

Analyzing Gun Violence in Chicago: Identifying the Spatio-Temporal Shift of Gun Violence in Chicago

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Abstract: Gun violence has long been a critical issue in urban centers across the United States, with Chicago often at the forefront of discussions due to its persistent crime rates and socio-economic disparities. Understanding the spatiotemporal patterns of gun violence is essential for identifying high-risk areas, guiding policy interventions, and improving urban safety. This study examines gun violence trends in Chicago from 2001 to 2020, dividing the data into two key decades: 2001-2010 and 2011-2020. The goal is to uncover how these patterns evolved over time and to investigate possible socio-economic and demographic influences. [3] Using advanced GIS tools, including “Summarize Within,” “Hotspot Analysis,” and “Compare Hotspot Analysis,” this study identifies shifts in gun violence hotspots and explores changes in spatial patterns. Additionally, a percentage change analysis provides insights into the areas with the most significant increases or decreases in incidents. This analysis serves as a foundation for understanding the broader implications of gun violence and urban development in Chicago.

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I. INTRODUCTION

Gun violence remains an enduring challenge in numerous urban centers across the United States, with Chicago often recognized as a critical case due to its persistently high incidence rates and socio-spatial inequalities. The interplay of systemic socioeconomic disparities, residential segregation, and disinvestment has rendered certain communities in Chicago—particularly those on the South and West Sides—more vulnerable to firearm-related crimes (Hwang and Sampson, 2014). Recognizing these spatial disparities necessitates an in-depth exploration of both the geographic and temporal dimensions of gun violence, particularly to inform targeted and data-driven policy interventions.

Spatial patterns of crime are rarely uniform or static. In Chicago, the geography of gun violence is influenced by a wide array of factors, including demographic change, urban redevelopment, and evolving policing strategies. Spatial analysis tools within Geographic Information Systems (GIS) offer a rigorous platform for examining these dynamics. As described by Chainey and Ratcliffe (2005), spatial crime analysis techniques—such as Hotspot Analysis and Comparative Hotspot Analysis—facilitate the identification of high-incidence clusters and emerging patterns, especially when used in conjunction with socio-economic and demographic variables. Furthermore, methods such as those implemented in CrimeStat (Levine, 2015) and the hotspot

matrix framework (Ratcliffe, 2004) have enhanced the capacity to visualize and understand complex spatial shifts in urban violence.

This study undertakes a comprehensive spatio-temporal analysis of gun violence in Chicago, focusing on a two-decade span from 2001 to 2020. Dividing the data into two distinct periods (2001–2010 and 2011–2020), the research applies GIS-based methodologies to identify persistent, emerging, and dissipating hotspots of violence. By incorporating contextual socio-economic indicators—such as income levels and racial demographics—the study seeks to uncover deeper insights into the mechanisms underlying spatial shifts in gun violence. The findings aim to contribute to the academic discourse on urban crime and provide an empirical basis for developing equitable and localized violence prevention strategies.

II. RESEARCH QUESTION

The central question is: **How have gun violence incidents shifted geographically in the city of Chicago?** The key is to highlight the change of spatial patterns between the two periods, and analyze the change, and potentially interpret it in terms of income and race.

A. Study Area

Chicago, the third-largest city in the United States, is located in the state of Illinois along the southwestern shores

of Lake Michigan. Known for its rich cultural history and economic significance, Chicago serves as a critical hub for transportation, finance, and commerce. The city spans approximately 234 square miles and is home to a diverse population of over 2.7 million residents, representing a broad array of ethnic and racial backgrounds. [2]

Chicago is divided into 77 community areas, each exhibiting unique socio-economic characteristics. While some neighborhoods boast thriving economic development, others face persistent challenges such as poverty, unemployment, and crime. Historically, gun violence has disproportionately affected neighborhoods on the South and West Sides, highlighting stark disparities in safety and quality of life across the city. [1]

The city's dense urban environment, coupled with its history of segregation and economic inequality, makes Chicago a compelling study area for analyzing the spatial patterns of gun violence. Its robust data infrastructure, including crime records and demographic statistics, provides an excellent foundation for conducting detailed spatiotemporal analyses. By focusing on Chicago, this project aims to uncover insights into urban crime dynamics and inform strategies for fostering safer communities.

