FINAL PROJECT REPORT

Integrating Food Access with Transit Services in Urban Areas of the Pacific Northwest: The Case of Seattle, Washington

by

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16. Abstract

This study examined how public transportation can help improve access to emergency food resources and lower the risk of food insecurity in American cities. For a case study of Seattle, Washington, we used the General Transit Feed Specification (GTFS) to measure the accessibility of food banks and food pantries at the census block group level. We found that approximately 40 percent of neighborhoods in the city of Seattle were within walkable distances or half a mile of the nearest food bank or pantry. However, general access to the food pantry network was highly constrained by pantry operating hours. We found Tuesday, Wednesday, and Thursday afternoons to be popular timeslots, and food banks were rarely open during weekends. Furthermore, transit access to the citywide food pantry network was unevenly distributed in that some neighborhoods associated with larger numbers of food insecure populations were simultaneously those with poor accessibility to emergency food resources. These neighborhoods were primarily located in South Seattle and near the city's northern edge. The results of regression models further indicated that convenient access to food banks or food pantries remains important for vulnerable communities. Finally, our study suggested that on-demand transit services or additional mobile food pantries would help bring free food to vulnerable communities, especially when regular public transit services are constrained by catastrophic circumstances such as the onset of the COVID-19 pandemic.

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LIST OF ABBREVIATIONS

ACS	American Community Survey
EFS	Emergency food services
GIS	Geographic information system
GTFS	General Transit Feed Specification
SNAP	Supplemental Nutrition Assistance Program
SDOT	Seattle Department of Transportation
WIC	Special Supplemental Nutrition Program for Women, Infants, and Children

EXECUTIVE SUMMARY

Recent years have witnessed an increased risk of hunger and food insecurity in American cities, and nearly 11 percent of U.S. households were considered food insecure at the end of 2019. Catastrophic events such as the COVID-19 pandemic and the even more recent inflation of food prices have worsened the problem. In this study, we analyzed food insecurity, food access, and transportation networks to better understand the accessibility of emergency food providers and to research how transit access to food pantries and food banks could play a role in decreasing the danger of food insecurity in urban areas. We drew upon the case of the city of Seattle, Washington, where rising numbers of homeless and food-insecure populations have attracted more attention from the public.

We calculated the minimized travel time by using a big dataset called the General Transit Feed Specification (GTFS) and applied geo-visualization techniques to map neighborhoods that had poor access to the food pantry network while simultaneously experiencing food insecurity. We found that a food bank could serve 40.7 percent of census block groups in the city within walking distance (or half a mile), and 45.5 percent of neighborhoods could reach a food bank within 10 minutes by riding public transit. However, the temporal access to emergency food services (EFS) was highly uneven, as afternoons on Tuesdays, Wednesdays, and Thursdays provided the most available resources, and only a very small number of food pantries operated during weekends. The results of bivariate mapping further indicated that current public transit services might be limited in serving vulnerable communities in South Seattle and pockets near the northern edge of the city where residents experienced a higher risk of food insecurity.

In conclusion, on-demand transit services or routing of mobile food pantries to these neighborhoods could help fill the gap and improve EFS access in Seattle.

CHAPTER 1. INTRODUCTION

Food insecurity refers to uncertain or limited access to resources and a higher risk of hunger due to insufficient supply of nutritious food to maintain health and well-being (Coleman-Jensen, 2018). It has been estimated that nearly 11 percent of Americans were, to some extent, food insecure in 2019 before the onset of the COVID-19 pandemic. Studies have also found that various individual-level socioeconomic conditions, such as poverty and unemployment, contribute to the likelihood of food insecurity (Fitzpatrick et al., 2021; Li et al., 2022). To mitigate the risk of food insecurity, specific governmental programs have been established; the Supplemental Nutrition Assistance Program (SNAP) (commonly known as the food stamp program) is considered the most important program because it provides the widest coverage for vulnerable communities in the U.S.

Besides SNAP, other federal programs aim to mitigate the risk of food insecurity, including the Special Supplemental Nutrition Program for Women, Infants, and Children (WIC) program, which emphasizes women, infants, and children, and the national school lunch or school breakfast programs targeting food-insecure students (Li et al., 2022). Additionally, community-level efforts, especially food banks and food pantries, are a crucial source of support for people who suffer from hunger and food insecurity. Bazerghi et al. (2016) found that food banks significantly affect the provision of food assistance by directly distributing donated and purchased groceries to families facing food insecurity. This is particularly true when public service is not accessible (Loopstra and Tarasuk, 2012).

In fact, the risk of food insecurity might be linked to transportation. High transport costs for grocery shopping and a low level of food access mean that residents may prefer to purchase convenient, fast food nearby, resulting in nutritional insecurity (Jin et al., 2023). For minorities and vulnerable populations, public transit and walking remain critical transportation methods in automobile-centric metropolitan areas. For example, Chen and Clark (2016) examined half-mile buffers centered on food stores and addressed the temporal dimension of food access via walking in a city of Ohio. Mikelbank (2021) examined transit access to food banks in another city in Ohio. Using data on regional transit network scheduling, the study suggested that spatial and temporal access was relatively lower in urban-fringe neighborhoods. Besides food insecurity, many studies have found that neighborhoods with good access to food retailers that sell fresh vegetables and fruits are associated with healthier food consumption habits and outcomes. Residents in these neighborhoods have reported a lower likelihood of obesity and chronic diseases such as cardiovascular diseases (Cooksey-Stowers et al., 2017; Kelli et al., 2019). Recent research has also found that during catastrophic circumstances such as the COVID-19 pandemic, food banks or food pantries play a key role in lowering the risk of food insecurity, but ways to improve the accessibility of these emergency food services remain understudied (Allen and Farber, 2021; Chakraborty et al., 2022).

