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Law Enforcement Murdered in the Line of Duty: A County-Level Analysis of Contributing Factors

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ABSTRACT AND ARTICLE INFORMATION

The current study examines the macro-level covariates influencing law enforcement officers (LEOs) shot and killed in the line of duty. Social disorganization theory, as well as literature on police training, police presence, and gun availability, creates the theoretical framework underpinning the current investigation. LEO firearm deaths between 2011 and 2019 were obtained from the Officer Down Memorial Page (ODMP), aggregated to the county level, then merged with county- and state-level data from secondary sources. Negative binomial regression was utilized to examine the effect of social disorganization, police training, police presence, and gun availability on LEO firearm deaths. Of the social disorganization measures, resource disadvantage is found to have the strongest impact on LEO firearm deaths. While population instability and density also significantly increase these deaths, ethnic heterogeneity has a significant negative effect. Furthermore, police presence has a protective effect against these murders, while gun availability increases these deaths. Limitations of the study, along with policy implications and suggestions for future research, are discussed.

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With over 60 million encounters between police officers and citizens in any given year (Harrell & Davis, 2020), there is ample opportunity for these interactions to turn violent and even deadly. The research literature on these fatal encounters has focused heavily on the killing of citizens by law enforcement (see Barber et al., 2016; Edwards et al., 2019, as examples) and the conducive conditions and precipitating factors contributing to such events (Fridel et al., 2020; Peeples, 2021; Ridgeway, 2016). A much smaller set of recent literature, however, has centered on the killing of police in the line of duty, even though policing ranks in the top three for occupations with the most workplace homicides (U.S. Bureau of Labor Statistics, 2017).

The approach of researchers attempting to understand law enforcement officer (LEO) deaths has varied. Some studies have focused on officer characteristics (Blair et al., 2016; Gibbs et al., 2014; Kachurik et al., 2013) and incident-level variables (Blair et al., 2016; Breul & Luongo, 2017; Chapman, 1998), while others have focused on offender characteristics (Hine et al., 2016). Additionally, macro-level studies analyzing city or micro-areas within a city (Caplan et al., 2014; Gibbs et al., 2018; Kent, 2010), county (Kaminski, 2008; Kovandzic & Sloan, 2002), state (Mustard, 2001; Swedler et al., 2015), and national (Cohen & Garis, 2018; Kaminski & Marvell, 2002) characteristics have been conducted. Researchers utilizing a macro-level approach to ascertain why these fatal incidents occur have applied theories such as social disorganization theory (Fridel et al., 2020; Kaminski, 2008), routine activities theory (Fridell et al., 2009), and criminal opportunity theory (Kaminski, 2008).

Studies have also investigated how policies and practices within agencies impact LEO deaths. Examining everything from training to the use of bulletproof vests and body cameras to departmental size and partnered patrol cars, researchers have generally found these measures to be beneficial in reducing LEO assaults and deaths (Fridell et al., 2009; Willits, 2014). However, these studies have typically been narrowly focused, analyzing the impact found among a small subset of agencies (Fridell et al., 2009; Kaminski, 2004; Willits, 2014).

Though there are several ways in which officers can be feloniously killed, most of these fatal encounters involve firearms (Breul & Luongo, 2017). According to Zimring and Arsiniega (2015), gunfire accounted for 90% of police killed by suspects between 2008 and 2012. While some of the research on LEO deaths has included measures of firearm access (Fridel et al., 2020; Kaminski & Marvell, 2002; Swedler et al., 2015), these studies vary in their measurement of gun availability resulting in inconsistent findings. Furthermore, these studies failed to isolate LEO firearm deaths from other felonious killings. Arguably, gun availability measures may have better predictive power for firearm deaths specifically than for overall LEO deaths.

Line of duty deaths remain an area of concern for researchers, especially as recent calls for attention to officer-involved shootings, social justice movements, and anti-police rhetoric have undoubtedly made police-citizen encounters more tense for all parties involved. Understanding the macro-level factors associated with LEO deaths may provide insight for agency responses to police-citizen interactions. As such, the current study contributes to the scholarly literature by (a) examining LEO deaths for a more recent time period, (b) utilizing county-level data to provide a nationwide examination of these deaths, (c) employing a more comprehensive measure of firearm access, (d) including a measure aimed at capturing the presence of illegal guns in a county, and (e) considering the impact of minimum training hours required of officers. Utilizing data from the Officer Down Memorial Page (ODMP), the 2015 American Community Survey's (ACS) five-year estimates, and other secondary sources, a county-level study of factors thought to explain LEO firearm deaths between 2011 and 2019 is conducted. Structural variables drawn from social disorganization theory, along with measures of law enforcement presence, law enforcement training, and gun availability, are analyzed.

