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Accessibility of Public Transportation in Chicago

Introduction

While the Americans with Disabilities Act (ADA) of 1990 is certainly a crucial law in the United States that protects people with disabilities from discrimination in employment and in the provision of private and public services, it is not without its shortcomings. Notably, for people who use wheelchairs or who live with ambulatory (walking or stair climbing) difficulties, the ADA does not guarantee universal accessibility of all public transportation infrastructure. While all *newly built* (post-1990) public transit stations are required to be fully accessible (as per §12146), on the subject of older stations, Section 12147 states, "It shall be considered discrimination for a public entity that provides designated public transportation to fail…to make *key stations* (as determined under criteria established by the Secretary by regulation) in rapid rail and light rail systems readily accessible to and usable by individuals with disabilities, including individuals who use wheelchairs" (Americans with Disabilities Act 1990; emphasis added). In other words, only major stations built before 1990 are required to be accessible, not ones with low traffic volume or importance.

This is why many stations within Chicago's public transportation network are not accessible for people in wheelchairs or with ambulatory difficulties. WheelchairTravel.org maintains a list of transit stations that are inaccessible, often because they lack an elevator to the train platform (*Chicago Public Transportation*, n.d.), while the official Chicago Transit Authority (CTA) train map must mark all accessible stations with a wheelchair icon (Chicago Transit Authority, 2021). This issue may be especially problematic if there are inaccessible stations in areas with high populations of people with ambulatory difficulties, and even more so if those stations are in areas with higher rates of poverty. In a study on individual-level mobility data from 2003 to 2013, Klien & Smart (2019) find that poverty is a major factor that limits car ownership (p. 408), and furthermore that families below the census-designated poverty line are less likely than families above the line to be able to access a car in response to the onset of a walking difficulty among one of their members (p. 410). Thus, in areas with greater poverty or lower car ownership, it is even more important for accessible public transportation to be available, as it may be the only method of travel for people with ambulatory difficulties who cannot afford a car.

The intersection of ambulatory difficulty, poverty, and transit accessibility has already been studied in New York City, where only a quarter of the city's world-famous subway system is accessible (Diaz 2020). In New York, individuals with disabilities are twice as likely to live in poverty as those without (*Subway Accessibility Maps*, n.d.). A lack of accessible transit only compounds the issue, as such individuals, with less access to the wealth needed to purchase and maintain a car, are often deprived of economic opportunities as a result (*Subway Accessibility Maps*, n.d.). Most problematically, accessible stations are generally less frequent in areas with higher poverty and higher ambulatory difficulty rates than they are overall, while "in the poorest areas of NYC with the highest population density of people with disability, there are often 3 or more stops in a row that are not accessible" (*Subway Accessibility Maps*, n.d.). There is thus the greatest need for accessible transit in New York in the areas where it is least available.

The following study will thus attempt to characterize the inaccessible stations in Chicago's CTA network, both overall, in order to determine whether these stations are generally located in areas with higher rates of ambulatory difficulty and poverty and lower rates of vehicle ownership, and individually, in order to determine which stations are in greatest need of accessibility upgrades, based on the same factors. While the broad analysis will provide insight into the current structure of the CTA rail system and the degree to which accessible stations are spatially distributed in areas where they are needed the most, the local analysis will analyze the spatial characteristics surrounding each station to determine how the CTA might best allocate resources towards the improvement that distribution. Of course, the best course of action for the disabled community would be for the CTA to make its transit network universally accessible; however, in the face of funding and time constraints, it is unlikely that the CTA will be capable of upgrading all of its stations at the same time.

Data

Data on both the CTA stations themselves and their surrounding tracts were used in this study. Station data were downloaded from the Chicago Data Portal (Chicago Transit Authority 2018), which included the point locations of the stations, as well as a dummy variable ("ADA"), which determined whether or not each station was accessible. Demographic data for all census tracts in Cook County were extracted from 2019 U.S. American Community Survey (ACS) 5-year estimates using the "tidycensus" package in R (U.S. Census Bureau 2019; Walker 2020). The census variables used were as follows:

Census variable	Custom name	Concept (paraphrased)
B99185_002	"amb_dfclt"	Civilian noninstitutionalized > 5 yrs. old population with ambulatory difficulty
B992512_003	"no_vhcl"	Population without vehicle available
B17001_002	"pov"	Population with income below poverty level in past year
B01003_001	"population"	Total population

