FACTORS INFLUENCING RIDERSHIP IN A ZERO-FARE BUS NETWORK:

A CASE STUDY OF INTERCITY TRANSIT IN THURSTON COUNTY, WA STATE

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ABSTRACT

Factors Influencing Ridership in a Zero-fare Bus Network: A Case Study of Intercity Transit in Thurston County, WA State

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This study examines the factors influencing ridership in Intercity Transit's zero-fare bus network in Thurston County, Washington. Implemented in 2020, the zero-fare policy aimed to increase ridership and improve accessibility. However, the concurrent onset of the COVID-19 pandemic complicated the policy's impact. Through a mixed-methods approach combining surveys, geospatial analysis, and statistical modeling, this research investigates the interplay between fare elimination, demographic factors, and external shocks in shaping public transit use. Findings reveal that while the zero-fare policy positively influenced ridership among certain groups, particularly low-income and transit-dependent populations, the pandemic significantly disrupted expected outcomes. This study contributes to the growing body of literature on fare-free public transportation and offers insights for transit agencies considering similar policies, especially in mid-sized urban areas facing unique challenges.

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Introduction

Public transportation plays a vital role in urban mobility, offering numerous benefits including reduced traffic congestion, lower emissions, and increased accessibility.[1] As cities worldwide grapple with growing populations, environmental concerns, and social equity issues, the importance of efficient and inclusive public transit systems has never been more apparent. Beyond simply moving people from point A to point B, robust public transportation networks can significantly impact urban quality of life, economic vitality, and environmental sustainability.[2]

In recent years, a growing number of transit agencies have explored innovative policies to boost ridership and improve equity, with zero-fare transit emerging as a particularly intriguing approach.[3] [4] This concept, which eliminates the need for passengers to pay fares, represents a paradigm shift in how we view public transportation.[5] Researchers have found that by removing financial barriers, zero-fare policies can dramatically increase ridership, particularly among low-income populations, while also streamlining operations and reducing administrative costs associated with fare collection.[6] [7]

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[1] Dorina Pojani and Dominic Stead, "Sustainable Urban Transport in the Developing World: Beyond Megacities," *Sustainability* 7, no. 6 (June 2015): 7784–7805, https://doi.org/10.3390/su7067784.
[2] Kostas Mouratidis, "Urban Planning and Quality of Life: A Review of Pathways Linking the Built Environment to Subjective Well-Being," *Cities* 115 (August 1, 2021): 103229, https://doi.org/10.1016/j.cities.2021.103229.
[3] Krzysztof Grzelec and Aleksander Jagiełło, "The Effects of the Selective Enlargement of Fare-Free Public Transport," *Sustainability* 12, no. 16 (January 2020): 6390, https://doi.org/10.3390/su12166390.
[4] Owen Bull, Juan Carlos Muñoz, and Hugo E. Silva, "The Impact of Fare-Free Public Transport on Travel Behavior: Evidence from a Randomized Controlled Trial," *Regional Science and Urban Economics* 86 (January 1, 2021): 103616, https://doi.org/10.1016/j.regsciurbeco.2020.103616.
[5] Karl Storchmann, "Externalities by Automobiles and Fare-Free Transit in Germany — A Paradigm Shift?," *Journal of Public Transportation* 6, no. 4 (October 1, 2003): 89–105, https://doi.org/10.5038/2375-0901.6.4.5.
[6] Storchmann, "Externalities by Automobiles and Fare-Free Transit in Germany"
[7] Daniel Baldwin Hess, "Decrypting Fare-Free Public Transport in Tallinn, Estonia," *Case Studies on Transport Policy* 5, no. 4 (December 1, 2017): 690–98, https://doi.org/10.1016/j.cstp.2017.10.002.

The idea of fare-free public transit isn't entirely new - small-scale experiments date back to the 1960s - but its implementation in larger urban areas is a more recent phenomenon.[8] As climate change concerns intensify and cities seek ways to reduce car dependency, the potential of zero-fare transit to reshape urban mobility patterns has captured the imagination of policymakers and transit advocates alike.[9]

However, the implementation of zero-fare policies is not without challenges. Questions of financial sustainability, potential overcrowding, and the true impact on car use remain subjects of ongoing research and debate.[10] Moreover, the recent global COVID-19 pandemic has added a new layer of complexity to these discussions, forcing transit agencies to reconsider their approaches in light of public health concerns and drastically altered ridership patterns.[11]

It is within this context that I examine the case of Intercity Transit in Thurston County, Washington. Serving the cities of Olympia, Lacey, Tumwater, and Yelm, the largest local public transportation provider Intercity Transit implemented a zero-fare policy in 2020 after thorough review of various options. The decision aimed to fulfill nine community-defined priorities, including making fare collection more efficient and increasing ridership. By eliminating fares, Intercity Transit sought to reduce travel times through faster boarding, improve environmental outcomes, and enhance access and equity by removing financial barriers, particularly for low-income residents.[12]

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[8] Bull, Muñoz, and Silva, "The Impact of Fare-Free Public Transport on Travel Behavior."
[9] Grzelec and Jagiełło, "The Effects of the Selective Enlargement of Fare-Free Public Transport."
[10] Wojciech Kębłowski, "Why (Not) Abolish Fares? Exploring the Global Geography of Fare-Free Public Transport," *Transportation* 47, no. 6 (December 1, 2020): 2807–35, https://doi.org/10.1007/s11116-019-09986-6.
[11] Fariba Siddiq et al., "Transit's Financial Prognosis: Findings from a Survey of U.S. Transit Systems during the COVID-19 Pandemic," *Public Works Management & Policy*, March 27, 2023, https://doi.org/10.1177/1087724X231160097.
[12] "Zero-Fare Services," Intercity Transit, accessed April 20, 2023, https://www.intercitytransit.com/zerofare-faqs.

While the agency had anticipated a boost in ridership following the transition to a zero-fare model, a dramatic 51% decrease in ridership occurred promptly after the onset of the COVID-19 pandemic in 2020. Despite the fare elimination, recovery had since stalled short of pre-pandemic levels. This unexpected outcome presented an intriguing discrepancy that warranted further investigation.[13]

This research aims to address the following questions: What factors explain why eliminating fares did not sustainably increase ridership for Intercity Transit as initially anticipated? And, more broadly, what factors influence ridership in a zero-fare public transportation system?

By exploring Intercity Transit's experience, this research contributes to the broader literature on zero-fare transit policies and their effectiveness in different settings, offering insights into the interplay between fare-free policy, external shocks, and local transportation dynamics. These findings may prove valuable for transportation planners and policymakers considering similar initiatives, particularly in mid-sized urban areas facing unique challenges.

The remainder of this thesis is organized as follows: Section 2 presents a comprehensive literature review on public transportation benefits and zero-fare policies. Section 3 details the study approach, data collection, and analysis methods. Section 4 provides an overview of Thurston County's transportation landscape and Intercity Transit's zero-fare policy implementation. Section 5 presents the results of the analyses, while Section 6 discusses the implications of these findings. Finally, Section 7 concludes the study, summarizing key insights and suggesting directions for future research.

[13] "The Profile: Thurston County Statistics & Data," Thurston Regional Planning Council, WA, December 2023, https://www.trpc.org/391/The-Profile-Thurston-County-Statistics-D.

Literature Review

Benefits of Public Transportation

Public transportation provides numerous community-wide benefits beyond basic mobility and access. Researchers have extensively examined public transportation's impacts on economics, the environment, public health, and social equity.[14] Understanding these advantages is important when making decisions around urban planning and transportation policy.

Environmental Benefits

Public transportation plays a crucial role in creating more sustainable cities and regions by reducing energy consumption and greenhouse gas emissions from the transportation sector.[15]

According to the Federal Transit Administration, 18.3% of buses in the U.S. are now hybrid electric, emitting 55% less greenhouse gases per passenger mile than the average single-occupancy vehicle. Moreover, public transportation saves the U.S. 6.0 billion gallons of gasoline annually.[16] A single person switching from a private car to public transit can reduce their annual CO_2 emissions by 4,800 pounds. [17]

In addition to reducing greenhouse gas emissions, public transportation also decreases other harmful pollutants like carbon monoxide, volatile organic compounds, nitrogen oxide, and particulate matter.[18] These emission reductions yield significant public health benefits: lower

[14] Faissal Jelti, Amine Allouhi, and Kheira Anissa Tabet Aoul, "Transition Paths towards a Sustainable Transportation System: A Literature Review," *Sustainability* 15, no. 21 (January 2023): 15457, https://doi.org/10.3390/su152115457.
[15] Susan A. Shaheen and Timothy E. Lipman, "Reducing Greenhouse Emissions and Fuel Consumption: Sustainable Approaches for Surface Transportation," *IATSS Research* 31, no. 1 (January 1, 2007): 6–20, https://doi.org/10.1016/S0386-1112(14)60179-5.
[16] Matthew Dickens, "2023 Public Transportation Fact Book" (*American Public Transportation Association*, March 2023), https://www.apta.com/wp-content/uploads/APTA-2023-Public-Transportation-Fact-Book.pdf.
[17] "Transit and Sustainability," Federal Transit Administration, October 21, 2023, https://www.transit.dot.gov/regulations-and-programs/environmental-programs/transit-and-sustainability.
[18] Krystian Pietrzak and Oliwia Pietrzak, "Environmental Effects of Electromobility in a Sustainable Urban Public Transport," *Sustainability* 12, no. 3 (January 2020): 1052, https://doi.org/10.3390/su12031052.

levels of these air pollutants from fewer vehicles on the road leads to improved respiratory health and fewer early deaths, especially in dense urban areas.[19] [20]

Furthermore, by reducing the number of single-occupancy vehicles on roadways, public transportation helps alleviate traffic congestion in urban areas.[21] One study of Salt Lake City's University's light rail system estimates that the light rail line reduced daily vehicle traffic on the study corridor by about 50%, while another study of Los Angeles finds that when a strike halted transit service for five weeks, average highway congestion delay increased 47%, although only 11% of Los Angeles commutes use transit.[22] The congestion-reduction benefits have even higher values in larger and more congested urban areas.[23] The reduction in time spent on the road from expanded public transit further promotes energy conservation and emission reduction goals at local and national levels.

Economic & Social Equity Benefits

Public transportation offers significant cost savings compared to private vehicle ownership and use over the long term. According to a report by the American Public Transportation Association, individuals who use public transportation can save an average of $10,000 annually by avoiding expenses associated with owning, operating, and maintaining a private vehicle.[24]

[19] Ioannis Manisalidis et al., "Environmental and Health Impacts of Air Pollution: A Review," *Frontiers in Public Health* 8 (February 20, 2020), https://doi.org/10.3389/fpubh.2020.00014.
[20] Pietrzak and Pietrzak, "Environmental Effects of Electromobility in a Sustainable Urban Public Transport."
[21] Tina Hodges, "Public Transportation's Role in Responding to Climate Change" (*Federal Transit Administration*, January 1, 2010), https://rosap.ntl.bts.gov/view/dot/17277.
[22] Reid Ewing, Guang Tian, and Allison Spain, "Effect of Light-Rail Transit on Traffic in a Travel Corridor," *Transportation Research and Education Center (TREC)*, June 1, 2014, https://doi.org/10.15760/trec.56.
[23] Todd Litman, "Evaluating Public Transit Benefits and Costs: Best Practices Guidebook" (*Victoria Transport Policy Institute*, May 2023), https://www.vtpi.org/tranben.pdf.
[24] Dickens, "2023 Public Transportation Fact Book."

For lower-income households especially, access to affordable public transportation enhances longer-term financial security by freeing up funds for other essential needs, including food, healthcare and education. [25] According to a report by Federal Transit Administration, a worker can save at least 50% per year on commuting, by using transit services instead of a personal vehicle.[26]

Moreover, public transportation contributes to the broader economy. The American Public Transportation Association reports that every $1 invested in public transportation generates $5 in economic returns. This includes job creation, increased property values, and enhanced business activity near transit hubs.[27]

In terms of equitable access and social inclusion, public transportation provides affordable mobility options for all community residents when designed properly.[28]

According to the 2010 Census, 41.8 million Americans age 18+ have disabilities; 40 million Americans are age 65+, many of whom do not or should not drive; and 32 million American adults are living below the poverty level. These vulnerable people, as well as other zero-vehicle households and households without a licensed driver, rely much more on non-auto modes like public transit, walking, bicycling, and taxi/ride-hailing services.[29]

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[25] Ipek N. Sener, Richard J. Lee, and Zachary Elgart, "Potential Health Implications and Health Cost Reductions of Transit-Induced Physical Activity," *Journal of Transport & Health* 3, no. 2 (June 2016): 133–40, https://doi.org/10.1016/j.jth.2016.02.002.
[26] Fang Zhao and Thomas Gustafson, "Transportation Needs of Disadvantaged Populations: Where, When, and How?," *Federal Transit Administration*, no. 30 (February 2013), https://www.transit.dot.gov/sites/fta.dot.gov/files/FTA_Report_No._0030.pdf.
[27] Economic Development Research Group, "Economic Impact of Public Transportation Investment 2020 Update" (*American Public Transportation Association*, February 2020), https://www.apta.com/wp-content/uploads/APTA-Economic-Impact-Public-Transit-2020.pdf.
[28] Karen Lucas et al., "Transport Poverty and Its Adverse Social Consequences," *Proceedings of the Institution of Civil Engineers - Transport* 169, no. 6 (December 2016): 353–65, https://doi.org/10.1680/jtran.15.00073.
[29] Zhao and Gustafson, "Transportation Needs of Disadvantaged Populations."

High-quality public transportation can increase access to opportunities for disadvantaged populations: job accessibility for low-income workers; access to healthcare facilities for seniors and people with disabilities; access to educational institutions for students from low-income families.[30] By connecting these transit-dependent individuals to opportunities and civic participation, public transportation greatly promotes social equity and enhances their quality of life.

