2023 Public Transportation Unmet Needs Study

WSDOT PUBLIC TRANSPORTATION DIVISION

CONTENTS

EXECUTIVE SUMMARY

PURPOSE

WSDOT's Public Transportation Division began the Public Transportation Unmet Needs Study in 2021 to answer two questions:

- What is the unmet need for public transportation in the state?
- How much would it cost to provide access to public transportation for those whose needs are unmet?

> Unmet needs are the estimated number of trips that people across the state would have made but did not, because of a lack of access to either a personal vehicle or to public or private transportation services they could afford. Examples of unmet trips include trips for medical appointments, grocery shopping, and other essential services; work shifts; family or community events; social gatherings; recreation; and opportunities to contribute to civic life and public projects.

The study also provides vital information to decisionmakers when making policy or funding decisions about the scope of unmet public transportation needs. Prior to this study, WSDOT did not have a model or method to quantify unmet trips, representing a gap in our knowledge and research. The economic model developed through this study will allow WSDOT to better estimate statewide needs and their associated costs in order to inform WSDOT's public transportation grants and plans.

KEY FINDINGS

Quantitative findings

- **Common characteristics of mobility-challenged households:** Households which are more likely to be mobility-challenged and have more unmet public transportation needs than the average Washington household have the following characteristics: limited income, members living with physical impairments, more workers than personal vehicles, or members over 70 years old.
- **Number of mobility-challenged households:** There are more than 270,000 mobility-challenged households in areas of Washington state with limited public transportation (i.e., fewer than 10 transit stops per square mile).
- **Number of forgone trips:** Annually, mobility-challenged households collectively forego nearly 29 million trips they would have made if they had better access to transportation.
- **Annual cost of unmet needs:** The annual cost to meet the unmet public transportation needs of Washington residents is more than $890 million, or roughly $3,300 per household with unmet public transportation needs.

Qualitative findings

- Elements of unmet public transportation needs—including a lack of frequency and reliability, limited service areas, and cost—are related to a lack of funding, staffing, or resources.
- Incomplete non-motorized travel networks and inadequate shelters make it difficult for public transportation riders to comfortably and safely access public transportation.
- People who are underserved by current public transportation services include those who work outside of traditional workday schedules, need on-demand services, need to travel between jurisdictions, have lower incomes, and live in rural areas.
- Not having access to reliable transportation reduces riders' independence, autonomy, and quality of life.
- Successfully meeting unmet public transportation needs across the state needs will require a flexible approach that takes local factors into consideration.

NEXT STEPS

WSDOT began the Unmet Public Transportation Needs Study in late 2021. In its 2022 session, the Legislature directed WSDOT to conduct the Frequent Transit Service Study (ESSB 5689 – 2022 Sect. 221 (15)) and develop initial and final reports about statewide transit service benchmarks. WSDOT published the initial report in December 2022 and will publish the final report in July 2023.

WSDOT will analyze the Public Transportation Unmet Needs Study alongside the Frequent Transit Service Study and other studies for a fuller picture of transportation access in Washington state. This will inform the upcoming Statewide Public Transportation Plan; Statewide Human Services Transportation Plan; and other reports, plans, and studies related to public transportation.

INTRODUCTION

PURPOSE

WSDOT's Public Transportation Division began the Public Transportation Unmet Needs Study in 2021 to answer two questions:

- What is the unmet need for public transportation in the state?
- How much would it cost to provide access to public transportation for those whose needs are unmet?

The study also provides vital information to decisionmakers when making policy or funding decisions about the scope of unmet public transportation needs. Prior to this study, WSDOT did not have a model or method to quantify unmet trips, representing a gap in our knowledge and research. The economic model developed through this study will allow WSDOT to better estimate statewide needs and their associated costs in order to inform WSDOT's public transportation grants and plans.

BACKGROUND

In its 2016 Washington State Public Transportation Plan, WSDOT described public transportation as "a broad array of transportation services and systems, public and private, that are accessible and available to the public, which do not involve a single person in a motorized vehicle." The plan also lays out the following vision for public transportation in Washington state:

> *"Transportation partners in Washington work together to provide a system of diverse, integrated public transportation options. People throughout the state use these options to make transportation choices that enable their families, communities, economy, and environment to thrive."*

Unmet needs are the aggregate number of trips that people across the state would have made but did not, because of a lack of access to either a personal vehicle or to public or private transportation services they could afford.

Unmet public transportation needs result from a variety of factors that limit or prevent riders from making trips they need to thrive. Sometimes, transportation services do not exist when and where riders need them. In other cases, physical, policy, or administrative barriers make services harder for riders to use. Barriers to accessing transportation services may lead to additional problems, including disparate health outcomes, lower wages and earning potential, and poorer quality of life.

QUANTITATIVE FINDINGS AND APPROACH

KEY FINDINGS

- **Common characteristics of mobility-challenged households:** Households with limited income, members living with physical impairments, more workers than personal vehicles, or members over 70 years old are more likely to be mobility-challenged than the average Washington household and more likely to have unmet public transportation needs.
- **Number of mobility-challenged households:** There are more than 270,000 mobility-challenged households in areas of Washington state with limited public transportation (i.e., fewer than 10 transit stops per square mile).
- **Number of forgone trips:** Annually, mobility-challenged households collectively forego nearly 29 million trips they would have made if they had better access to transportation.
- **Annual cost of unmet needs:** The annual cost to meet the unmet public transportation needs of Washington residents is more than $890 million, or roughly $3,300 per household with unmet public transportation needs.

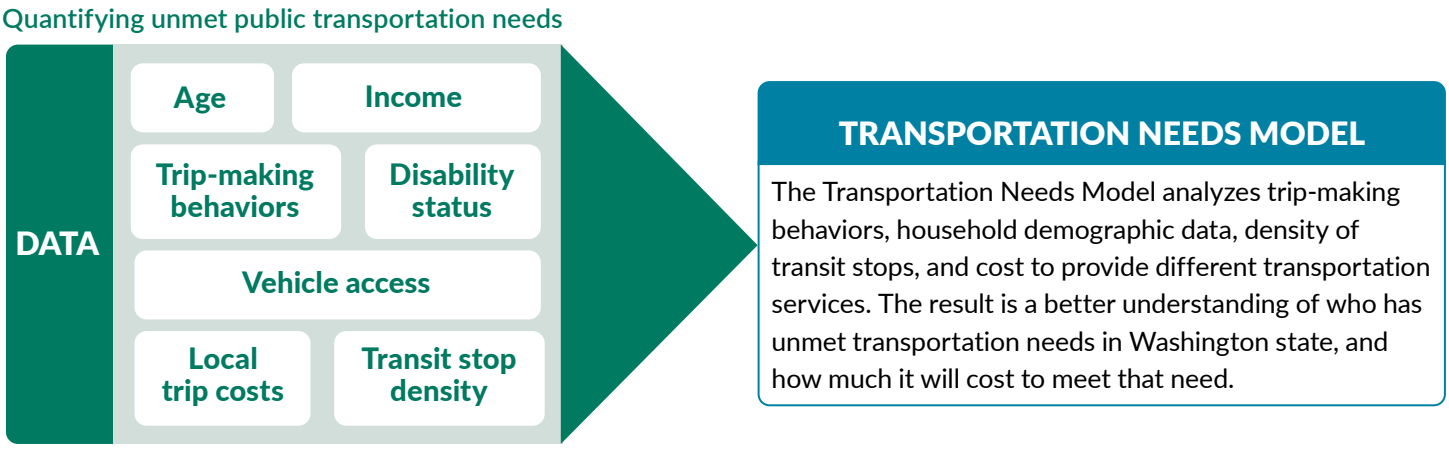
DEVELOPING THE TRANSPORTATION NEEDS MODEL

WSDOT developed the Transportation Needs Model for estimating unmet transportation needs. The model adapts an approach called Stochastic Frontier Analysis, which is often used in industrial performance analysis.

Stochastic Frontier Analysis assumes, within a given industry, that each firm produces outputs by combining a mix of inputs, such as capital and labor. To achieve a given level of performance, a firm must use a specific combination of inputs. When analyzing different firms within an industry, researchers can estimate an "efficiency frontier" that defines the greatest output possible across all combinations of inputs. Using the frontier, it is possible to measure how far a firm is from the efficiency frontier.

In WSDOT's model, the agency used similar techniques to estimate unmet transportation needs for individual households using trips as outputs that households produce. As such, households that make fewer trips than predicted by the efficiency frontier have unmet transportation needs.

Figure 1: Transportation Needs Model



WSDOT used the 2019 Puget Sound Regional Council (PSRC) Household Travel Survey along with other data about the costs of travel (e.g., U.S. Census Public Use Microdata Sample) for the Transportation Needs Model. WSDOT selected the survey data because it is readily available and regularly updated; and it encompasses a wide variety of urban, suburban, and rural areas as well as the full range of public transportation availability in King, Snohomish, Pierce, and Kitsap counties.

Based on data from the PSRC Household Travel Survey, the Transportation Needs Model demonstrates household travel efficiency as a product of the availability of public transportation services within a household's census tract in the Puget Sound region.

WSDOT also applied the model to a list of synthetic households representing each household in Washington. WSDOT used synthesized households because there is currently no statewide data set comparable to the PSRC's Household Travel Survey. The result was a count of missed trips for each household in Washington state.

APPLYING THE TRANSPORTATION NEEDS MODEL ACROSS WASHINGTON

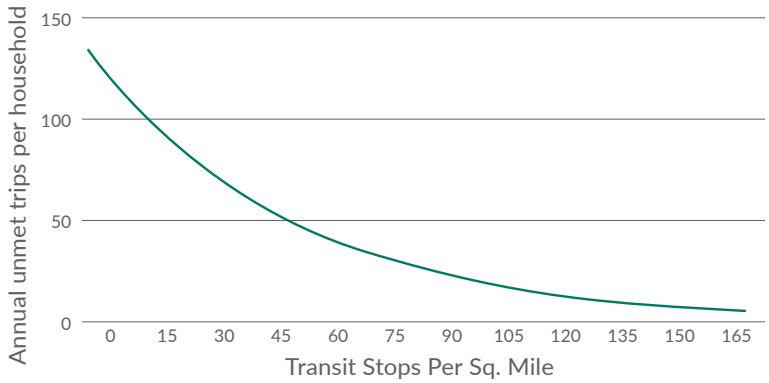
When WSDOT applied the Transportation Needs Model across Washington, the model showed annual unmet trips decreased as stop density increased. Conversely, as stop density decreased, unmet trips rose.

This relationship shows households with poor public transportation access (as measured by stop density) are more likely to have unmet transportation needs (as measured by unmet trips).

However, other factors can cause or prevent unmet transportation needs.

For example, households with higher incomes and access to privately owned vehicles are unlikely to have unmet transportation needs even if they live in places with poor public transportation access. On the other hand, for households with lower incomes and limited access to privately owned vehicles, poor public transportation access has a negative effect on making trips.

Figure 2: Household Annual Unmet Trips by Transit Stop Density



Race and ethnicity in this study

During the course of the Unmet Needs Study, WSDOT looked at the relationship between race and ethnicity and trips made by households and found that race and ethnicity are not as reliable at predicting the number of trips a household will make as other demographic factors like income, disability status, and the age of the head of household.

However, WSDOT recognizes that race and ethnicity do intersect with some of those other factors. Because of systemic racism, People of Color may be more likely than the general population to, for example, have lower incomes. However, because income, disability status, household size, number of cars per working adult, and the number of nearby transit stops all do a better job than race and ethnicity of explaining the trips that households make, those are the factors that WSDOT focused on in this analysis and in these results.

The model also showed that places with higher concentrations of households with lower incomes and limited public transportation are more likely to be associated with missed trips, indicating unmet transportation needs. Further, households with limited income, members living with physical impairments, more workers than personal vehicles, or members over 70 years old are more likely than the average Washington household to have unmet public transportation needs.

Broadly, the model showed more than 270,000 Washington state households face constraints that make them more likely to have unmet transportation needs. These households collectively forego nearly 29 million trips they would have made if they had better access to transportation.

ESTIMATING THE COST OF UNMET TRANSPORTATION NEEDS

WSDOT used results from the Transportation Needs Model to estimate the cost of unmet needs for households, counties, and communities across Washington. WSDOT's estimates took into account that unmet trips are not identical in length, location, purpose, timing, mode, and cost. To make cost estimates, WSDOT also used Medicaid trip reimbursement cost data.

Washington state residents eligible for Medicaid are also eligible for transportation cost reimbursement for Medicaid services. Medicaid reimbursements correspond to actual costs and detailed records of those costs and services provided (e.g., mode of transportation, distance of trips, trip location) are publicly available. Medicaid trip reimbursement rates also vary by location, reflecting local conditions, costs, and demands. Finally, Medicaid trips include those that support people with disabilities or mobility limitations, as opposed to commute trips in urban places.