III. DATA AND METHODS

A. Data Preparation and Segmentation

The dataset used for this analysis includes geolocated records of gun violence incidents in Chicago from 2001 to 2020. The data was segmented into two decades—2001-2010 and 2011-2020—to facilitate a comparative analysis of trends over time. This temporal segmentation is critical for identifying patterns that may have emerged or dissipated due to socio-economic or policy-driven factors. [1]

B. Spatial Aggregation

The "Summarize Within" tool was applied to join point data (individual incidents) with the city limits shapefile of Chicago. This ensured that all incidents were spatially contextualized within the city's administrative boundaries. The summarized data provides aggregate counts of gun

violence incidents for each decade, enabling an effective spatial comparison.

C. Hotspot Analysis

The "Hotspot Analysis" tool (Getis-Ord Gi*) was employed to identify statistically significant clusters of gun violence. This method determines areas of high and low incident densities, visualizing regions where violence is concentrated. Hotspot Analysis is particularly effective in highlighting systemic patterns, such as chronic hotspots or emerging areas of concern.

D. Graduated Symbol Mapping

To enhance visualization, graduated symbols were used to represent the density of gun violence incidents across Chicago neighborhoods. Larger symbols were assigned to higher densities, creating a clear visual distinction between areas with varying intensities of violence.

E. Comparative Hotspot Analysis

The "Compare Hotspot Analysis" tool was utilized to assess changes in spatial patterns between the two decades. This analysis identifies areas where gun violence clusters have persisted, dissipated, or newly emerged, providing insights into the shifting dynamics of urban crime.

F. Socio-Economic Correlation

To contextualize the spatial patterns, the analysis incorporated demographic and socio-economic data, such as median household income and racial composition. This step aimed to explore potential correlations between these variables and gun violence trends. [2]

IV. RESULTS

A. Graduated Symbol Mapping

The graduated symbol maps vividly displayed the contrast between the two decades. The 2011-2020 map showed a notable increase in medium-density areas, suggesting a diffusion of gun violence incidents beyond the historically high-density neighborhoods. This trend may reflect changes in urban dynamics, such as population shifts or the displacement of crime due to gentrification.

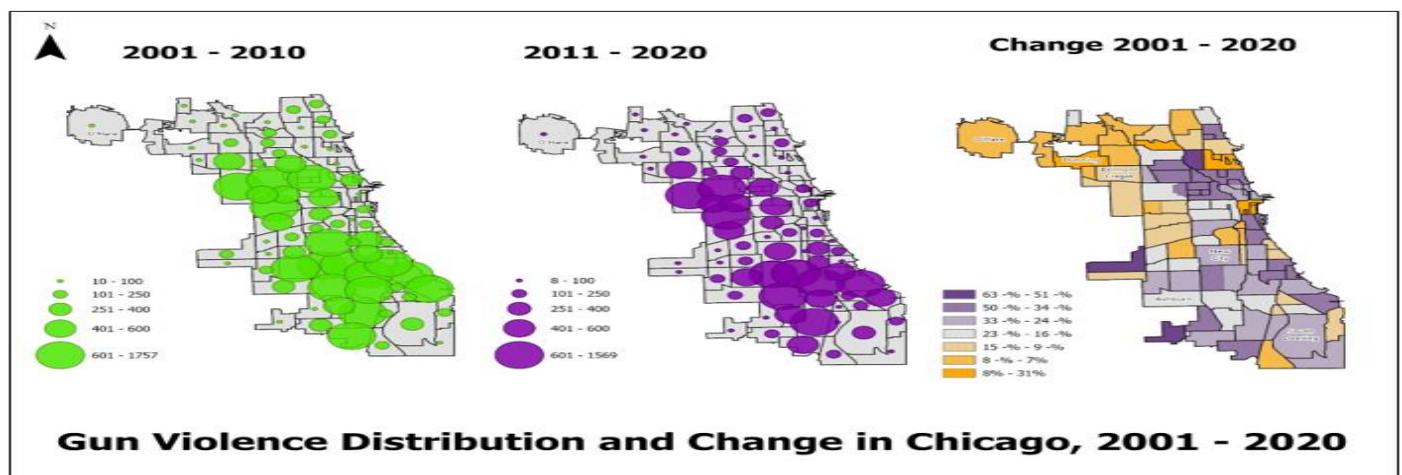


Fig 1 Figure 1 below shows the Distribution of Gun Violence in Chicago between two Distinct Time Periods, 2001-2010 and 2011-2020. The shift or Changes between the time Periods is also Displayed.

