

Access Burden:

A Data Driven Definition to Address Transportation Equity

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## ABSTRACT

A destination's accessibility can be quantified in the financial and temporal burdens undertaken to reach it. Destinations that can be described as fundamental to life are jobs, education, medical services, shopping, and recreation. The non-uniform distribution of these amenities results in increased temporal burden in low-access communities. This increased burden could influence transportation mode decisions as residents seek to increase the number of amenity destinations from which they can choose. Some of these mode choices and their associated financial burden (transit fares, motor fuel) stand to impact underserved communities disproportionately. This study utilizes the Python programming language to merge emergency medical service location data with census tract level demographic data to analyze cumulative emergency healthcare opportunity disparities in underserved communities within the city of Chicago, Illinois, and within Cook County but outside of the Chicago city boundary. The five variables used in this study to identify areas vulnerable to greater suffering attributed to access burden are informed by the Biden administration's *Executive Order on Advancing Racial Equity and Support for Underserved Communities* [1] and sourced from the CDC's Social Vulnerability Index, a database to aid the identification of communities less resilient to external stressors. These variables are estimated population percentages of persons beneath the Federal poverty line, unemployed, minority (non-white), disabled, and persons with no vehicle access. This study identifies two high vulnerability communities, Bronzeville and Dolton, Illinois, are identified and maps them with isochrone catchment overlays to quantify the number of hospitals and urgent care facilities reachable in a 15-minute time interval by various travel modes: walking, transit, cycling and driving. The data-driven methodology utilized in this study can be replicated to other areas of variable geographic resolution to identify communities more vulnerable to suffering attributed to access burden. This prioritization can be used to inform community investment to address the systemic disparities of centralized urban amenity distributions.

## INTRODUCTION

Access to essential services in communities can vary widely. For example, consider the notion of the food desert. Its definition is in its name: an area deserted of food resources. More explicitly, the Food Empowerment Project describes food deserts as geographic regions where residents' access to affordable, healthy food options is restricted or nonexistent due to the absence of grocery stores within a convenient traveling distance [2]. There are components to this definition: affordability, health impact, options, access restriction, absence of amenity and convenient traveling distance. This definition is powerful for its commutability across other amenities, but less so across demographics. Affordability is variable from one individual to another. Availability of options and level of access is dependent on starting location and amenity distribution. Convenient traveling distance for some is by no means convenient traveling distance for all.

The variance across these components illustrates the space for inequitable distribution of access burdens, and resultant disproportionate suffering attributed to the temporal and financial costs of travel. This study aims to identify increased vulnerability to the ill-effects of access burden by effect of the non-uniform amenity distributions of urban landscapes and the demographic qualifications of underserved communities. These demographics include the impoverished and unemployed, upon whom the financial access burden of travel cost weighs more heavily. They include underrepresented minority populations, historically excluded from services and areas by systemic redlining and infrastructural segregation. Also included are people with disabilities, for some of whom the less expensive travel modes of walking and cycling may not be an option, and those without vehicle access, who may be deprived variety due to any of the numerous reasons a person may not own a vehicle.

While essential to life, food is only one of its necessities. Beyond traditional lists of the basic needs for survival (food, clothing and shelter), the dictations of modern society require access to economic opportunity in the form of employment, education and healthcare. This study defines those destinations that are fundamental to modern life as jobs, school, medical services, shopping and recreation. This study focuses on the relationship between emergency medical service (EMS) and demographic distributions to develop a replicable methodology for quantifying access burden across communities of variable vulnerability and geographic resolution.

This study makes a comparison between the EMS amenity catchment of two regions: each highly vulnerable to the ill-effects of increased access burden, but one within city limits, the other outside the city but within the county, situated much further from the reach of the nearby urban center. The University of Minnesota's Access Across America series [3] measures accessibility to jobs in metropolitan areas across the U.S., calculating this access metric by way of cumulative opportunity, or the number of locations reachable from a point within a certain time threshold. This study emulates this method, incorporating a demographic lens to address transportation equity and inform the deployment of transportation justice.

