. NC Operating Statistics include monthly miles and hours by mode and trips by mode and trip funder, including Medicaid, general public, and/or other contract. Additional data on trip return rates (trips offered to the transit system but returned back to the broker) were provided by ModivCare, the private NEMT broker with the largest volume of trips. The researchers attempted to acquire NEMT claims data from NC DHHS to further analyze NEMT trips, but the request has not been fulfilled as of July 2022. The initial request was made in February 2022.

The survey was distributed to all public transportation providers and reminders to participate were sent by the researchers via the North Carolina Public Transportation Association. The completely voluntary survey was available online using SmartSheet software and contained questions related to each transportation broker (DSS, ModivCare, and OneCall) about the trips carried, funding amounts requested and paid, reasons for trip requests being returned, and qualitative comments. In total, 19 out of a potential 78 transit systems responded to the survey each month from July 2021 through December 2021. However, two systems reported zero NEMT trips before the transition, meaning there was no comparison and two systems did not carry any brokered NEMT trips. These four systems were removed, resulting in a sample of 15.

Transit systems in the analysis represent rural, suburban, and urban communities across North Carolina. As of 2022, there are 78 coordinated community transportation systems in the state, but not all provided NEMT services before and/or after Medicaid Transformation. Responding to the survey was optional and therefore self-selective and also required that surveys be submitted for each month, meaning six observations per site. With 15 complete responses, the response rate is at least 19%. Because of the diversity in system size and geographic locations, it is believed that the survey sample is representative of the state as it includes urban, suburban, and rural sites from the mountains to the coast.

Table 2 names the transit systems, county served, population *(18),* geographic area (replacing Piedmont with Central for easier interpretation) *(19)*, and square miles *(20)*.

Table 2. Transit Systems Included in the Analysis

Name	County	Geography	Population	Square Miles
Alleghany in Motion	Alleghany	Mountain	10,888	235
Avery County Transportation	Avery	Mountain	17,806	247
CCATS	Carteret	Coastal	67,686	506
COLTS	Lee	Central	63,285	255
Duplin County Public Transportation	Duplin	Coastal	48,715	816
JCATS	Johnston	Coastal	215,999	791
Lenoir County Transportation	Lenoir	Central	55,122	401
Martin County Transit	Martin	Coastal	22,0312	461
Mitchell County Transportation	Mitchell	Mountain	14,903	221
OUTS	Onslow	Coastal	204,576	763
Rutherford County Transit	Rutherford	Mountain	64,444	564
Sampson Area Transportation	Sampson	Coastal	59,036	945
Transportation Lincoln County	Lincoln	Central	86,810	298
Union County Transportation	Union	Central	238,267	632
WAVE	New Hanover	Coastal	225,702	192

The survey collected data related to both private brokers. However, because ModivCare serves the 4 statewide PHPs while OneCall served the single regional PHP, over 85% of the private broker NEMT trips carried by public transportation were for ModivCare. Because this analysis is observing the impact of Medicaid Transformation on public transportation, the data for the private brokers are aggregated and not presented by company. The logic behind this presentation of facts, supported by the experiences of public transportation during NC Medicaid Transformation, is private for-profit vendors may be replaced at any time, so analyzing differences between the companies is not informative until some sort of stability is observed.

Descriptive statistics of NEMT trips by transit system are shown in Table 3.

Table 3. NEMT Trips Served by Transit System, July 2021 to December 2021

Transit System	Total NEMT Trips	DSS Trips	ModivCare Trips	OneCall Trips	Private Broker Total	Private Broker Percent
Alleghany in Motion	1,172	1,103	66	3	69	6%
Avery Count Transportation	573	456	93	24	117	20%
CCATS	3,846	3,233	558	55	613	16%
COLTS	4,981	4,668	291	22	313	6%
Duplin County Public Trans.	4,635	4,262	225	148	373	8%
JCATS	19,039	16,486	2,176	377	2,553	13%
Lenoir County Transit	10,270	9,513	755	2	757	7%
Martin County Transit	5,031	4,707	309	15	324	6%
Mitchell County Transportation	1,344	1,168	167	9	176	13%
OUTS	12,744	10,627	1,743	374	2,117	17%
Rutherford County Transit	4,514	3,676	647	191	838	19%
Sampson Area Transportation	7,118	6,227	753	138	891	13%
Transportation Lincoln County	5,273	5,039	179	55	234	4%
Union County Transportation	5,638	4,980	618	40	658	12%
WAVE	9,826	9,779	0	47	47	0.5%
Total	**96,004**	**85,924**	**8,580**	**1,500**	**10,080**	**10%**

Analysis

The analysis is structured based on specific research questions developed from the pre-implementation concerns of the coordinated public transportation providers and the availability of data and include:

1. Will public transit be able to contract with private brokers?
2. Will public transit be offered trips from private brokers?
3. Are all transit systems experiencing the same impacts on trip volumes?
4. Are per trip invoices comparable between DSS and private brokers?
5. Do private brokers pay fully and on-time?
6. Do the private brokers offer trips that public transportation systems can accept?
7. Are public transit systems offered trips first by private brokers?
8. What comments did the transit systems enter into the survey?

Each section has a conclusion statement that summarizes the findings from the analysis. There is a separate conclusion section that summarizes the findings, followed by a robust discussion.

1. Will Public Transit Systems be able to Contract with Private Brokers?

Public transportation providers initially expressed concerns regarding whether or not they could agree upon acceptable contract terms with the private brokers. In 2019, prior to Medicaid Transformation and the COVID-19 pandemic, 70 out of 78 (90%) coordinated public transportation systems contracted with DSS and these contracts continued after Medicaid Transformation. During the study period, only 54 (69%) of the coordinated public transportation systems contracted with at least one of the private brokers[1]. Thus, 16 transit systems were unable to establish agreeable contractual terms with the private brokers, a 23 percent reduction (Figure 3).

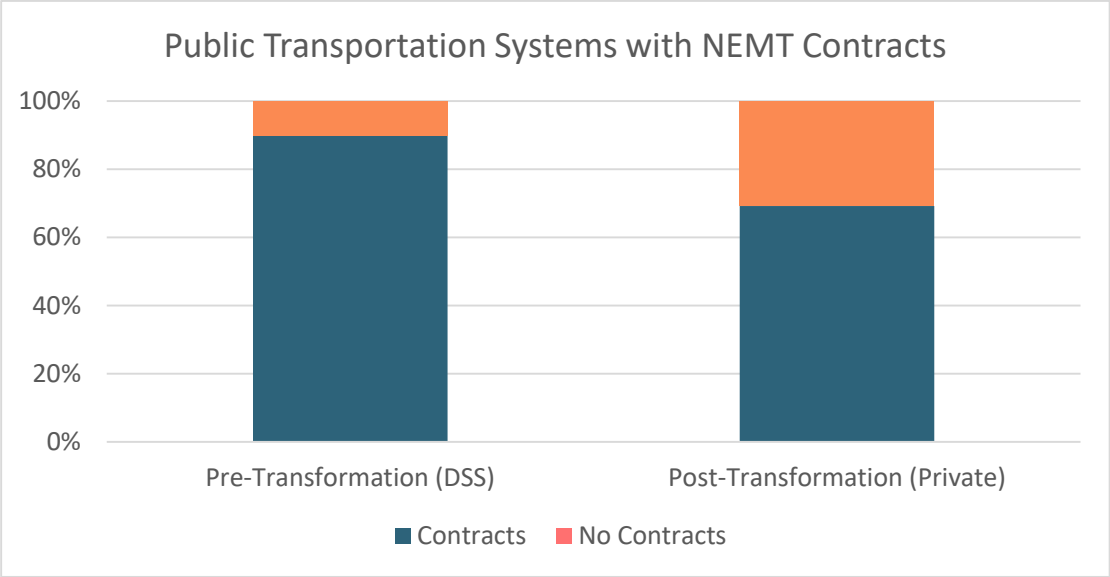


Figure 3. Public Transportation Systems with NEMT Contracts Pre- and Post- Medicaid Transformation

Conclusion: Nearly 25% of the transit systems with DSS contracts were unable to agree on terms with the private brokers.

2. Will Public Transit Systems Receive Trips from Private Brokers?

Transit agencies also expressed concern that private brokers would not offer trips to public transportation at the same volumes they received prior to Medicaid Transformation. To determine how trip volumes have changed since NC Medicaid Transformation, prior year data from the 2019 and 2020 NC Operating Statistics is combined with the FY21 survey data. Overall, the total number of NEMT trips provided after Medicaid Transformation are greater than those provided for the same period in 2020 when vaccines were not widely available and significant COVID-19 precautions were still in place. But, as is shown in

[1] Conversations with the North Carolina Public Transportation Association Executive Director, June 19, 2022

Figure 4, total trips are still well below levels prior to COVID-19 (blue line) The dip in September 2019 is due to a major hurricane that severely impacted the number of trips provided.

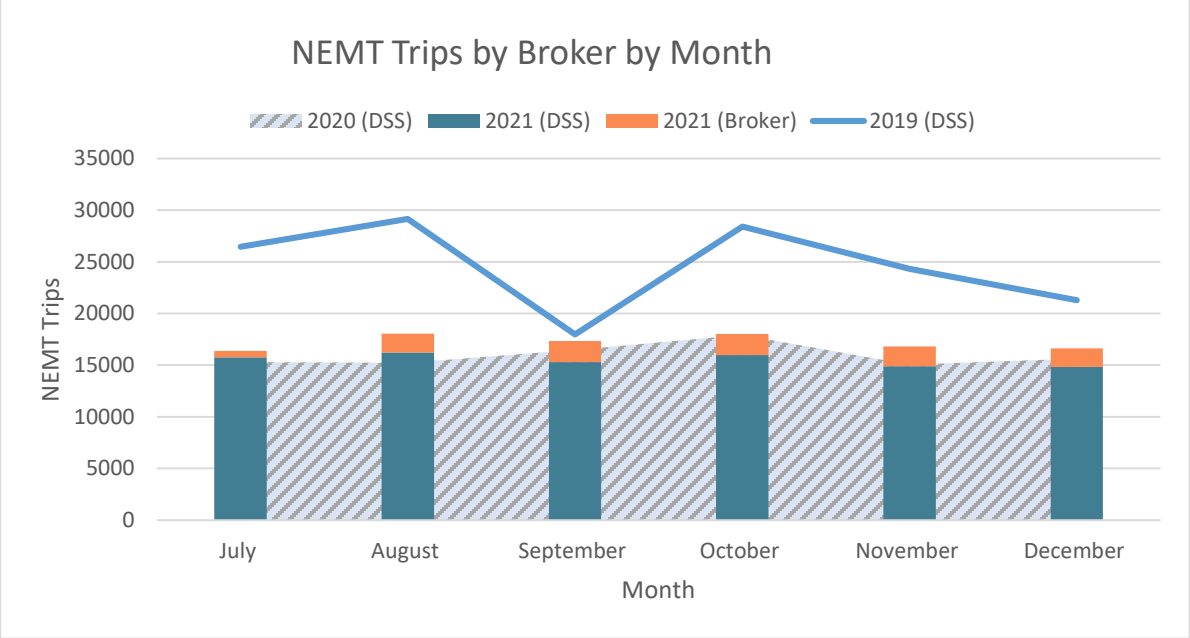


Figure 4. NEMT Trips by Broker by Month

Figure 4 also shows growth in NEMT trips served for the private brokers between July and August 2021. Upon the initial rollout in July, public transportation systems received few trips from the private brokers. The North Carolina Public Transportation Association was able to secure a commitment from the PHPs and private brokers that public transportation should be given the 'right of first refusal' for NEMT trips toward the end of July 2021. It is possible this policy commitment had an impact on trips offered to public transportation from July to August or it could be that a new sense of urgency for all parties resulted in resolving contracting issues and data sharing agreements. An analysis about the 'right of first refusal' is found later in this document.

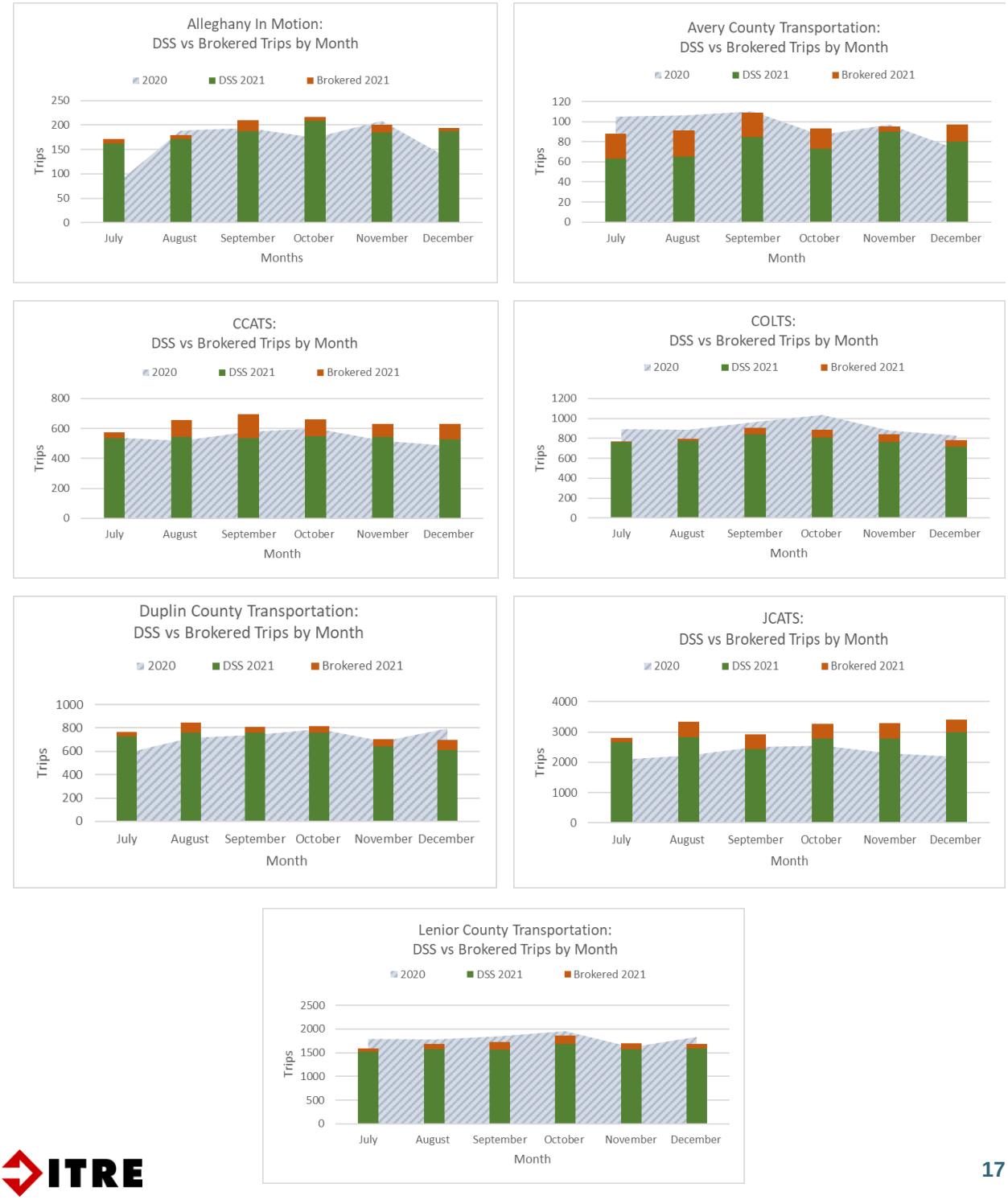
It is difficult to determine if transit systems would have returned to 2019 NEMT levels due to a myriad of factors, including NC Medicaid Transformation but also behavioral changes and practices such telemedicine. The researchers attempted to gather additional data from NC DHHS on all NEMT services, but the data request had not been fulfilled as of June 2022.

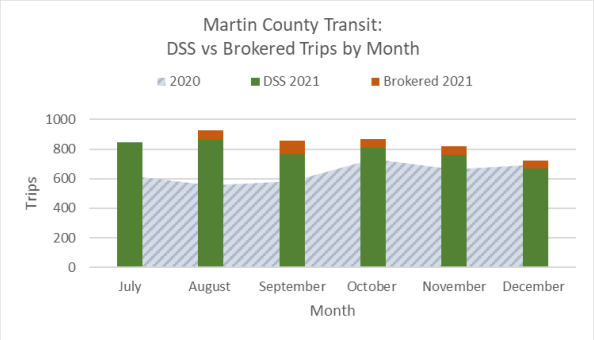
Conclusion: Total NEMT trips after Medicaid Transformation are slightly higher than 2020, but well below 2019 levels.

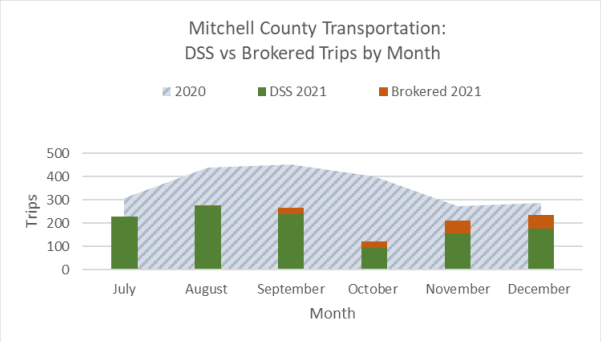
3. Are all transit systems experiencing the same changes in trip volumes?

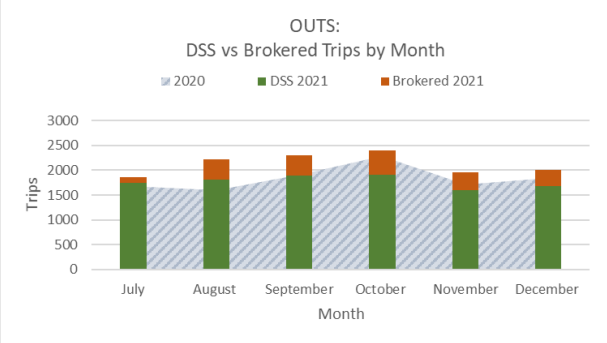
Figure 5 addressed transit systems in aggregate and shows that 2020 and 2021 NEMT trips were roughly comparable. Similar charts were created for each transit system to determine if individual transit systems experienced similar changes in trip volumes between 2020 and 2021 (Figure 5). All trips in 2020 originated from DSS whereas 2021 trips originate from DSS and the private brokers.

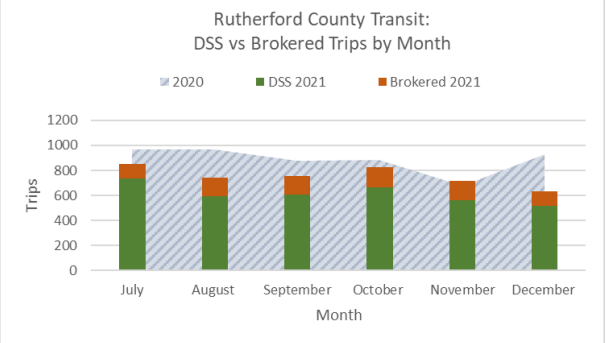
Figure 5. Brokered Trips by Transit System

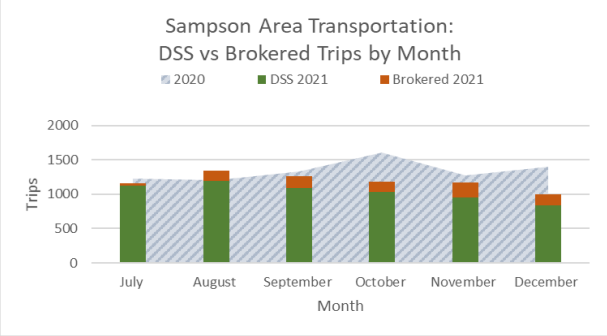


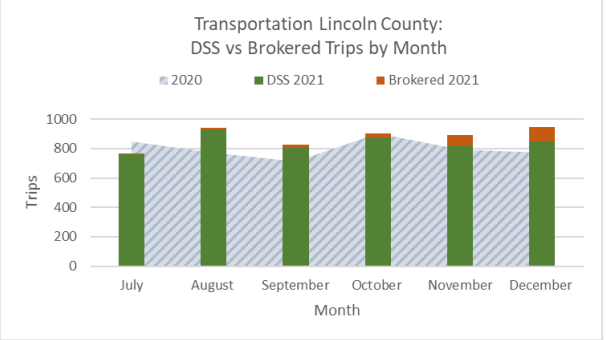

Martin County Transit:
DSS vs Brokered Trips by Month
2020
DSS 2021
Brokered 2021
Trips
1000
800
600
400
200
0
July
August
September
October
November
December
Month

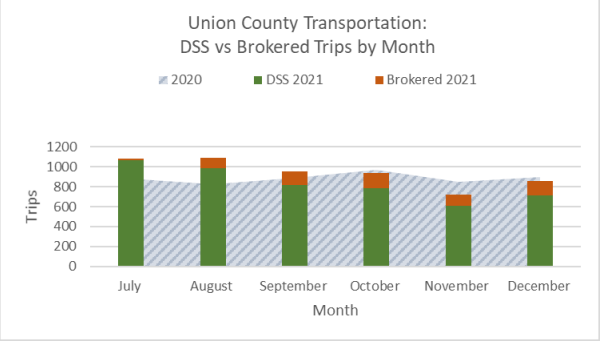

Mitchell County Transportation:
DSS vs Brokered Trips by Month
2020
DSS 2021
Brokered 2021
Trips
500
400
300
200
100
0
July
August
September
October
November
December
Month

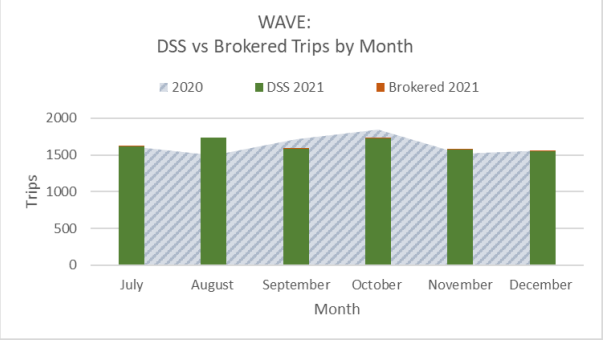

OUTS:
DSS vs Brokered Trips by Month
2020
DSS 2021
Brokered 2021
Trips
3000
2500
2000
1500
1000
500
0
July
August
September
October
November
December
Month


Rutherford County Transit:
DSS vs Brokered Trips by Month
2020
DSS 2021
Brokered 2021
Trips
1200
1000
800
600
400
200
0
July
August
September
October
November
December
Month


Sampson Area Transportation:
DSS vs Brokered Trips by Month
2020
DSS 2021
Brokered 2021
Trips
2000
1500
1000
500
0
July
August
September
October
November
December
Month


Transportation Lincoln County:
DSS vs Brokered Trips by Month
2020
DSS 2021
Brokered 2021
Trips
1000
800
600
400
200
0
July
August
September
October
November
December
Month


Union County Transportation:
DSS vs Brokered Trips by Month
2020
DSS 2021
Brokered 2021
Trips
1200
1000
800
600
400
200
0
July
August
September
October
November
December
Month


WAVE:
DSS vs Brokered Trips by Month
2020
DSS 2021
Brokered 2021
Trips
2000
1500
1000
500
0
July
August
September
October
November
December
Month

The charts in Figure 5 show that some transit systems, such as JCATS and Martin County Transportation, have exceeded 2020 NEMT trips from DSS alone. The addition of brokered trips means JCATS is well above 2020 levels. However, COLTS and Mitchell County Transportation, as examples, have not exceeded 2020 levels in any month, even with the brokered trips. For these and other transit systems with lower NEMT volumes, do these trips still exist, and if so, who is carrying them?

Conclusion: The impact of Medicaid Transformation on transit systems is uneven.

4. Are per trip invoices comparable between DSS and private brokers?

This research question addresses the concern that allowable billing rates from private brokers may be lower than DSS rates. To fully answer whether per trip invoices from DSS and the private brokers are comparable, it is necessary to understand whether trip characteristics are also comparable, such as pickup/drop off windows, the ability to load multiple passengers on the vehicle, deadhead, wait time, trip origins and destinations, etc. on an individual trip-level and that the administrative burden is equivalent. Without access to the trip requirements and the actual trip data, a direct comparison of per trip invoices requires the assumption that the trips are comparable between DSS and the private brokers. The assumption of equivalency is made even though, anecdotally, the transit systems claim that pickup and drop off windows are difficult to negotiate with the brokers, the administrative burden is greatly increased, and grouping trips is more difficult. If true, these conditions would result in an expectation of higher per trip invoices to the private brokers as compared to DSS. However, the opposite outcome has been observed.

Over the six-month study period, DSS was invoiced a total of $31.08 per trip whereas the private brokers were invoiced $29.94 per trip, a difference of $1.14 per trip, or 4% lower than DSS. Figure 6 shows the invoice amounts per trip by month and indicates that invoices sent to DSS were higher in July, September, and October 2021, whereas the invoices sent to both sets of brokers were similar in August, November, and December 2021.

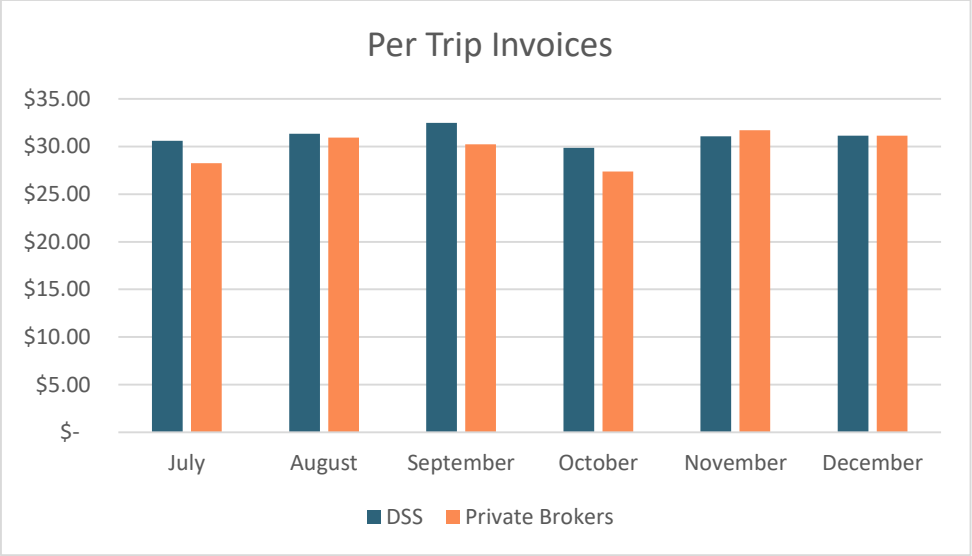


Figure 6. Per Trip Invoices by Broker

Although a 4% difference in invoice rates may seem trivial, public transportation received $21.5 million in Medicaid contracts in Fiscal Year 2019. Assuming all other trip and service characteristics are equal, a 4% decrease in revenues after Medicaid Transformation is fully implemented would result in a loss of $850,000.

Conclusion: The per trip invoices to the private brokers are lower than for DSS.

5. Do Private Brokers Pay Fully and On-Time?

Another primary concern from the public transportation providers was whether the private brokers would be as reliable at paying invoices as DSS. During the study period, public transit systems invoiced DSS for $2.8 million and DSS paid $2.65 million. Thus, DSS paid 94% of what they were invoiced but 6% was unpaid, possibly because of disputes concerning eligibility and services provided (Figure 7). Meanwhile, private brokers were invoiced $300,000 and paid $271,000, or 89%.

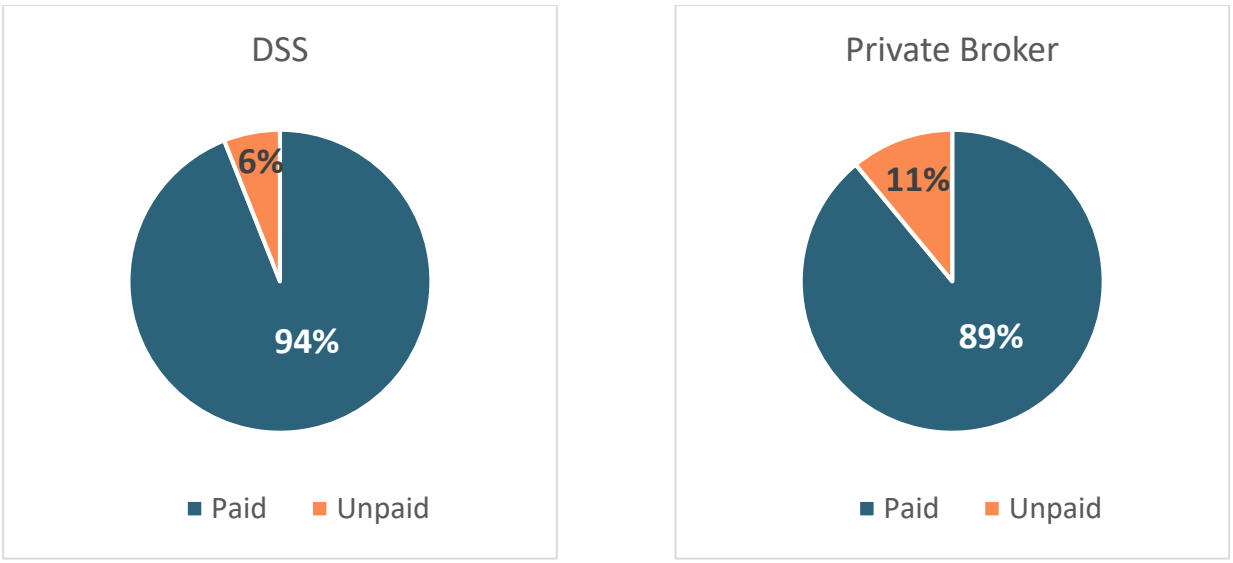


Figure 7. Invoice Amounts Paid and Unpaid by Broker

Table 4 shows the percent of claims paid by month in 2021 compared to invoice amounts for DSS and the two private brokers. All brokers had difficulty paying during the first month of the transition causing underpayments that were mostly resolved in later months. However, except for September, DSS was consistently a more reliable payer than the private brokers. And, being greater than 100%, the October DSS percent paid likely indicates a catch-up payment from September which could be the result of the federal fiscal year ending in September.

Table 4. Percent of Claims Paid by Month

Month	DSS Percent Paid	Private Broker Percent Paid
July	84%	67%
August	96%	88%
September	89%	95%
October	104%	95%
November	98%	96%
December	91%	79%
Total	**94%**	**89%**

The data sharing relationship between the private brokers and transit systems may improve over time, which could result in greater accuracy in developing invoices and issuing payments. But, for now, DSS is a more reliable payer than the private brokers.

Conclusion: DSS is more reliable at paying invoices on-time and in-full than the private brokers.

6. Do the private brokers offer trips that public transportation systems can accept?

Even in cases where public transportation has the right of first refusal, just because a trip is offered does not mean it is a trip that can be served. Transit systems need to consider a plethora of factors when determining whether to accept a trip, including pickup/drop off times, pickup/drop off windows, type of vehicle, attendants/guests, the ability to load multiple passengers on the vehicle, deadhead, wait time, trip origins and destinations, and other features. All of these factors must be compared against the expected reimbursement the transit system will receive. If all of the factors do not add up, the transit system returns the trip to the broker and the broker will find another provider to serve the trip.

It is not easy for the transit systems to compile data on which trips are returned because this function occurs in the private broker's software portal, meaning returned trips do not exist in the transit system's software. Therefore, the data analyzed in this section were provided by ModivCare, the largest private transportation broker. The data are for the entire state, not just the survey sample sites, and is from December 2021.

According to ModivCare's data, public transportation providers were offered around 10,000 trips statewide, with 36% of the trips offered being returned and not served by coordinated public transportation systems. Private providers, meanwhile, were offered around 22,000 trips and returned 13% (Table 5). The characteristics of the trips offered to the providers are unknown, as is whether the private or public transportation provider was offered the trip first. Figure 8 displays these results in pie charts.

Table 5. Trips Offered, Carried, and Returned by Provider Type

Provider Type	Trips Offered	Trips Carried	Trips Returned	Return Rate
Public Transportation	10,093	6,421	3,672	36.4%
Private Providers	21,696	18,890	2,806	12.9%
Total	31,789	25,311	6,478	20.4%

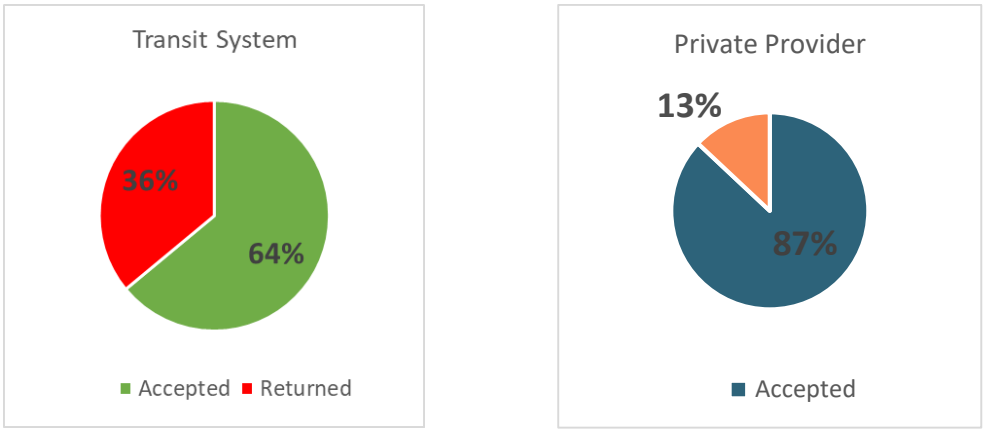


Figure 8. December ModivCare Acceptance and Return Rates for Public and Private Providers

A return rate of 36% means that for every 100 trips assessed to the transit system, they determined 36 of these trips could not be served because of reasons described below. This results in a higher

administrative burden relative to DSS brokered trips because each trip offered is evaluated by a staff person. This also results in a financial burden because the transit systems use limited resources to return trips and they are not reimbursed for this resource use.