Table 1: Variables used from the U.S. Census Bureau 2019 5-year ACS estimates

The first three variables were total counts, so "population" was used as a denominator to make them spatially intensive. All three variables will be used to compare areas around inaccessible stations to each other and to areas around accessible stations to determine whether, and *which*, inaccessible stations are located in areas with high levels of ambulatory difficulty than others, as well as high levels of poverty and low levels of vehicle ownership, which may make ambulatory difficulties more challenging to deal with. It should be noted that the census definition of poverty is rather complicated, and is based on a threshold that accounts for the number and age of dependents in a family, rather than relying on a simple cutoff (U.S. Census Bureau 2021). In the case of this study, the responsiveness of this definition to the individual circumstances of each household is helpful, as it likely is a better indicator of whether or not a family based on its specific composition has income to spare on the purchase of a vehicle.

Methods

1. Census variables for tracts in Cook County were extracted using “tidycensus” in R, as described above, with the geometry of the tracts included (projected into EPSG:3435, in which Eastern Illinois is presented as a flat plane). One tract had to be excluded, as it had no population or geometry, and was likely an error. In all, there were 1318 tracts remaining. The tract data were then exported from R as a shapefile.
2. In QGIS, 5 minute, 10 minute, and 15 minute walking isochrones were calculated for each station using the “ORS [OpenrouteService] Tools” plugin. These polygons, circling around each station, represent how far an average person could travel to from the station (or the reverse) within the allotted time, based on street network data from OpenStreetMap (OpenStreetMap contributors 2021). Though the smallest isochrone might be the most realistic service area for a person with difficulty walking, the other two were included to gain additional insight about the areas surrounding each station. Furthermore, while a lack of an

elevator may be prohibitive for someone in a wheelchair, a longer travel time to the station may not be, and thus demographics in areas farther away from the station were important to consider as well. These isochrones thus represented the area within which demographic characteristics surrounding each station were calculated.

3. Isochrones of 5, 10, and 15 walking times were each categorized in three groups: **"ALL"**, which included all isochrones; **"ADA"**, which included only accessible station isochrones; and **"NOT"**, which included only inaccessible station isochrones. There were thus nine categories total (three for each distance band). The isochrones of the three "NOT" categories were further geoprocessed using the QGIS "Difference" function, removing all overlap with "ADA" isochrones of the same distance band. Thus, locations that were within 5 minutes of an inaccessible station but also within 5 minutes of an accessible station were removed from the 5 minute "NOT" isochrones. However, locations that were within 5 minutes of an inaccessible station were not removed if they were only within 10 or 15 minutes of an accessible station, and so forth. This way, locations within the "NOT" isochrones of each distance band represent areas that are near inaccessible stations and do not have an accessible alternative within the same travel distance, and thus have the potential to benefit the diabled community the most through accessibility upgrades. The result is presented below as **Map 1**.
4. For Results Part 1 (comparing accessible and inaccessible stations overall): Within each of the nine categories, isochrones were combined using the QGIS "Dissolve" function, creating nine regions. Each region was then assigned values for the three demographic variables using the "Area Weighted Average" function from a plugin of the same name. This operation took the weighted average of the variables from each overlapping census tract, weighted by the degree of overlap. The resulting statistics are presented below in Results Part 1.