In this report, we present a case study of the city of Seattle, Washington. We first examined the spatial inequality of access to emergency food services (e.g., food banks, food pantries, or other free food resources provided by charitable organizations). Instead of the Euclidean-distance measure of food access, we leveraged General Transit Feed Specification (GTFS) data or high-resolution transit feed specification datasets to measure the travel time from each census block group to nearby food banks and the whole food pantry network of the city. In addition, we employed regression models to better understand the association between neighborhood-level social vulnerability metrics (e.g., transport, income, poverty, food insecurity) and food access concerning emergency food services. The report concludes with a couple of policy recommendations for stakeholders.

CHAPTER 2. DATA AND METHODS

2.1. Foodbanks and Food Pantries

The data on the locations of food banks and food pantries were gathered from the open data program of the city of Seattle. The dataset was available through the Seattle Food Committee's “Find a Food Bank” dashboard (Howell, 2020). The City of Seattle, Public Health Seattle, and King County published the dashboard. The public dataset includes information regarding free food resources in King County as of August 2021. The list of food banks or free food providers was created in response to the crisis during the COVID-19 pandemic. Public health agencies and partners identified that there were 50 food banks, 97 meal delivery programs, and 65 community organizations providing free food boxes and meals to King County residents. In addition to the physical locations of these emergency food providers, the dashboard also supplies information regarding hours of operation every month. Because the list had not been updated since August 2021, some of these operations might have closed or changed their operating hours as a result of the phase-out of funding or resources in the post-pandemic era. Therefore, we verified the operating hours by visiting their web pages individually. The final list consisted of 93 food banks or food pantries within the city limits.

2.2. Transit Access Analysis with the Generalized Transit Feed Specification (GTFS)

The transportation network data used in this study were also compiled from the open data portal mentioned above, and they are made available by the Seattle Department of Transportation (SDOT). General transit feed specification (GTFS) data were downloaded directly from Transitfeeds.com; these were originally posted by King County and Sound Transit in 2023 and 2021, respectively. These datasets include bus or train routes, stop locations, and schedules related to the public transit system in Seattle. They can be imported into ArcGIS network analyst by using a predefined template developed by the ESRI team (see more details in the Appendix). The GTFS data and road network geographic information system (GIS) files were then combined using the ArcGIS public transit toolbox to calculate minimized travel times of using public transit, driving, and walking. Drawing upon the results of network analysis, we also used a geo-visualization method, such as bivariate mapping, and statistical analysis, such as OLS regression models, to identify specific neighborhoods that might have relatively poorer access to food banks and to examine how their sociodemographic characteristics could be related to the transportation accessibility of food banks.

CHAPTER 3. RESULTS

3.1. Food Insecurity and the Distribution of Food Banks in Seattle

The city of Seattle could be considered a microcosm of national challenges concerning delivering food aid services to vulnerable populations. Even though the city is one of the wealthiest, with a median household income of $105,391 in 2021, housing and transportation costs are more expensive than those in similar tech hubs in the U.S. According to a report published by the Urban Institute of Washington D.C., and the Walmart Foundation, in 2016-2017 9.4 percent of households in the greater Seattle area received SNAP or food stamps, whereas the number of households in similar cities was 8.5 percent.

Meanwhile, nearly 34 percent of households in the Seattle region reported suffering from the high stress of unaffordable housing in comparison to 27 percent of households at the national level. The average rate of food-insecure households in Seattle was as high as 12 percent before the onset of COVID-19, whereas the share of such households in similar cities was approximately 10 percent (Table 3.1). In addition, in the Seattle region, the proportion of children who were food insecure was approximately 16 percent in 2016-2017, lower than the ratio at the state level but slightly higher than that in peer cities (Table 3.1).

Table 3.1. Food insecurity in the greater Seattle area

	King County	Washington	Peer-group
% of food insecure households 2016	12.2	12.0	10.3
% of food insecure households 2017	11.5	11.5	9.9
Food insecure, children (2016) (%)	15.6	17.5	14.9
Food insecure, children (2017) (%)	15.5	17.3	14.6
Limited access to healthy food (%)	2.8	5.5	5.4
Households receiving SNAP (%)	9.4	12.6	8.5
Households receiving SNAP or cash assistance (%)	10.0	13.3	9.2

Source: https://apps.urban.org/features/disrupting-food-insecurity/?county=King_County&state=WA

Note that during the COVID-19 pandemic, food insecurity worsened for vulnerable populations, such as people of color, senior residents, children, and people with disability. For instance, from March 2020 to April 2020, there was a 23 percent increase in households who received essential food benefits in Seattle in comparison to February 2020, and this also was an annual growth of 20 percent in comparison to the same period in 2019 (https://kingcounty.gov/depts/health/covid-19/data/impacts/food.aspx).