The transit survey asked to select the reasons why public transportation returned trips to the brokers. Multiple selections were possible, but the number of trips for each reason was not collected because of the recordkeeping burden on the transit systems. Figure 9 shows the primary reason for returned trips is the trips are outside of the transit system's service area (81%). Like the coordinated public transportation systems, DSS is county-based so staff would only be aware of trips associated with clients assigned to the county based on home address.

Being offered trips for customers residing outside of the service area is new phenomenon for the transit systems. The second most frequently cited reason, 73 percentage points lower, is the trip is outside of the service time.

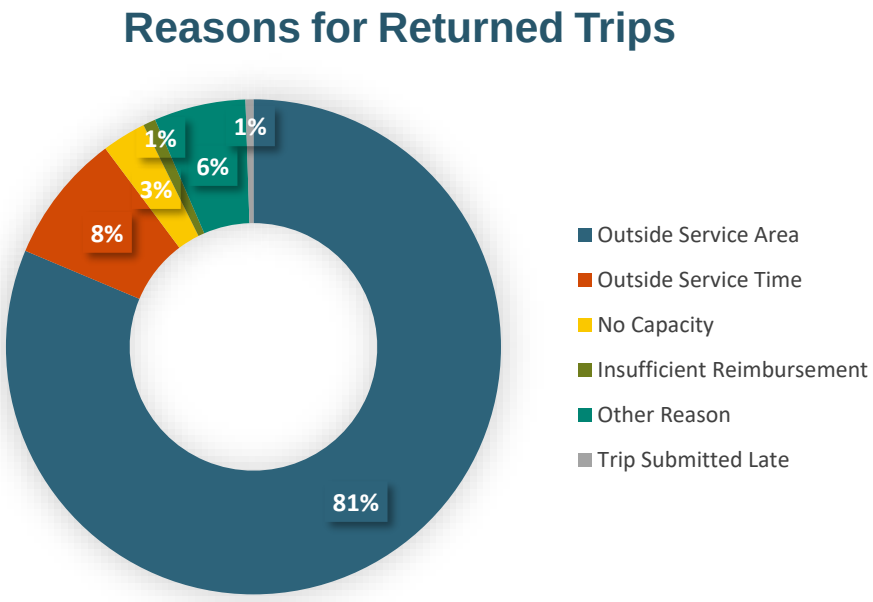


Figure 9. Reasons for Returned Trips from Transit Systems

Conclusion: Transit systems reject over 1/3 of the trips offered to them by private providers.

7. Are public transit systems offered trips first by private brokers?

As previously noted, the North Carolina Public Transportation Authority worked with the PHPs and private brokers in late July 2021 to forge an agreement that public transportation would be given the 'right of first refusal'. The researchers attempted to acquire NEMT claims data from DHHS but have been unsuccessful as of July 2022. The lack of data transparency means it is difficult to know exactly how many trips could have been offered to public transportation.

However, according to ModivCare's data in Table 5, public transportation systems were offered around 10,000 trips in December 2021 while 25,000 trips were carried, meaning at least 15,000 trips were not offered to the transit systems first. In the most optimistic scenario where each trip offered to the transit system was offered to them first, transit systems are given the 'right of first refusal' for 40% of the trips. If, alternatively, private providers were sent the trips first, private providers received the 'right of first refusal' for 87% of the trips.

Thus, it is clear that public transportation is not being offered all trips first, at least as of December 2021. It is possible the private brokers understand the capabilities of public transit systems and do not offer trips they could or would not serve, which seems unlikely considering the prevalence of returned trips outside of the service area and operating hours of the transit system. Thus, the 36% return rate by public transportation indicates that the private brokers and public transportation have not succeeded in defining and/or communicating which trip types are acceptable.

Conclusion: Transit systems are not offered most trips first by private brokers.

8. What comments did the transit systems enter into the survey?

The survey allowed transit systems to enter comments using free text. A total of 47 comments were entered over the 6-month period. These comments were categorized by topic and shown by frequency in the pie chart below (Figure 10).

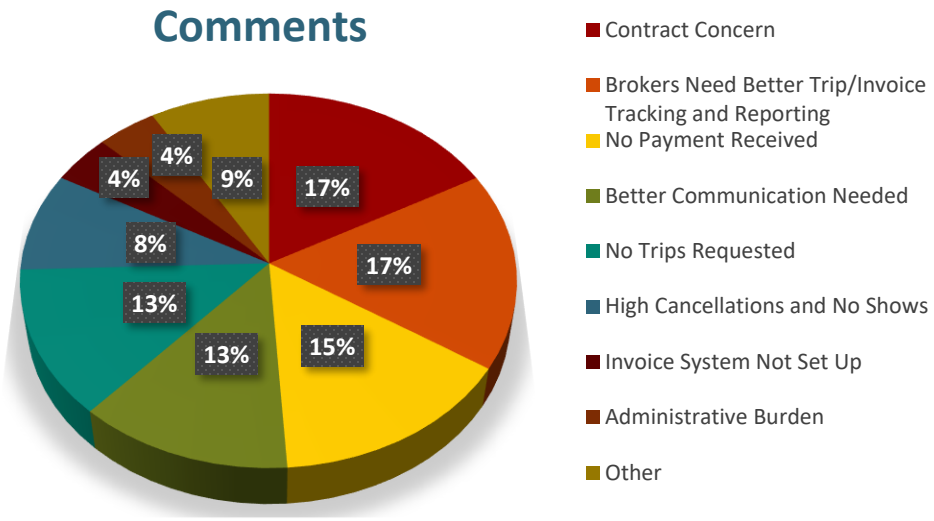


Figure 10. Transit System Comments

Conclusion: Public transit systems expressed concerns about numerous topics related to Medicaid Transformation and NEMT provision.

Conclusions

After the first six months of the initial phase of Medicaid Transformation in North Carolina, some of public transportation's fears going into the project have been validated while others have not. In many cases, public transportation was included as an NEMT provider by the private brokers and it was even agreed upon to give public transportation the 'right of first refusal'. However, this agreement has not reliably translated into action. Individual transit agencies are experiencing disparate effects, with some seeing an increase in NEMT trips and others experiencing decreases.

The conclusions from the analysis section are summarized below and discussed in the next section.

1. Nearly 25% of the transit systems with DSS contracts were unable to agree on terms with the private brokers.
2. Total NEMT trips after Medicaid Transformation are slightly higher than 2020, but well below 2019 levels.
3. The impact of Medicaid Transformation on transit systems is uneven.
4. The per trip invoices to the private brokers are lower than for DSS.
5. DSS is more reliable at paying invoices on-time and in-full than the private brokers.
6. Transit systems reject over 1/3 of the trips offered to them by private providers.
7. Transit systems are not offered most trips first by private brokers.
8. Public transit systems expressed concerns about numerous topics related to Medicaid Transformation and NEMT provision.

Discussion

Medicaid Transformation in North Carolina, even with its limited roll-out in Phase 1, had a measurable impact on the coordinated public transportation providers across the state that provide general public and life-sustaining transportation.

With the disruption of the Covid-19 pandemic and lack of comprehensive NEMT trip data from NC DHHS, it is not possible to determine how many trips would have gone to the public transportation providers without Medicaid Transformation. Overall, trips are higher in the last six months of 2021 than the same months in 2020, but some transit systems remain below their 2020 level. Plus, because Covid-19 vaccines were not available, the last six months of 2020 is likely not a good benchmark for how many trips should be expected in 2021. Medicaid trips have historically been the backbone of many public transit systems in North Carolina. When NEMT trip volumes decrease for public transit, overall community mobility may also decrease because transit systems do not have the demand or financial capacity to send vehicles across their service areas at different times or to long-distance medical facilities.

Even if private broker trip volumes are high, invoices sent to private brokers are 4% less per trip than DSS and invoice payments rates are 5 percentage points lower for private brokers in the first six months after Medicaid Transformation. When these two hits on revenue are combined, it means transit systems will either need to cut expenses or generate revenues from other funders to cover losses associated with serving NEMT trips from private brokers. It is unlikely that expenses for NEMT services can be cut

because the service rules of the private brokers do not allow much flexibility for moving trips to allow for grouping and more efficient service. Thus, it is likely that other funders such as Area Agencies on Aging, local government funds, state, or federal funds will need to contribute more per trip to make up for the loss of funding provided by private for-profit NEMT brokers.

After Medicaid Transformation is complete in December 2022, assuming the observed patterns remain, the difference between DSS and private broker payments are expected to result in an annual loss of $1.1 million to public transportation based on FY19 funding levels (pre-COVID). This number is in addition to the $850,000 decrease in bills allowed to be sent to the private brokers, resulting in a total potential annual loss of close to $2 million annually to North Carolina's public transportation industry, or 9% of their Medicaid revenue.

Even more important than the loss of $2 million in operating revenue is the loss of $2 million in contract revenue that can be used to match federal grants. For example, the Federal Transit Administration assists with capital funds for vehicles and other equipment at a rate of 80% Federal and 20% local. Thus, the loss of $2 million could result in transit systems being unable to access an additional $8 million in Federal funds, for a total loss of $10 million per year unless matching funds are available from other sources.

Public transit systems in North Carolina are accustomed to dealing with government entities which are consistent and do not profit from the business relationships. The introduction of private for-profit transportation brokers results in the introduction of competition. Competition means every transaction is relational, where the brokers will send trips to the provider most likely to generate a profit. Thus, historic trends from a private NEMT broker may not indicate future trends. If a new private transportation provider enters a market, public transportation may experience sudden and drastic decreases in NEMT business. If the private provider exits the market, the public provider may experience the same types of increases. If providers suddenly enter and exit the market, public transit systems will face wild swings in Medicaid trip volumes and revenues and non-Medicaid services will likely be impacted.

As Medicaid Transformation was struggling to be implemented in July 2021, earning a commitment from the PHPs and private brokers for public transportation to have the 'right of first refusal' was important for the public transportation industry and making that commitment was likely an important show of good faith effort from the PHPs and private brokers to NC DHHS. However, the data clearly show that, at least as of December 2021, this commitment was not being honored because a maximum of 40% of the trips were offered first to public transportation. It could be that the private brokers did not fully make or stick to the commitment or that they learned over the ensuing months what trips public transit would accept and adjusted, an unlikely conclusion since public transportation returned 36% of the trips offered in December. A commitment to continuing a robust 'right of first refusal' program requires some confidence that the trips will be accepted. If the operational and payment terms are unacceptable to the public transportation systems and this is known, the trips will be refused which only creates delay and administrative burden for all parties. The 'right of first refusal' in itself should not be the goal. Instead, the goal should be the 'right of first refusal' for reasonable trips, meaning trips that fit into the existing service delivery model of the public transportation systems without consuming an unacceptable amount of resources and public subsidy to benefit the private for-profit brokers.

Even if public transportation systems form mutually beneficial relationships with the current private NEMT brokers, the short history of these brokers in North Carolina has shown that their relationships with PHPs is also a cause for upheaval. National MedTrans was one of the three brokers involved with the substantial planning efforts for the Phase 1 rollout of Medicaid Transformation, only to be acquired and replaced by ModivCare before implementation. OneCall survived through the planning phase and operated for ten months before opting out and being replaced by MTM. Changing transportation brokers has impacts on the Medicaid beneficiaries, but also requires substantial effort and expense for the transit systems in terms of the administrative burden to develop a new contract but also to learn a new software program that may differ greatly from the previous version.

Finally, the qualitative experiences of public transportation systems with Medicaid Transformation should continue to be collected by the State, the PHPs, and the NEMT brokers. Public transit providers are in daily contact with the Medicaid beneficiaries and have firsthand knowledge of their concerns. The quantitative data is important, but the State, PHPs, and NEMT brokers should have a system in place to collect information that is not being adequately measured through quantitative processes.

In summary, the long-term relationship between public transportation systems, private brokers, Prepaid Health Plans, and NC DHHS is still being formed. The initial experiences, however, show that public transportation providers are likely to have difficulty maintaining positive working relationships with private NEMT brokers unless something changes. There are many actors involved and many moving parts, making it difficult to predict where the relationship will settle.

Further research needs to be conducted as the next phase of Medicaid Transformation is unveiled in December 2022. The data collection process for this research should be repeated for the next few years to further understand the impact of Medicaid Transformation on overall access to healthcare and other essential destinations, especially in rural areas, and the overall health of public transportation. In addition to tracking and reporting on the aggregate trends, future research should explore whether spatial, demographic, or other characteristics explain the uneven impacts experienced by the transit systems.

References

1. Edrington, Suzie & Cherrington, Linda & Burkhardt, Jon & Garrity, Richard & Raphael, David & Borders, Stephen & Peterson, Ross & Dalton, Jeremy & Collette, Patricia. (2018). Handbook for Examining the Effects of NEMT Brokerages on Transportation Coordination. 10.17226/25184.
2. Eisenberg Y, Owen R, Crabb C, Morales M. Rideshare transportation to health care: evidence from a Medicaid implementation. The American Journal of Managed Care. 2020 Sep;26(9):e276-e281. DOI: 10.37765/ajmc.2020.88492. PMID: 32930556.
3. Starbird LE, DiMaina C, Sun CA, Han HR. A Systematic Review of Interventions to Minimize Transportation Barriers Among People with Chronic Diseases. J Community Health. 2019 Apr;44(2):400-411. doi: 10.1007/s10900-018-0572-3. PMID: 30206755; PMCID: PMC6450539.
4. Musumeci M, Rudowitz R. Medicaid non-emergency medical transportation: overview and key issues in Medicaid expansion waivers. Kaiser Family Foundation. February 24, 2016. Accessed July 17, 2022. https://www.kff.org/medicaid/issue-brief/medicaid-non-emergency-medical-transportation-overview-and-key-issues-in-medicaid-expansion-waivers/
5. Adelberg M, Simon M. Non-emergency medical transportation: will reshaping Medicaid sacrifice an important benefit? *Health Affairs*. September 20, 2017. Accessed July 17, 2022. https://www.healthaffairs.org/do/10.1377/hblog20170920.062063/full/
6. Kim, J., Norton, E.C. and Stearns, S.C. (2009), Transportation Brokerage Services and Medicaid Beneficiaries' Access to Care. Health Services Research, 44: 145-161. https://doi.org/10.1111/j.1475-6773.2008.00907.x
7. Monast, Kai. “Managed Care Organizations and Coordinated Transportation”. White Paper for the North Carolina Department of Transportation. August 13, 2018.
8. Burkhardt, Jon E. and Richard Garrity. "Sharing the Costs of Human Services Transportation." *Transportation Research Record* 4, no. 2277 (2012): 57-64.
9. Federal Transit Administration. “Coordinated Public Transit Human Services Transportation Plans”. https://www.transit.dot.gov/funding/grants/coordinated-public-transit-human-services-transportation-plans. April 27, 2022.
10. National Center for Mobility Management. “States At A Glance (List)”. https://nationalcenterformobilitymanagement.org/states-at-a-glance/states-at-a-glance-list/. Accessed September 9, 2022.
11. General Assembly of North Carolina. “An Act to Transform and Reorganize North Carolina’s Medicaid and NC Health Choice Programs”. Session Law 2015-245, House Bill 372. 2015. https://www.ncleg.gov/enactedlegislation/sessionlaws/html/2015-2016/sl2015-245.html
12. North Carolina Department of Health and Human Services. “Fact Sheet Introduction to Medicaid Transformation: Part 1 – Overview.” 2021. https://medicaid.ncdhhs.gov/fact-sheet-

introduction-medicaid-transformation-part-1-overview/download?attachment?attachment?attachment, Accessed June 3, 2022.

13. North Carolina Department of Health and Human Services. “Transformation: North Carolina's Transformation to Medicaid Managed Care”. 2022. https://medicaid.ncdhhs.gov/transformation, Accessed April 4, 2022
14. North Carolina Department of Health and Human Services. “Standard Plan Regions”. 2022. https://medicaid.ncdhhs.gov/standard-plan-regional-map. Accessed June 3, 2022
15. LogistiCare. “LogistiCare Announces Acquisition of National MedTrans”. May 7, 2020. https://www.logisticare.com/news/logisticare-announces-acquisition-of-national-medtrans. Accessed July 5, 2022.
16. North Carolina Department of Health and Human Services. “Health Plans”. 2022. https://medicaid.ncdhhs.gov/health-plans, Accessed June 3, 2022.
17. Tippett, Rebecca. First Look at 2020 Census for North Carolina. Carolina Demography, University of North Carolina at Chapel Hill. 2021. https://www.ncdemography.org/2021/08/12/first-look-at-2020-census-for-north-carolina/. Accessed July 19, 2022.
18. Secretary of State Elaine F. Marshall. “NC Climate and Geography”. North Carolina Secretary of State. https://www.sosnc.gov/divisions/publications/kids_page_geography, Accessed July 19, 2022.
19. USA.com. “North Carolina Land Area County Rank”. http://www.usa.com/rank/north-carolina-state--land-area--county-rank.htm. Accessed July 19, 2022.

Takeaways from DSS Coordinator Interviews on NC Medicaid Transformation

Dr. Noreen McDonald
The University of North Carolina at Chapel Hill

May 2023

Background

Previous research has demonstrated that transportation is a substantial barrier to accessing health care for many Americans, leading to missed medical appointments and/or delayed care. These barriers disproportionately burden publicly insured patients aged 18-65 as well as those with disabilities and without a household vehicle, groups which are more likely to be enrolled in Medicaid and take advantage of Non-Emergency Medical Transportation (NEMT) services (Cochran et al., 2022). Medicaid recipients have also been found to have greater odds of reporting transportation barriers after controlling for other sociodemographic and health factors than the general population (Wolfe et al., 2020). North Carolina's Medicaid Transformation and resulting changes in health care delivery are likely to impact Medicaid recipients throughout the state and their ability to access care.

NC Medicaid is required to provide NEMT for all Medicaid beneficiaries who request assistance, and this service will continue throughout the state's transformation. Patients transitioned over to Standard Plans under managed care will now utilize state transportation brokers to receive NEMT rather than their local Departments of Social (DSS).[2] These private brokers may make decisions that reduce or alter NEMT requests, impacting the finances and operations of public transportation agencies currently contracted to provide rides to and from medical appointments.[3] Given the likely impacts to both community transportation systems and riders currently utilizing NEMT services, this project investigated how access to health care has changed and will continue to change throughout Medicaid Transformation by speaking it stakeholders on the ground. Because the transition shifts NEMT coordination and reimbursement away from local DSS and to private brokers, the team interviewed staff from county DSS to better understand how they have been affected by Medicaid Transformation. DSS coordinators currently interact most directly with Medicaid beneficiaries utilizing NEMT services and have substantial insight into their transportation needs and the ways in which the transformation affects their access to care.

[2] https://www.cms.gov/Medicare-Medicaid-Coordination/Fraud-Prevention/Medicaid-Integrity-Program/Education/Non-Emergency-Medical-Transport

[3] https://rip.trb.org/view/2003216

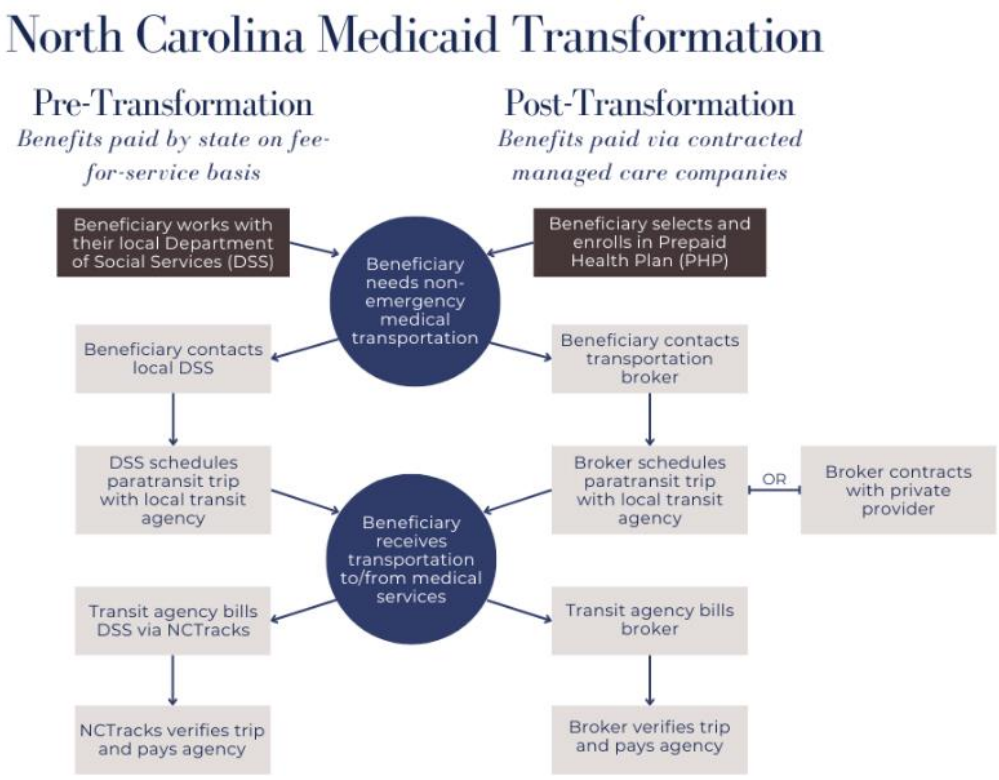
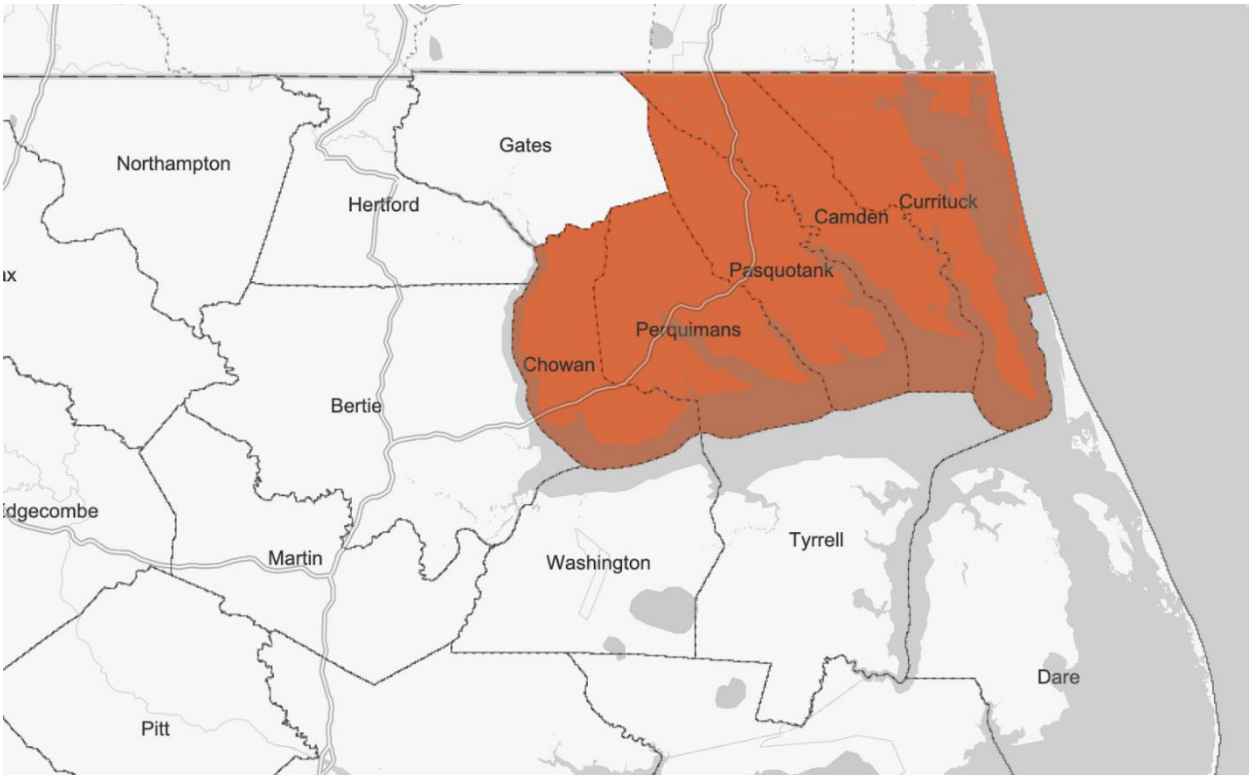


Figure 1. NC Medicaid Transformation Overview

Overview and Methods

This research explores how healthcare access in five small, rural counties in northeastern North Carolina both has and will be impacted as the state completes its Medicaid Transformation. The transition from fee-for-service Medicaid benefits to managed and tailored care will impact the counties' ability to ensure patients have reliable transportation to and from healthcare. The Inter-County Public Transportation Authority (ICPTA), based out of Elizabeth City, North Carolina, was chosen as the public transportation system used to study to impacts of the transition. ICPTA serves Pasquotank, Perquimans, Camden, Chowan, and Currituck counties, and provides all residents with scheduled demand-responsive transportation services to essential destinations such as grocery stores, medical facilities, and employment sites.

The researchers contacted all five counties served by ICPTA and interviewed staff from three county DSS about transportation access for their Medicaid recipients before and after the transformation. This included a representative from Pasquotank, the largest of these counties and home to Elizabeth City, Northeastern North Carolina's economic hub, as well the smaller Currituck and Perquimans counties. ICPTA provides rides within the five counties for a flat fare, and also offers out-of-town medical transportation to Virginia and Greenville for residents of select counties on designated days at a higher rate. The image below shows the location of all five counties in the northeastern-most corner of North Carolina.



Source: Author

Figure 2. The Five North Carolina Counties Served by ICPTA

Table 1. County Demographics

	Chowan	Perquimans	Pasquotank	Camden	Currituck
Population	13,772	13,130	40,821	10,835	29,653
Area	173 mi²	247 mi²	227 mi²	240 mi²	262 mi²
Density	79.4/mi²	52.6/mi²	178.8/mi²	43.1 mi²	107.3/mi²
County Seat (Population)	Edenton (4,391)	Hertford (1,925)	Elizabeth City (18,703)	Camden (914)	Currituck (716)
Race or Ethnicity *Non-Hispanic White*	60.4%	72.5%	54.1%	80.4%	85.7%
Black/African American	33.5%	21.8%	36.2%	11.1%	5.8%
Asian	0.8%	0.6%	1.4%	1.9%	1.1%
Hispanic/Latino/Spanish	3.9%	3.4%	6.3%	/3.8%	5.1%
Multiracial/Multiethnic	1.7%	2.1%	3.3%	3.4%	2.5%
Other Race/Ethnicity	0.9%	0.5%	0.8%	0.6%	0.9%

Source: United States Census QuickFacts, 2021

Interview Findings

1. NEMT Process Pre-Transformation

NEMT is a covered benefit for NC Medicaid recipients under Managed Care and Medicaid Direct and allows beneficiaries to access health care services from Medicaid providers. Eligible patients are able to have medically necessary transportation arranged and/or paid for via this service.[4] ICPTA is the only transit agency that serves each of the five counties, and each county DSS coordinates with the company to provide transportation services for their Medicaid recipients. When requesting NEMT assistance, clients in the region have two options: (1) scheduled paratransit trips through ICPTA, or (2) mileage reimbursement for their own or a driver's vehicle. Patients are made aware of NEMT eligibility and options during both managed care program intake and Medicaid recertification.

County DSS caseworkers work with each client to determine whether a van or reimbursement is a better option for them based on their situation. If beneficiaries have a reliable vehicle or way of getting back and forth on their own, the DSS generally provides reimbursement for them. One interviewee noted that "if a client says 'I'm going to Greenville and I don't trust my car,' [the DSS will] put them in a van." ICPTA offers rides Monday-Friday, 4:30 am – 7:30 pm, and all appointments are required to be scheduled a minimum of 48 hours in advance except under extenuating circumstances. Out-of-town medical transportation is available for appointments outside the local area but operates on limited hours and requires additional notice for scheduling.[5] Geographic availability and ride time may be limited system-wide due to the ongoing regional driver shortage.

To initiate a NEMT trip request, patients contact their county's DSS transportation coordinator and provide all required eligibility and scheduling information. The coordinator sends the request to ICPTA and contacts the patient to let them know the pickup time once the agency has set the day's schedule. After the trip has been completed, ICPTA sends DSS the bill and the records are verified and uploaded to NCTracks, the state's Medicaid Management Information System, for payment.[6] One DSS representative praised their county's "exceptional" communication with ICPTA, stating that "anything we've had any questions or concerns about… my coordinator can go right to the phone and find out… that relationship is strong and I think it'll continue to be."

ICPTA generally accepts all ride requests within their service area, and only rejects those requested outside of working hours, without sufficient notice, or in the case of external factors such as storms making travel difficult or unsafe. The county DSS coordinators have very rarely seen ride refusals or cancellations, but one reported a recent isolated incident in which they had to reschedule a child's appointment after ICPTA cancelled on short notice because the driver was "not really familiar with the area and didn't want to go into [it] because they said they were uncomfortable because it's not safe." Clients may also occasionally be suspended from NEMT services if they are repetitive no-shows or have behavioral issues on the vehicle.

For mileage reimbursement, the county DSS requires clients to submit a verification form signed by their Medicaid-enrolled healthcare provider. One representative described the process for their county in detail:

---

[4] https://files.nc.gov/ncdma/documents/County/county-playbook/NCMT-Fact-Sheet-NEMT-Part-2.pdf
[5] https://icpta.net/information/routes-fares/
[6] https://www.nctracks.nc.gov/content/public/

"we send the client the form, they go to the doctor, they get the forms signed, they turn it in by a specific date, and then we issue payment usually within 15 days." This process likely applies to the other counties as well. The DSS may deny reimbursement requests if the trip was not requested in advance, if the forms were not completed by a Medicaid provider, or if the service received is not covered by Medicaid. Some counties are also able to "give [patients] gas vouchers to a local place" instead of reimbursement, and some may also utilize local taxi services as a last resort if no other transportation options are available. One interviewee noted that many clients transitioned to the Standard Plan already had their own transportation or felt burdened by the process and "didn't want to mess with the paperwork to get the gas vouchers and just took care of [gas payments] themselves."

2. Patient Perception of Changes

When Managed Care launched statewide in July 2021, over 1.5 million Medicaid beneficiaries began receiving care through NC Medicaid Managed Care health plans.[7] Despite receiving welcome packets informing them about their new health plan and changes to care, many beneficiaries from the three counties were not fully aware of Medicaid Transformation and "were completely surprised that there was going to be a change because they tend not to read their mail." The counties reported that patients seemed generally wary of the forthcoming changes, and some even were confused about whether they would be required to change providers or lose access to certain treatments. One representative expressed that patients "should have more information" and "shouldn't have to be all concerned and worried that everything's changing, and call their caseworker in a panic."

DSS employees have generally stepped in to play an important role in explaining the new Medicaid processes to patients and reassuring them that they and their loved ones will still be able to continue receiving care. One DSS representative shared: "I had a client come in here two days ago… yelling and screaming when she came in, but by the time she left she was happy, pleased, and everything was good because I could explain it… help her understand what this meant for her disabled daughter that she was scared she wasn't gonna be able to get treatment for."

3. Transformation So Far

During the first round of the transformation, starting July 1, 2021, 15% of Medicaid beneficiaries statewide were transferred to managed care. The remaining 85% will be enrolled in Tailored Plans, a version of managed care that also provides additional specialized services for individuals requiring a higher level of care. While originally scheduled for December 1, 2022, the implementation of these tailored plans has been pushed back to October 1, 2023 to allow additional time for the brokers to contract with providers and be ready for a full rollout.[8]

The counties in this region have not seen significant impacts of the transformation yet, largely due to the types of patients who are affected. Pasquotank County, despite being the largest of the three counties, had only around 7 patients who met the criteria for managed care. Many patients in the area are either dually enrolled in both Medicare and Medicaid or are high-frequency users such as dialysis recipients and will be transitioned over in the second round. The counties have also found that many of the patients that

[7] https://www.ncdhhs.gov/news/press-releases/2021/06/30/nc-medicaid-managed-care-launch-statewide-july-1
[8] https://www.ncdhhs.gov/news/press-releases/2023/02/27/ncdhhs-delays-implementation-nc-medicaid-managed-care-behavioral-health-and-idd-tailored-plans

have been transitioned over to Prepaid Health Plans (PHPs) were not those utilizing NEMT services, and thus the number of patients they are providing transportation for has not decreased a great deal yet.

One DSS representative noted that although they have not seen a huge decrease in NEMT requests, they have seen "an increase in complaints about the PHPs" from their patients. One county recently had a client with chronic illnesses who had been transitioned over ask the DSS for help after they repeatedly had rides scheduled but then no driver show up. They shared: "oh it's just been terrible… she has to go to the doctor two or three times per week… and they just either would not show up, or they would say they couldn't drive there, she'd met her limit." The DSS coordinators have expressed frustration that "[their] hands are tied" and there is not much they can do to help clients who they are no longer coordinating NEMT for. DSS staff are doing their best to help patients "wrap their heads around all of this new process, just to get to the doctor to be seen and get their prescriptions and get paid," but are struggling to address this confusion "without causing more information overload."

4. Changes to DSS's Role

The most notable difference from Medicaid Transformation for the county DSS will be in their relationship with patients. Thus far the DSS's primary role in facilitating the overall transition has been providing patients with resources and information, and their engagement is likely to decrease as the transformation continues. In the words of one of the coordinators: "We haven't done anything additional. Maybe a few more client interactions, maybe a few more… phone calls to explain or give the enrollment broker's number or the plan's number. Billing has dropped to half of the time that it was taking, because you've got half the clients, or you know about."

After the transformation is complete, the counties will continue arranging NEMT services for select patients, such as those who are dual enrolled or receiving NC Medicaid Direct.[9] After the remaining changes are rolled out in April 2023, any beneficiaries under either managed care or the tailored plan will need to go through their PHPs and transportation brokers instead of the DSS to arrange transportation services. At this point, the counties will need to re-evaluate their staffing needs based on the reduced NEMT caseload, such as Currituck County's contracted transportation coordinator.

