

Introduction

In the heart of Chicago's urban expanse, a city renowned for its architectural marvels and vibrant economy, lies a less visible but equally significant facet of urban existence: multidimensional poverty. This form of poverty transcends conventional income-based metrics, encompassing a spectrum of deprivations that households face, from inadequate healthcare and education to limited employment opportunities, insecure housing, and restricted access to digital technologies. The complexity and invisibility of these issues pose a significant challenge, not only to the affected individuals but also to policymakers and stakeholders aiming to devise effective interventions.

This study is motivated by the need to illuminate the multifaceted nature of urban poverty, providing a holistic view that goes beyond monetary constraints to include various dimensions of deprivation. By employing advanced visualization techniques to analyze and present the American Community Survey (ACS) 5-Year Estimates for 2022, this research endeavors to uncover the intricate patterns of deprivation that pervade Cook County. The goal is not merely to present data but to tell the story of a city's hidden struggles, offering insights that could guide targeted policies and initiatives.

Research Questions

The central research question driving this study is: How can the complex landscape of multidimensional poverty in Cook County be unraveled to reveal the underlying patterns of deprivation and inform policy decisions?

Motivation

This question reflects a commitment to advancing the understanding of urban poverty and contributing to the broader discourse on equitable urban development and social justice.

The significance of this research lies in its potential to shift the narrative on poverty from a single-dimensional view to a more comprehensive understanding that considers the interplay of various factors affecting urban households. By shedding light on the nuanced aspects of deprivation, this study aims to foster a more empathetic and informed approach to addressing urban poverty, ultimately contributing to the creation of more inclusive and equitable urban spaces.

Methods

The foundation of this research is built upon the ACS 5-Year Estimates for 2022, sourced from the U.S. Census Bureau. A careful selection of 15 deprivation indicators was made to encapsulate the multifaceted nature of poverty, touching on vital aspects in multiple different fields such as healthcare, education, employment, housing, and digital accessibility. These variables are:

1. Income - percentage receiving public assistance
2. Education - percentage of kids not enrolled in school
3. Health - percentage of adults without health insurance
4. Health - percentage of children with disability status
5. Health - percentage of adults with disability status
6. Housing - percentage overcrowded: more than 2 occupants per room
7. Housing - percentage cost-burdened
8. Living Conditions - percentage without plumbing facilities
9. Living Conditions - percentage without kitchen facilities
10. Digitalization - percentage without computer
11. Digitalization - percentage without internet access

12. Digitalization - percentage internet access without subscription
13. Employment - percent unemployed
14. Employment - percent not in labor force

Constructing the Deprivation Matrix

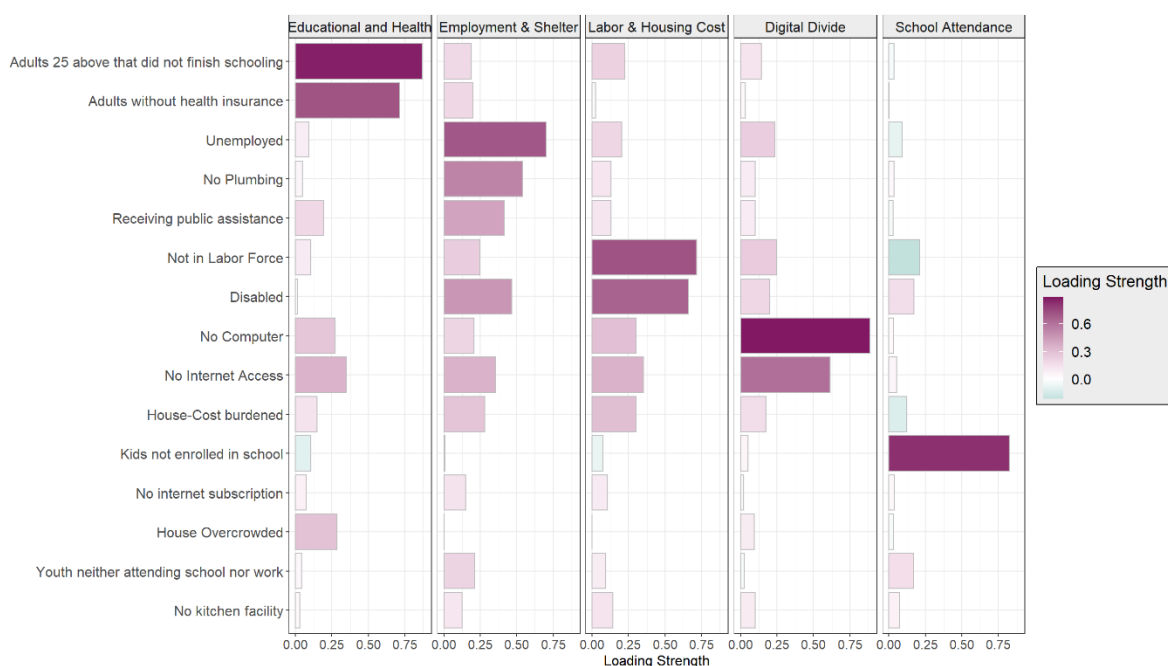
Data cleaning and preprocessing were undertaken to construct the deprivation matrix. The deprivation matrix was constructed as a comprehensive framework to represent the multidimensional aspects of poverty within Cook County. Typically, deprivation cutoffs are thresholds used to determine whether a household is considered deprived in a particular dimension. These cutoffs are crucial in generating a raw deprivation matrix, as they help to classify the population into different categories based on their level of deprivation.

