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

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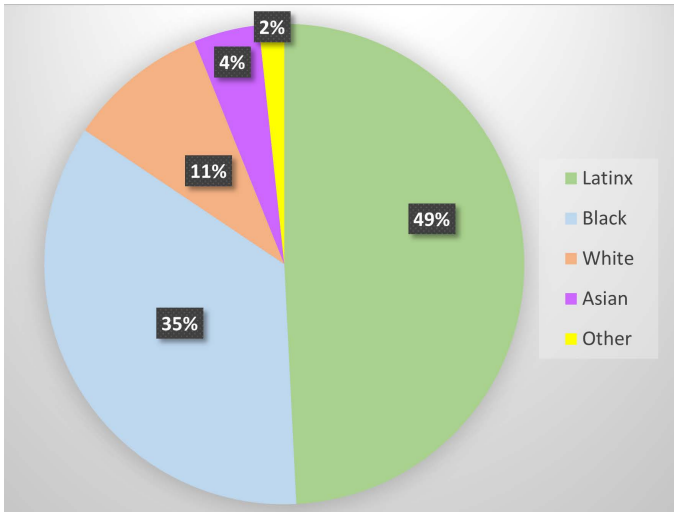
1.0 COMPREHENSIVE VISUALIZATION DASHBOARDS

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 (K - 8). In recognition of their condition, the 1997 Executive Order (EO) 13045, 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." The Chicago Public School (CPS) district administration implicitly recognizes the importance of 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 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 dominant characteristic, with 79.1% of these students living in below-poverty households.

The emissions from Toxic Release Inventory (TRI) facilities in their communities 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. For this reason, it is important to quantify the state of disparities and identify the overburdened areas. This information 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 sensitive 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:617. https://data.cityofchicago.org/Education/Chicago-Public-Schools-School-Profile-Information-/8i6r-et8s/data
- Toxics Release Inventory (TRI) Program (2018 data). Available at: https://www.epa.gov/toxics-release-inventory-tri-program/tri-data-and-tools

Preparation and preliminary analysis was performed with the IBM® SPSS® Modeller 18.2.1. Geospatial data integration, mapping, and initial spatial analysis were performed using ESRI’s ArcGIS Pro. 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. 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 (2017-2018). 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 does pose any problems. For practical and communication purposes, the selected spatial scale of analysis for this MCVD is the recognizable neighborhood area level. The potential for scale effects 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 adjacency to TRI School Burden score. For each school, i, the 1-mile TRI school 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 burden for each school, i. For practical purposes, we will aggregate the burden at a Chicago community area scale, z, as follows:

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

where:

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

For example, New City, a neighborhood area in the South West section of Chicago, has ten 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 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 that all communities bear. The distances of each community's burden score from this average will determine how severe the disparity is. To visualize the distribution of the TRI School 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).

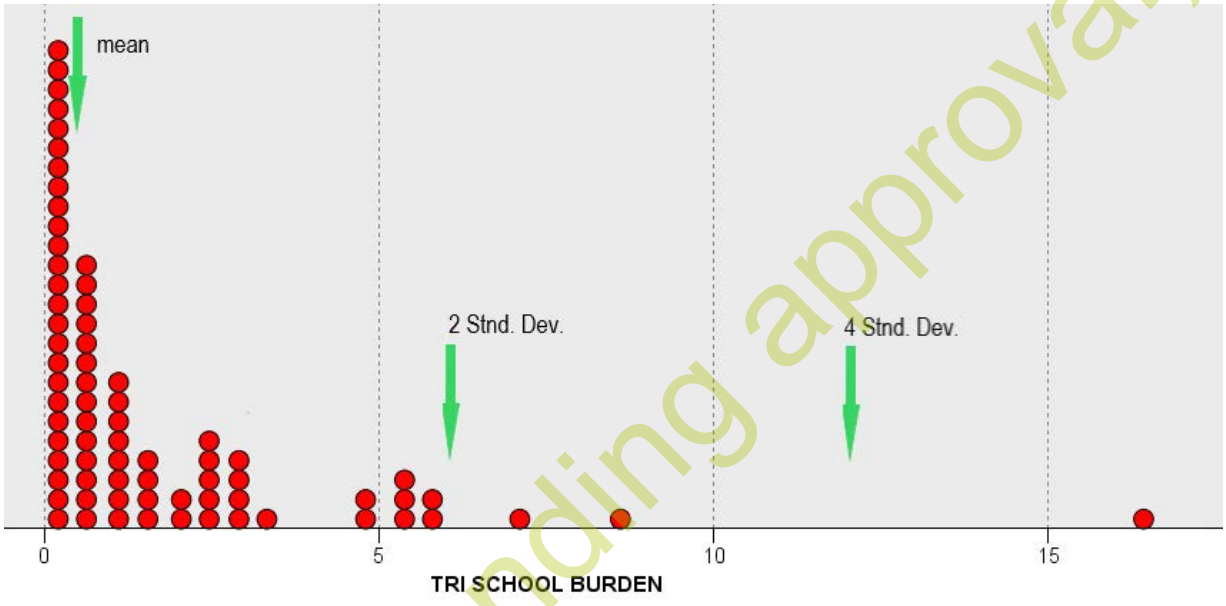


Figure 1. Dot Plot of TRI School Burden scores at a community area level.