Patients in these counties have expressed that while their transportation needs are still being met, they are not receiving the same level of human services from the PHPs and transportation brokers. Clients have been able to establish strong, trusting relationships with their DSS coordinators over the years, and are now experiencing a different, less personable dynamic under the PHPs. In the words of a supervisor from one of the larger counties: "[The NEMT coordinator] knows a lot about what's going on with [the patients], she helps advise them, you know, how to keep up with their appointments… you know there's more to the transportation than just logging the appointment. You have to talk to a lot of these folks to make sure they understand the process."

The counties also anticipate that decreased contact may lead to gaps in important knowledge about a patient's case. For example, less frequency in speaking with patients may "[make] them think that they don't have to contact [the DSS] with their changes… addresses, phone numbers, you know, new jobs, new babies, things like that." While relieving the DSS staff of some of their NEMT caseload, the

[9] https://ncmedicaidplans.gov/learn/benefits-and-services/nc-medicaid-direct-services

transformation may also make it more challenging for the counties to access valuable patient information that comes along with frequent contact.

5. Long-Term Impacts

The NEMT system has been in place for a long time, and the DSS have seen first-hand how challenging it can when "major changes… come down the pipe" from the state and the DSS is left "having to pick up the slack and… get it to work" within the existing processes. County representatives expressed a disconnect between top-down policies and the actual implementation on the ground. One interviewee noted that the availability of transportation for medical appointments "is always taking a back seat, no pun intended," and is an area that has not received adequate attention from the state office or concrete guidance. Smaller counties in particular desire more support from the state and involvement in the day-to-day operations of program rollout, as they feel as though they have been largely left to their own devices to implement these substantial changes.

After NC Medicaid Transformation is complete, patients on standard or tailored plans will contact the PHPs to arrange NEMT, while only those who are dually enrolled or exempt will continue their direct relationship with the DSS. While the counties anticipate a normal "acclimation period where the clients are trying to get used to calling someone different," one DSS representative shared "serious concerns" with the rest of the transition. As PHPs take over coordinating NEMT for Medicaid beneficiaries, clients are likely to experience a decrease in customer service. Social services "talk with someone completely different than [sic] an actual business," and the PHPs will not have the same obligation to develop individual relationships and provide the human services component alongside arranging transportation.

While there may be some initial administrative burden for the DSS as staff spend time explaining to patients how to arrange NEMT rides, the transformation will likely lead to less time spent on paperwork and billing as more patients are transitioned over. The counties anticipate that the overall number of patients utilizing NEMT benefits will likely stay the same through the transformation, but this largely depends on whether the new process seems easier or harder for patients. The coordinators generally believe that "the number of people who are receiving [transportation benefits] will probably grow if the process [for reimbursement] is easy," but this remains to be seen.

The top priority for all interviewees throughout the transformation process, regardless of who is coordinating transportation services, comes down to: "are those clients really getting the services they need, are they able to get to the doctor?" In particular, DSS coordinators stressed the need for handicap-accessible vehicles, as providing NEMT involves "dealing with a lot of folks that have mobility issues." For patients who transition to managed and tailored care, the services received are supposed to be equivalent to those obtained under Medicaid Direct. However, this is dependent upon whether the PHPs and brokers are "adequately set up" to ensure patients are getting the transportation they need to access medical care. DSS staff are generally optimistic and confident in ICPTA's ability to continue providing a high level of service, stating that they are "on top of it" and "[have] done a great job with getting [the transformation] really moving forward and alleviating a lot of [concerns]."

Findings and Opportunities for Future Research

Though the five counties served by ICPTA are much smaller and more rural than many others affected by the NC Medicaid transformation, the findings from these interviews provide valuable insight into the on-the-ground impacts of the rollout for counties across the state. Several themes emerged from the conversations with county DSS staff:

- Few patients utilize ICPTA's ride services compared to those who request reimbursement, but NEMT rides are an essential benefit for those who do. Many patients have chronic conditions that require reliable transportation services multiple days per week. Limited NEMT service hours, driver availability, and geographic coverage can be particularly challenging for those living in smaller rural areas with no other transportation options. Those who rely on ICPTA to access medical care need consistent transportation, regardless of who is coordinating rides.

- DSS staff, particularly those in smaller areas, have a high level of familiarity with patients and their individual needs. Due to the personalized nature of scheduling NEMT rides, staff often develop strong relationships with clients and play a key role in providing them with the information and resources they need. This constant contact also ensures that the DSS is aware of any changes to a client's case. For patients transitioned to a private broker, this direct connection to DSS staff is weakened.

- Counties need additional support from the state in order to successfully implement substantial changes to service delivery. DSS staff may find it challenging to incorporate new policies into existing processes, particularly when provided with minimal guidance to implement these changes. The state office can ensure a smooth transformation by providing counties with sufficient resources and information and playing a larger role in on-the-ground rollout.

While some barriers to providing substantial NEMT services are due to the small, rural nature of this area, counties across the state have likely experienced similar challenges throughout the NC Medicaid transformation. Counties with larger populations and greater resources may be affected by the rollout in very different ways, but DSS staff play a key role in illuminating the on-the-ground impacts of widespread policy changes for any areas affected.

Appendix A: Interview Questions

Questions for Interviews with DSS – August-September 2022

PART I: PROVIDER QUESTIONS

1. Can you confirm your name and title?
2. Could you briefly describe the goals of your organization and the services it provides?
3. What is your position and responsibilities?
    a. How long have you been in this position? With the organization?
    b. How does your role relate to arranging and managing non-emergency medical transportation?

PART II: PROCEDURAL QUESTIONS

One component of this transition is a shift from DSS coordinating non-emergency medical transportation and reimbursement to private brokers taking on this role. I'd like to start by asking you about how things have worked up to this point, and then what they will look like after transformation is complete.

1. Prior to starting Medicaid transformation, if a beneficiary needed NEMT, can you briefly tell me how that process worked, and what the role of DSS has been up to this point?
    a. How do you determine which transportation provider to send trip requests to (i.e., Are they still all to coordinated public transit agencies)?
        i. Has this changed at all since Medicaid transformation began?
2. How often do you see a provider reject a trip request?
    a. Public vs. private providers?
        i. What do you do when this happens?
        ii. What might this look like when PHPs and brokers are managing transportation?
3. As of July 1, 2021, 15% of beneficiaries were transferred to arranging NEMT trips using Prepaid Health Plans (PHPs) and transportation brokers, while the other 85% will transfer in December 2022.
    a. Can you describe how the first part of the transition went from your organization's perspective?
    b. What is your organization's role in facilitating the overall transition? How far along is your organization is in that process?
        i. For example, is your organization taking any steps to disseminate information to beneficiaries about the upcoming changes to the NEMT arrangement process?
4. To the best of your knowledge, how will the process of arranging NEMT work when the transition is complete (i.e., when the other 85% of beneficiaries are transitioned to PHPs and brokers), and how will it be different from now?

PART III: ADMINISTRATIVE EFFECTS

1. Given your experiences with the Phase 1 transition in July 2021, what are DSS's primary concerns in anticipating the Phase 2 transition?
    a. Has there been increased administrative burden due to the transition?
2. Are there unique needs in your county that your DSS/transportation provider(s) have adapted to?
    a. Do you anticipate difficulties in the new service model adapting to these needs?
3. Will DSS have a role in assisting with transportation after the transition is complete?
    a. If so, what might that look like?
4. How will the termination of DSS's role in brokering and scheduling trips affect DSS and its operations?
    a. Are there benefits to the organization from this transition?
    b. Are there negatives for the organization from this transition?

PART IV: EFFECTS ON BENEFICIARIES

As you are aware, beneficiaries are used to getting transportation arrangements from DSS, not from the managed plan providers, but this will be changing.

1. Historically, how have beneficiaries been made aware that NEMT is a benefit available to them through Medicaid?
    a. Do you anticipate any potential barriers to awareness of this benefit in the new system?
    b. Are beneficiaries typically aware of the upcoming changes?
        i. If yes, are there common concerns they express?
2. From the perspective of DSS, does it seem that the Prepaid Health Plans and/or brokers will have transportation networks (i.e., services for both for arranging rides and providing them) set up?
    a. Will they be adequate? Why or why not?
    b. What effects might we see for beneficiaries if they are not adequately set up?
        i. Are there difficulties you anticipate in transitioning the remaining beneficiaries to the new system?
3. Some beneficiaries (~15% of NEMT trips) have already been transitioned to using private brokers to arrange NEMT. Have there been notable differences in their experiences from the perspective of DSS?
    a. Have beneficiaries continued to contact DSS to attempt to arrange NEMT?
    b. Have beneficiaries been unable to arrange a trip, cancel appointments, been late to appointments, etc.?
4. As the remaining 85% of beneficiaries transition to the new system, do you anticipate other difficulties in accessing transportation and/or care? In other words, are there new friction points between beneficiaries and access to care? For example:
    a. Will people use their transportation benefits more or less?

b. Will the booking process be different for people who need assistance in making arrangements?
c. Are there aspects of the new system that might make it difficult to or discourage beneficiaries from arranging care in the first place?
d. Do you foresee new bottlenecks in accessing / scheduling public transit after the transition?
e. With services like transportation being decoupled from DSS, do you anticipate decreased contact between beneficiaries and DSS? Might this decrease the amount of exposure they get to other services they need?

WRAPPING UP

1. Is there anything we did not ask about that you would like to tell us or that you feel we should add? That we should ask other counties?
2. We currently are planning to speak with all the DSS offices in the 5-county region. Given what we talked about today, are there other parties you recommend we talk to?
   a. Medical providers?
   b. Other major facilities you coordinate with?

Appendix B: Related Works

1. Cochran, A. L., McDonald, N. C., Prunkl, L., Vinella-Brusher, E., Wang, J., Oluyede, L., & Wolfe, M. (2022). Transportation barriers to care among frequent health care users during the covid pandemic. *BMC Public Health*, *22*(1). https://doi.org/10.1186/s12889-022-14149-x
2. Oluyede, L., Cochran, A. L., Prunkl, L., Wang, J., Wolfe, M., & McDonald, N. C. (2022). Unpacking transportation barriers and facilitators to accessing health care: Interviews with care coordinators. *Transportation Research Interdisciplinary Perspectives*, *13*, 100565. https://doi.org/10.1016/j.trip.2022.100565
3. Oluyede, L., Cochran, A. L., Wolfe, M., Prunkl, L., & McDonald, N. (2022). Addressing transportation barriers to health care during the COVID-19 pandemic: Perspectives of Care Coordinators. *Transportation Research Part A: Policy and Practice*, *159*, 157–168. https://doi.org/10.1016/j.tra.2022.03.010
4. Wolfe, M. K., McDonald, N. C., & Holmes, G. M. (2020). Transportation barriers to health care in the United States: Findings from the National Health Interview Survey, 1997–2017. *American Journal of Public Health*, *110*(6), 815–822. https://doi.org/10.2105/ajph.2020.305579

Impact of Pandemic and Medicaid Expansion on Car-Share Transit Systems in Rural Communities

Dr. Burcu Adivar
Fayetteville State University

May 2023

Abstract

COVID-19 restrictions, state and government policies had significant impact on mobility and transit services with ride sharing. The magnitude of this impact differed greatly depending on population characteristics, geography, government guidelines, and transit system's operating policies. This study explores the impact of the pandemic on ride share behaviors and regional transit service performance in Elizabeth City and surrounding counties in North Carolina. We used a trip dataset provided by Inter-County Public Transportation Authority (ICPTA) serving five rural counties, including Perquimans, Pasquotank, Camden, Chowan, and Currituck. The data collection period spanned from January 2019 to April 2022 with 302,017 trips, 3,306 users, 2,826 distinct origins, 2,815 distinct destinations and 56 vehicles. Findings indicated that average trip distance decreased in 2022 and 2021 (compared to 2019) by 1.11 miles and trip range decreased by 30 miles. The average trip duration dropped from 24 minutes in 2019 to 21 minutes in 2021 and 16 minutes in 2022. While there was a slight difference in cancellations and no shows in 2019 and 2021, the rate of cancellations almost doubled in 2022. When these averages were coupled with transit service performance and the population data, interesting associations were observed. The findings could help to better understand transit service customers' as well as providers' reactions when preparing for future pandemics.

Introduction

Healthcare access, especially for the underserved population, is a huge concern for various stakeholders in many countries (Butler et al., 2021). There has been a considerable concern for economic healthcare access among the underserved population in North Carolina. The lack of healthcare access results in negative health outcomes and disparities for many people. Transportation is among the key barriers to health access for the underserved population (Khairat et al., 2019). Among the solutions to this challenge is integrating public and private transportation. Therefore, the report seeks to evaluate the potential of transit and Mobility as a Service (MaaS) to enhance economic healthcare access for the underserved population in NC. MaaS is a mobility service that includes transportation through a bus, train, taxis, cars, etc.

Access to healthcare is a fundamental human right. However, the most underserved population in North Carolina is challenged to access essential healthcare services due to limited transportation challenges (Khairat et al., 2019). At least a million individuals in NC live in a household without a car or have barriers limiting effective transportation (NCDOT, 2022). The underserved population includes low-income households, disabled, elderly populations, and rural communities, disproportionately impacted by transport on healthcare access. Public transportation, including trains, light rails, and buses, is concentrated in urban areas and not easily accessible in rural areas. Private transportation means such as taxis and ride-hailing are expensive for low-income households. The lack of efficient, affordable, and accessible transportation is a barrier to achieving healthcare services (Riegel, 2023). These limitations cause these groups to have challenges accessing healthcare services such as preventative care, emergency care, and chronic disease management (Khairat et al., 2019). Therefore, exploring alternative transportation remedies for these challenges is imperative by incorporating transit and MaaS to enhance healthcare for these populations. Transit and MaaS will improve access, reduce transportation costs, increase efficiency, and sustainably enhance health outcomes through its integrated approach of combining convenient, seamless, and affordable travel experiences for NC residents.

Literature Review

The literature review will provide a brief background of the previous research on the topic, using NCDHHS information on healthcare transportation, NCDOT information on grants for expanding transit services in 11NC communities, and ENO-center of transportation that seeks the opportunity for future Mobility. These reviews aim to explore the potential integration of public and private transport systems to enhance healthcare access in NC, with a special focus on the North Carolina Office of Transit (NCOT) and the Institute for Community Prosperity and Transportation Action (ICPTA).

Previous research indicates numerous studies evaluating the effect of transport on healthcare access, with many evaluating the important role of ensuring access to healthcare services (Wolfe et al., 2020; Khairat et al., 2019; Riegel, 2023). For instance, Wolfe et al. (2020) reports that transport barriers contribute to healthcare disparities in rural areas. On the other hand, the National Academy of Medicine (2022) found that transport-related barriers influence health-related outcomes for people suffering from chronic conditions and low-income households. The report considers partnerships among healthcare facilities, and transportation can address challenges experienced by underserved populations (National Academy of Medicine, 2022). Similarly, Cochran et al. (2021) study conducted in North Carolina indicated a third of residents experienced transport barriers in 2020/21, especially people with disabilities and households without a vehicle. The major transportation barriers included a lack of driver and car availability, indicating the transport problem is a complex issue of the circumstantial problem of inability to access or pay for transport when accessing healthcare (Cochran et al., 2021).

Additionally, various research studies have highlighted the potential of MaaS in enhancing health access for individuals facing transport-related barriers (Ditmore & Miller, 2021). The North Carolina Department of Health and Human Services (NCDHHS) provides several programs and services to improve healthcare transportation for individuals in North Carolina (NCDHHS, 2022). For example, it provides Medicaid services using various programs such as NEMT (Non-emergency Medical Transportation) program to reduce transport-related barriers. The system utilizes various transportation options such as non-emergency medical vehicles, taxis, and public transit for individuals and families with low incomes and the elderly (NCDHHS, 2022). The systems have effectively offered funding for transportation challenges through various grants for individuals with disabilities, older adults, and low-income individuals.

NCDOT (North Carolina Department of Transport), the government agency for planning and maintaining NC transport, received $10.4 million to expand on-demand services in the 11 NC communities to benefit the underserved populations (NCDOT, 2022). These populations require safe, efficient, reliable, and affordable transportation system. Thus, there is a need for investment in a multi-modal system that improves healthcare access and morbidity for those without vehicles, the elderly, the disabled, and disadvantaged transport groups in NC (Riegel, 2023).

Utilizing the transit and Mobility-as-a-Service (MaaS) can address these challenges by integrating various modes of transport into one platform, making it easier for the underserved population to access different transport modes (NCDOT, 2022). MaaS can offer cost-effective transportation solutions for underserved populations to access healthcare appointments, pharmacy services, and other resources that enhance their health. Therefore, expanding the NCDOT grant on on-demand transit services in underserved NC populations will enhance positive outcomes (Riegel, 2023).

The ENO-Center of Transport (2022) has reported various issues of morbidity in NC and the potential of incorporating MaaS to enhance healthcare for underserved populations to provide equitable morbidity for those with limited vehicle access. ENO report also considers socioeconomic conditions of increasing prices in urban areas, movement of the lower-income individual away from public transport or walkable areas, migration to rural areas for older and low-income households, increased commute time, and fewer options for transport choices resulting in negative health outcomes and cost (Ray, 2020).

ENO-center of Transport (2022) indicates there has been inherently inequitable transportation that favors people who own and can drive a car. Additionally, at least a million people in NC live in a household without a car or have challenges that limit their access to transportation services (NCDOT, 2022). Additionally, the NC population of residents above 65 years is expected to increase by half by 2040, whereas the share of the population above 85 years will increase by 116% (NCDHHS, 2020). The challenges include disability, inability to share rides with other adults, and faulty vehicles. Transit in MaaS presents a flexible solution that can be incorporated into many modes of transport through mobile applications (Pangbourne et al., 2020).

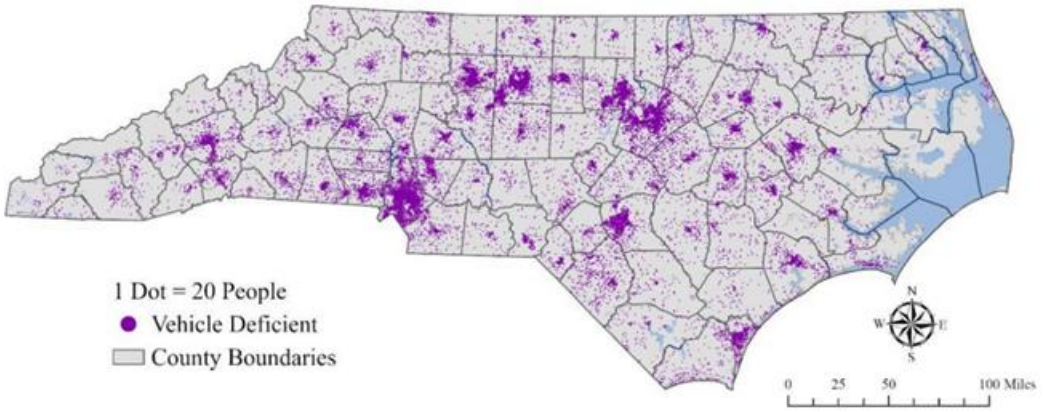


Figure 0: Map showing Vehicle deficient adults in all areas of North Carolina. Source: (ENO, 2023)

Study Region

The geographical region targeted in this study consists of multiple counties in northeastern North Carolina surrounding Elizabeth City (Figure 1). With the mission of “connecting people, products and places safely and efficiently with customer focus, accountability and environmental sensitivity to enhance the economy and vitality of North Carolina” (ncdot.gov, 2022), NCDOT supports a complex system of transit for specific needs of residents within this five-county region. The transit services are comprised of thousands of individual trips, each of which has unique traits and may require specific types of resources. With this study, we aim to develop insights about the state of transit services for developing strategies to improve access to healthcare for potential future pandemics.

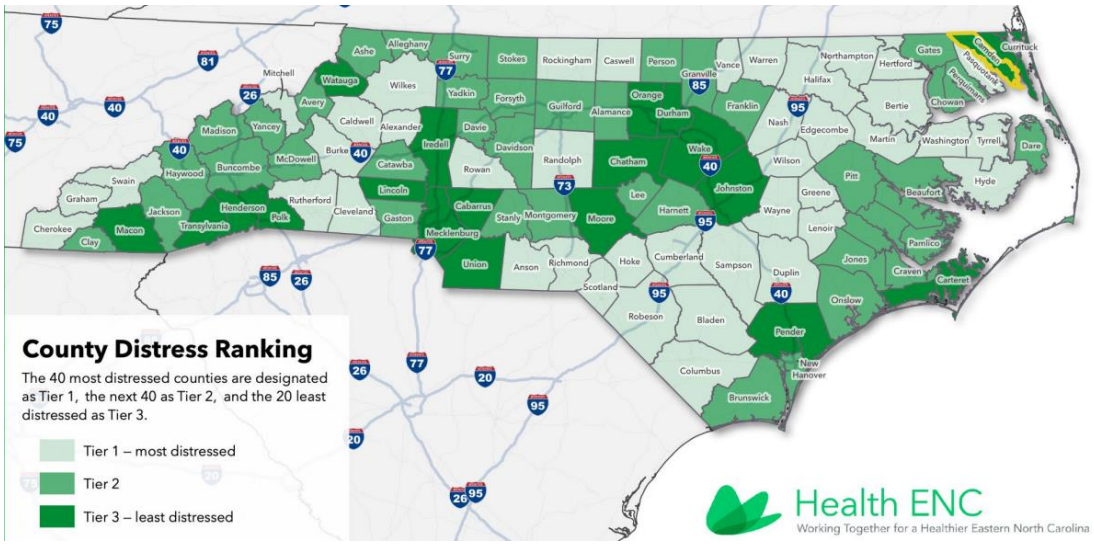


Figure 1. Map of the study region with county distress ranking

According to the North Carolina Department of Commerce annual rankings, the ICPTA service region consists of Tier 1, Tier 2 and Tier 3 counties. Camden and Currituck Counties have been designated as the least distressed and Pasquotank County has the most distressed designation for 2021. In addition to economic barriers, study region encounters significant shortage in terms of healthcare workforce (Figure 2).

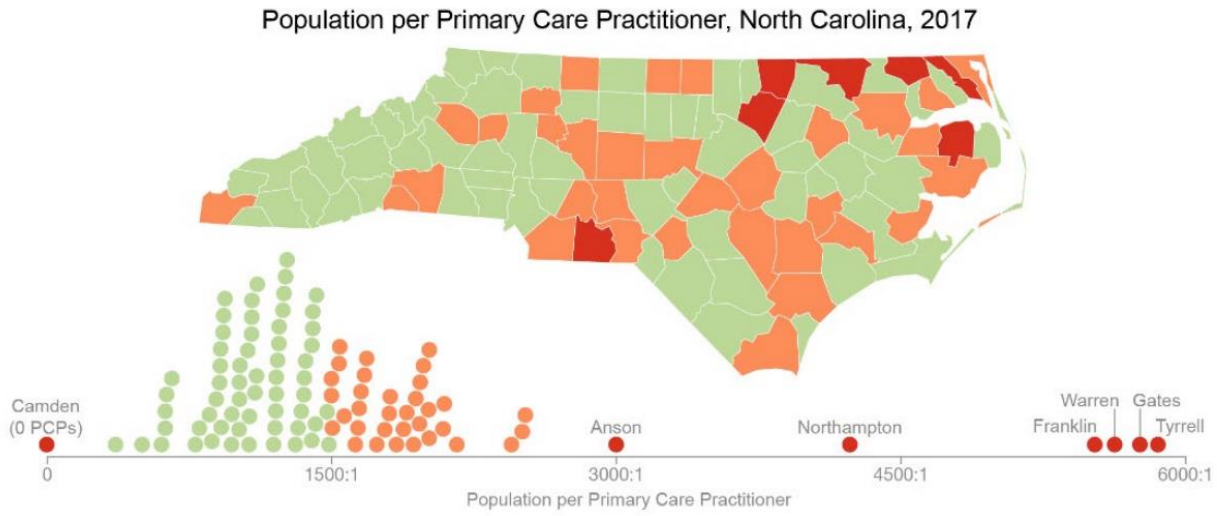


Figure 2. Population per Primary Care Practitioner

Source: https://nchealthworkforce.unc.edu/blog/primary_care_nc/

Data Collection

This study includes three major sources for data collection for behavioral, transit performance and population parameters over a three-year period. The behavioral parameters are extracted from ICPTA trip dataset encompassing dates of service from July 1, 2019 through March 30, 2022. The performance parameters are obtained by merging the daily trip data with monthly income statements. Finally, the population data is retrieved from U.S. Census Database. There are discrete events that have occurred within the study period (the onset of a pandemic and the transition to managed care Medicaid plans) that have potential to affect dynamics of transit operations.

Regarding the discrete events that occurred during the timeline of data capture and created the pivot points for many of the pre and post data analysis, the dates were selected based on well-publicized government records. On 13 March 2020, President Trump issued a national emergency because of COVID-19, (White House, 2020), signifying our first discrete event. This order via governors, placed non-essential services and businesses in a stay at home and social distancing posture. This in effect stopped or significantly slowed down business and personal transactions. Consequently, the data for this study is broken down by pre-Covid (0) and post-Covid (1) markers. This second discrete event is the transition of North Carolina Medicaid from a fee for service model that was operated and managed by the state to a managed care model operated by five private insurance companies on July 1, 2021 (NCDHHS, 2022). Therefore, this date was used to represent the transition from the legacy Medicaid program to the new program structure. This also predicated designation of data as pre-transition (0) and post-transition (1).

Data Description

The trip dataset captures information about each trip made, including the coordinates and name of the origin and destination, the date, the service request time, the start and end times of the trip, direct miles, the duration in minutes, the mobility requirement, the type of funding used, indicator for no show, cancellation and completion, vehicle ID, trip ID, and trip purpose. The income sheet includes the number of passengers for each funding category (Medicaid, Title III, RGP, SKILLS, DHSS, EDTAP, etc.), number of trips, total revenue for each month of the study period. Performance data variables (fleet size; total and monthly revenue; revenue per trip, per mile, per vehicle; miles per trip, per month, per vehicle; trips per vehicle) have been derived from the existing data.

Table 1. Behavioral and Performance Data Summary

Behavioral Parameters	2019	2020	2021	2022
Miles per Passenger	9.64	9.29	8.53	8.53
Trip Range	137.0	107.0	133.0	107.0
Trip Duration (Minutes)	23.8	23.2	21.5	15.7
Total Number of Trip Requests	122,532	56,533	63,691	59,261
Number of No Shows	469	79	340	1506
Percentage of No Shows	0.4%	0.1%	0.5%	2.6%
Number of Trips Cancelled	21,914	10,194	11,966	20,873
Percentage of Cancellations	18.2%	18.2%	18.8%	36.2%
Number of Trips Completed	98,263	45,824	51,216	35,294

Percentage of Completions	80.2%	81.1%	80.4%	59.6%
Number of Trips Shared	8,907	3,438	4,092	1,059
Percentage of Shared Rides	7.3%	6.1%	6.4%	1.8%
Number of Trips Required Lift Van	30,855	15,425	14,409	7,520
Percentage of Lift Van	25%	27%	23%	13%
Transit Performance Parameters	**2019**	**2020**	**2021**	**2022**
Fleet Size	40	29	40	75
Total Revenue	$743,173	$825,783	$869,900	$274,499
Monthly Revenue	$123,862	$68,815	$72,492	$91,500
Number Trips per Month	7,660	3,667	4,121	4,723
Revenue per Trip	$16.17	$19.59	$17.50	$19.43
Revenue per Mile	$1.74	$2.18	$2.10	$2.30
Revenue per Vehicle	$18,579	$28,475	$21,748	$3,660
Monthly Revenue per Vehicle	$3,097	$2,373	$1,812	$1,220
Total Miles	428,704	415,098	435,306	121,852
Miles per Trip	9.33	9.26	8.96	8.55
Miles Per Month	71,451	35,611	36,176	40,617
Miles per Vehicle per month	1,786	1,228	904	542
Trips per Vehicle per month	192	126	103	63

Since 2019, there seems to be significant changes in the number of shared rides as well as funding category. As presented in Table 2, Elderly and Disabled Transportation Assistance Program (EDTAP) had been the top funding category before the pandemic. Over four years funding categories such as EDTAP, Job Access and Reverse Commute (JARC), Title III, Adult Services and SKILLS programs shave significantly reduced funding for the ICPTA trips. From 2019 to 2021, the number of trips funded by any of the listed programs decreased by 48%. The Regional Grant Program (RGP) that allocates funds to transportation projects that support regional transportation goals is observed to have increased support considering 8,653 trips in the first quarter of 2022 only.

Table 2. Number of Trips by Funding Category and Year

Funding Source	2019	2020	2021	2022	Total
EDTAP	50,895	13,491	12,241	21	76,648
RGP	12,190	3,938	9,730	8,653	34,511
MONARCH	15,606	5,451	9,665	3,051	33,773
TITLE III	15,368	3,821	12,660	1,501	33,350
MEDICAID	10,028	8,343	6,230	2,147	26,748
DHHS CARES	0	16,090	4,888	12	20,990
STATE OPERATING GRANT	8,518	1,673	992	0	11,183
EDTAP-Disabled	773	0	3,917	4,644	9,334
EDTAP-Elderly	1,175	0	2,234	3,114	6,523

JARC	3,084	1,964	0	0	5,048
SKILLS INC	1,128	782	473	1	2,384
Adult Services-Elderly	1,416	248	0	0	1,664
ELIZ CITY HEALTH & REHAB	987	253	22	0	1,262
Adult Services-Disabled	803	170	0	0	973
WORKFORCE DEV	525	306	73	0	904
DHHS COVID Vaccine	0	0	467	0	467
ONE CALL	0	0	90	126	216
VOC Rehab	0	0	4	117	121
HERITAGE CARE	27	0	0	0	27
DSS	4	2	5	0	11
DISABILITY RIGHTS OF NC	3	0	0	0	3
HEALTH DEPT-High Risk	2	1	0	0	3
All	**122,532**	**56,533**	**63,691**	**23,387**	**266,143**

Table 3 presents the number of shared rides for the same destination. Since 2019, there has been approximately 50% decrease in shared rides.

Table 3. Number of Shared Rides

Number of Passengers Sharing a Ride					
Year	**Number of Shared Rides**	**Min**	**Mean**	**Std Dev**	**Max**
2019	8907	2	2.75	1.12	9
2020	3438	2	2.64	1.15	9
2021	4092	2	2.74	1.40	10
2022	1059	2	2.58	1.07	8
All	**17496**	**2**	**2.71**	**1.20**	**10**

Other important determinants affecting not only the travel behavior but also the funding category are mobility and trip purpose. According to the trip dataset containing 302,017 trip requests, 266,143 reported mobility requirements such as ambulatory, wheelchair or ambulatory requiring lift. Of those, 25% required lift or wheelchair capability, which impacts onboarding and total trip times.

Table 4. Mobility and Trip Purpose Breakdown by Year

Mobility	2019	2020	2021	2022	All	% Total
Ambulatory	91,677	41,108	49,282	18,303	200,370	75.3%
Ambulatory Requiring Lift	19,015	10,261	9,520	3,340	42,136	15.8%
Wheelchair	11,840	5,164	4,889	1,744	23,637	8.9%
All	**122,532**	**56,533**	**63,691**	**23,387**	**266,143**	**100%**

Trip Purpose	2019	2020	2021	2022	All	% Total
Non-Medical	27,203	7,380	12,239	4,650	51,472	19.5%
Medical*	20,503	12,204	12,600	3,912	49,219	18.6%
Employment	14,540	10,982	13,957	5,874	45,353	17.1%
Dialysis*	14,109	13,140	10,475	3,910	41,634	15.7%
MONARCH*	15,882	5,397	9,694	3,036	34,009	12.9%
Nutrition	12,270	2,563	1,068	679	16,580	6.3%
Adult Day Care*	7,854	2,191	1,416	293	11,754	4.4%
Education	7,924	1,547	1,270	784	11,525	4.4%
SKILLS	1,149	1,008	810	159	3,126	1.2%
All	**121,434**	**56,412**	**63,529**	**23,297**	**264,672**	**100%**

*Healthcare related purpose

Table 4 indicates that 88% of the trip requests indicated a specific trip purpose such as non-medical (19.5%), employment (17.1%), education (4.4%), etc. Grouping medical, dialysis, Monarch (mental health), and adult day care trips as "healthcare" purpose, we can conclude that overall, 52% of the trips in the ICPTA dataset corresponds to access to healthcare. Ratio of healthcare trips constituted at least 58% of the ICPTA trips in 2020 (Figure 3).