WSDOT estimates the annual cost to meet the unmet public transportation needs of Washington residents is more than $890 million, or roughly $3,300 per household with unmet public transportation needs. This per-household estimate is an average and is much higher for households in rural counties.

Figure 3: Annual Unmet Trips Per Resident Household (Census Tracts)

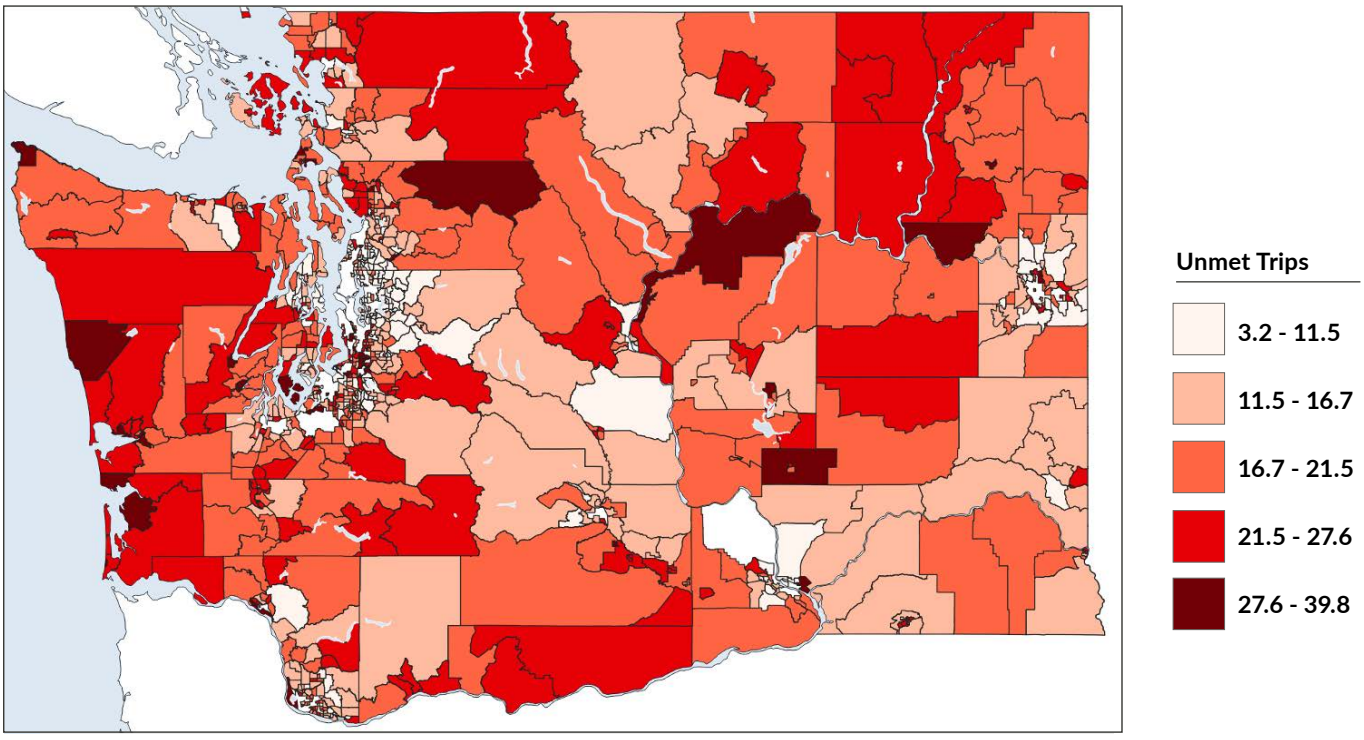
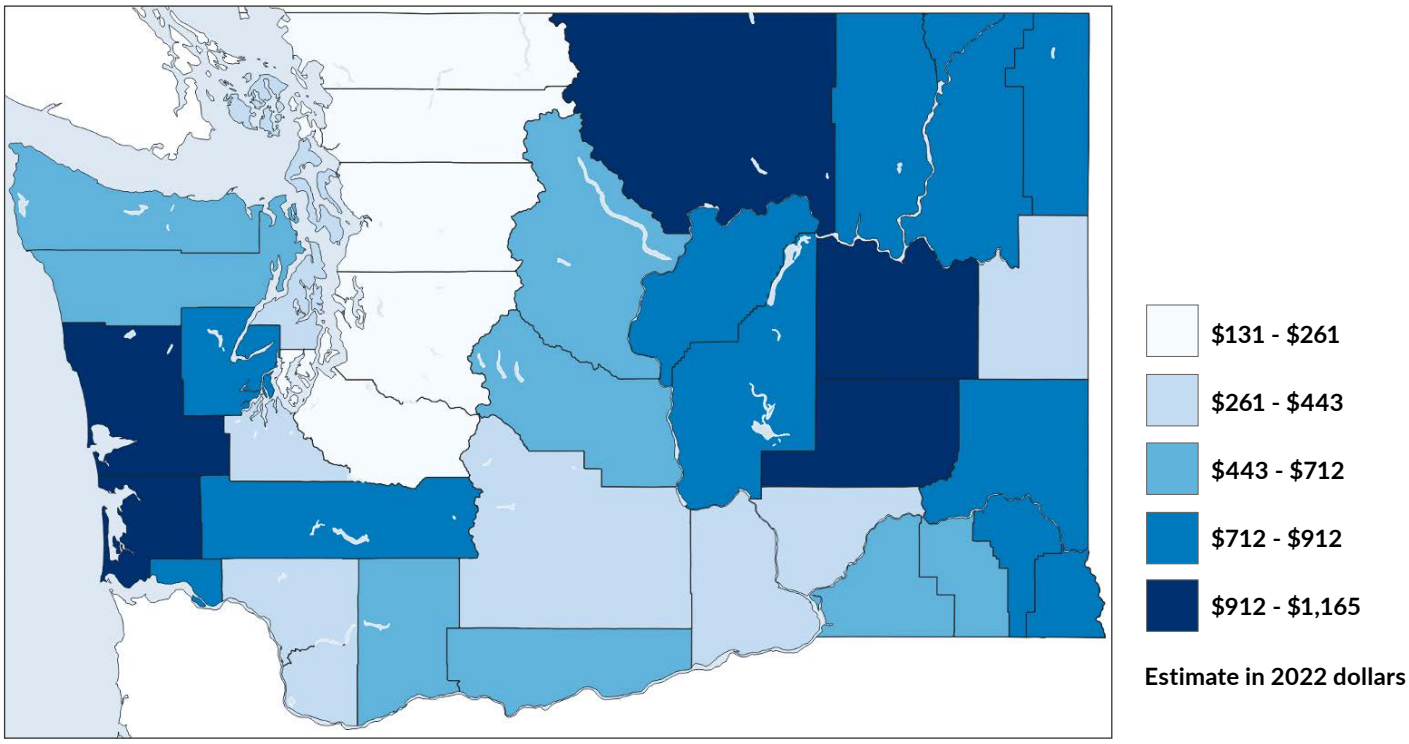


Table 1: Costs of Unmet Transportation Needs

County	Annual unmet trips	Cost		
		County	Household	Households with unmet transportation needs
Adams	147,000	$6,960,000	$1,160	$5,600
Asotin	180,000	$8,300,000	$910	$4,500
Benton	696,000	$23,030,000	$320	$3,500
Chelan	358,000	$19,930,000	$700	$5,700
Clallam	527,000	$23,470,000	$710	$4,300
Clark	1,886,000	$53,270,000	$300	$3,100
Columbia	37,000	$1,210,000	$670	$2,900
Cowlitz	592,000	$16,720,000	$400	$2,900
Douglas	215,000	$11,990,000	$790	$6,400
Ferry	73,000	$2,680,000	$880	$3,400
Franklin	287,000	$9,480,000	$350	$4,300
Garfield	18,000	$850,000	$870	$4,600
Grant	594,000	$28,080,000	$910	$5,100
Grays Harbor	703,000	$27,260,000	$950	$3,800
Island	670,000	$11,330,000	$330	$1,800
Jefferson	218,000	$9,690,000	$660	$4,300
King	4,969,000	$116,410,000	$130	$2,500
Kitsap	1,035,000	$46,070,000	$440	$4,900
Kittitas	329,000	$10,880,000	$590	$3,300
Klickitat	198,000	$5,590,000	$630	$2,800
Lewis	661,000	$25,610,000	$840	$3,800
Lincoln	99,000	$4,660,000	$1,030	$4,900
Mason	536,000	$20,780,000	$860	$4,000
Okanogan	341,000	$18,990,000	$1,070	$5,400
Pacific	238,000	$9,220,000	$990	$3,600
Pend Oreille	122,000	$4,480,000	$780	$3,700
Pierce	3,352,000	$80,880,000	$250	$2,600
San Juan	166,000	$2,800,000	$340	$1,700
Skagit	710,000	$12,010,000	$250	$1,800
Skamania	108,000	$3,060,000	$640	$3,000
Snohomish	2,620,000	$76,650,000	$260	$3,200
Spokane	1,687,000	$58,920,000	$290	$3,500
Stevens	378,000	$13,860,000	$790	$3,600
Thurston	1,148,000	$44,470,000	$400	$4,100
Wahkiakum	52,000	$1,460,000	$770	$2,900
Walla Walla	436,000	$14,410,000	$640	$3,200
Whatcom	1,049,000	$17,730,000	$200	$1,800
Whitman	306,000	$14,140,000	$790	$3,900
Yakima	991,000	$32,770,000	$390	$3,900
Statewide totals	**28,732,000**	**$890,150,000**	**$310**	**$3,300**

Figure 4: Annual Household Cost of Unmet Transportation Needs by County



QUALITATIVE FINDINGS AND APPROACHES

KEY FINDINGS

- Elements of unmet public transportation needs—including a lack of frequency and reliability, limited service areas, and cost—are related to a lack of funding, staffing, or resources.
- Incomplete non-motorized travel networks and inadequate shelters make it difficult for public transportation riders to comfortably and safely access public transportation.
- People who are underserved by current public transportation services include those who work outside of traditional workday schedules, need on-demand services, need to travel between jurisdictions, have lower incomes, and live in rural areas.
- Not having access to reliable transportation reduces riders' independence, autonomy, and quality of life.
- Successfully meeting public transportation needs across the state needs will require a flexible approach that takes local factors into consideration.

QUALITATIVE RESEARCH APPROACHES

WSDOT used two qualitative research methods for the Unmet Transportation Needs Study: plan analysis and stakeholder interviews.

Plan analysis

WSDOT reviewed 13 statewide, regional, and local plans and reports from planning organizations, transportation departments, and disability rights advocacy groups.

Plans and reports reviewed:

- 2016 Washington State Public Transportation Plan
- 2022 Washington Statewide Human Services Transportation Plan
- Benton-Franklin Human Services Transportation Plan
- Chelan Douglas Human Services Transportation Plan
- Coordinated Public Transit – Human Services Transportation Plan for Spokane County
- Northeast Washington Regional Transportation Plan 2024
- Oregon Department of Transportation Needs Assessment
- Peninsula Regional Transportation Planning Organization Regional Transportation Plan 2040
- Puget Sound Regional Council Coordinated Transit-Human Services Transportation Plan
- Skagit Coordinated Public Transit-Human Services Transportation Plan
- Southwest Regional Transportation Planning Organization Coordinated Public Transit – Human Services Transportation Plan
- Transportation Access for Everyone: Washington State
- Whatcom County Human Services Transportation Plan: 2018 Update

Findings from this review contributed to a foundational understanding of unmet public transportation needs in Washington. The plans and reports WSDOT reviewed include feedback compiled from robust community engagement efforts across Washington.

Stakeholder interviews

WSDOT used the foundational understanding gained from its plan review to develop an interview script that the agency could adapt to various audiences. WSDOT used the script to conduct interviews with 18 transportation providers and advocacy organizations, along with six public transportation users.

Interviews supported the following goals:

- Validate unmet public transportation needs identified in the plan review.
- Identify additional unmet public transportation needs not included in the plan review.
- Understand the effects of unmet public transportation needs.
- Investigate disproportionate effects on specific populations.
- Gather input on potential limits of WSDOT's quantitative Transportation Needs Model.

Plan review findings

The following table illustrates themes and findings from WSDOT's review of 13 statewide, regional, and local plans and reports from planning organizations, transportation departments, and disability rights advocacy groups.