Individual Health Benefits

Public transit riders often achieve health benefits compared to driving alone thanks to built-in incidental exercise.[31] Transit commuters tend to walk up to 30 additional minutes total each day accessing bus stops and rail stations versus driving door-to-door, according to a study conducted in Melbourne, Australia.[32]

This additional physical activity from walking to and from transit yields measurable public health outcomes for individuals. These include lower population rates of obesity, diabetes, cardiovascular disease, and potentially longer lifespans.[33]

Meanwhile, transit trips require less mental effort than driving in congested conditions with road stressors like traffic, accidents, and construction, thus public transit can reduce stress levels compared to driving in congested conditions. One study found that among people who live

[30] Karen Lucas, "Transport and Social Exclusion: Where Are We Now?," Transport Policy, *Urban Transport Initiatives*, 20 (March 1, 2012): 105–13, https://doi.org/10.1016/j.tranpol.2012.01.013.
[31] Sener, Lee, and Elgart, "Potential Health Implications and Health Cost Reductions of Transit-Induced Physical Activity."
[32] Vicki Brown et al., "Better Transport Accessibility, Better Health: A Health Economic Impact Assessment Study for Melbourne, Australia," *International Journal of Behavioral Nutrition and Physical Activity* 16, no. 1 (October 22, 2019), https://doi.org/10.1186/s12966-019-0853-y.
[33] Sener, Lee, and Elgart, "Potential Health Implications and Health Cost Reductions of Transit-Induced Physical Activity."

in the most congested cities, public transit commuters report about 6% lower stress levels than car commuters. [34]

Furthermore, Edwards quantified the health cost savings associated with transit-induced physical activity in the United States, estimating about $5,500 per person-year for transit users.[35] This suggests a potential nationwide savings of $20 billion if 20% of sedentary adults switched to public transit.

Zero-fare / Fare-free Policy

Zero-fare transit, more commonly known as fare-free public transport (FFPT), is a transportation scheme that offers public transit services without requiring any direct payment from users. The concept essentially entails eliminating fares and other payment models for public transportation. By making these services free of charge, it typically aims to promote their use by removing financial barriers that may discourage people from choosing public transit over other modes of transportation such as private vehicles.[36]

Implementing FFPT

There are different approaches to implementing FFPT. The most common form is a hybrid model where only certain categories of passengers such as students, seniors, or low-income residents can ride for free while other users still need to purchase tickets or passes. For example, Brussels introduced free public transport for all primary and secondary school pupils in

[34] Marta Aranha Conceição et al., "The Effect of Transport Infrastructure, Congestion and Reliability on Mental Wellbeing: A Systematic Review of Empirical Studies," *Transport Reviews* 43, no. 2 (July 20, 2022): 264–302, https://doi.org/10.1080/01441647.2022.2100943.
[35] Sener, Lee, and Elgart, "Potential Health Implications and Health Cost Reductions of Transit-Induced Physical Activity."
[36] Oded Cats, Yusak O. Susilo, and Triin Reimal, "The Prospects of Fare-Free Public Transport: Evidence from Tallinn," *Transportation* 44, no. 5 (September 1, 2017): 1083–1104, https://doi.org/10.1007/s11116-016-9695-5.

the city.[37] [38] Another approach is to make the entire transit network within a certain zone or region fare-free, encompassing bus, tram, and metro/subway lines.[39] [40] The Estonian city of Tallinn was the first in the world to make all public transportation fully free of charge to all residents and visitors in 2013.[41] Some cities adopt a limited fare-free period to test the impacts. For instance, Dunkirk in France eliminated fares for one year from 2018 to 2019 on all 69 lines of its urban public transit network.[42] [43]

Pros and Cons of FFPT

The benefits of FFPT principally come from the promotion of public transit usage. Thus, the most common arguments of proponents are the same as the benefits of public transit in a general way: FFPT has the potential to significantly increase ridership, reducing traffic congestion and greenhouse gas emissions, benefiting public health and social equity.

While fare elimination policies may seem attractive in concept for users, since they allow users to ride for free, there are several potential drawbacks to consider. One of the main concerns is the substantial cost of implementing and maintaining such a fare-free system long-term. Besides, large-scale FFPT also usually involves network upgrades and capacity expansion to absorb demand growth. Eliminating fare revenues requires an alternative public funding source

[37] Astrid De Witte et al., "The Impact of 'Free' Public Transport: The Case of Brussels," *Transportation Research Part A: Policy and Practice* 40, no. 8 (October 1, 2006): 671–89, https://doi.org/10.1016/j.tra.2005.12.008.
[38] Wojciech Kębłowski, "Free Public Transport: Scope and Definitions," in Free Public Transport And Why We Don't Pay To Ride Elevators, ed. Dellheim Judith and Jason Prince (Montreal: Black Rose Books, 2018), 1–6, https://researchportal.vub.be/en/publications/free-public-transport-scope-and-definitions.
[39] Nils Fearnley, "Free Fares Policies: Impact on Public Transport Mode Share and Other Transport Policy Goals," *International Journal of Transportation* 1, no. 1 (December 31, 2013): 75–90, https://doi.org/10.14257/ijt.2013.1.1.05.
[40] Joel Volinski, Implementation and Outcomes of Fare-Free Transit Systems (Washington, D.C.: Transportation Research Board, 2012), https://doi.org/10.17226/22753.
[41] Cats, Susilo, and Reimal, "The Prospects of Fare-Free Public Transport."
[42] Henri Briche and Maxime Huré, "Dunkirk as a New 'Laboratory' for Free Transit," trans. Waine Oliver, Metropolitics, June 29, 2017, https://metropolitics.org/Dunkirk-as-a-New-Laboratory-for-Free-Transit.html.
[43] Cees van Goeverden et al., "Subsidies in Public Transport," European Transport 32, no. 5–25 (2006), http://hdl.handle.net/10077/5892.

to compensate for the loss, which places a bigger financial burden on local tax authorities. Financing frequently combines central and local state subsidies with new income sources like employer or local taxes.[44] [45] That is why short-term pilot projects are needed before most agencies consider implementing FFPT on a long-term basis.

Additionally, FFPT may lead to overcrowding issues on transit vehicles as ridership spikes, degrading the level of customer comfort and service quality if not properly addressed. In other words, the service levels need to be expanded accordingly to maintain a reasonable level of riding experience quality. [46] [47]

Another issue is the lack of demand management. Without fares influencing travel behaviors, there is less leverage for authorities to redistribute or regulate demand across different transit modes, routes, and times through incentives like shorter waiting times on less crowded services.[48]

Empirical findings also pose questions to FFPT. Some opponents argue FFPT generates "useless mobility", which in this context refers to "trips that would not have taken place if the fare-free policy had not been implemented", and risks operator insolvency eventually.[49] [50] [51] In

[44] Kębłowski, "Free Public Transport."
[45] CUTR, "Advantages and Disadvantages of Fare-Free Transit Policy," Research Reports, November 1, 2002, https://doi.org/10.5038/CUTR-NCTR-RR-2002-17.
[46] Fearnley, "Free Fares Policies."
[47] Robert Cervero, "Transit Pricing Research: A Review and Synthesis," *Transportation* 17, no. 2 (February 1, 1990): 117–39, https://doi.org/10.1007/BF02125332.
[48] Storchmann, "Externalities by Automobiles and Fare-Free Transit in Germany."
[49] Herbert J. Baum, "Free Public Transport," Journal of Transport Economics and Policy 7, no. 1 (1973): 3–19.
[50] Yves Duhamel, "Gratuité ses Transports Publics Urbains et Repartition Modale : Retour sur Rapport Final" Axiales, PREDIT, ADEM (June 29, 2004), https://www.utp.fr/index.php/note-publication/gratuite-des-transports-publics-urbains-et-repartition-modale.
[51] Lawrence B. Doxsey and Bruce D. Spear, "Free-Fare Transit: Some Empirical Findings," in Transportation Research Record, 1981, http://onlinepubs.trb.org/Onlinepubs/trr/1981/799/799-010.pdf.

terms of sustainability, limited evidence shows that FFPT has facilitated modal shift, though this shift is mostly from walking and cycling rather than cars.[52] [53] [54]

Prerequisite of FFPT

Several factors shape the feasibility of FFPT. Primarily, fare revenues should not constitute a substantial portion of the transit agency's income; otherwise, FFPT may adversely impact their financial stability, especially in the initial stages. [55] Also, the transit networks should have excess capacity that would allow a certain extent of passenger flow surge.[56]

From an external perspective, since FFPT is subsidized from public funds, whether or not a consensus can be reached with taxpayers directly determines the feasibility of the project. According to CUTR and Van Goeverden et al., the likelihood of a successful FFPT initiative increases in areas where public opinion research indicates that residents perceive fare elimination as a tax-funded public service similar to roads, rather than as a free commodity. [57] [58] This perception is essential for fostering political consensus and ensuring the long-term financial sustainability of fare-free transit systems.

Some best practices for FFPT include establishing integrated multi-modal transit networks, which help manage demand by offering various transportation options and optimizing existing capacities before investing in additional infrastructure.[59] [60] Collaborating with larger

[52] Cats, Susilo, and Reimal, "The Prospects of Fare-Free Public Transport."
[53] van Goeverden et al., "Subsidies in Public Transport."
[54] Doxsey and Spear, "Free-Fare Transit."
[55] David C. Hodge, James D. Orrell III, and Tim R. Strauss, "Fare-Free Policy: Costs, Impacts on Transit Service, and Attainment of Transit System Goals," Washington State Department of Transportation, March 1994, http://www.wsdot.wa.gov/research/reports/fullreports/277.1.pdf.
[56] Volinski, Implementation and Outcomes of Fare-Free Transit Systems.
[57] CUTR, "Advantages and Disadvantages of Fare-Free Transit Policy."
[58] van Goeverden et al., "Subsidies in Public Transport."
[59] Cervero, "Transit Pricing Research: A Review and Synthesis."
[60] Todd Litman, "Transit Price Elasticities and Cross-Elasticities," Journal of Public Transportation 7, no. 2 (April 1, 2004): 37–58, https://doi.org/10.5038/2375-0901.7.2.3.

urban or metropolitan regions can provide access to more funding resources due to their larger populations and broader tax bases compared to independent municipal efforts. Research also indicates that implementing temporary fare-free trials, along with conducting quantitative studies to demonstrate their benefits, can strengthen the case for long-term FFPT proposals.[61] [62]. This approach allows agencies to gather data on ridership impacts, cost-effectiveness, and public reception before committing to permanent policy changes.

FFPT Outcomes

Ridership is an important indicator for evaluating the quality of public transit operations. Empirical evidence shows FFPT tends to significantly increase ridership on public transport, with rates varying from 12% to 76%. [63] [64] [65] For example, almost a year after the introduction of FFPT, public transport usage in Tallinn increased by 14%, with a patronage rise of 24% due to an increase in the average public transport trip length.[66] FFPT also led to a trip generation effect among low-income and unemployed users, resulting in a more than 20% increase in the market share of public transport for these demographics.[67] Moreover, the increase in the number of inhabitants registered in Tallinn following the FFPT implementation contributed to the policy's financial viability. This additional income from tax collection allowed the City of Tallinn to cover the costs associated with fully subsidizing public transport operational expenses.[68]

[61] Maxime Huré, "Free Public Transport: From Social Experiment to Political Alternative?," trans. Oliver Waine, Metropolitics, March 20, 2013, https://metropolitics.org/Free-public-transport-from-social.html.
[62] Kębłowski, "Why (Not) Abolish Fares?"
[63] Cats, Susilo, and Reimal, "The Prospects of Fare-Free Public Transport."
[64] van Goeverden et al., "Subsidies in Public Transport."
[65] Volinski, Implementation and Outcomes of Fare-Free Transit Systems.
[66] Cats, Susilo, and Reimal, "The Prospects of Fare-Free Public Transport."
[67] Cats, Susilo, and Reimal, "The Prospects of Fare-Free Public Transport."
[68] Cats, Susilo, and Reimal, "The Prospects of Fare-Free Public Transport."

The share of new passengers from other transport modes varies, with studies reporting previous car users constituting 10-25% of new passengers.[69] As for the spatial scale, smaller systems appear to benefit more in relative terms, while the benefits for big cities may be less pronounced due to their complex transit systems and higher operational costs, potentially making long-term implementation more challenging. [70] [71] [72]

Literature Gap

The literature review reveals a robust body of research on the benefits of public transportation and the potential impacts of zero-fare policies. However, there is a notable gap in studies focusing on zero-fare transit in mid-sized communities, particularly in the context of external shocks like the COVID-19 pandemic. While larger cities have been extensively studied, the experiences of smaller locales like Thurston County have received less attention.

This study aims to address this gap by examining the implementation of a zero-fare policy in a mid-sized community, coinciding with the onset of a global pandemic. The insights gained from Thurston County's experience may be more relevant and applicable to a wider range of similarly-sized communities across the country, contributing to a more nuanced understanding of zero-fare transit policies in diverse contexts.

[69] van Goeverden et al., "Subsidies in Public Transport."
[70] Hodge, Orrell III, and Strauss, "Fare-Free Policy."
[71] Volinski, Implementation and Outcomes of Fare-Free Transit Systems.
[72] Fearnley, "Free Fares Policies."

Methods

This study employed a mixed-methods approach, combining quantitative and qualitative data collection and analysis techniques to examine the factors influencing ridership in Intercity Transit's zero-fare bus network. The research design centered on a case study of Thurston County, Washington, with a focus on Intercity Transit's implementation of its zero-fare policy.

Data analysis was conducted on the data collected from the survey. For most of the survey results, qualitative analysis was conducted; for some specific types of results, geospatial analysis and quantitative analysis were conducted, respectively.