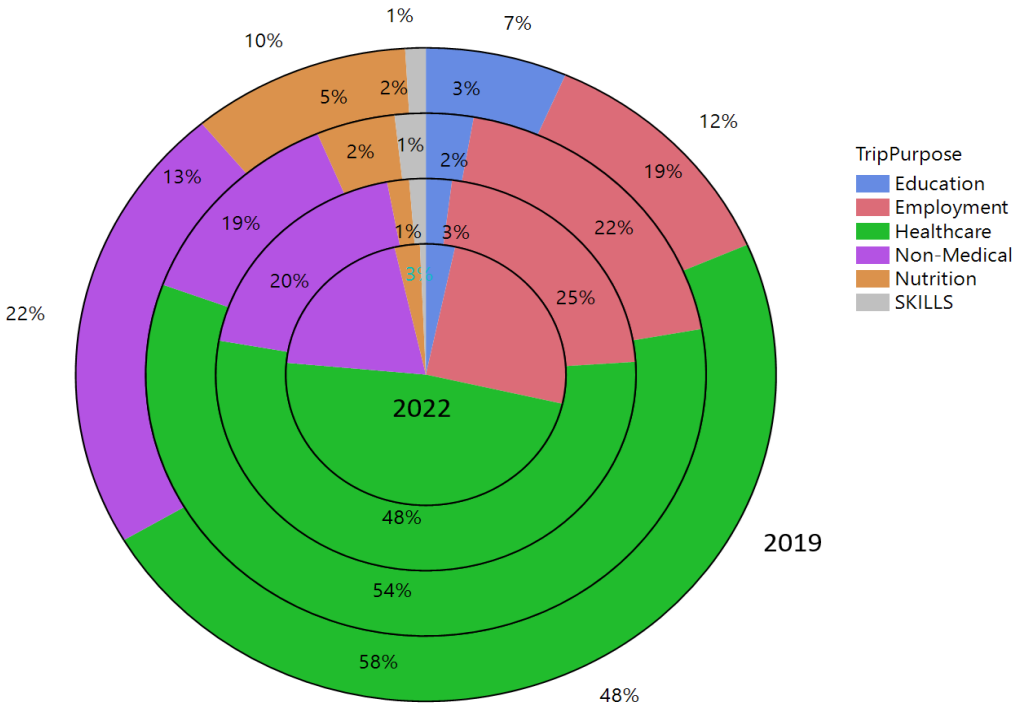


Figure 3. Trip Purpose by Year

Table 5. County-level Population Data for the Study Region (aggregated for 5 counties)

Population Characteristics	2019	2020	2021
Population size	105,860	105,147	104,926
Percent insured	89%	*90%*	*91%*
Male	49	49	49
Female	51	51	51
White alone	72%	71%	70%
Black or African American alone	20%	19%	19%
American Indian and Alaska Native alone	0%	0%	0%
Asian alone	1%	1%	1%
Native Hawaiian and other Pacific Islander alone	0%	0%	0%
Some other race alone	1%	1%	1%
Two or more races	2%	4%	4%
Hispanic or Latino (of any race)	4%	3%	4%
Living arrangement - In Family Households	84%	84%	84%
Percent with Disability	15%	*15%*	*14%*
Unemployment rate	4%	*4%*	*3%*
Percent not in labor force	24%	*24%*	*23%*
Worked full-time in the past 12 months	56%	56%	58%
Workers (16+) who did not work from home	95%	93%	92%
Below 138% of the poverty threshold[10]	18%	18%	17%
Vehicle Ownership (0 or 1 vehicles)	18%	17%	16%
Number of vehicles in use by workers aged 16-64	39,155	40,070	40,660
Vehicles Available for Transport to Work			
No vehicle available	2.54%	1.52%	1.84%
1 vehicle available	19.92%	18.86%	16.14%
2 vehicles available	37.90%	40.86%	40.80%
3 or more vehicles available	39.68%	38.78%	41.24%
Percent Allocated			
Means of transportation to work	9.34%	10.26%	
Time arriving at work from home	19.62%	21.06%	
Travel time to work	14.42%	15.96%	

Table 5 represents aggregated population data for the study region. Although the study region is set to include five North Carolina counties, the trip dataset includes 17 counties, nine of which are in the state of Virginia and one in West Virginia. The other two North Carolina counties (Pitt and Dare) are also included as a pickup point in the dataset since their destination is located in the study region. For descriptive purposes, trip data pertaining to all seventeen counties are presented in Table 6. As noted, 99% of the trips originate from five counties, namely Perquimans, Pasquotank, Camden, Chowan, and Currituck Counties, included in the study region. Notable population characteristics are the percentage of working full-time (56%-58%), Medicaid eligibility (17%-18%), vehicle ownership (16-18%), and the percentage of vehicle availability for transport (18-23%). From 2019 to 2021, vehicle ownership+availability and employment rates showed improvement with the percent working from home increasing from 5% to 8%.

[10] Eligible for Medicaid coverage

Table 6. Number of Trips by Origin County and Year

County	2019	2020	2021	2022	Total	% Total
Pasquotank (NC)	82,230	38,203	45,254	36,385	202,072	66.91%
Chowan (NC)	14,564	6,829	6,653	5,891	33,937	11.24%
Perquimans (NC)	11,098	5,397	6,164	5,601	28,260	9.36%
Currituck (NC)	9,974	3,810	3,881	9,585	27,250	9.02%
Camden (NC)	3,725	1,715	1,201	1,401	8,042	2.66%
Portsmouth (VA)	14	161	186	135	496	0.16%
Chesapeake (VA)	243	110	68	57	478	0.16%
Norfolk (VA)	200	99	113	58	470	0.16%
Virginia Beach (VA)	253	114	52	34	453	0.15%
Pitt (NC)	148	70	79	91	388	0.13%
Hampton (VA)	11	11	15	5	42	0.01%
Suffolk (VA)	17	6	10	5	38	0.01%
Dare (NC)	25	0	3	3	31	0.01%
Marion (VA)	12	4	4	2	22	0.01%
Henrico (VA)	10	1	3	1	15	0.00%
Newport News (VA)	5	1	4	4	14	0.00%
Richmond (VA)	3	2	1	3	9	0.00%
All	**122,532**	**56,533**	**63,691**	**59,261**	**302,017**	**100.00%**

Research framework and model

In this research, we will use various statistical analysis methods including multivariate ANOVA, linear and nonlinear regression, association, and contingency analysis to assess the impact of various factors on behavioral and performance outcomes as presented in Figure 4.

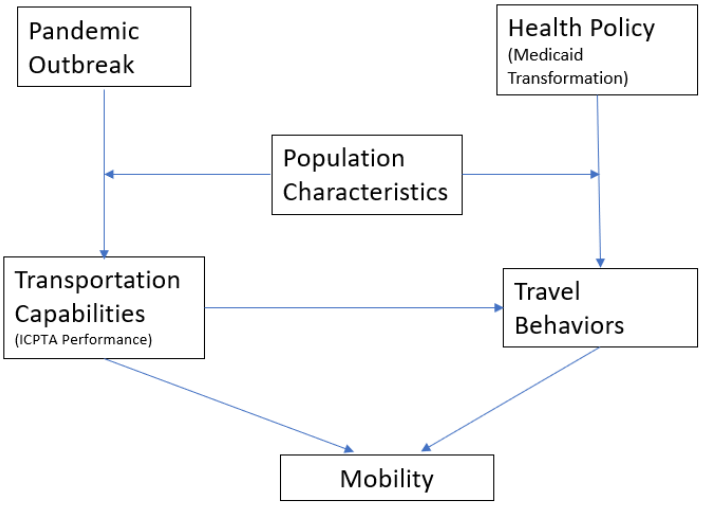


Figure 4. Research framework

Results

We assessed univariate and bivariate relationships in the data using parametric and non-parametric tests. The analysis was conducted with the use of JMP software, version 16.0 Pro. Simple and multiple linear regression models were used to explore the behavioral and performance related factors associated with the pandemic and Medicaid expansion policy.

Table 7. Correlation of study of behavioral and policy variables

	Pandemic	H_Policy	Cancel	NoShow	Complete	RequestTime	PUTime	StartTime	DOTime	Duration	DirMile
Pandemic	1.000 **										
H_Policy	0.645 **	1.00 **									
Cancel	-0.081 **	-0.124 **	1.00 **								
NoShow	-0.046 **	-0.087 **	-0.047 **	1.00 **							
Complete	0.085 **	0.147 **	-0.930 **	-0.1598**	1.00 **						
RequestTime	-0.894 **	-0.768 **	0.010* *	0.0189**	-0.0019	1.00 **					
PUTime	-0.889 **	-0.845 **	0.250 **	0.0813**	-0.2788**	0.999**	1.00 **				
StartTime	-0.894 **	-0.768 **	0.009 **	0.0189**	-0.0014	1.000 **	1.00 **	1.00 **			
DOTime	-0.888 **	-0.815 **	-0.030 **	0.0093**	0.0245**	1.000 **	1.00 **	1.00 **	1.00 **		
Duration	0.101 **	0.112 **	-0.108 **	-0.0391**	0.1164**	-0.050**	-0.121**	-0.049**	-0.021**	1.00 **	
DirMile	0.054 **	0.040 **	-0.015**	-0.0002	0.0100**	-0.051**	-0.047**	-0.051**	-0.048**	0.858**	1.00 **

* p <0.05 ** p < 0.001

Table 7 shows the relationship between the change “before-after” of the pandemic and policy variables on the assessed behavioral variables including trip cancellation, no-show, completion, request, and pickup time (PUTime), drop-off time (DOTime), trip duration and trip miles. The pandemic and Medicaid expansion

policy variables were significantly correlated to many travel behaviors ($p \leq 0.001$ and $0.1 \leq r \leq 0.25$). Particularly, onset of pandemic and Medicaid expansion variables indicated positive correlations with the trip duration ($p \leq 0.001$ and $0.1 \leq r \leq 0.12$), direct miles ($p \leq 0.001$ and $0.04 \leq r \leq 0.06$) and trip completion ($p \leq 0.001$ and $0.09 \leq r \leq 0.15$). They have indicated significant negative correlations with the trip request time, pick up and trip start time ($p \leq 0.001$ and $-0.9 \leq r \leq -0.75$). Additionally, a significant positive correlation ($p \leq 0.001$ and $r=0.645$), has been reported between pandemic and Medicaid expansion policy.

As the regression models for the analysis shows, there is a significant effect of pandemic and Medicaid expansion policy on the two travel behavior variables, trip duration and trip distance. Table 8 presents the one-way ANOVA and non-parametric statistical test results for the behavioral factors associated with the onset of pandemic and health policy change, i.e. Medicaid expansion. Table 9 presents the results of statistical test results for the transit performance factors associated with the onset of pandemic and health policy change. Additionally, Figure 5 and 6 presents the confidence intervals and control limits for the trip duration, later arrival and no-show rates to emphasize the change in travel behavior patterns.

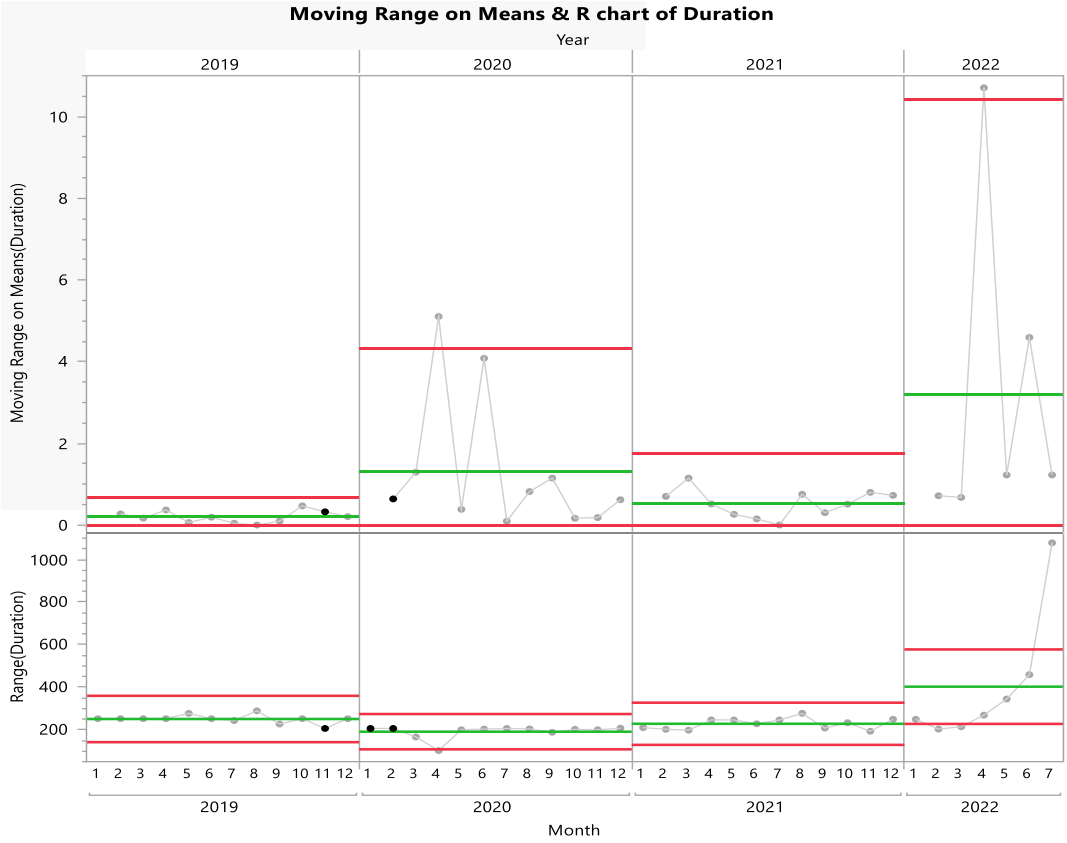


Figure 5. Control charts for trip duration over years

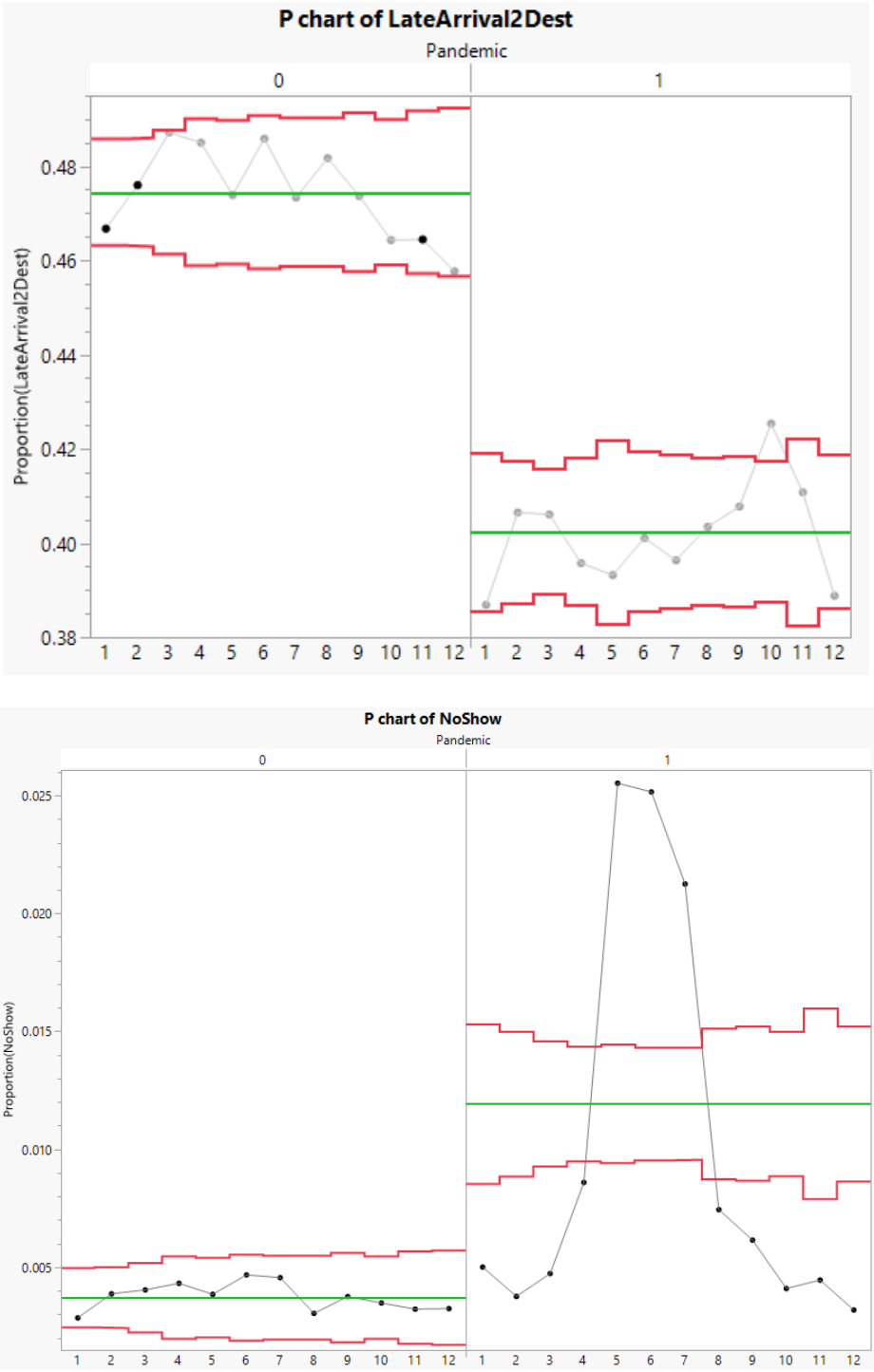


Figure 6. Control charts indicating the difference in late arrival and no-show rates before (0) and after (1) pandemic.

Table 8. Behavioral Factors Associated with the Onset of Pandemic and Health Policy Change

	Pandemic=0						Pandemic=1						Kruskal-Wallis Test			t-Test	
	N	Mean	Std Dev	Std Err Mean	Lower 95%	Upper 95%	N	Mean	Std Dev	Std Err Mean	Lower 95%	Upper 95%	χ^2	DF	Prob> χ^2	t Ratio	Prob > |t|
Trip Distance (Miles)	147110	9.71	10.47	0.03	9.65	9.76	154904	8.57	10.33	0.03	8.52	8.63	1144.94	1	<.0001*	-29.872	<.0001*
Trip Duration Est. (Minutes)	146933	23.96	23.47	0.06	23.84	24.08	154904	19.32	22.43	0.06	19.21	19.43	4889.50	1	<.0001*	-55.416	<.0001*
Trip Duration-Actual	124163	39.04	41.12	0.12	38.81	39.27	115854	29.75	32.22	0.09	29.57	29.94	3562.63	1	<.0001*	-61.827	<.0001*
Requested Arrival Time	147113	701.29	166.18	0.43	700.45	702.14	119030	694.16	180.40	0.52	693.14	695.19	44.63	1	<.0001*	-10.499	<.0001*
Pickup Time	125084	659.45	194.33	0.55	658.37	660.52	135253	653.07	197.72	0.54	652.02	654.13	55.27	1	<.0001*	-8.295	<.0001*
Drop-off Time	124623	697.26	194.08	0.55	696.18	698.34	117040	677.80	199.61	0.58	676.65	678.94	534.35	1	<.0001*	-24.278	<.0001*

	Pandemic=0					Pandemic=1					Two-sample Proportion Test				
	N	x	Proportion p (%)	N-x	1-p	N	x	Proportion p (%)	N-x	1-p	proportion difference	Lower 95%	Upper 95%	Odds Ratio	p-value
Percentage of No Shows	147113	546	0.18%	146567	99.63%	154904	1848	0.61%	153056	99.21%	0.82%	0.76%	0.88%	3.241	<.0001*
Percentage of Cancellations	147113	26637	18.11%	120476	81.89%	154904	38310	24.73%	116594	75.27%	6.63%	6.33%	6.92%	1.486	<.0001*
Percentage of Completions	147113	117772	80.06%	29341	19.94%	154904	112825	72.84%	42079	27.16%	7.22%	6.69%	7.52%	0.668	<.0001*
Percentage of Shared Rides	106024	10657	10.05%	95367	89.95%	105668	6839	6.47%	98829	93.53%	3.58%	3.3452	3.81%	0.620	<.0001*
Percentage of Lift Van	147113	36923	25.10%	110190	74.90%	154904	31286	20.20%	123618	79.80%	4.90%	4.61%	5.20%	0.755	<.0001*
Percentage of Late Arrivals	124623	59132	47.45%	65491	52.55%	100027	40256	40.25%	59771	59.75%	7.20%	6.792	7.61%	0.746	<.0001*

	Health Policy Change = 0						Health Policy Change = 1						Kruskal-Wallis Test			t-Test	
	N	Mean	Std Dev	Std Err Mean	Lower 95%	Upper 95%	N	Mean	Std Dev	Std Err Mean	Lower 95%	Upper 95%	χ^2	DF	Prob> χ^2	t Ratio	Prob > |t|
Trip Distance (Miles)	210039	9.40	10.51	0.02	9.35	9.44	91975	8.50	10.16	0.03	8.43	8.56	394.83	1	<.0001*	-22.209	<.0001*
Trip Duration-Est. (Minutes)	209862	23.28	23.07	0.05	23.18	23.38	91975	17.68	22.54	0.07	17.54	17.83	8038.66	1	<.0001*	-62.353	<.0001*
Trip Duration-Actual	177671	36.02	39.04	0.09	35.84	36.20	62346	30.40	31.81	0.13	30.15	30.65	845.92	1	<.0001*	-35.705	<.0001*
Requested Arrival Time	210042	697.99	170.89	0.37	697.26	698.72	56101	698.54	179.41	0.76	697.06	700.03	0.23	1	0.6323	0.653	0.5137
Pickup Time	178899	654.84	195.72	0.46	653.94	655.75	81438	658.97	196.99	0.69	657.62	660.33	20.19	1	<.0001*	4.971	<.0001*
Drop-off Time	178364	689.67	195.86	0.46	688.76	690.58	63299	682.67	200.13	0.80	681.12	684.23	79.16	1	<.0001*	-7.593	<.0001*

	Health Policy Change = 0					Health Policy Change = 1					Two-sample Proportion Test				
	N	x	P	N-x	1-p	N	x	p	N-x	1-p	Prop. Diff.	Lower 95%	Upper 95%	Odds Ratio	p-value
Pct. of No Shows	210042	594	0.28%	209448	99.72%	91975	1800	1.96%	90175	98.04%	1.67%	1.58%	1.77%	7.04	<.0001*
Pct. of Cancellations	210042	38081	18.13%	171961	81.87%	91975	26866	29.21%	65109	70.79%	11.%	10.7%	11.4%	1.86	<.0001*
Pct. of Completions	210042	169023	80.47%	41019	19.53%	91975	61574	66.95%	30401	33.05%	13.5%	13.%	13.9%	0.49	<.0001*
Pct. of Shared Rides	153707	14317	9.31%	139390	90.69%	57985	3179	5.48%	54806	94.52%	3.8%	3.6%	4.07%	0.57	<.0001*
Pct. of Lift Van	210042	53457	25.45%	156585	74.55%	91975	14752	16.04%	77223	83.96%	9.4%	9.11%	9.71%	0.56	<.0001*
Pct. of Late Arrivals	178364	80613	45.20%	97751	54.80%	46286	18775	40.56%	27511	59.44%	4.36%	4.13%	5.14%	0.83	<.0001*

Table 9. Transit Performance Factors Associated with the Onset of Pandemic and Health Policy Change

	Pandemic=0						Pandemic=1						Kruskall-Wallis Test			t-Test	
	N	Mean	Std Dev	Std Err Mean	Lower 95%	Upper 95%	N	Mean	Std Dev	Std Err Mean	Lower 95%	Upper 95%	χ^2	DF	Prob> χ^2	t Ratio	Prob > |t|
Monthly Revenue	8	$ 121,506	$13,907	$ 4,917	$ 109,879	$ 133,133	25	$69,652	$ 22,047	$ 4,409	$ 60,552	$ 78,753	17.6471	1	<.0001*	-7.851	<.0001*
Medicaid Revenue	8	$ 12,315	$ 1,643	$ 581	$ 10,941	$ 13,688	25	$ 7,534	$ 2,400	$ 480	$ 6,543	$ 8,525	14.2941	1	<.0002*	-6.345	<.0001*
Non-Medicaid Revenue	8	$ 109,191	$13,392	$ 4,735	$ 97,995	$ 120,387	25	$62,118	$ 21,047	$ 4,209	$ 53,431	$ 70,806	17.2959	1	<.0001*	-7.430	<.0001*
Number of Trips per Month	8	6761	853	302	6047	7474	25	3296	1249	250	2780	3812	17.6471	1	<.0001*	-8.844	<.0001*
Number of Medicaid Trips	8	721	105	37	633	809	25	453	108	22	408	497	15.9291	1	<.0001*	-6.236	<.0001*
Total passengers	8	7482	865	306	6759	8205	25	3749	1262	252	3228	4270	17.6471	1	<.0001*	-9.417	<.0001*
Revenue per Trip	8	$ 16.25	$ 0.65	$ 0.23	$ 15.71	$ 16.80	25	$ 18.82	$ 1.96	$ 0.39	$ 18.01	$ 19.63	13.3593	1	<.0003*	5.631	<.0001*
Revenue per Mile	8	$ 1.70	$ 0.13	$ 0.04	$ 1.59	$ 1.80	25	$ 2.20	$ 0.47	$ 0.09	$ 2.01	$ 2.39	4.8884	1	<.0001*	9.280	<.0023*
Miles per trip	8	9.64	0.72	0.26	9.03	10.24	25	8.92	2.07	0.41	8.07	9.78	5.2425	1	0.0220*	-1.469	0.0761
Total Miles per month	8	71837	7067	2498	65929	77745	25	33540	12649	2530	28318	38761	17.6471	1	<.0001*	-10.771	<.0001*
Miles - Medicaid Trips/month	8	7302	1080	382	6399	8204	25	3386	1068	214	2945	3827	17.6471	1	<.0001*	-8.951	<.0001*

	Health Policy Change=0						Health Policy Change=1						Kruskall-Wallis Test			t-Test	
	N	Mean	Std Dev	Std Err Mean	Lower 95%	Upper 95%	N	Mean	Std Dev	Std Err Mean	Lower 95%	Upper 95%	χ2	DF	Prob> χ^2	t Ratio	Prob > |t|
Monthly Revenue	24	$ 81,401	$33,525	$ 6,843	$ 67,244	$ 95,557	9	$84,416	$ 20,633	$ 6,878	$ 68,556	$ 100,275	0.5294	1	0.4669	0.311	0.7587
Medicaid Revenue	24	$ 9,535	$ 2,904	$ 593	$ 8,308	$ 10,761	9	$ 6,448	$ 2,219	$ 740	$ 4,742	$ 8,154	6.6928	1	<.0097*	-3.256	<.0042*
Non-Medicaid Revenue	24	$ 71,866	$31,079	$ 6,344	$ 58,742	$ 84,989	9	$77,968	$ 18,897	$ 6,299	$ 63,442	$ 92,493	0.7908	1	0.3738	0.683	0.5014
Number of Trips per Month	24	4098	2155	440	3188	5008	9	4238	1022	341	3452	5023	0.6536	1	0.4188	0.251	0.8037
Number of Medicaid Trips	24	567	142	29	507	627	9	386	118	39	296	477	8.2383	1	0.0041*	-3.707	0.0017*
Total passengers	24	4665	2266	462	3709	5622	9	4624	1109	370	3772	5476	0.5899	1	0.4425	-0.070	0.9445
Revenue per Trip	24	$ 18.19	$ 2.33	$ 0.47	$ 17.21	$ 19.17	9	$ 18.21	$ 1.15	$ 0.38	$ 17.32	$ 19.10	0.4184	1	0.5178	0.03	0.9746
Revenue per Mile	24	$ 1.98	$ 0.47	$ 0.10	$ 1.78	$ 2.18	9	$ 2.34	$ 0.37	$ 0.12	$ 2.06	$ 2.63	4.0057	1	0.0453	2.315	0.0326*
Miles per trip	24	9.53	1.87	0.38	8.74	10.32	9	7.94	1.24	0.41	6.99	8.90	5.8833	1	0.0153*	2.814	0.0102*
Total Miles per month	24	44784	22451	4583	35304	54265	9	37596	11977	3992	28389	46802	0.1324	1	0.7160	-1.183	0.2473
Miles - Medicaid Trips/month	24	4861	2044	417	3998	5724	9	2934	1004	335	2162	3706	8.9477	1	0.0028*	-3.601	0.0012*

Discussion

The discussion will focus on two main areas, the effects of pandemic and the Medicaid expansion on travel behaviors and transit service providers' performance.

Travel Behavior

Table 8 shows that passenger travel behaviors significantly changed after the COVID 19 outbreak. Specifically, they used shared rides for shorter trips in terms of distance (9.71 vs. 8.57 miles) and estimated duration (23.96 vs. 19.32 minutes). As a result of pandemic restrictions and social distancing, we observe a reduction in actual trip durations (39.04 vs. 29.75 minutes), which could stem from less traffic congestion and/or fewer number of passengers sharing rides. The significant reduction in mean requested arrival time as well as mean drop-off time indicates that passengers demand was shifted to earlier in the day. Shifted demand for earlier trips resulted in earlier pick-up times and hence 7.2% reduction in late arrival rate, as expected. In addition to timing, pandemic had significantly increased the percentage of no shows (.18% to .61%), cancellations (18.11% to 24.73%), while decreasing the proportion of the completed trips (80.06% to 72.84%), percentage of shared rides (10.05% to 6.47%). Interestingly, with the onset of pandemic, the proportion of trips requiring lift van has decreased by 5%.

Analysis of the impact of Medicaid expansion on travel behaviors is summarized in the lower section of Table 8. According to one-way factor analysis, health policy change seems to have significant negative effect on mean trip distance (9.40 vs. 8.50 miles), estimated trip duration (23.28 vs. 17.68 minutes) and actual duration (36.02 vs. 30.40 minutes). The health policy change did not show any significant effect on the requested arrival time. However, there seems to be a significant shift to travel later in the day. Medicaid transformation seems to have bigger impact on no shows and cancellations, resulting in 13.5% reduction in number of completed trips. The individual trip data indicates 3.8% reduction in shared-rides, 9.4% reduction in lift van requirement and 4.4% reduction in late arrivals.

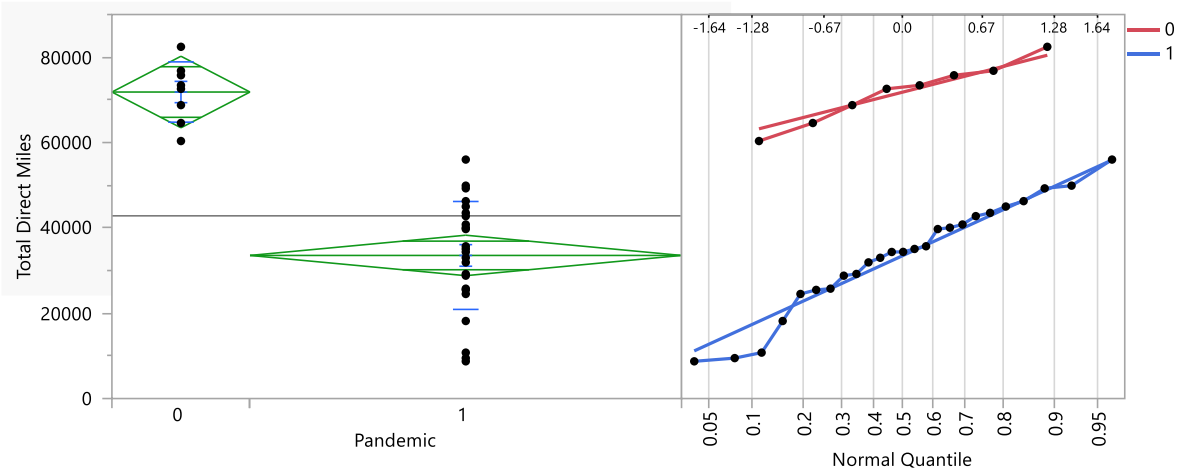


Figure 7. Total miles before and after pandemic

Transit Performance

Analysis of the financial data received from the transit service provider is summarized in Table 9. According to the analysis, there is a significant negative impact of the pandemic on number of passengers, number trips per month and number of Medicaid-funded trips. In parallel with this, the revenues from both Medicaid and non-Medicaid trips show significant reduction. The average monthly revenue before pandemic was reported to be $121,506 and it decreased to $69,652. Note that the pandemic slightly increased the percentage of Medicaid-trip revenues from 10% to 11%. Despite the reduction in number of trips and the revenue, we observe significant increase in revenue per trip, which can be explained by drop in the shared rides. However, the significant increase in revenue per mile can be explained by (less significant) reduction in miles per trip.

Compared to the pandemic impact, the impact of Medicaid expansion (i.e. health policy change) on transit performance was not that significant. We observe significant positive changes in Medicaid revenue, number of Medicaid trips, revenue per mile, miles per trip and Medicaid trip miles. Although Medicaid expansion was observed for only nine months, there seems to be significant positive impact of health policy change on mobility and access to healthcare.

Conclusion and Limitations

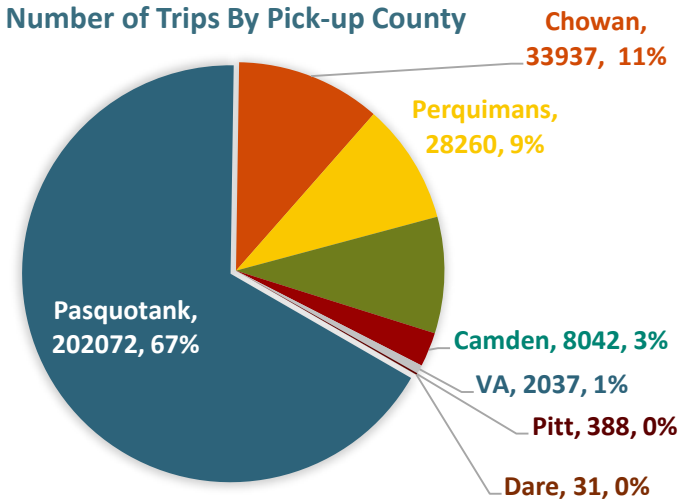
With the support of NCDOT, the research team aimed at analyzing the effects of pandemic and health policy change, the dimensions of ICPTA performance, and the MaaS capabilities that support equitable access to healthcare. This study adds to the current literature on how to use big data to assess the effects of pandemic and the Medicaid expansion on travel behaviors and service providers' performance. Our hypothesis that pandemic and social distancing is likely to reduce the demand for shared ridership was supported by the results. The travel behavior (no shows, cancellations, etc.) was significantly different in the absence of pandemic and Medicaid expansion.

