ABSTRACT

Title of Thesis:	THE ASSOCIATION BETWEEN GHOST GUN USAGE AND NEIGHBORHOOD DISADVANTAGE
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This study examined the relationship between Privately Made Firearm (PMF) usage and multiple characteristics of neighborhood disadvantage in a large metropolitan city. PMFs, also known as ghost guns, are unserialized firearms typically ordered as parts and constructed by hand at home. Police data containing PMF recovery incidents, categorized as criminal or non-criminal incidents, from 2020 to 2023 were obtained and mapped onto census data to find the PMF rate per 1,000 people in each census tract. Linear regression models were conducted to determine if neighborhood disadvantage from 2015 to 2019 was predictive of PMF use. Neighborhood disadvantage was measured through unemployment rate, poverty rate, and percent of residents over 25 without a high school diploma. Findings show that higher neighborhood disadvantage was significantly and positively associated with higher PMF rate per 1,000 people by census tract for all PMF recovery incidents, criminal incidents alone, and non-criminal incidents. This research provided important contributions to firearm research and demonstrated that, like violent crime, PMF use was more common in more disadvantaged neighborhoods.

THE ASSOCIATION BETWEEN GHOST GUN USAGE AND NEIGHBORHOOD DISADVANTAGE

by

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Introduction

In December 2023, a 2 year-old girl named Charlee Gamble accidentally shot and killed herself with an unsecured, untraceable firearm owned by her father (Philippe-Auguste, 2024). Charlee's father had purchased a ghost gun, or a Privately Made Firearm (PMF), because he was barred from legitimately purchasing a licensed firearm after a 2021 conviction for assault. His neglect and failure to safely secure the illegal PMF resulted in his daughter's death and a 10-year conviction for manslaughter.

Like Charlee's father, PMFs are often purchased by people who are unable to obtain a gun through traditional, regulated means, whether it be due to age restrictions or background checks (Biasi et al., 2024). PMFs are a viable and easy method to obtain a firearm while circumventing background checks because they can be ordered online as separate parts to be assembled at home by the purchaser (Wintemute, 2021). Since the Bureau of Alcohol, Tobacco, Firearms and Explosives (ATF) did not consider the unconstructed frame and receiver parts as firearms until 2022, manufacturers were not required to register the parts with a serial number (Biasi et al., 2024). This rendered PMFs virtually untraceable to the ATF (Wintemute, 2021).

Over the past decade, PMFs have shifted from a rare occurrence to a routine encounter for law enforcement officers. Between 2016 and 2021, the ATF received over 45,000 PMF reports from potential crime scenes (ATF, 2023). Out of the 45,000 recovered PMFs, 692 were involved in homicide or attempted homicide cases, demonstrating PMFs' impact on violent crime. Thus, PMFs have risen to prominence within gun violence discussions in the media, legal sphere, and government.

Due to the relevance of PMFs, it is crucial to understand where PMFs are concentrated in city neighborhoods. Examining the correlates of violent crime can help explain the spatial

distribution of PMFs across neighborhoods. Criminological theory suggests that one of the most consistent correlates of crime is neighborhood disadvantage. According to social disorganization theory, structural conditions, such as neighborhood disadvantage, weaken informal social controls, which leads to an increase in crime (Shaw & McKay, 1942). To understand patterns of PMF use, it is important to examine whether this theorized relationship is applicable to PMFs.

Prior research has drawn connections between neighborhood disadvantage and general firearm usage (Semenza et al., 2023). Higher neighborhood disadvantage, measured through a combination of socioeconomic disadvantage markers (e.g., poverty, unemployment, female-headed households) and racial segregation, predicts the presence of gun violence. Interestingly, prior research on gun violence fails to focus specifically on the relationship between neighborhood disadvantage and PMF use. Karni and Cameron (2023) state that the main problem with PMFs is their heightened use in day-to-day gun violence, which disproportionately affects communities of color. Thus, there is a need for research that highlights the most at-risk neighborhoods for PMF violence.

Although the ATF has increased its regulation of PMFs through the passing of the ATF Final Rule 2021R-05F in 2022 to require serial numbers on all firearm parts (Everytown Research & Policy, 2022), its enforcement faces multiple practical and legal challenges. The recency of the Final Rule means that many existing PMFs still do not have serial numbers and remain untraceable (Wintemute, 2021). Furthermore, the Final Rule was challenged multiple times in court (Liptak, 2023). Thus, due to the difficulty in regulating PMFs, there was a significant need for further research on perpetration patterns and risk factors associated with PMFs. In this study, I tested whether the spatial distribution of PMFs followed a pattern like

violent crime by examining the extent to which the presence of PMFs was associated with neighborhood disadvantage.

Despite prior research outlining an existing relationship between general gun violence and neighborhood disadvantage (Semenza et al., 2023), we did not know whether PMFs follow the same pattern. Thus, I hypothesized that neighborhoods with more disadvantage would be associated with higher PMF rates. Secondly, I hypothesized that the association between neighborhood disadvantage and PMF rate would be greater for criminal incidents than for non-criminal incidents. Through this study, I studied the extent to which neighborhood disadvantage was associated with the spatial distribution of PMFs to see whether it was related in the same way as general gun violence. This research will help law enforcement and lawmakers adjust gun violence policies to better address PMF violence patterns.

Theoretical Framework

Neighborhood Disadvantage and General Gun Violence

The relationship between neighborhood disadvantage and general gun violence can be explained using Shaw and McKay's social disorganization theory (1942). Social disorganization theory posits that the characteristics of neighborhoods predict crime in that area. Disorganization, often measured using characteristics such as poverty, residential instability, and ethnic heterogeneity, was thought to weaken informal social controls in the community (e.g., social networks, institutional participation), allowing for more neighborhood crime. In the first study testing social disorganization theory, Sampson and Groves (1989) found that sparse friendship networks, unsupervised teenage peer groups, and low organizational participation mediated the relationship between neighborhood disadvantage (low socioeconomic status, residential mobility, racial and ethnic heterogeneity, family disruption, and urbanization) and neighborhood crime. These findings demonstrate the ability of social disorganization theory to predict the presence of crime.