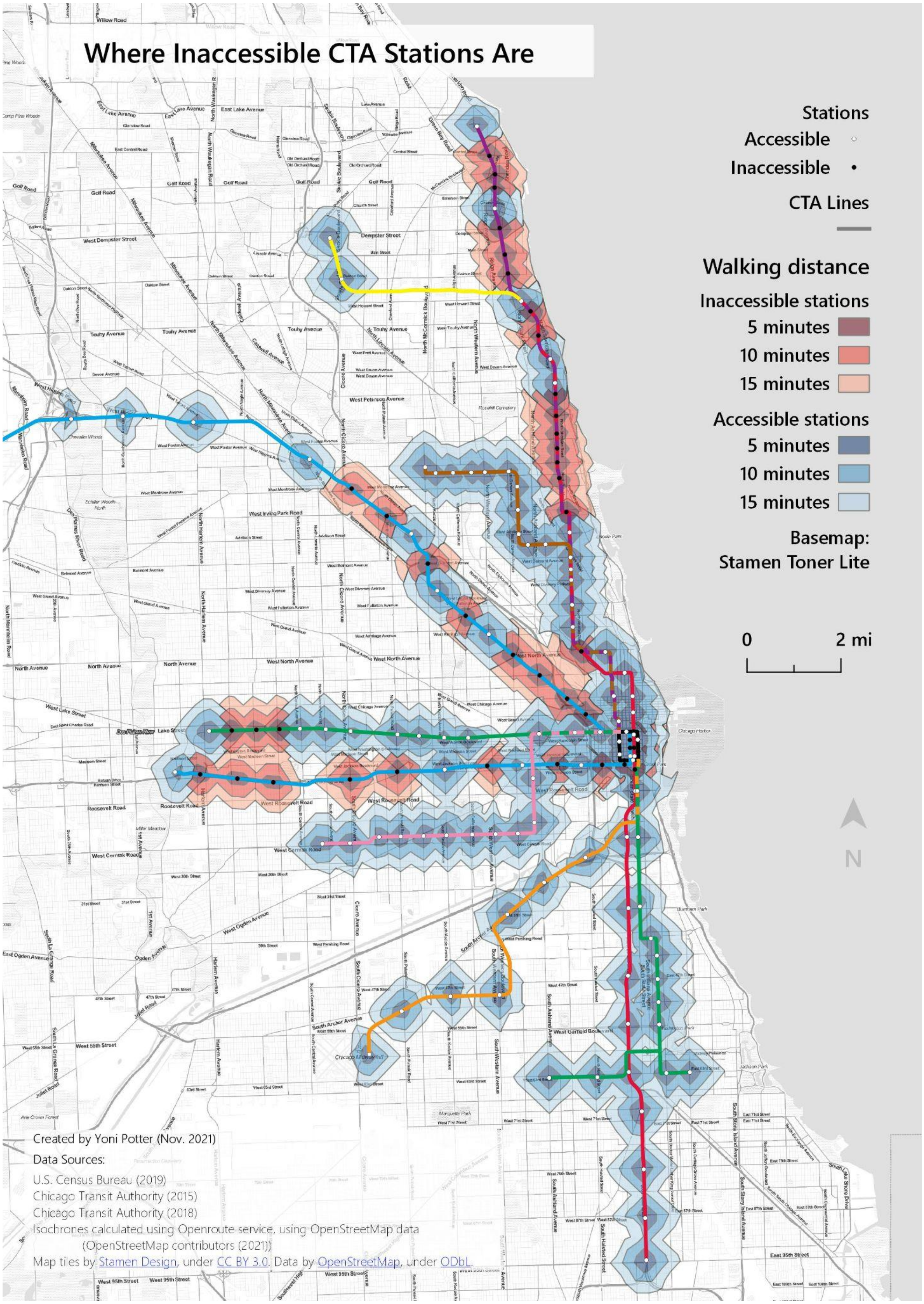
5. For Results Part 2 (assessing inaccessible stations individually): All "NOT" isochrones of each distance band were assigned area weighted average values of vehicle ownership and poverty, like before, but individually for each station. However, because the goal of this local analysis is to determine which stations would benefit most from accessibility upgrades, an estimated total count of people with ambulatory difficulties was used instead of a rate. This was done by (a) using the "Random Points inside Polygons" tool to generate and randomly distribute a number of points equal to the count of people with ambulatory difficulties within each census tract, and then (b) by using the "Count Points in Polygon" tool to estimate the count within each isochrone (using the average of five iterations). This count, as well as the area weighted average of poverty and vehicle ownership for each distance band, were joined back to the stations. Finally, the three variables were simplified into quartiles (presented as values 1 - 4), which were then averaged between distance bands.[1] These scores are presented in Results Part 2, and are mapped in **Map 2**.

Results

Part 1: Comparing Accessible and Inaccessible Stations Overall

Map 1 shows the locations of all accessible and inaccessible CTA stations, as well as the dissolved 5, 10, and 15-minute walking distance bands around them.[2] This map should be used for reference when comparing the statistics of each dissolved region. In all, out of 144 stations, 101 were accessible and 43 were inaccessible.

[1] This way, values within 5 minutes of each station would be weighted more strongly than those 15 minutes away, as 15 minute distance bands were generally inclusive of the areas within the 5 minute bands. This is because people who live closer are more likely to use the station, and are thus stronger stakeholders.
[2] O'Hare station on the Blue Line had to be excluded due to space constraints, although it is accessible.