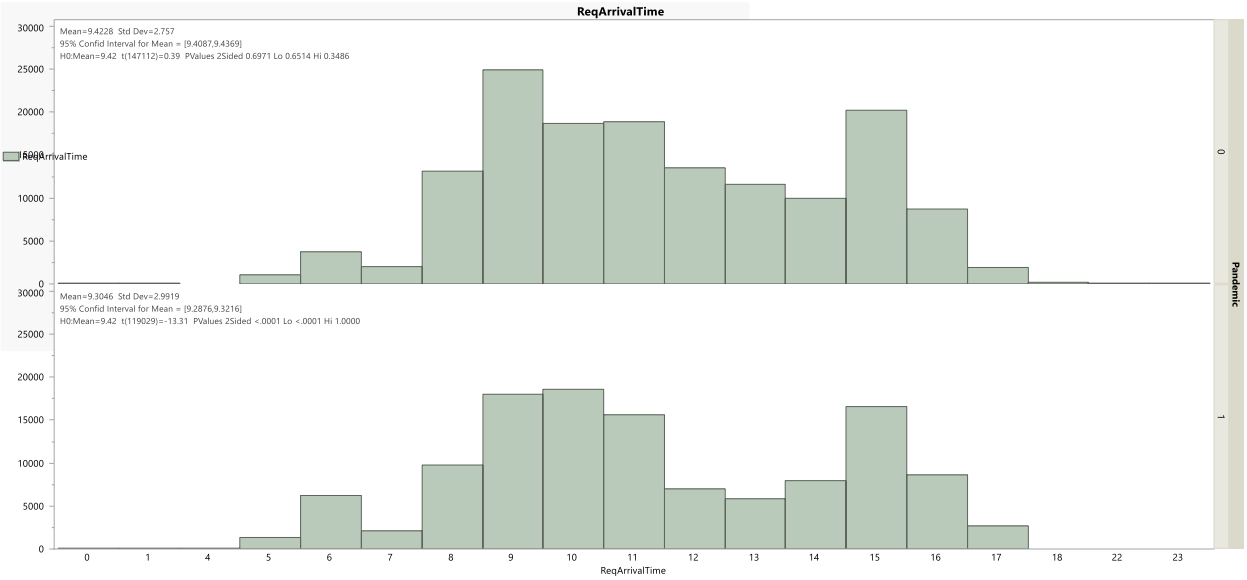
The variables used in this study were limited to what was available in the ICPTA trip database file. The inclusion of other potential variables, such as the traveler demographics, route details and vehicle occupancy rates would have influenced the outcomes that emerged. Another important limitation is that the policy assessed, and the data analyzed in this study are US and NC-based, and the findings mostly apply to NC service providers and policymakers and may not be generalized to other states or countries.

References

1. Butler, L., Yigitcanlar, T., & Paz, A. (2021). Barriers and risks of Mobility-as-a-Service (MaaS) adoption in cities: A systematic review of the literature. *Cities*, *109*, 103036.
2. Cochran, A. L., McDonald, N., Prunkl, L., Vinella-Brusher, E., Wang, J., Oluyede, L., & Wolfe, M. (2021). Transportation barriers to care among frequent health care users during the COVID pandemic. doi:10.31235/osf.io/qf7kt
3. Ditmore, C. J., & Miller, A. K. (2021). Mobility as a service operating model to enable public policy. *Transportation Research Record: Journal of the Transportation Research Board*, *2675*(11), 141-149. doi:10.1177/03611981211026664
4. ENO. (2022). Addressing transportation disparities by embracing the future of mobility. Retrieved March 26, 2023, from https://www.enotrans.org/article/addressing-transportation-disparities-by-embracing-the-future-of-mobility/
5. Khairat, S., Haithcoat, T., Liu, S., Zaman, T., Edson, B., Gianforcaro, R., & Shyu, C. R. (2019). Advancing health equity and access using telemedicine: a geospatial assessment. *Journal of the American Medical Informatics Association*, *26*(8-9), 796-805.
6. National Academy of Medicine. (2022). Improving Health Care through Transportation. Retrieved March 26, 2023, from https://www.nationalacademies.org/trb/blog/improving-health-care-through-transportation
7. NCDHHS. (2020). North Carolina's Aging Population. Retrieved March 26, 2023, from https://www.ncdhhs.gov/state-demographic-slides-2020pdf/open
8. NCDHHS. (2022). Medicaid Transportation. Retrieved March 26, 2023, from https://medicaid.ncdhhs.gov/about-us
9. NCDOT. (2021). NCDOT earns grant to expand access to on-demand transit for thousands of north carolinians. Retrieved March 26, 2023, from https://www.ncdot.gov/news/press-releases/Pages/2022/2022-12-21-ncdot-grant-transit.aspx
10. Pangbourne, K., Mladenović, M. N., Stead, D., & Milakis, D. (2020). Questioning mobility as a service: Unanticipated implications for society and governance. *Transportation research part A: policy and practice*, *131*, 35-49.
11. Ray, R. A. (2020). Increasing Access to Essential Health Functions: The Role of Transportation in Improving America's Health. Retrieved from https://trid.trb.org/view/1724245
12. Riegel, L. (2023). "It's about moving people." a conversation with Ryan Brumfield of NCDOT's integrated mobility division. *North Carolina Medical Journal*, *84*(2). doi:10.18043/001c.73017
13. Wolfe, M. K., McDonald, N. C., & Holmes, G. M. (2020). Transportation barriers to health care in the United States: Findings from the national health interview survey, 1997–2017. *American Journal of Public Health*, *110*(6), 815-822. doi:10.2105/ajph.2020.305579

Appendix





ANALYSIS OF TRIP DURATION

SUMMARY OF FIT

RSquare	0.44352
RSquare Adj	0.443287
Root Mean Square Error	16.99565
Mean of Response	22.90974
Observations (or Sum Wgts)	221860

ANALYSIS OF VARIANCE

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	93	51054504	548973	1900.535
Error	221766	64057542	289	Prob > F
C. Total	221859	115112046		<.0001*

EFFECT SUMMARY

Source	LogWorth	PValue
Funding	5038.654	0.00000
StartTime	3071.062	0.00000
TripPurpose	1765.494	0.00000
DOTime	1169.640	0.00000
PUX	669.675	0.00000
RequestTime	297.068	0.00000
DOX	254.335	0.00000
Pandemic	114.339	0.00000
PUY	99.105	0.00000
PUTime	60.526	0.00000
DOY	47.435	0.00000
Mobility	22.506	0.00000
PolicyChange	6.917	0.00000
Day	2.702	0.00198
EndTime	.	.
Year	.	.
Month	.	.
DateOfTrip	.	.
LiftVan	.	.

ANALYSIS OF TRIP DISTANCE

SUMMARY OF FIT

RSquare	0.510142
RSquare Adj	0.509388
Root Mean Square Error	6.337984
Mean of Response	7.94017
Observations (or Sum Wgts)	28622

ANALYSIS OF VARIANCE

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	44	1195472.1	27169.8	676.3703
Error	28577	1147939.2	40.2	Prob > F
C. Total	28621	2343411.3		<.0001*

PARAMETER ESTIMATES

Term		Estimate	Std Error	t Ratio	Prob>|t|
Intercept	Biased	-16894.21	39350.36	-0.43	0.6677
PolicyChange	Zeroed	0	0	.	.
Pandemic	Zeroed	0	0	.	.
LiftVan	Biased	0.4637115	0.253986	1.83	0.0679
DateOfTrip	Biased	0.0013674	0.000131	10.45	<.0001*
Day		0.0240304	0.056989	0.42	0.6733
Month	Biased	0.7906859	1.716934	0.46	0.6451
Year	Biased	8.547951	20.68012	0.41	0.6794
PUX	Biased	-7.404354	0.39797	-18.61	<.0001*
PUY	Biased	1.1370093	0.479771	2.37	0.0178*
DOX		-2.192599	0.165788	-13.23	<.0001*
DOY		-4.183556	0.331701	-12.61	<.0001*
RequestTime		0.0001228	1.139e-5	10.78	<.0001*
PUTime		-0.000168	3.825e-5	-4.40	<.0001*
StartTime		-0.003022	0.000045	-67.06	<.0001*
DOTime		0.0016998	0.000133	12.82	<.0001*
EndTime	Zeroed	0	0	.	.
Mobility[Ambulatory]	Biased	0.3972503	0.1731	2.29	0.0217*
Mobility[Ambulatory Requiring Lift]	Zeroed	0	0	.	.
Funding[DHHS CARES-CHOW]		-3.248955	0.821702	-3.95	<.0001*
Funding[DHHS CARES-PASQ]		-2.290077	0.780622	-2.93	0.0034*
Funding[DHHS CARES-PERQ]		1.5501674	0.804382	1.93	0.0540
Funding[DHHS COVID Vaccine]		-4.20382	0.840662	-5.00	<.0001*
Funding[DSS - PERQ]		0.8980907	4.361547	0.21	0.8369
Funding[EDTAP-5310]		-0.986923	0.779951	-1.27	0.2058
Funding[EDTAP-Disabled]		0.1417201	0.849055	0.17	0.8674
Funding[EDTAP-Elderly]		-1.894491	0.814491	-2.33	0.0200*
Funding[Medicaid-Camden]		4.386995	1.064987	4.12	<.0001*
Funding[Medicaid-Chowan]		-5.877693	0.81307	-7.23	<.0001*
Funding[Medicaid-Currituck]		4.4858223	0.926085	4.84	<.0001*
Funding[Medicaid-Pasquotank]		-2.343977	0.78999	-2.97	0.0030*
Funding[Medicaid-Perquimans]		2.0578835	0.802786	2.56	0.0104*
Funding[MONARCH-Camd]		-2.186314	3.779849	-0.58	0.5630
Funding[MONARCH-Curr]		5.1009817	3.755108	1.36	0.1743
Funding[MONARCH-Pasq]		-7.898858	3.741796	-2.11	0.0348*
Funding[MONARCH-Perq]		-3.214025	3.76364	-0.85	0.3931
Funding[RGP NO FARE]		1.5653754	0.786907	1.99	0.0467*
Funding[SKILLS INC]		1.9513367	0.901745	2.16	0.0305*
Funding[TITLE III-Camden]		1.4435265	1.038744	1.39	0.1646
Funding[TITLE III-Chowan]		-2.776395	0.863938	-3.21	0.0013*
Funding[TITLE III-Pasquotank]		-2.374325	0.791139	-3.00	0.0027*
Funding[TITLE III-Perquimans]		6.3245359	0.859936	7.35	<.0001*
TripPurpose[Adult Day Care]		-0.535736	0.602549	-0.89	0.3739
TripPurpose[Dialysis]		-3.335293	0.57303	-5.82	<.0001*
TripPurpose[Education]		2.0405444	0.646425	3.16	0.0016*
TripPurpose[Employment]		-0.3103	0.568372	-0.55	0.5851

Term	Estimate	Std Error	t Ratio	Prob>|t|
TripPurpose[Medical]	0.5198402	0.571414	0.91	0.3630
TripPurpose[MONARCH]	2.111155	3.924817	0.54	0.5907
TripPurpose[Non-Medical]	-0.874396	0.572427	-1.53	0.1266

Rural Transit Usage Patterns During Substantial Events:

COVID-19 and NC's Medicaid Transformation

Dr. Trung Tran
Fayetteville State University

May 2023

Goal and Objectives Goal and Objectives

The goal of this research is to evaluate access to healthcare and economic opportunities in small cities and rural areas before and after COVID and Medicaid Transformation by investigating the spatial and temporal patterns of needs for public transportation to health care and economic opportunities as well as vehicles activities responding to the needs.

As a result, the research is to answer the following questions:

1. How did on-demand transit usage change over time due to COVID and Medicaid Transformation events?
2. How did vehicle activity and ridership change due to COVID and Medicaid Transformation events?

Data

The primary dataset used in this project was the trip dataset covering the studying period from 2019 to 2022. The dataset included more than 302,000 records representing vehicle trips formed by pairs of pick-up and drop-off locations. Each trip was characterized by multiple attributes. The data dictionary of the dataset is presented in Table 1.

Table 2. Data dictionary of the pick-up/drop-off dataset.

Field Names	Descriptions	Data Types	Data Domains
TripID	Identification numbers of trips	Long	
Cancel	Whether a trip was cancelled or not (1 = canceled)	Boolean	
PUAddress	Pick-up address	String	
PUX	Pick-up longitudes	Double	
PUY	Pick-up latitudes	Double	
DOAddress	Drop-off addresses	String	
DOX	Drop-off longitudes	Double	
DOY	Drop-off latitudes	Double	
DateOfTrip	Dates of trips	Date	
RequestTime	Times of requests made by customers	Date	

PUTime	Times vehicles arriving at pick-up locations	Date	
StartTime	Times vehicles departing from pick-up locations	Date	
DOTime	Times vehicles arriving at drop-off locations	Date	
EndTime	Times vehicles leaving from drop-off locations	Date	
CustID	Identification numbers of customers	Long	
Vehicle	Identification numbers of vehicles	String(7)	
NumPass	Number of passengers	Long	
TripPurpose	Trip purposes	String	Nutrition, Education, Non-Medical, Medical, Dialysis, Employment, MONARCH, Adult Day Care, SKILLS
Funding	Source of funding	String	TITLE III-Chowan, TITLE III 033-Chow Medical, RGP, WORKFORCE DEV, EDTAP-Elderly, EDTAP-5310, TITLE III 033-Pasq Medical, TITLE III-Pasquotank, RGP-$4 Extra Trip, EDTAP-Disabled, Medicaid-Chowan, HERITAGE CARE, NO SHOW RGP, STATE OPERATING GRANT, TITLE III-Perquimans, EDTAP, MONARCH-Perq, Medicaid-Perquimans, Medicaid-Currituck, TITLE III-Currituck Site, TITLE III-Pow Pt Site, EDTAP-Currituck Sites, EDTAP-Powells Point, ELIZ CITY HEALTH & REHAB, Medicaid-Pasquotank, RGP-Transfer Bus to Bus, MONARCH-Pasq, Medicaid NO SHOW Pasq, Medicaid-Camden, TITLE III 033-Perq Medical, Medicaid Client-DENIALS-Chowan, Medicaid NO SHOW Chow, TITLE III 033-Camd Medical, Medicaid Client-DENIALS-Currituck, SKILLS INC, MONARCH-Curr, Adult Services-Elderly, TITLE III-Camden, RGP NO FARE, Medicaid NO SHOW Curr, Adult Services-Disabled, JARC, RGP-SPECIAL TRIP, MONARCH-Chow, NO SHOW-SKILLS, Medicaid Cap DA Chowan, RGP-EMPL/FAM,

			Medicaid NO SHOW Camden, Medicaid NO SHOW Perq, EDTAP-SPECIAL TRIPS, NO SHOW-WORKFORCE DEV, Medicaid Client-DENIALS-Pasquotank, HEALTH DEPT-High Risk, EDTAP-HAMPTON VA, RGP - COA, WORKFIRST-PERQ, Medicaid Client-DENIALS-Perquimans, RGP/Medicaid Self-Pay, DSS - PERQ, DISABILITY RIGHTS OF NC, DSS - CHOW, RGP-HAMPTON VA, DHHS CARES-PASQDHHS CARES-CHOW DHHS CARES-PERQ RGP-SAME DAY MONARCH-Camd DHHS CARES-CURR DHHS COVID Vaccine ONE CALL DHHS CARES-CAMD VOC Rehab
Mobility	Types of mobility	Strong	Ambulatory, Ambulatory Requiring Lift, WheelChair
Cost		Double	
Fare		Double	
AgencyBill		String	

To facilitate a series of spatio-temporal analyses, the dataset was preprocessed by first removing trips that were cancelled (Cancel = 1) and then subsetting into five subsets. The subsetting process was based on time as follows.

- Subset 1: PreCOVID. This subset was created by extracting trips with request time from 3/15/2019 to 4/14/2019.
- Subset 2: PeakCOVID: 3/15 – 4/14/2020
- Subset 3: PostCOVID/PreMEDIC: 3/15 – 4/14/2021
- Subset 4: PostMEDIC 2021: Oct 2021
- Subset 5: PostMEDIC 2022: 3/15 – 4/14/2022

Temporal Variation of On-Demand Transit Usage Analysis

Changes of on-demand transit usage were revealed by a series of descriptive statistical analyses of the entire trip dataset as well as subsets of the trip datasets.

Daily Trip Frequency

One way to evaluate the impact of COVID and Medicaid Transformation events is to investigate the change of trip frequency before and after the events. We believe that while COVID reduced the trip frequency, Medicaid Transformation increased trip frequency to health care and economic opportunities.

To understand changes of trip frequency, we first conducted a descriptive statistic of the full trip dataset with more than 302,000 trip records introduced above.

Specifically, Figure 1 provides information on the average of daily number of bus trips taken per year, along with the corresponding standard deviation between 2019 and 2022. In 2019, this average number was 6,720 trips (standard deviation = 2,781). The large standard deviation demonstrates that the number of daily bus trips varied well from day to day in 2019. The following year, in 2020, the average decreased critically to 3,862 trips, a decrease of 42% trips from 2019. However, the average increased consistently in 2021 and 2022 to 4,310 trips (12% increase from 2019) and 5,484 trips (27% increase from 2020), respectively. Moreover, the standard deviation in 2021 and 2022 further decreased more than 50% as compared to the standard deviation in previous years, demonstrating that the daily number of trips taken was more consistent in 2021 and 2022. In addition, even though there were changes in the averages of daily number of trips between the years, the large standard deviations did not enable a conclusion on a statistically significant change in the daily number of trips between the years.

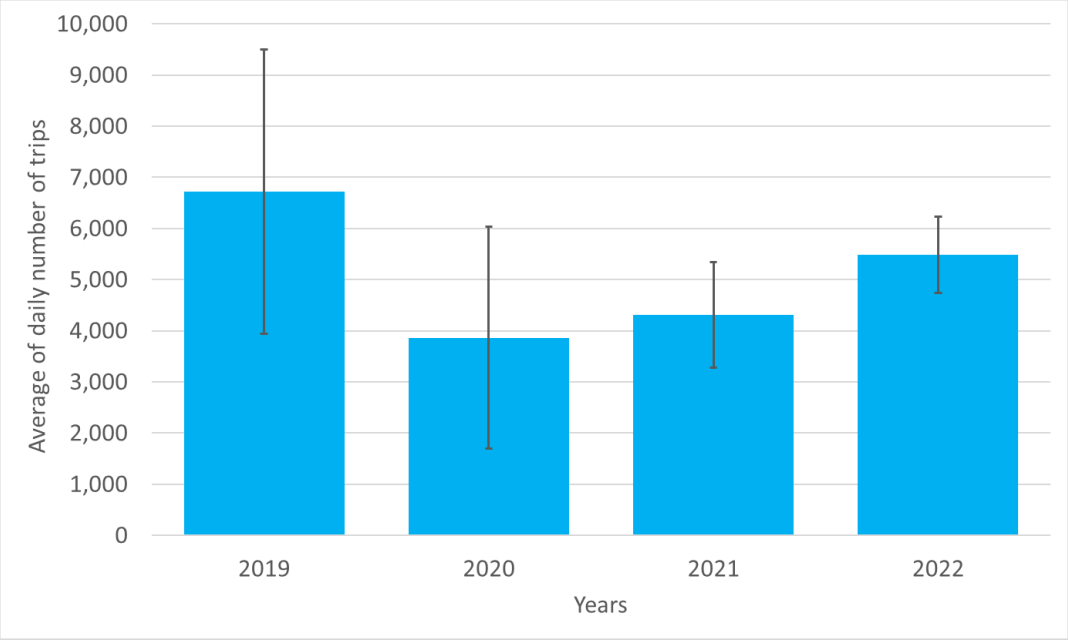


Figure 1. Average of daily number of trips by year in 2019-2022. Error bars represent a standard deviation.

Trip Frequency by Weekday and Month

To better gain insight into whether there were specific week-days when on-demand transportation were more preferred, the number of trips of the entire studying period (2019-2022) were counted by week-day as well as by month and presented in the calendar heat chart in Figure 2. Data showed that Wednesdays became the most preferred day of the week in almost all months, except Aprils, Mays, and Novembers, when the trip frequency on Wednesdays in January-March, June-July, September-October, and December was in the top 20 percentile as compared to other week-days. Tuesdays was found to be much less preferred than other week-days given that none of its monthly frequency belonging to the top

20 percentile. Besides, Aprils and Mays were not the preferred months with their trip frequency falling in the bottom 20-40 percentiles across all week-days. Overall, data showed that there was a temporal pattern indicating that there were days in a week people would use the transportation service more than other days.

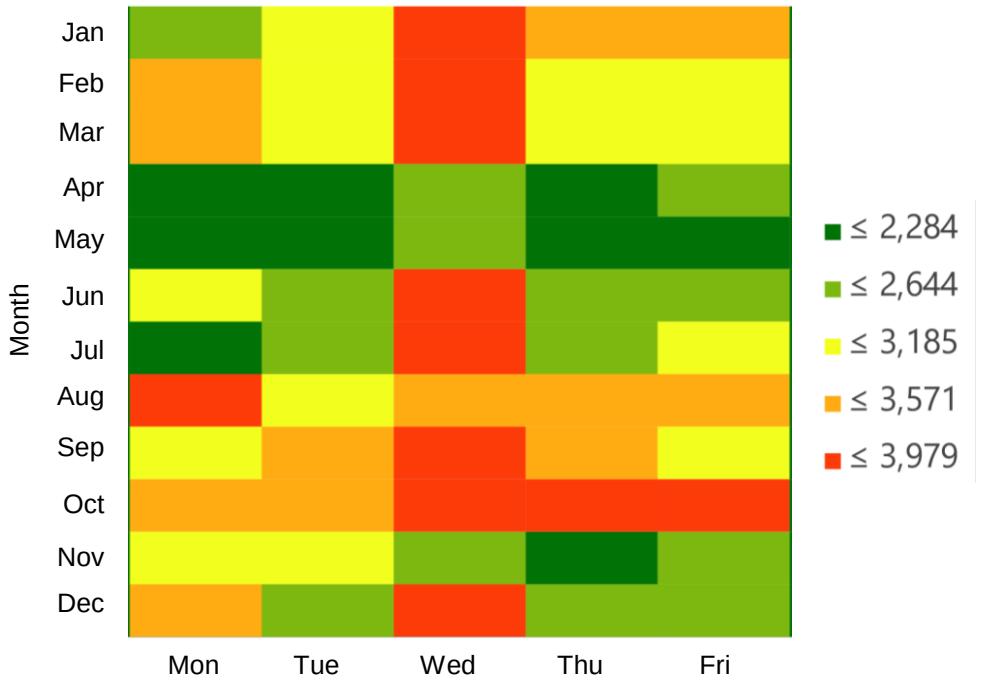


Figure 2. Trip frequency by weekday and month between 8/2019 – 7/2022. Data were classified into quantiles.

Trip Frequency by Trip Purpose and by Event

Beside investigating the overall dataset, we also investigated changes in trip frequency by trip purpose and by event. There were four events we focused on: pre COVID (PreCOVID), peak COVID (PeakCOVID), post COVID and pre Medicaid Transformation (PostCOVID/PreMEDIC), post Medicaid Transformation in 2021 (PostMEDIC 2021), and post Medicaid Transformation in 2022 (PostMEDIC 2022). Therefore, in this analysis, we perform descriptive statistical analysis with the five subsets described above. The total number of trips during each time period was recorded and compared against each other by trip purpose (Figure 3). Trip purposes were extracted from the dataset, including Adult Day Care, Dialysis, Education, Employment, Medical, MONARCH, Non-Medical, Nutrition, and SKILLS.

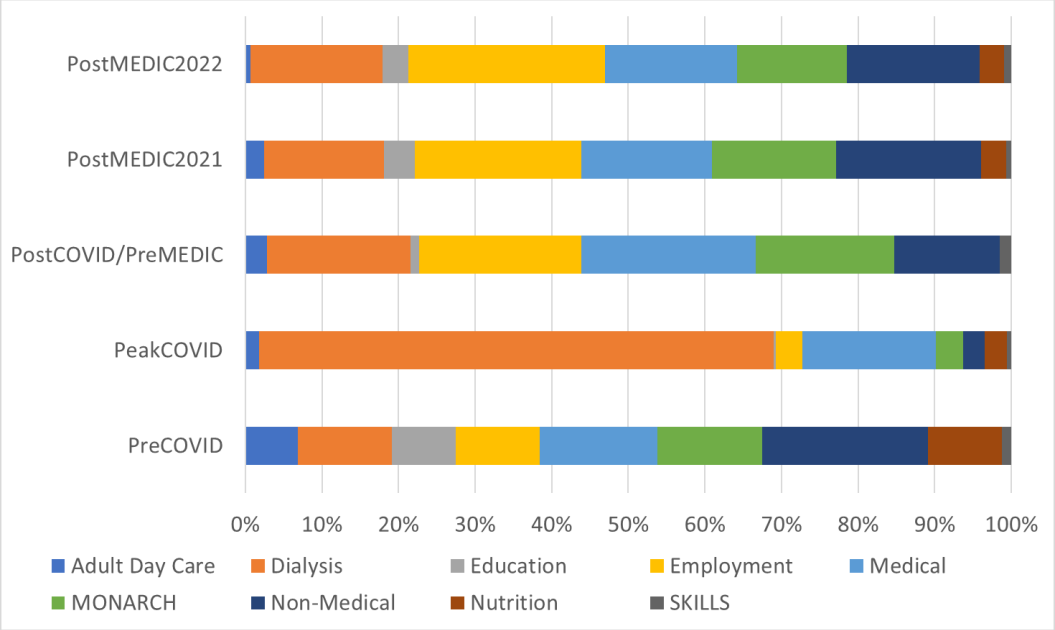


Figure 3. Percentages of trips by purpose for different time periods: PreCOVID (3/15 – 4/14/2019), PeakCOVID (3/15 – 4/14/2020), PostCOVID/PreMEDIC (3/15 – 4/14/2021), PostMEDIC 2021 (Oct 2021), PostMEDIC 2022 (3/15 – 4/14/2022).

The analysis of trips by purpose in Figure 3 showed a critical decrease in the number of trips taken during the peak of the COVID-19 pandemic for almost all purposes except for Dialysis, with some increase in the post-COVID/post-MEDIC 2021 time period. The number of trips appears to have increased even further in the post-MEDIC 2022 time period, compared to the previous years. Specifically, it appears that trips to Dialysis, Employment, and Medical appointments remained relatively consistent throughout the time periods with only minor fluctuations, except for the peak-COVID period. However, there were critical decreases in the number of trips for categories such as Adult Day Care, Education, and Nutrition since the peak of the pandemic, with some increase in the post-COVID/post-MEDIC 2021 and post-MEDIC 2022 time periods.

Overall, the data suggested that while some categories of trip purpose, such as Medical, were less affected by the pandemic, others, such as Adult Day Care and Nutrition, experienced critical declines in usage of the transportation service during the peak of the pandemic. The recovery of on-demand transportation usage in the post-COVID/post-MEDIC 2021 time period may indicate a return to more typical usage patterns, while the increase in trips in the post-MEDIC 2022 time period suggests continued growth in need of on-demand transportation.

Trip Frequency by Hour

In addition, we also investigated if there were specific hours in a day that people preferred to be picked up. The summary of trip frequency by event and by daily hour in Figure 4 pointed out that while there were an overall changes in trip frequency between events, there were specific hours in a day that were more preferred. Specifically, there were two hourly periods 9:00 – 11:00 in the morning and 13:00 in the

afternoon that people preferred to be picked up for various purposes. The hourly period between noon and 14:00 in the afternoon was least preferred for pick-ups.

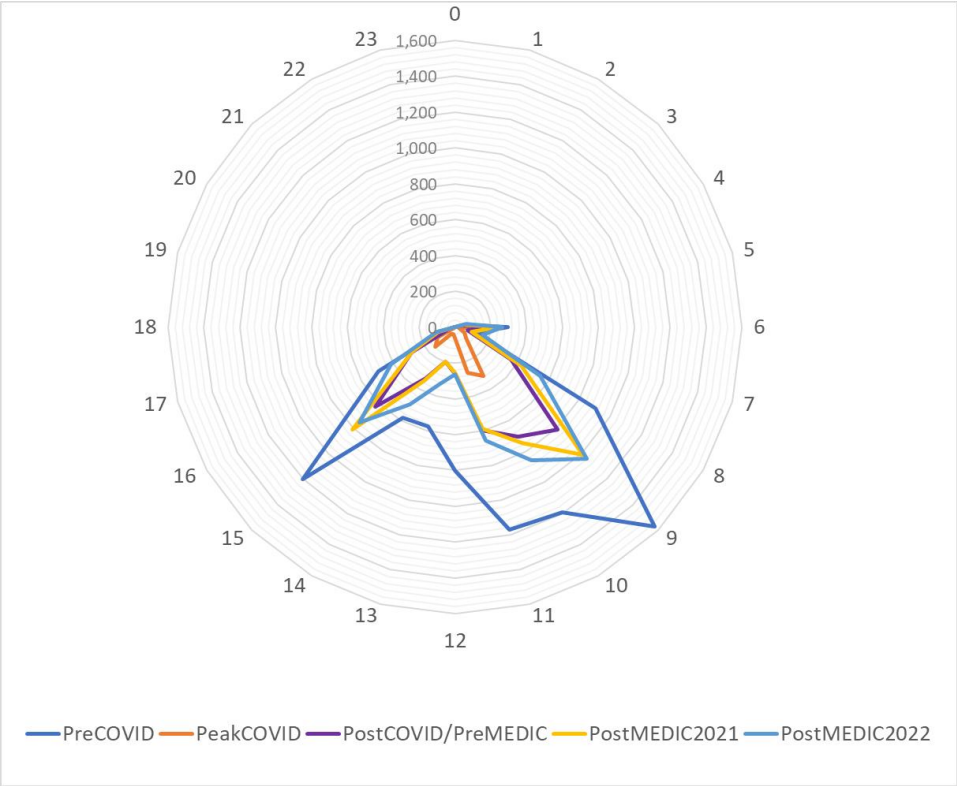


Figure 4. Pick-up request frequency made during different time periods: PreCOVID, PeakCOVID, PostCOVID/PreMEDIC, PostMEDIC2021, and PostMEDIC2022.

Vehicle Operation Analysis

Vehicle Service Space

To understand how ICPTA responded to on-demand transportation needs, we investigated the service spaces of vehicles using GIS. In this research, a service space of a vehicle is the convex hull of the minimum bounding area enclosing all stops visited by the vehicle. Therefore, to delineate the service spaces of all vehicles we first mapped all pick-up and drop-off locations based on their longitudes and latitudes provided in the trip dataset. Since we were interested in the changes of the service spaces between and after COVID and Medicaid Transformation events, we merged pick-up and drop-off locations for each of the five subsets listed above. Then, for each of the five merged datasets, we ran the Minimum Bounding Geometry operator in ArcGIS Pro with input features being the pick-up and drop-off locations of each of the five merged datasets to create a convex hull of the input pick-up and drop-off

locations. This process generated five convex hull polygons representing five service spaces of vehicles during the five events. Maps of the service spaces are presented in Figure 5.

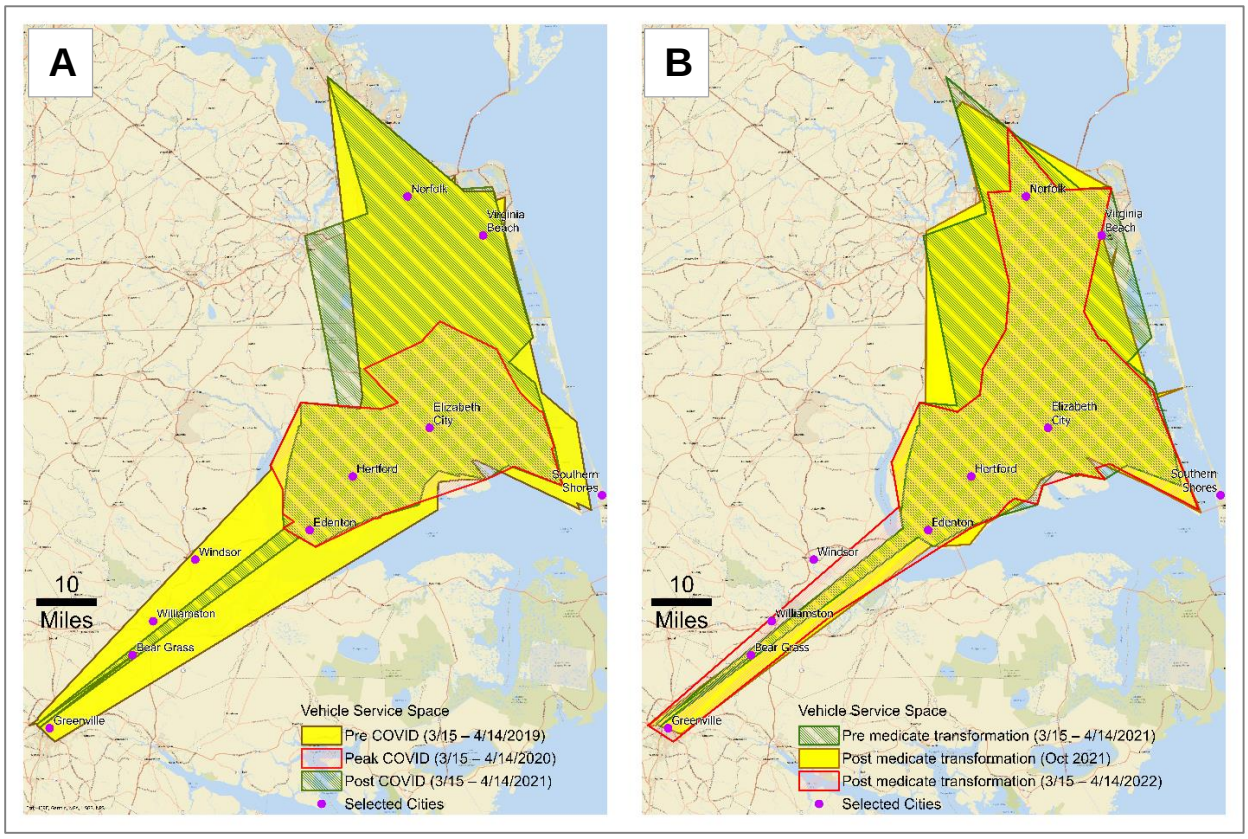


Figure 5. Service spaces of vehicles during different time periods: (A) PreCOVID, PeakCOVID, PostCOVID; and (B) PreMEDIC, PostMEDIC 2021, PostMEDIC 2022.

In Figure 5A, the vehicle service spaces of the pre-, peak-, and post-COVID time were critically different. Indeed, the vehicle service space of the peak-COVID was around the three cities of Elizabeth, Hertford, and Edenton whereas the vehicle service space of the pre- and post-COVID times expanded toward Greenville in North Carolina as well as Norfolk and Virginia Beach in Virginia. The vehicle service spaces of the pre- and post-Medicaid Transformation were also found to be different (Figure 5B). The space of the post-Medicaid Transformation in 2022 was found to be slightly smaller than that of the pre- and post-Medicaid Transformation in 2021.