Human Subjects Research approval was obtained from The Evergreen State College's Institutional Review Board prior to starting the research. I also received permission from Intercity Transit for access to their historical ridership dataset, together with great assistance from Intercity Transit's maintenance team in questionnaire distribution.

Case Study Selection

Intercity Transit served as an instructive case study for examining factors influencing ridership outcomes following a transition to zero fares. Several attributes made Intercity Transit particularly well-suited for this research:

Firstly, Intercity Transit's goals for the zero-fare initiative closely aligned with this study's focus on equity, accessibility, and ridership impacts. By comparing the actual outcomes of Intercity Transit's zero-fare policy with their initial objectives, I was able to conduct a thorough evaluation of the policy's effectiveness. This approach enabled me to measure the extent to which the agency achieved its intended goals in areas such as ridership increase, operational efficiency, and equity improvements.

Secondly, as the local transit agency for Thurston County, I was familiar with Intercity Transit, which allowed me to establish quick and effective communication channels with the agency for this research. Intercity Transit generously agreed to share historical ridership figures and assisted with survey dissemination, greatly enhancing the research methods.

Thirdly, as a midsized county and agency, Thurston County, being a mid-sized area, offered a research setting that was not dominated by the complex dynamics of large metropolitan regions. This allowed for the identification of lessons and insights that could be more easily applied to other similar-sized communities. While smaller locales have received less attention in existing literature, their experiences could resonate more broadly with the numerous mid-sized transit systems across the country.

These characteristics made Intercity Transit an ideal candidate for this in-depth case study, offering valuable insights into the real-world implementation of a zero-fare policy in a mid-sized community during unprecedented times.

Data Collection

Survey

A comprehensive survey was designed to gather information on respondents' demographics, travel patterns, and perceptions of the zero-fare system, in order to elicit any correlation between people's bus-riding frequency and their demographic characteristics or travel preference. The survey also aimed to determine the extent of Olympia residents' satisfaction with Intercity Transit's Zero-Fare policy implementation, since the initiation at the beginning of 2020.

This survey contained a series of questions, of which the count can vary depending on participants' answers. Both closed-ended and open-ended were included. Designing the questionnaire in this way made it possible to collect a combination of quantitative and qualitative

responses; this design also allowed participants to express their preferences by selecting or not selecting specific options while also providing explanations for their choices.

The survey was pre-tested with 20 individuals from the Master of Environmental Studies program cohort to ensure validity and reliability. Feedback received helped refine the wording and structure of some questions.

The survey was distributed through multiple channels:

- An online version was shared via the Inside Evergreen email system to current students, faculty, and staff in the Evergreen community. It was also shared on Olympia Food Co-op's website and social media platforms.

- Paper copies of flyers with QR codes were made available at grocery stores on their bulletin boards, including Olympia Food Co-op and Olympia Farmers Market. With assistance from Intercity Transit staff, these flyers were also posted at Intercity Transit bus stops.

Survey distribution took place between February 16th and March 31st, 2024, with an anticipated goal of obtaining at least 200 responses. By the end of the survey period, 547 valid responses were received.

The survey included a mix of multiple-choice questions, Likert scale ratings, and open-ended questions. It collected data on:

- Basic demographic variables (age, gender, location of residence, household characteristics)

- Employment status and vehicle ownership

- Familiarity with and usage of Intercity Transit buses

- Travel routines for bus system users

- Perceived barriers to or motivations for ridership

This combination of closed and open-ended question formats allowed for the capture of both quantitative data for statistical analysis and rich qualitative insights from respondents' own words. All questions and response options were carefully designed and tested to ensure clarity, internal validity, and minimizing potential risks or discomforts to participants.

For the complete survey questionnaire, please see Appendix 1.

Historical Ridership Data

To provide context on ridership trends before and after the zero-fare implementation, historical ridership data from 2019 through 2022 was acquired from Intercity Transit. This quantitative data served to supplement the survey results and provided a broader perspective on ridership patterns over time.

Data Analysis

Qualitative Analysis

Qualitative content analysis was the primary analytical method applied to the answers from open-ended questions. This approach aimed to identify patterns and correlations in perspectives across different respondent demographics and experiences.

In the context of qualitative research, "code" refers to simple tags assigned to survey responses in order to categorize them in the frame of the research, while "theme" refers to larger and/or more abstract higher-level concepts that tend to connect a series of codes together.

The analysis process, conducted using Atlas.ti software, involved the following steps:

1. Familiarization with the data through thorough reading of all responses.

2. Development of an initial coding scheme based on recurring notions and concepts identified in the literature review.

3. Refinement of the coding scheme through further comprehension of responses.

4. Application of the refined coding scheme to all responses.

5. Grouping of codes into broader themes and subthemes.

6. Calculation of the frequency of each code and theme to identify the most common issues and perspectives raised by respondents.

This process allowed for a systematic analysis of the qualitative data, revealing key themes and concerns among respondents.

Quantitative Analysis

Quantitative data analysis was conducted for numerical and categorical data from closed-ended questionnaire items, using R, a programming language for statistical computing. The analysis focused on examining relationships between the response variable, "people's bus-riding frequency" (categorized and ranked with 9 ordered levels, ranging from the highest frequency category to the lowest), and various predictor variables, including demographic characteristics and spatial factors.

The following statistical techniques were employed:

1. Ordinal Logistic Regression: This method was used to model the relationship between bus-riding frequency and four discrete numeric predictor variables: age, number of people in the household, number of vehicles in the household.

2. Chi-squared Test or Fisher's Exact Test: These tests were performed for categorical predictor variables such as gender and household annual income level to assess their relationship with bus-riding frequency.

All statistical tests were conducted with a significance level of $\alpha = 0.05$. Effect sizes were calculated and reported alongside p-values to provide a more comprehensive understanding of the results.

Geospatial Analysis

Geocoded location data was visualized through GIS mapping software to examine relationships between proximity to transit infrastructure and ridership behaviors.

Geographic information analysis was conducted using ArcGIS Pro software. The primary goal was to examine the relationship between respondents' proximity to bus stops and their reported frequency of bus use. The analysis process included:

1. Geocoding respondents' addresses and mapping them alongside Intercity Transit's bus stop locations.

2. Calculating the distance from each respondent's location to the nearest bus stop using the distance measurement function.

3. Creating buffer zones around bus stops at distances of 0.25, 0.5, and 1 mile to categorize respondents based on their proximity to transit access.

4. Generating heat maps to visualize the density of survey respondents in relation to bus routes and stops.

This spatial analysis allowed for the identification of areas with high response rates but potentially low transit accessibility, providing valuable insights into the geographic factors influencing transit use.

Integration of Analyses

To provide a comprehensive understanding of the factors influencing ridership in Intercity Transit's zero-fare system, I integrated the findings from the qualitative, quantitative, and spatial analyses. This triangulation of methods allowed me to corroborate findings across different data sources and analytical approaches, strengthening the validity of the conclusions.

For instance, the spatial analysis showing higher ridership among those living closer to bus stops was supported by quantitative data on frequency of use and qualitative comments about convenience. This integration of methods provided a more nuanced picture of transit use in Thurston County, revealing how different factors interact to influence ridership patterns.

Case Study

Thurston County Transportation Overview

Thurston County's estimated population in 2023 was 303,400 residents, representing steady growth in recent years.[73] Vehicle ownership rates among households are high, with over 95% of households owning at least one vehicle.[74] This suggests that many residents rely heavily on personal automobiles for transportation needs, aligning with the fact that Americans are highly dependent on cars for travel.[75] However, as populations and commuting needs change over time, ensuring adequate public transportation options remains important.

Commute Patterns

While the majority (73%) of employed Thurston County residents work within the county boundaries.[76] , commute patterns have diversified significantly over the past 60 years. Between 1960 and 2020, there has been a substantial increase in both the number of people leaving Thurston County for work (outbound commuters) and those arriving from other counties (inbound commuters). This trend indicates a growing interconnectedness with neighboring areas, even as most residents continue to work locally.

In the most recent 5-year estimate between 2016 and 2020, over 36,000 Thurston County residents commuted out of the county for work each day, while 23,600 people commuted into Thurston County daily from other counties for their jobs.[77]

[73] "The Profile: Thurston County Statistics & Data," TRPC.
[74] "The Profile: Thurston County Statistics & Data," TRPC.
[75] Ralph Buehler and John Pucher, "Sustainable Transport in Freiburg: Lessons from Germany's Environmental Capital," *International Journal of Sustainable Transportation* 5, no. 1 (January 1, 2011): 43–70, https://doi.org/10.1080/15568311003650531.
[76] "The Profile: Thurston County Statistics & Data," TRPC.
[77] "The Profile: Thurston County Statistics & Data," TRPC.

The share of Thurston County workers traveling outside the county for employment has nearly doubled over the past 50 years, rising from 14% in 1970 to 27% for the 2016-2020 period.

Mode Split and Travel Time

According to 5-year commute data for 2017 through 2021, the largest share (74%) of Thurston County workers drove alone to their jobs. The next most used modes were working from home (11.4%), followed by carpooling (9.3%). Significantly fewer residents walked or biked to work (2.3%) or took public transportation (1.7%).[78] The proportion of public transportation users is lower than the country-wide average of 5% and presents an opportunity for improvement. [79]

Travel times for Thurston County residents' commutes have lengthened noticeably over the past 25-30 years. In 1990, less than half (46%) of workers experienced commutes of 20 minutes or longer. However, by the 2017-2021 period, over half (58%) now face commute durations over 20 minutes.[80]

Most of this increase has been in the highest travel time brackets, as the portion of commutes over 30 minutes has grown from 23% in 1990 to 37% currently.[81] This suggests road and transit networks have not kept pace with expanding development patterns, leading to worsening congestion for many local commuters.

Intercity Transit

Intercity Transit is the largest provider of public transportation in Thurston County aside from school buses. As of late 2023, the agency operates 18 fixed bus routes connecting cities and

[78] "The Profile: Thurston County Statistics & Data," TRPC.
[79] "New Census Report Shows Public Transportation Commuters Concentrated in Large Metro Areas of the United States," US Census Bureau, October 8, 2021, https://www.census.gov/newsroom/press-releases/2021/public-transportation-commuters.html.
[80] "The Profile: Thurston County Statistics & Data," TRPC.
[81] "The Profile: Thurston County Statistics & Data," TRPC.

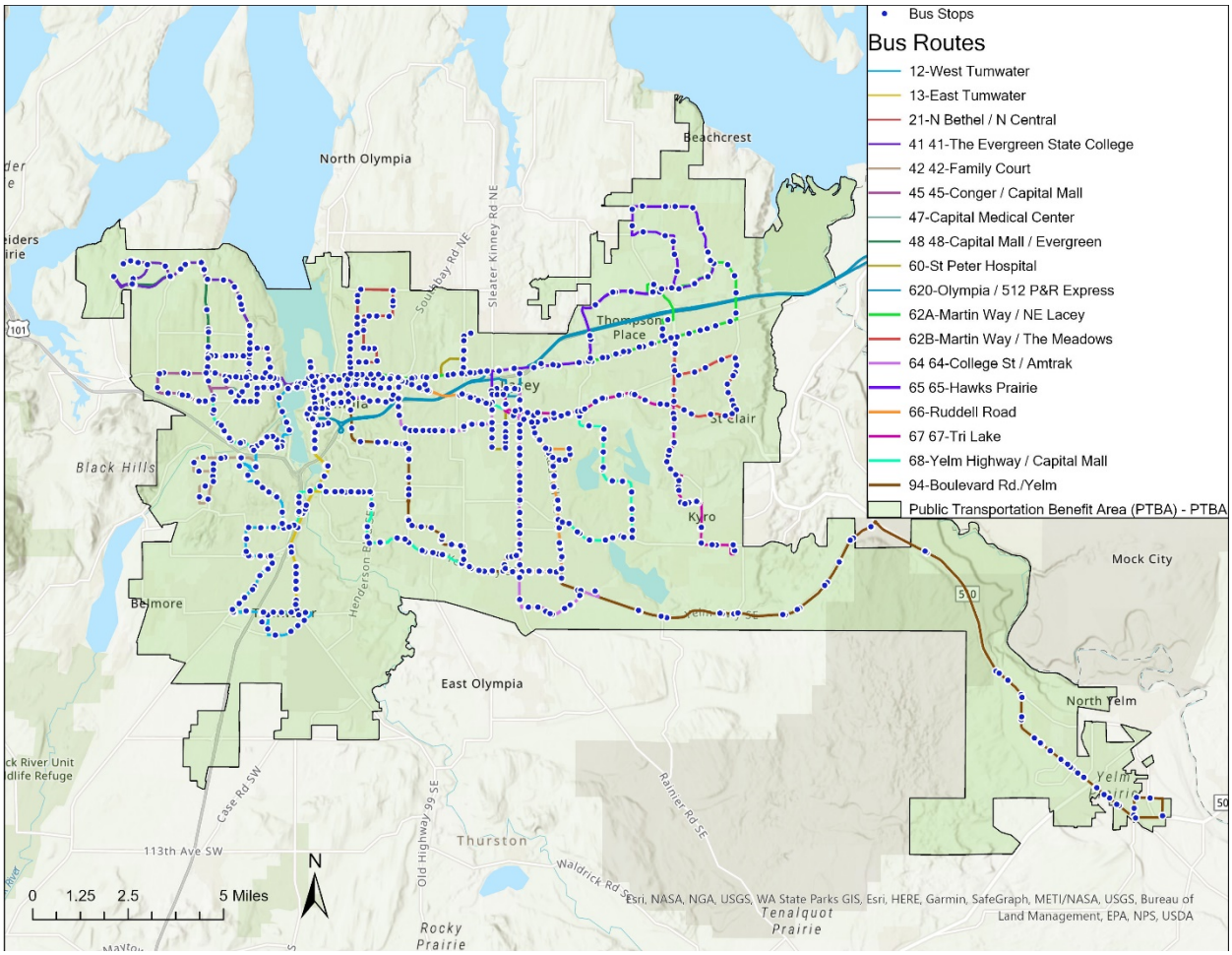


Figure 1. Intercity Transit Public Transportation Benefit Area (PTBA)

towns across the county, covering Lacey, Olympia, Tumwater, and Yelm. This includes an express route serving Pierce County as well. In addition, Intercity Transit offers a robust vanpool program, door-to-door Dial-A-Lift services for people with disabilities, and various educational programs.[82]

Zero-fare Policy Implementation

Intercity Transit decided to implement a zero-fare policy after careful review of a number of different options. The decision was made to fulfill nine community-defined priorities, including making fare collection more efficient and integrated with peer transit systems. After

[82] "Zero-Fare Services," Intercity Transit.

considering various options, the Authority determined that zero-fare offers the most economical, effective, and fastest way to deliver the transformational service voters wanted. Zero-fare transit systems report many benefits, including increased ridership, improved environment, reduced congestion, enhanced access and equity, and reduced barriers for those who cannot afford to pay. Zero fare also makes boarding easier and faster, which reduces travel times for all.[83]

Funding the Zero-fare System

Intercity Transit funds the zero-fare system through sales tax revenue. Fares accounted for less than 2 percent of Intercity Transit's net revenue, and after considering the capital and operational costs of a new system, the difference was deemed negligible. The agency viewed the opportunity to offer faster service, increase ridership, and improve access and equity as a far better investment.