B. Hotspot Analysis

➤ 2001-2010:

The hotspot analysis revealed that gun violence was heavily concentrated in the South Side and West Side neighborhoods, particularly in areas such as Englewood, Austin, and Garfield Park. These neighborhoods have long been associated with socio-economic challenges, including poverty, unemployment, and limited access to resources.

➤ 2011-2020:

The spatial distribution of hotspots expanded, with new clusters emerging in neighborhoods such as Humboldt Park, North Lawndale and Roseland. While the South Side and West Side continued to dominate in terms of density, the emergence of new hotspots suggests a broader spatial spread of gun violence across the city.

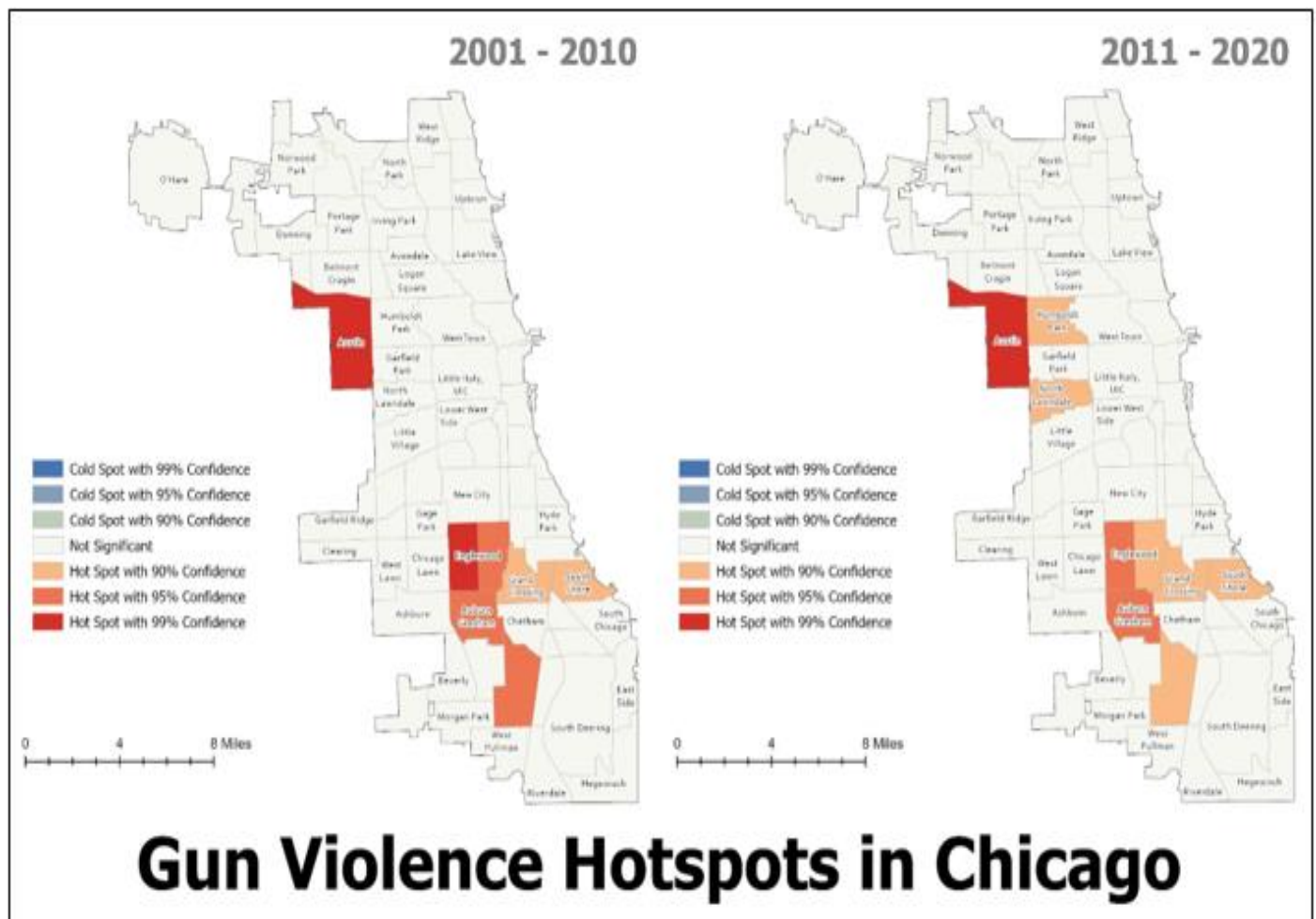


Fig 2 The map attempts to show the differences in gun violence concentration between the two time periods. It is clear that the same areas which were known for the highest rates of gun violence from 2001-2010, still had higher rates between 2011-2020. Areas like Englewood, Auburn Gresham, and Southshore etc. It should be noted that the intensity went lower though, with new areas emerging as hotspots from 2011-2020.