Spatial Distribution of Vehicle's Stops

While the previous analyses pointed out that COVID-19 and Medicaid Transformation could have relationships to the change in trip frequencies, it was unclear whether those events were related to the spatial distributions of daily pick-up and drop-off stops visited by vehicles. To answer this question, we

also investigated the daily spatial distributions of stops (both pick-ups and drop-offs) during the five time periods defined above (PreCOVID, PeakCOVID, PostCOVID/PreMEDIC, PostMEDIC2021, and PostMEDIC2022).

To do so, standard deviational ellipses (SDEs) were created for daily stops during the studying time periods (Figure 6). It was expected that each daily SDE encompassed approximately 63 percent of the daily stops with more stops concentrating around the SDE's center and less stops toward the SDE's periphery. Moreover, the SDE's major and minor axis lengths could suggest whether the stops had elongated distribution along the longer axis, and thus had a particular orientation.

When comparing data during the three time periods pre-, peak-, and post-COVID (Figure 6 A-C), it was found that not only were the daily numbers of stops different but also were their spatial distributions. Indeed, while the majority (about 63%) of stops during the peak-COVID period concentrated only around three cities (Elizabeth, Hertford, and Edenton), the majority of stops during the pre- and post-COVID concentrated in multiple cities along the US-17 corridor in North Carolina, such as Greenville, Williamston, Edenton, Hertford, and Elizabeth, as well as the two cities in Virginia, Norfolk and Virginia Beach. Moreover, the density of stops during the pre-COVID was the highest when comparing with the peak- and post-COVID periods, demonstrated by the critically high density of SDEs in the pre-COVID period.

A comparison of SDEs between the three periods pre-MEDIC, post-MEDIC 2021, and post-MEDIC 2022 (Figure 6 D-F) did not provide any important differences. Indeed, all three periods have similar spatial distributions of daily stops concentrating along the US-13, US-17, NC-168, and I-464 corridors. Overall, the SDEs of all five studying periods showed that the corridors US-13, US-17 connecting Greenville and Elizabeth City is the busiest route with high concentrations of stops as compared to other corridors. Moreover, Elizabeth City, Hertford, and Edenton were the three cities with the highest concentration of stops as compared to other cities.

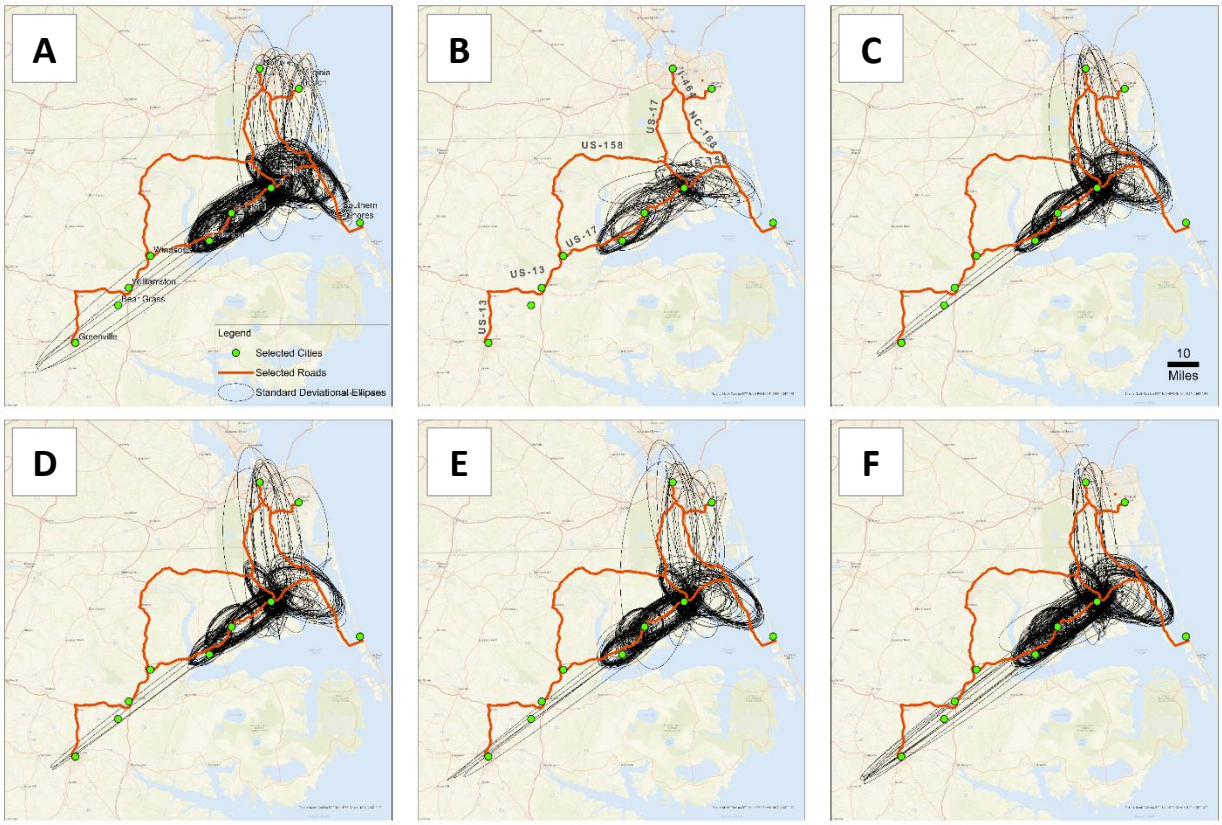


Figure 6. Directional spatial distributions of stops (pick-ups and drop-offs) visited by all vehicles during different time periods: (A) PreCOVID, (B) PeakCOVID, (C) PostCOVID, (D) PreMEDIC, (E) PostMEDIC 2021, (F) PostMEDIC 2022. Directional spatial distributions of stops visited by vehicles are statistically represented by Standard Deviational Ellipses. Each ellipse represents about 60 percent of stops visited by a vehicle, with more stops toward the center and fewer stops toward the periphery of the ellipse.

Ridership

We also investigated ridership by vehicle during the five time periods (Figure 7). We were looking into the information about the average maximum ridership at different time periods, along with the standard deviation of maximum ridership. The time periods are categorized as PreCOVID, PeakCOVID, PostCOVID/PreMEDIC, PostMEDIC 2021, and PostMEDIC 2022. It was found that the average maximum ridership during the PreCOVID period was 6.2, with a standard deviation of 2.6. This indicates that, on average, the transportation system experienced a high level of ridership before the COVID-19 pandemic, with a significant amount of variability in the maximum ridership values. During the PeakCOVID period, the average maximum ridership decreased to 3.0, with a standard deviation of 1.5. This indicates that the pandemic significantly impacted ridership, resulting in a sharp decline in the number of passengers using the transportation system. The standard deviation value suggests that there was less variability in the maximum ridership values during this period.

In the PostCOVID/PreMEDIC period, the average maximum ridership increased to 4.6, with a standard deviation of 2.4. This suggests that there was a gradual recovery in ridership after the initial impact of the

pandemic, but the values remained lower than the PreCOVID period. The standard deviation value indicates that there was still some variability in the maximum ridership values during this period. The PostMEDIC 2021 and 2022 periods also showed an increase in the average maximum ridership, with values of 5.1 and 4.7, respectively. The standard deviations for these periods were 2.2 and 1.7, respectively, indicating that there was still some variability in ridership during these periods, but less than in the PreCOVID period.

Overall, the dataset provides valuable insights into the impact of the COVID-19 pandemic on ridership in the transportation system, as well as the gradual recovery in ridership after the pandemic. The information can be useful for transportation planners and policymakers to make decisions about future investments and improvements in the transportation system.

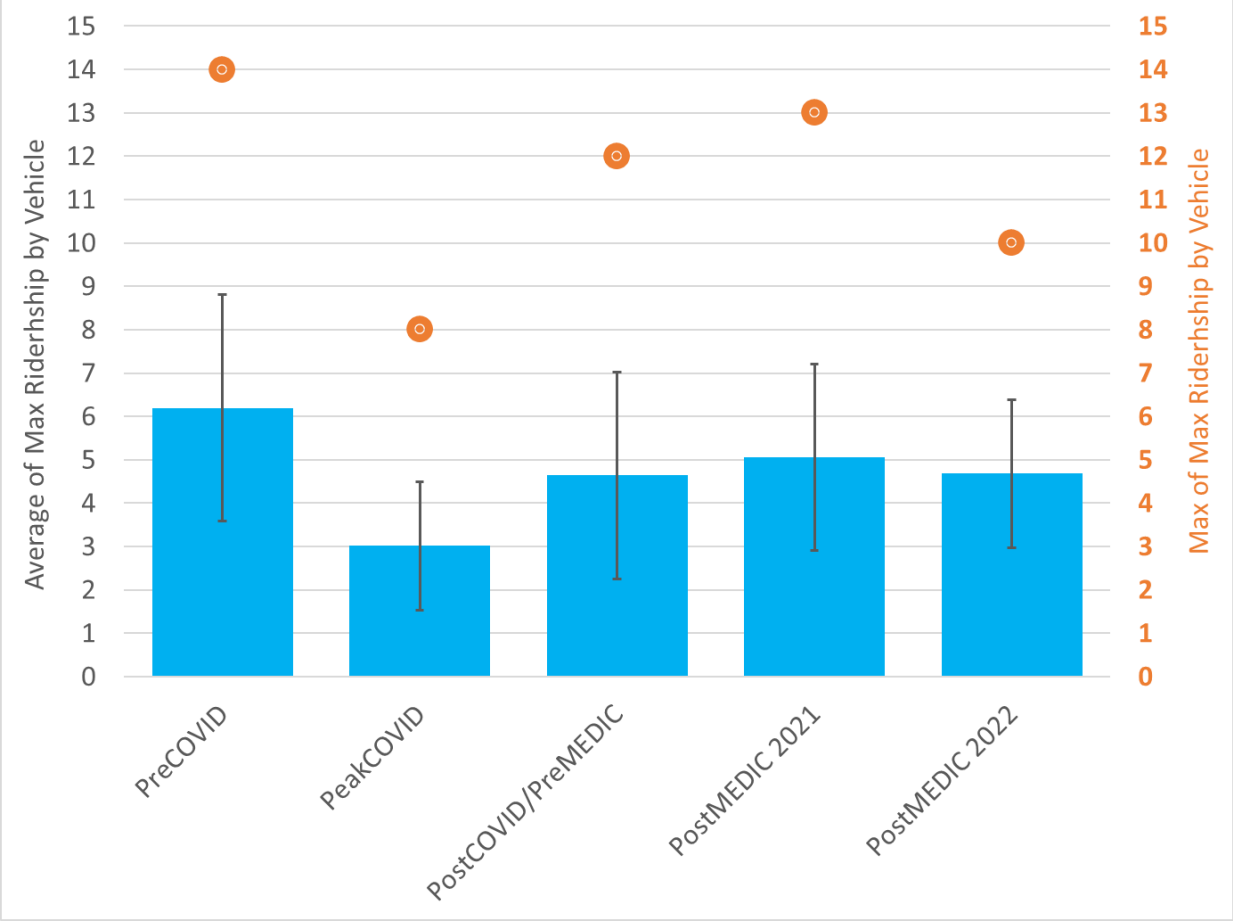


Figure 7. Vehicle's ridership statistics at different time periods.

Max Ridership by Vehicle is the maximum number of riders of a vehicle at one of the stops during its trip. In this chart, the bars represent the averages of Max Ridership by Vehicle, which are the means of Max

Ridership of all vehicles during the studying time periods. The error bars represent one standard deviation. The dots (orange color) in the chart represent the max of all Max Ridership by Vehicle during the studying time periods. It was assumed that only one passenger was picked up or dropped off at a stop.

To better understand the temporal distribution of ridership, we investigated the max of max ridership by week day for the five time periods (Figure 8). During the PreCOVID period, the highest maximum ridership values were observed on Wednesdays and Thursdays, with values of 14 and 14, respectively. Mondays had the lowest maximum ridership value of 12, while Fridays had a value of 11. This suggested that Wednesdays and Thursdays were the busiest days for the transportation system, with the highest number of passengers using it.

During the PeakCOVID period, the maximum ridership values decreased significantly across all weekdays, with the highest value of 8 observed on Mondays. Tuesdays, Wednesdays, and Fridays had maximum ridership values between 4 and 5, indicating a sharp decline in the number of passengers using the transportation system. In the PostCOVID/PreMEDIC period, the maximum ridership values increased compared to the PeakCOVID period but remained lower than the PreCOVID period. Thursdays had the highest maximum ridership value of 12, followed by Wednesdays and Mondays with values of 11. Tuesdays and Fridays had values of 11 and 10, respectively.

During the PostMEDIC 2021 period, the maximum ridership values were highest on Thursdays with a value of 13, followed by Tuesdays and Wednesdays with values of 11. Mondays and Fridays had values of 9 and 10, respectively. In the PostMEDIC 2022 period, the highest maximum ridership value was observed on Mondays with a value of 8, followed by Tuesdays and Wednesdays with values of 9. Thursdays and Fridays had values of 9 and 9, respectively.

Overall, the dataset suggested that Wednesdays and Thursdays were the busiest days for the transportation system before the COVID-19 pandemic, and there was a significant decline in ridership during the PeakCOVID period. While ridership increased in the PostCOVID/PreMEDIC and PostMEDIC 2021 periods, it remained lower than the PreCOVID period. The dataset can be useful for transportation planners and policymakers to make decisions about future investments and improvements in the transportation system, such as increasing capacity on Wednesdays and Thursdays to accommodate the high demand.

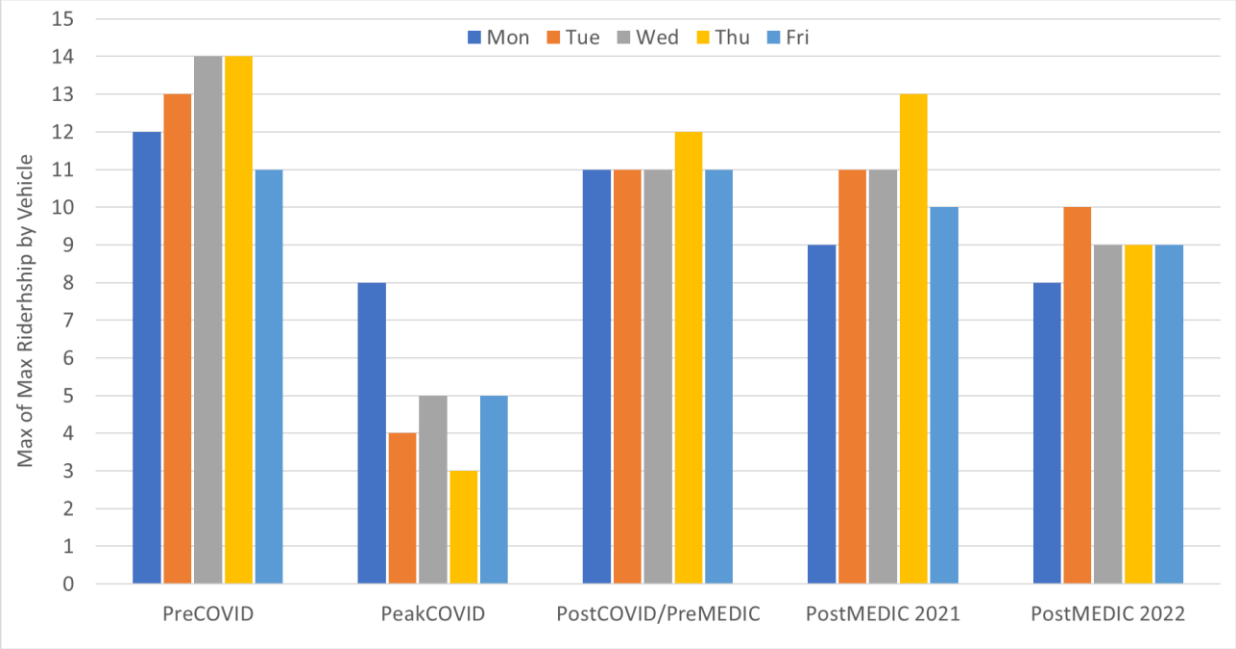


Figure 8. Max of Max Ridership by Vehicle summarized by week day at different time periods.

Conclusion

In this study, we conducted a series of spatial and temporal analyses of trips made by ICPTA's vehicles based on the trip dataset of more than 300,000 records with more than 20 attributes. We found that COVID and Medicaid Transformation events had association with changes in the spatial and temporal patterns of trips even though the changes associated with COVID event were clearer than changes associated with the Medicaid Transformation event. Further research is underway to predict the spatio-temporal distributions of stops, and thus vehicle spaces as a result of unusual events.

Dwell Time and Performance Analysis

Dr. John Park
North Carolina A&T

May 2023

Overview

Paratransit scheduling system can significantly benefit from improved accuracy in dwell time estimation, defined as the time required for a vehicle to stop to board or alight passengers (Figure **1**). Adjusting dwell time for paratransit service improved on-time performance of the service, optimized routes, and reduced associated operational costs (Garnier et al., 2020) [11]. However, Garnier et al., 2020 presented large variation (22.9%) in the paratransit dwell time data, which caused poor performance of the dwell time estimation. In addition, factors such number of passengers boarding (ambulatory and wheelchair) used in Garnier et al., (2020) are not key-contributing factors anymore due to the Medicaid privatization. Rather than using a binary location variable (Non-residential), spatiotemporal patterns of the dwell time could give us the better results. Fortunately, in this study, we had trip purposes to be used as one of factors. The team 1) develops a model that estimate dwell time, 2) analyzes the on-time performance, and 3) proposes framework for integration of paratransit data into TransModeler simulation.

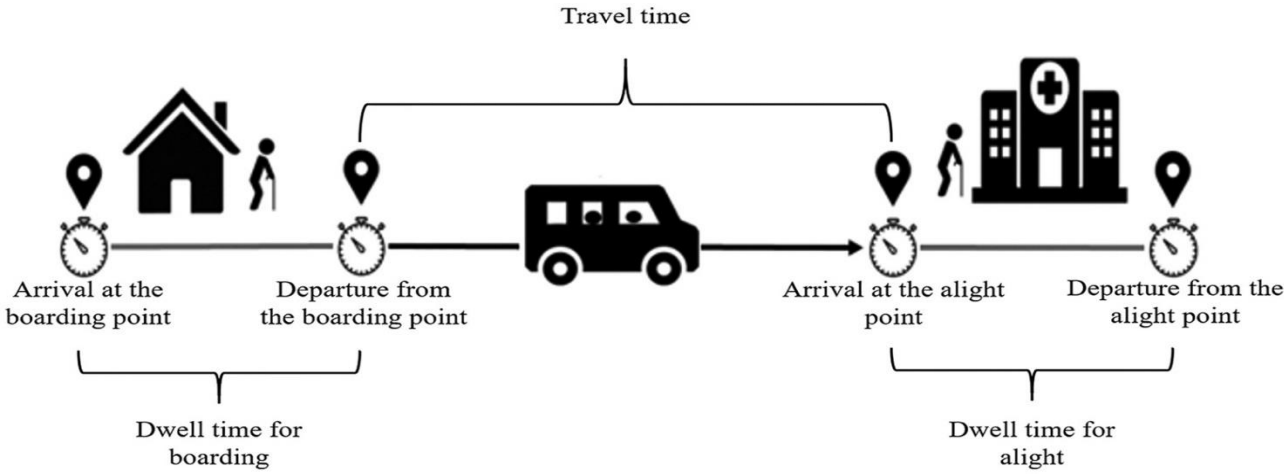


Figure 1. Definition of the dwell time and time components (Garnier et al. 2020)

Dwell Time Prediction

Our assumption is that dwell time could take more time when driver is looking for the right address in different time of day depending on location of the pickup and customer's individual need and capabilities.

Exploratory Data Analysis

Before showing the performance of developed model, various exploratory analysis results are recorded here followed by Key findings in each section.

[11] Garnier, Camille et al. "Adjusting Dwell Time for Paratransit Services." *Transportation Research Record*2674 (2020): 638 - 648.

OUTLIER REMOVAL AND SPATIOTEMPORAL ANALYSIS

To deal with the large variation dwell time estimation model cannot handle, we removed outliers defined as outside of the 3 times of standard deviation. The main purpose of this analysis was to visualize spatiotemporal distribution of dwell time classified into three high, moderate, and low.

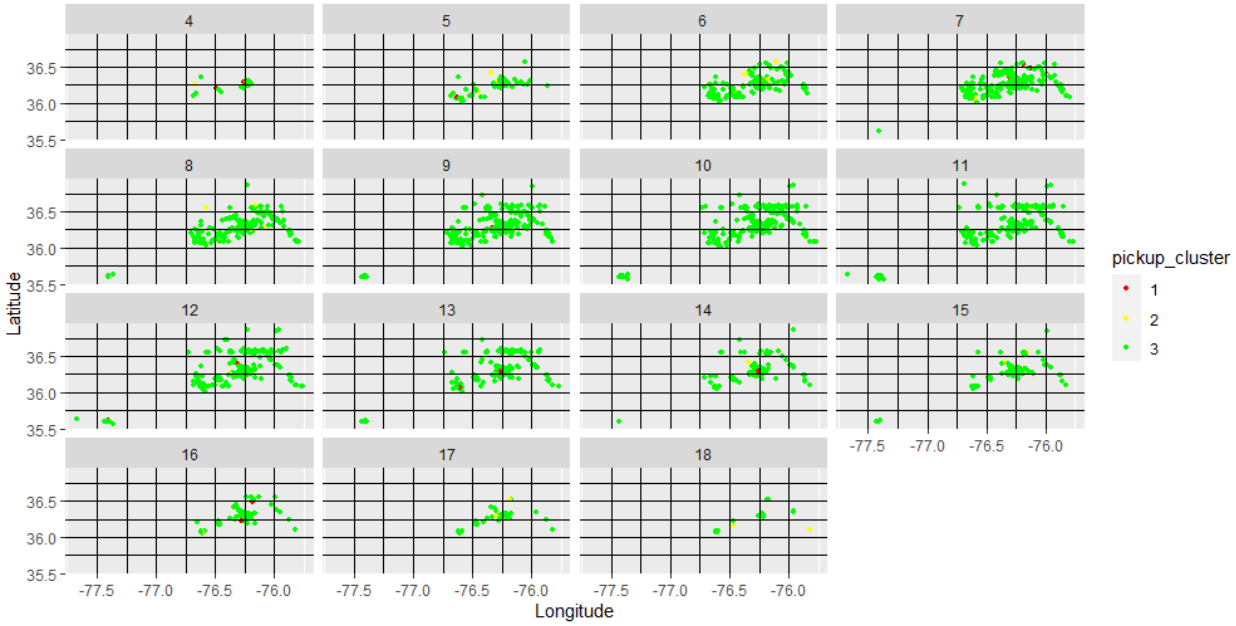


Figure 2. Spatiotemporal distribution of dwell time classified into three groups: red (long), yellow (moderate), and short (green).

We further investigated dwell time classification on each zone throughout the day.

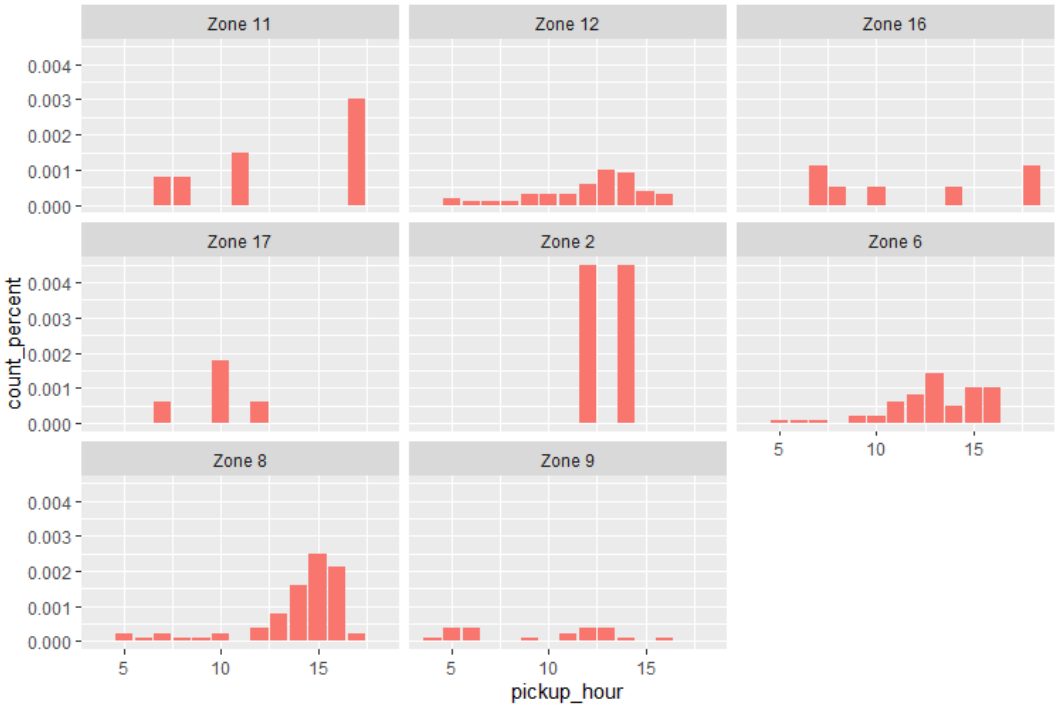


Figure 3. Spatiotemporal distribution of 'long' dwell time.

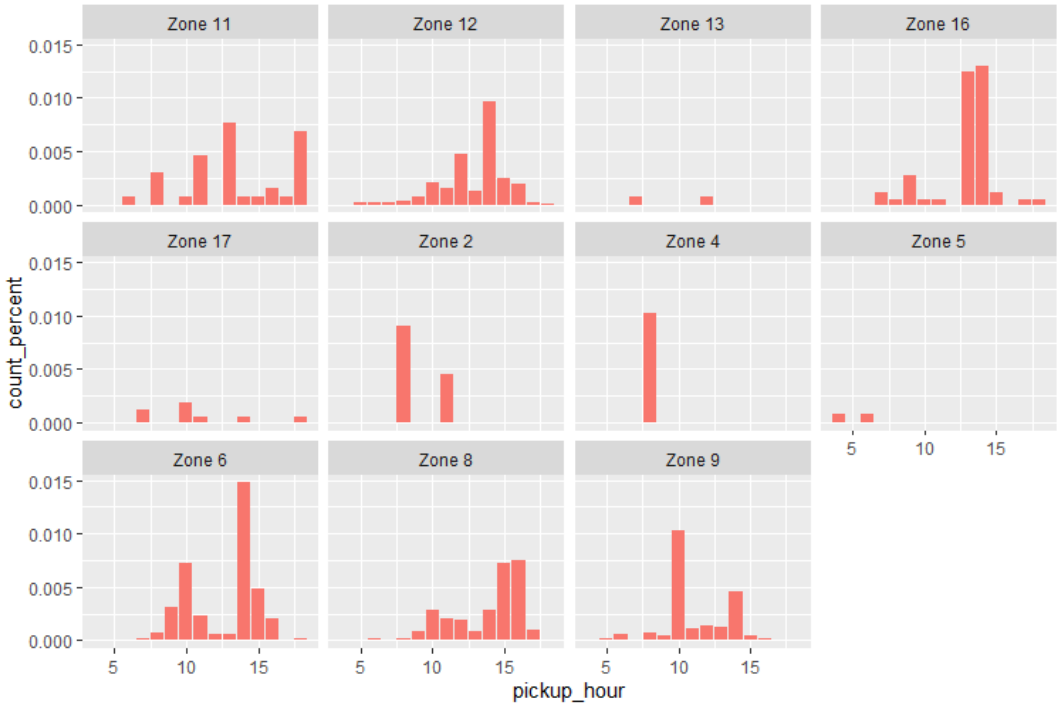


Figure 4. Spatiotemporal distribution of 'moderate' dwell time.

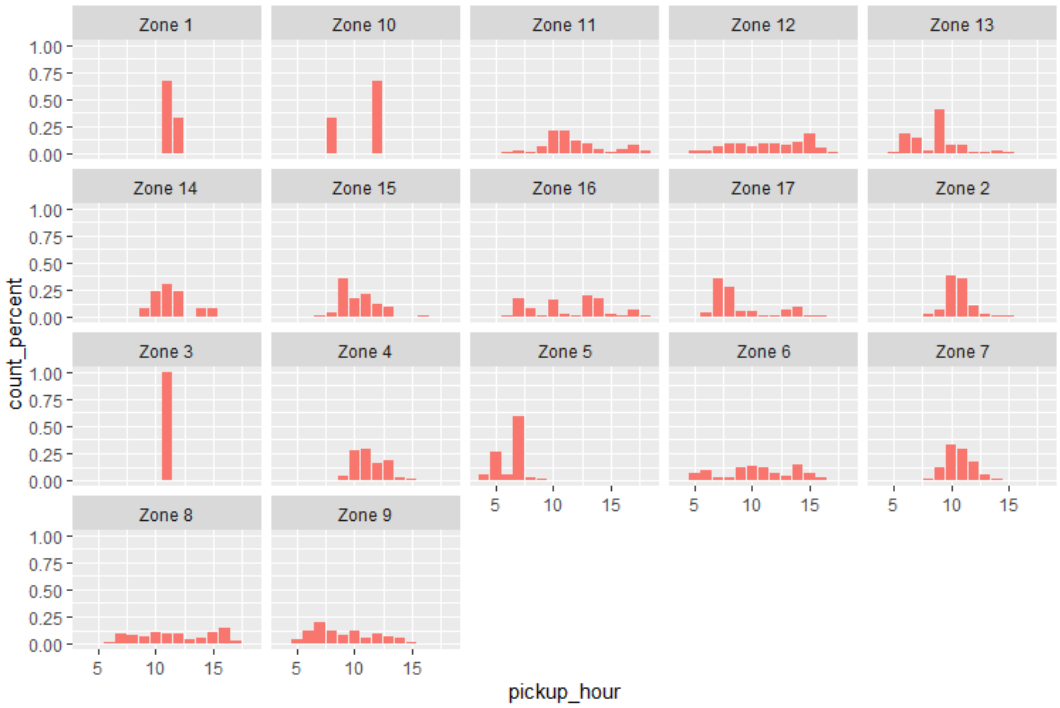


Figure 5. Spatiotemporal distribution of 'short' dwell time.

PROPOSED NEW ZONE AS LOCATION CLUSTER

Neither outlier removal nor spatiotemporal factors turn-out to be a key factor for dwell time estimation. Dwell time estimation model cannot handle the high dimensional location variability as latitude and longitude. A cluster analysis was conducted on the pick-up longitude and latitude coordinates to combat the incorrect zip codes present in the data with hopes to define our own zones that exist in Elizabeth City. Eleven clusters were found from the K-means cluster with the F value of 164.5 and Pr (>F) <2e-16 which means statistically significant clustering performance.

Key findings: when a particular time and location is anticipated to have longer dwell time, extra buffer in the pick-up time window can be placed.

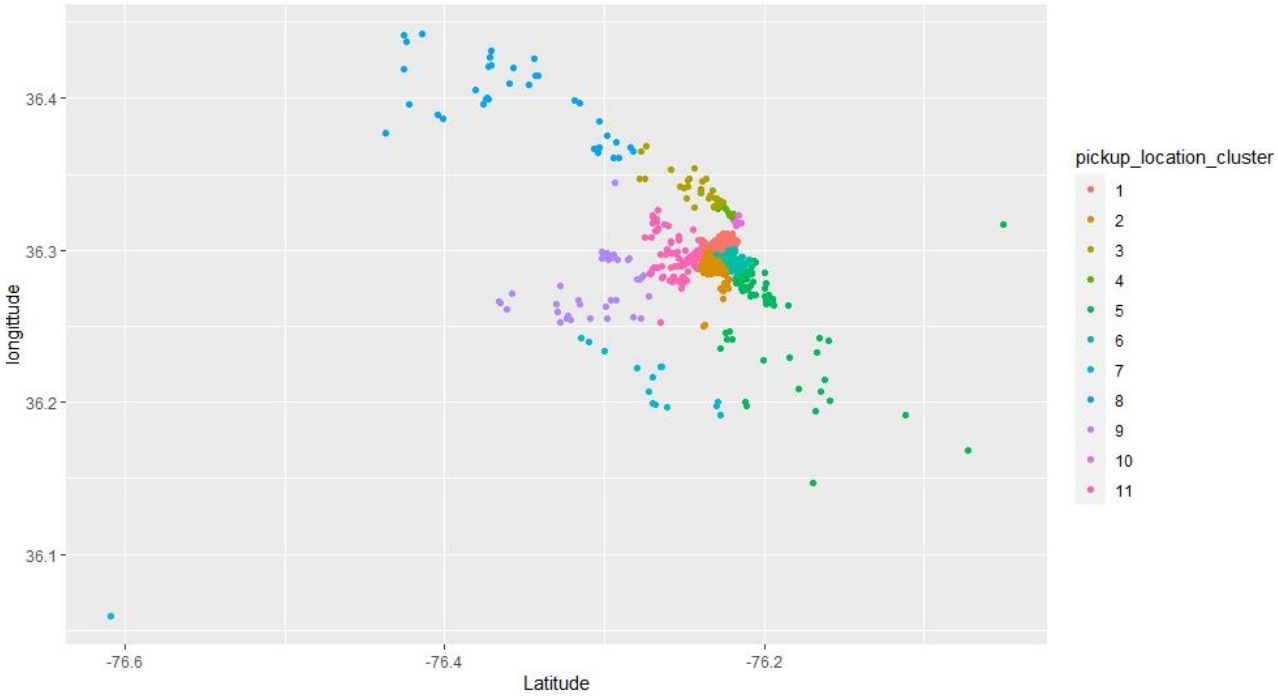


Figure 6. Elizabeth City Scatter plot of pick-up coordinates clusters

Figure 7 demonstrates the distribution of dwell time among different cluster locations.