Prior to the zero-fare implementation, Intercity Transit collected about $600,000 in prepaid fares from local partners including the State of Washington, non-profit organizations, municipalities, and colleges. With the move to zero-fare, these partners can now invest those resources toward other goals, from expanding scholarships to increasing workforce development or ensuring access to medical appointments.[84]

Initial Impact and COVID-19 Disruption

In 2019, prior to the zero-fare implementation, Intercity Transit's ridership had begun to grow after four consecutive years of decline. [85] The agency anticipated continued growth in 2020 with the introduction of the zero-fare policy. However, the onset of the COVID-19 pandemic in early 2020 dramatically disrupted these expectations.

[83] "Zero-Fare Services," Intercity Transit.
[84] "Zero-Fare Services," Intercity Transit.
[85] "The Profile: Thurston County Statistics & Data," TRPC.

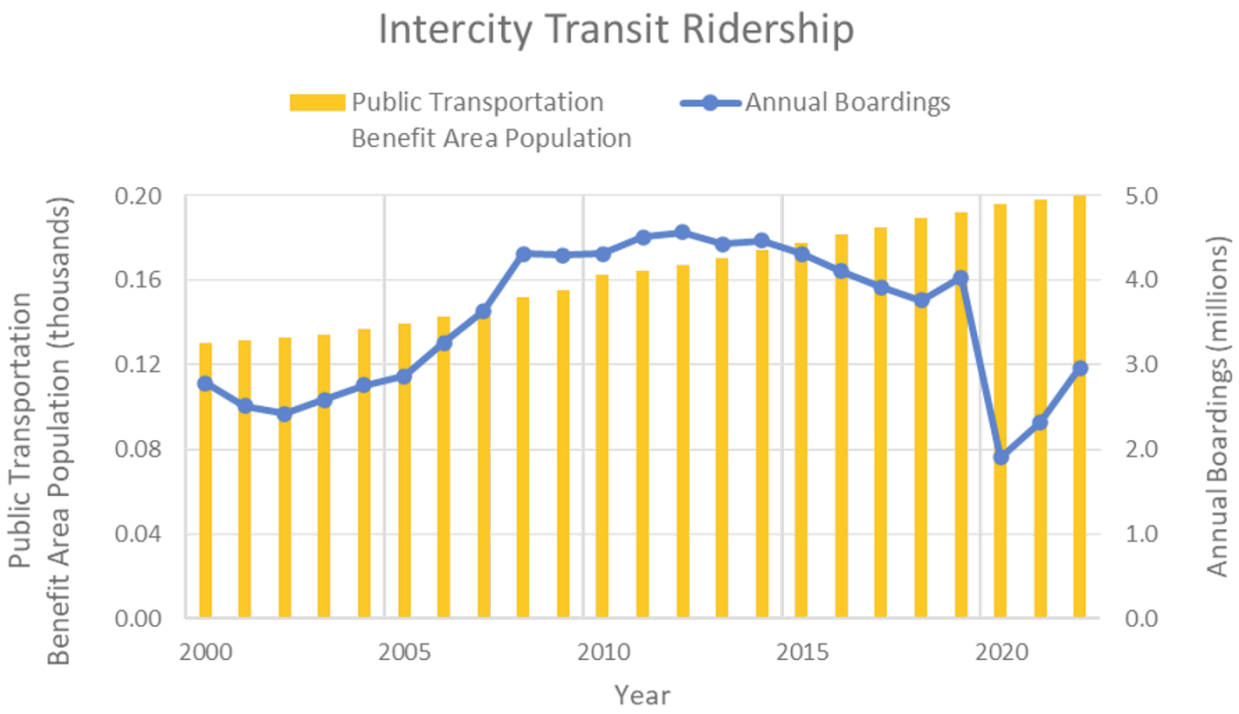


Figure 2. Intercity Transit Ridership Trends: PTBA Population (bar) and Total Annual Boardings (curve)

Between 2019 and 2020, total ridership dropped by 51% as the transit provider and its ridership responded to the pandemic.[86] This significant decrease occurred despite the implementation of the zero-fare policy, which under normal circumstances would have been expected to boost ridership.

During the pandemic, people's perceptions of shared enclosed spaces were significantly impacted, leading to considerable challenges for various public service industries, including public transportation.[87] While ridership began to increase again in 2021 and 2022, it had not yet returned to pre-pandemic levels from 2019. Additionally, the primary driver of this rebound remains unclear—whether it is primarily attributable to the easing of pandemic restrictions or the implementation of zero-fare policies.

[86] "The Profile: Thurston County Statistics & Data," TRPC.
[87] Gregory D. Erhardt et al., "Why Has Public Transit Ridership Declined in the United States?," *Transportation Research Part A: Policy and Practice* 161 (July 2022): 68–87, https://doi.org/10.1016/j.tra.2022.04.006.

Results

Survey Results Overview

As of March 31st, 2024, the anticipated end of the survey period, a total of 547 valid responses were received. Of these, 335 participants provided their geospatial location information, and 336 participants provided answers to the open-ended question, sharing valuable feedback on their bus-riding experiences, including suggestions and complaints.

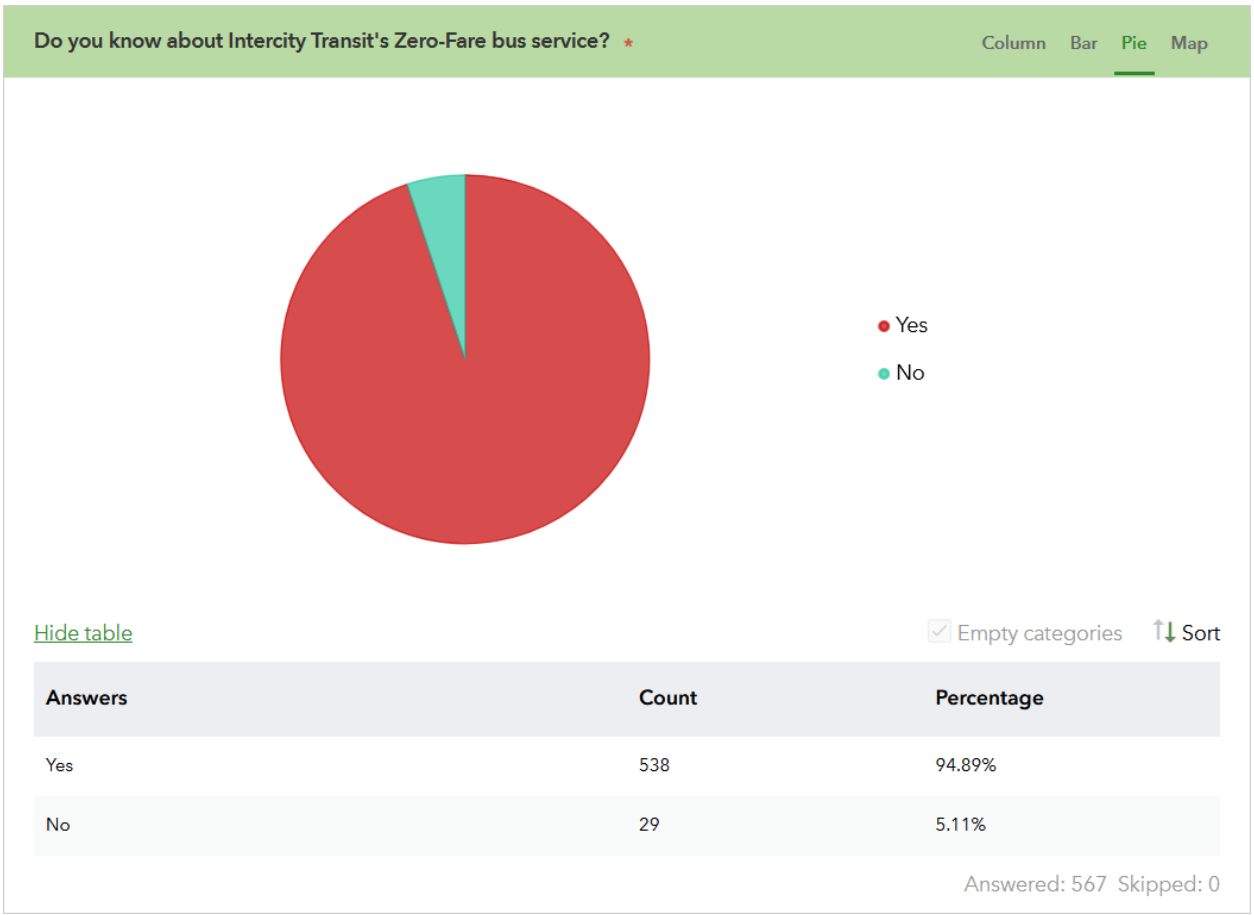


Figure 3. People's awareness of Zero-Fare bus service

Awareness of Zero-Fare Service

The survey revealed that over 95% of participants were aware of Intercity Transit's Zero-Fare bus service. This high level of awareness suggests that Intercity Transit's communication efforts about the policy change have been largely successful. However, it's important to note that

this high level of awareness may be partially attributed to the survey distribution methods, which included promoting the survey at bus stops, potentially attracting a higher proportion of existing bus riders.

Bus Riding Frequency

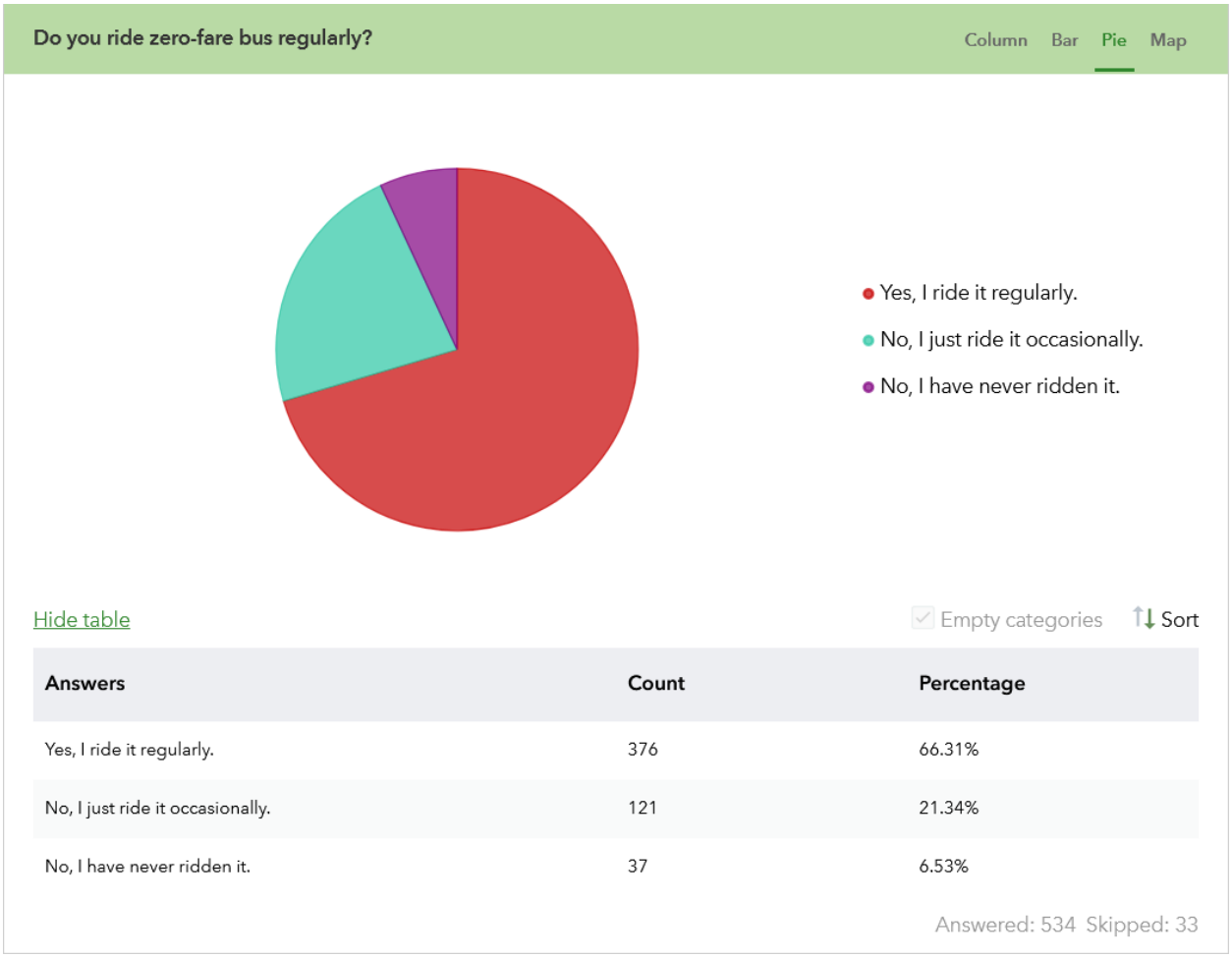


Figure 4: People's bus-riding frequency

Among respondents who were aware of the Zero-Fare bus service, over 55% reported riding the bus regularly or occasionally, while 20% indicated that they do not currently use the bus. This distribution suggests that while the zero-fare policy has attracted a substantial number of riders, there remains a significant portion of the population that does not use public transit despite being aware of its free status.