C. Comparative Hotspot Analysis

The comparative analysis revealed several key trends:

➤ Persistent Hotspots:

Areas such as Englewood and Austin remained consistent hotspots across both decades, indicating entrenched issues that require sustained intervention.

➤ Emerging Clusters:

New hotspots in neighborhoods like Roseland suggest a shift in violence patterns, potentially driven by socio-economic changes or policing strategies.

➤ Dissipating Hotspots:

Some areas, such as Bronzeville, showed a clear reduction in hotspot intensity, reflecting successful intervention strategies or demographic shifts.

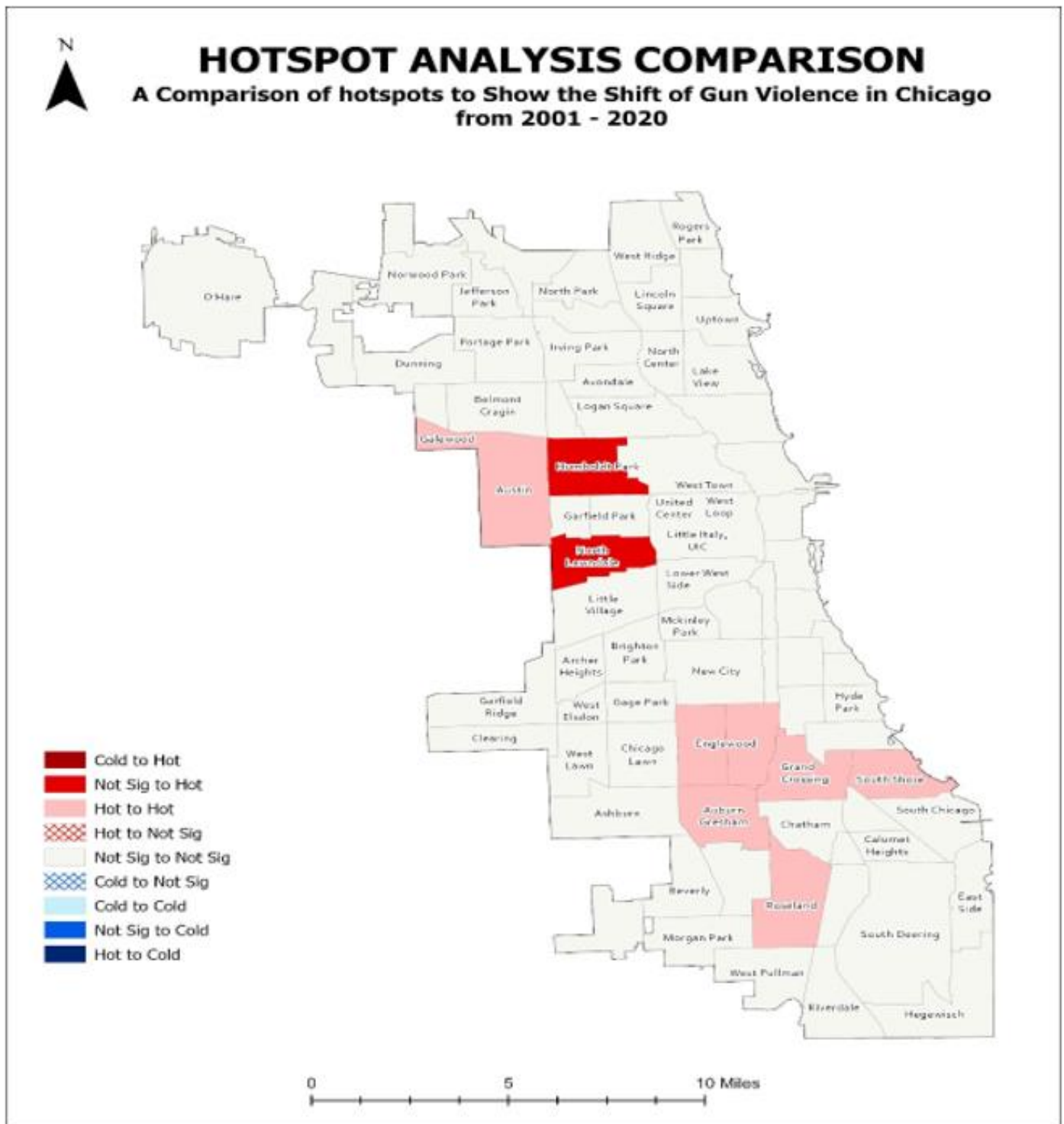


Fig 3 Englewood, Auburn Gresham, Southshore etc. maintained high levels of gun violence though the intensity was reduced. Areas like Humboldt Park and North Lawndale emerged as new hot spots from 2011-2020. This map therefore shows a significant spatio-temporal shift of gun violence within the city.

D. Percentage Change Mapping

Several neighborhoods experienced significant changes in gun violence over the two decades:

➤ Increased Violence:

North Lawndale, Roseland, and Humboldt Park saw sharp increases in gun violence, with some areas experiencing over a 50% rise in incidents. These increases may correlate

with socio-economic factors such as declining household incomes or reduced access to social services.

➤ Decreased Violence:

Hyde Park, Bronzeville, and Lake View showed marked reductions in gun violence, with decreases ranging from 20% to 40%. These neighborhoods have seen significant urban investment and gentrification, which may have contributed to improved safety.