In our case, we deviate from the standard practice by setting the deprivation cutoffs at 0%. This means that we consider any level of deprivation within a household as significant enough to count towards the overall deprivation score for a census tract. By employing this approach, we are able to capture the full spectrum of deprivation levels, from the most mild to the most severe.

Factor Analysis

Factor analysis was then applied to the deprivation matrix to identify underlying patterns of deprivation, or 'latent factors,' that bind various indicators together. This statistical method helped in distilling complex, multidimensional data into a set of key factors that represent broad domains of deprivation. The results of the factor analysis were visualized in *Figure 1* using bar graphs to depict the factor loadings, thereby illustrating the contribution of each indicator to the identified factors.

Figure 1: Multidimensional Poverty Indicators in Chicago: A Factor Analysis



Design Choices:

Faceted Bar Charts for Clarity and Comparison: The decision to employ faceted bar charts in the visualization of factor loadings was driven by the need for clarity and ease of comparison. This design choice allows the audience to intuitively grasp the strength and relevance of each indicator across different factors, facilitating a side-by-side evaluation.

Manual Reordering for Enhanced Readability: The indicators within the faceted bar charts were manually reordered to prioritize readability and cognitive flow. This deliberate arrangement ensures that the audience can trace the narrative thread linking related indicators, thereby unraveling the latent characteristics that underpin each factor of deprivation. By guiding the viewer's eye through a logical sequence (from left to right, and top to bottom) , this design choice aids in the digestion of information and enhances the overall interpretability of the visualization.

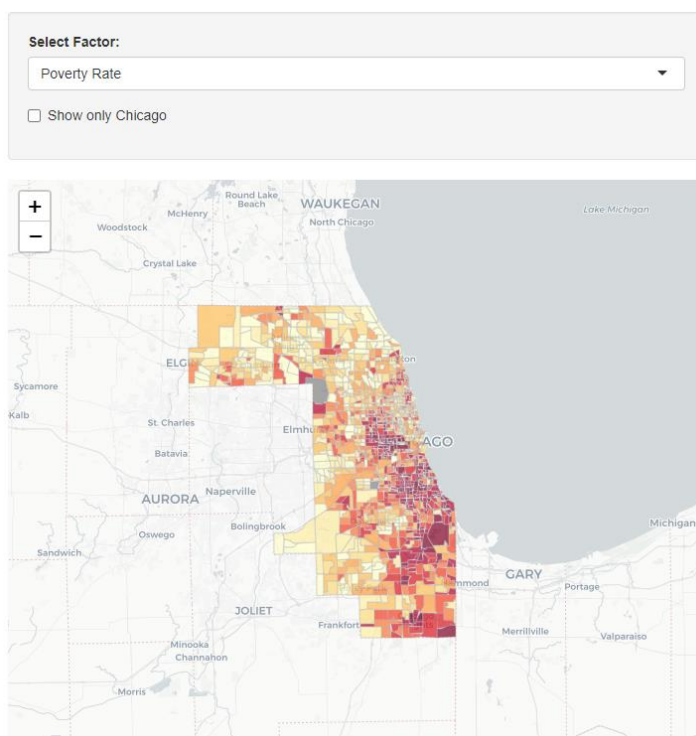
Diverging Color Palette for Visual Discrimination: The utilization of a 'continuous_diverging' scale, and the "Cyan-Mage" color palette, was chosen to maximize visual discrimination between varying loading strengths. This color scheme was selected for its aesthetic appeal as well as for its functionality in distinguishing subtle differences in factor loadings.

Distinctive Boxing of Bars for Precision: Each bar within the visualization is distinctly boxed to enhance differentiation and precision. This subtle yet critical design element addresses the challenge in visualizing data points that are close to zero, but have very small values. By enclosing each bar within a defined boundary, the visualization ensures that no data point is overlooked, no matter how minimal its value.