Demographic Profile

Respondents ranged in age from 13 to 78, with the largest group between 18-29 years old. Most lived in Olympia or nearby areas. Regarding employment status, 68.2% reported being employed, 17.4% unemployed, 35.5% students, and 4.4% retired.

Household characteristics of respondents who provided this information were as follows:

- Household size: predominantly 1-3 people (78%)

- Annual household income: most commonly $10,000 or less (21.3%), followed by $25,000-$50,000 (19.6%); only 6.1% earning more than $150,000 annually

- Vehicle ownership: 33.1% own 1 vehicle, 25.2% own 2 vehicles, 10.4% own more than 3 vehicles, and 30.7% of all respondents do not own any vehicle.

This demographic profile reveals a diverse range of respondents, with a notable proportion of lower-income individuals and those without access to personal vehicles, groups that are often more reliant on public transportation.

Commute Patterns

Among respondents with commute needs, the most common commute method was bus riding (61.3%), followed by driving alone (31.8%), walking (29.7%), and carpooling (17.9%). This result is not consistent with the commonly-held belief that the majority of people primarily use personal vehicles for commuting. The survey results indicate a higher proportion of public transit usage, which may be influenced by the zero-fare policy and the sampling methodology that likely overrepresented bus riders. Further details regarding this overrepresentation will be discussed in the discussion section.

Commuting times varied significantly depending on mode, but most respondents reported completing their commute trip within 40 minutes.

Geospatial Analysis Results

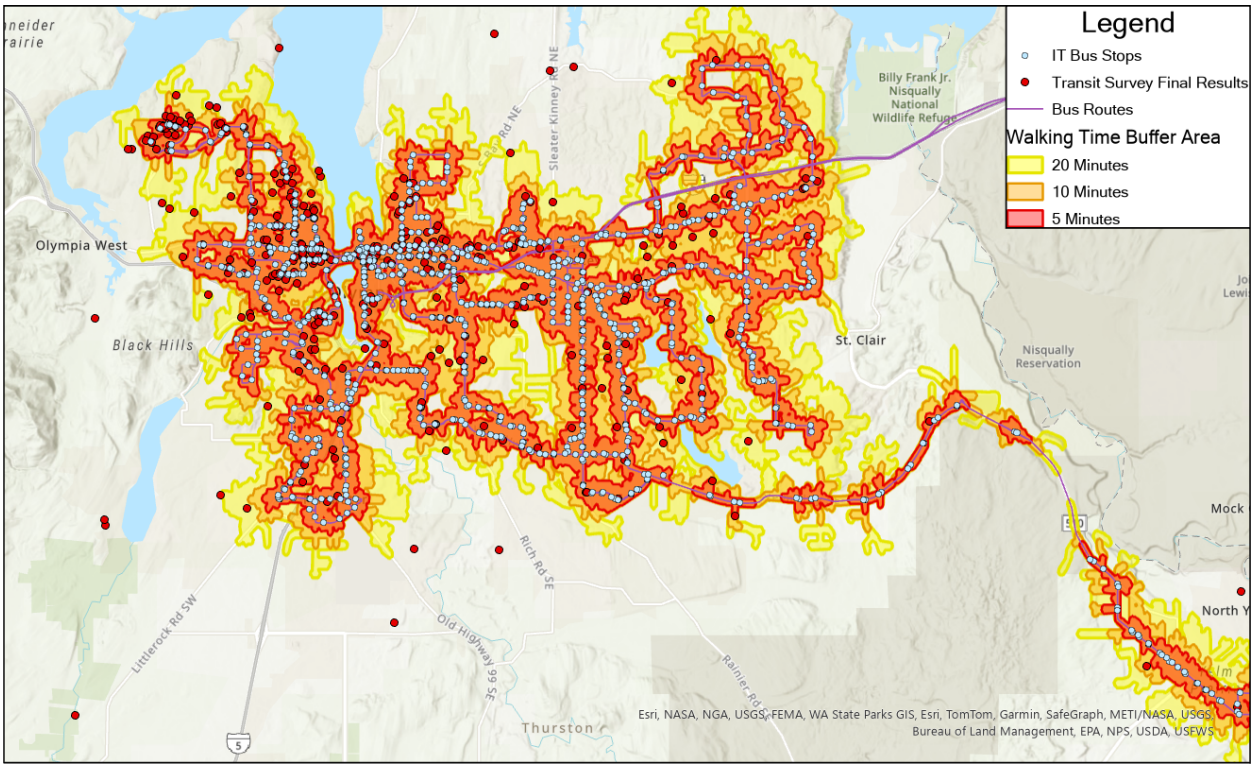


Figure 5: Map of Bus Stop Walking Time Buffer Area

A geospatial analysis was conducted on the 335 survey responses that included geospatial location data. Distances from each respondent's location to the nearest Intercity Transit bus stop were calculated using ArcGIS software. The results revealed the following:

- 254 respondents (76%) lived within a 5-minute walk (about 0.25 miles) of a bus stop
- Another 31 respondents lived between 0.25-0.5 miles from a stop
- 27 more respondents lived 0.5-1 miles away

In total, 312 respondents (93%) were within a 20-minute walk of transit. This high level of proximity to transit stops for most respondents suggests good coverage of the transit network in populated areas.

The drawn buffer zones visualized density patterns, identifying clusters near routes but also areas potentially underserved by transit access. This information could be valuable for Intercity Transit in planning future route expansions or modifications.

Statistical Analysis Results

Ordinal Logistic Regression

An ordinal logistic regression analysis was conducted to model the relationship between the ordinal response variable "bus-riding frequency" and three discrete numeric predictor variables: age, number of people in the household, and number of vehicles in the household. Detailed results of ordinal logistic regression are presented in Appendix 2-1.

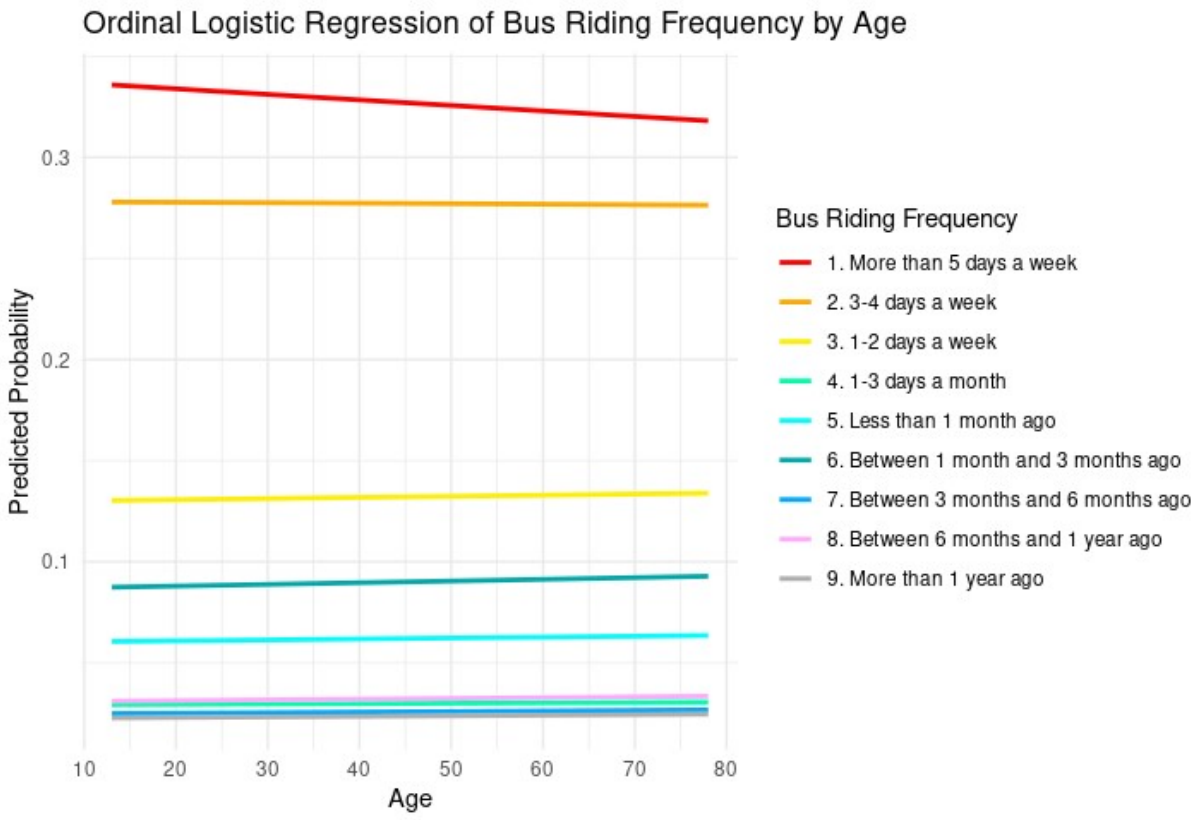


Figure 6: Predicted Probabilities Plot of Ordinal Logistic Regression between Bus-riding Frequency and Age

The results show a coefficient for the age variable of 0.001242, which indicates that the probability of a person being in a higher bus-riding frequency category slightly increases as their age increases, holding all other factors constant. However, this coefficient is not statistically significant, as the t-value of 0.2217, which is lower in absolute value than the critical t-value of 1.660 at a 95% significance level, has a p-value greater than the typical significance level of 0.05. This means we cannot conclude that age has a significant effect on bus-riding frequency.

As for both the number of people and vehicles in the household, the coefficients are -0.1655 and -0.1852 respectively. These negative coefficients indicate that the probability of a person being in a higher bus-riding frequency category decreases as there are either more people or more vehicles in their household. These coefficients are statistically significant, as the t-values of -3.047 and -2.171, respectively, which are higher in absolute value than the critical t-value of 1.660 at a 95% significance level, both have p-values smaller than the typical significance level of 0.05. This means we can conclude that both the number of people and the number of vehicles have a significant negative effect on bus-riding frequency.

It is intuitive that households with more vehicles tend to rely more on driving, rather than using public transit. The more cars a household has access to, the more likely they are to be dependent on private vehicles for their travel needs.

Similarly, the negative relationship between household size and bus-riding frequency can be explained by the increased trip chaining (multi-stop travel) requirements that larger households face. In large families, individuals may have more complex travel patterns, needing to make multiple stops for tasks like dropping off/picking up family members, running errands, or managing other household responsibilities. These types of “trip chaining” behaviors are

probably less convenient or feasible to accomplish using public transit compared to private vehicles.

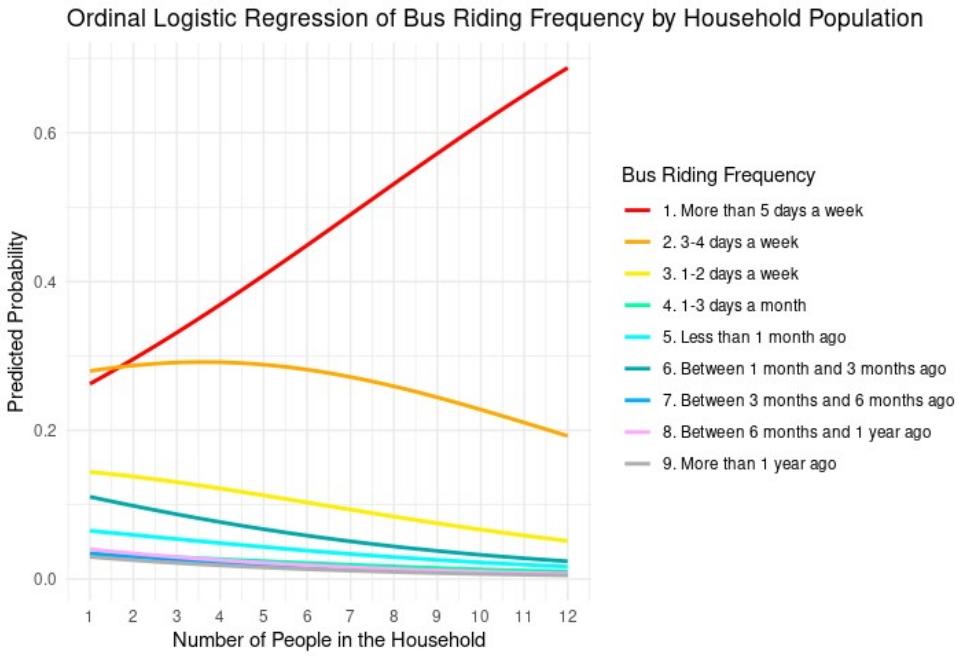


Figure 7: Predicted Probabilities Plot of Ordinal Logistic Regression between Bus-riding Frequency and Household People Count