## PROGRESS

### Data Collection

The scope of this study is Cook County, Illinois, home to the city of Chicago, the most populous county in the state of Illinois, and the second most populous county in the United States after Los Angeles County, California. Census tract boundary data was obtained from the U.S. Census Bureau Mapping Files depository [4]. The boundary data is in geographic polygon shapefile format, a geospatial vector datatype utilizing longitudinal and latitudinal coordinates for location.

Hospital location data was obtained from the U.S. Department of Homeland Security's (DHS) Homeland Infrastructure Foundation-Level Data (HIFLD) database, a tool intended to inform community resiliency and support research [5]. The hospitals included are children, chronic disease, critical access, general acute care, long term care, military, psychiatric, rehabilitation, special, and women's hospitals. HIFLD hospital data is derived from various sources including but not limited to PDFs, tables and webpages before being cleaned, geocoded and converted into geographic point shapefile format.

Urgent care facility location data was also obtained from HIFLD. Urgent care facilities are defined as locations capable of providing emergency medical care beyond what can normally be provided by an ambulance or doctor's office. This delivery of medical care occurs outside of a hospital emergency department on a walk-in basis without need for a scheduled appointment [6]. The dataset excludes administrative offices, physician offices, workman compensation facilities, free standing emergency rooms, and hospitals. The location data is in geographic point shapefile format.

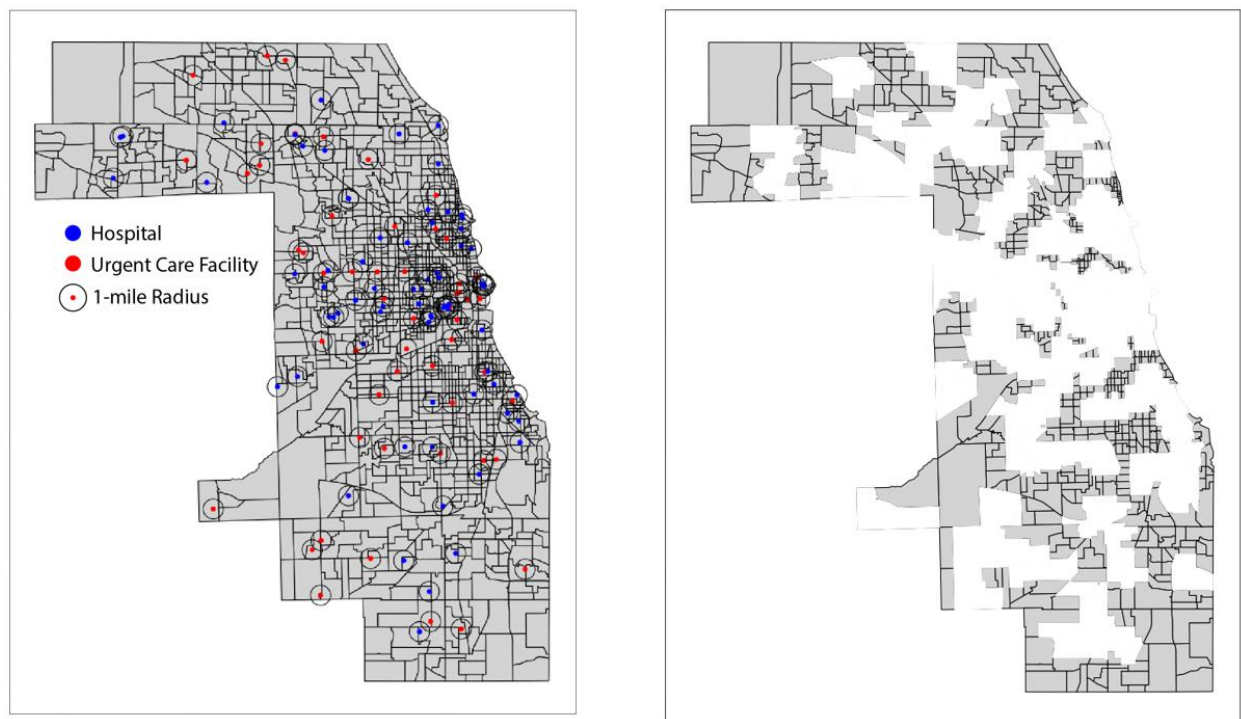
Demographic data was obtained from the Center for Disease Control and Prevention's (CDC) Agency for Toxic Substances and Disease Registry (ATSDR) Social Vulnerability Index (SVI). The SVI database uses U.S. Census data for 15 social factors to define a community's social vulnerability, or the potential for mal effects caused by external stressors on human health at the tract resolution [7]. This study considers five of the 15 variables in the identification of communities most vulnerable to disproportionate temporal and financial hardships attributed to access burden. These variables are estimated population percentages of persons beneath the Federal poverty line, unemployed, minority (non-white), disabled, and persons with no vehicle access.