In the context of general gun violence, social disorganization theory explains that areas with neighborhood disadvantage would have weakened informal social controls, leading to higher rates of gun violence. Prior research has confirmed this theory, finding higher neighborhood disadvantage in areas with higher gun violence. In a study by Henry and colleagues (2024), the researchers analyzed gun violence by looking at the medical charts of all residents in Camden County, New Jersey who entered a Level 1 trauma center for a firearm injury. They took the addresses of the qualifying patients and examined the characteristics of their neighborhoods to look at the relationship between neighborhoods and gun violence. Areas

with higher disadvantage had the most firearm injuries, demonstrating a clear relationship between neighborhood disadvantage and general gun violence.

In another study, social disorganization theory explained the relationship between neighborhood disadvantage and distance of residence-to-crime for firearms offenses (Cwick & Williams, 2024). In areas of higher neighborhood disadvantage, there were weakened informal social controls, which significantly decreased the residence-to-crime distance. Individuals who lived in disadvantaged areas committed firearms offenses closer to home, resulting in higher crime rates in that area. The consistency of the prior research findings shows that social disorganization theory reliably explains the relationship between neighborhood disadvantage and general gun violence.

Neighborhood Disadvantage and PMF Use

Prior research has not looked at the relationship between neighborhood disadvantage and PMFs separately from general gun violence. If PMF use follows the same patterns as general gun violence, social disorganization theory would predict that areas with higher neighborhood disadvantage would be associated with higher rates of PMF use. I expected that the spatial distribution of PMFs would be related to neighborhood disadvantage in the same way as violent crime because PMFs may be more accessible by people with lower socioeconomic status. PMFs are less expensive than firearms purchased from a licensed firearms dealer, which may make them more attractive to individuals living below the poverty line. Additionally, PMFs may be easier to obtain than firearms purchased through licensed manufacturers because of the lack of background checks prior to purchase. The ease of purchase may make it easier for individuals who are underage or have prior convictions to own a firearm. If this is true, this may explain why areas with higher neighborhood disadvantage could have higher PMF rates.

In one of the few studies examining PMFs, De Biasi and colleagues (2024) compared PMF type and crime type between two cities in California - Los Angeles and San Diego. Although they did not test the relationship between neighborhood characteristics and PMF rate, Los Angeles was described by the researchers as a much more racially diverse and less affluent city than San Diego. When looking solely at the number of PMFs recovered by the Los Angeles Police Department versus the San Diego Police Department, Los Angeles had over 3.5 times more PMFs than San Diego. Since the more disadvantaged city reported more PMFs, this follows the assumption of social disorganization theory and supports my hypothesis that neighborhoods with higher disadvantage would be associated with higher PMF rates.

Current Study

My study aimed to answer the following overarching question: Is the spatial distribution of PMFs associated with neighborhood disadvantage in the same way as violent crime? I hypothesized that areas with higher neighborhood disadvantage would be associated with higher PMF rates. I also hypothesized that specifically, the association between neighborhood disadvantage and PMF rate would be greater for criminal incidents than for non-criminal incidents. For this study, I used geocoded police data to examine the spatial distribution of PMFs in one city.

Prior research on this topic focused solely on general firearms use and neighborhood disadvantage rather than PMF-specific use. Thus, there was a need to expand research to include the involvement of PMFs in crime to understand PMF patterns. Furthermore, by separating the PMF recovery incidents into criminal and non-criminal incidents, crime-type differences could be observed to further understand the usage patterns of PMFs and their involvement in violent crime. Finally, this research examined whether the spatial distribution of PMF use was related to neighborhood disadvantage in the same way as general gun violence and highlighted any key differences. The findings of this research were important because they provide a foundation for future application of other criminological theories to explain and analyze PMFs. Information resulting from this study can be used to guide interventions for people living in at-risk neighborhoods and provide a starting point for future research on PMF violence.

Data and Methods

Analytic Sample

The focus city, hereafter referred to as Midwestern City, has over 2.5 million residents and a median household income of approximately $74,000 in 2020 (U.S. Census Bureau, n.d.). Following prior research on neighborhood disadvantage and gun violence (Semenza et al., 2023), I used census tracts to measure neighborhoods in my study. It is important to recognize that census tracts are not always consistent from year to year, as they are often redefined based on the population each decade. Furthermore, census tracts are drawn by the government and do not necessarily follow the cultural or historical identities of neighborhoods. Census tracts may group areas together that do not represent the residents' perceptions of neighborhood boundaries. However, I used census tracts in this study because they allowed me to use data collected by the U.S. Census Bureau to measure key neighborhood characteristics.

ACS data were collected from the 5-year estimate from 2015 to 2019 in Midwestern City. The data included multiple measurements of socioeconomic disadvantage to represent neighborhood disadvantage. Some census tracts did not contain any census bureau information as they did not have anyone living in that tract. This could be because the census tract only consists of a school, an airport, or a body of water, which does not have anyone residing there permanently. Furthermore, some census tracts were changed and added in the decennial census in 2020, which was after the ACS estimates from 2015 to 2019 were collected, so they were also empty. Any empty census tracts were dropped from the sample prior to analysis (n = 28). This resulted in 836 viable census tracts in Midwestern City used in this study.

To measure PMF rate, I requested access to PMF recovery data collected by 13 different police departments across the country. These cities were chosen for their varied locations and

large, diverse populations. Out of the 13 cities, three cities responded and provided data. Two of the cities had very small sample sizes, with less than 75 PMF recoveries over the past five years. Thus, I only used data from Midwestern City in this study, which reported 2,242 PMF recoveries from 2020 to 2023. The data included the recovery date, type of crime committed, and the location where the PMF was recovered. The data did not include the name or birth date of the subject or any other identifying information; I cannot connect the PMF incident information to a specific individual. Importantly, the data included whether the PMF was recovered during a criminal offense (n = 2029), or a non-criminal offense (n = 213), such as a weapon recovery, weapon turn-in, or a found weapon.