Literature Review

Several criminological theories exist to explain crime and criminality, many of which have been used in studies of felonious police deaths. Due to its prominence in macro-level research, the current study draws primarily from social disorganization theory. As such, the impact of its structural components on police firearm deaths is thoroughly explored below. However, as evident from prior research in this area, social disorganization theory alone cannot fully explain these deaths. To provide a more complete analysis of this phenomenon, additional covariates thought to influence LEO firearm deaths, along with their theoretical supports (i.e., rational choice perspective, opportunity theory, and routine activities theory), are also presented.

Social Disorganization theory

Developed by Shaw and McKay (1942), social disorganization theory centers on how structural community disruption negatively affects the community's ability to control residents' behavior and to come together for the greater good. In their seminal

work, Shaw and McKay (1942) examined why Chicago crime rates remained high, even when populations changed. Their original model focused on three structural components of place: low socioeconomic status, heterogeneity, and population turnover. In an expansion of this theoretical model, Sampson and Groves (1989) added measures of family disruption and urbanization as relevant structural factors. It is well established in the literature how each of these factors influence crime rates across various types of crime (i.e., property vs. violent crime) and levels of analysis (i.e., cities, counties, and states), with research typically indicating a positive relationship between these structural components and crime rates (see Land et al., 1990; McCall et al., 2010; Sampson & Groves, 1989; Sampson et al., 1997, among others). For a complete review of the literature on the history and development of social disorganization theory, see Bellair (2017) and Kubrin (2009).

Given these communities tend to have higher rates of crime, it is expected that these areas will have an increased likelihood for police-citizen encounters with offenders that may turn deadly (Kaminski, 2004; Peterson & Bailey, 1988). Having turned to crime as a solution to their circumstance, criminals may be more likely to fight back against police to escape and avoid punishment (Jacobs & Carmichael, 2002; Kaminski, 2004). It is important to note, however, that interactions with police are not limited to criminal encounters. Citizens may respond negatively to police if they feel their autonomy or personal safety is threatened, or if they question the legitimacy of the police. Additionally, they may attack police if violence has occurred prior to the police's arrival, to defend others against the police, or if they feel contempt for police (Gibbs et al., 2014). Police legitimacy has been found to be lower in more disorganized communities than in less deteriorated areas (Gau et al., 2012). As such, encounters in these places may result in more police fatalities.

Research on whether these structural components can explain felonious LEO homicides has been mixed (Kaminski, 2008). The most convincing evidence is the ability of low socioeconomic status and family disruption to explain police homicide victimization (Fridel et al., 2020; Jacobs & Carmichael, 2002; Kaminski, 2004, 2008; Peterson & Bailey, 1988). In his study testing the effects of structural covariates on officers killed between 1990 and 2000, Kaminski (2008) found economic disadvantage (poverty, unemployment, and income) to be positive and significantly related to these incidents. These results are echoed by Fridel et al. (2020). Adding education and two measures of family disruption (female-headed households and marriage [reverse coded]) to their disadvantage factor, Fridel et al. (2020) found that police were more likely to be killed (relative to citizen fatalities by police) in areas with high levels of concentrated disadvantage. These findings indicate that it is essential to include these components in studies of police homicide victimization.

Ethnic heterogeneity, urbanization, and population turnover have received less attention and support in the literature on LEO deaths overall. In the limited studies capturing ethnic heterogeneity (Batton & Wilson, 2006; Chamlin, 1989; Fridel et al., 2020; Fridell & Pate, 1995; Lott, 2000), few have found a significant relationship (Chamlin, 1989). Chamlin's (1989) state-level study indicated police killings by civilians was higher where there was a larger Spanish population. More commonly, studies include racial composition (i.e., percent Black) as either an independent or control variable. This measure is generally related to increased police murders (Bailey & Peterson, 1994; Jacobs & Carmichael, 2002; Kaminski, 2004, 2008; Kaminski & Stucky, 2009; Kent, 2010; Swedler et al., 2015). Operationalizing heterogeneity as a single measure of racial composition, however, does not sufficiently capture this concept. As such, further research including a more complete measure of ethnic heterogeneity is warranted.