Geographically speaking, the distribution of food-insecure households in Seattle is concentrated in the southern portion of the city (Figure 3.1), and some neighborhoods near the south edge of the downtown area and the northern border of the city also experience high levels of food insecurity. The distribution of food banks is uneven, with a larger number of food banks concentrated near the downtown area and fewer in the southwestern and northeastern portions of the city (Figure 3.1a).

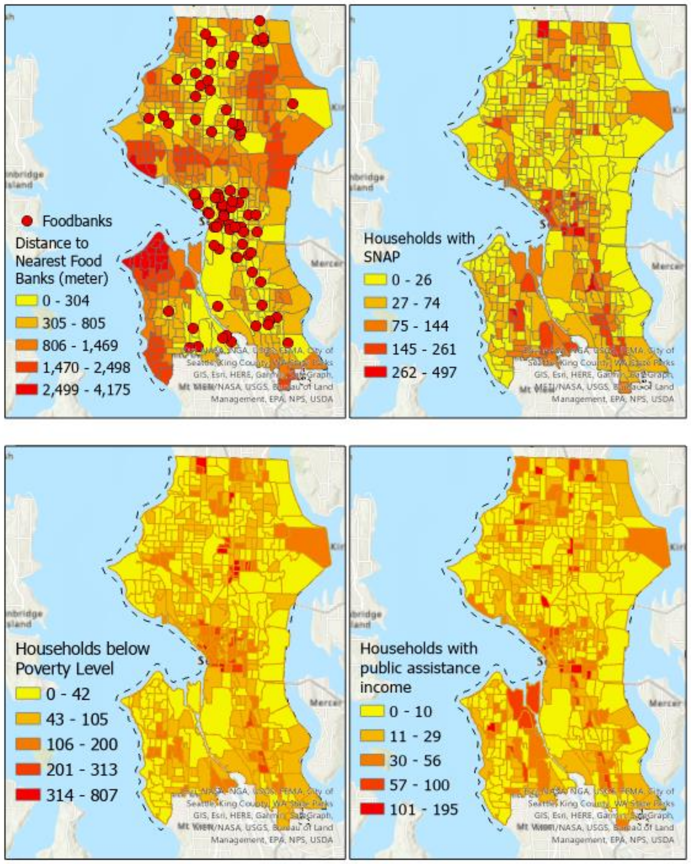

Figure 3.1. Food bank proximity for vulnerable neighborhoods in Seattle

Figure 3.2 shows a weekly summary of the operating hours of food banks in Seattle. As found in other studies (Mikelbank, 2021), most food banks or pantries were open on Tuesdays, Wednesdays, and Thursdays, contributing to the majority of operating hours weekly (Figure 3.2). Interestingly, most food banks scheduled their distribution hours in the early afternoon, with some operating during peak traffic hours such as 3:00 to 5:00 pm, when congestion is often a big issue in Seattle.

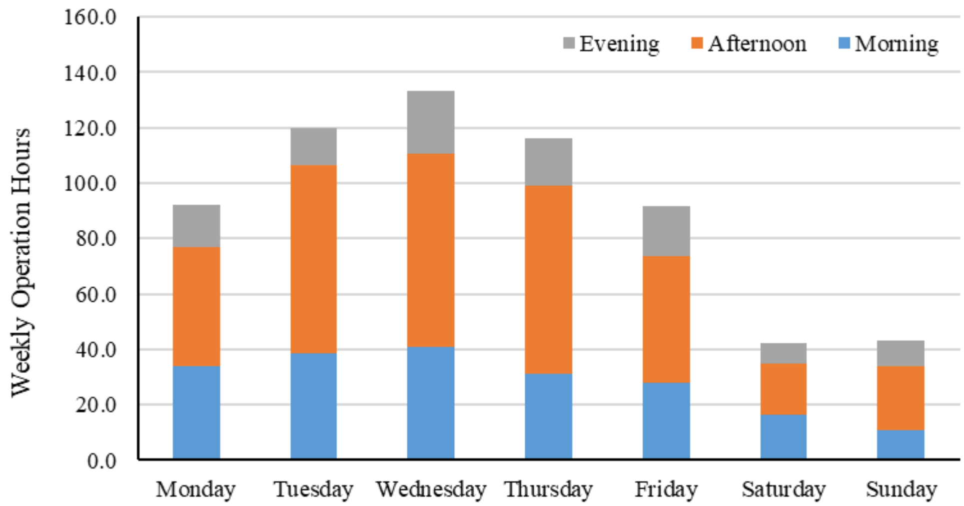

Figure 3.2. Hours of operation for food banks in Seattle

3.2. Transit Access to Food Banks or Food Pantries

With a particular focus on public transit, this section summarizes the results of our transport network or travel-time analysis. We first analyzed walking and transit-based access to the nearest food banks and pantries. Second, we mapped the median transit-based travel time (in minutes) from each census block group to all food pantries and driving time (in minutes) within 1 hour. We also compared travel time via public transit to regular commute-to-work trips using public transportation. All accessibility results were based on the assumption that the departure time was 12:00 pm on Wednesdays, when most food banks in the city were open.