Measures

Outcome 1: PMF Rate per 1,000 People by Census Tract – All Incidents

The outcome variable for this study was the rate of PMFs per 1,000 people by census tract across all four years, 2020 to 2023. Using ArcGIS Pro, a geospatial mapping software, I plotted all the PMF recovery incidents (N = 2242) onto a map of Midwestern City's census tracts. Using the Spatial Join tool, I calculated the number of PMF recoveries from each census tract for each year from 2020 to 2023. Then, using Stata, I divided the count per census tract by the total population and multiplied it by 1,000. This resulted in the outcome variable of PMF rate per 1,000 people by census tract.

Outcome 2: PMF Rate per 1,000 People by Census Tract – Criminal Incidents

To focus solely on criminal incidents, I used Stata to generate a PMF rate that only considered the PMF recovery incidents that were marked as a criminal incident (n = 2029). This created an outcome variable that specifically examined criminal incidents in each census tract for each year from 2020 to 2023.

Outcome 3: PMF Rate per 1,000 People by Census Tract – Non-Criminal Incidents

To examine the non-criminal incidents, I used Stata to generate another PMF rate that only captured the PMF recovery incidents that were non-criminal (n = 213). This resulted in an outcome variable that only considered the non-criminal incidents in each census tract for all four years.

Explanatory: Neighborhood Disadvantage

In this study, neighborhood disadvantage was calculated using the sum of the z-scores of three measurements of socioeconomic status: poverty rate, unemployment rate for those over age 16, and the percentage of residents over age 25 who did not have a high school diploma. Prior research examining neighborhood disadvantage in the context of general gun violence has measured disadvantage using various combinations of socioeconomic status. Some of these included poverty rate, unemployment rate, proportion of families on welfare, rate of female-headed households, and the percentage of residents over age 25 who did not have a high school diploma (Beardslee et al., 2021; Chamberlain & Hipp, 2015; Kravitz-Wirtz et al., 2022; Thomas et al., 2022; Wehrman, 2010). Thus, poverty rate, unemployment rate, and the percentage of residents over age 25 who did not hold a high school diploma were chosen for their frequent use in prior research studies to measure neighborhood disadvantage.

After gathering the ACS 5-Year Estimates from 2015 to 2019, the totals for the number of people below the poverty line and the number of people over age 25 who did not have a high school diploma were divided by each census tract's population and multiplied by 100 to obtain the rate per census tract. Unemployment rate was already in the form of a percentage. These rates were standardized into z-scores and summed. The sum was equal to the amount of neighborhood

disadvantage in that census tract. Higher z-score sums reflected more neighborhood disadvantage. See Figure 1.

Control Variables

The following external factors were controlled to address potential instances of spuriousness in the analyses. These were characteristics of the neighborhood that could potentially explain the association between neighborhood disadvantage and PMF rate.

Racial and Ethnic Make-Up

Prior research has connected higher gun violence rates to areas with a greater concentration of racial minorities (Johnson et al., 2021). Jackson and colleagues (2023) reported that overall, underrepresented minority populations were more involved with general gun violence than White people. Thus, it was important to control for race and ethnicity in this study.

To measure race and ethnicity, the ACS 5-Year Estimate from 2015 to 2019 for the number of non-Hispanic White and non-Hispanic Black people in each census tract were collected. These counts were divided by the total population in each census tract per year and multiplied by 100 to obtain the percentage.

Hispanic and Foreign-Born Immigrants

The number of Hispanic and foreign-born immigrants present in a neighborhood may have an effect on the relationship between PMF rate per census tract and neighborhood disadvantage. Prior research findings stated that immigrants overall were less likely to commit violent crimes than individuals born in the United States (Vaughn & Salas-Wright, 2018). Specifically, they also found that Hispanic immigrants were less likely than US-born individuals to commit violent crime. Furthermore, a study by Ousey and Kubrin (2014) found a correlation

between lower gun violence rates and more immigration. Thus, I controlled for the Hispanic and foreign-born immigrant population in this study.

To measure the percentage of Hispanic and foreign-born immigrant residents in each census tract year, I used data from the 2015 to 2019 ACS 5-Year Estimate that had the count of foreign-born residents and the count of Hispanic residents in a census tract. To obtain the percentage, the count of foreign-born residents per census tract per year was divided by the total census tract population and multiplied by 100. This was repeated for Hispanic residents. These percentages were standardized into z-scores and added together. The sum measured the Hispanic and foreign-born immigrants in the census tract.

Residential Stability

The amount of residential stability in a neighborhood may have an impact on the relationship between PMF rate and neighborhood disadvantage. As explained by social disorganization theory, residential stability (or the opposite - residential mobility) was an important neighborhood characteristic that could impact the relationship between neighborhood disadvantage and PMF (Shaw & McKay, 1942). Higher residential stability meant that more people were continuing to live in the same neighborhood. Less residential stability (more residential mobility) meant that residents were choosing to leave and move out of the neighborhood. Social disorganization theory explained that areas with less residential stability were associated with higher crime rates. Thus, if this was true for PMFs, there could be an impact of residential stability on the relationship between neighborhood disadvantage and PMF rate.

To account for residential stability, I used the 2015-2019 ACS 5-Year estimate to calculate the percent of the census tract population who were age 1 and over that lived in the same house one year ago. I then divided the count by the total census tract population and multiplied by 100 to obtain the percentage.

Male Population

Gender composition of each neighborhood could have an effect on the rate of PMF usage. Prior research on general gun violence found that men were more likely than women to commit firearm offenses (Armstrong & Carlson, 2019). In fact, over 90% of murders where the perpetrator's gender was known were committed by men (Levant, 2022). Thus, I controlled for the male population in my study.