Similarly, the operationalization of urbanization has varied in the literature with researchers including measures of population size, density, and/or percent urban. Contrary to the expectations of social disorganization theory, much of this research has found an insignificant relationship between these measures and felonious LEO deaths (Bailey & Peterson, 1994; Fridell & Pate, 1995; Jacobs & Carmichael, 2002; Kaminski, 2004; Kent, 2010; Lott, 2000; Peterson & Bailey, 1988). Many of these studies focused on cities, which in essence, partially controls for the effects of urbanization. In a county-level analysis, Kaminski (2008) found measures of urbanization (population structure [logged population size and density] and percent urban) significantly decrease the murder of LEOs. Additional research, therefore, is needed to determine if this finding was an anomaly or can be replicated across diverse places.

Lastly, measures of population turnover (or instability) are least likely to be included in this line of research. The few studies that exist utilized measures that capture the inverse (i.e., population stability), such as the population living in the same house as five years prior and owner-occupied housing units (Fridel et al., 2020; Kaminski, 2004, 2008). As with urbanization, the findings of these studies contradict expectations of social disorganization theory. While Kaminski's (2004, 2008) studies failed to find a significant

relationship, Fridel and colleagues (2020) found that officers were at a significantly higher risk of being killed (relative to killing civilians) where there was more residential stability (i.e., less instability). The lack of consistent inclusion of this factor in LEO research warrants further exploration of this measure's effect on LEO deaths.

Though not the focus of the current study, it is important to note that many of these results are mimicked in research analyzing non-lethal assaults against law enforcement within and across cities (Gibbs et al., 2018; Kaminski et al., 2003; Willits, 2014). Specifically, Kaminski and colleagues (2003) found that factors measuring disadvantage (economic distress, family disruption, and African American population) and transitional areas (residential stability [inversely related], density, age 15-29, and college population) were associated with an increase in assaults against law enforcement across block groups. Willits' (2014) agency-level study echoes these findings, indicating that the LEO assault rate was higher where there was more disadvantage (poverty, unemployment, income, female-headed households, and renters [an indicator of population turnover]). Similarly, Gibbs and colleagues (2018) found concentrated disadvantage was significantly related to violence against Baltimore police. However, like much of the LEO homicide research, other measures of social disorganization (residential mobility and immigration concentration) failed to predict these acts of violence (Gibbs et al., 2018).

Taken together, these studies give credence to the ability of some components of social disorganization theory to explain felonious LEO deaths. The findings regarding low socioeconomic status and family disruption (commonly combined into measures of resource disadvantage) are most consistent. Given their significant impacts on homicide, these variables cannot be ignored in any macro-level criminological examination, regardless of the theoretical underpinnings of the study. What has not been as thoroughly explored regarding felonious police killings, however, is how these variables work in conjunction with the other structural components of social disorganization theory to impact these deaths. Few (if any) prior studies in this area have examined all five theoretical components together in one model. Thus, the current study fills this gap in the literature by testing the effect of all structural variables outlined in social disorganization theory on police firearm deaths. Utilizing recent county-level data, a more complete picture of these relationships under current social conditions is provided.

Law Enforcement Factors – Officer Training and Presence

Encounters between police officers and citizens can be stressful for all parties involved. Many have argued that police training could be the key to how these situations are handled, thus impacting the outcome of these interactions. Training requirements can vary drastically from state to state, both in terms of length of training and content. In the United States, states average approximately 21 weeks of required training before one can become a police officer (Buehler, 2021). This training often consists of six major subject areas: operations, weapons (including defensive tactics and use of force), legal education, self-improvement, community policing, and special topics (Buehler, 2021). Of particular concern to researchers examining fatal police-citizen interactions is the weapons subject area. Specifically, much of the research regarding the effect of training on police-citizen encounters has revolved around police use of force resulting in the death of a suspect rather than the police officer (Andersen & Gustafsberg, 2016; Jennings & Rubado, 2017; H. Lee et al., 2010).

