Midwest Comprehensive Visualization Dashboards: Environmental Justice and Neighborhood Schools in Chicago, Illinois

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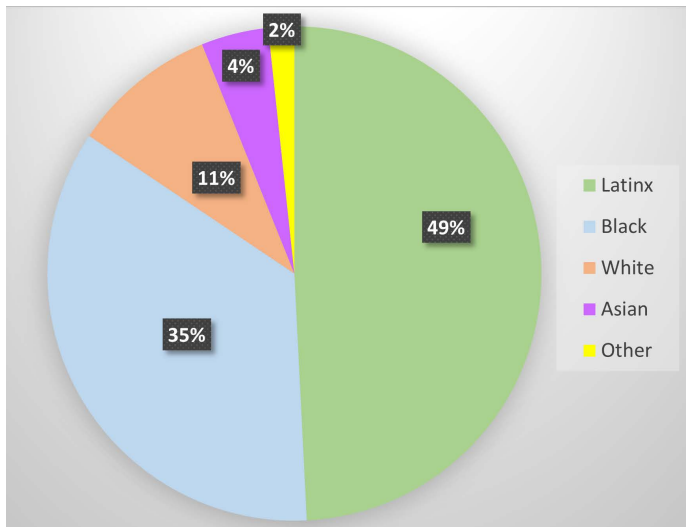
1.0 COMPREHENSIVE VISUALIZATION DASHBOARDS

The UIC School of Public Health (UIC-SPH) Emergency Management and Resiliency Planning (EMRP) program will be presenting a series of Midwest Comprehensive Visualization Dashboards (MCVD) focusing on environmental health and justice issues in this region. The primary objective of the current dashboard (MCVD: EJ.1) is to create visualizations that lead to operational insights supporting data-driven decisions with a focus on environmental justice issues. It is the first in a series of dashboards aiming to identify the distribution of environmental hazards in Chicago neighborhoods.

2.0 BACKGROUND AND OBJECTIVES

The Illinois Environmental Justice Act (415 ILCS 155/1) aims to "ensure that communities are not disproportionately impacted by degradation of the environment or receive a less than equitable share of environmental protection and benefits." The core concept of this act is Environmental Justice (EJ) which "is based on the principle that all people should be protected from environmental pollution and have the right to a clean and healthy environment. Environmental justice is the protection of the health of the people of Illinois and its environment, equity in the administration of the State's environmental programs, and the provision of adequate opportunities for meaningful involvement of all people with respect to the development, implementation, and enforcement of environmental laws, regulations, and policies."

A prerequisite for validating a state of EJ in a community is identifying disparities in the distribution of environmental benefits and burdens. In a previous study involving Chicago neighborhoods, the distribution of environmental hazards were documented, focusing on the South West area of the city.[1] In this study, a different approach is adopted. The emphasis is placed on a sensitive and relatively immobile population living in these communities: kindergarten (age 5 to 6) to 8th-grade school children (henceforth K-8). In recognition of their vulnerability, the 1997 Executive Order (EO) 13045 (62 FR 19885; April 23, 1997), states that "each Federal agency: (1) shall make it a high priority to identify and assess environmental health risks and safety risks that may disproportionately affect children; and (2) shall ensure that its policies, programs, activities, and standards address disproportionate risks to children that result from environmental health risks or safety risks." Guided by this EO the Office of Children's Health Protection (OCHP) was created aiming to "ensure that all EPA actions and programs address the unique vulnerabilities of children." At a local level, the Chicago Public School (CPS) district administration implicitly recognizes the importance of environmental equity stating that "equity is more than a series of stand-alone initiatives: it is the driving core value which informs every decision we make, from capital improvements to curriculum design."[2]

For the current study, to avoid residency issues, students in neighborhood public schools were only included since most of these children are likely to reside as well in the local communities. Based on the information from the CPS district data portal, the K-8 student population for the 2016-2017 school year was 181,357, concentrated in 328 schools. The adjacent figure depicts the racial composition of this population; as seen, almost half of the student body is Latinx. Poverty is another prominent characteristic, with 79.1% of these students living in below-poverty households.