Data from the ACS 5-Year Estimate from 2015 to 2019 measured the neighborhood gender composition. To obtain the percentage of males, the count of males per census tract was divided by the total census tract population and multiplied by 100.

Population 15 to 24 Years Old

The percentage of 15- to 24-year-olds in a census tract also may have an impact on the relationship between neighborhood disadvantage and PMF rate (Males, 2015). Prior research that connected the age-crime curve to homicide rates and general gun violence (Males, 2015) found that gun homicide rates peak at age 19 before declining. Thus, in this study, I controlled for the population of 15- to 24-year-olds in each census tract.

Data were obtained from the ACS 5-Year Estimate from 2015 to 2019 containing the age distribution per census tract. The number of 15- to 24-year-olds was divided by the total population in each census tract per year and multiplied by 100 to obtain the percent per census tract.

Analytic Approach

For my analyses, I conducted three linear regression models to examine the relationship between neighborhood disadvantage and PMF rate per 1,000 people by census tract for (1) all incidents, (2) criminal incidents, and (3) non-criminal incidents. I chose linear regression models as my analytic method because the outcome variables of PMF rate were continuous. Additionally, the linear regression models allowed me to account for theoretically relevant control variables. The linear regressions operated on the assumption that neighborhood disadvantage came first and predicted the outcome variable PMF rate per 1,000 people by census tract.

Results

In this study, I hypothesized that greater neighborhood disadvantage would be associated with higher PMF rates. I also hypothesized that the association between neighborhood disadvantage and PMF rate would be greater for criminal incidents than for non-criminal incidents.

Descriptive Statistics

Table 1 provides the descriptive information for all the measures for the Midwestern City census tracts from the 2015 to 2019 estimates (N = 836). From 2015 to 2019, Midwestern City had an average of 3511.55 residents per census tract (SD = 1741.47). The average census tract population was 33.74% non-Hispanic Black, 32.27% non-Hispanic White, and 26.11% Hispanic. In each census tract, 19.45% were below the poverty level, 9.67% were unemployed, and 18.58% were foreign-born. The majority (68.77%) of the population was over 25 years of age and 15.51% of that population did not have a high school diploma. 84.32% of residents lived in the same house one year ago. Furthermore, 48.42% of residents in each census tract were male and 13.27% of residents were between the ages of 15 to 24.

The average PMF rate for 1,000 residents across 836 census tracts for all recovery incidents was 0.26 (SD = 0.45); See Figure 2. For criminal incidents, the PMF rate per 1,000 residents by census tract was 0.23 (SD = 0.40); See Figure 3. For non-criminal incidents, the rate per 1,000 residents by census tract was much lower (M = 0.07, SD = 0.18); See Figure 4.

Linear Regression Models

Predicting PMF Rates for All PMF Incidents

First, I conducted a set of linear regression models analyzing PMF rate per 1,000 people by census tract for all the recovery incidents (N = 2242) with neighborhood disadvantage. To

account for heteroskedasticity, I used robust standard errors in my linear regression. When examining neighborhood disadvantage and PMF rate without control variables, each one standard deviation increase in neighborhood disadvantage was associated with a 0.09 increase in PMF rate ($p < 0.001$). When including the control variables, each one standard deviation increase in neighborhood disadvantage was associated with a 0.07 increase in PMF rate ($p < 0.001$). See Table 2.

Predicting PMF Rates for Criminal PMF Incidents

Next, I conducted a set of linear regression models comparing the PMF rate per 1,000 people by census tract that only considered criminal incidents ($n = 2029$) with neighborhood disadvantage. I continued to use robust standard errors in my linear regression to account for heteroskedasticity. Without controls, each one standard deviation increase in neighborhood disadvantage was associated with a 0.08 increase in PMF rate ($p < 0.001$). When including the control variables, each one standard deviation increase in neighborhood disadvantage was associated with a 0.07 increase in PMF rate ($p < 0.001$). See Table 3.

Predicting PMF Rates for Non-Criminal PMF Incidents

Finally, I conducted a set of linear regression models with the PMF rate per 1,000 people by census tract for non-criminal incidents ($n = 213$) and neighborhood disadvantage using robust standard errors. Without including the control variables, each one standard deviation increase in neighborhood disadvantage was associated with a 0.01 increase in PMF rate ($p < 0.001$). When including the control variables, each one standard deviation increase in neighborhood disadvantage was associated with a 0.01 increase in PMF rate ($p < 0.01$). See Table 4.

Comparing the Coefficients of Criminal and Non-Criminal Incidents

I conducted a seemingly unrelated regression model to compare the coefficients of my criminal and non-criminal PMF rate models. A seemingly unrelated regression is a statistical test that allows for the comparison of coefficients across related models with different outcomes. I found that the coefficients were significantly different (X^2 (1) = 29.90, $p < 0.001$).

Discussion

The association between neighborhood disadvantage and PMF rate per 1,000 people by census tract was positive and statistically significant across all my regression models, even when including control variables. These findings demonstrated that areas with higher neighborhood disadvantage were associated with a higher PMF rate per 1,000 people by census tract for all PMF recovery incidents. Thus, hypothesis 1 was supported. The second hypothesis predicted that disadvantaged neighborhoods would be associated with higher PMF rates in criminal incidents when compared to non-criminal incidents. After comparing the coefficients from the criminal and non-criminal incidents using a seemingly unrelated regression, there was a significantly larger increase in PMF rate per 1,000 people by census tract for criminal incidents than non-criminal incidents. Thus, hypothesis 2 was supported. In summary, I concluded that the spatial distribution of PMF rate was associated with neighborhood disadvantage in the same way as general gun violence in Midwestern City. Social disorganization theory can be used to support the findings of this study, explaining that areas with more neighborhood disadvantage led to weakened informal social controls, which led to an increase in PMF use.