Theme	Findings		
	Mentioned in at least seven of 12 plans	Mentioned in 4-6 plans	Mentioned in three or fewer plans
Accessibility	• Coordination to expand cross-county, inter-urban, and inter-tribal transportation options • Expanded non-emergency, on-demand human services transportation and paratransit • More affordable transportation services, including on-demand services, and especially for community members with low incomes or disabilities • Expanded service boundaries and service hours, including early morning, late night, and weekend services • Expanded and improved services in rural areas, especially those that connect rural areas to larger cities and resources • Complete pedestrian network, including sidewalks, curb ramps, and accessible pedestrian signals on arterial crossings	• More flexible space for those using mobility devices in transit vehicles, including paratransit vehicles	• Improved public transportation travel speeds, frequency, and reliability to make public transportation more accessible and convenient • Responsibly maintained accessible transportation infrastructure, including elevators, automatic doors, braille signage, and functioning audio systems on all transit services • Accessible public involvement efforts for public transportation projects, including both remote and in-person engagement options • Improved park-and-ride services, including solutions for overcrowding and infrastructure investments for users with special needs, bicyclists, and pedestrians

Theme	Findings		
	Mentioned in at least seven of 12 plans	Mentioned in 4-6 plans	Mentioned in three or fewer plans
Safety	• Greater investment in rider comfort and safety, including accessible features, seating, and shelter at all transit stops	• Clear transportation roles for public transportation providers during emergency and disaster response and communication systems to inform riders of procedure changes in an emergency. Emergency preparedness that includes the needs of nondrivers and disable community members.	• Procurement of new and resilient vehicle fleets that can withstand weather extremes • Diversity, equity, and inclusion training for service providers related to the appropriate assistance of riders who are people of color, immigrant riders, and riders with disabilities • Oversight to ensure boarding denials are demonstrably based on passenger and driver safety
Communication	• Outreach to share easy-to-understand information about available services and eligibility requirements. • Reduced paperwork to access services, and permission for applicants to self-identify needs • Improved tools for finding rider assistance, amenities, routes, and arrival times across services • Facilitated cross-agency coordination to improve efficiency of services, decrease transfer times, and bridge gaps between providers • Centralized technology systems, wayfinding features, farebox polices, and fare assistance programs across transportation providers to improve ease of use	• Improved outreach campaigns for community members with limited internet access and English proficiency	• Bus stops adjacent to key destinations for shopping, education, services, and recreation • Permission for parents and caregivers to ride with their children and other family members in specialized transportation services

Theme	Findings	
	Mentioned in four to six of the reviewed plans	Mentioned in three or fewer of the reviewed plans
Policy & administrative	• Data collection to assess transportation burden, unmet transportation needs, and pick-up failures, as well as innovative and interdisciplinary solutions to public transportation challenges	• Increased funding, staffing, and resources for providers to meet transportation needs and fix aging infrastructure • Integrated access to transit and land use in planning, environmental review, and permitting to create opportunities for residents with low incomes to live closer to public transportation services and key resources, where housing is often more expensive • Additional strategies for local jurisdictions and partners to reduce drive-alone vehicle trips • Equity in funding for existing services and expansion of services in rural and urban areas • Decriminalization of fare evasion to minimize harm experienced by those unable to provide proof of payment • Recruitment of BIPOC, low-income, and disabled community members for agency and leadership positions. Compensation for advisory committees or other accessibility and equity consultant work.

STAKEHOLDER INTERVIEW FINDINGS

WSDOT asked stakeholders to reflect on public transportation needs in their communities, including limitations or barriers that stakeholders personally experience or see others experiencing while accessing public transportation.

Of the 24 stakeholders WSDOT interviewed, more than a third mentioned the unmet public transportation needs below. Additionally, each stakeholder contributed local perspective and potential transportation solutions that could help address needs in their community.

Expanded service boundaries and service hours

"Many community members who rely on transit to meet their basic needs live outside of our current service area. Those who can access services often need them at different times than they're currently available."

Stakeholders who were public transportation users and providers identified the need for expanded service boundaries and service hours, noting the need for public transportation access to essential services and recreation centers. Some public transportation providers identified underserved portions of their service areas, while those primarily serving rural communities shared the need to increase transportation services broadly across their jurisdictions.

Public transportation providers and public transportation riders also noted the need for expanded (i.e., early morning, evening, weekend) service hours in areas with existing service. Public transportation riders shared that expanded service hours would improve access to essential services for community members who work during peak commute hours. Additionally, expanded service hours would contribute to employment access for community members who have or are seeking jobs with shifts not served by traditional peak commute hours.

Complete non-motorized travel networks

"I rarely know in advance when construction on a sidewalk or at a bus station will happen, which throws off my commute or puts me in an unsafe situation."

Stakeholders frequently mentioned the need for more accessible public transportation features, including:

- More flexible spaces on buses for wheelchairs and strollers
- More priority seating
- Repairs to elevators, escalators, sidewalks, and crosswalks

While some stakeholders mentioned the need for specific sidewalk improvements, including removal of sidewalk barriers and more communication preceding construction disruptions, stakeholders in rural communities shared the need for general expansion of safe sidewalks, crosswalks, and multi-modal networks.

Public transportation providers noted challenges addressing insufficiencies to accessibility infrastructure without resources to support coordination with the other local planning jurisdictions.

"We need more funding and support from the state to provide equitable transit services, and that funding needs to be distributed fairly to meet the needs of both urban and rural areas."

Increased funding, staffing, and resources

Public transportation providers expressed the need for additional funding, staffing, and resources to meet the diverse needs of riders in their jurisdictions. Specifically, public transportation providers shared the need for funding to:

- Hire additional staff and pay competitive wages.
- Purchase new transportation vehicles and maintain existing ones.
- Balance the burden of rising fuel costs.

Several public transportation providers also mentioned the difficulty of hiring and retaining qualified drivers in the current competitive labor market. People with a commercial driver's license are in high demand in the commercial trucking industry and it can be difficult for public transportation providers to compete with the wages and benefits offered by private businesses.

Additionally, public transportation providers noted that not all types of funding are equal. These stakeholders stressed that grant funding, a major source of revenue, is not guaranteed year-to-year, making long-term planning and operations management difficult. Rural providers shared that the requirement to provide matching funds for some grants can make those funding sources inaccessible.

Public transportation providers emphasized the challenge of expanding and improving services in their jurisdictions while burdened with understaffing and limited funding for current operations. Human services transportation providers, small municipalities, and rural public transportation providers often expressed the need for increased and more equitably distributed funding and resources.

More accessible information about available services and eligibility requirements

Both public transportation providers and public transportation riders frequently noted the need for more reliable and easy-to-understand information about available public transportation services, fare-assistance programs, and eligibility requirements, especially for services in rural communities.

Public transportation riders shared that insufficient communication about service changes and construction can lead to unpredictable, frustrating, or dangerous traveling experiences.

Public transportation providers expressed the need for improved outreach campaigns and additional funding for mobility management programs to help riders access the services available in their communities.

Expanded cross-jurisdictional transportation and coordination

Public transportation riders and providers expressed the need for coordination between counties, states, tribal nations, and programs to decrease transfer times and bridge the gaps between public transportation providers in different jurisdictions.

Under the current conditions, inter-jurisdictional routes are often inconvenient and require multiple transfers. This barrier largely affects community members accessing nearby resources across a jurisdictional border.

Representatives of public transportation providers and local jurisdictions also noted the need for coordination between planning agencies to develop a more seamless network of pedestrian infrastructure, affordable housing, and transportation.

Improved bus stop amenities

"In rural areas especially, you'll find bus stops on gravel shoulders of high-speed roads without shelters. It's difficult to imagine travelling to these stops and waiting there in the rain or extreme heat of the summer."

Stakeholders noted that insufficient bus stop amenities (e.g., shelters) contribute to missed trips in areas where services may otherwise be available.

Public transportation riders expressed feeling unsafe without bus shelters, especially along high-speed roads.

Public transportation providers noted heavy rain and extreme heat, each of which is both becoming more common, are deterrents for riders when bus shelters are missing.

Stakeholders also expressed the need for public restrooms near stations, which would improve access to public transportation services for older riders, riders with disabilities, and riders who are pregnant or travelling with small children. Generally, stakeholders shared that improved bus stop amenities would increase convenience and comfort of public transportation trips, which riders might otherwise avoid in current conditions.

Improved transportation travel frequency and reliability

Stakeholders who are public transportation riders and providers frequently noted the need for improved public transportation capacity, frequency, reliability, and comfort, especially for fixed-route transit, on-demand services, and routes with service transfers.

Stakeholders representing rural communities noted that some large rural areas have limited to no public transportation options. In rural communities with access to public transportation, existing services lack the frequency and reliability present in more densely populated areas of the state.

More affordable transportation services

Stakeholders frequently mentioned the cost of public transportation as a barrier that forces riders to forego trips. The cost of on-demand services, ride-hailing, private transportation, and medical transportation is particularly prohibitive, which results in riders consolidating or skipping trips altogether. As such, stakeholders expressed support for new or expanded fare-assistance programs and free fares for youth. Some public transportation providers shared support for existing or new fare-free programs for all riders.

Other needs identified by stakeholders

In addition to the public transportation needs described above, some stakeholders described the following needs in their communities related to public transportation:

- Data-collection efforts to better understand transportation burdens and barriers.
- Consistent tools and practices across public transportation providers.
- Adaptive planning for climate change and natural disasters.
- Equitable enforcement of rules and norms on public transportation to keep riders and drivers safe.
- Equity training for public transportation providers.

Stakeholders also noted the need for public infrastructure and city planning improvements, like expanded broadband access and affordable housing opportunities in areas with reliable public transportation. Though these needs are not directly related to public transportation access, coordination between public transportation providers and land-use planners, housing planners, and utility planners is needed to deliver these quality-of-life improvements.

Who transportation providers are serving

When asked who providers are seeking to serve with existing resources, stakeholders described the following groups:

- Older adults
- Veterans
- Community members with disabilities
- Youth and children
- Immigrants and refugees
- Community members who live on tribal reservations
- Community members with limited English proficiency
- Community members seeking specific medical services

Underserved communities

Stakeholders noted inadequate services for community members:

- Who do not meet the eligibility requirements to access programs tailored for the groups above but still require support accessing public transportation services.
- With work shifts outside of conventional commuting hours.
- Who are travelling between service jurisdictions.
- Who need on-demand services.
- Who earn lower incomes, especially those who cannot afford housing near frequent transit services.
- Who are without internet access.

Disproportionate effects

WSDOT asked stakeholders to identify disparities in public transportation needs based on race, age, income level, or disability.

Providers shared that they sometimes have trouble building trust and engaging with community members who speak languages other than English in their service areas. Providers also noted service disparities for community members with disabilities. These groups often overlap with the underserved communities above, further increasing the likelihood of unmet public transportation needs.

Geographical disparities

Stakeholders also shared that communities served by fixed-route transit and first-/last-mile services, most often in urban areas, experience better public transportation services than community members residing in more rural communities.

Public transportation providers and riders representing rural communities generally described limited and lower quality services even though significant numbers of vulnerable communities reside in rural areas.

Stakeholders also noted that community members who speak languages other than English, community members with disabilities, people who are older, and tribal reservation communities are more likely to experience barriers to meeting their transportation needs.

The human cost of unmet public transportation needs

As noted above, the 2016 Washington State Public Transportation Plan states that people throughout the state use public transportation to make transportation choices that enable their families, communities, economy, and environment to thrive. Unmet public transportation needs are the result of factors that limit or prevent community members from accessing the transportation they need to thrive. Unmet public transportation needs can in turn cause disparate health outcomes, lower wages and earning potential, and poorer quality of life.

During interviews, WSDOT asked public transportation providers and riders how the barriers they described translate to effects on their riders, community members, or themselves. The themes below summarize participants' feedback.

A "tax on time"

Stakeholders described the additional time and coordination needed to travel using less efficient public transportation compared to more robust public transportation or personal vehicles.

For example, riders may need to research when services are available and whether they qualify for those services, walk long distances, or ride on a bus that stops frequently. Each of these factors can produce a rider's experience that takes more time in which they could otherwise spend in ways that increase their quality of life.

Reduced independence and autonomy

Stakeholders shared that when the available public transportation services cannot meet their needs, riders must rely on friends, family members, or neighbors for rides.

Riders shared that this reliance limits their autonomy to find and secure employment opportunities, make plans, follow a schedule, or take care of personal or spontaneous needs. As a result, some riders often feel like they are burdens on their communities.

"We have communities in the state with total reliance on single-occupancy vehicles. As a result, community members need to own a car to have full autonomy."

"People should be able to age in their homes rather than being forced to move when they can no longer drive because there are no transportation services in their area."

"Public transportation services are vital for people without cars. They are the difference between employment and unemployment, and isolation and connection."

Reduced quality of life

Stakeholders described the types of opportunities that people who are dependent on public transportation miss out on when public transportation needs are unmet:

- Medical appointments and other essential services
- Work shifts
- Family or community events
- Social gatherings
- Recreation
- Opportunities to contribute to civic life and public projects

These missed trips limit their opportunities for care, social connection, economic opportunities, and community-building, which can contribute to a poorer quality of life.

Missing transportation services

WSDOT asked stakeholders about public transportation services available in their communities and jurisdictions. Depending on their geographic location, stakeholders' responses ranged from virtually no existing options to a rich network of fixed-route transit, vanpool, rideshare, on-demand services, paratransit, transportation assistance programs, Medicaid transportation, human services transportation, and shuttles.