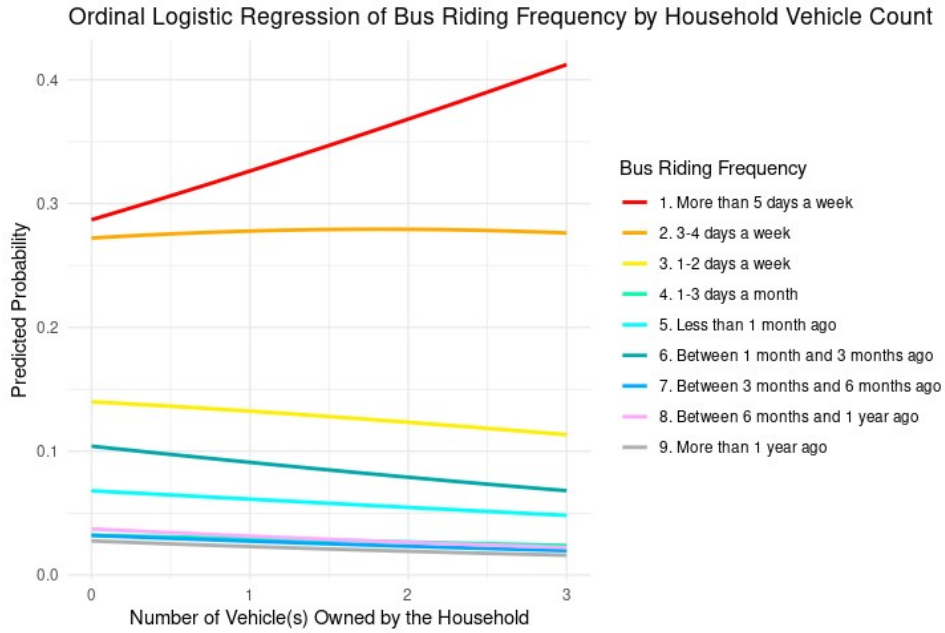


Figure 8: Predicted Probabilities Plot of Ordinal Logistic Regression between Bus-riding Frequency and Household Vehicle Count

Chi-Squared Test & Fisher's Exact Test

Chi-squared tests were conducted to model the relationship between the ordinal response variable "bus-riding frequency" and two categorical predictor variables: gender and household annual income level. Due to low count values in some cells of the contingency tables, I also performed Fisher's exact tests to ensure the reliability of the results. The findings from both methods were consistent. Detailed results of chi-squared tests and Fisher's exact tests are presented in Appendix 2-2 and 2-3, respectively.

Both the chi-squared test and Fisher's exact test indicated no statistically significant correlation between gender and bus-riding frequency. This suggests that bus usage patterns do not significantly differ between genders in the sample. (p-value = 0.5763 for chi-squared, p-value = 0.6437 for Fisher's exact, both not attaining the significance level of $\alpha = 0.05$)

As for household annual income level, indicates a statistically significant correlation between income level and bus-riding frequency, suggesting that bus-riding frequency does vary among people at different household annual income levels. (p-value < 0.0001 for both chi-squared and Fisher's exact, both attaining the significance level of $\alpha = 0.05$)

To visually present the frequency distribution of each group, mosaic plots were constructed for the two contingency tables (Figures 8 & 9). Cells highlighted in blue or red suggest significant differences in standardized residuals compared to the other groups. In the instance of gender, colors are absent in the cells, indicating a lack of significant differences among the standardized residuals, which aligns with the findings of the preceding data analysis.

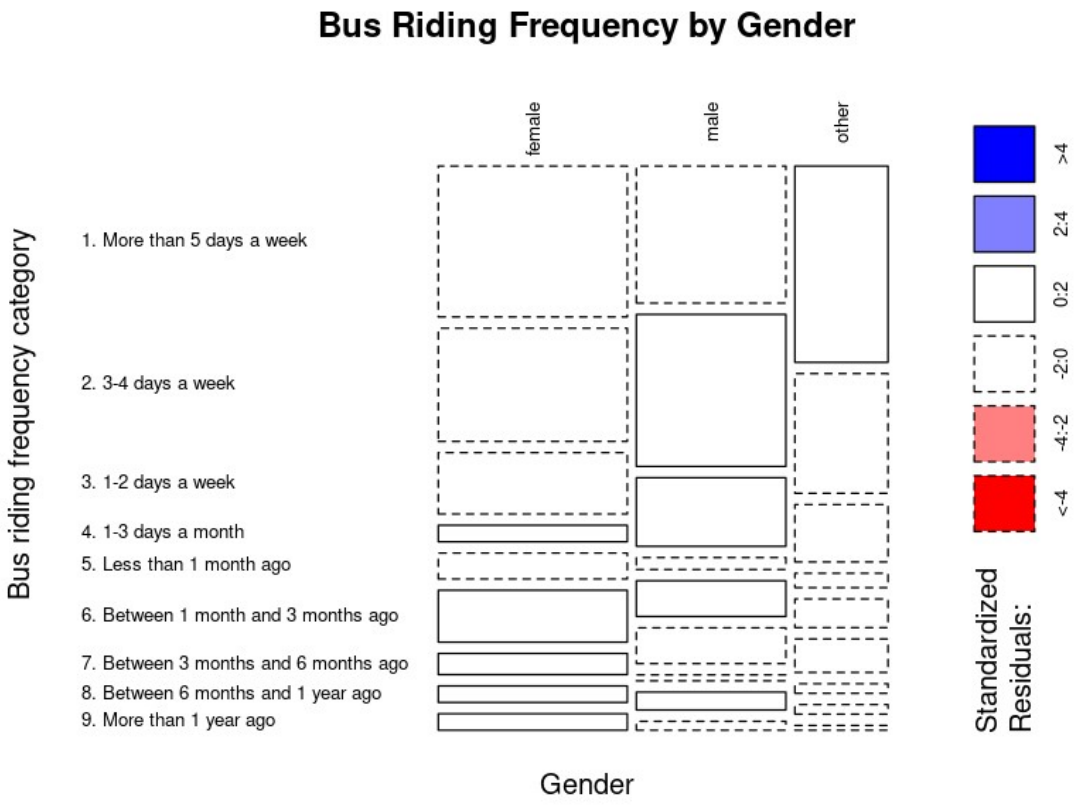


Figure 9: Mosaic Plot of Chi-Squared Test between Bus-riding Frequency and Gender

However, for income levels, the presence of red cells in the upper right corner, and blue cells in the upper left and lower right corners, suggests that people at lower income levels tend to use public transit more often, while people at higher income levels do so less frequently. This finding is aligned with the literature review, which suggests that people with lower income usually cannot afford individual travel options and prefer to use public transportation, while

people at higher income level may prefer not to share space with others when they have chance to travel alone. [88]

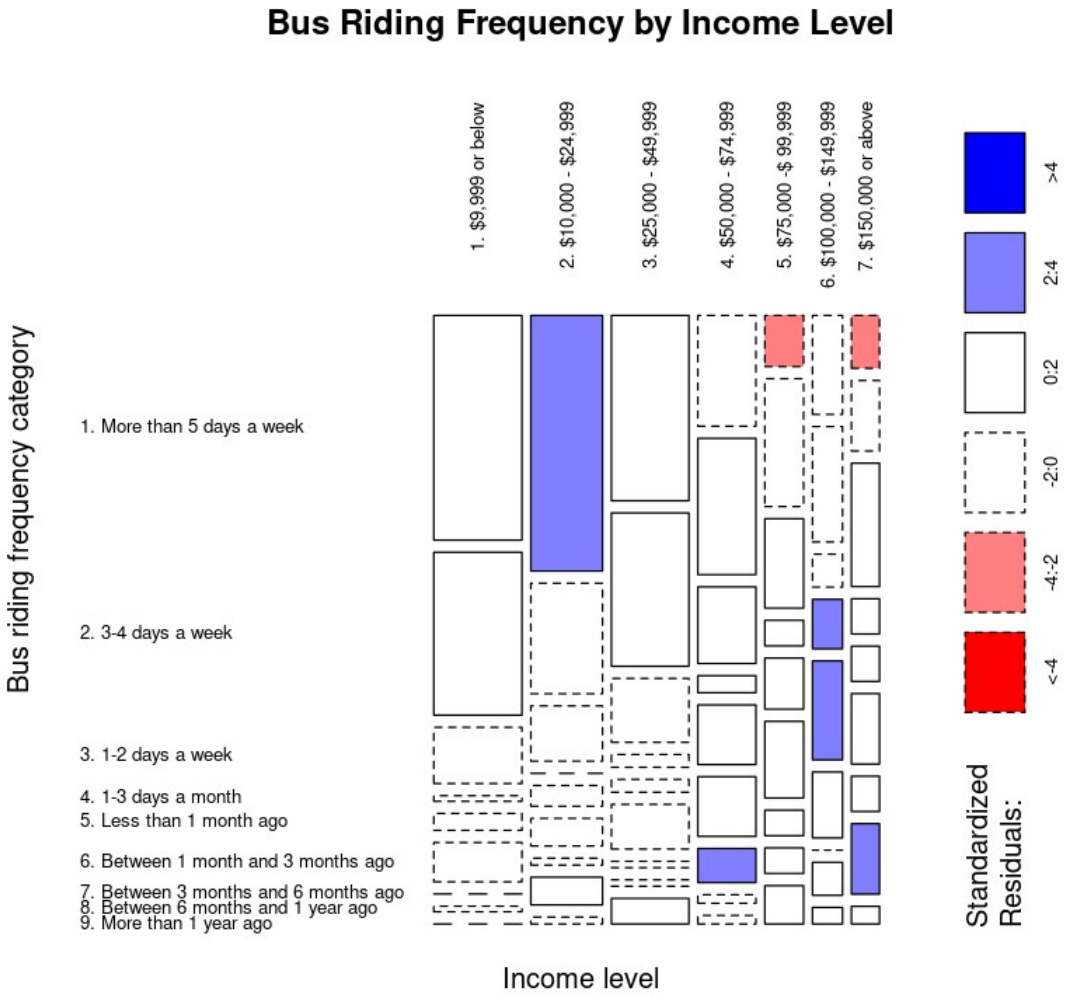
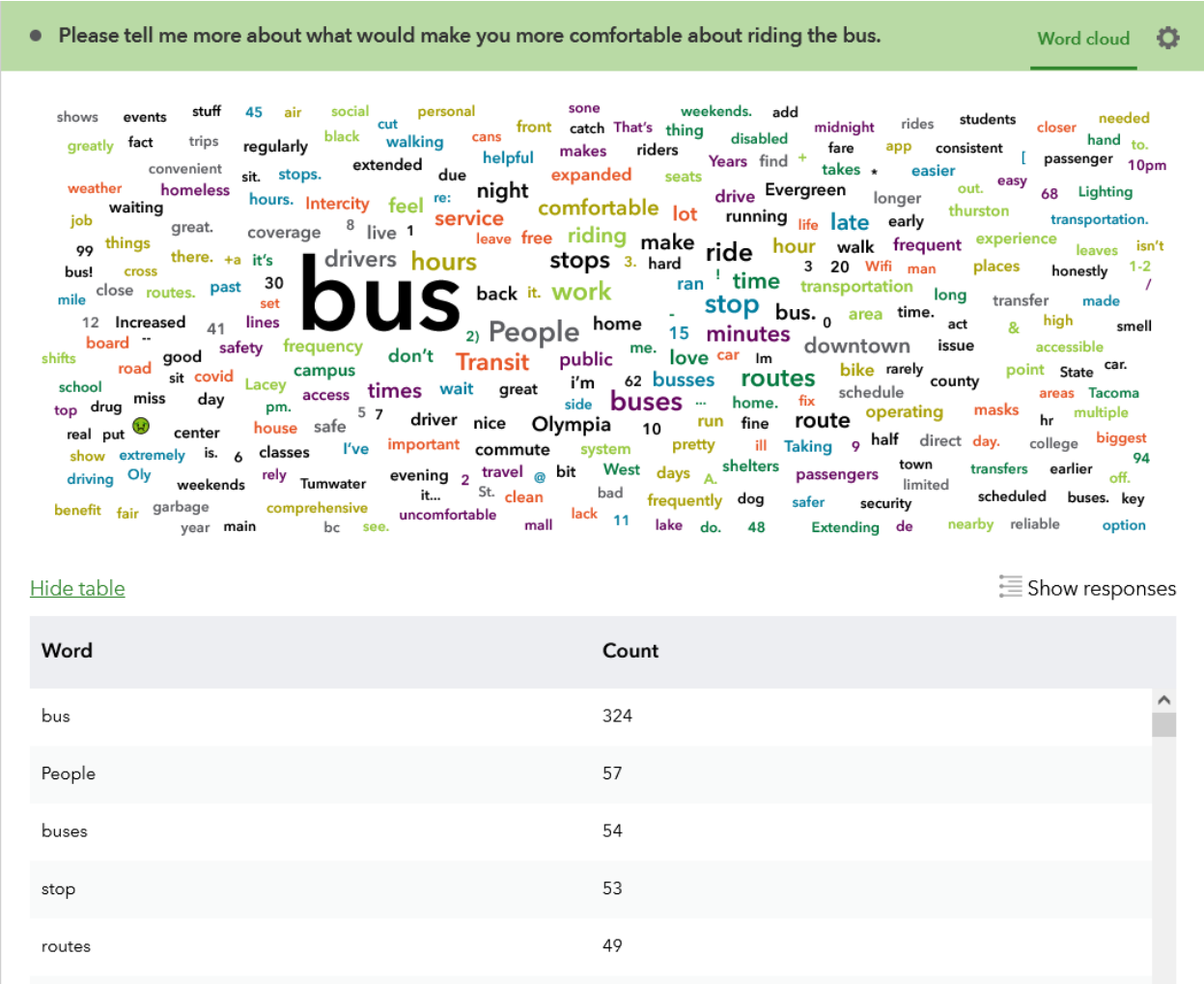


Figure 10: Mosaic Plot of Chi-Squared Test between Bus-riding

[88] Todd Litman, "Evaluating Transportation Equity: Guidance For Incorporating Distributional Impacts in Transportation Planning" (*Victoria Transport Policy Institute*, November 2023). https://www.vtpi.org/equity.pdf.