The inclusion of control variables in my linear regression models allowed me to consider other correlates of crime that could have played a role in the relationship between neighborhood disadvantage and PMF rate. However, they did not alter the overall findings. Neighborhood disadvantage had a significant positive effect on PMF rate with and without controls. Interestingly, some of the control variables were not significantly related to PMF rate. Across all three PMF rate outcome variables, the percent of males, percent of residents age 15 to 24, and percent of residents living in the same house one year ago were not significantly related to PMF rate. This finding indicated that PMF rates may follow slightly different patterns than general

gun violence. Further research is needed to understand why some established crime correlates were not predictive of PMF rate. Additionally, none of the control variables were associated with the non-criminal PMF rate, indicating that crime correlates were not effective in predicting patterns of non-criminal PMF offenses.

Limitations and Future Directions

While conducting this research, I was limited by the lack of publicly available data measuring and tracking PMF recoveries. The study data were collected from a single city in the Midwest, which affects the generalizability of the results. PMF use may be different depending on the city, as different states may regulate PMFs at varying levels of severity. Law enforcement may be more likely to recover PMFs in stricter gun-law states than those with more relaxed regulations, which could impact the PMF rate per 1,000 people by census tract.

Additionally, since my study relied on observational recovery data collected by the Midwestern City police department, there are external factors that I could not account for that may explain the relationship between neighborhood disadvantage and PMFs. For example, the data were limited to the location of the PMF recovery and did not provide any demographic information about the perpetrator. Furthermore, there was no explanation or motive connected to the PMF recovery information, which eliminated any details about possible gang involvement or use in multiple crimes.

Future research should increase the scope of the data to include multiple cities from different states around the United States. Furthermore, the range of years considered should be expanded beyond 2020 to 2023 to strengthen directionality. In this study, neighborhood disadvantage was assessed using three variables, but future studies should include more measures to have a more comprehensive understanding of disadvantage as explained by social disorganization theory. This could include the percentage of female-headed households or percent of families on welfare as a control variable or measure of disadvantage.

If these findings are replicated, this study has implications for decreasing PMF violence in disadvantaged neighborhoods. Communities can provide resources to unemployed residents to

help them find a job. For example, setting up employment centers and job fairs may help decrease unemployment rates. Furthermore, communities can support individuals and families who are living below the poverty line. Some ideas include creating food banks, providing funds to assist with paying bills, and lowering the cost of rent. Finally, communities can support young people in completing their high school education and earning a diploma. This might include tutoring services, after school programs, college tours, and information about financial aid.

Law enforcement and policymakers should be aware that neighborhood disadvantage places individuals living in those areas at risk for PMF violence. Research on the relationship between neighborhood disadvantage and PMF violence showed that characteristics of neighborhoods can affect a person's likelihood of committing crime. Since PMFs may be purchased by people with past involvement in the justice system, law enforcement and policymakers should provide more resources to those reentering disadvantaged neighborhoods. This could include community support groups, job opportunities, and educational and vocational programs. Additionally, government funding should be allocated to educate those living in disadvantaged neighborhoods about the danger of PMF violence. These interventions will hopefully create safer neighborhoods with less PMF violence.

Conclusion

Like 2-year-old Charlee Gamble, many people die because of PMF violence. Research was needed to understand correlates of crime related to PMF use, such as neighborhood disadvantage. This study found that the spatial distribution of PMFs was related to neighborhood disadvantage in the same way as general gun violence. These findings have important implications for reducing the danger and harm of PMFs. In the immediate future, there should be continued support for the ATF Final Rule 2021R-05F as a starting point for federal regulation of PMFs. At the state level, there should be legislation that requires serial numbers on all firearms and firearm parts as well as stricter regulation of firearms manufacturers and dealers. It is my hope that this and future studies will be used to develop interventions to reduce the presence and use of PMFs in all neighborhoods, especially those affected by poverty, unemployment, and lower educational attainment.

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Table 1. Midwestern City Descriptives - 2015 to 2019

	M	*SD*
Population Per Census Tract	3511.55	1741.47
Race and Ethnicity		
% Non-Hispanic Black	33.74	39.08
% Non-Hispanic White	32.27	29.84
% Hispanic	26.11	28.43
Educational Attainment (Over Age 25)		
% Over Age 25	68.77	9.10
% No High School Diploma	15.51	11.40
% Below Poverty Level	19.45	13.13
Unemployment Rate	9.67	8.10
% Foreign-Born	18.58	14.96
% Male	48.42	4.82
% Age 15-24	13.27	6.84
% Living In Same House 1 Year Ago	84.32	8.41

Note. $N = 836$ Census Tracts. All values are rounded to two decimal places before being converted into percentages, but the exact numbers were used for calculations. Unemployment rate was already in the form of a percentage prior to calculation.

Table 2. Midwestern City Linear Regression - All Incidents

Model 1: PMF Rate Without Controls	*β*	Robust *SE*
Neighborhood Disadvantage	0.09**	0.01
R^2 = 0.25		
Model 2: PMF Rate With Controls	*β*	Robust *SE*
Neighborhood Disadvantage	0.07**	0.01
% Non-Hispanic Black	< 0.01*	< 0.01
Hispanic and Foreign-Born Immigrants	-0.06**	0.01
% Age 15-24	< 0.01	< 0.01
% Male	0.01	< 0.01
% Living In Same House 1 Year Ago	< 0.01	< 0.01
R^2 = 0.39		

Note. *$p < 0.01$, **$p < 0.001$. Includes all census tracts for all years - 2020, 2021, 2022, 2023 (N = 836). Includes all PMF incidents (N = 2242).