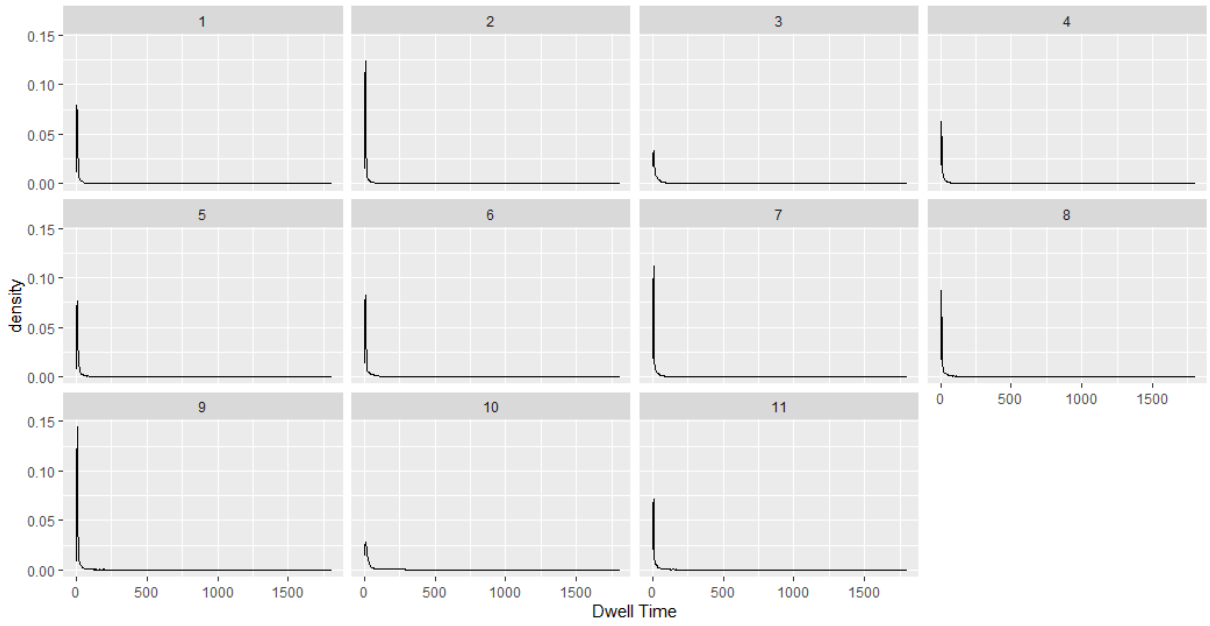


Figure 7. Dwell time density function by cluster

Figure 8 describes statistics of the different zones created in regard to dwell time (=loading time). Please note that cluster 2 has one of the highest trip frequencies but the mean loading time is one of the lowest. Therefore, we examine cluster 2 more closely to determine what factors are contributing to this finding.

	pickup_location_cluster	mean_loading_time	std_loading_time	sum_loading_time	mean_duration_trip	std_duration_trip	percent_of_loading_time	trip_frequency
1	1	37.41377	106.5185	289620	8.620204	10.84813	0.04396509	7741
2	2	40.73005	120.1615	498210	11.288996	15.81937	0.07562960	12232
3	3	52.09757	183.2156	372706	19.861336	20.25649	0.05657776	7154
4	4	52.40977	170.0326	448680	27.278472	24.92299	0.06811082	8561
5	5	84.81493	187.3159	1923857	23.953137	22.57993	0.29204660	22683
6	6	41.19827	123.2845	290489	11.092469	18.08103	0.04409700	7051
7	7	57.67617	150.0267	147651	32.356250	15.54050	0.02241381	2560
8	8	70.21779	170.3664	333043	28.228547	17.44152	0.05055681	4743
9	9	58.26680	169.6481	234116	22.049527	14.22569	0.03553943	4018
10	10	57.11480	173.7617	445267	23.153412	22.61850	0.06759271	7796
11	11	75.60033	213.8627	1603861	14.457129	15.39925	0.24347036	21215

Figure 8. Statistics of pick-up coordinates clusters

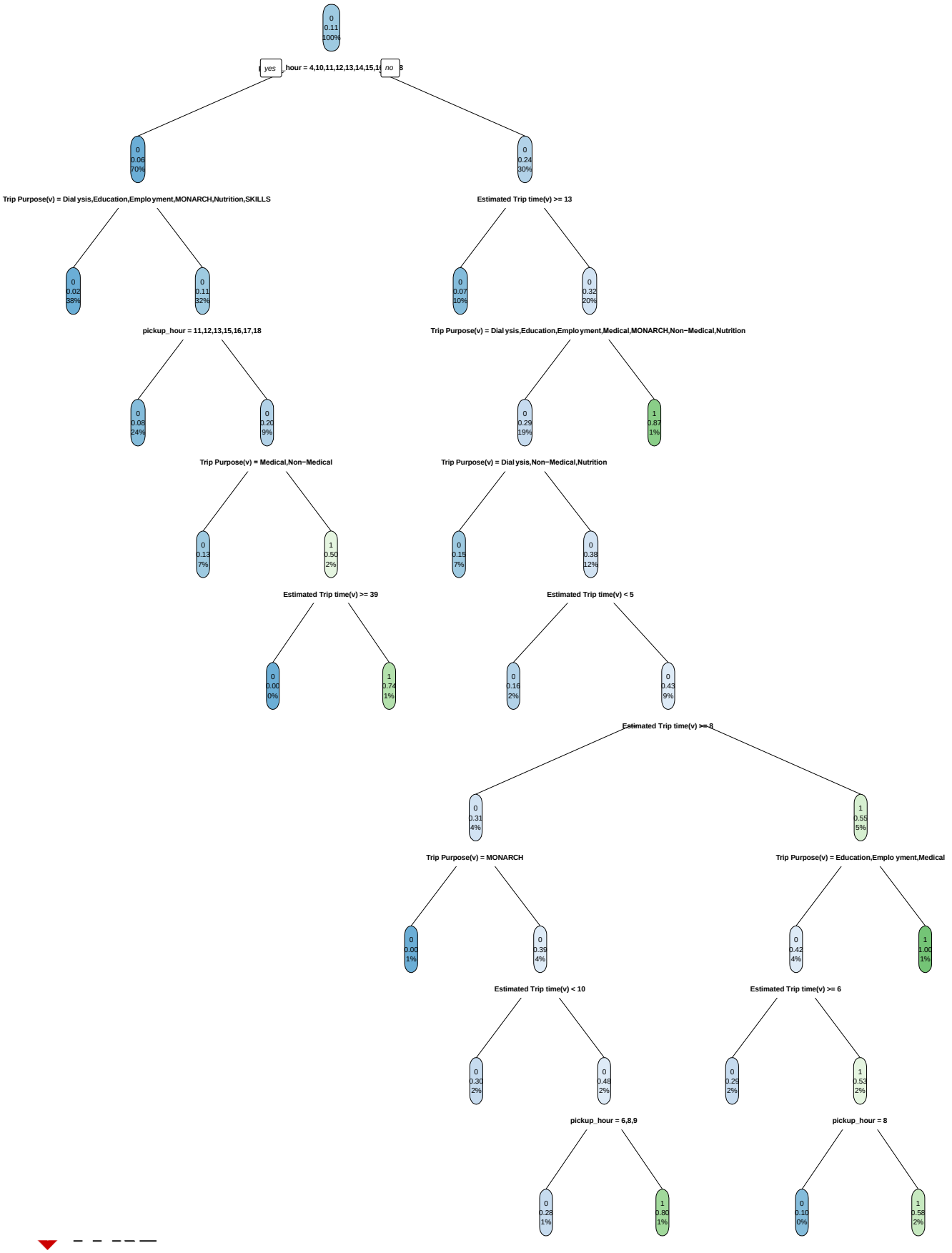
Before presenting the dwell-time estimation model, we further investigated what would be the primary distinguishing factors in cluster 2 areas and what statistical features with factor analysis is making other cluster areas higher dwell time. The decision tree shows how well the different combination of factors can determine the two location groups. Group 0: location cluster 1,3,4,5,6,7,8,9,10,11 and Group 1: location 2.

The following decision tree used three factors: Trip Purpose, Pick up hour, Estimated duration of trip. With 91% of accuracy, the decision tree decision tree split the data set into location cluster 2 and others. Note that this model is see interactions between factors not a dwell time estimation model.

Figure 9. Optimal data separation model for dwell-time estimation

After extensive exploratory studies, the team found that one of the main sources of the variability was on each passengers' trip frequency. After trial and error, any trip frequency below 26 generate a meaningful result, therefore we only included any passenger at least 26 requested and completed trips. The theoretical or other reasons why 26 was found could be further investigated in the future study.

On this filtered pick-up data, we further investigated the temporal distribution of mean dwell time, standard deviation, and ratio between standard deviation and mean. We could find clear pattern that off-peak hours shows significantly higher dwell time than peak hours, while the mean ratio were less than 7.3.


0
0.11
100%
yes
hour = 4,10,11,12,13,14,15,1
no
0
0.06
70%
0
0.24
30%
Trip Purpose(v) = Dial ysis,Education,Emplo yment,MONARCH,Nutrition,SKILLS
Estimated Trip time(v) >= 13
0
0.02
38%
0
0.11
32%
0
0.07
10%
0
0.32
20%
pickup_hour = 11,12,13,15,16,17,18
Trip Purpose(v) = Dial ysis,Education,Emplo yment,Medical,MONARCH,Non−Medical,Nutrition
0
0.08
24%
0
0.20
9%
0
0.29
19%
1
0.87
1%
Trip Purpose(v) = Medical,Non−Medical
Trip Purpose(v) = Dial ysis,Non−Medical,Nutrition
0
0.13
7%
1
0.50
2%
0
0.15
7%
0
0.38
12%
Estimated Trip time(v) >= 39
Estimated Trip time(v) < 5
0
0.00
0%
1
0.74
1%
0
0.16
2%
0
0.43
9%
Estimated Trip time(v) >= 8
0
0.31
4%
1
0.55
5%
Trip Purpose(v) = MONARCH
Trip Purpose(v) = Education,Emplo yment,Medical
0
0.00
1%
0
0.39
4%
0
0.42
4%
1
1.00
1%
Estimated Trip time(v) < 10
Estimated Trip time(v) >= 6
0
0.30
2%
0
0.48
2%
0
0.29
2%
1
0.53
2%
pickup_hour = 6,8,9
pickup_hour = 8
0
0.28
1%
1
0.80
1%
0
0.10
0%
1
0.58
2%

	pickup_hour	mean_dwell_time	sd_dwell_time	sd_to_mean_ratio
1	4	174.66667	426.65648	2.442690
2	5	114.52778	834.40702	7.285630
3	6	51.04348	145.42398	2.849022
4	7	48.89815	188.64544	3.857926
5	8	36.10823	79.55644	2.203278
6	9	47.29825	116.28029	2.458448
7	10	676.40625	1459.59300	2.157864
8	11	98.15254	432.03739	4.401693
9	12	491.86000	1684.33995	3.424430
10	13	510.33333	1492.40871	2.924380
11	14	179.89209	375.55147	2.087649
12	15	143.97765	388.08509	2.695454
13	16	66.91667	124.45770	1.859891
14	17	14.60000	17.15420	1.174945

Figure 10. Pick-up hour statistics across the different time of the day.

Dwell Time Estimation Model

To further increase the prediction accuracy of the model, we classified the dwell time to less than 250 seconds and above 250 seconds. Future studies could further extend the dwell time classification from binary to multiple. By using the current model, instead of the current practice where only maximum time window is set, we allocate put more efficient resources with less operating cost.

We quickly ran the random forest model which gives us the rank of variables (Figure #). After trial and error, we chose following factors for three dwell time estimation model: Vehicle, PUcluster, pickup_hour, TripPurpose, weekday, Covid, Via_software, and Mobility needs.

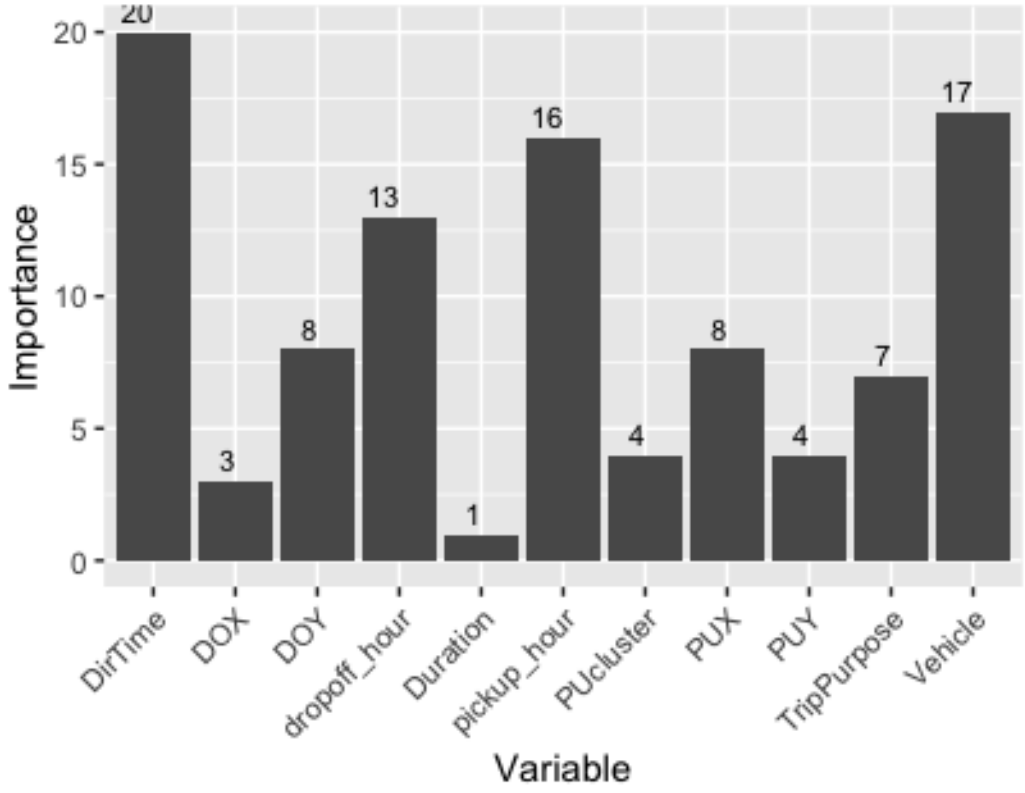


Figure 11. Importance of variable each number as percentage.

This dwell time estimation study only focused on the pick-up requests. The decision tree model performed better than random forest and logistic regression models. The details of the model variables used in this study are followings:

LOGISTICS REGRESSION MODEL

A logistics regression model was run with the splitting ratio (train was 70% and test was 30%) and features, and an accuracy of 89.45% was obtained.

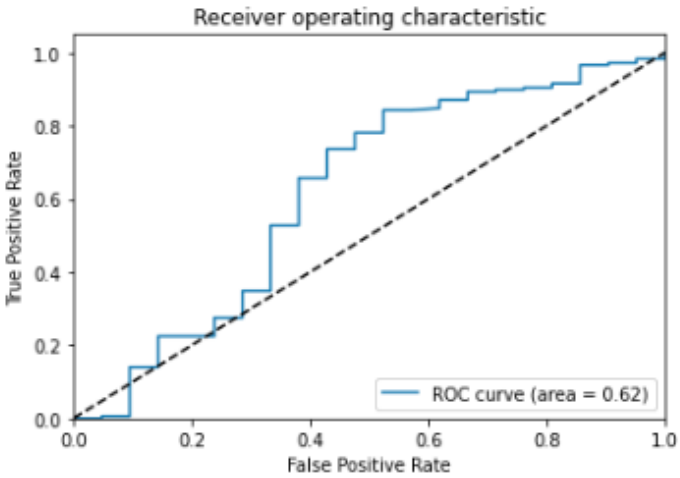


Figure 12. The receiver operating characteristic (ROC)

The receiver operating characteristic (ROC) curve that was created as a graphical representation of the performance of a binary classifier by varying its discrimination threshold. The area under the ROC curve (AUC) was calculated as a measure of the model's predictive performance. An AUC of 0.62 indicated that the model had moderate predictive power in distinguishing between the two classes. In other words, the model was able to correctly classify 62% of the cases, which was better than random guessing (50%), but still had room for improvement. The shape of the ROC curve could also provide insights into the model's sensitivity and specificity and could be used to select an optimal threshold for classification.

The coefficient table to be added here.

RANDOM FOREST MODEL

The random forest model produced Decision tree model produced an accuracy of 90.71% with the same training-testing ratio.

DECISION TREE MODEL

Decision tree model produced an accuracy of 92.11% presented below.

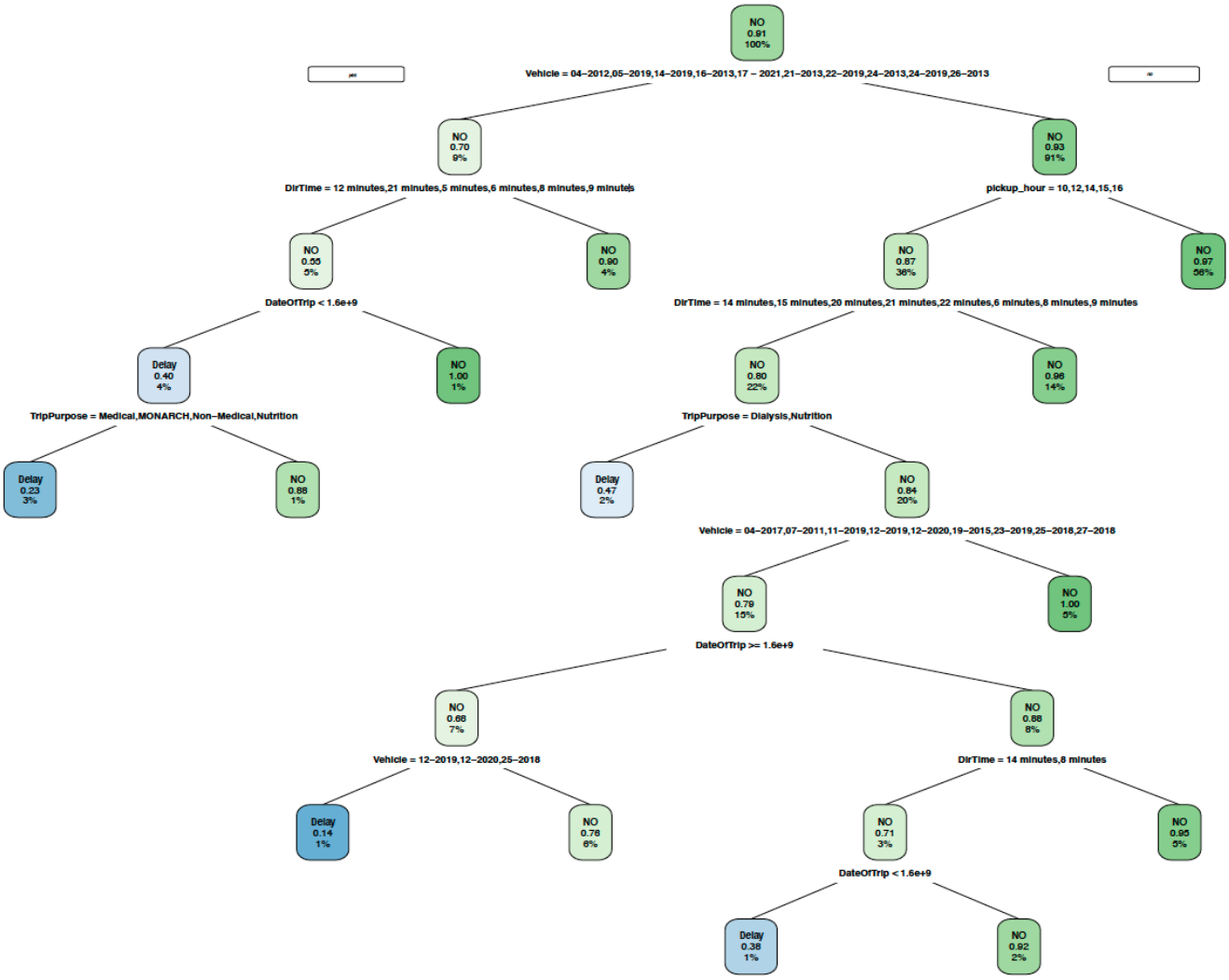


Figure 11. The decision tree model for dwell time estimation

On-time Performance Analysis

One-time Pick-up and Drop-off Window

Current practice in the paratransit industry is to view an on-time pickup as a vehicle arrival within an on-time window established by the transit agency (alternatively termed the pickup window or the “be ready time”). The pickup window serves to distinguish between an on-time pickup and a late or early one; it also defines the period during which the rider is expected to be ready and waiting for the vehicle to arrive. The pickup window should not be longer than 30 minutes (e.g., Federal Transit Agency (FTA)). The pickup occurring during the planned window can optimize the total cost of serving all the requests by each vehicle.

For many trips, an on-time drop-off is as important, or more important, than an on-time pickup. FTA has been clear that timely drop-offs are an essential part of on-time performance. Several other FTA ADA compliance reviews found problematic patterns of late arrivals. In a similar vein, early drop-offs at a destination should not be earlier than one-half hour. Transit agencies can establish a window for timely drop-offs (the “drop-off window”). Since early drop-offs should not be earlier than one-half hour, the window should not exceed “from 30 minutes before the appointment time, to the appointment time (-30/0).”

Exploratory Analysis of on-time Performance

To provide an accurate assessment of the on-time performance of the current operations of ICPTA, we identify two main classes of trips: (1) common destination trips and (2) common origin trips. In common destination trips, also referred to as pickups, customers are picked up from different locations (e.g., customer’s homes) to a common destination (e.g., medical facility). In this case, the time record in the RequestTime field for the ICPTA dataset shows the customers requested time (scheduled) to get to the destination or customer’s preferred arrival time at the common destination (e.g., medical facility). This field is used to estimate the on-time performance for common destination trips (pickups). For example, for a given request time, the difference between the RequestTime and DestArrive (arrival time at the common destination) fields estimates the on-time performance of the trip. In origin common trips, also referred to as drop-offs, customers are picked up from a common origin (e.g., medical facility) to different destinations (e.g., customers home). In this case, the time record in RequestTime field for the ICPTA data set shows the customer requested time () to be picked from the origin or the customer’s preferred pick-up time at the common origin (e.g., medical facility). This field is used to estimate the on-time performance for common origin trips (drop-offs). For example, for a given request time, the difference between the StartTime (departure time at the common origin) and RequestTime fields estimates the on-time performance of the trip. The actual class for the on-time performance (Late, Early, On-time) is defined according to the guidelines of the FTA.

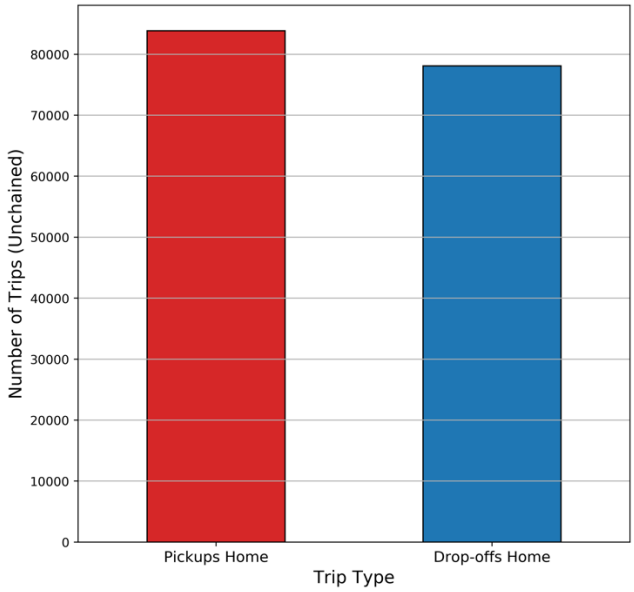


Figure 12. Number of Pickups and Drop-offs for ICPTA from 09/01/2018-09/30/2020

To begin, we first group the two main classes of trips. Figure # shows the unchained trip version of the total number of pickups and drop-offs. By unchained trips, we mean that each record in the dataset represents a single customer's trip. A complete analysis of the dynamics and operations of ICPTA is seen when the trips are represented in a chained manner. Particularly, by combining different customer trip records based on certain criteria (e.g., run, arrival time, etc.), a single chained trip will consist of multiple pick-up or drop-off locations. This will be further discussed when describing the simulation requirement for TransModeler. In general, we observe there are as many pickup trips (≈ 51%) as there is drop-off trips (≈ 48%) with pickups being slightly more. With this understanding, we now proceed to assess the on-time performance for the two types of trips.

Figure # shows the general distribution of on-time performance for pickups and drop-offs. Looking at Figure 2(a), we observe that majority of the trips representing approximately 49% of pickups fulfilled the scheduled requested time (considering the time window defined by FTA) for the common destinations (i.e., on-time trips). This means that customers arrived at their destinations within 30 minutes of their scheduled appointments (e.g., medical appointments). We also see that about 32% of the trips were too early, that is, customers arrived more than 30 minutes early for their scheduled appointments. This situation is undesirable and imposes very real difficulties on many customers. Finally, we estimate about 18% of the trips were late. This is the most undesirable case due to its implications, especially for medical appointments. A late trip may lead to a missed appointment with the doctor, which may negatively impact the customer's overall wellbeing. Contrary to the trend observed for pickups (common destination trips), we observe that majority of the drop-offs (common origin trips) representing approximately 54% (Figure 2(b)) were too early, that is the trips started earlier than the requested pick-up time. A negative implication of this is seen when a vehicle arrives well before the announced pickup window, and if passengers are not ready, they are given a no-show. We also see that about 36% of the trips fulfilled the scheduled

requested pick-up time (considering the time window defined by FTA). This means that for these trips, the vehicles arrived at the common origin 30 mins of their requested time to be picked up. Finally, we estimate about 10% of the trips were late. This implies that the vehicles arrived to pick up the customers after 30 mins of the requested pick-up time. Although this is also undesirable, its implication is arguably not as dire as common destination trips which are usually related to medical appointments.

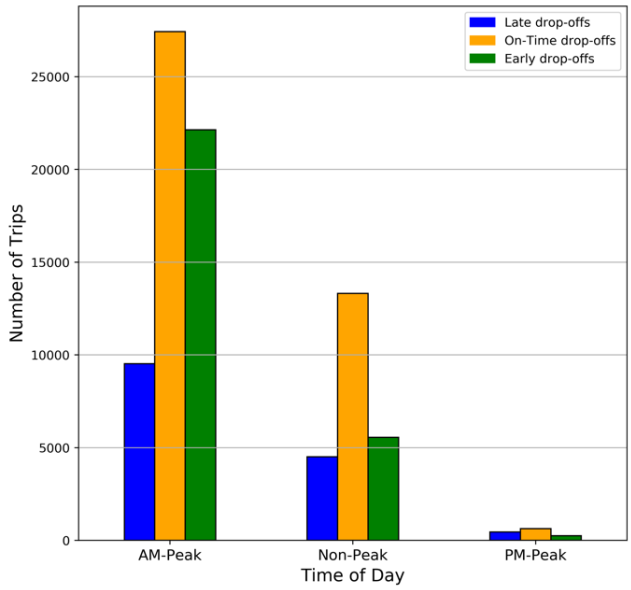


Figure 13. General distribution of origin and destination common trips for Elizabeth city ICPTA from 09/01/2018-09/30/2020. The distribution is classified under three major peak hours.

To further investigate the on-time performance distribution for pickups and drop-offs to understand what might be driving the on-time performance trends, we consider the time of day for a trip. We identify three main times of interest: AM-Peak Period – 6 am – 9 am, PM-Peak - 3 pm – 6 pm, Non-Peak – all other trip times outside this range. Figure 3 shows the general distribution of common origin and destination trips for ICPTA. Looking at Figure 3(a), we observe that a majority of the pickups (common destination) were scheduled for the morning peak periods. This is expected since most medical appointments are scheduled for the morning and afternoon. In contrast, we see that most of the drop-offs (common origin) have the lowest trip schedule in the morning but the number of trips peaks in the afternoon. This is because customers usually return from their appointments in the afternoon after their morning appointment trips (e.g., medical appointments). For pickups we observe that most of the majority of the trips were on-time, occurring mainly in the morning, followed by early drop-offs. On the other hand, most common origin trips are very early, occurring mainly in the afternoons, followed by on-time pickups.

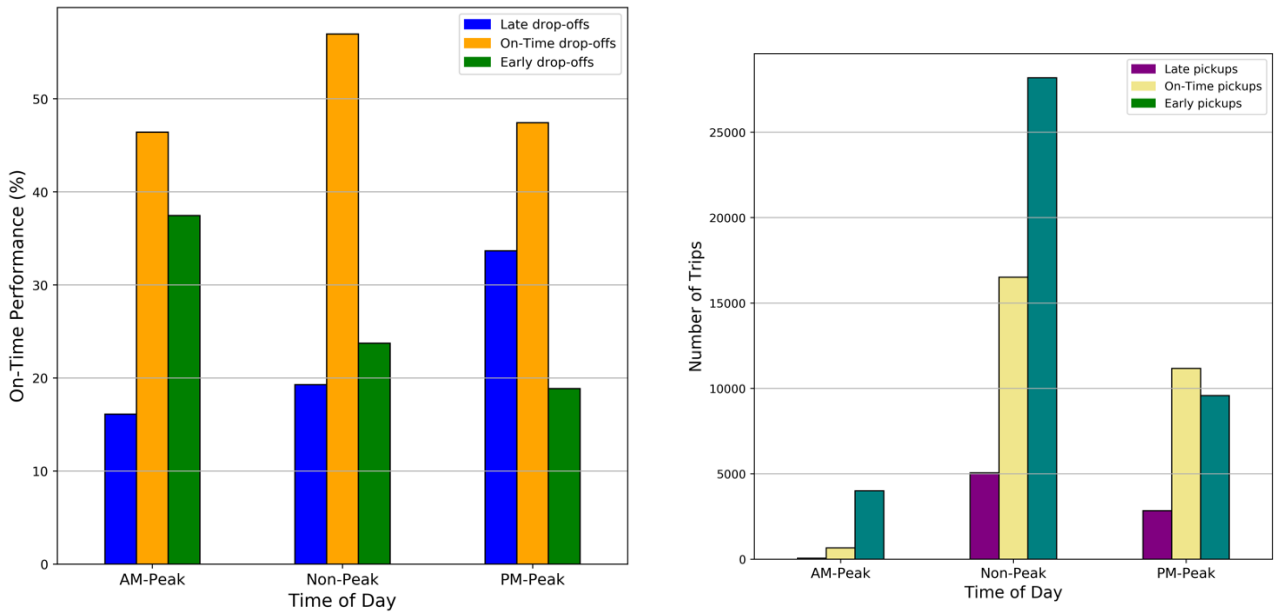


Figure 14. Percentage of on-time performance for trips occurring at different times of the day

Lastly, in Figure 14 we estimate the percentage of on-time performance for trips occurring at different times of the day. We observe that the percentage of late drop-offs considering the time of day gradually increases from approximately 16% to 33% as we go from morning to evening. In contrast, an opposite trend is seen for early drop-offs, gradually decreasing from approximately 6 37% to 18%. This is possibly due to the addition of an excessive extra time cushion during the morning peak periods in anticipation of roadway congestion. For the common origin trips, we observe that the percentage of late pick-ups considering the time of day gradually increases from approximately 2% to 12% as we go from morning to evening. The same increasing trend is also observed for on-time pick-ups. In contrast, we see that while the percentage of early pick-ups is very high (≈ 83%) in the morning, we observe a gradual decrease in the percentage of early pick-ups from morning (≈ 83%) to evening (≈ 40%).

TransModeler Integration

This project focused on updating year 2020 simulation to reflect the most recent road geometry and traffic changes by interpolating the 2008 and 2040 simulation data. The framework for evaluating simulation using Google API has also been developed. With great help of Caliper, the team developed a tool to add optimal microtransit operations into existing fixed-route and zone-based transit. Transportation engineers and operators can test new pick-up and drop-off strategies on the fly and visualize the differences in performance in various scenarios.

Model Integration Overview

There are two databases that were given to the team when we started the project: the signalized intersection geometry and operations and the Elizabeth City Road network inventory. The datasets include a previously created road network with signal timings. Both simulation datasets are running properly on the Transmodeler. When the simulation is running, it displays a pop-up window with warnings and messages of the data files being used along with trip data. On the road network, it shows cars driving in a randomized way according to the traffic signals included. The team spent significant time correcting the road network to align with the Google Map view. One of work we did was checking road connections in the simulation. This image below is an example of a typical error in the road network geometry.

Figure 15. Example of the faulty road connections found and corrected in the road network.