 The emissions from Toxic Release Inventory (TRI) reporting facilities in their communities[1] are the major environmental hazards these children are exposed to. Under the environmental equity principle, the proximity of schools to TRI facilities should be randomly distributed regardless of location and the community's socioeconomic position (SEP) characteristics. A total lack of disparities (i.e., random distribution) is an unlikely status due to the asynchronous development of industrial zones, urban development, and school districts in Chicago. For this reason, it is important to quantify the state of disparities and identify the overburdened areas. The distribution of disparities is vital for prioritizing amelioration and re-zoning programs within the city (e.g., Greening of Industry initiatives which is "a method to attain sustainable economic growth and promote sustainable economies. It includes policymaking, improved industrial production processes, and resource-efficient productivity."[3]). In addition, these overburdened areas with their vulnerable population qualify to become the prime site locations for air quality monitoring networks by state or city environmental quality agencies.

The primary goal of the current MCVD:EJ.1 is to provide the means to visualize the level of disparities in the City of Chicago regarding the proximity to TRI reporting facilities to schools. In this context, the term "disparities" refers to the hypothesis that school children do not share equally (proportionally) the hazards posed by the TRI facilities. Spatial hazard distribution disparities do not necessarily imply an elevated health risk due to exposure; however, they signify a structural inequity that cannot be ignored.

3.0 DATA SOURCES AND LIMITATIONS
The primary data sources for this study are:

- Chicago Public Schools (CPS) - School Profile Information SY1617. Available at:
  https://data.cityofchicago.org/Education/Chicago-Public-Schools-School-Profile-Information-/8i6r-et8s/data
- USEPA Toxics Release Inventory (TRI) Program (2017 data). Available at:
  https://www.epa.gov/toxics-release-inventory-tri-program/tri-data-and-tools

o Preparation and preliminary analysis was performed with the IBM® SPSS® Modeller 18.2.1.
o Geospatial data integration, mapping, and spatial analysis were performed using ESRI's ArcGIS Pro.
o The socioeconomic data used to study the characteristics of the study area were obtain from the U.S. Census Bureau American Community Survey; 2018 release of 5-year estimates.

The TRI site has a section on the "Important Considerations for Using TRI Data" that lists the characteristics and limitations of this database.

A limitation for this and similar spatial proximity studies is that environmental quality monitoring data are not available to explore associations with health outcomes. For this reason, surrogates of hazard exposure are used, the most common being proximity measures.[4] As stated in our objectives section above, the MCVD: EJ.1 does not aim to identify health outcomes related to potential exposures. At this stage of the study, the MCVD can be used as a tool for prioritizing re-zoning strategies, implementing industrial greening initiatives, and identifying air quality monitoring sites that will yield reliable data for health outcome studies.

Data availability dictates the time frame of this study (2017). Given the assumption that the societal distribution of the burden of environmental hazards is not a status that evolves rapidly in time; then, this selected time frame is timely. For practical and communication purposes, the selected spatial scale of analysis for this MCVD is the recognizable Chicago community area level. The potential for scale effects can not be ignored and it is a topic that is further explored in a forthcoming publication.

4.0 PROXIMITY TO TRI FACILITIES

For the current MCVD, a radius of 1.0 mile is used for each of the neighborhood schools in Chicago; in the original study, 0.5, 1.0, 1.5, and 2.0 miles radii are applied to compare results (not shown). To establish a meaningful proximity metric of the societal distribution of the burden, we will introduce the TRI School Proximity Burden score. For each school, i, the 1-mile TRI school proximity burden score is defined as:

$$(\text{TRI School Burden})_i = (\text{PSS} \times \text{TRIs})_i$$

where:

PSS = the percent of neighborhood school students (from the total student population) in each school, i.

TRIs = the number of TRI reporting facilities near school i within a 1-mile radius.

This metric establishes the distribution of the proximity burden for each school, i, as a relative to the other schools score. For practical purposes, we will aggregate the TRI school burden at a Chicago community area scale, z, as follows:

$$\text{TRI School Burden}|_z = \sum_{i=1}^{n_z} (\text{TRI School Burden})_i = \sum_{i=1}^{n_z} (\text{PSS} \times \text{TRIs})_i$$

where:
n_z = the number of schools in the community area z.