### Data Analysis

Essential to meaningful analysis of the data collected was harmonization of the disparate data types. EMS location data was sourced in geographic point format, while census tract location data and demographic data were sourced in geographic polygon format. The Python programming language was implemented in the union of the datasets, first by the alignment of the geographic data's Coordinate Reference Systems (CRS). The data CRS was set to EPSG:3857, or the spherical Mercator projected coordinate system, used for rendering maps in Google, OpenStreetMap and more. The geographic data frames were then merged, the resultant

data frame trimmed to the scope of this study: Cook County, Illinois and the city of Chicago, by qualified FIPS code identifier.

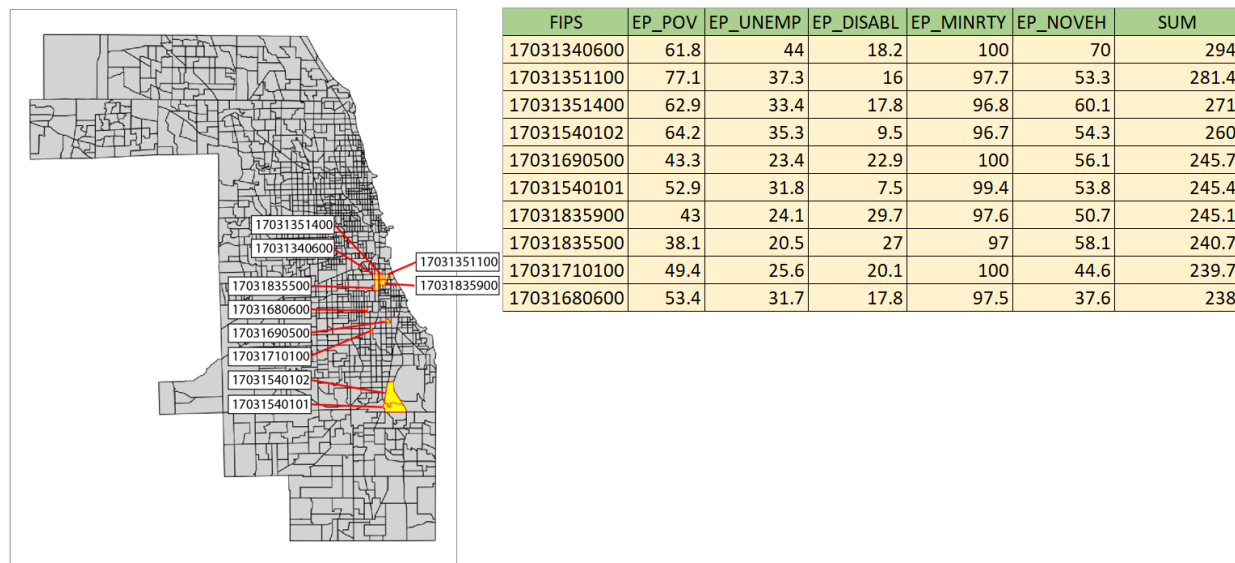
With the alignment of the geographic data CRS, point data (hospital and urgent care facility locations) could be placed within the dimensions of polygon data (SVI and boundary data for Cook County census tracts), and by this means tracts containing either a hospital or urgent care facility were removed from consideration for analysis. EPSG:3857 was chosen specifically for its units of measurement in meters which would be utilized to generate a 1-mile radius boundary around each hospital and urgent care facility. Tracts were excluded from consideration if their boundaries intersected the 1-mile radius of either amenity, as seen in Figure 1.