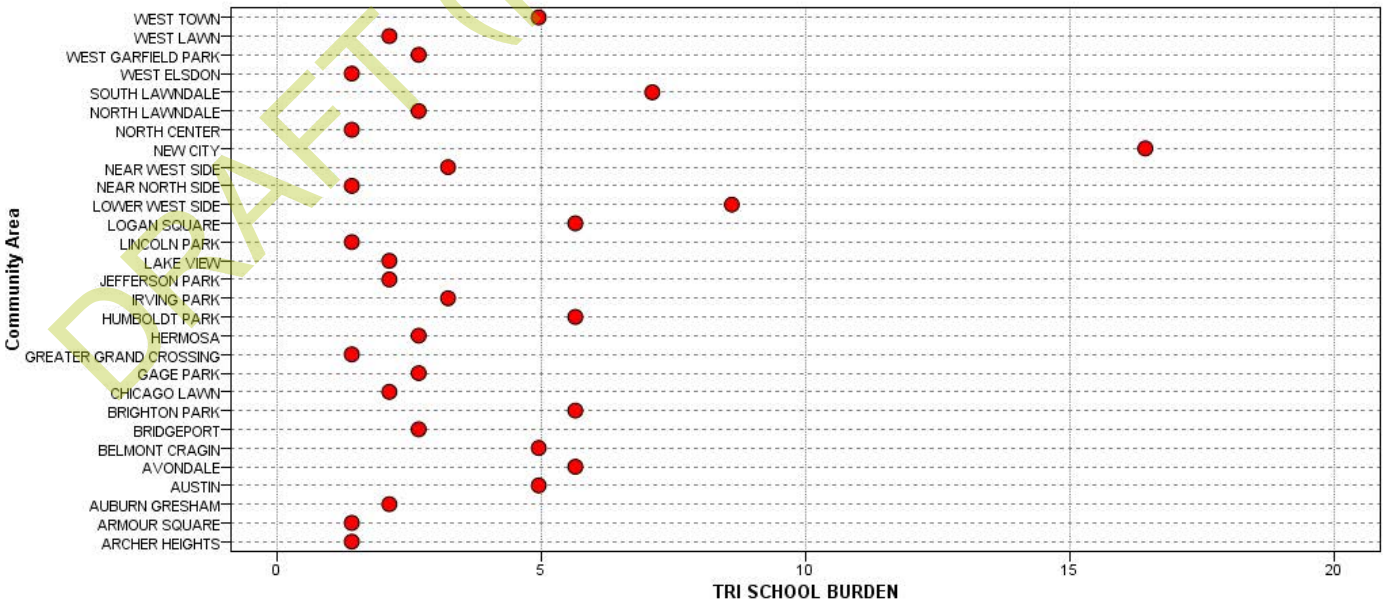


Figure 2. Dot Plot of TRI School Burden scores at a community area level with a value above 1.

Both Figures establish that this hazard distribution is significantly unequal. As seen, a few only community areas bear a high burden 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 Burden Distribution