Generally, stakeholders representing non-urban or less densely populated areas of the state described fewer or more limited public transportation options available in their communities.

When asked to describe public transportation services missing in their communities or jurisdictions, stakeholders most frequently mentioned:

- Weekend, early-morning, and late-night services (which are essential for riders who need services outside of typical commuter peaks, community members who work late night or weekend shifts, and transit-dependent community members)
- On-demand services for emergency and non-emergency trips
- Park and ride lots
- Rideshare programs
- Express services
- Inter-jurisdictional services

The range of available public transportation services and the diversity of transportation needs across the state, especially between urban and rural communities, emphasizes the need for user-centered, localized solutions. Though participants shared consensus on the missing services above, there is no one-size-fits-all solution for addressing unmet public transportation needs across the state.

STUDY CONCLUSION

When people have access to adequate public transportation, they can more easily take advantage of economic opportunities, contribute to their communities, and care for themselves and their families.

However, many people in Washington state cannot access the transportation services they need.

Sometimes, a lack of resources means that public transportation services do not exist when and where people need them. In other cases, physical, policy, or administrative barriers make existing services difficult for people to use.

Quantitative research in this study shows that households with limited income, members living with physical impairments, more workers than personal vehicles, or members over 70 years old are more likely to be mobility-challenged than the average Washington household and more likely to have unmet public transportation needs. Additionally, qualitative findings show people who live in more rural communities, tribal members, and those who work outside of traditional commuting hours are likely to face barriers accessing public transportation services.

Based on the annual cost to meet the unmet public transportation needs of Washington residents—more than over $890 million or roughly $3,300 per household with unmet public transportation needs—addressing the unmet need for public transportation services across Washington state will require a number of changes. These include:

- Additional resources.
- Rethinking how local agencies access funding.
- Better coordination among the local and state agencies responsible for transportation, land use, housing, and utility infrastructure planning.
- Solutions that take local conditions and needs into consideration.

NEXT STEPS

WSDOT began the Unmet Public Transportation Needs Study in late 2021. In its 2022 session, the Legislature directed WSDOT to conduct the Frequent Transit Service Study (ESSB 5689 – 2022 Sect. 221 (15))and develop initial and final reports about statewide transit service benchmarks. WSDOT published the initial report in December 2022 and will publish the final report in July 2023.

WSDOT will analyze the Public Transportation Unmet Needs Study alongside the Frequent Transit Service Study and other studies for a complete look at transportation access in Washington state. This will inform the upcoming Statewide Public Transportation Plan; Statewide Human Services Transportation Plan; and other reports, plans, and studies related to public transportation.

APPENDIX: TECHNICAL MEMO

WSDOT
UNMET TRANSPORTATION NEEDS STUDY

Unmet Needs Estimation Methodology

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INTRODUCTION

UNDERSTANDING AND APPROACH

Better Understanding "Unmet" Transportation Needs

The Washington State Department of Transportation is attempting to develop methods and practices that are designed to produce an estimate of the quantity of unmet transportation needs faced by households in Washington state. This is an ambitious requirement that places a range of demands upon the analyst and necessitates innovative approaches to the analytical tasks involved. It is also the case that estimating such "needs" involves conceptual challenges as well as technical challenges, such as establishing a suitable definition of "unmet need" and determining the most appropriate approach to developing estimates of the costs of meeting those needs. For this reason, this method report is intended to provide a theoretical foundation as well as a methodological starting point for the estimation of unmet transportation needs.

Concurrent with the development of this report are other efforts to better understand the mobility challenges faced by Washington households. In particular, households with limited incomes, those with household members with physical impairments, and households comprised of elderly individuals are more dependent on non-auto modes of transport as compared with the "average" Washington household. Where transit services are limited, these mobility-challenged households often have difficulty accessing basic household maintenance services, human services, and medical services. These circumstances have led to an interest in better understanding the scale of these mobility challenges, the range of options for improving access to necessary activities, and the magnitude of costs involved in meeting those needs.

These other studies include the Joint Transportation Committee (JTC) Non-Driver Study and the Frequent Transit Service Study (FTSS). The estimation of unmet transportation needs is inherently difficult. The notion is that some households have a demand for transportation that is not fully realized due to constraints faced by those households. At its root, this is a universal phenomenon where all households have a demand for travel in excess of the amount of transportation that is supplied to that household. In economic parlance, the demand for travel might be nearly unlimited if the cost of travel was zero and it is the interplay between demand and supply at a given price that determines the final quantity of travel that is supplied to and consumed by households.

Some quantity of unmet need is of interest as a matter of public policy. This is because of a couple of reasons. First, some households faced particular mobility challenges that merit remedy through public sector intervention. These households may include a disabled person who cannot drive or make use of typically available alternatives to driving. Or these households may include the elderly who likewise are less independently mobile outside of the home. And some households simply lack the financial resources to either own and operate a private vehicle or pay for transit services. Secondly, the public sector has already determined that it has a role to play in the direct provisioning of transportation services. The state invests in road and highway infrastructure and importantly also underwrites the expense of providing transit services to its citizens. Those transit services, however, are not uniformly provided throughout the state being principally located in urban places where transit technology is more cost-effective to deploy.

This report is focused on the estimation of a particular set of unmet transportation needs. A need experienced by certain households and in specific locations. It is a need defined by the confluence of household limitations (budget, mobility, demographics) and transit service availability (lack of transit service options). And since an unmet need is a need that is

not directly observed (it is hard to count a trip that is not taken) the methods involved in its estimation are innovative and involve advanced statistical techniques.

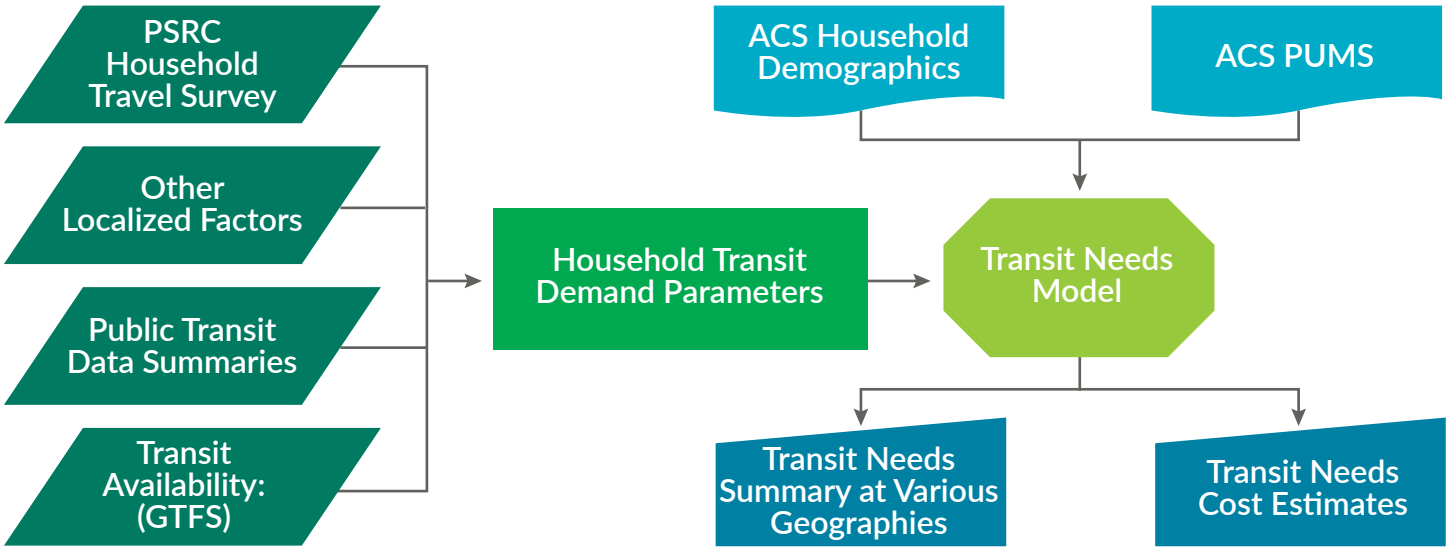
Overview of the Approach to Estimating Unmet Needs

The estimation technique used to quantify unmet transportation needs involves the adaptation of methods that are most often used in the analysis of industry efficiency. Within a given industry each firm produces outputs by combining a mixture of capital, labor, and other inputs. The mathematical expression of the relationship between inputs and outputs is labeled a production function. For a particular level of production, a firm must employ specific combinations of inputs. When analyzing many different firms within an industry it is feasible to estimate an efficiency frontier that defines the maximum output possible across all the combinations of inputs. An individual firm can produce up to this frontier, but not beyond it without changing the amount or mix of inputs. But not all firms operate at the efficient frontier, some fail to execute at this maximum level of efficiency. And it is possible to measure just how far from the efficient frontier any firm is operating. The statistical tool for estimating the frontier, and for measuring how individual firms compare with that frontier, is referred to as Stochastic Frontier Analysis.

These same techniques can be adapted in order to estimate unmet transportation needs for individual households. Households take the place of firms and trips become the unit of production. The inputs into trip production are attributes of the household (size, income, workers, age) and attributes of the location in which households reside (population density and transit accessibility). An efficient trip production frontier is estimated and individual households are compared with that frontier. Households that produce fewer trips than are estimated through the efficient frontier are said to have "unmet" transportation needs. The model specifics are described in detail later in this report. But essentially the model is specified so that transit accessibility determines an inefficiency score for each household, such that "inefficient" households exhibit an unrealized latent demand for trip-making.

The general process for implementing this procedure is as follows. Each step is discussed in detail in Section 3 of this report. The Stochastic Frontier Analysis is implemented in the statistical modeling software package STATA. The model was estimated using the 2018 panel of the Puget Sound Regional Council

Figure 1: Unmet Need Estimation Work Flow



Source: ECONorthwest

Household Travel Survey. Transit service availability was derived from public domain transit service feed (GTFS) data. Once estimated the models are applied to a database of synthetic households that represents each household in the state of Washington. The result of this model application is a count of "unmet" trips for each household. These trip counts are then summed by Census geography (tract, county) for reporting purposes. The final step is to apply dollar values to the count of unmet trips. This last step is the least straightforward of all the steps in the process and Section 5 of this report addresses this topic in some length.

More on How These Methods Relate to Other Efforts

Non-Driver Study:

The Washington (WA) State Legislature directed the JTC to conduct a study to estimate how many nondrivers are in Washington State and the demographics of this population, as well as identify the availability of transportation options for nondrivers and the impact those options have on access to daily life activities. This study used available Census and FHWA/DOL data, identify the different population groups that make up the nondrivers in Washington State. Findings concluded that Public transit access to daily life activities is restricted to the extent of the fixed-route network and the span of service, and that access to a vehicle provides almost universal access to daily life activities statewide

Frequent Transit Service Study:

In its 2022 session, the Legislature directed WSDOT to conduct a study that proposes a definition of frequent fixed route transit and documents how many people in Washington live within a half-mile walk of frequent fixed route transit. WSDOT was also directed to analyze where gaps in frequent transit exist and provides potential funding scenarios to address those gaps.

These two studies, alongside this Unmet Needs Study will provide a more complete picture about access to public transportation in Washington State.

ESTIMATING UNMET TRANSPORTATION NEEDS

As described earlier in the introductory section of this report, a novel approach to estimating unmet household transportation needs was developed by adapting an analysis that was designed to understand the efficiency of industry productivity. This method is generally referred to as frontier analysis. There are two dominant approaches in the field. One approach is called Data Envelopment Analysis (DEA) which is a non-parametric programming technique for estimating a deterministic frontier. The other approach is called Stochastic Frontier Analysis (SFA) and is a modified form of linear regression analysis. The aim of SFA is to estimate both technical and allocative efficiency through the adoption first of a firm-level production cost function. Given specific inputs to production a particular level of output is feasible. Achieving lower levels of output indicates an inefficient production process.

In this current effort, the SFA approach has been used. But instead of estimating an industry production frontier, the SFA model is estimating household trip production as a function of the characteristics of the household and of the availability of automobile and transit supply. Once again, given these inputs the households should "produce" a certain level of output in the form of tripmaking. Households that "produce" fewer trips than what is indicated by the estimated efficient frontier are said to have trip demands that are "unmet".

Stochastic Frontier Analysis

The adaption of Stochastic Frontier Analysis from method of estimating firm production efficiency to the estimation of unmet travel demand is novel but conceptually straight-forward. Firms face a production efficiency problem that involves combining available input, which are costly, in order to maximize their profit. Households likewise have efficiency problem to solve when they engage in trip-making behaviors. Characteristics of households drive their need for travel outside the home, and transportation is a costly

input into their engagement in necessary or desirable activities. Household attempt to maximize their utility, or well-being by balancing the costs and benefits of trip-making.