**Figure 1:** Hospital and Urgent Care Facility locations, 1-mile radius and parsed census tracts that do not intersect the 1-mile boundaries. Cook County, IL

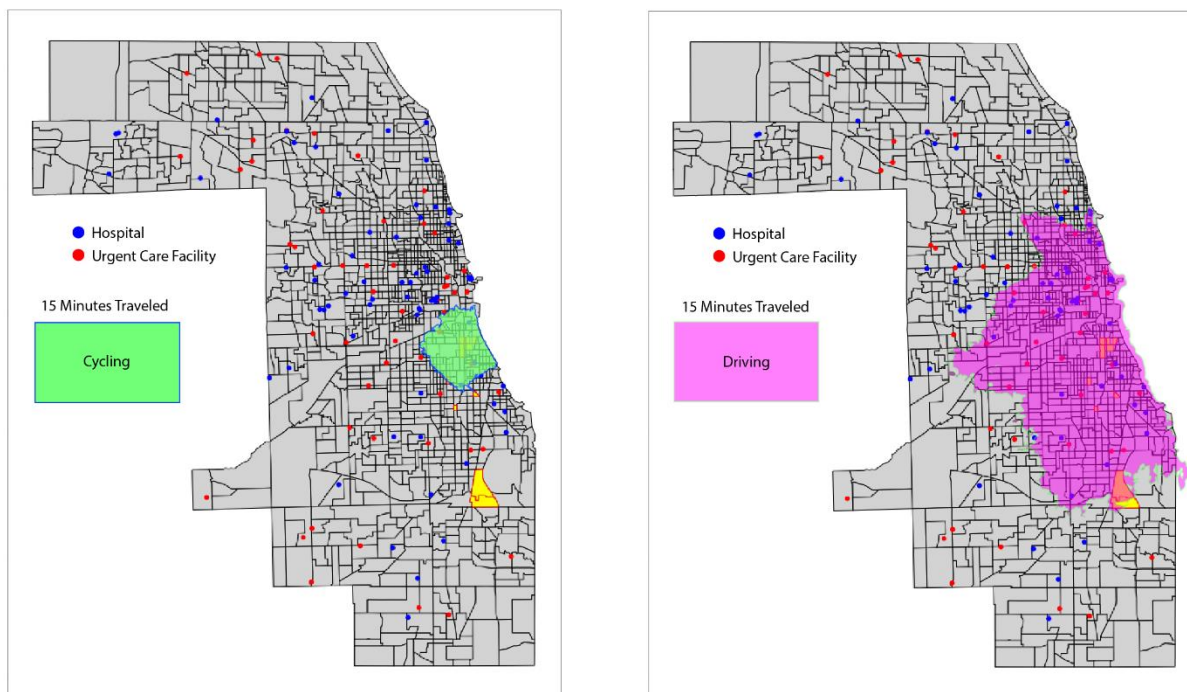
Of the 1,318 census tracts in Cook County, 524 met the criteria for analysis by containing neither hospital nor urgent care facility, and not intersecting the 1-mile radius amenity boundary. Of the remaining tracts, a sum of the percentage points in each of the five demographic variables considered was used to rank the tracts in potential access burden vulnerability. The ten most vulnerable tracts were identified and plotted in Python using the GeoPandas package, and the resultant map was used to identify the community area of Bronzeville for specific analysis. Bronzeville census tracts accounted for four out of the five most vulnerable, and five out of the ten most vulnerable tracts within City of Chicago boundaries. Income per capita in the identified Bronzeville census tracts ranged from as low as \$8,561, or one-quarter the amount in Chicago, \$37,103, to no higher than \$16,253, or about two-fifths of the amount in Chicago (ACS). Poverty statistics ranged from 40.1% to 75% (margin of error 10%) of persons below the Federal poverty line, significantly greater than double the rate in Chicago: 18.4%.