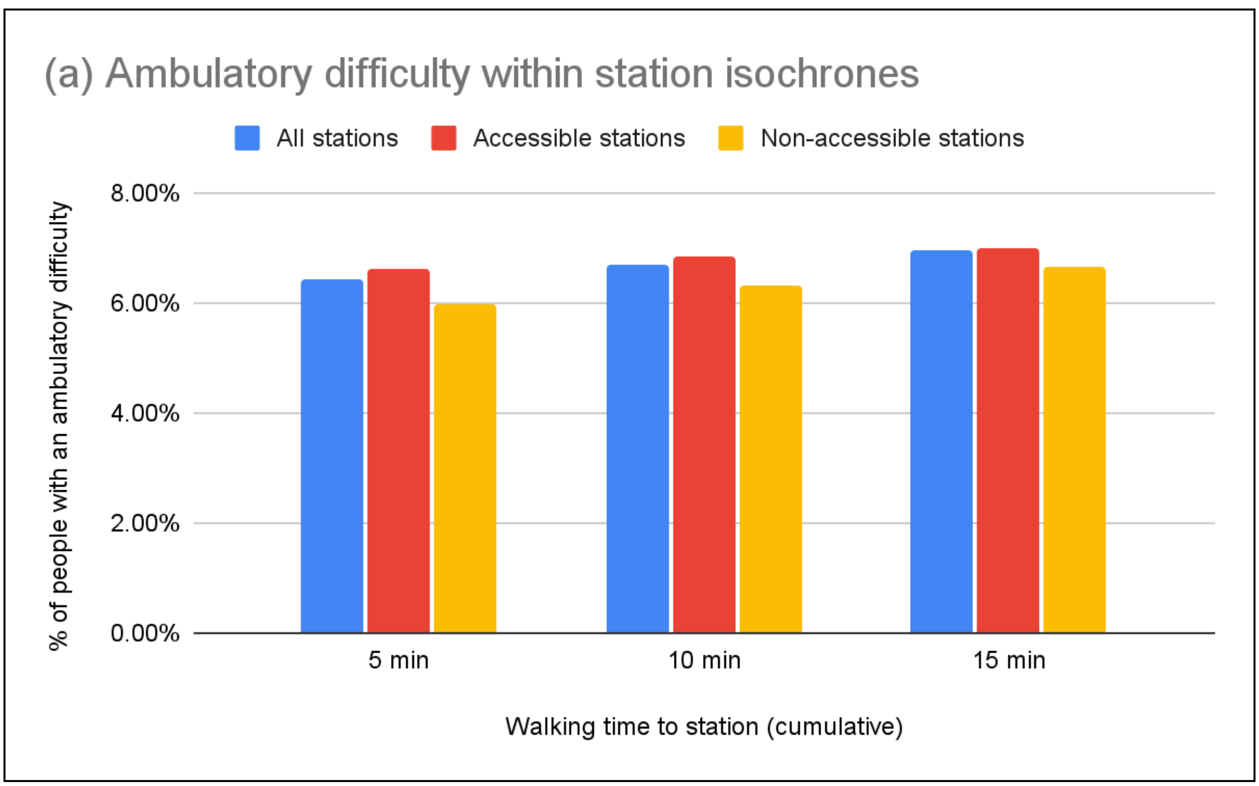


Map 1: Accessible and inaccessible stations in Chicago, and the isochrones around them

Table 2 and **Figures 1 (a - c) and 2** summarize the area weighted average values of each variable for each dissolved region ("ALL", "ADA", and "NOT") and distance band:

	Ambulatory difficulty				No vehicle				Poverty			
Distance	ALL	ADA	NOT	%DIF*	ALL	ADA	NOT	%DIF*	ALL	ADA	NOT	%DIF*
5 min	0.0644	0.0662	0.0599	-9.82%	0.432	0.425	0.448	5.34%	0.186	0.200	0.151	-26.8%
10 min	0.0670	0.0683	0.0630	-7.88%	0.415	0.411	0.429	4.35%	0.192	0.205	0.149	-29.3%
15 min	0.0695	0.0701	0.0666	-5.00%	0.402	0.400	0.410	2.58%	0.190	0.200	0.143	-30.0%

Table 2: Area weighted average of each variable within each dissolved region of isochrones. "ALL" includes the dissolved regions surrounding all stations, "ADA" includes the dissolved regions surrounding all accessible stations, and "NOT" includes the dissolved regions surrounding all inaccessible stations, excluding areas that are within the same distance band to an accessible station.
*"%DIF" is the percentage difference between values for "NOT" regions and "ADA" regions, relative to "ALL" regions (["NOT" - "ADA"] / "ALL"). Positive %DIF indicates that values surrounding inaccessible stations are higher than values surrounding accessible stations, and vice versa. **Figure 2** visualizes "%DIF" for each variable and distance band.