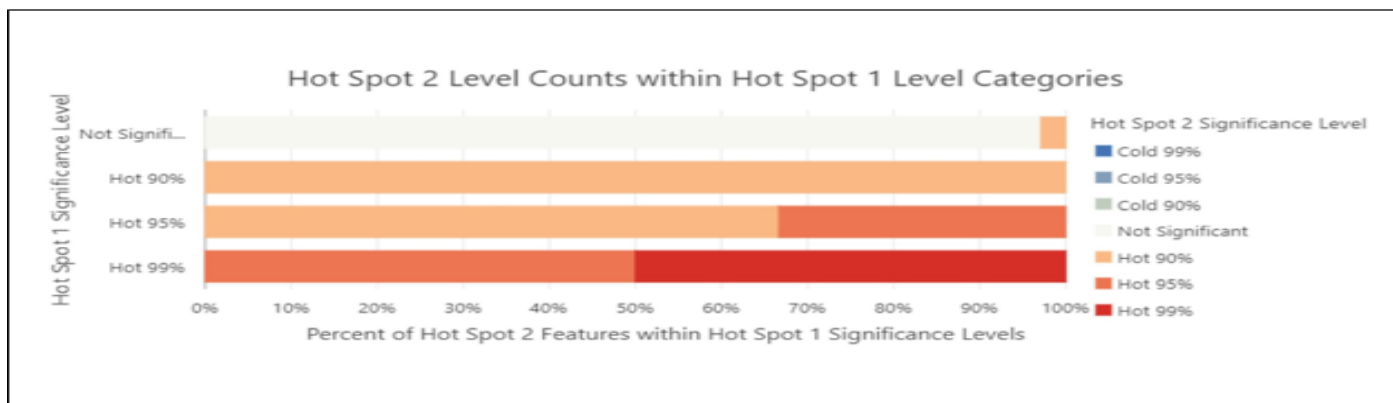


Fig 4 Shows the percentage change of gun violence incidents between the hotspot maps of Fig 2 as displayed in Fig 3.

V. DISCUSSION

The analysis highlights significant changes in the spatial patterns of gun violence in Chicago over the two decades. These shifts can be attributed to a complex interplay of socio-economic, demographic, and policy-driven factors:

A. Economic Inequality:

Persistent poverty in neighborhoods like Englewood and Austin continues to drive high levels of gun violence. Economic deprivation often correlates with increased crime rates, highlighting the need for targeted economic development initiatives. [3]

B. Urban Redevelopment:

Gentrification in neighborhoods like Bronzeville and Hyde Park has likely contributed to reductions in gun violence. However, this process often displaces crime to adjacent areas, as evidenced by the emergence of hotspots in nearby neighborhoods. [6]

C. Policing Strategies:

Changes in law enforcement practices, including community policing initiatives and targeted crime reduction programs, may have influenced the spatial distribution of gun violence. However, the uneven impact of these strategies suggests the need for a more comprehensive and equitable approach. [5]

D. Demographic Shifts:

Population changes, including migration patterns and shifts in racial composition, have likely played a role in the observed trends. For example, neighborhoods experiencing an influx of higher-income residents often see reductions in crime rates.