A similar selection process was used to identify vulnerable communities within Cook County but outside of the city boundaries of Chicago and a 1-mile radius of any of Chicago Transit Authority bus or rail station. Of the tracts in Cook County, 204 met these criteria for analysis. Python was used to plot the ten most vulnerable tracts of these 204, and the resultant map was used to identify the community area of Dolton for analysis and direct comparison to the more centrally located Bronzeville. Dolton area census tracts accounted for six out of the ten most vulnerable tracts within Cook County but outside of the Chicago city boundaries. Income per capita in the identified Dolton census tracts ranged from as low as \$18,790, or one-half the amount in Cook County, \$37,552, to no higher than \$22,137, about three-fifths the amount in Cook County. Poverty statistics ranged from 23.1% to 38.1% (margin of error 10%) of persons below the Federal poverty line, the high end being more than double the rate in Cook County: 14.4%.



**Figure 2:** Ten most vulnerable census tracts within City of Chicago boundary by estimate percent population beneath poverty, unemployed, minority, disabled and no vehicle access. Bronzeville is the community area containing the cluster of five most northern highlighted tracts.

With the identification of these community areas, accessibility by mode metrics in the form of cumulative opportunity metrics – the total amount of EMS destinations reachable within a 15-minute travel time threshold – were calculated using isochrone catchment map overlays. Isochrone maps depicting the areas accessible from both Bronzeville and Dolton tract boundaries were generated using the TravelTime API for walking, transit, cycling and driving transit modes. The hospitals and urgent care facilities that fell within each isochrone boundary by mode were then tallied as being reachable within the 15-minute threshold for each community (Appendix). This approach emulates the methodology utilized in the University of Minnesota’s *Access Across America* series for assessing job accessibility in major metropolitan areas and could be replicated to other areas of variable geographic resolution. Similarly, the method could readily be applied to a variety of services and amenities, including those that fall within the categories described by this study as fundamental to life: education, shopping and recreation.



BRONZEVILLE CATCHMENT: 15 MINUTES BY MODE		
MODE	HOSPITAL	URGENT CARE
Walking	0	0
Transit	2	1
Cycling	4	2
Driving	38	26

DOLTON CATCHMENT: 15 MINUTES BY MODE		
MODE	HOSPITAL	URGENT CARE
Walking	0	0
Transit	0	0
Cycling	2	0
Driving	11	8

**Figure 3:** 15-minute isochrone EMS catchment maps for Bronzeville by cycling and driving modes, and catchment tally for Bronzeville and Dolton by all modes.

EMS catchment rates for both communities are remarkable for their similarity in non-automobile transit mode. Neither community area had a single hospital or urgent care facility within a 15-minute walk of their outermost boundary. The cumulative opportunity metric for Bronzeville residents increases to three destinations accessible by transit travel mode within 15-minutes, whereas the Dolton catchment remains at zero. Cycling catchment increases the reachable destinations from Bronzeville to a count of six and marks the first reachable destinations from Dolton: two hospitals and zero urgent care facilities, one third the number of EMS facilities reachable from Bronzeville and representative of poor variety amongst accessible amenities. The cumulative opportunity disparity is greatest on consideration of the driving travel

mode. 64 EMS destinations: 38 hospitals and 26 urgent care facilities, are reachable from Bronzeville within a 15-minute driving time threshold, as compared to 19 from Dolton. While the increase in accessible destinations is dramatic for both communities, Dolton residents enjoy less than 30% the number of EMS destinations accessible by a 15-minute drive than their similarly vulnerable counterparts more centrally located in the community of Bronzeville.