Thus far, researchers have not established a link between officer training and LEO deaths (Fridell et al., 2009; Kaminski, 2004). These studies, however, are relatively outdated, analyzing police deaths that occurred nearly two decades ago. As coverage of fatal police-citizen interactions and calls for reform have increased (Eder et al., 2021), it is possible that states have made significant and important changes to their training requirements in more recent years to address the public's concerns. Analyzing the impact of training on LEO firearm deaths in the current study will provide updated information on this potential relationship.

Relatedly, police presence may also influence the rate of officer deaths in a community. There are two competing hypotheses regarding this relationship. From an opportunity standpoint, more officers in the community would increase the potential for police-citizen encounters. More interactions mean more potential for a deadly outcome. This is particularly true in criminogenic areas where agencies tend to have higher rates of police officers per capita (Kovandzic & Sloan, 2002). Support for this hypothesis is provided by Willits (2014), who found that police density was positively associated with assaults against officers.

On the other hand, the capable guardian aspect of routine activities theory would suggest that having more officers decreases their risk of injury or death. Officers serve as capable guardians (or individuals who can prevent a crime from occurring). Similarly, the rational choice perspective ascertains

that offenders commit crime after a cost-benefit analysis (Cornish & Clarke, 1986). A larger police presence could have a deterrent effect, making potential offenders reconsider their actions if they believe the risk of getting caught outweighs the benefits of committing the crime. Research supporting this notion has found that locations with a greater police presence experience less crime (Klick & Tabarrok, 2005; Kovandzic & Sloan, 2002).

Additionally, in communities with more officers per capita, agencies can incorporate policies that require officers to respond to calls with a partner and would provide an increased ability to provide backup to high-risk situations (Fridell et al., 2009). Having multiple officers on scene may reduce the risk of an encounter escalating as there is both an increase in capable guardians and a decrease in the offender's odds of successfully getting away (though it is also recognized that offenders desperate to avoid apprehension may go to great lengths to do so as noted above). Results from Fridell and Pate (2001) support this argument, finding that officer assaults were higher among single-officer patrol cars than partnered cars. Testing the impact of departmental size specifically, Fridel and colleagues (2020) found officers from smaller departments are more likely to be killed than to use deadly force against citizens. These findings lend credence to the protective effect that having more officers provides for fellow police. Based on prior literature, incorporating a measure of LEO presence is important to ascertain its impact on county-level LEO firearm fatalities.

Gun Availability

Much research and debate has surrounded how the availability of guns in the United States influences the nation's crime rates. Literature in the area has been mixed, with some researchers finding an increase in crime and violence related to gun availability (Blumstein, 1995; Cook et al., 1995), while others find either a reduction in crime (Lott, 1998; Lott & Mustard, 1997) or no influence (Kleck, 1997). The Zimring-Cook hypothesis states the presence of guns will result in more interpersonal conflicts turning deadly simply because of the injuries caused by such a weapon (Cook, 1983; Kleck & McElrath, 1991). Others have argued that the presence of a gun will make potential offenders react more violently. In their study of intent and violent escalation, Phillips and Maume (2007) found that the presence of a gun increases the odds of an interaction turning violent, regardless of the original intent of the offender. Those on the opposite side of the issue contend that gun-wielding victims may deter would-be criminals who are typically looking for an easy target who will not put up a fight. From a rational choice perspective, some potential criminals may forego violent acts if they believe that facing an armed victim would cause the costs to outweigh the benefits (Lott, 1998; Lott & Mustard, 1997).

Police-citizen encounters provide a unique situation for testing the effect of gun access on homicide because officers are always armed in these interactions. The possibility of facing an armed offender adds an increased level of risk for officers. Like gun research in general, research analyzing the impact of gun access on firearm fatalities of police officers has been mixed, with some finding an increased risk of death where gun ownership is higher (Lester, 1984; Swedler et al., 2015), while others report no significant association (Kaminski & Marvell, 2002). These studies encounter the same issues that plague gun homicide research, namely, how to measure this variable as there is no national database of gun ownership. Most studies, therefore, use indirect measures, such as gun magazine subscriptions, firearm crime or suicide rates, or gun permits, to name a few (Doucet et al., 2016). Gun crimes (particularly homicide) and gun suicides are common proxies in studies of police deaths (see Fridel et al., 2020; Fridell & Pate, 1995; Kaminski & Marvell, 2002; Lester, 1984; Swedler et al., 2015, among others).