Interactive Geospatial Visualization

In the next step, I used the statistical model obtained from Factor Analysis to assign an indicator of deprivation for each census tract id. To bring spatial context to the data, an interactive geospatial visualization was developed where the distribution of multidimensional poverty across Cook County was mapped in *Figure 2*.

Figure 2: Spatial Distribution of Poverty & Latent Factors (Interactive)



The interactive dashboard serves as a tool for dissecting the complex landscape of urban poverty. By mapping the nuanced contours of poverty's spatial distribution, this dashboard illuminates the latent dimensions of deprivation revealed through factor analysis. These granular depictions empower users to conduct detailed spatial comparisons, unravelling the geographic nuances of poverty in Chicago.

For example, the pronounced concentration of factors such as *Employment and Shelter* and *Education and Health* within specific localities underscores the urgent need for targeted policy interventions. In these identified areas, specific strategies such as housing initiatives that subsidize renovations, can directly address the localized nature of these deprivations. Tailoring policies to the unique characteristics of each neighborhood ensures that resources are efficiently allocated, directly benefiting those in most need.

Conversely, the more diffused patterns associated with *Labor and Housing Costs*, *The Digital Divide*, and *School Attendance* suggest systemic issues that pervade beyond individual neighborhoods. These widespread challenges call for overarching policy frameworks that address the broader infrastructural and societal deficits. Enhancing digital infrastructure, for instance, should not only focus on expanding access but also on ensuring affordability and fostering digital literacy across the board. Such inclusive strategies are pivotal in bridging the digital divide, thereby facilitating equitable access to essential services and opportunities.

Design Choices:

Spatial Dashboard Utilization: The decision to employ a map-based interactive dashboard was driven by the intrinsic link between poverty and its geographical context. This approach enables the visualization of poverty's spatial dynamics, offering insights into how deprivation varies not only across the city but within or between neighborhoods. The interactive elements of the dashboard encourage active engagement, allowing users to explore, compare, and discern spatial patterns of deprivation with ease. This interactivity is also helpful in a policy setting where policymakers are provided with the ability to pinpoint priority areas for intervention, tailor policy recommendations, and allocate resources with greater precision.

Color Palette Selection: The choice of the *YlOrRd* (Yellow-Orange-Red) color palette from [ColorBrewer](#) was made based on its perceptual qualities and accessibility features. This sequential palette is known for its colorblind-friendly design, ensuring that the visualization is inclusive and interpretable by a wide audience, including individuals with common forms of color vision deficiency. Additionally, the gradient from yellow to red intuitively conveys increasing levels of deprivation, facilitating an immediate and clear understanding of the data.

Pop-up Feature Integration: To enhance the user experience and provide contextual information, pop-up features were integrated into the dashboard. These pop-ups activate upon interaction with a census tract, revealing detailed data that enriches the user's understanding of each area's specific context. Key information displayed includes:

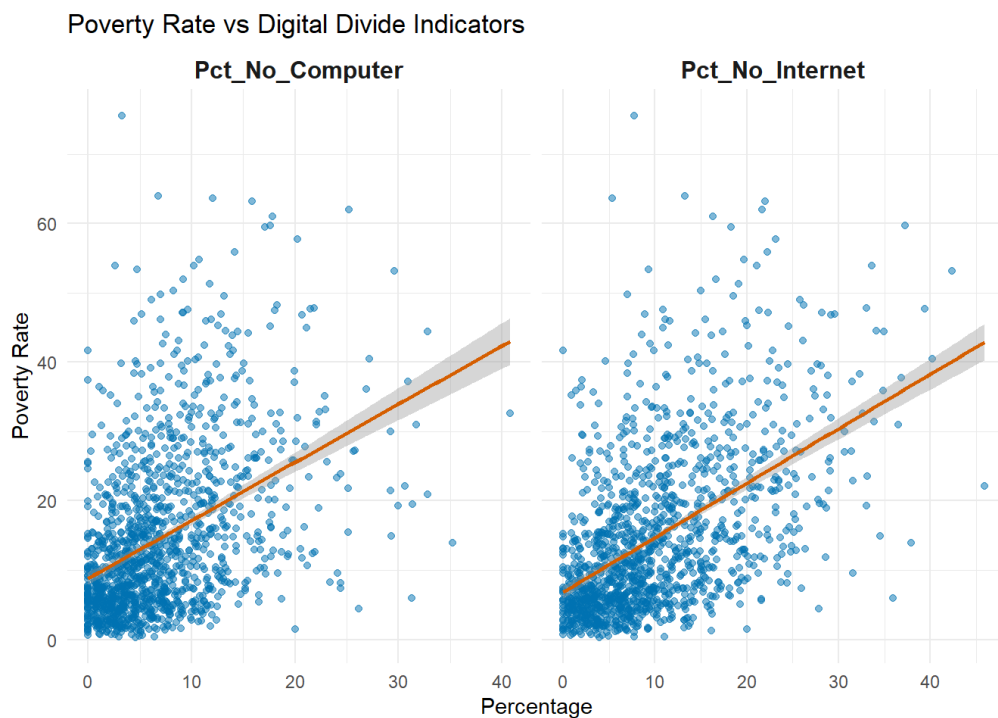
- **Poverty Rate:** Presenting the poverty rate within pop-ups offers a conventional metric for comparison, enabling users to contextualize the multidimensional deprivation scores against traditional poverty measures. This juxtaposition fosters a more nuanced appreciation of the complexities of urban poverty.
- **Community Name:** Including the name of the community within the pop-up helps users familiarize themselves with the geographic landscape of Cook County, enhancing the spatial relevance and relatability of the data.