As shown in Table 3.2, nearly all census block groups in Seattle were served by a food bank or food pantry within 2 miles' walking distance, while more than 60 percent of census block groups were more than a half-mile away from the nearest food bank. In contrast, it took approximately 15 minutes on average for residents in the city of Seattle to reach the nearest food bank or food pantry via public transit. Additionally, 467 out of 552, or approximately 85 percent of census block groups, in Seattle were within 20 minutes of a food bank if public transit services were available (Table 3.2). Among these 467 census block groups, the current transit travel time would be, on average, 13 minutes. Within 30 minutes of transit-based travel time, residents who lived in 97 percent of neighborhoods could reach a food bank.

Table 3.2. Walking distance and public transit travel time to the nearest pantries

Walking Distance or Transit Time	# of Neighborhoods	Share of total
CBG_half_mile	219	39.67%
CBG_1 mile	382	69.20%
CBG_2 mile	522	94.57%
CBG_10 MINUTES	251	45.47%
CBG_20 MINUTES	467	84.60%
CBG_30 MINUTES	536	97.10%

Furthermore, as shown in Figure 3.3, transit-based travel times tended to be more evenly distributed in the city of Seattle, with a lower standard deviation value of 8 minutes in comparison to a standard deviation of 12 minutes for walking. In short, by focusing on the accessibility of the nearest food banks/pantries, our results suggest the important role that public transit may play in accessing free food resources in Seattle.

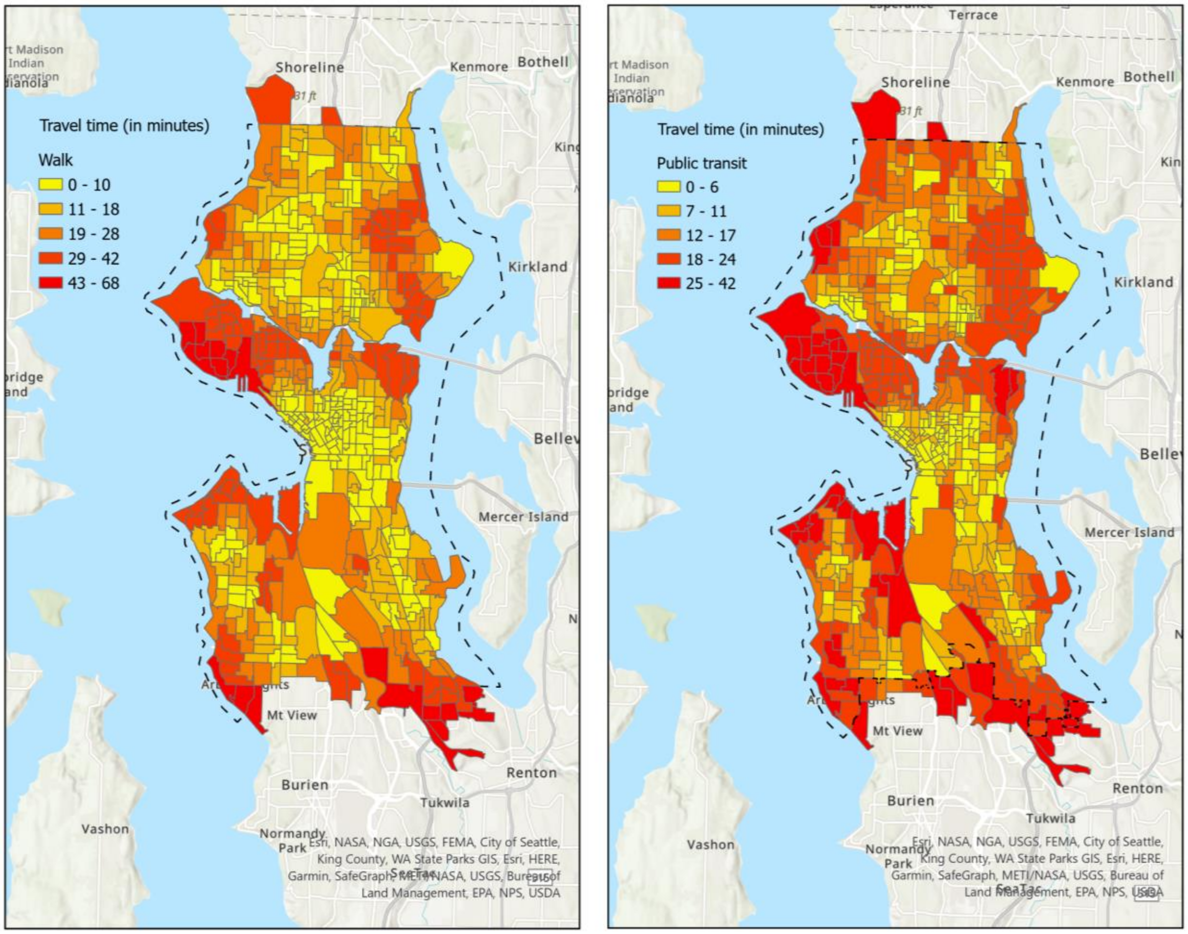

Figure 3.3. Travel time to the closest food pantry by walking or public transit (in minutes)

Figure 3.4 and Figure 3.5 further illustrate overall accessibility to the whole pantry network. Here we focused on the differences between travel by car and public transit instead of comparing walking and transit, assuming that residents would not consider accessing just the nearest food bank. The cut-off value, in this case, was set at 60 minutes. We also standardized the driving and transit travel times by using the statistics of commute-to-work trips from the American Community Survey (ACS).