For example, New City, a community area in the South West section of Chicago encompassing the neighborhoods of Canaryville and Back of the Yards, has ten (10) public schools in this category (i.e., n_z = 10). Conceptually, the TRI School Burden$|_z$ score provides an estimate of the hazard distribution that each community area bears due to the proximity of its schools to TRI reporting facilities within a 1-mile radius.

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Under conditions of environmental equity, this burden score should be normally distributed. As we noted above, this is an unlikely situation. In reality, the distribution will be skewed, and the majority of burden scores will aggregate at the low end of the distribution with a few only scores forming the high-end tail. The sample mean of the scores provides an estimate of the "average" TRI school burden and establishes a threshold of comparison. The distances of each community's burden score from this threshold will determine how severe the disparity is. To visualize the distribution of the TRI school proximity burden scores, we will use the following Dot Plot (Figure 1). This distribution indicates that three (3) community areas encompass schools with a burden significantly above the average in terms of their proximity to TRI sites within a 1-mile radius (i.e., 2 standard deviations above the mean burden).

Figure 1. Dot Plot of TRI school proximity burden scores at a community area level.

Figure 2. Dot Plot of TRI school proximity burden scores at a community area level with a value above 1.

Both Figures establish that this proximity hazard distribution is significantly unequal. As seen, a few community areas bear a high burden (i.e., above the mean) due to the proximity of their neighborhood schools to TRI reporting facilities within a 1-mile radius. As stated above, "spatial hazard distribution disparities do not necessarily imply an elevated health risk due to exposure; however, they signify a structural inequity that cannot be ignored."

5.1 MCVD: The spatial TRI school proximity burden distribution

Figure 3. The spatial distribution of TRI School Proximity Burden scores at a community area level

The above MCVD map shows the distribution of the TRI school proximity burden. As seen, the high burden areas are not randomly distributed within the City of Chicago and some areas are alloted a significant burden (i.e., above two (2) standard deviations from the mean; see also Figure 1). This finding underlines the need to further examine the SEP characteristics of the communities that bear the elevated proximity burden.

The original interactive maps are at:

➢ https://univofillinois.maps.arcgis.com/apps/dashboards/975bf6c0b41e4274a22adf8388987b56

5.2 MCVD: The racial dimension of disparities

The MCVD:EJ.1 provides the means to visualize the disparities and display the TRI school proximity burden scores in relation to the Latinx student population per community. This bivariate representation reveals the areas with an elevated burden and a high (or low) level of a Latinx student population.

The bivariate map, or more accurately choropleth map, enables users to visualize the spatial relationship between the burden and the Latinx student concentration for each community area. The tertiles of the two variables create the bivariate map, and we assigned the visually distinguishable 3x3 color scheme in the adjacent figure above. Thus, areas with an extreme discordance between the two variables are easily identified (i.e., the Low-Low and High-High light orange and dark brown edges of the color scheme).

As seen from the bivariate representation above, the three community areas identified in the previous section (bearing the highest level of TRI school proximity burden) are as well communities with a predominant Latinx student population.

6.0 BENEFIT DISTRIBUTION

The MCVD: EJ study identified a number of schools with zero TRI reporting facilities at various radii. This status (i.e., zero TRI proximity) raises another question:

- ▪ are environmental benefits equally shared among the student population in Chicago?

In this context, an environmental benefit is the lack of TRI reporting facilities at various radii.