- **Average of Neighboring Scores:** Displaying the average deprivation scores of neighboring census tracts allows users to conduct comparative analyses with ease, highlighting disparities and commonalities in deprivation levels across adjacent areas. This feature encourages a broader examination of spatial relationships and community-level patterns of poverty.

Comparative Visualizations with Scatterplots

Finally, I dove into one topic – ‘Digital Divide’. To further explore the relationships between poverty rate and these dimensions of deprivations (informed by the factor analysis), scatterplots were employed. These visualizations allow for a comparative analysis, highlighting correlations between various deprivation factors and the poverty rates. By juxtaposing these variables, scatterplots offer insights into the degree to which two variables are correlated.

Figure 3: Poverty rates vs. Deprivations in Digital Equity



Design Choices:

Inclusion of Trendlines: Trendlines serve as a visual summary of the correlation between these two variables, providing a clear, immediate understanding of the direction and strength of their relationship.

Standard Errors to Visualize Uncertainty: Accompanying the trendlines with shaded areas representing Standard Errors (SEs) introduces an essential layer of context to the analysis—uncertainty. This choice describes inherent variability in the data, offering a more nuanced and honest portrayal of the analysis. This aspect is motivated by the desire to present a truthful and transparent representation of the data, as it can be difficult to identify patterns in scatterplots.

Discussion

Learnings from the Visualization

Through this comprehensive exploration of multidimensional poverty in Cook County, my wish is for the audience to gain insights into the complex interplay of factors that contribute to urban

deprivation. The visualizations elucidate not just the prevalence of poverty, but its multifaceted nature—spanning healthcare, education, housing, digital access, and employment. Key learnings include:

- **Spatial Disparities:** The interactive geospatial visualization vividly illustrates how poverty clusters within certain neighborhoods, highlighting geographic disparities that demand targeted interventions.
- **Dimensionality of Poverty:** Factor analysis reveals that poverty is a myriad of deprivations, offering a nuanced understanding of urban poverty that transcends traditional income-based measures.
- **Digital Divide:** The focused analysis on the Digital Divide underscores a critical, often overlooked aspect of urban poverty, spotlighting the essential role of digital access in contemporary society.

Truthfulness, Functionality, and Aesthetics

- **Truthfulness:** Every visualization is anchored in rigorously processed ACS data, ensuring an accurate and honest representation of Cook County's deprivation landscape. The inclusion of Standard Errors in *Figure 3*, boxing bars in *Figure 1*, were done to be truthful to the analysis. The website also comes with a short Discussion Paper that encodes the statistical methods used for reproducibility.
- **Functionality:** The visualizations are designed with the user in mind, ensuring clarity, ease of interpretation, and interactivity. The use of faceted bar charts, interactive maps, and comparative scatterplots allows the audience to engage with the data meaningfully, facilitating a deeper understanding of complex relationships.
- **Beauty and Aesthetics:** The visualizations strike a balance between aesthetic appeal and clarity, employing color palettes and design elements that are not only visually pleasing but also enhance readability and accessibility. The thoughtful design ensures that the visualizations are not just informative but also engaging, inviting the audience to explore and reflect on the data.

Insightfulness and Enlightenment

- **Insightfulness:** Beyond presenting data, the visualizations unearth deeper insights into the dynamics of urban poverty, revealing patterns and correlations that might not be apparent from raw data alone. The use of factor analysis provides a structured framework for understanding how different dimensions of deprivation interconnect.
- **Enlightenment:** The choice of presenting these visualizations on a website with an accompanying discussion paper allows findings of a complex statistical analysis to be made accessible to the general public, as well as the policymaker who might be more interested in the methods used to arrive at specific conclusions.