As shown in Figure 3.4, in general, the duration of driving time measured by the median minimized travel time was 22 minutes on average, whereas the minimized travel time via public transit was 42 minutes. In considering the regular commute-to-work travel time, the variation in public transit travel time was more evident (Figure 3.5). Specifically, the standard deviation of transit-based travel time was 1.14, whereas the standard deviation of driving-based travel time was barely 0.16, which indicates the uneven spatial distribution of transit services or access in the city.

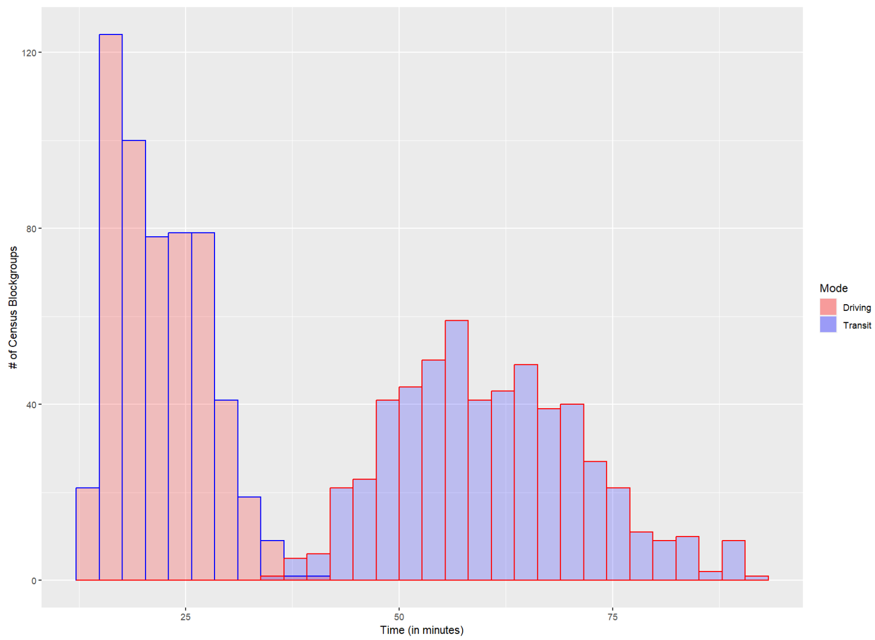

Figure 3.4. Median minimized travel time (in minutes) for trips to the pantry network

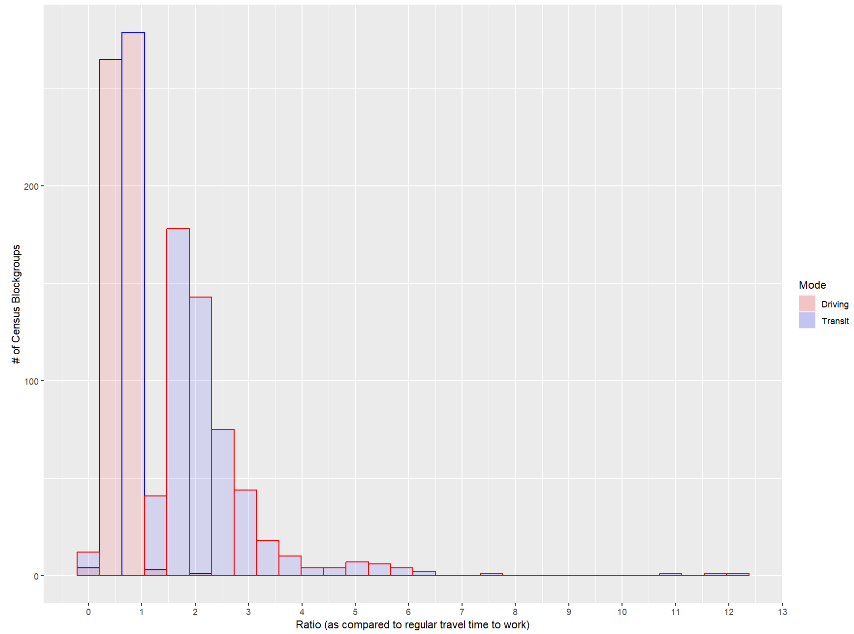

Figure 3.5. Standardized transit and general accessibility to food banks

3.3. Social Vulnerability and Food Access

To better understand how social vulnerability was associated with transit access to emergency food resources in Seattle, we first mapped the geography of social vulnerability. We added these results to previous results of transit-based food access, followed by regression analysis to address how these sociodemographic characteristics were related to poor access to EFS.

As shown in Figure 3.6a, when we used the share of households that had relied on food stamps or SNAP benefits in the past five years as a proxy for food insecurity instead of the absolute number of households that had received food-stamp benefits, a relatively larger number of neighborhoods in the southeastern portion of the city limits was associated with higher levels of food insecurity, with more than 15 percent of households associated with the SNAP program.

Our bivariable visualization results further showed that neighborhoods in the southeastern and northwestern parts of Seattle (Figure 3.6c) were areas with poor access to food banks and high risk of food insecurity. In contrast, neighborhoods in West Seattle or the urban fringe of downtown would have better transit access to the food pantry network. However, a larger number of households therein were also under the pressure of food insecurity (Figure 3.6b and 3.6c).