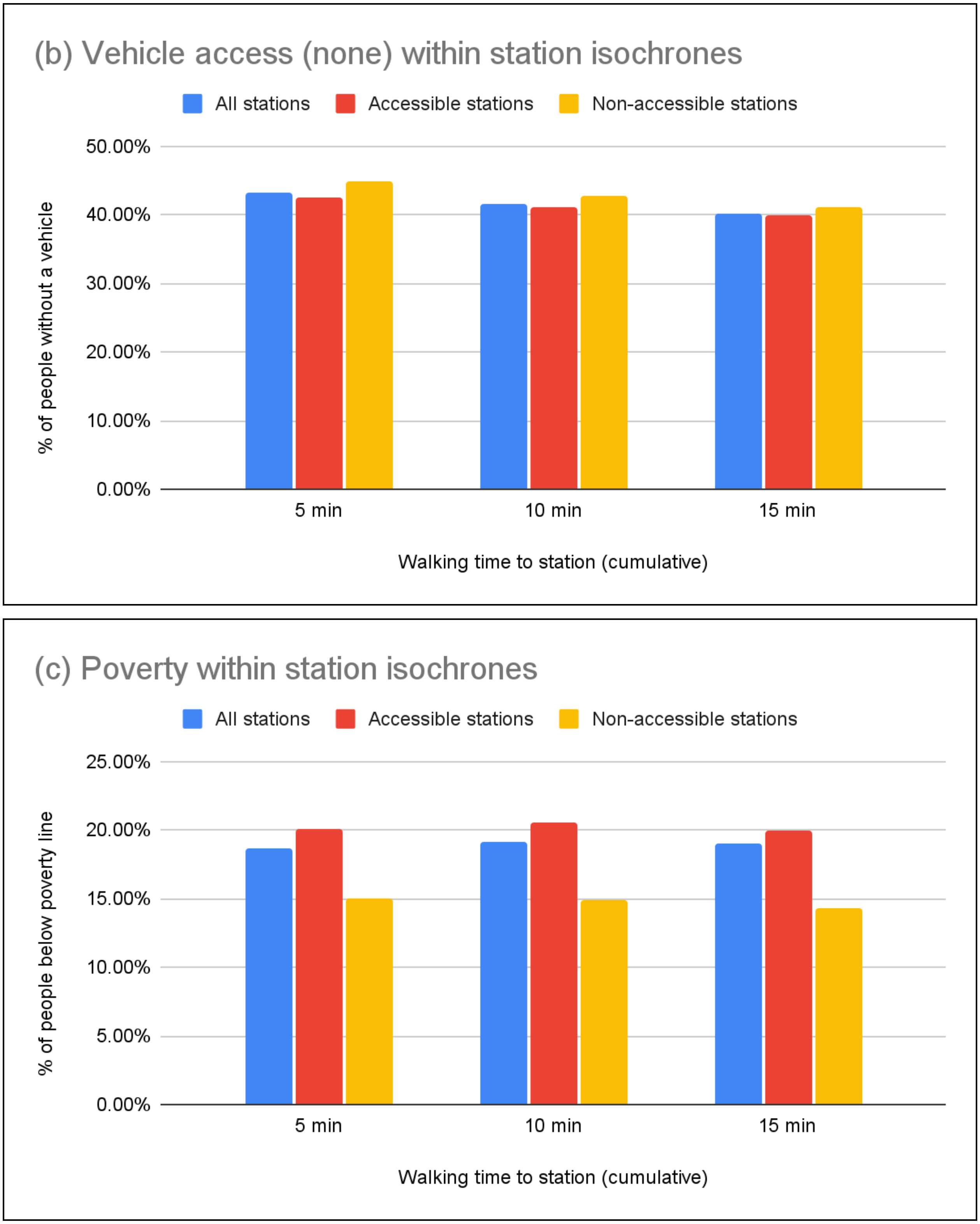


Figure 1: Column charts for area weighted averages of each variable within each region.