Qualitative Analysis Results



Word	Count
bus	324
People	57
buses	54
stop	53
routes	49

Figure 11: Open-ended question word cloud

The responses to the open-ended question "Please tell me more about what would make you more comfortable about riding the bus" provided rich insights into respondents' experiences and perceptions of the zero-fare system. Key themes on improvement suggestions that emerged from the qualitative analysis include:

1. Extended operating hours (25.6%): There was a significant demand for later evening service, particularly on weekends, as most of the bus services ended before 9pm on weekdays and ended even earlier on weekends. Respondents noted that this would allow them to use public

transit for late-night work shifts, classes, and social/cultural events downtown without concerns over transport home. As one respondent noted:

> *"Extended operating hours, especially later into the night would be helpful to me - I take night classes at Evergreen and am also often out late in downtown Olympia, but I cannot always rely on a bus running late enough to get me home with the present schedule."*

Another respondent emphasized the impact on their work life:

> *"Extended operating hours would improve my quality of life so much. I have to take the bus to and from work and am limited by how early and late the buses run."*

2. Increased frequency (18.2%): Many respondents expressed a desire for more frequent service, especially during off-peak hours and weekends. The current 30-minute intervals caused stress when a bus was missed, and longtime waiting discouraged short trips. A common request was for 15-minute intervals between buses instead of the current 30-minute intervals. This would reduce wait times and improve the reliability of connections. One respondent succinctly stated:

> *"If most routes came every 15 minutes and service went until midnight I would have 0 complaints."*

Another highlighted the impact of infrequent service on their commute:

> *"Sometimes in the morning my bus is late and I miss my connecting bus. I would also like for more frequent buses so I don't have to wait as long."*

3. Expanded route coverage (15.8%): Some respondents suggested expanding route coverage to better connect residential areas, especially rural areas, with major destinations and employment centers. As one user commented:

> *"Expanded rural service ie littlerock and Delphi rd"*

Better integration with neighboring transit providers like Mason Transit was also cited to open up opportunities. Others were looking forward to the reinstatement of specific routes:

> *"Expanded route coverage is my primary concern - I'm eagerly awaiting the return of the Lacey corridor express bus!"*

4. Comfort and cleanliness (9.9%): Intercity Transit has been conducting disinfection after each trip to minimize health risks, which was highly appreciated. While many respondents shared their experience of feeling comfortable on buses in the current post-pandemic context, some expressed concerns about maintaining clean and comfortable buses. This included regular cleaning and providing safe spaces for vulnerable passengers:

> *"More frequent cleaning of the bus from top to windows to interior side walls to the floor. Ensuring there is a safe space near the driver for uncomfortable people such as older women like myself."*

5. Bus stop infrastructure (8.9%) and on-board infrastructure (4.4%): Improvements to bus stops, particularly the addition of real-time arrival information, were suggested as ways to enhance the user experience:

> *"Real time arrival information signs would encourage me to use the bus more often."*

Some respondents suggested adding amenities like charging stations and Wi-Fi, though concerns about potential misuse were also raised:

> *"Charging stations and Wi-Fi would be really nice but I feel that there would be a large group who would abuse that luxury."*

Other themes that emerged, though less frequently, included higher punctuality, enhanced customer service, and fewer detours or transfers.

While safety concerns were not among the most frequently mentioned issues, the comments that did address safety highlighted significant concerns that merit attention:

> *"I don't feel safe riding the bus. It would be helpful to have more information on what IT can do to ensure the safety of passengers on their buses and near their transit centers."*

Another respondent shared a troubling experience:

> *"Higher level of safety, I have been harassed multiple times on the bus and the bus drivers don't do or say anything. I had to get off at a random stop in the middle of the night because a guy on the bus kept trying to touch me and I called out for the bus driver and no one would help me."*

These qualitative insights provide valuable context for the quantitative findings and highlight specific areas where Intercity Transit might focus improvement efforts. The predominance of service-related suggestions (extended hours, increased frequency, and expanded coverage) indicates that while the zero-fare policy has removed financial barriers, operational aspects of the service remain crucial in determining rider satisfaction and potentially influencing ridership levels. Additionally, the comments on safety, though fewer in number, reveal critical incidents that could significantly impact perceptions of the service and willingness to use public transit.

Discussion

Factors Influencing Ridership in the Zero-Fare System

The mixed-methods analysis reveals a complex interplay of factors influencing ridership in Intercity Transit's zero-fare system. While the elimination of fares has removed a significant barrier to transit use, particularly for lower-income individuals, other factors continue to shape ridership patterns.

Demographic and Household Characteristics

The statistical analyses uncovered variations in transit use that aligned with economic circumstances and available transportation options. Lower-income households earning under $25,000-$50,000 relied most heavily on transit. This aligns with previous research suggesting that zero-fare policies can have the greatest impact on low-income populations by removing financial barriers to mobility.

The strong negative correlation between vehicle ownership and bus usage underscores the role of personal vehicle access in transportation choices. However, it's noteworthy that a small percentage of respondents with more than two vehicles still reported regular bus use. This suggests that factors beyond mere vehicle ownership, such as environmental concerns or the convenience of certain routes, may influence transit use decisions even among households with multiple vehicles. This finding highlights the complex nature of transportation choices and suggests that targeted marketing of the zero-fare policy's benefits could potentially attract more choice riders from multi-vehicle households.

The negative relationship between household size and bus-riding frequency was somewhat unexpected. One possible explanation is that larger households may have more complex travel patterns, requiring the flexibility that personal vehicles provide for activities like

dropping off children at school or running multiple errands. This finding suggests that Intercity Transit might consider strategies to make bus use more attractive for larger households, such as family-oriented fare products or routes that better connect residential areas with schools and shopping centers.

Proximity to Transit

The geospatial analysis revealed that proximity to bus stops is a crucial factor in determining transit use. Respondents living within a 5-minute walk of a bus stop were approximately twice as likely to be frequent bus users compared to those living further away. This underscores the importance of transit accessibility in promoting ridership.

the fact that 93% of the respondents lived within a 20-minute walk of a bus stop, yet only 55% reported regular or occasional bus use, suggests that proximity alone is not sufficient to ensure high ridership. Other factors, such as service frequency, route directness, and perceived convenience compared to driving, likely play significant roles in individuals' transportation choices.

Service Characteristics

The qualitative analysis of open-ended responses highlighted several service-related factors that influence ridership:

1. Frequency of Service: Many respondents indicated that more frequent service, particularly during off-peak hours and weekends, would encourage them to use the bus more often. The desire for 15-minute intervals instead of 30-minute intervals was a common theme.

2. Extended Service Hours: The lack of late-night and early-morning service was cited as a barrier to bus use, particularly for those working non-standard hours or wanting to use transit for evening social activities.

3. Route Coverage: Some respondents noted that current routes did not adequately serve their needs, suggesting that expanded or reconfigured route coverage could increase ridership.

These findings suggest that while the zero-fare policy has removed the cost barrier, other aspects of service quality remain crucial in determining transit use.

COVID-19 Impact

The ongoing influence of the COVID-19 pandemic on transit ridership cannot be overstated. Despite the implementation of the zero-fare policy, Intercity Transit experienced a 51% decrease in ridership in 2020, with levels remaining far below pre-pandemic numbers at the time of this study.

The survey responses indicate that concerns about health and safety in shared spaces continue to influence transit use decisions for some individuals. This aligns with broader research on the psychological effects of the pandemic on transportation choices.[89] The persistence of these concerns even as broader public health risks have receded suggests that rebuilding ridership to pre-pandemic levels may require ongoing efforts to address perceived health risks associated with public transit use.

Effectiveness of the Zero-Fare Policy

While the full impact of the zero-fare policy has been obscured by the concurrent onset of the COVID-19 pandemic, the findings suggest that the policy has had positive effects, particularly for certain segments of the population.

The high proportion of lower-income respondents in the sample who reported regular bus use indicates that the zero-fare policy may be successfully removing financial barriers to transit

[89] Madeleine E. G. Parker et al., "Public Transit Use in the United States in the Era of COVID-19: Transit Riders' Travel Behavior in the COVID-19 Impact and Recovery Period," Transport Policy 111 (September 1, 2021): 53–62, https://doi.org/10.1016/j.tranpol.2021.07.005.

access for economically vulnerable populations. This aligns with one of the key objectives of the policy: enhancing access and equity.

Moreover, the strong appreciation for the zero-fare policy expressed in many open-ended responses suggests that the policy has improved mobility and financial situations for many riders. However, the persistence of other barriers to transit use, such as limited service hours and frequency, indicates that fare elimination alone is not sufficient to maximize ridership. This suggests that complementary investments in service improvements may be necessary to fully realize the potential benefits of the zero-fare policy.

Implications for Transit Planning

Based on my findings, several implications for transit planning and policy emerge:

1. Targeted Service Improvements: While the zero-fare policy has removed cost barriers, addressing other barriers related to service quality could further boost ridership. Increasing service frequency, extending service hours, and optimizing route coverage based on community needs could make public transit more attractive to a broader range of potential riders.

2. Focus on Transit-Dependent Populations: My findings reinforce the importance of public transit for lower-income individuals and those without access to personal vehicles. Continued efforts to tailor services to the needs of these transit-dependent populations could further enhance the equity benefits of the zero-fare policy.

3. Attracting Choice Riders: While the zero-fare policy appears to be serving transit-dependent populations well, there may be opportunities to attract more choice riders (those with access to personal vehicles). Strategies could include emphasizing the environmental benefits of transit use, improving the convenience of bus travel for short trips, and marketing the cost savings of using free public transit over driving and parking.

4. Addressing COVID-19 Concerns: Given the ongoing impact of pandemic-related concerns on ridership, Intercity Transit may need to continue emphasizing their safety and cleaning protocols. Clear communication about these measures could help rebuild confidence among riders who remain wary of shared spaces.

5. Land Use and Transit Integration: The strong relationship between proximity to bus stops and likelihood of transit use underscores the importance of integrating transit planning with land use decisions. Encouraging transit-oriented development and ensuring new residential and commercial developments are well-served by transit could support long-term ridership growth.

6. Multimodal Integration: Given the complex travel needs of larger households, exploring ways to better integrate bus services with other modes of transportation (e.g., bike-sharing, park-and-ride facilities) could make transit more attractive for those with diverse trip patterns.

Conclusion

This study examined the factors influencing ridership in Intercity Transit's zero-fare bus network in Thurston County, Washington. Through a mixed-methods approach combining surveys, geospatial analysis, and statistical modeling, I investigated the interplay between fare elimination, demographic factors, and external shocks in shaping public transit use.

The findings reveal a complex picture of transit use in the context of a zero-fare policy. While the elimination of fares has removed a significant barrier to transit access, particularly for lower-income and transit-dependent populations, other factors continue to play crucial roles in determining ridership levels. These include proximity to transit stops, service frequency and hours of operation, household size and vehicle ownership.

The implementation of the zero-fare policy coincided with the onset of the COVID-19 pandemic, presenting unique challenges in evaluating its effectiveness. Despite these challenges, my research suggests that the policy has had positive impacts, particularly in enhancing mobility and financial situations for economically vulnerable populations. However, the persistence of ridership levels below pre-pandemic numbers indicates that fare elimination alone is not sufficient to maximize transit use.

This study contributes to the growing body of literature on fare-free public transportation by providing insights from a mid-sized urban area, a context that has received less attention in previous research. My findings highlight the importance of considering local context and external factors when implementing and evaluating zero-fare policies.

Several limitations of this study should be noted. The potential overrepresentation of bus riders in the sample, due to survey distribution methods which relied heavily on posters at bus stops, may have skewed some results. Future studies could benefit from a more randomized

sampling approach. Additionally, the unique circumstances of the COVID-19 pandemic make it challenging to isolate the effects of the zero-fare policy from the impacts of the public health crisis. Unfortunately, I did not sufficiently differentiate the survey questionnaire during the data collection phase to obtain valid data for assessing the impact of COVID-19 effectively.

Looking forward, this research suggests several avenues for future study:

1. Longitudinal analysis of ridership patterns: As pandemic-related concerns subside, a long-term study tracking ridership trends could provide valuable insights into the sustained impact of the zero-fare policy. This could help distinguish between the effects of fare elimination and those of external factors like public health crises.

2. Service improvement impact assessment: Given the strong emphasis on extended operating hours, increased frequency, and expanded route coverage in the qualitative findings, future research could evaluate the impact of implementing these service improvements on ridership levels and user satisfaction. This could involve pilot studies of extended night services or increased frequency on select routes.

3. Comparative analysis with similar-sized communities: A study comparing Thurston County's experience with zero-fare transit to that of other mid-sized communities could help identify common trends and unique local factors influencing the policy's success.In conclusion, while Intercity Transit's zero-fare policy has shown promise in enhancing transit accessibility and equity, realizing its full potential may require complementary investments in service improvements and targeted strategies to address diverse community needs. As cities worldwide grapple with challenges of sustainability, equity, and post-pandemic recovery, the lessons from Thurston County's experience with zero-fare transit offer valuable insights.

For transit agencies considering similar initiatives, this research underscores the importance of:

1. Tailoring zero-fare policies to local contexts and needs
2. Investing in service improvements alongside fare elimination
3. Developing strategies to attract both transit-dependent and choice riders
4. Integrating transit planning with broader urban development and sustainability goals
5. Maintaining flexibility to adapt to unexpected challenges, such as public health crises

As we move towards more sustainable and equitable urban transportation systems, zero-fare policies represent a promising approach. However, their effectiveness depends on careful implementation, ongoing evaluation, and a willingness to adapt to changing circumstances and community needs.