Utilizing a direct measure of ownership from the Behavioral Risk Factor Surveillance System, along with the percent of suicides committed with a firearm, Swedler and colleagues (2015) found an increase in police fatalities where gun access was higher. These results are supported by the work of Fridel and colleagues (2020), which found an increase in these fatalities (relative to officers using fatal force) was related to higher rates of gun ownership (measured as firearm suicides). Kaminski and Marvell (2002), however, found no relationship between firearm use (measured as firearm homicides) and police homicide. The varied nature of these studies (and others), particularly in relation to the operationalization of gun ownership, highlights the importance of continued research in this area. Employing a one-dimensional measure of gun ownership or accessibility underestimates the presence of guns in the United States. As such, the current study adds to the literature by utilizing a comprehensive and multidimensional approach to more adequately assess how gun availability impacts police firearm fatalities.

Summary of Expectations

Research on the predictors of line of duty deaths among LEOs has shown that there is still a need for a more complete understanding of the factors impacting these unique homicides. While there are some consistencies, the review above has revealed much of the literature is mixed regarding the influence

of several variables on LEO deaths. Based on findings from the LEO literature, as well as research on crime rates in general, each of the five structural components of social disorganization theory is expected to be positively related to LEOs murdered with a gun in the line of duty. Specifically, where there is (a) a higher concentration of indicators of low socioeconomic status, (b) greater ethnic diversity, (c) increased population turnover, (d) increased family disruption, and (e) increased density, there will be more LEO firearm deaths. Additionally, an increase in officer training as well as in officer presence within the community are expected to decrease LEO firearm deaths. Finally, it is predicted that higher levels of gun availability will result in an increase in LEO firearm deaths. These expectations are tested in the following section utilizing county-level data from the United States.

Data and Measures

Multiple data sources were utilized to compile the dataset for the current study. The Officer Down Memorial Page (ODMP) provides information on LEOs who have died, regardless of the cause of death. For each officer, the site provides a picture of the officer (in most, not all cases) along with information on the details surrounding the death. The site also provides the officer's age, agency, tenure within the agency, and details about their personal life (such as marital status and if they have children). The explanatory and control variables were obtained from the 2015 American Community Survey's (ACS) five-year estimates, the 2010 Decennial Census, the FBI's Uniform Crime Reports, individual state websites, the Bureau of Alcohol, Tobacco, Firearms and Explosives (ATF), and the RAND Corporation.

Unit of Analysis

The current study analyzes county-level data. Complete data were available for 3,118 of the 3,142 U.S. counties or county equivalents. While conducting county-level analyses allow for more broad generalizations across space, using a spatially large aggregate may raise concerns about within-unit heterogeneity (Osgood & Chambers, 2000). There can be variation within counties in terms of both structural conditions and law enforcement presence, with the potential for county-level characteristics to be skewed by large pockets of urban areas. Prior research has found, however, that structural covariates of homicide are invariant across space, indicating that the chosen unit of analysis should not significantly impact the results (Land et al., 1990; McCall et al., 2010). While cities have been a common focus for studies of LEO deaths, only analyzing these places creates an urban bias in this line of research. There are several agencies whose jurisdiction extends beyond (or does not include) city limits, such as sheriff's offices, highway patrol, state troopers, and tribal authorities (among others). Analyzing only cities, therefore, would exclude these LEO deaths. This particularly affects officers in rural places, as many rural counties rely solely on county-level agencies for crime control (Weisheit et al., 2006). In the current sample, 44.3% of all LEO firearm deaths were of officers employed by agencies other than local city police departments. Furthermore, it is not feasible to utilize smaller units for a nationwide study as this would produce too many zero values. Thus, using smaller units of analysis typically requires limiting the sample to larger places. This, again, imparts an urban bias and does not allow for a true nationwide study. To address these issues, a county-level analysis was deemed most appropriate for the current study.