In addition to the association between food access and food insecurity, we further utilized data on other indicators related to households' social vulnerability to address underlying factors that might worsen the spatial inequality of food access in Seattle. The data were made available from the 2017-2021 ACS from the U.S. Census Bureau and the data portal of nhgis.org. These indicators included income poverty measured by the share of households in a census block group with income below the poverty level and the share of households that received a public assistance. The proxy of food insecurity was the share of households with assistance directly from USDA's SNAP program, mentioned above.

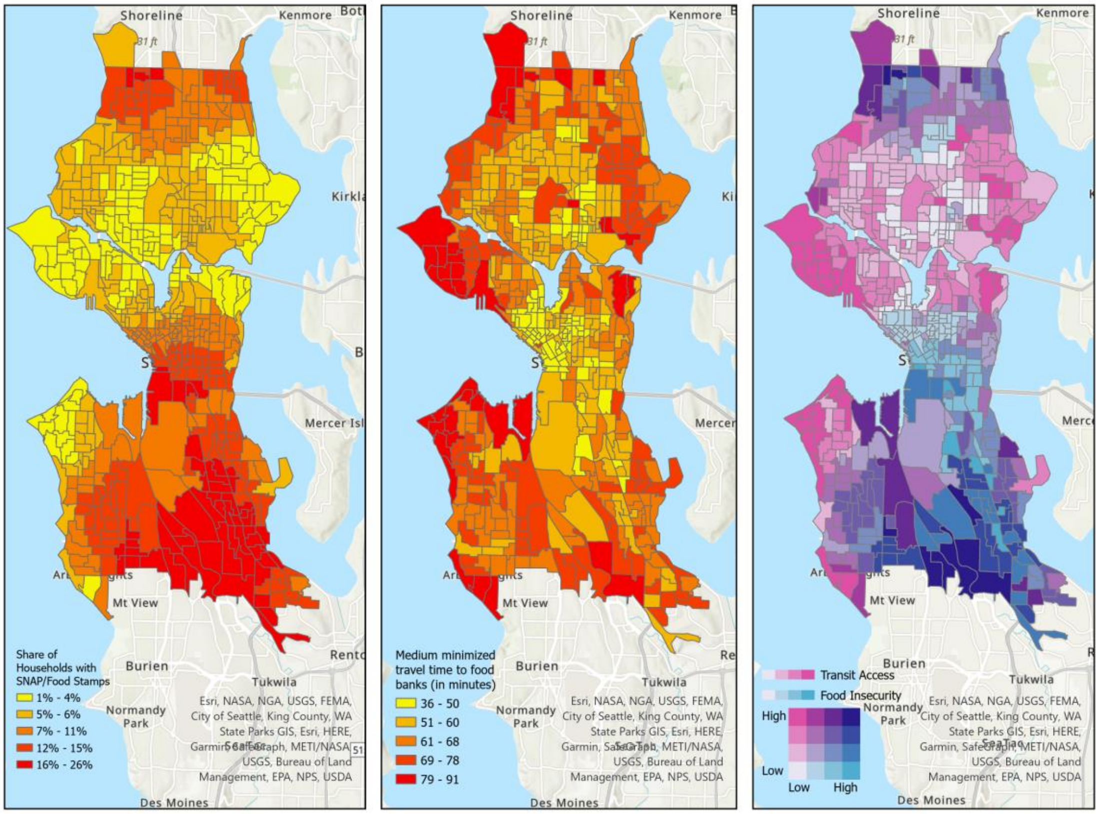

Figure 3.6. Map of (a) food insecurity, (b) transit access to food banks, and (c) bivariate visualization

Two variables were designated as proxies for transport poverty, including the share of households in a census block group that did not have a car, and another indicator related to transit reliance, which was the share of work trips via public transit conducted by workers from households below 150 percent of the poverty level. Specifically, because no data were available at the census block group level for vehicle ownership or transit reliance, an appointment layer tool, in conjunction with a spatial join operation in ArcGIS, was used to derive the estimates (see https://pro.arcgis.com/en/pro-app/latest/help/analysis/business-analyst/data-apportionment-and-layers.htm for more details).

As shown in Table 3.3, both transit- and walk-based travel times for trips to food banks were negatively associated with neighborhood-level social vulnerability, including income levels, poverty, vehicle ownership, and reliance on public transit. Specifically, travel time via public transit declined significantly for census blocks with more households in poverty, without a car, or receiving public assistance. It is also worth noting that the magnitude of the coefficients associated with transit reliance was the highest among these indicators. In other words, the spatial distribution of food bank accessibility was aligned with community vulnerability and dependence on transit services. Furthermore, temporal access, i.e., operating hours, affected access to emergency food resources.