Table 3. Midwestern City Linear Regression - Criminal Incidents Only

Model 1: PMF Rate Without Controls	*β*	Robust *SE*
Neighborhood Disadvantage	0.08**	0.01
R^2 = 0.25		
Model 2: PMF Rate With Controls	*β*	Robust *SE*
Neighborhood Disadvantage	0.06**	0.11
% Non-Hispanic Black	< 0.01*	< 0.01
Hispanic and Foreign-Born Immigrants	-0.05**	0.01
% Age 15-24	< 0.01	< 0.01
% Male	0.01	< 0.01
% Living In Same House 1 Year Ago	< 0.01	< 0.01
R^2 = 0.38		

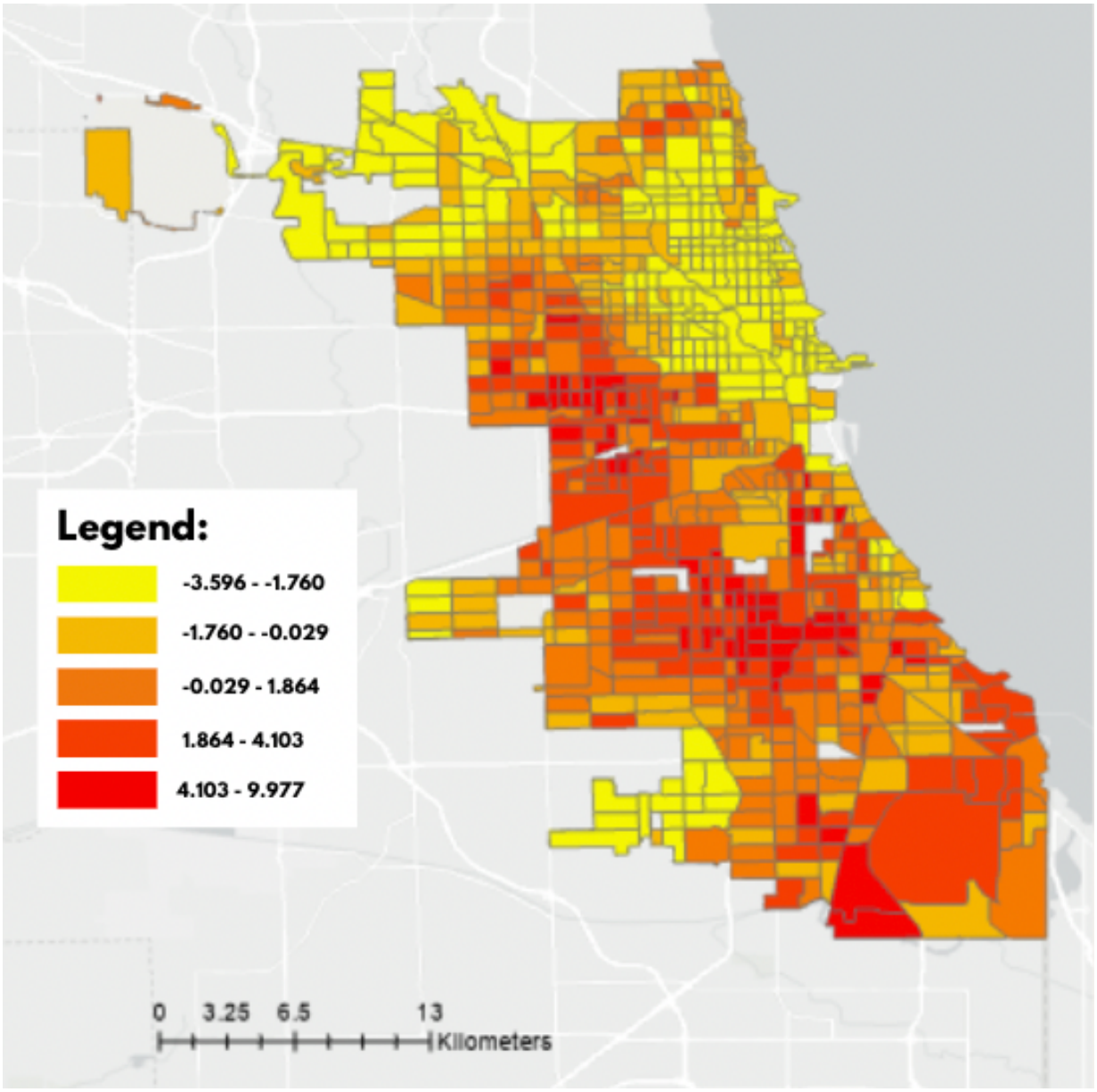
Note. *$p < 0.01$, **$p < 0.001$. Includes all census tracts for all years - 2020, 2021, 2022, 2023 (N = 836). Includes only criminal PMF incidents (n = 2029).

Table 4. Midwestern City Linear Regression - Non-Criminal Incidents Only

Model 1: PMF Rate Without Controls	*β*	Robust *SE*
Neighborhood Disadvantage	0.01*	< 0.01
R^2 = 0.04		
Model 2: PMF Rate With Controls	*β*	Robust *SE*
Neighborhood Disadvantage	0.01*	< 0.01
% Non-Hispanic Black	< 0.01	< 0.01
Hispanic and Foreign-Born Immigrants	-0.01	0.01
% Age 15-24	< -0.01	< 0.01
% Male	< 0.01	< 0.01
% Living In Same House 1 Year Ago	< 0.01	< 0.01
R^2 = 0.05		