E. Systemic Inequities:

The persistence of gun violence in certain areas underscores broader systemic issues, including racial inequality, lack of access to education and healthcare, and the prevalence of illegal firearms.

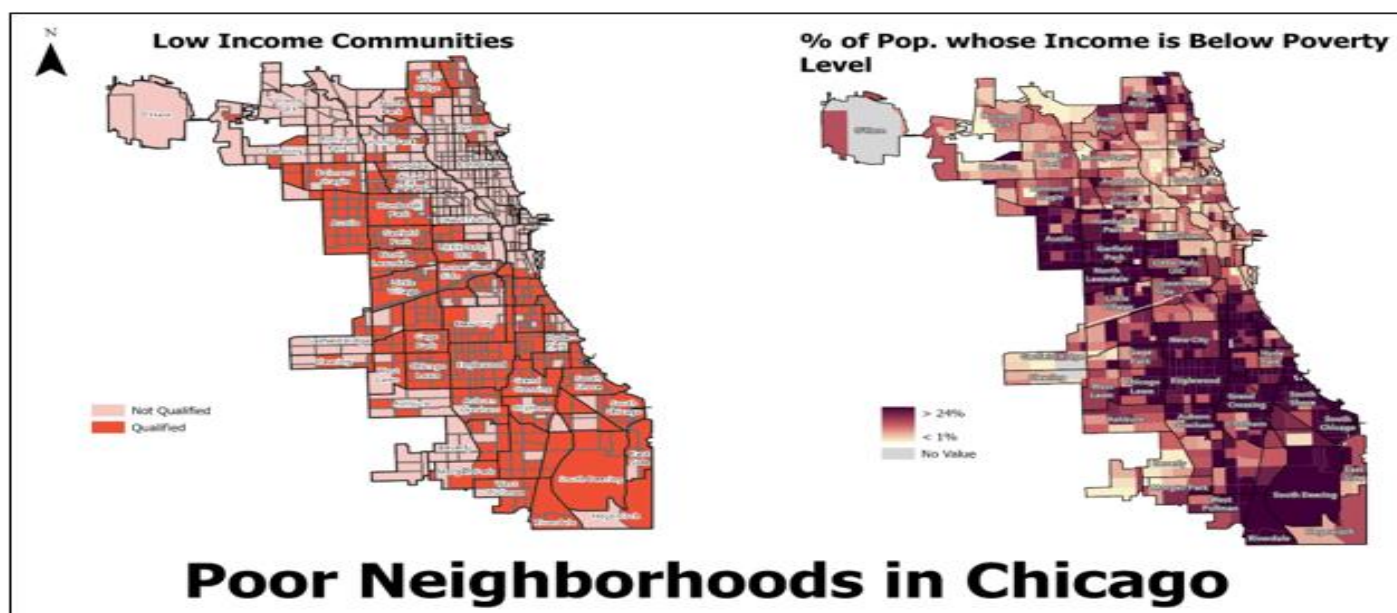


Fig 5 The maps here show that the areas like Englewood, Humboldt Park, Auburn Grisham, North Lawndale, etc. are some of the poorest communities in Chicago, with most of their inhabitants living below the poverty level. Between 2011-2020, areas like North Lawndale began experiencing higher levels of poverty after most middle-class families started moving towards the North. It's no wonder that subsequently, gun violence began to increase in the community.