A paper[1] published in the Stata Journal describes stochastic frontier analysis as follows:

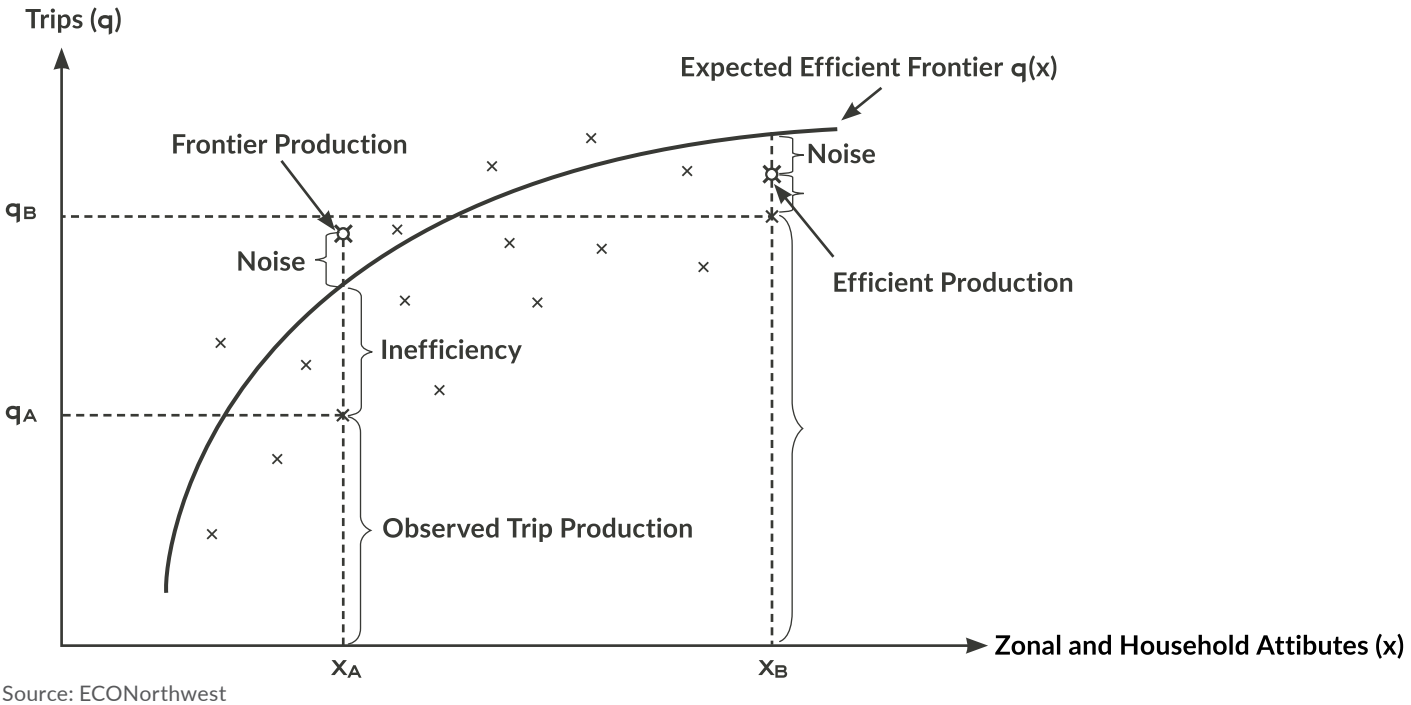
> *The SF model is motivated by the theoretical idea that no economic agent can exceed the ideal "frontier", and deviations from this extreme represent individual inefficiencies. From the statistical point of view, this idea has been implemented by specifying a regression model characterized by a composite error term in which the classical idiosyncratic disturbance, aiming at capturing measurement error and any other classical noise, is included with a one-sided disturbance that represents inefficiency. Whether cross-sectional or panel data, production or cost frontier, time invariant or varying inefficiency, parametric SF models are usually estimated by likelihood-based methods, and the main interest is on making inference about both frontier parameters and inefficiency.*

[1] Belotti, Federico and Silvio Daidone; *Stochastic frontier analysis using Stata*; The Stata Journal (2013), Number 4, pp. 719–758

Just as the firm production frontier (the outer boundary at which firms can produce given their size and access to inputs, etc.) defines a idealized state against which actual firm operations can be compared, the household trip-making frontier is also a useful point of comparison. Households will make trips at the frontier boundary if they can be efficient in maximizing their well-being. But barriers to achieving this efficiency results in behavior that is rarely at the edge of this boundary. One of those barriers is poor access to publicly available transportation services that aid in personal mobility, especially for persons who have limited income, face a disability, or for other reasons cannot make use of personal vehicles.

Figure 2 is a graphic depiction of the efficiency frontier. Household characteristics (x), such as size, number of workers, and presence of children, are determinants of trip demand (q). The expected efficiency frontier is the line q(x). Observed trip production is usually something other than at the efficient frontier and this difference between observed and expected values is comprised of both a random component (noise) and an inefficiency component. The inefficiency component, in the analysis that is described is this report, is associated with poor access to public transit and its correlates.

Figure 2: Frontier Analysis Diagram



Source: ECONorthwest

The inherent noisiness of household trip-making behavior, unaccounted-for explanatory variables, the spatial generality of transit accessibility measures, and other factors do complicate the interpretation of such a model. But the SFA model is a suitable and innovative approach to estimating something that in other respects remains hidden from view—the demand for household trips that are not taken.

Household Survey Data

In order to estimate such a frontier model, it is necessary to have information about the trip-making behaviors of a suitable cross-section of Washington State households. Suitable datasets would include a large number of randomly selected households, would report a range of household-level attributes (size, age, income, etc.), and would also establish comprehensive information about the trips made by all members of these households over a discrete period of time.

The Puget Sound Regional Council implements a household travel survey program that generates datasets that meet these requirements. The household travel survey covers households living in the four Central Puget Sound counties (King, Kitsap, Pierce, and Snohomish).

For purposes of this effort, the 2018 Household Survey was selected. This survey dataset has a large sample of participating households, pre-dates COVID-19 disruptions, and can be reasonably matched with U.S. Census data products such as American Community Survey census tract summary files and Public Use Microdata Sample files. The 2018 Household Survey includes travel diary records for over 6,000 households living within the central Puget Sound region. Importantly, households are included from a broad range of geographic settings including those with frequent and high-intensity transit services as well as settings with little or no transit or other urban services. This range of urbanized conditions permits the SFA model to be estimated such that the intensity of available transit services becomes a meaningful predictor of household trip production "efficiency".

Each household in the survey dataset is associated with person-level records, vehicle records, and person trip records. Of specific interest to this project is the following household information:

- Size (number of persons in household)
- Number of working persons
- Number of children present
- Number of vehicles available to the household
- Age of head of household
- Household income
- Location of household (census tract)
- Person-level trip records (including start time, stop time, location, mode, purpose, etc.)

In addition to controlling for household characteristics, the frontier analysis attempts to estimate household efficiency as a function of the availability of suitable transit-type services. In order to include transit accessibility in the model, each household record in the survey had appended to it a measure of transit stop density calculated from publicly available transit feed data. Each household is associated with a census tract and for each census tract, transit stop locations were summed and divided by the land area within the census tract.

Measures of transit availability are not limited to this relatively simple metric. But for purposes of this initial model, it was decided that a simple measure should be tested and other measures developed and further tested over time. It is the case that many measures of urbanization are correlated and in the end fewer measures are preferred over many measures. But this remains an area of the modeling that should be refined and explored more in the future.

The household survey dataset was loaded into the statistical modeling program Stata where variables could be easily transformed and evaluated for inclusion in the frontier model.

Table 1. Sample Data Key Variable Descriptive Statistics

Variable	Mean	Std. dev.
Total Trips	1.126	.427
Number of persons	2.48	1.34
Age (H of H)	42.0	1.1
Per Capita Income	50.299	17.742
Population density (tho./sqmi)	6.520	7.091
Transit stops (/sqmi)	28.1	43.6

Model Estimation and Results

The model used in this analysis is a form of Stochastic Frontier Analysis. The statistical modeling software Stata has modeling packages that facilitate the estimation of SFA. SFA is a modified regression model where the dependent variable is the measure of productivity (trip-making) and the independent variables are the contributions to household production of trips (household characteristics, auto and transit availability). Unlike a standard regression which assumes a random normally distributed error term, the SFA regression includes two separate components to the error term. One component is random and normally distributed (accounting for the normal noisiness of the observations in the dataset) while the other term is generally a one-sided distribution which respects that the frontier being estimated is a boundary.

The way to conceptualize what the model is doing is to image we are comparing two households that are identical in terms of size, workers, income, vehicles available, etc. However, one of these identical households lives in a setting where transit access is good and the other household does not. But for the difference in transit access we might expect these two households to make the same number of type of trips each day (or at least expect that across many such households, over many days the average number of trips would be similar. If these two "identical" households had access to personal vehicles then the difference in transit access might not present a barrier to mobility for the household with poor transit access. But if these "identical" households were limited by income and had no access to personal vehicles then we might observe that the household with good transit access actually make more trips outside the home per day than the household with poor transit access. In this particular example the number of fewer trips made by the household with poor transit access can be thought of as demand for trip-making that goes "unmet".

In the SFA the "unmet" trips are estimated statistically across all the households in the survey dataset, accounting for the natural variability in household behavior, as well as the variability that is associated with various degrees of transit accessibility. The dependent variables is the total trips made by the household per day less the count of daily trips with a destination at the home. In the household survey a trip is a one-way journey between and origin location and a destination location. By removing the trips with a destination at the home our measure becomes something closer to a tour of activities that respects that households often join trips together into a chain in order to meet budgetary or scheduling constraints. The natural log of variables are included in the model. And the measure of transit stop density is used in the second stage of the regression as a determinant of household "efficiency" in generating trips.

Figure 3 displays Frontier model estimation results with coefficients, z scores and confidence intervals at the 95% confidence level. In addition to predicted values of the dependent variable for each household, the model can be used to predict a measure of technical efficiency. Technical efficiency measures how close each household is to the efficiency boundary. So, for example, a household with a technical efficiency score of .95 is 95 percent efficient in generating trips. The lower the technical efficiency score the larger the difference between the number of trips the household "demands" and the number of trips that are actually "met". That difference can be converted into an estimate of "unmet" trip needs.

Figure 3: Frontier Model Estimation Results

Stoc. Normal/half-normal model — Number of obs. = 5,932

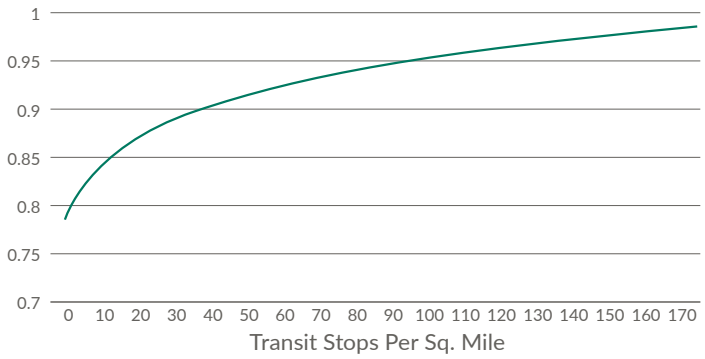
com_tothome	Coefficient	Robust std. err.	z	P>|z|	[95% conf.	interval]
com_tothome						
ln_np	.2529334	.0566028	4.47	0.000	.1419939	.3638729
ln_age	.016957	.045983	0.37	0.712	-.073168	.1070821
ln_inc	.1195721	.0163915	7.29	0.000	.0874453	.1516988
ln_noc	.4237132	.0649904	6.52	0.000	.2963344	.5510921
ln_veh	.1323813	.0617455	2.14	0.032	.0113623	.2534002
lnsig2v						
_cons	-1.445999	.1314327	-11.00	0.000	-1.703602	-1.188396
lnsig2u						
stopd	-.0348436	.0231141	-1.51	0.132	-.0801465	.0104593
_cons	-2.344679	1.1676	-2.01	0.045	-4.633132	-.0562257
sigma_v	.4852944	.0318918			.4266458	.5520052

Source: ECONorthwest

Post estimation, the relationship between technical efficiency and transit accessibility can be explored. Figure 4 displays a plot of technical efficiency scores against household transit accessibility as measured by the density of transit stops within the residential census tract. As transit stop density increases, technical efficiency approaches 100 percent. The relationship is non-linear and as transit stop density approaches zero, technical efficiency drops rapidly.