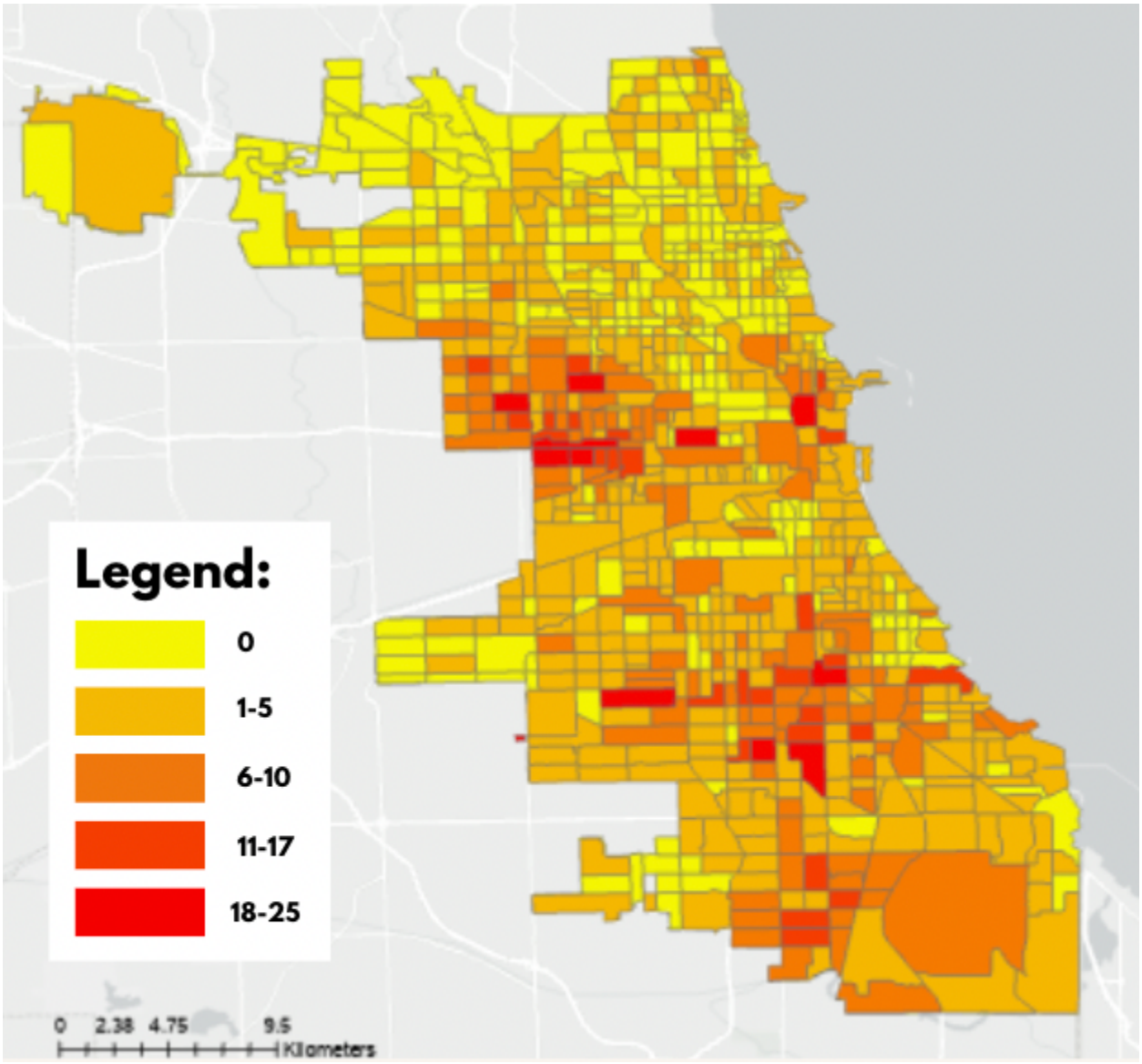
Note. *$p < 0.01$, **$p < 0.001$. Includes all census tracts for all years - 2020, 2021, 2022, 2023 (N = 836). Includes only non-criminal PMF incidents (n = 213).

Figure 1. Neighborhood Disadvantage (2015 to 2019)



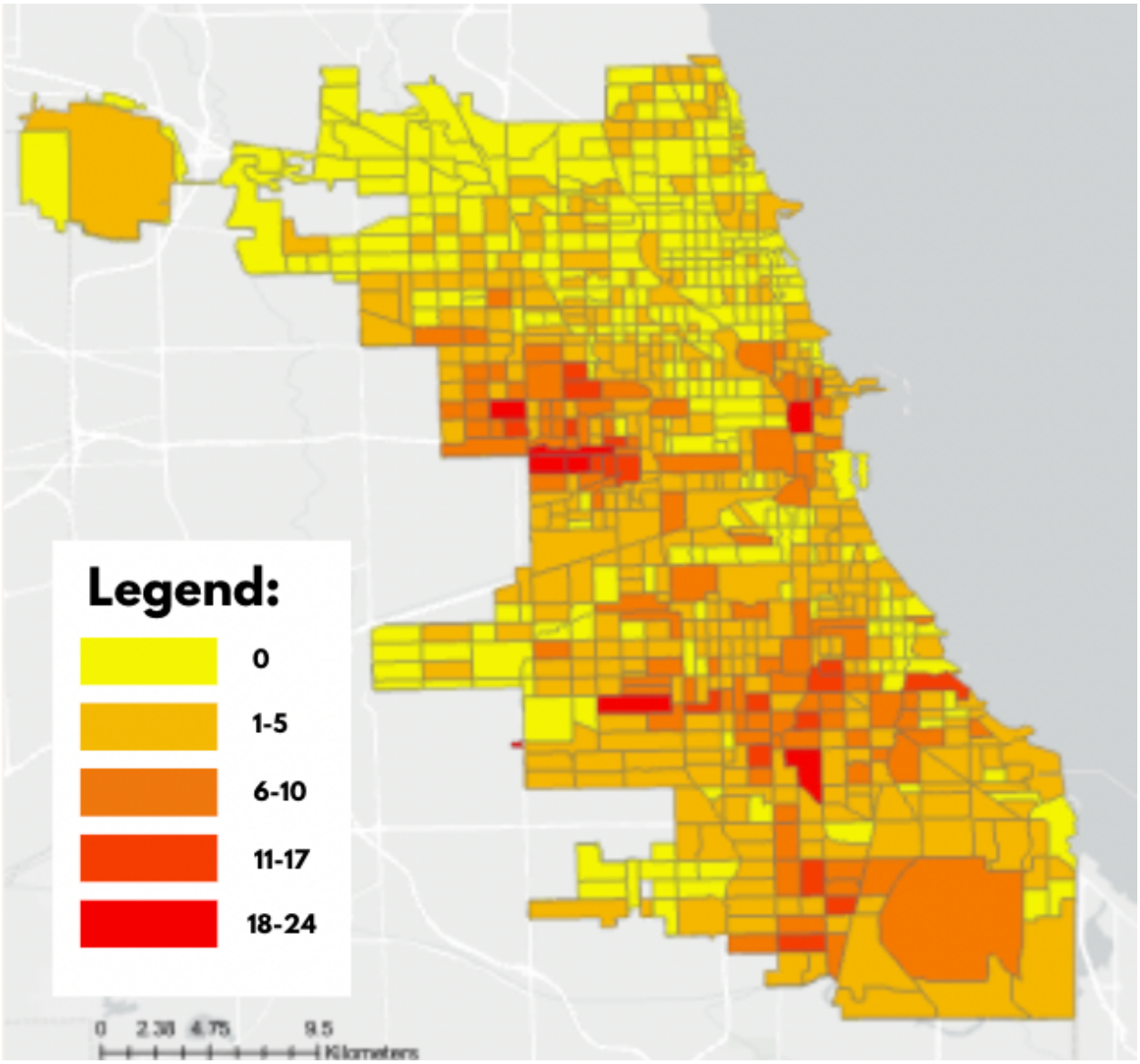
Note. Neighborhood disadvantage = z-score sum of three measures of disadvantage (percent of people below the poverty line, number of people over age 25 without a high school diploma, unemployment rate). Higher z-scores = more neighborhood disadvantage. 2015-2019 across 836 census tracts.