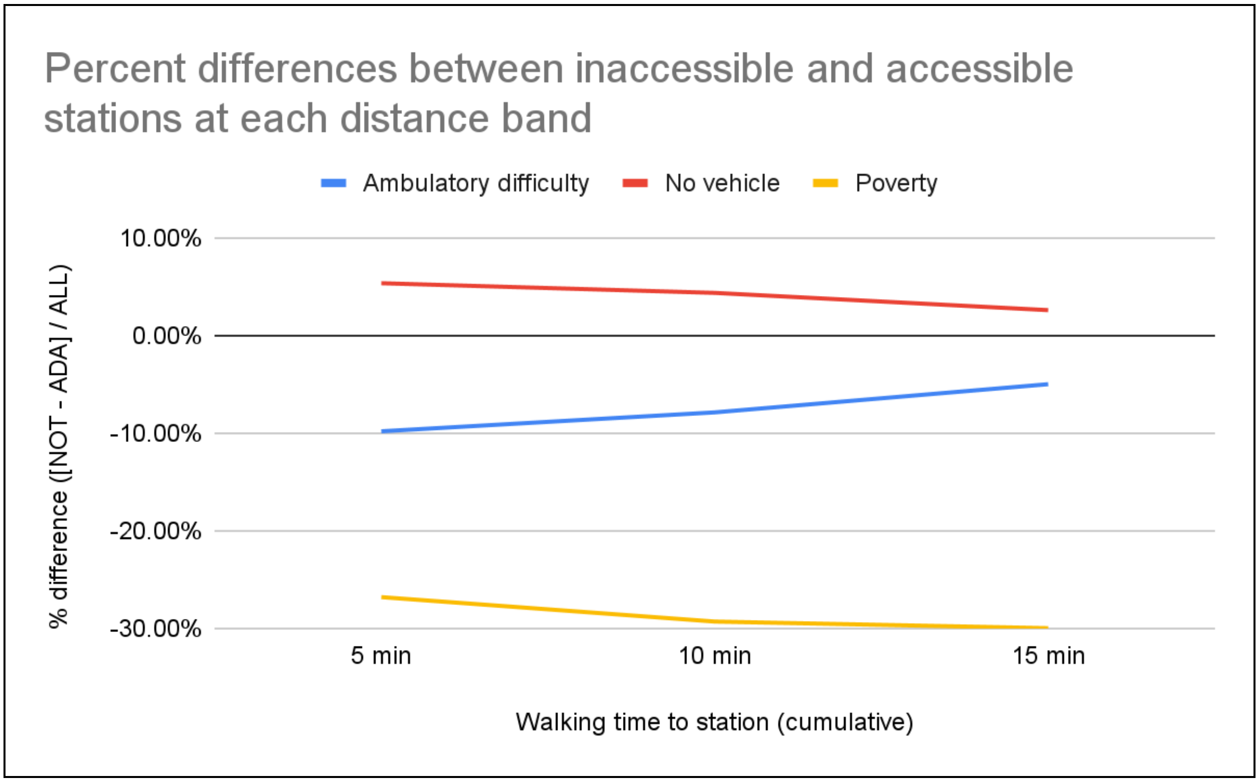
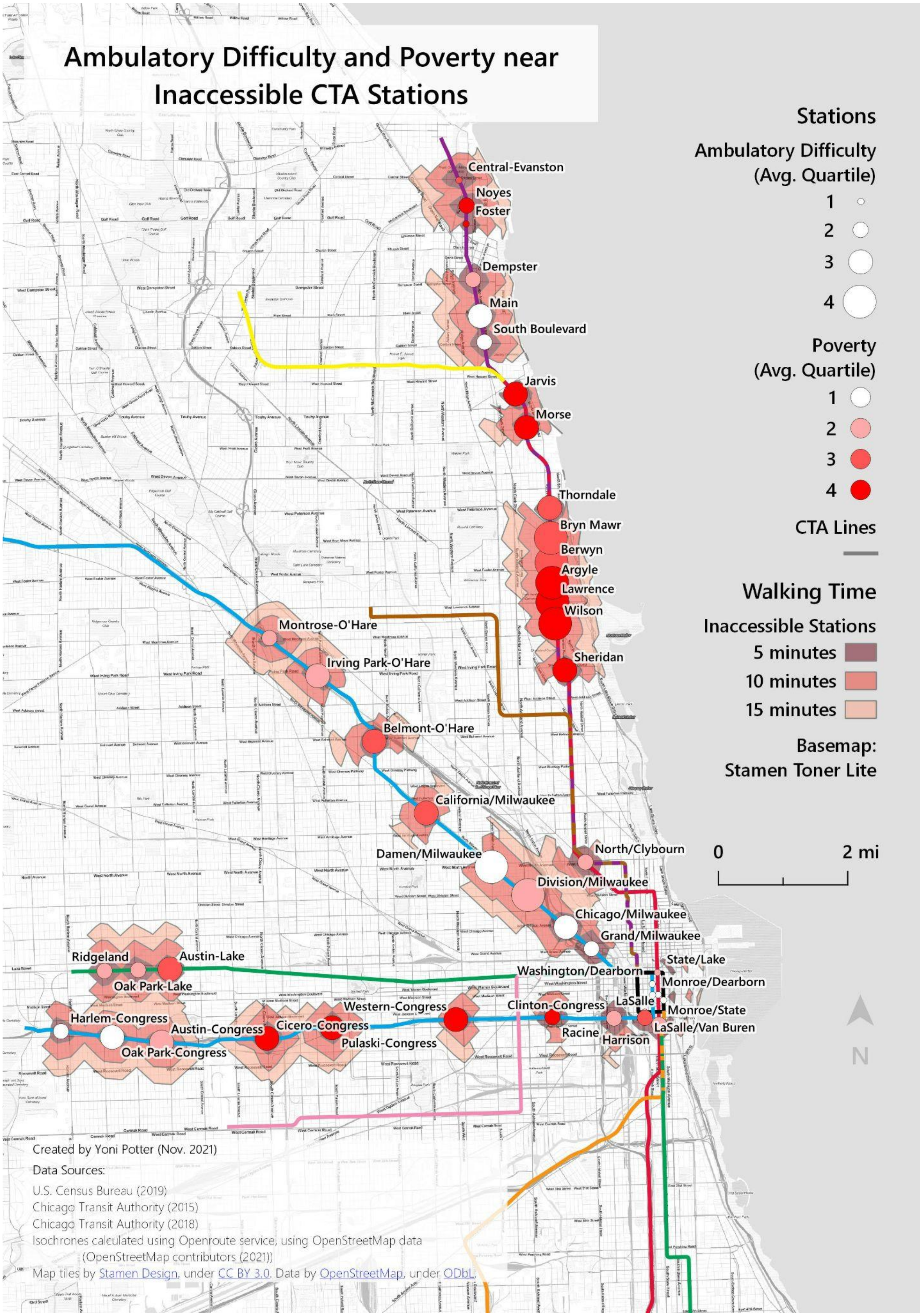