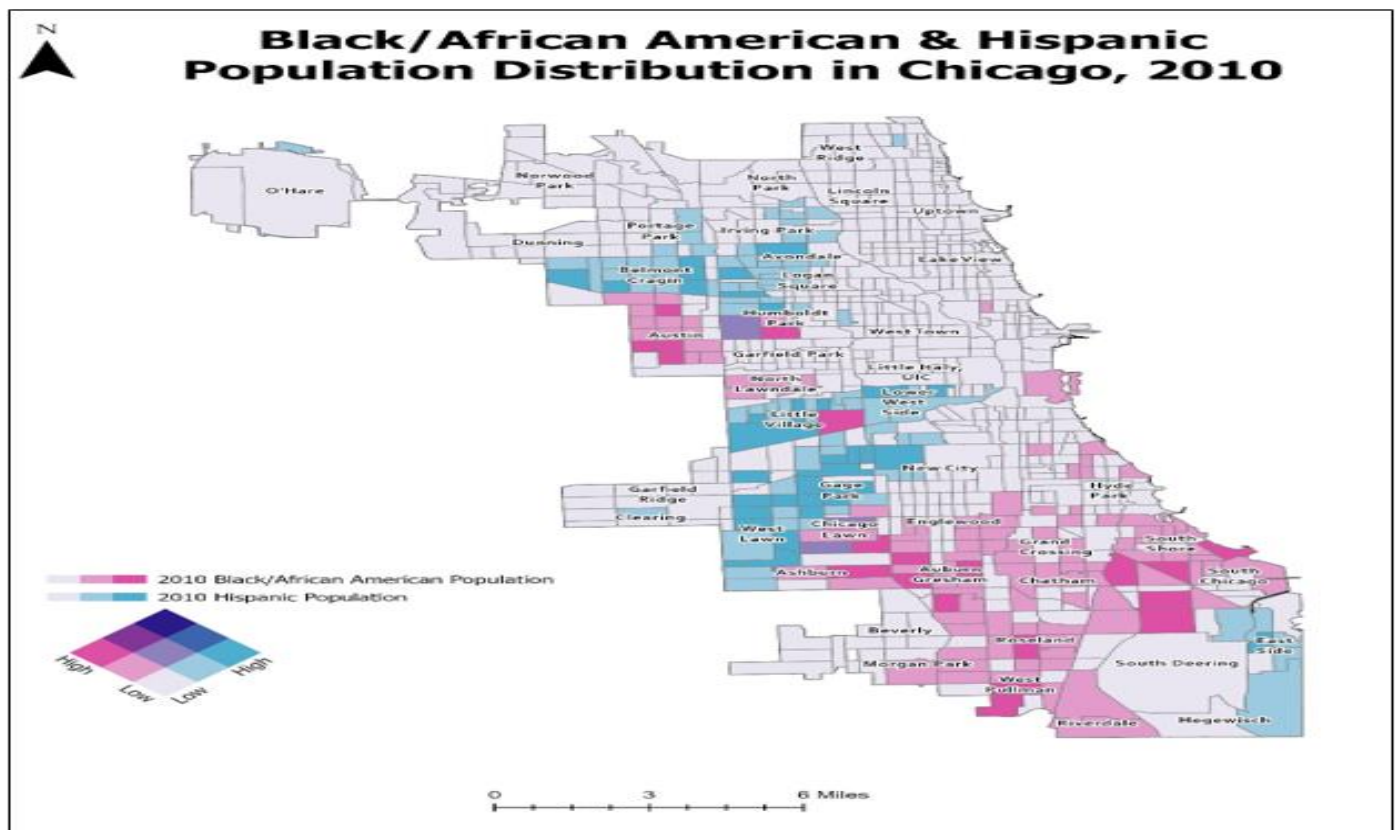


Fig 6 This map shows the race distribution of Black/African Americans and Latinos or Hispanics in Chicago as of 2010. From the map, we can identify that gun violence was dominant in communities with high percentages of Black/African Americans mostly, and a few Hispanics or Latino populations.