Figure 2. Spatial Distribution of PMFs for All Incidents (2020 to 2023)



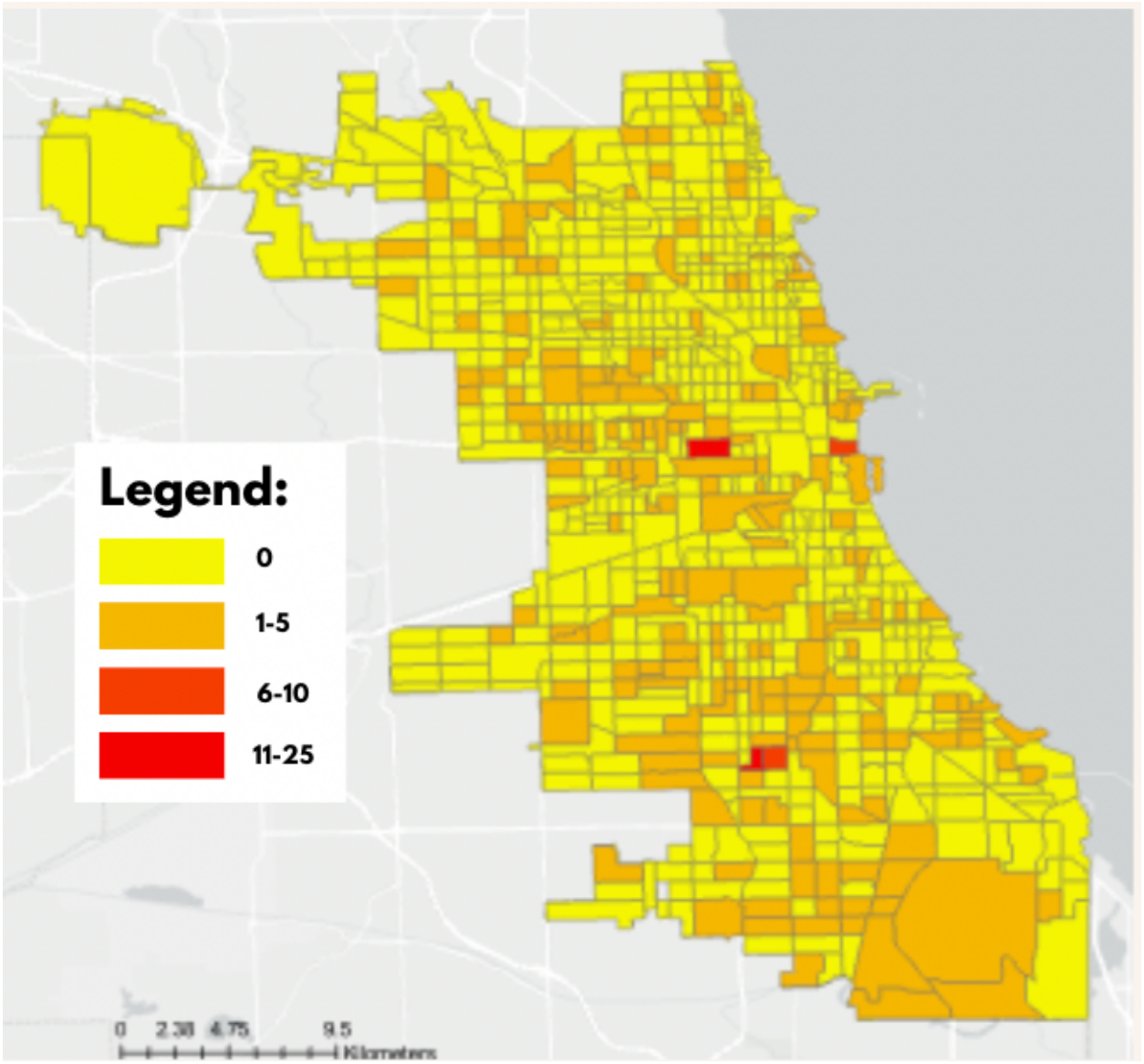
Note. 2,242 PMFs across 836 census tracts, 2020-2023.

Figure 3. Spatial Distribution of PMFs for Criminal Incidents (2020 to 2023)



Note. 2,029 PMFs across 836 census tracts, 2020-2023.

Figure 4. Spatial Distribution of PMFs for Non-Criminal Incidents (2020 to 2023)



Note. 213 PMFs across 836 census tracts, 2020-2023.