Table 3.3. Regression analysis of social vulnerability and access to food banks

Variable	Model 1: Median minimized travel time (in minutes) via transit	Model 2: Transit access (standardized index by the travel time of regular work trips via transit)	Model 3: Travel time (in minutes) to nearest EFS via transit	Model 4: Travel time (in minutes) to the nearest EFS via walking
% of households using food stamps	0.019***	0.028***	-0.035	-0.074
% of households below the poverty	-0.154***	-0.009*	-0.101**	-0.171***
% of households w public assistantship	-0.199*	0.001	-0.111	-0.038
% of households w/o a single vehicle	-0.285***	-0.010**	-0.172***	-0.234***
% of households who are transit reliant	-14.987***	0.506	-12.390***	-15.488***
# of observations	552	552	552	552
Adj. R square	0.155	0.045	0.141	0.127

Note: * denotes p<0.05; ** denotes p<0.01; *** denotes p<0.001

CHAPTER 4. CONCLUDING REMARKS

As food insecurity has been mounting in American cities, food banks or food pantries have been playing a more critical role in providing a safety net, especially for disadvantaged communities. In this project, we leveraged a big dataset called the General Transit Feed Specification (GTFS) and GIS network analysis methods to explore the spatial, temporal, and transit access to emergency food providers or services in Seattle, Washington, while addressing the associations between social vulnerability and accessibility to emergency food services (EFS). Our findings wee as follows.

First, although more than 60 percent of census block groups in the city of Seattle were located beyond a walkable distance from the nearest food bank, more than 80 percent of neighborhoods could reach a food bank within 20 minutes by public transit. Geographically speaking, neighborhoods in South Seattle experienced more challenges in accessing EFS via public transportation than other areas within the city of Seattle.

Second, the opening hours of food banks or food pantries is another key issue worth addressing. Currently, Tuesday, Wednesday, and Thursday afternoons are the most popular times, whereas most food banks are closed during weekends.

Third, even though transit access to food banks is largely aligned with the spatial distribution of vulnerable communities, there are neighborhoods in South Seattle and pockets near the northern edge of the city where residents are more likely to experience food insecurity and inadequate access to food pantries.

Finally, given the importance of public transit in accessing EFS among disadvantaged populations, transportation agencies should consider providing on-demand services when large-size food banks are open. In addition, charitable organizations may also consider routing mobile food pantries to those vulnerable communities with poor transit access to the network.

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Urban Institute of Washington D.C., and the Walmart Foundation

APPENDIX: GTFS TRANSIT FEED PROCESSING

General Transit Feed Specification (GTFS) data refers to the standardization of public transit data, including the locations of stops, schedules, and network configurations. This appendix provides additional technical details regarding data collection and processing of GTFS data for the project on transit access to emergency food resources or food banks in Seattle.

- Download GTFS data from a portal webpage of TransitFeeds.com. The datasets used here were the most recent datasets uploaded from King County Metro (2023) and Sound Transit (2021).
- Use GIS (geographic information system) tools in ArcGIS Pro. 3.0 to map stops, schedules.
- Inspect that the GTFS data follow the standardization set by Google.
- Download the road/street network dataset from the Seattle Open Data Portal by accessing the City of Seattle's "Street Network Database (SND)." Seattle GeoData, 23 Mar. 2022, https://data-seattlecitygis.opendata.arcgis.com/datasets/SeattleCityGIS::street-network-database-snd/about
- Use the GTFS To Public Transit Data Model to import GTFS datasets.
- Open the geoprocessing pane and search for the tool: https://pro.arcgis.com/en/pro-app/latest/tool-reference/public-transit/gtfs-to-public-transit-data-model.htm.
    - Inputs for this tool are in the folder containing the provided GTFS data, and a Feature Dataset that we can create using the Create Feature Dataset tool. Everything else can be left blank.
    - Run the tool.
    - After these steps, the output resembls the following, where points represent stops and lines represent stop connections:

- Import a Streets feature, namely, Street Network Database (SND), and modify the fields by inspecting the attribute table and clicking on “Add Field” following the tutorial from ESRI.
    - Once in the “add field pane,” add two fields to the attribute table of the roads/street network, a **RestrictPedestrians** field and a **ROAD_CLASS** field that should look similar to what is shown below:

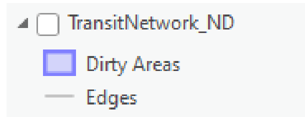
☑	☐	RestrictPedestrians	PedestrianRestriction	Text	✓	☐				254
☑	☐	ROAD_CLASS	Road_Class	Short	✓	☐	Numeric			

- Copy this Streets feature into the main project **Feature Dataset,** as it will be integrated into the Network Dataset.
- Return to the Geoprocessing pane and open the **Connect Public Transit Data Model to Streets** tool.
- Click **https://pro.arcgis.com/en/pro-app/latest/tool-reference/public-transit/connect-public-transit-data-model-to-streets.htm** for an online tutorial about how to link the stops to the street network.

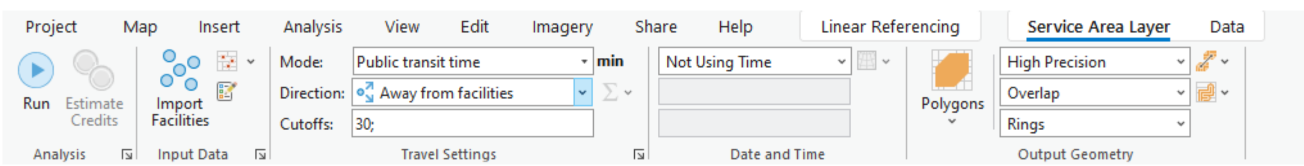
- Inputs are the project Feature Dataset and modified features of streets.
- Search distance in this study is set to the minimum, although if desired this can be modified to increase points included within the search radius.
- Run the tool.
- Zoom in. New features have been added to the map called *Stops on Streets* that when shown with the original stops data will appear like this:

- Use the template that can help create a network dataset in the geodatabase. The template is downloaded by clicking https://pro.arcgis.com/en/pro-app/latest/help/analysis/networks/create-and-use-a-network-dataset-with-public-transit-data.htm
- To import the data downloaded from the link above into ArcGIS Pro, use the **Create Network Dataset from Template tool.** (see https://pro.arcgis.com/en/pro-app/latest/tool-reference/network-analyst/create-network-dataset-from-template.htm)
- This template file can be found by going to Tutorial > PublicTransit > TransitNetworkTemplate.xml
  - Input should be an .xml file, specifically the TransitNetworkTemplate.xml xml file.
  - The set output location should be the main project dataset we have been working in.
  - Run the tool.

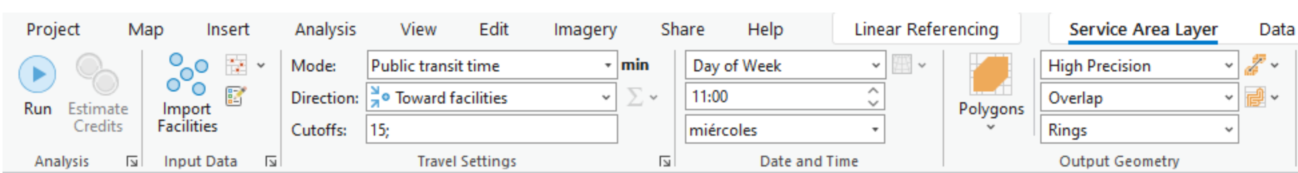
- What should appear is a *TransitNetwork_ND* with a Dirty Area of points that do not fall within the area of the streets network, as shown below:



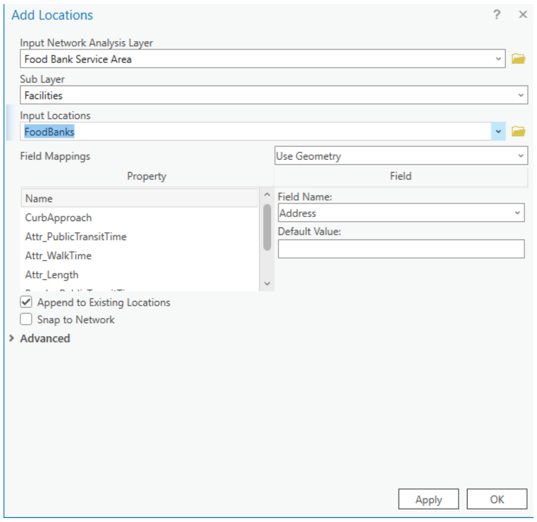
- Return to the Geoprocessing pane and open the **Build Network** tool.
  - The input here will be the TransitNetwork_ND dataset that was created in the previous step.
  - Run the tool.
  - Note: A warning is likely to appear so check the warnings, and if there are no significant issues to troubleshoot, continue on to the next step. If a preventative error does occur, refer to ESRI's help services for the specific error cited.
- **Create a Service Area Analysis as an example application of the GTFS-based analysis**. Access this through the geoprocessing pane and by searching "Create a Service Area Analysis."
  - What will appear is something similar to this:



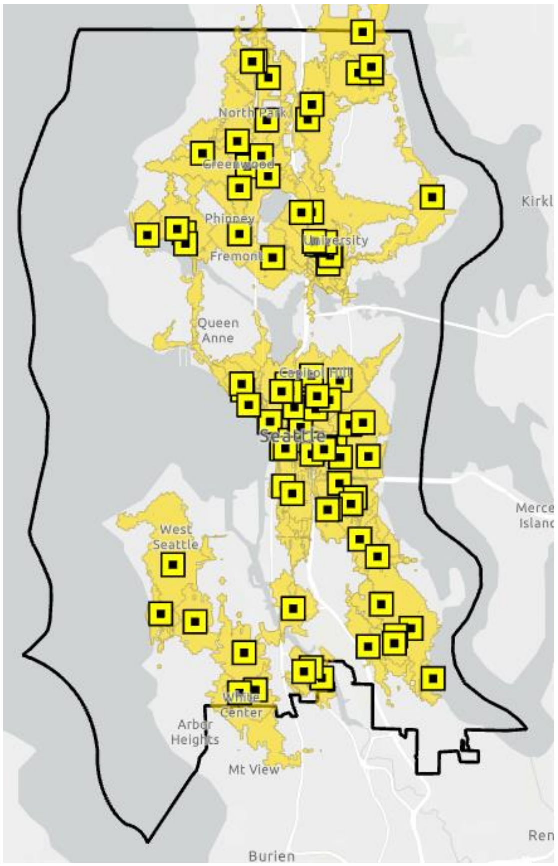
  - Which for this example was modified to these specifications:



  - Using the import facilities tool in the Service Area Layer, import the desired facilities, here those of the Seattle food banks and SNAP store locations were used:



- Then run the Service Area Analysis tool, and an output like this should appear:



- The tool results in a service area feature that shows a combined walking and public transportation time going toward a food bank location. This allows the observance of an area that is reachable through public transportation/walking within an approximately 15-minute travel time.