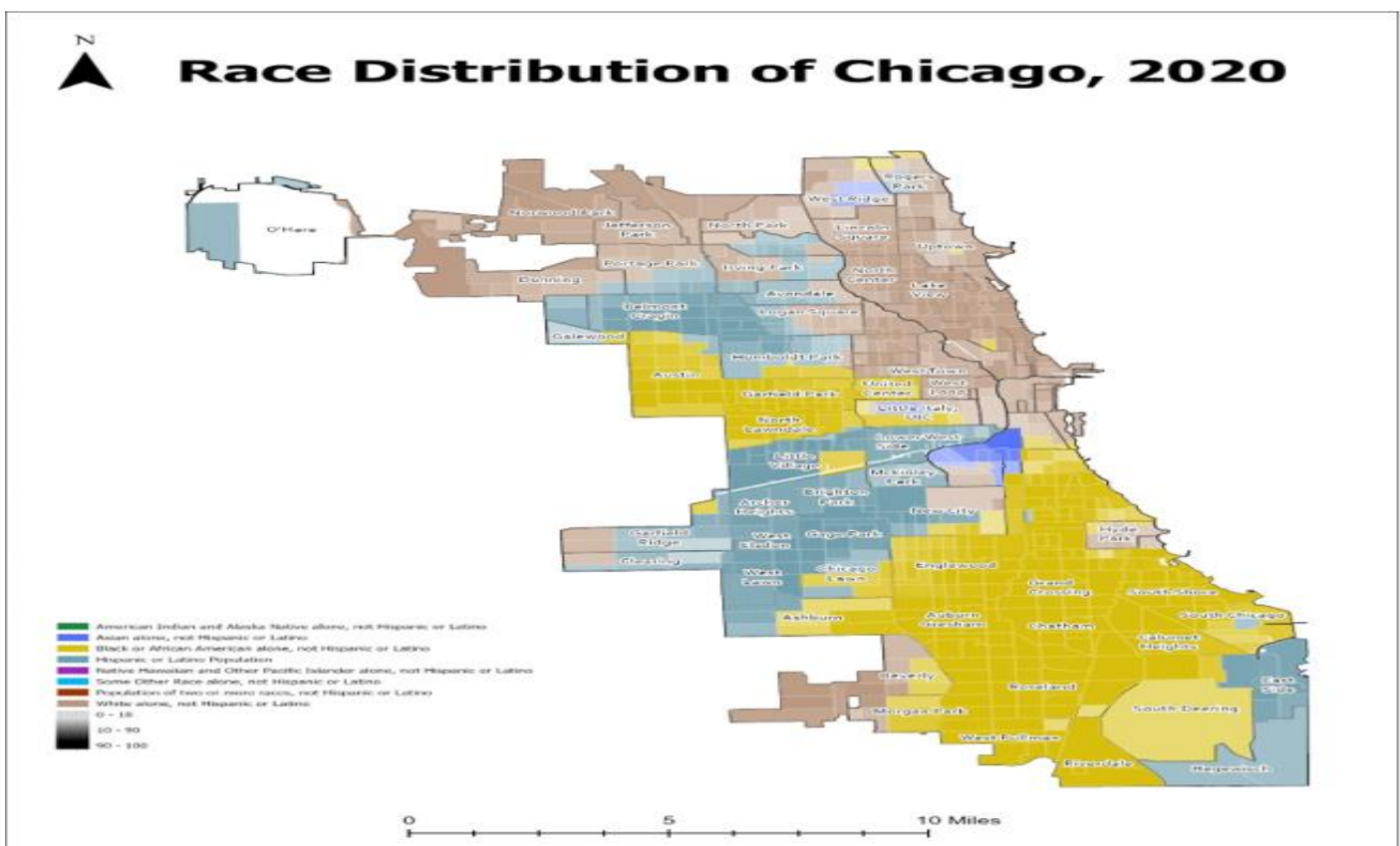


Fig 7 The race distribution of Chicago's population as of 2020. This map, in comparison to the one in Fig 5, shows that gun violence has always shifted or moved around the Black Community mainly.

VI. LIMITATIONS

While this analysis provides valuable insights, several limitations must be acknowledged:

➤ *Data Completeness:*

The accuracy of the analysis depends on the completeness and reliability of the gun violence dataset. Missing or misclassified incidents could skew the results.

➤ *Temporal Resolution:*

Aggregating data into decade-long intervals may obscure short-term trends or anomalies, such as spikes in violence due to specific events.

➤ *Boundary Constraints:*

The analysis is limited to Chicago's administrative boundaries, potentially excluding incidents near the city's edges that may influence overall patterns.

➤ *Socio-Economic Data:*

The analysis uses socio-economic variables as contextual factors but does not establish causation. Further statistical modeling would be required to confirm these relationships.

➤ *Underreporting:*

Community distrust in law enforcement may lead to underreporting of gun violence incidents, particularly in marginalized neighborhoods.

VII. CONCLUSION

This spatiotemporal analysis of gun violence in Chicago from 2001 to 2020 reveals both persistent and emerging patterns. While some neighborhoods have seen significant improvements, others continue to struggle with high levels of violence. The use of advanced GIS tools, such as Hotspot Analysis and Comparative Hotspot Analysis, has provided a clear picture of these trends, enabling targeted interventions and informed decision-making.

Moving forward, efforts to reduce gun violence must address the underlying socio-economic and systemic factors driving these patterns. This includes investing in economic development, implementing equitable policing strategies, and improving access to education and social services. By taking a holistic approach, policymakers can work toward creating a safer and more equitable urban environment for all Chicago residents.

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