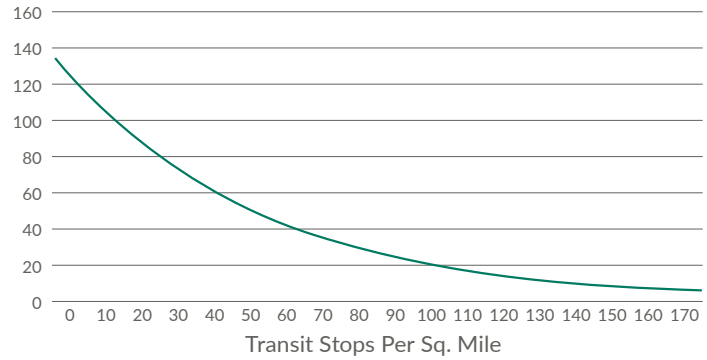
The measures of technical efficiency can be used to calculate the number of unmet trips per household, and this value can be annualized. For example, if a household in the survey is observed making 4 trips per day and has an estimated technical efficiency of .88 then there are approximately 0.5 trips per day that are "unmet", or 130 trips per year. The average number of unmet trips per year is plotted against transit stop density in Figure 5. Like the relationship between transit stop density and technical efficiency, stop density and the number of unmet trips form a non-linear relationship. The average number of annual unmet trips approaches zero as stop density increases and as stop density approaches zero the number of unmet trips rises sharply.

Figure 4: Technical Efficiency of Trip Generation by Transit Stop Density



Source: ECONorthwest

Figure 5: Household Annual Unmet Trips by Transit Stop Density



Source: ECONorthwest

Implications of the Results

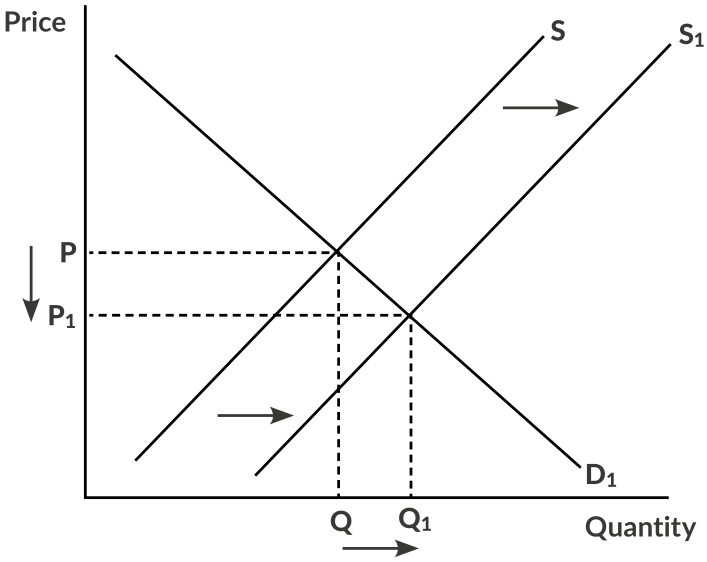
The results of the SFA model estimation imply that households with poor access to transit are vulnerable to having unmet transportation needs. However, this observation needs to be interpreted with some caution. The model identifies that transit stop density is associated with unmet needs on average. For individual households, there are factors that may contribute to unrealized trip demands, and there are factors that will attenuate this relationship. Households with relatively high incomes with access to personal vehicles will be unlikely to have unmet transportation needs even though they may live in locations with poor transit access. These households may have even self-selected into these home locations because they require less access to urban services, or prefer locations with a lower density of urban amenities. The estimated effect of transit stop density on unmet transportation needs should not necessarily to applied to these households. Where, on the other hand, households have limited access to personal vehicles and have lower incomes it is reasonable to conclude that transit accessibility becomes a binding constraint on trip-making behavior.

It is also not the case that eliminating unmet transportation needs could be achieved by providing better transit service alone. In many rural locations, this would simply not be feasible, and even if feasible it might not meet the specific needs of many households. A household with a member who would benefit from mobility assistance may choose to live where transit services are poor simply because traditional public transportation services will not meet their mobility requirements.

It is also the case that lowering the cost to access transportation will always result in more household trip-making. Transportation is a "normal good", meaning that demand for transportation increases as price declines. In Figure 6 below transportation demand is represented along with a shift in supply. The equilibrium price and quantity are represented by (P) and (Q) respectively where demand (D1) intersects with supply (S). But when new supply (S1) is brought online the new equilibrium price and quantity shifts to (P1) and (Q1). With an increase in supply, the price has dropped and the quantity demanded has increased.

Transportation demand is always a function of how much a household must pay for transportation services. The objective of public policy is not to ensure that unpriced demand for transportation is satisfied. This would be a dramatically inefficient result. Instead, public objectives include ensuring that households do not face undue hardship in accessing transportation, either due to limits on household income or due to other binding constraints such as infirmity or disability.

Figure 6: Demand for Transportation and a Shift in Supply



Source: ECONorthwest

The SFA model does provide us with insights into what conditions are likely to be associated with substantial unmet transportation needs. Specifically, locations with higher concentrations of lower-income households and limited transit supply. And with some additional analysis, we can extend those results to help identify the general magnitude of the unmet needs in order to quantify and even monetize those estimates. The rest of this report describes those steps and their findings.

APPLYING THE MODEL TO WASHINGTON HOUSEHOLDS

The SFA model was estimated on a household travel survey sample that was administered in the central Puget Sound region. That model has yielded a novel method for estimating unmet household transportation needs. But those results, on their own, will not provide an estimate of the magnitude of those unmet needs across the state of Washington. To produce such a result it is necessary to devise a means of applying the SFA model to some representation of the entire universe of households within Washington. And that representation of households must contain the necessary information about household demographics and transit access that was available for model estimation.

The approach to addressing this challenge that was selected was to statistically synthesize every household in the state. Population synthesis is a technique often used in travel demand modeling. In short, it is a family of techniques that generate a list of households and their characteristics from a sample of households from a large geography (e.g. county or state) and aggregate information about the population of households from smaller geographies (e.g. census tracts). The product is a list of every household in the state along with their household characteristics and the census tract in which they reside.

Once a synthetic household population was developed it was possible to load the household list into the Stata software and apply the SFA model. The SFA model predicts the daily number of trips each household makes as well as the measure of technical efficiency relative to the household trip-making efficient frontier. The result of this process is a calculated count of the unmet trips by each household in each census tract in Washington state. This list can be sorted, filtered, and summarized to produce an estimate of the magnitude of unmet transportation needs for the state of Washington as a whole of its respective counties and census tracts.

Synthesizing Households

Synthesizing households is often the first step in travel demand estimation. It is a necessary step if individual persons or households are needed in the demand modeling process. The U.S. Census produces summaries of population and household characteristics at various census geographies and provides access to a public use sample of individual household and population records. But information about the entire population is suppressed for confidentiality reasons. In estimating travel demand it is necessary to have information at the household level which allows for the estimation of joint distributions of household or population characteristics. Or, in the case of more advanced demand modeling techniques, travel behavior can be simulated directly from a comprehensive list of households and their household population. The process described here is consistent with the simulation of household behavior directly, but where the application of the SFA model will permit the estimation of the unmet demand as well as the observed trip-making behaviors.

Specifically, for current purposes household sample data from the U.S. Census Public Use Microdata Sample (PUMS) for individual Washington State Public Use Microdata Areas (PUMAs) served as the seed information for the synthetic household population. American Community Survey (ACS) household and population summary files at the census tract level were used as the control totals for the synthetic household population. The PopulationSim software was used to generate the synthetic population. That software and its application are described in the following paper[2]. PopulationSim is an open platform for population synthesis developed by Resource Systems Group for the Oregon Department of Transportation. It is a shared, open, platform that can be easily adapted for statewide, regional, and urban transportation planning needs. It is implemented in the python programming language and is part of the ActivitySim travel demand modeling framework. The software can be accessed through GitHub[3].

[2] https://trid.trb.org/view/1496005
[3] https://github.com/ActivitySim/populationsim

The synthesized household population includes the same attributes of households as those that were utilized in the SFA model estimation. These include persons per household, number of workers, number of children, age of the head of household, income, and number of vehicles available to household members. And for each household, a transit stop density variable was appended. This lays the groundwork for the application of the SFA model to the full synthetic household population.

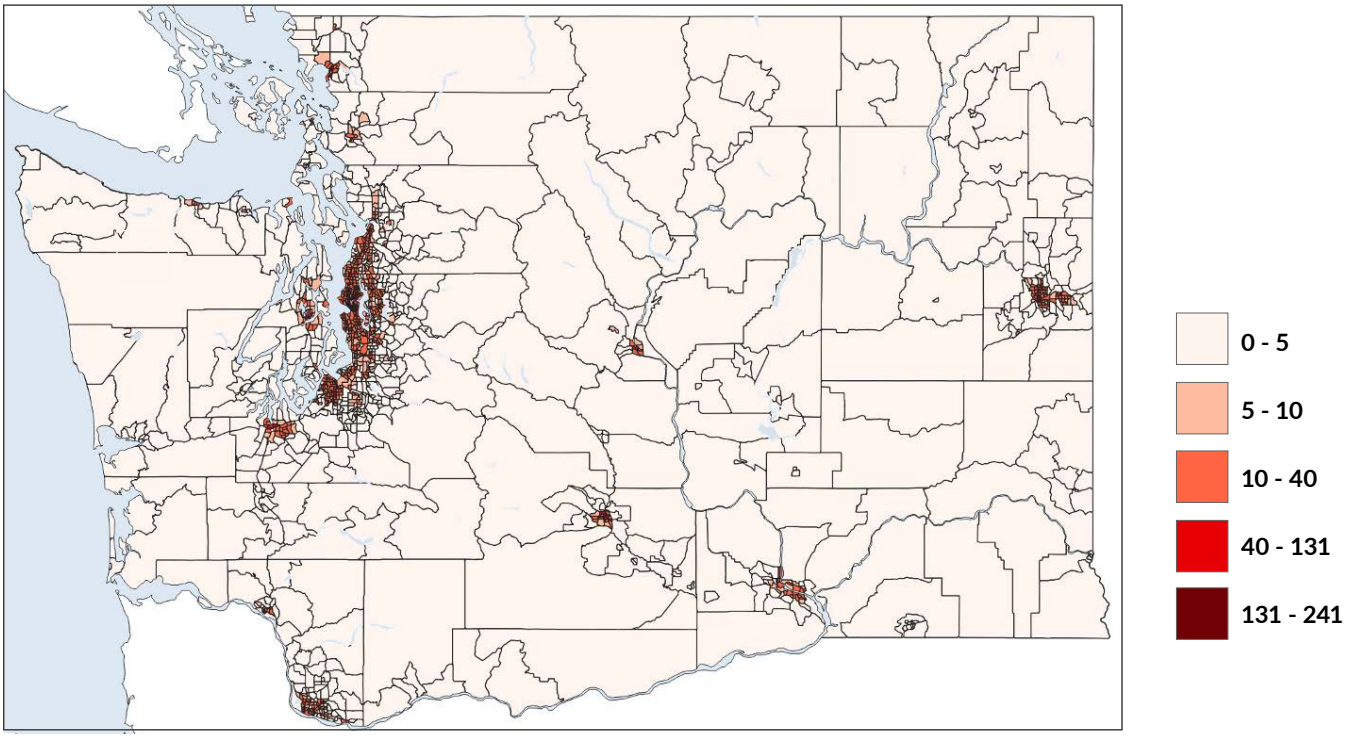
Applying the Unmet Needs Model to the Synthetic Population

The SFA model was applied in the estimation of trips, technical efficiency measures and unmet needs estimates for the synthetic household population for Washington state. The product of this model application is an individual record for each household in the synthetic population. As discussed previously not every households in Washington state has unmet transportation needs. Yet the SFA model will estimate a technical efficiency score for each household which translates into a calculation of unmet needs. This is due, in part, to the stochastic nature of the SFA model and the boundary introduced by the efficiency frontier (technical efficiency scores can never be greater than 1.0). To address this issue the household records are first filtered to isolate households that are likely candidates for experiencing mobility barriers.

This first filter applied is one that captures all households that live in locations with transit stop density of less than ten stops per square mile. As can be seen in Figure 7 this filter captures the greater part of the state of Washington outside of the most urbanized locations.