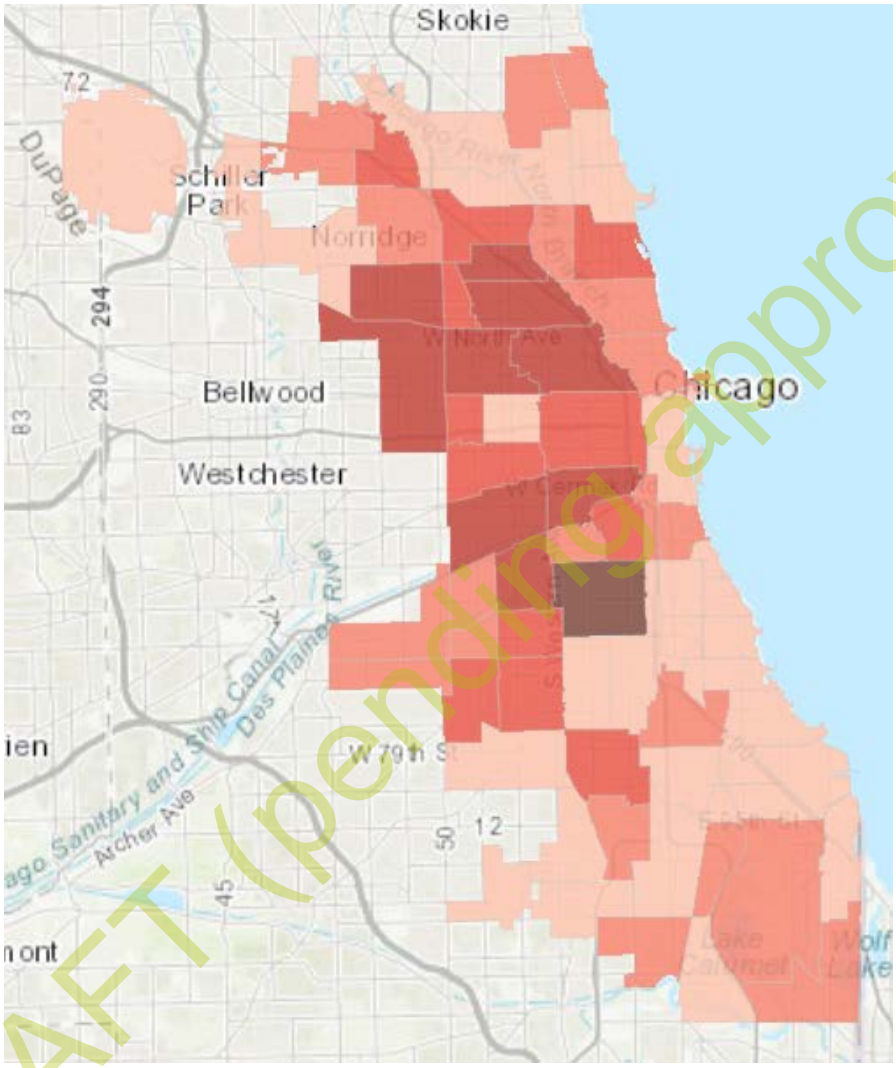
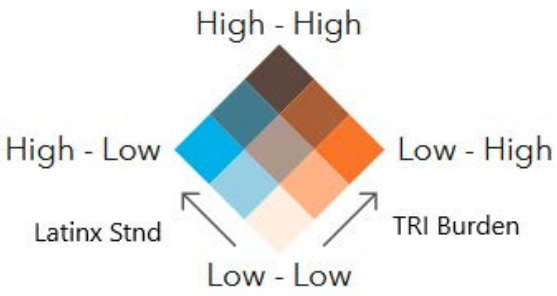


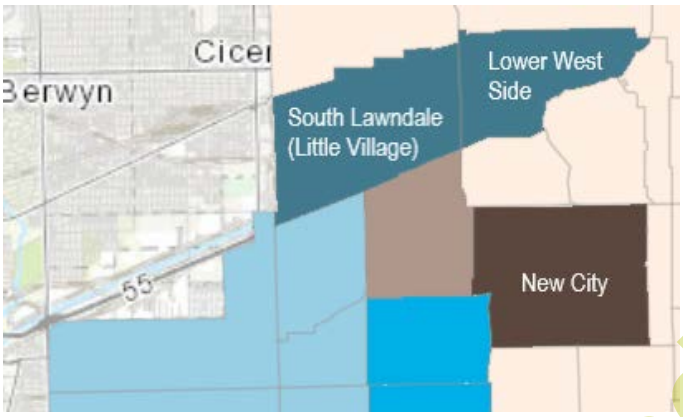
Figure 3. The spatial distribution of TRI School Burden scores at a community area level

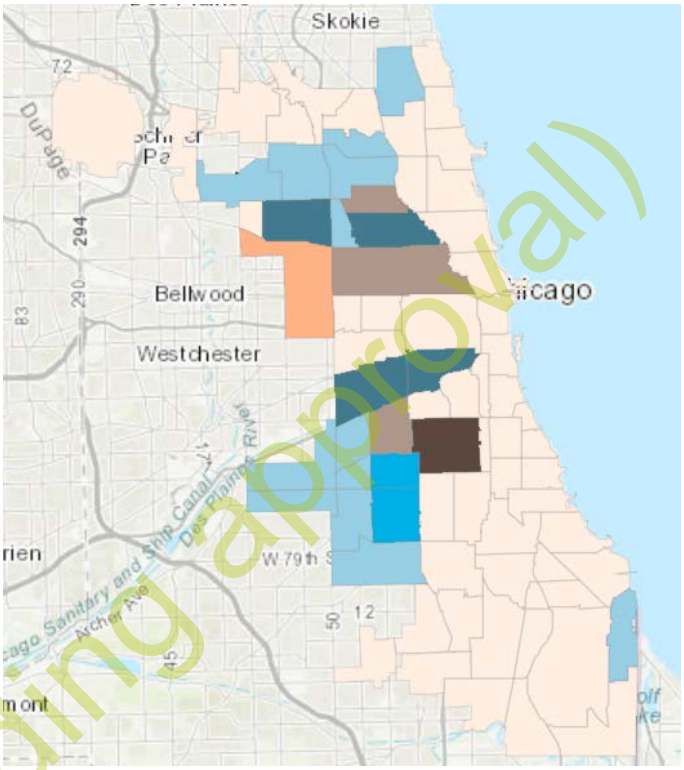
The above MCVD map shows the distribution of the TRI school burden. As seen, the high burden areas are not randomly distributed within the City of Chicago. This finding underlines the need to further examine the the SEP characteristic of the communities the bear this elevated burden.