Figure 2: Change in percent difference in variables (between inaccessible and accessible stations, relative to stations overall) in each distance band. Positive percent difference indicates that values surrounding inaccessible stations are higher than values surrounding accessible stations, and vice versa.

A pattern clearly emerges that distinguishes the areas surrounding accessible and inaccessible stations: areas surrounding inaccessible stations tend to have slightly higher rates of non-vehicle ownership, slightly lower rates of ambulatory difficulty, and lower rates of poverty than those surrounding accessible stations. While the first of these findings does suggest that vehicle ownership is lower near inaccessible stations, the last indicates that this is likely by choice, as areas surrounding inaccessible stations tend to be more affluent as well. As **Map 1** indicates, many of the inaccessible stations tend to be in more dense, walkable neighborhoods (see *Living in Chicago* 2021), so it makes sense that people in these areas would be less likely to own a car. Furthermore, vehicle ownership among the whole population does not necessarily reflect vehicle ownership only among people with ambulatory difficulties (about 7.4% of the population of Cook County (U.S. Census Bureau 2019)), as such data were unfortunately unavailable, so such results need to be taken with caution. The other two findings indicate that inaccessible stations are generally located where there would be less need for accessibility, whether because the CTA has deliberately installed elevators and other accessibility measures in areas with the greatest need, because people with the greatest need for accessible public transit self-select to live near accessible stations, or because of some other indirect or random influence. Though it would be far better for those living with ambulatory difficulties for all stations to be accessible, at least those that are inaccessible are not where accessibility is needed the most. However, use of public transit is not only characterized by a starting location near one's home, but also by a destination that may vary greatly by individual need. If higher paying jobs, for example, were to be located nearby inaccessible stations (which seems likely considering the lower rates of poverty in such areas), then people with ambulatory difficulties would have a harder time traveling to these jobs regardless of whether or not they live near an accessible station, especially if they cannot afford a car.

Part 2: Assessing Inaccessible Stations Individually

While the broad analysis indicates that inaccessible stations are generally not located where accessible transit is needed the most, it is also useful to identify which of these inaccessible stations would benefit their local communities the most by implementing accessibility upgrades (especially elevators). For this analysis, the vehicle ownership variable will be dropped, as it is likely non-indicative of whether or not a person *can* afford a car if they need, as discussed above (whereas poverty likely is, according to Klien & Smart (2019); see above).