The experience of Intercity Transit in Thurston County serves as a valuable case study in the potential and challenges of zero-fare public transportation. By continuing to study and refine such initiatives, we can work towards creating more accessible, sustainable, and resilient transit systems that serve the diverse needs of our communities.

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Appendix 1. Complete Survey Questionnaire

(Beginning of questionnaire)

Questionnaire about Intercity Transit Zero-Fare Bus

I'm a student of Master of Environmental Studies Program from The Evergreen State College. I'm currently conducting a research study to understand the factors that influence people's decisions about using public transportation in Thurston County.

Your participation in this survey will help provide valuable insights. The results will be used to help Intercity Transit continue improving services and promoting ridership. The survey should take around 10 minutes to complete. Your responses will remain completely anonymous.

Thank you in advance for your time and participation. If you have any other questions, please feel free to contact the researcher at sihe.sun@evergreen.edu.

Personal Information

In this section, we will need you to provide some necessary information to help us better categorize and analyze the data.

Your personal information is collected only for research purpose and will not be disclosed.

Basic information

1. Name of respondent

You can retake this survey by referring to the same name. Feel free to use initials or nickname if you would prefer. Up to 24 characters allowed.

2. Age of respondent

You can skip this question if you prefer not to answer.

3. To which of the following gender do you most identify?*

- Male
- Female
- Non-binary
- Prefer not to answer
- Other

4. Where do you live?*

This survey mainly focuses on residents in Olympian region, but you are also welcome to respond if you are from other places!

- Lacey
- Olympia
- Tumwater
- Yelm
- Other

5. If possible, please specify the location of your residence.

If your current location does not represent your residence location, you can modify it manually.

(Geospatial data input unit)

6. Which of the following describe(s) your personal current employment status?*

Select all that apply.

- ☐ Employed for wages
- ☐ Self-employed
- ☐ Seeking opportunities
- ☐ Out of work but not actively searching
- ☐ Student
- ☐ Retired
- ☐ Prefer not to answer
- ☐ Other

Household information

7. How many people are there in your household?*

Include yourself

- 1
- 2
- 3
- 4
- 5 or above

8. What is the total annual income of your household?*

- $9,999 or below
- $10,000 - $24,999
- $25,000 - $49,999
- $50,000 - $74,999
- $75,000 -$ 99,999
- $100,000 - $149,999
- $150,000 or above
- Prefer not to answer

9. Does your household own any vehicle?*

- Yes
- No

(If "Yes" to question 9) **10. How many vehicles does your household own?**

- 1
- 2
- 3 or above

Zero-fare Bus

11. Do you know about zero-fare bus?*

Including 18 bus lines, run by Intercity Transit in Lacey, Olympia, Tumwater, and Yelm

- Yes
- No

(If "Yes" to question 11) **12. Do you ride zero-fare bus regularly?**

- Yes, I ride it regularly.
- No, I just ride it occasionally.
- No, I have never riden it.

(If "Yes" to question 12) **13. For the last six month, how often do you ride zero-fare bus?**

- More than 5 days a week
- 3-4 days a week
- 1-2 days a week
- 1-2 days a month
- Less than 1 day a month

(If "Occasionally" to question 12) **14. When was the last time you rode zero-fare bus?**

Note: Intercity Transit's five-year zero-fare demonstration project went into effect on January 1, 2020.

(Date input unit)

(If "Yes" or "Occasionally" to question 12) **15. How is your overall zero-fare bus riding experience?**

- Very bad
- Bad
- Neutral
- Good
- Very good

(If "No" to question 11) **Intercity Transit has suspended fare collections for all of their bus service as part of a five-year demonstration project, making it easier and more accessible for riders to use public transportation.**

For further information, please visit Intercity Transit's website

(If "No" to question 11) **16. Now you know that you don't need to pay to ride the bus run by Intercity Transit in the Olympian region. Are you interested in riding zero-fare bus?**

- o Yes
- o No

(If "No" to question 12 or to question 16) **17. What's preventing you from riding zero-fare bus?**

Select all that apply.

- ☐ I don't like the idea of "subsidizing transit".
- ☐ It could be crowded on the bus.
- ☐ I feel not safe on the bus.
- ☐ I have no travel needs that require bus riding.
- ☐ There is not bus stop near my residence location and/or daily commuting destination.
- ☐ The bus schedule does not match my daily travel plan.
- ☐ It takes too long for the bus to get to my destination.
- ☐ Other

18. What improvement might encourage you to use zero-fare bus service more often?

Select all that apply.

- ☐ Expanded route coverage
- ☐ Increased frequency
- ☐ Extended operating hours
- ☐ Bus stop infrastructure
  e.g. shelters, bike racks, real-time arrival information, etc.
- ☐ On-board infrastructure
  e.g. charging facilities, bicycle accommodations, etc.
- ☐ Enhanced customer service
- ☐ Comfort and cleanliness
- ☐ Other
- ☐ It works just fine now

19. Tell us more about what makes you more comfortable to ride the bus!

(If "Yes" or "Occasionally" to question 12) **Thanks for your participation.**

We are glad to hear that you are actively using Intercity Transit's bus service. Intercity Transit is now making effort to upgrade their services, hopefully your travel experience will be more satisfying in the future!

(If "Yes" question 16) **That sounds great! Don't hesitate to give it a try!**

Thanks for your participation. You are welcome to retake this survey anytime and tell us about your impression.

(If "No" to question 12 or to question 16) **Thanks for your participation.**

We are sorry to hear that the current bus service doesn't go well with you. Intercity Transit is now making effort to upgrade their services, hopefully your need of transit can be satisfied in the future.

(End of questionnaire)

To view the online version, please consult: https://arcg.is/1PmLPC

Appendix 2. Statistical Analyses Results

2-1 Ordinal Logistic Regression Results (with R)

Responsive variable: Bus-riding frequency

Model 1: Age as predictive variable

```
Call:
polr(formula = Frequency ~ Age, data = age_order_table, Hess = TRUE)

Coefficients:
       Value Std. Error t value
Age 0.001242     0.0056  0.2217

Intercepts:
                                                                        Value
1. More than 5 days a week|2. 3-4 days a week                          -0.6657
2. 3-4 days a week|3. 1-2 days a week                                   0.4792
3. 1-2 days a week|4. 1-3 days a month                                  1.0831
4. 1-3 days a month|5. Less than 1 month ago                            1.2433
5. Less than 1 month ago|6. Between 1 month and 3 months ago            1.6296
6. Between 1 month and 3 months ago|7. Between 3 months and 6 months ago  2.4761
7. Between 3 months and 6 months ago|8. Between 6 months and 1 year ago   2.8830
8. Between 6 months and 1 year ago|9. More than 1 year ago              3.7763
                                                                     Std. Error
1. More than 5 days a week|2. 3-4 days a week                           0.2060
2. 3-4 days a week|3. 1-2 days a week                                   0.2041
3. 1-2 days a week|4. 1-3 days a month                                  0.2097
4. 1-3 days a month|5. Less than 1 month ago                            0.2121
5. Less than 1 month ago|6. Between 1 month and 3 months ago            0.2197
6. Between 1 month and 3 months ago|7. Between 3 months and 6 months ago  0.2495
7. Between 3 months and 6 months ago|8. Between 6 months and 1 year ago   0.2729
8. Between 6 months and 1 year ago|9. More than 1 year ago              0.3563
                                                                     t value
1. More than 5 days a week|2. 3-4 days a week                          -3.2308
2. 3-4 days a week|3. 1-2 days a week                                   2.3480
3. 1-2 days a week|4. 1-3 days a month                                  5.1654
4. 1-3 days a month|5. Less than 1 month ago                            5.8619
5. Less than 1 month ago|6. Between 1 month and 3 months ago            7.4160
6. Between 1 month and 3 months ago|7. Between 3 months and 6 months ago  9.9246
7. Between 3 months and 6 months ago|8. Between 6 months and 1 year ago  10.5634
8. Between 6 months and 1 year ago|9. More than 1 year ago              10.5975

Residual Deviance: 1670.724
AIC: 1688.724
```

Model 2: Number of people in the household as predictive variable

```
Call:
polr(formula = Frequency ~ Population, data = population_order_table,
    Hess = TRUE)

Coefficients:
            Value Std. Error t value
Population -0.1655    0.05433  -3.047

Intercepts:
                                                                        Value
1. More than 5 days a week|2. 3-4 days a week                          -1.1986
2. 3-4 days a week|3. 1-2 days a week                                   0.0035
3. 1-2 days a week|4. 1-3 days a month                                  0.6167
4. 1-3 days a month|5. Less than 1 month ago                            0.7809
5. Less than 1 month ago|6. Between 1 month and 3 months ago           1.1310
6. Between 1 month and 3 months ago|7. Between 3 months and 6 months ago  1.9863
7. Between 3 months and 6 months ago|8. Between 6 months and 1 year ago   2.4222
8. Between 6 months and 1 year ago|9. More than 1 year ago              3.3161
                                                                     Std. Error
1. More than 5 days a week|2. 3-4 days a week                           0.1718
2. 3-4 days a week|3. 1-2 days a week                                   0.1612
3. 1-2 days a week|4. 1-3 days a month                                  0.1653
4. 1-3 days a month|5. Less than 1 month ago                            0.1677
5. Less than 1 month ago|6. Between 1 month and 3 months ago           0.1749
6. Between 1 month and 3 months ago|7. Between 3 months and 6 months ago  0.2082
7. Between 3 months and 6 months ago|8. Between 6 months and 1 year ago   0.2368
8. Between 6 months and 1 year ago|9. More than 1 year ago              0.3293
                                                                      t value
1. More than 5 days a week|2. 3-4 days a week                          -6.9771
2. 3-4 days a week|3. 1-2 days a week                                   0.0215
3. 1-2 days a week|4. 1-3 days a month                                  3.7299
4. 1-3 days a month|5. Less than 1 month ago                            4.6554
5. Less than 1 month ago|6. Between 1 month and 3 months ago           6.4680
6. Between 1 month and 3 months ago|7. Between 3 months and 6 months ago  9.5408
7. Between 3 months and 6 months ago|8. Between 6 months and 1 year ago  10.2284
8. Between 6 months and 1 year ago|9. More than 1 year ago             10.0690

Residual Deviance: 1622.439
AIC: 1640.439
```

Model 3: Number of vehicle(s) in the household as predictive variable

```
Call:
polr(formula = Frequency ~ Vehicle, data = vehicle_order_table,
    Hess = TRUE)

Coefficients:
          Value Std. Error t value
Vehicle -0.1852    0.08532  -2.171

Intercepts:
                                                                          Value
1. More than 5 days a week|2. 3-4 days a week                            -0.9104
2. 3-4 days a week|3. 1-2 days a week                                     0.2371
3. 1-2 days a week|4. 1-3 days a month                                    0.8421
4. 1-3 days a month|5. Less than 1 month ago                              1.0000
5. Less than 1 month ago|6. Between 1 month and 3 months ago             1.3806
6. Between 1 month and 3 months ago|7. Between 3 months and 6 months ago  2.2329
7. Between 3 months and 6 months ago|8. Between 6 months and 1 year ago   2.6694
8. Between 6 months and 1 year ago|9. More than 1 year ago                3.5634
                                                                       Std. Error
1. More than 5 days a week|2. 3-4 days a week                             0.1339
2. 3-4 days a week|3. 1-2 days a week                                     0.1284
3. 1-2 days a week|4. 1-3 days a month                                    0.1359
4. 1-3 days a month|5. Less than 1 month ago                              0.1391
5. Less than 1 month ago|6. Between 1 month and 3 months ago             0.1489
6. Between 1 month and 3 months ago|7. Between 3 months and 6 months ago  0.1866
7. Between 3 months and 6 months ago|8. Between 6 months and 1 year ago   0.2178
8. Between 6 months and 1 year ago|9. More than 1 year ago                0.3158
                                                                       t value
1. More than 5 days a week|2. 3-4 days a week                            -6.8004
2. 3-4 days a week|3. 1-2 days a week                                     1.8464
3. 1-2 days a week|4. 1-3 days a month                                    6.1957
4. 1-3 days a month|5. Less than 1 month ago                              7.1907
5. Less than 1 month ago|6. Between 1 month and 3 months ago             9.2741
6. Between 1 month and 3 months ago|7. Between 3 months and 6 months ago 11.9647
7. Between 3 months and 6 months ago|8. Between 6 months and 1 year ago  12.2571
8. Between 6 months and 1 year ago|9. More than 1 year ago               11.2848

Residual Deviance: 1686.952
AIC: 1704.952
```

2-2. Chi-Squared Test Results (with R)

Responsive variable: Bus-riding frequency

Model 1: Gender as predictive variable

```
        Pearson's Chi-squared test

data:  gender_con_table
X-squared = 14.301, df = 16, p-value = 0.5763

Warning message:
In chisq.test(gender_con_table) :
  Chi-squared approximation may be incorrect
```

Model 2: Household annual income level as predictive variable

```
        Pearson's Chi-squared test

data:  income_con_table
X-squared = 96.273, df = 48, p-value = 4.441e-05

Warning message:
In chisq.test(income_con_table) :
  Chi-squared approximation may be incorrect
```

2-3. Fisher's Exact Test Results (with R)

Responsive variable: Bus-riding frequency

Model 1: Gender as predictive variable

```
        Fisher's Exact Test for Count Data with simulated p-value
        (based on 2000 replicates)

data:  gender_con_table
p-value = 0.6437
alternative hypothesis: two.sided
```

Model 2: Household annual income level as predictive variable

```
        Fisher's Exact Test for Count Data with simulated p-value
        (based on 2000 replicates)

data:  income_con_table
p-value = 0.0004998
alternative hypothesis: two.sided
```