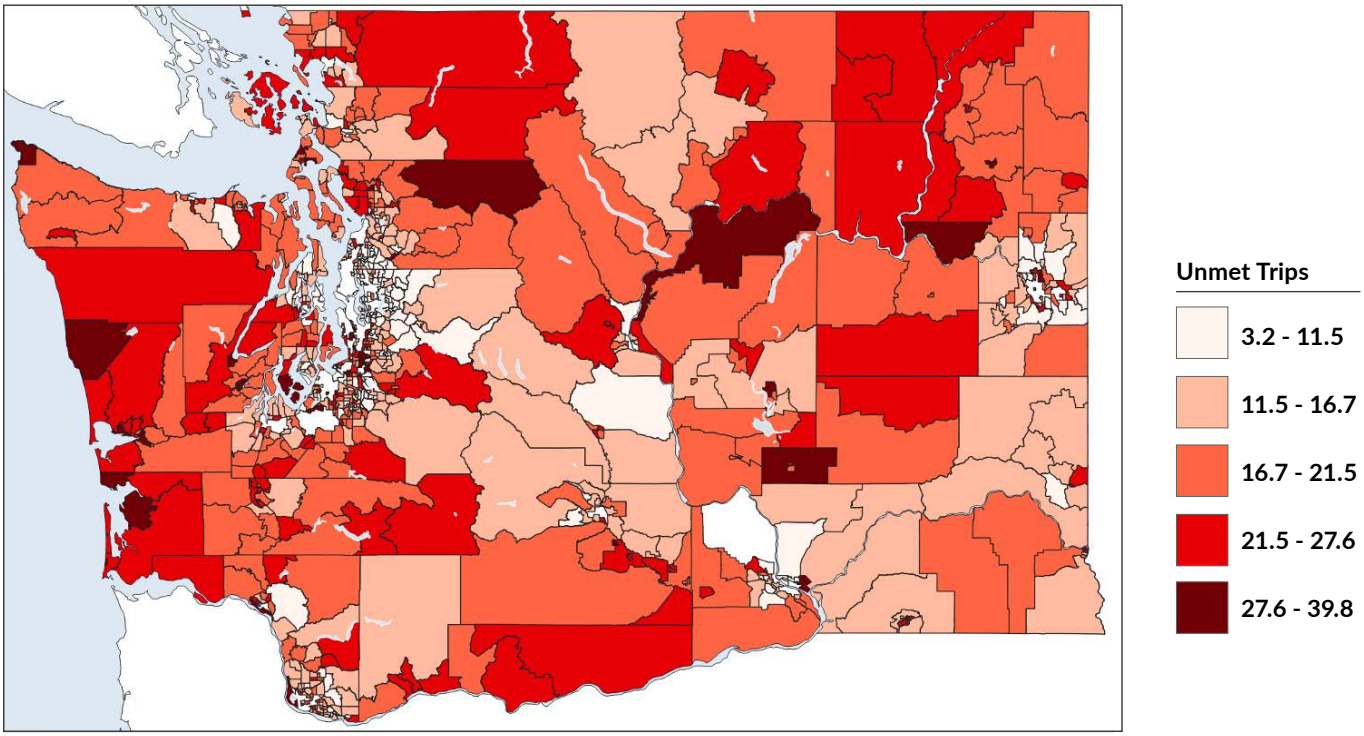
Next these records were filtered for households that earned below 80 percent of the area median income, had a head of household in excess of 70 years old, had a household member with a disability, or had no vehicles or fewer vehicles available than workers. The filters resulted in a total of more than 270,000 households that potentially face constraints that contribute to unmet transportation needs. The calculation of unmet needs is a straight-forward process of applying the technical efficiency scores to the household trip counts and then annualizing the result assuming an annualization factor of 300 applying different weights for weekdays and for weekends.

Figure 7: Transit Stop Density (Stops per Sq. Mi.)



Source: ECONorthwest

Figure 8: Annual Unmet Trips Per Resident Household (Census Tracts)



Source: ECONorthwest

Figure 8 displays the census tract results for household unmet needs in the form of trip counts measured on a per household basis. The denominator is the total count of households located in the census tract. This provides insight into the intensity of the unmet need by location. Census tracts with a lower population of households with unmet needs, or with households with fewer unmet needs will show up as having a lower level of need per total household.

ESTIMATING THE COSTS OF UNMET NEEDS

The final and possibly the most challenging step in the process of estimating unmet transportation needs it to turn the count of unmet trips into a monetary equivalent. If every unmet trip were identical in length, location, purpose, timing, mode, and cost then this step might be trivial. But demand for travel is non-standardized, occurs under a very wide range of conditions, and is not reducible to a simple transportation widget. This challenge is made more complicated by the fact that unmet trips are not observed directly and so little inference can be made about the particulars that might inform the cost estimation process.

It is tempting to simply examine existing transit service provider cost information in an attempt to extract a simple unit cost to apply to the unmet trip counts. Transit operators in the state of Washington contribute local data to an annual Summary of Public Transportation. From this summary we see that urban fixed-route service costs on average around $8.00 in agency funds per trip, and rural fixed-route service an average of around $13.00 per trip. But these averages obscure the high degree of variability in the costs of providing service. And other types of service, such as demand response or route-deviated service, face very different costs. And in places where traditional transit services are not financially viable other forms of mobility service (e.g. taxis and rideshare services) might fill a void.

Many human service providers have begun to also provide transportation to and from their service centers for clients that require mobility assistance. This is another form of transportation with its own unique costs and benefits. For the purposes of this report a fairly simple and rigid costs model will need to be used in order to develop a standardized estimate of unmet needs. But that fact should not end the discussion of costs. Ideally cost estimates will be

refined as better local information is developed and as specific strategies are devised to address the unmet transportation needs.

Approaches to Cost Estimation

Estimating the costs of unmet transportation needs begins with establishing some basis for how something we don't directly observe influences the welfare of the households facing mobility challenges. The costs of unmet needs should be estimated in a manner that is independent from the any specific services, approach, or technology, that we imagine could be used to address the unmet need. If costs are entangled with technology choices then our logic is circular and the mobility solution that we imagine deploying determines the "value" of addressing the unmet transportation need.

So to begin with we turn to economic theory. Households engage transportation in order to participate in activities that are considered important. Transportation itself is a secondary cost that must be borne in order to benefit from the primary activity. In this sense individuals have a "willingness to pay" for transportation. If their "willingness to pay" exceeds the actual costs of the transportation services then the individual makes a trip. If "willingness to pay" is less than the price of travel then no trip is made. When no trip is made the individual is forgoing the benefits of engaging in the activity that the trip was facilitating. Returning to Figure 6 we see that in the original equilibrium state for every point on the demand curve for travel (D1) above the price (P) there is "willingness to pay" that is higher than the price. These individuals enjoy what is called consumer surplus. The total consumer surplus is defined by the region of the chart below the demand curve (D1) and above the price (P). In the case where supply shifts outward and price drops we see that consumer surplus increases. Consumer surplus is now the region below the demand curve (D1) and above the price (P1).

There are a few important observations about this general price theory. First, travel demand is in part determined by the price of transportation. If the price of travel was zero everyone would consume more travel. A second related point is that not all travel is of equal importance to individual consumers. A trip to the doctor might be more important (valuable) than a trip to the mall, and a first trip to the grocery store may be more important than a second one in as many days. Third, people make choices about which trips they take based on how valuable those trips are and the costs to make the trip. And finally, those choices are constrained by income. This final point is critical and implies that "willingness to pay" can be a misleading indicator of value when it is unduly constrained by limits in income.

Ideally, we would still use consumer surplus as our means of estimating the value of unmet trips. This is because it is household "welfare" that is important for determining value not the cost of providing and particular transportation service. If the services cost more than the improvement in household welfare then deploying those services will be less desirable than some alternative means of meeting household needs. In practice observing changes in household welfare is difficult. Increasing household income might remove the constraint on "willingness to pay" but again we face the question of by how much do we need to increase household income.

So we return to the practical questions of estimating the costs of unmet needs. And broadly speaking we are left with two choices. We can look to the costs associated with directly providing the public transportation services that address the unmet trip demands. Or we can try to estimate the costs associated with reducing the price to households for accessing services that are generally already available but too expensive.

An example of the latter approach would be providing vouchers for taxi or rideshare services. There are many questions to answer, all centered around how we determine the value of the voucher. It is important to note that the value of a voucher that effectively addresses the unmet need is not the full cost of providing the transportation service. Instead, the voucher simply needs to reduce the price to the individual enough to make their "ability to pay" plus the voucher exceed the price of the service. Such a program is a potentially viable approach to meeting unmet needs, but determining the value of the voucher is still difficult at this time without market research and in practice would likely involve some experimentation and tailoring to local conditions.

This brings us back to estimating costs using data about currently provided transportation services. But there is so much variation in service type and cost across the many Washington state providers. And costs vary considerably even within a single provider service area. Demand response service is sometimes two to three times more expensive to provide than fixed-route services. It is nearly impossible to simply select one set of cost conditions for use in the estimation of the cost of unmet transportation needs.

Since unmet needs are likely to be a poor match with trip activities that are currently being well served by existing conventional transit services, it is useful to look farther afield. Washington state residents that are eligible for Medicaid are also eligible for reimbursement for transportation required in order to receive Medicaid-supported services. The transportation service reimbursements are brokered by one of a few brokerages across the state. Reimbursements are for actual costs incurred and as such, there is a detailed accounting of costs and service details such as mode of transport, the distance of trips, and their location. The trips themselves might make use of existing public transit systems but might also use private services and even airlines in the case of long-distance travel.

The brokered services result in different average trip reimbursement rates across the regions which reflects local conditions and demands. This source of cost information about trip-making offers a reasonable basis for estimating the costs of unmet needs. Costs reflect local conditions as well as reflect the kind of trips that support the provision of services to households with disabilities or mobility limitations, as opposed to commuting trips within urban places. Table 2 is a table of trips counts and average costs by mode from recently reported brokered services.

These reimbursable costs for transportation services rendered become the central pillar of a cost model that turns estimates of unmet trips into a programmatic estimate of the costs of the unmet transportation needs. The cost model is a household-level model, where households reside in census tracts, and census tracts are associated with counties and Medicaid brokerage regions.

Table 2: Average Trip Costs by Mode

Mode (All Regions)	Trips	Share	Average Cost
Public Bus	1,069,321	31.6%	$2.48
Ambulatory	1,327,918	39.2%	$41.56
Non-Ambulatory	383,192	11.3%	$56.68
Public Bus - ADA	93,754	2.8%	$2.70
Voucher	442,889	13.1%	$8.80
Mileage	32,290	1.0%	$16.50
Volunteer - Agency	21,228	0.6%	$106.21
Volunteer - Broker	6,966	0.2%	$71.21
Airline	215	0.0%	$305.88
Commercial Bus	559	0.0%	$85.14
Train	979	0.0%	$54.11
Ferry	9,586	0.3%	$26.23

Source: ECONorthwest, and Washington Summary of Public Transportation 2019

Preliminary Results of the Cost Estimation

The importance of reasonable cost assumptions cannot be overstated. The programmatic estimates are dependent on trip unit cost assumptions that represent a real opportunity to serve the needs of households' unmet travel demands. As a result, it is not necessarily the case that traditional transit services can be deployed to meet these needs with the level of funds implied in the programmatic cost estimates. For the programmatic cost estimate to serve as a basis for policy, it is important that mobility services of some kind could be reasonably deployed to address the unmet needs; whether those services are public transit, private mobility services, taxis/rideshare services, transport from human service providers, or even vouchers to buy down the costs of other available services in the marketplace.

It will be useful to revisit over time the cost assumption used in this approach to estimating the magnitude of unmet transportation needs. The current method produces a sensible starting position for better understanding the magnitude of the need, but it is unlikely to be the final word. Table 3 displays the final results of the preliminary estimate of the cost of unmet needs by county, including annual unmet trips, annual costs of unmet trips, costs per total households, and costs per household with unmet needs.

Table 3: Preliminary Costs of Unmet Needs by County

COUNTY	ANNUAL UNMET TRIPS	ANNUAL COSTS	COSTS/HH	COSTS/HH W/NEED
Adams	147,000	$6,960,000	$1,160	$5,600
Asotin	180,000	$8,300,000	$910	$4,500
Benton	696,000	$23,030,000	$320	$3,500
Chelan	358,000	$19,930,000	$700	$5,700
Clallam	527,000	$23,470,000	$710	$4,300
Clark	1,886,000	$53,270,000	$300	$3,100
Columbia	37,000	$1,210,000	$670	$2,900
Cowlitz	592,000	$16,720,000	$400	$2,900
Douglas	215,000	$11,990,000	$790	$6,400
Ferry	73,000	$2,680,000	$880	$3,400
Franklin	287,000	$9,480,000	$350	$4,300
Garfield	18,000	$850,000	$870	$4,600
Grant	594,000	$28,080,000	$910	$5,100
Grays Harbor	703,000	$27,260,000	$950	$3,800
Island	670,000	$11,330,000	$330	$1,800
Jefferson	218,000	$9,690,000	$660	$4,300
King	4,969,000	$116,410,000	$130	$2,500
Kitsap	1,035,000	$46,070,000	$440	$4,900
Kittitas	329,000	$10,880,000	$590	$3,300
Klickitat	198,000	$5,590,000	$630	$2,800
Lewis	661,000	$25,610,000	$840	$3,800
Lincoln	99,000	$4,660,000	$1,030	$4,900
Mason	536,000	$20,780,000	$860	$4,000
Okanogan	341,000	$18,990,000	$1,070	$5,400
Pacific	238,000	$9,220,000	$990	$3,600
Pend Oreille	122,000	$4,480,000	$780	$3,700
Pierce	3,352,000	$80,880,000	$250	$2,600
San Juan	166,000	$2,800,000	$340	$1,700
Skagit	710,000	$12,010,000	$250	$1,800
Skamania	108,000	$3,060,000	$640	$3,000
Snohomish	2,620,000	$76,650,000	$260	$3,200
Spokane	1,687,000	$58,920,000	$290	$3,500
Stevens	378,000	$13,860,000	$790	$3,600
Thurston	1,148,000	$44,470,000	$400	$4,100
Wahkiakum	52,000	$1,460,000	$770	$2,900
Walla Walla	436,000	$14,410,000	$640	$3,200
Whatcom	1,049,000	$17,730,000	$200	$1,800
Whitman	306,000	$14,140,000	$790	$3,900
Yakima	991,000	$32,770,000	$390	$3,900
ALL COUNTIES	**28,732,000**	**$890,150,000**	**$310**	**$3,300**

Source: ECONorthwest

The cost estimate of unmet needs is also displayed in the maps that follow. Figure 9 plots the total annual costs of unmet needs by county while Figure 10 displays the per household unmet needs when averaged over total county households.