Map 2: Inaccessible stations classified by ambulatory difficulty (size) and poverty (color)

Map 2 classifies each of the inaccessible stations by quartiles of ambulatory difficulty (size) and poverty (color), averaged between all three distance bands (rounded to the nearest whole number). Thus, the stations that are the largest, as well as darkest in color, are the stations that are most in need of accessibility upgrades. **Table 3** summarizes each of the stations in the top quartile for ambulatory difficulty (on average), as well as those in the third quartile with high levels of poverty. As per the results below, Lawrence Station, on the Red Line, is most in need of accessibility upgrades, with Argyle Station on the Red Line as a close second. Overall, these stations tend to be on the far northern section of the Red Line, and at a moderate distance out on both branches of the Blue Line, and none of them are transfer stations.

Station name	Line	Ambulatory quartile (avg.)	Poverty quartile (avg.)
Stations in the top quartile for ambulatory difficulty			
Lawrence	Red	4	4
Argyle	Red	4	3.667
Berwyn	Red	4	3
Bryn Mawr	Red	4	3
Division/Milwaukee	Blue	4	2
Damen/Milwaukee	Blue	4	1
Wilson	Red	3.667	4
Stations in the 3rd quartile for ambulatory difficulty, but the top quartile for poverty			
Pulaski-Congress	Blue	3.333	4
Sheridan	Red	3.333	3.667
Cicero-Congress	Blue	3	4
Morse	Red	3	4
Jarvis	Red	3	3.667
Western-Congress	Blue	2.667	4

Table 3: Notable stations with high levels of ambulatory difficulty and poverty

Conclusion

Though inaccessible stations in Chicago tend to be in areas with lower rates of ambulatory difficulty, non-vehicle ownership, and poverty, it is still important to install elevators and implement other accessibility measures in these stations. As this analysis found, the stations at which accessibility upgrades would benefit their local area the most tend to cluster in three areas—on the Red Line between Sheridan and Jarvis stations, on the Blue Line between Division and Damen stations, and on the Blue Line between Western and Cicero stations. Though it would be most beneficial for the CTA to install elevators and the like in *all* inaccessible stations, these are the stations that should be prioritized monetarily or temporally for such upgrades. One caveat to these findings, however, is that once a station becomes accessible, the measured catchment areas for all adjacent stations would have to be recalculated, as the overlap with the newly accessible station would have to be removed. For example, if an elevator is built in Lawrence Station (the station where accessibility upgrades are most needed), Argyle station (the station with the second highest scores) will have fewer people with ambulatory difficulties in its catchment area, and thus its quartile score will drop. For this reason, the CTA should also prioritize funding in stations that are reasonably spaced apart from each other in order to avoid redundancy in their efforts (though stations in between would still eventually be made accessible).

A few limitations to the research methods used above should be mentioned. First of all, though isochrones surrounding inaccessible stations excluded areas within the same distance to an accessible station, some travellers might prefer certain stations over others, or may need to use a station on a different line. However, adjacent accessible stations are usually on the same line (and if not, almost all transfer stations are accessible); though it may be more inconvenient to use another station within the same distance band, it is still usually possible to reach the same destination from it.

However, this limitation brings up yet another; not only must origins be considered, but destinations as well. Though this is beyond the scope of this paper, further research on the destinations that people with ambulatory difficulties need to reach (as well as the locations of possible destinations if they were to reroute due to the new presence of accessible transit) using network analysis would be highly valuable in assessing which stations should be prioritized for accessibility upgrades.

Finally, it should be noted that poverty rates overall are not necessarily reflective of poverty rates among people with ambulatory difficulties. Although poverty status is likely less responsive to whether or not a person has an ambulatory difficulty or to the presence of accessible transit than vehicle ownership (which had to be dropped for the second part of this analysis for this reason), it would be more useful to measure poverty among people with ambulatory difficulties for the purposes of this analysis. However, such data were not publicly available from the American Community Survey, likely due to privacy reasons, and thus could not be used without special permission from the U.S. Census Bureau.

Acknowledgements

OpenrouteService data © openrouteservice.org by HeiGIT and available from https://openrouteservice.org/

OpenStreetMap map data © OpenStreetMap contributors (available under the Open Database License: https://opendatacommons.org/licenses/odbl/) and available from https://www.openstreetmap.org

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