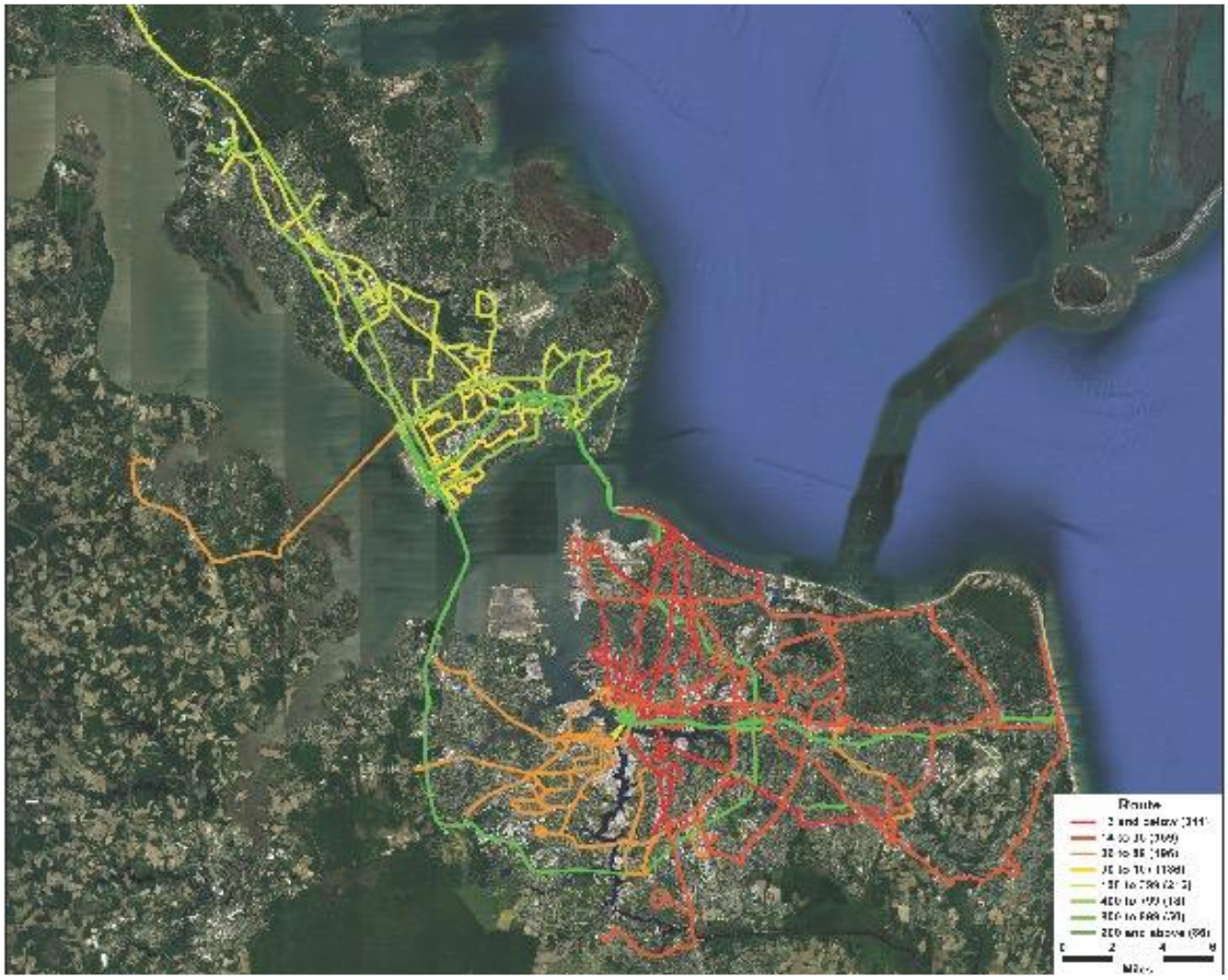


Figure 16. Hampton road transit network visualization in TransModeler overlaid on a satellite image.

TransModeler relies on the following four key elements for modeling transit systems:

- A route system that defines one or more routes and stops making up the entire transit system
- Transit vehicle types, including attributes of the vehicle that influence dwell times at stops
- A transit schedule containing the scheduled arrival times for one or more stops on each route and for one or more trips serving each route.
- Current geographic files for Hampton roads route system.

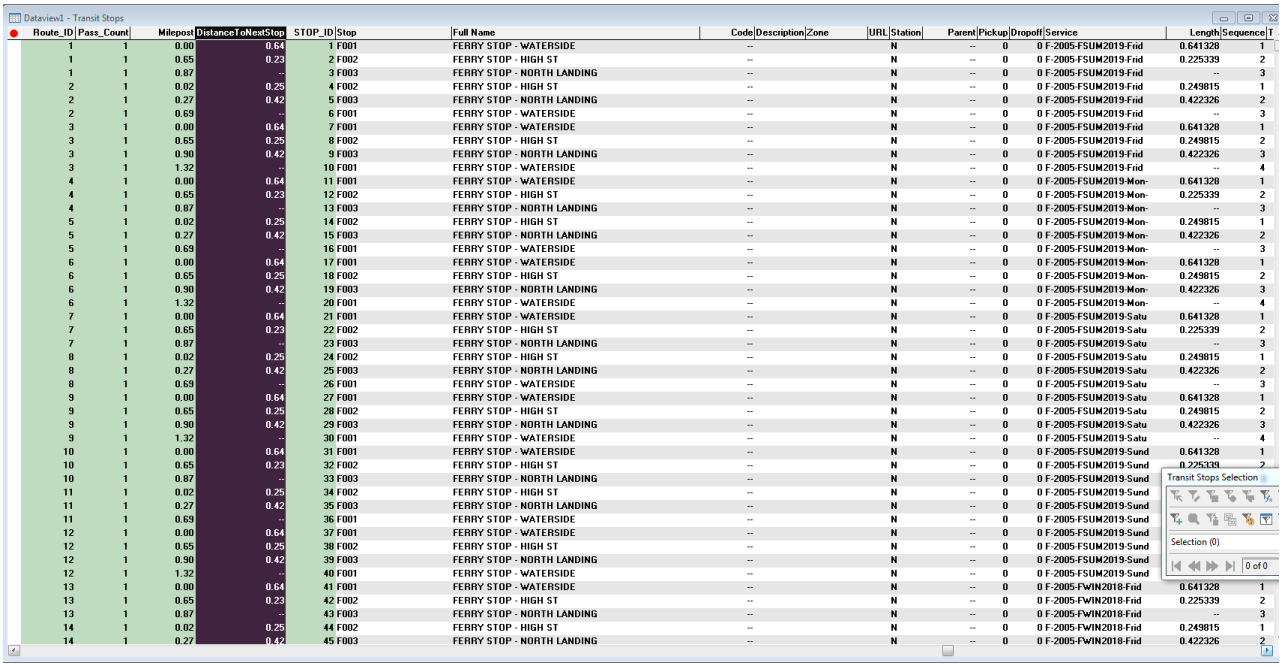
The following component can be integrated in the future.

- A simulation database that defines the transportation network on which the transit routes are based, including bus lanes and wayside stops

Dataview1 - Transit Routes

Trip	Sign	Service	Agency Name	Agency URL	Agency Phone	Length	Direction	M	Tu	W	Th	F	Sa	Su	ScheduleStartTime	ScheduleEndTime
8832651		F-2010-FWIN2020-Friday-01	Hampton Roads Transit (HRT)	http://www.gohrt.com/	(757) 222-6100		F	N	N	N	N	Y	N	N	5:30:00 AM	11:45:00 PM
8832653		F-2010-FWIN2020-Friday-01	Hampton Roads Transit (HRT)	http://www.gohrt.com/	(757) 222-6100		F	N	N	N	N	Y	N	N	5:30:00 AM	11:45:00 PM
8833035		F-2010-FWIN2020-Mon-Thu-01	Hampton Roads Transit (HRT)	http://www.gohrt.com/	(757) 222-6100		F	Y	Y	Y	Y	N	N	N	5:30:00 AM	11:45:00 PM
8833002		F-2010-FWIN2020-Mon-Thu-01	Hampton Roads Transit (HRT)	http://www.gohrt.com/	(757) 222-6100		F	Y	Y	Y	Y	N	N	N	5:30:00 AM	11:45:00 PM
8832824		F-2010-FWIN2020-Saturday-01	Hampton Roads Transit (HRT)	http://www.gohrt.com/	(757) 222-6100		F	N	N	N	N	Y	N	N	5:30:00 AM	11:45:00 PM
8832791		F-2010-FWIN2020-Saturday-01	Hampton Roads Transit (HRT)	http://www.gohrt.com/	(757) 222-6100		F	N	N	N	N	Y	N	N	5:30:00 AM	11:45:00 PM
8832793		F-2010-FWIN2020-Saturday-01	Hampton Roads Transit (HRT)	http://www.gohrt.com/	(757) 222-6100		F	N	N	N	N	Y	N	N	5:30:00 AM	11:45:00 PM
8832993		F-2010-FWIN2020-Sunday-01	Hampton Roads Transit (HRT)	http://www.gohrt.com/	(757) 222-6100		F	N	N	N	N	N	Y	N	5:30:00 AM	11:45:00 PM
8832964		F-2010-FWIN2020-Sunday-01	Hampton Roads Transit (HRT)	http://www.gohrt.com/	(757) 222-6100		F	N	N	N	N	N	Y	N	5:30:00 AM	11:45:00 PM
8832966		F-2010-FWIN2020-Sunday-01	Hampton Roads Transit (HRT)	http://www.gohrt.com/	(757) 222-6100		F	N	N	N	N	N	Y	N	5:30:00 AM	11:45:00 PM
8628754		N-2005-NSUM2005-Holiday1-01-11111111	Hampton Roads Transit (HRT)	http://www.gohrt.com/	(757) 222-6100		F	Y	Y	Y	Y	Y	Y	N	5:15:00 AM	11:45:00 PM
8628742		N-2005-NSUM2005-Holiday1-01-11111111	Hampton Roads Transit (HRT)	http://www.gohrt.com/	(757) 222-6100		R	Y	Y	Y	Y	Y	Y	N	5:15:00 AM	11:45:00 PM
8628653		N-2005-NSUM2005-Holiday1-01-11111111	Hampton Roads Transit (HRT)	http://www.gohrt.com/	(757) 222-6100		F	Y	Y	Y	Y	Y	Y	N	6:19:00 AM	7:52:00 PM
8628665		N-2005-NSUM2005-Holiday1-01-11111111	Hampton Roads Transit (HRT)	http://www.gohrt.com/	(757) 222-6100		R	Y	Y	Y	Y	Y	Y	N	6:19:00 AM	7:52:00 PM
8628765		N-2005-NSUM2005-Holiday1-01-11111111	Hampton Roads Transit (HRT)	http://www.gohrt.com/	(757) 222-6100		F	Y	Y	Y	Y	Y	Y	N	4:45:00 AM	11:15:00 PM
8628764		N-2005-NSUM2005-Holiday1-01-11111111	Hampton Roads Transit (HRT)	http://www.gohrt.com/	(757) 222-6100		R	Y	Y	Y	Y	Y	Y	N	4:45:00 AM	11:15:00 PM
8629048		N-2005-NSUM2005-Holiday1-01-11111111	Hampton Roads Transit (HRT)	http://www.gohrt.com/	(757) 222-6100		F	Y	Y	Y	Y	Y	Y	N	5:45:00 AM	10:15:00 PM
8629021		N-2005-NSUM2005-Holiday1-01-11111111	Hampton Roads Transit (HRT)	http://www.gohrt.com/	(757) 222-6100		F	Y	Y	Y	Y	Y	Y	N	5:45:00 AM	10:15:00 PM
8629017		N-2005-NSUM2005-Holiday1-01-11111111	Hampton Roads Transit (HRT)	http://www.gohrt.com/	(757) 222-6100		R	Y	Y	Y	Y	Y	Y	N	5:45:00 AM	10:15:00 PM
8628990		N-2005-NSUM2005-Holiday1-01-11111111	Hampton Roads Transit (HRT)	http://www.gohrt.com/	(757) 222-6100		R	Y	Y	Y	Y	Y	Y	N	5:45:00 AM	10:15:00 PM
8628527		N-2005-NSUM2005-Holiday1-01-11111111	Hampton Roads Transit (HRT)	http://www.gohrt.com/	(757) 222-6100		F	Y	Y	Y	Y	Y	Y	N	6:12:00 AM	11:15:00 PM
8628493		N-2005-NSUM2005-Holiday1-01-11111111	Hampton Roads Transit (HRT)	http://www.gohrt.com/	(757) 222-6100		F	Y	Y	Y	Y	Y	Y	N	6:12:00 AM	11:15:00 PM
8628510		N-2005-NSUM2005-Holiday1-01-11111111	Hampton Roads Transit (HRT)	http://www.gohrt.com/	(757) 222-6100		R	Y	Y	Y	Y	Y	Y	N	6:12:00 AM	11:15:00 PM
8628958		N-2005-NSUM2005-Holiday1-01-11111111	Hampton Roads Transit (HRT)	http://www.gohrt.com/	(757) 222-6100		F	Y	Y	Y	Y	Y	Y	N	5:09:00 AM	11:52:00 PM
8628921		N-2005-NSUM2005-Holiday1-01-11111111	Hampton Roads Transit (HRT)	http://www.gohrt.com/	(757) 222-6100		R	Y	Y	Y	Y	Y	Y	N	5:09:00 AM	11:52:00 PM
8628975		N-2005-NSUM2005-Holiday1-01-11111111	Hampton Roads Transit (HRT)	http://www.gohrt.com/	(757) 222-6100		F	Y	Y	Y	Y	Y	Y	N	5:59:00 AM	11:22:00 PM
8628922		N-2005-NSUM2005-Holiday1-01-11111111	Hampton Roads Transit (HRT)	http://www.gohrt.com/	(757) 222-6100		R	Y	Y	Y	Y	Y	Y	N	5:59:00 AM	11:22:00 PM
8629162		N-2005-NSUM2005-Holiday1-01-11111111	Hampton Roads Transit (HRT)	http://www.gohrt.com/	(757) 222-6100		F	Y	Y	Y	Y	Y	Y	N	5:55:00 AM	11:03:00 PM
8629158		N-2005-NSUM2005-Holiday1-01-11111111	Hampton Roads Transit (HRT)	http://www.gohrt.com/	(757) 222-6100		R	Y	Y	Y	Y	Y	Y	N	5:55:00 AM	11:03:00 PM
8628623		N-2005-NSUM2005-Holiday1-01-11111111	Hampton Roads Transit (HRT)	http://www.gohrt.com/	(757) 222-6100		F	Y	Y	Y	Y	Y	Y	N	6:47:00 AM	9:47:00 PM
8628610		N-2005-NSUM2005-Holiday1-01-11111111	Hampton Roads Transit (HRT)	http://www.gohrt.com/	(757) 222-6100		R	Y	Y	Y	Y	Y	Y	N	6:47:00 AM	9:47:00 PM
8628528		N-2005-NSUM2005-Holiday1-01-11111111	Hampton Roads Transit (HRT)	http://www.gohrt.com/	(757) 222-6100		F	Y	Y	Y	Y	Y	Y	N	6:00:00 AM	10:00:00 PM
8628543		N-2005-NSUM2005-Holiday1-01-11111111	Hampton Roads Transit (HRT)	http://www.gohrt.com/	(757) 222-6100		R	Y	Y	Y	Y	Y	Y	N	6:00:00 AM	10:00:00 PM
8629129		N-2005-NSUM2005-Holiday1-01-11111111	Hampton Roads Transit (HRT)	http://www.gohrt.com/	(757) 222-6100		F	Y	Y	Y	Y	Y	Y	N	6:54:00 AM	10:00:00 PM
8629127		N-2005-NSUM2005-Holiday1-01-11111111	Hampton Roads Transit (HRT)	http://www.gohrt.com/	(757) 222-6100		R	Y	Y	Y	Y	Y	Y	N	6:54:00 AM	10:00:00 PM
8629095		N-2005-NSUM2005-Holiday1-01-11111111	Hampton Roads Transit (HRT)	http://www.gohrt.com/	(757) 222-6100		F	Y	Y	Y	Y	Y	Y	N	4:55:00 AM	11:45:00 PM
8629061		N-2005-NSUM2005-Holiday1-01-11111111	Hampton Roads Transit (HRT)	http://www.gohrt.com/	(757) 222-6100		R	Y	Y	Y	Y	Y	Y	N	4:55:00 AM	11:45:00 PM
8628559		N-2005-NSUM2005-Holiday1-01-11111111	Hampton Roads Transit (HRT)	http://www.gohrt.com/	(757) 222-6100		F	Y	Y	Y	Y	Y	Y	N	6:20:00 AM	10:50:00 PM
8628586		N-2005-NSUM2005-Holiday1-01-11111111	Hampton Roads Transit (HRT)	http://www.gohrt.com/	(757) 222-6100		R	Y	Y	Y	Y	Y	Y	N	6:20:00 AM	10:50:00 PM
8629209		N-2005-NSUM2005-Holiday1-01-11111111	Hampton Roads Transit (HRT)	http://www.gohrt.com/	(757) 222-6100		F	Y	Y	Y	Y	Y	Y	N	5:45:00 AM	11:41:00 PM
8629193		N-2005-NSUM2005-Holiday1-01-11111111	Hampton Roads Transit (HRT)	http://www.gohrt.com/	(757) 222-6100		R	Y	Y	Y	Y	Y	Y	N	5:45:00 AM	11:41:00 PM
8629256		N-2005-NSUM2005-Holiday1-01-11111111	Hampton Roads Transit (HRT)	http://www.gohrt.com/	(757) 222-6100		F	Y	Y	Y	Y	Y	Y	N	5:45:00 AM	11:03:00 PM
8629128		N-2005-NSUM2005-Holiday1-01-11111111	Hampton Roads Transit (HRT)	http://www.gohrt.com/	(757) 222-6100		R	Y	Y	Y	Y	Y	Y	N	5:45:00 AM	11:03:00 PM
8629251		N-2005-NSUM2005-Holiday1-01-11111111	Hampton Roads Transit (HRT)	http://www.gohrt.com/	(757) 222-6100		R	Y	Y	Y	Y	Y	Y	N	5:45:00 AM	11:03:00 PM
8628699		N-2005-NSUM2005-Holiday1-01-11111111	Hampton Roads Transit (HRT)	http://www.gohrt.com/	(757) 222-6100		F	Y	Y	Y	Y	Y	Y	N	6:15:00 AM	7:30:00 PM
8628687		N-2005-NSUM2005-Holiday1-01-11111111	Hampton Roads Transit (HRT)	http://www.gohrt.com/	(757) 222-6100		R	Y	Y	Y	Y	Y	Y	N	6:15:00 AM	7:30:00 PM
8628711		N-2005-NSUM2005-Holiday1-01-11111111	Hampton Roads Transit (HRT)	http://www.gohrt.com/	(757) 222-6100		F	Y	Y	Y	Y	Y	Y	N	6:15:00 AM	9:15:00 PM
8628726		N-2005-NSUM2005-Holiday1-01-11111111	Hampton Roads Transit (HRT)	http://www.gohrt.com/	(757) 222-6100		R	Y	Y	Y	Y	Y	Y	N	6:15:00 AM	9:15:00 PM
8628650		N-2005-NSUM2005-Holiday1-01-11111111	Hampton Roads Transit (HRT)	http://www.gohrt.com/	(757) 222-6100		F	Y	Y	Y	Y	Y	Y	N	7:10:00 AM	8:31:00 PM
8628637		N-2005-NSUM2005-Holiday1-01-11111111	Hampton Roads Transit (HRT)	http://www.gohrt.com/	(757) 222-6100		R	Y	Y	Y	Y	Y	Y	N	7:10:00 AM	8:31:00 PM
8628888		N-2005-NSUM2005-Holiday1-01-11111111	Hampton Roads Transit (HRT)	http://www.gohrt.com/	(757) 222-6100		F	Y	Y	Y	Y	Y	Y	N	4:45:00 AM	10:15:00 PM
8628873		N-2005-NSUM2005-Holiday1-01-11111111	Hampton Roads Transit (HRT)	http://www.gohrt.com/	(757) 222-6100		R	Y	Y	Y	Y	Y	Y	N	4:45:00 AM	10:15:00 PM
8508163		N-2005-NSUM2005-Saturday-01	Hampton Roads Transit (HRT)	http://www.gohrt.com/	(757) 222-6100		F	N	N	N	N	N	Y	N	5:15:00 AM	11:45:00 PM
8508151		N-2005-NSUM2005-Saturday-01	Hampton Roads Transit (HRT)	http://www.gohrt.com/	(757) 222-6100		R	N	N	N	N	N	Y	N	5:15:00 AM	11:45:00 PM
8508062		N-2005-NSUM2005-Saturday-01	Hampton Roads Transit (HRT)	http://www.gohrt.com/	(757) 222-6100		F	N	N	N	N	N	Y	N	6:19:00 AM	7:52:00 PM

Figure 17. Dataview for transit routes in Hampton Roads Transit



Dataview1 - Transit Stops

Route_ID	Pass_Count	Milepost	DistanceToNextStop	STOP_ID	Stop	Full Name	Code	Description	Zone	URL	Station	Parent	Pickup	Dropoff	Service	Length	Sequence	T
1	1	0.00	0.64	1	F001	FERRY STOP - WATERSIDE	--			N		--	0	0	F-2005-FSUM2019-Frid	0.641328	1	
1	1	0.65	0.23	2	F002	FERRY STOP - HIGH ST	--			N		--	0	0	F-2005-FSUM2019-Frid	0.225339	2	
1	1	0.87	--	3	F003	FERRY STOP - NORTH LANDING	--			N		--	0	0	F-2005-FSUM2019-Frid	--	3	
2	1	0.02	0.25	4	F002	FERRY STOP - HIGH ST	--			N		--	0	0	F-2005-FSUM2019-Frid	0.249815	1	
2	1	0.27	0.42	5	F003	FERRY STOP - NORTH LANDING	--			N		--	0	0	F-2005-FSUM2019-Frid	0.422326	2	
2	1	0.69	--	6	F001	FERRY STOP - WATERSIDE	--			N		--	0	0	F-2005-FSUM2019-Frid	--	3	
3	1	0.00	0.64	7	F001	FERRY STOP - WATERSIDE	--			N		--	0	0	F-2005-FSUM2019-Frid	0.641328	1	
3	1	0.65	0.25	8	F002	FERRY STOP - HIGH ST	--			N		--	0	0	F-2005-FSUM2019-Frid	0.249815	2	
3	1	0.90	0.42	9	F003	FERRY STOP - NORTH LANDING	--			N		--	0	0	F-2005-FSUM2019-Frid	0.422326	3	
3	1	1.32	--	10	F001	FERRY STOP - WATERSIDE	--			N		--	0	0	F-2005-FSUM2019-Frid	--	4	
4	1	0.00	0.64	11	F001	FERRY STOP - WATERSIDE	--			N		--	0	0	F-2005-FSUM2019-Mon-	0.641328	1	
4	1	0.65	0.23	12	F002	FERRY STOP - HIGH ST	--			N		--	0	0	F-2005-FSUM2019-Mon-	0.225339	2	
4	1	0.87	--	13	F003	FERRY STOP - NORTH LANDING	--			N		--	0	0	F-2005-FSUM2019-Mon-	--	3	
5	1	0.02	0.25	14	F002	FERRY STOP - HIGH ST	--			N		--	0	0	F-2005-FSUM2019-Mon-	0.249815	1	
5	1	0.27	0.42	15	F003	FERRY STOP - NORTH LANDING	--			N		--	0	0	F-2005-FSUM2019-Mon-	0.422326	2	
5	1	0.69	--	16	F001	FERRY STOP - WATERSIDE	--			N		--	0	0	F-2005-FSUM2019-Mon-	--	3	
6	1	0.00	0.64	17	F001	FERRY STOP - WATERSIDE	--			N		--	0	0	F-2005-FSUM2019-Mon-	0.641328	1	
6	1	0.65	0.25	18	F002	FERRY STOP - HIGH ST	--			N		--	0	0	F-2005-FSUM2019-Mon-	0.249815	2	
6	1	0.90	0.42	19	F003	FERRY STOP - NORTH LANDING	--			N		--	0	0	F-2005-FSUM2019-Mon-	0.422326	3	
6	1	1.32	--	20	F001	FERRY STOP - WATERSIDE	--			N		--	0	0	F-2005-FSUM2019-Mon-	--	4	
7	1	0.00	0.64	21	F001	FERRY STOP - WATERSIDE	--			N		--	0	0	F-2005-FSUM2019-Satu	0.641328	1	
7	1	0.65	0.23	22	F002	FERRY STOP - HIGH ST	--			N		--	0	0	F-2005-FSUM2019-Satu	0.225339	2	
7	1	0.87	--	23	F003	FERRY STOP - NORTH LANDING	--			N		--	0	0	F-2005-FSUM2019-Satu	--	3	
8	1	0.02	0.25	24	F002	FERRY STOP - HIGH ST	--			N		--	0	0	F-2005-FSUM2019-Satu	0.249815	1	
8	1	0.27	0.42	25	F003	FERRY STOP - NORTH LANDING	--			N		--	0	0	F-2005-FSUM2019-Satu	0.422326	2	
8	1	0.69	--	26	F001	FERRY STOP - WATERSIDE	--			N		--	0	0	F-2005-FSUM2019-Satu	--	3	
9	1	0.00	0.64	27	F001	FERRY STOP - WATERSIDE	--			N		--	0	0	F-2005-FSUM2019-Satu	0.641328	1	
9	1	0.65	0.25	28	F002	FERRY STOP - HIGH ST	--			N		--	0	0	F-2005-FSUM2019-Satu	0.249815	2	
9	1	0.90	0.42	29	F003	FERRY STOP - NORTH LANDING	--			N		--	0	0	F-2005-FSUM2019-Satu	0.422326	3	
9	1	1.32	--	30	F001	FERRY STOP - WATERSIDE	--			N		--	0	0	F-2005-FSUM2019-Satu	--	4	
10	1	0.00	0.64	31	F001	FERRY STOP - WATERSIDE	--			N		--	0	0	F-2005-FSUM2019-Sund	0.641328	1	
10	1	0.65	0.23	32	F002	FERRY STOP - HIGH ST	--			N		--	0	0	F-2005-FSUM2019-Sund	0.225339	2	
10	1	0.87	--	33	F003	FERRY STOP - NORTH LANDING	--			N		--	0	0	F-2005-FSUM2019-Sund	--	3	
11	1	0.02	0.25	34	F002	FERRY STOP - HIGH ST	--			N		--	0	0	F-2005-FSUM2019-Sund	0.249815	1	
11	1	0.27	0.42	35	F003	FERRY STOP - NORTH LANDING	--			N		--	0	0	F-2005-FSUM2019-Sund	0.422326	2	
11	1	0.69	--	36	F001	FERRY STOP - WATERSIDE	--			N		--	0	0	F-2005-FSUM2019-Sund	--	3	
12	1	0.00	0.64	37	F001	FERRY STOP - WATERSIDE	--			N		--	0	0	F-2005-FSUM2019-Sund	0.641328	1	
12	1	0.65	0.25	38	F002	FERRY STOP - HIGH ST	--			N		--	0	0	F-2005-FSUM2019-Sund	0.249815	2	
12	1	0.90	0.42	39	F003	FERRY STOP - NORTH LANDING	--			N		--	0	0	F-2005-FSUM2019-Sund	0.422326	3	
12	1	1.32	--	40	F001	FERRY STOP - WATERSIDE	--			N		--	0	0	F-2005-FSUM2019-Sund	--	4	
13	1	0.00	0.64	41	F001	FERRY STOP - WATERSIDE	--			N		--	0	0	F-2005-FWIN2018-Frid	0.641328	1	
13	1	0.65	0.23	42	F002	FERRY STOP - HIGH ST	--			N		--	0	0	F-2005-FWIN2018-Frid	0.225339	2	
13	1	0.87	--	43	F003	FERRY STOP - NORTH LANDING	--			N		--	0	0	F-2005-FWIN2018-Frid	--	3	
14	1	0.02	0.25	44	F002	FERRY STOP - HIGH ST	--			N		--	0	0	F-2005-FWIN2018-Frid	0.249815	1	
14	1	0.27	0.42	45	F003	FERRY STOP - NORTH LANDING	--			N		--	0	0	F-2005-FWIN2018-Frid	0.422326	2	

Transit Stops Selection

Selection (0)

0 of 0

Figure 18. Dataview for transit stops in Hampton Roads Transit

Simulation Model Integration

We have converted the origin and destination longitude/latitude coordinates into the centroid format with new TransModeler script that imported trip data file and located the longitude and latitude points that will be used into the software. We condensed the number of nodes being used to only cover the section surrounding the road network.

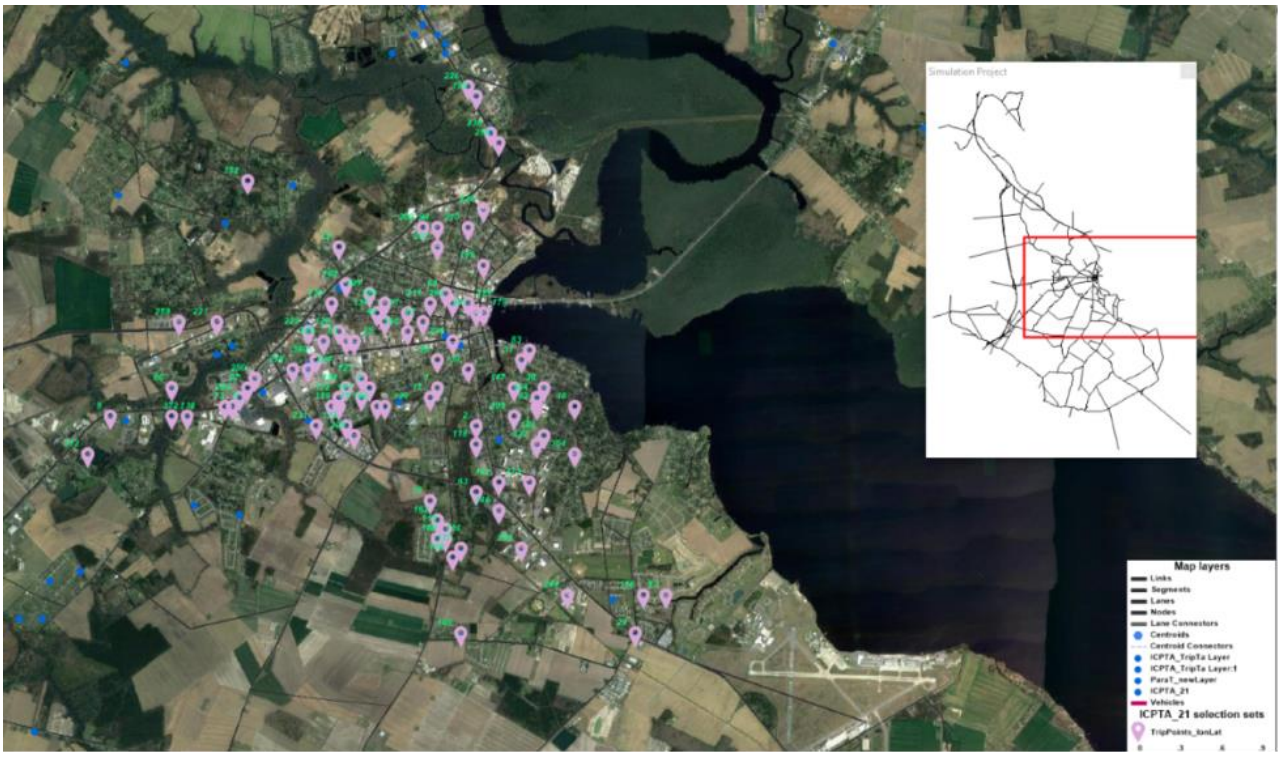


Figure 19. the selection of nodes by the in the area by the pink pin icon and its centroid number

We used unique IDs to integrate ICPTA trips with existing general trip. We did this by creating a new data table with all unique centroids and considering how they will be used for each origin and destination in each Trip ID from the original Trip Table data. Each of the centroids that are going to be used in the simulation was connected to the closet part of the road network. Originally, if the data points were close enough to the road network, the Transmodeler would automatically create centroid connectors. We have manually added centroid connectors to the centroids that were selected.

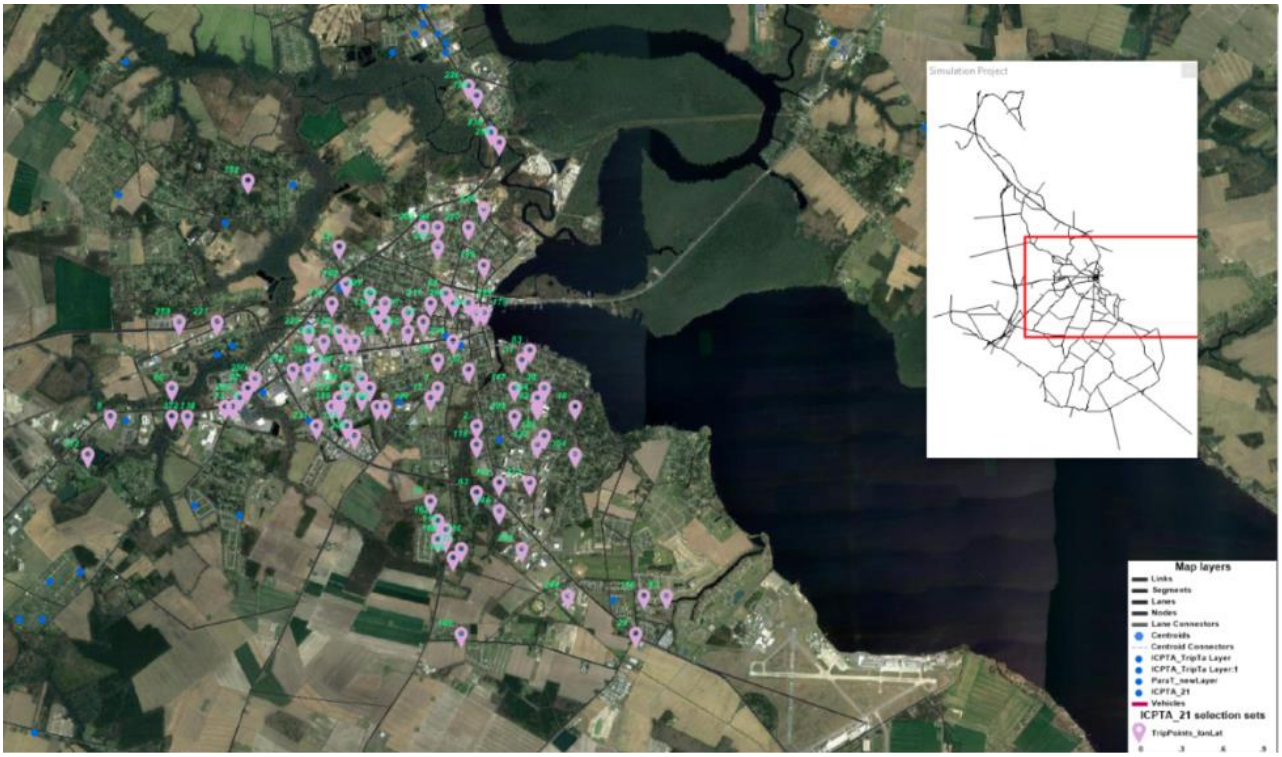


Figure 20. the centroid connectors are connected to the road network using the blue dotted lines

Based on Transmodelers output statistics, the Google API travel time can be compared for validation purpose.