To answer this question we compare the percent of the Latinx student population that enjoys this benefit with the combined student population of all the other races (White, Black, and Asian). Numerically, the two comparison groups are almost the same.
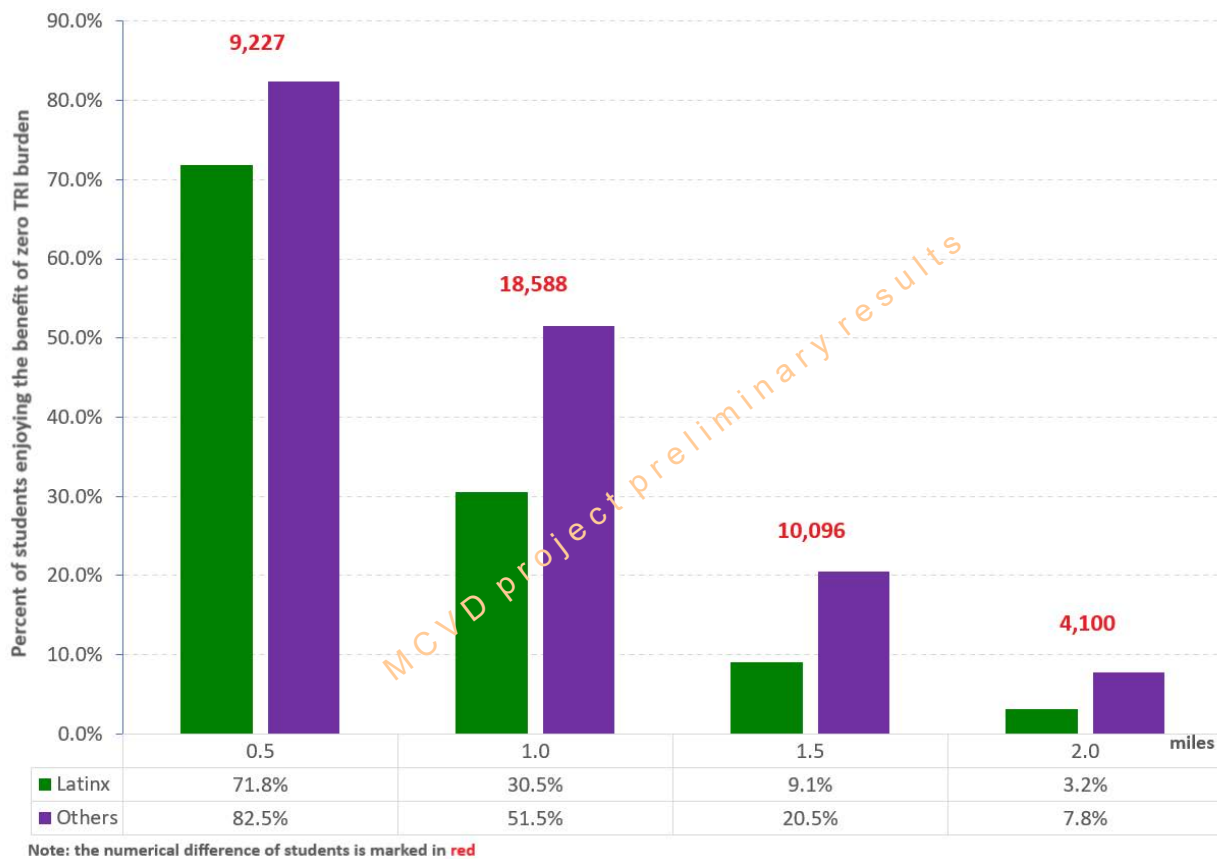
Figure 4. Distribution of environmental benefit among two groups

The above figure underlines that the environmental benefit of a zero TRI school proximity burden is not equally distributed in Chicago. For all the radii used, the Latinx school children are consistently at a disparity in comparison to the combine student population of Black, White and Asian students. This issue will be further explored in a forthcoming publication.

7.0 CONCLUDING REMARKS

The main purpose of this paper is to introduce the MCVD as a tool for identifying disparities. From this preliminary stage of the study the following conclusion is drawn:

- TRI reporting facilities in the Chicago area are likely to be concentrated near neighborhood public schools in communities which have a predominantly Latinx student population.

The unequal distribution of the TRI school burden underlines the need to:

- Re-examine the industrial zones of Chicago and establish a carrying capacity limit by, for example, considering the areas with an elevated burden due to the proximity of their schools to TRI reporting facilities.

- Establish air quality monitoring networks in the problematic locations identified by this study. This recommendation becomes even more expedient if the other hazard sources are accounted for (e.g., industrial diesel truck traffic, non-TRI reporting facilities such as asphalt plants, etc.).

8.0 REFERENCES

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2. CHICAGO PUBLIC SCHOOLS (CPS). Equity at CPS. https://www.cps.edu/strategic-initiatives/equity-at-cps/

3. United Nations Industrial Development Organization (UNIDO), Green Industry initiative. https://www.unido.org/our-focus-cross-cutting-services-green-industry/green-industry-initiative

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