5.2 MCVD: The racial dimension of disparities

The MCVD: EJ.1 provides the means to visualize the disparities and display the TRI School 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. 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 adjacent bivariate representation, the three community areas identified in the previous section (bearing the highest level of TRI school burden) are as well communities with a dominant 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 a 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.

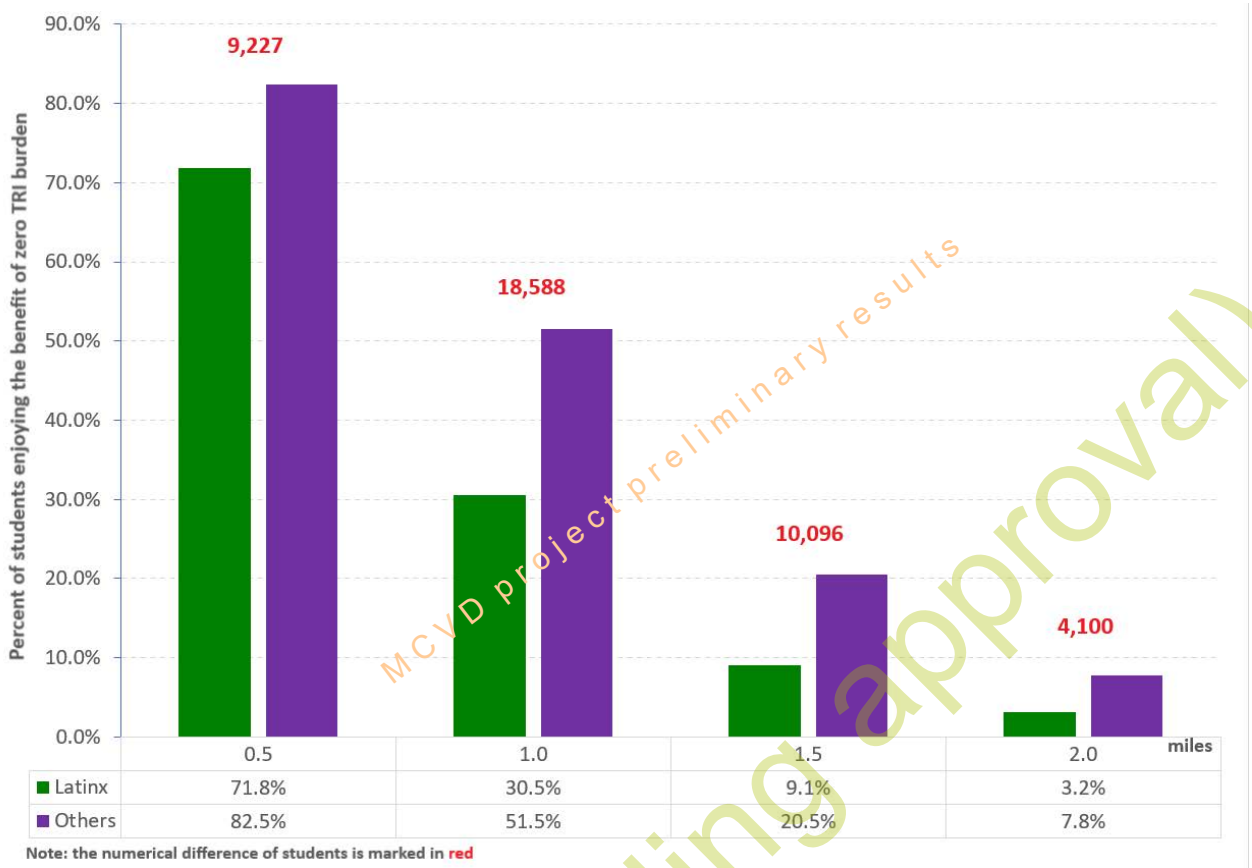


Figure 4. Distribution of environmental benefit among two groups

The above figure underlines that the environmental benefit of a zero TRI School 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 considering the areas with an elevated burden due to the proximity of their schools to TRI reporting facilities.
- Establish air quality monitoring programs in the problematic areas identified by this study. This recommendation becomes even more urgent 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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