## FUTURE WORK

A form of the methodology described in this study will be implemented in Argonne National Laboratory's upcoming project, Understanding Transportation Cost and Accessibility Burdens and Options for Disadvantaged Communities. The second of three tasks described in the recently approved project will identify cumulative opportunity metrics for the fundamental destinations of jobs, school, medical services, shopping and recreation, quantifying the access of different communities, highlighting locations where there is disproportionate access burden for underserved communities. The completion of this task will improve the Office of Energy Efficiency and Renewable Energy's (EERE) understanding of household transportation cost and accessibility burden, and how disadvantaged communities could benefit from usage of energy efficient vehicle technologies.

## IMPACT ON LABORATORY OR NATIONAL MISSIONS

Five tenets of energy justice intended to foster equity in DOE projects are considered in the National Renewable Energy Laboratory's (NREL) June '21 report Energy Justice: Key Concepts and Metrics Relevant to EERE Transportation Projects [8]. These tenets are **1. distributional justice**, ensuring the fair distribution of benefits and negative impacts of transportation, **2. procedural justice**, including the underrepresented in framing mobility and energy needs, **3. recognition justice**, promoting equity by addressing historic and ongoing inequalities, **4. cosmopolitan justice**, integrating energy life cycle assessments with social life cycles, and **5. restorative justice**, the union of all those with a stake in the aftermath and implications of environmental offenses in addressing challenges.

Further, the report provides guidance on how to approach the inclusion of equity and justice considerations in the decision-making process of DOE projects. This guidance instructs to identify factors that can contribute to inequality and exclusion of underrepresented groups including transportation affordability and income, race/ethnicity, (dis)ability and vehicle access. Additionally, the responsibility extends to the identification of factors that can contribute to regional marginalization including access to roads, transit, or shared mobility, and connections to jobs, schools, hospitals, groceries, etc. The guidance continues in its recommendations for how to collaborate with communities in designing and supporting programs that increase access to opportunities, time savings, and public and nonmotorized transport while decreasing travel costs for different individuals and groups.

The preceding study invokes the five tenets of energy justice and follows closely the equity inclusion guidance described in NREL's report in the defining and analysis of access burden in underserved communities.



## REFERENCES

1. “Executive Order on Advancing Racial Equity and Support for Underserved Communities through the Federal Government.” *The White House*, The United States Government, 21 Jan. 2021, [www.whitehouse.gov/briefing-room/presidential-actions/2021/01/20/executive-order-advancing-racial-equity-and-support-for-underserved-communities-through-the-federal-government/](https://www.whitehouse.gov/briefing-room/presidential-actions/2021/01/20/executive-order-advancing-racial-equity-and-support-for-underserved-communities-through-the-federal-government/).
2. “Food Deserts” *Food Empowerment Project*, [foodispower.org/access-health/food-deserts/](https://foodispower.org/access-health/food-deserts/).
3. Owen, Andrew; Levinson, David. (2014). Access Across America: Transit 2014. Center for Transportation Studies, University of Minnesota. Retrieved from the University of Minnesota Digital Conservancy, <https://hdl.handle.net/11299/168102>. U.S. Census
4. U.S. Census Bureau. – Census Tract Shapefile [Data file]. Retrieved from <https://www.census.gov/geographies/mapping-files/time-series/geo/tiger-line-file.html>
5. Homeland Infrastructure Foundation Level Data – Hospital and Urgent Care Shapefile [Data Set]. Retrieved from <https://hifld-geoplatform.opendata.arcgis.com/>
6. “About UCA.” *Urgent Care Association*, [www.ucaoa.org/About-UCA/UCA-Common-Words-Terms-Acronyms-and-Definitions](https://www.ucaoa.org/About-UCA/UCA-Common-Words-Terms-Acronyms-and-Definitions).
7. CDC - Social Vulnerability Index – SVI – Shapefile [Data file]. Retrieved from <https://www.atsdr.cdc.gov/placeandhealth/svi/index.html>
8. Romero-Lankao, Patricia and Erin Nobler. 2021. Energy Justice: Key Concepts and Metrics Relevant to EERE Transportation Projects. Golden, CO: National Renewable Energy Laboratory. NREL/MP-5400-80206. <https://www.nrel.gov/docs/fy21osti/80206.pdf>