Figure 9: Annual Cost of Unmet Needs (County)

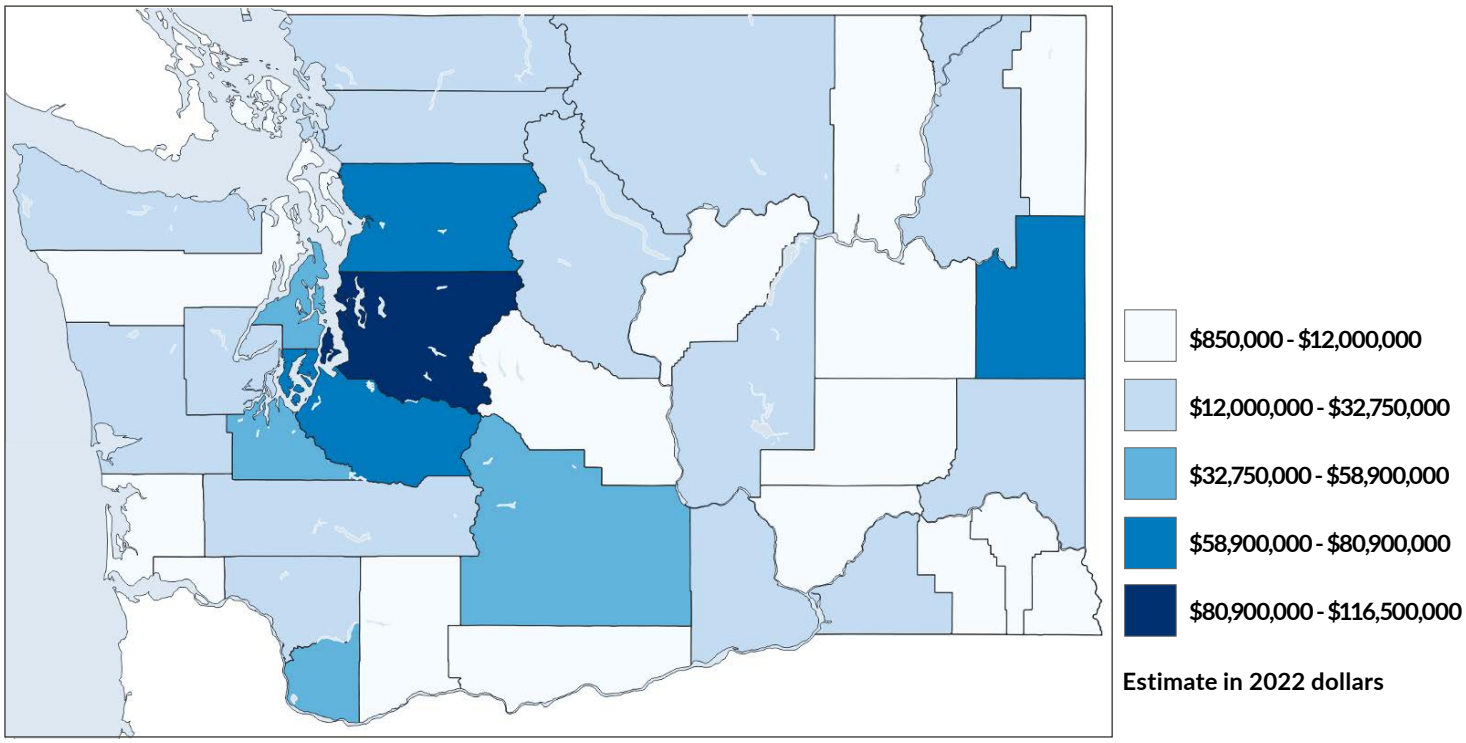
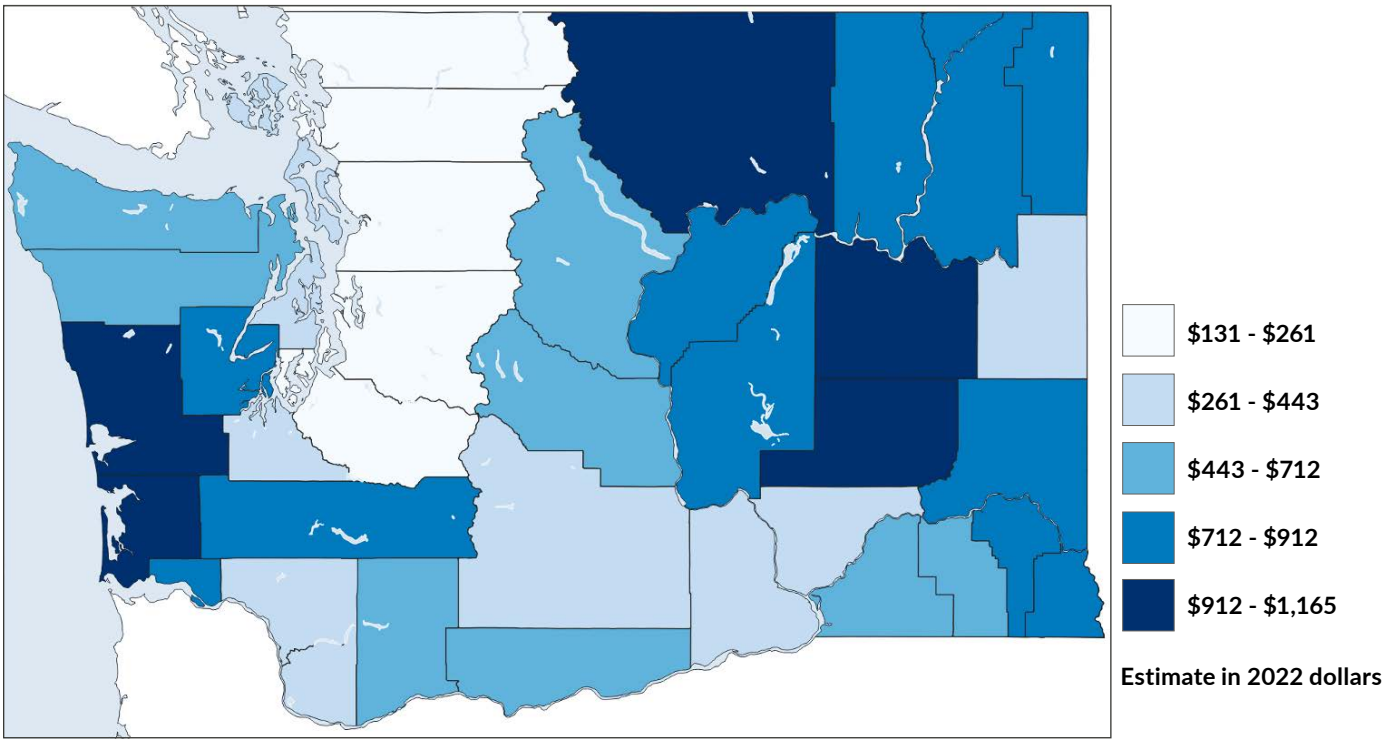


Figure 10: Annual Costs of Unmet Needs Per Household (County)



Source: ECONorthwest

CONCLUSIONS

AN INITIAL STEP

This report describes a novel approach to estimating the magnitude and cost of unmet transportation needs in Washington state, as well as the results of applying that method. The intent of this report is to establish a starting point for further discussion and refinement of a process for consistently estimating such needs on an ongoing basis. The steps involved in the analysis can be replicated, require generally available computer software to implement, and rely upon data that is maintained for public use. In this sense it is repeatable.

As a starting point for further work the estimates generated by these methods are informative (they represent a credible general estimate of the location and magnitude of needs) but not definitive (they are sensitive to assumptions, especially those made about how trip needs can best be served and funded. Combined with recent qualitative research and other studies underway to learn more about non-driving populations and the quality of transit access in Washington these results assist policymakers and transportation professionals and service providers in understanding what may be involved in ensuring the mobility needs of Washington residents are met.

NEXT STEPS

EcoNorthwest will provide a model to WSDOT Data Team which will allow the WSDOT Data Team to run future analyses accounting for updated information. The intention is that WSDOT will be able to improve upon this original model for future studies. Information from this model will inform policy and budget discussion in future sessions.

ENGLISH

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ESPAÑOL

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한국어 – KOREAN

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русский – RUSSIAN

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tiếng Việt – VIETNAMESE

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Thông tin về Đạo luật Người Mỹ tàn tật (Americans with Disabilities Act, ADA)

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Dịch vụ Tiếp âm Tiểu bang Washington theo số 711.

العَرَبِيّة – ARABIC

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中文 – CHINESE

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《美国残疾人法案》(ADA)信息

可向公平和民權辦公室發送電子郵件wsdotada@wsdot.wa.gov 或撥打免費電話 855-362-4ADA(4232)，以其他格式獲取此資料。听力丧失或听觉障碍人士可拨打711联系Washington州转接站。

Af-soomaaliga – SOMALI

Ciwaanka VI Ogeysiiska Dadweynaha

Waa siyaasada Waaxda Gaadiidka Gobolka Washington (WSDOT) in la xaqiijiyo in aan qofna, ayadoo la cuskanaayo sababo la xariira isir, midab, ama wadanku kasoo jeedo, sida ku qoran Title VI (Qodobka VI) ee Sharciga Xaquuqda Madaniga ah ah oo soo baxay 1964, laga saarin ka qaybgalka, loo diidin faa'iidooyinka, ama si kale loogu takoorin barnaamijyadeeda iyo shaqooyinkeeda. Qof kasta oo aaminsan in difaaciisa Title VI la jebiyay, ayaa cabasho u gudbin kara Xafiiska Sinaanta iyo Xaquuqda Madaniga ah (OECR) ee WSDOT. Si aad u hesho xog dheeraad ah oo ku saabsan hanaannada cabashada Title VI iyo/ama xogta la xariirta waajibaadkeena ka caagan takoorka, fadlan la xariir Iskuduwaha Title VI ee OECR oo aad ka wacayso (360) 705-7090.

Macluumaadka Xeerka Naafada Marykanka (ADA)

Agabkaan ayaad ku heli kartaa qaab kale adoo iimeel u diraaya Xafiiska Sinaanta iyo Xaquuqda Madaniga ah oo aad ka helayso wsdotada@wsdot.wa.gov ama adoo wacaaya laynka bilaashka ah, 855-362-4ADA(4232). Dadka naafada maqalka ama maqalku ku adag yahay waxay ku codsan karaan wicitaanka Adeega Gudbinta Gobolka Washington 711.

Translation Services

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Español - Spanish

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tiếng Việt-Vietnamese

các dịch vụ dịch thuật

Nếu quý vị không hiểu tiếng Anh, quý vị có thể yêu cầu dịch vụ trợ giúp ngôn ngữ, miễn phí, bằng cách gọi số 360-705-7921, hoặc email cho chúng tôi tại: PubTrans@wsdot.wa.gov

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한국어-Korean

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으로 전화하시거나 다음 이메일로 연락하셔서 무료 언어 지원 서비스를 요청하실 수 있습니다: PubTrans@wsdot.wa.gov

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русский-Russian

Услуги перевода

Если вам трудно понимать английский язык, вы можете запросить бесплатные языковые услуги, позвонив по телефону 360-705-7921, или написав нам на электронную почту: PubTrans@wsdot.wa.gov

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Arabic - اَلْعَرَبِيَّةُ

خدمات الترجمة

إذا كنت تجد صعوبة في فهم اللغة الإنجليزية، فيمكنك مجانًا طلب خدمات المساعدة اللغوية عن 705-7921)360(طريق الاتصال بالرقم أو مراسلتنا عبر البريد الإلكتروني: PubTrans@wsdot.wa.gov

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Af-soomaaliga - Somali

Adeegyada Turjumaada

Haddii ay kugu adag tahay inaad fahamtid Ingiriisida, waxaad, bilaash, ku codsan kartaa adeegyada caawimada luuqada adoo wacaaya 360-705-7921 ama iimayl noogu soo dir: PubTrans@wsdot.wa.gov

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中文 – Chinese

翻译服务

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MORE INFORMATION

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