Dependent Variable

The dependent variable analyzed in this study is the number of duly sworn LEOs feloniously shot and killed in the line of duty for each county in the United States from 2011 to 2019. These years covered the most recent data at the start of the project. Additionally, there were several high-profile cases of police being murdered (i.e., the ambush of Dallas and Baton Rouge police in 2016) during this time (Lane, 2021). Though most interactions with police are not deadly, these incidents reflect the most serious form of violence that may be experienced by LEOs. Additionally, homicide data are considered a reliable indicator of violence. These crimes are more likely to be accurately reported, and, unlike other violent or property crimes, there is less discretion in classifying homicides (Gove et al., 1985).

The ODMP was utilized to obtain counts of LEO deaths by county. Cases were limited to officers killed by gunfire. Those who were shot and died immediately or within one year of suffering their injuries were included in the analysis. Officers who died from complications with wounds inflicted years earlier were excluded. This distinction is important to ensure the dependent variable is explained by the currently measured independent variables. The structural characteristics that may or may not have predicted an officer being shot years (or decades) ago may not be the same as those used to explain more recent police murders. Additionally, officers from Puerto Rico or other territories were excluded from the analysis. Based on the officer's agency of employment, the LEO's death was coded to the appropriate county. For state police or other officers with vast jurisdictions (i.e., Tribal Police), the event

was coded in the county in which the incident occurred.

The counts of LEO deaths coded from the ODMP were then compared to the annual counts provided by the FBI in their Law Enforcement Officers Killed and Assaulted (LEOKA) reports. A comparison of these sources showed data compiled from the ODMP are relatively consistent with the FBI reports. The LEOKA data include any officer feloniously killed, those who died years later from complications, and officer deaths in territories (U.S. Federal Bureau of Investigation, n.d.). These cases account for most of the discrepancy between the LEOKA data and the data used in this study. Any LEOKA cases fitting the criteria used for case selection from (but were not part of) the ODMP were coded into the dataset and included in the final analyses.

This comparison also revealed 47 cases of LEOs shot and killed in the line of duty that were reported by the ODMP but were not included in the FBI's LEOKA data. The ODMP includes line of duty deaths of any LEO and does not employ the criteria outlined in the LEOKA data when reporting these deaths. To count as a LEOKA death, the officer must have been a duly sworn member of a law enforcement agency, had full arrest powers, have worn a badge, and have carried a firearm. Additionally, their death must have resulted from injuries sustained while acting in an official capacity (U.S. Federal Bureau of Investigation, n.d.). In a re-examination of those specific ODMP cases, the reason(s) for exclusion from the LEOKA data could not be ascertained. Therefore, these cases were retained for inclusion in the final analyses. Upon completion of case comparisons, LEO gunfire deaths were summed across the study years for each county providing the data for the dependent variable.

Explanatory Variables

To test the structural components of social disorganization theory, several variables were included in the analyses. Poverty, unemployment, and high school dropouts serve as measures of low socioeconomic status. Poverty is the percent of the county population whose income in the past 12 months fell below the poverty line. Unemployment is the percent of the county's civilian labor force aged 16 years or older that is currently unemployed. Finally, high school dropouts is the percent of the county population aged 18 years and older who have not earned a high school diploma or GED. The presence of foreign-born and Hispanic populations captures the ethnic heterogeneity component of social disorganization theory. Foreign-born is the percent of the county population who were born in other countries to non-U.S. citizens, while Hispanic is the percent of the county population that is Hispanic or Latino (regardless of race). Population turnover, the third component of social disorganization theory, is measured as the percent of the county population that was not living in the same house as the prior year. Female-headed households, measured as the percent of county households with children under 18 years of age that are headed by a female, serves as the measure of family disruption. The ACS's 2015 five-year estimates provided the relative percentages for each of the above variables. Finally, density is measured as the number of people per square mile in a county. This variable was calculated by dividing the population counts from the ACS 2015 five-year estimates by the county land area. The 2010 Census was utilized to obtain information on land area as this was the most recently available data that align with the 2015 population measure.

Law enforcement factors are accounted for in the current study through two variables: law enforcement presence and training. To measure law enforcement presence, the number of sworn LEOs reported to the FBI's Uniform Crime Reporting program by city, county, state, university, tribal, or other agencies between 2011 and 2018 was obtained and aggregated to the county level. City, university, and tribal agencies were coded to the appropriate county based on location.[1] Counts from state agencies (or any other agency whose jurisdiction crossed county lines) were apportioned to counties based on population size. Due to the voluntary nature of reporting to the UCR program and inconsistent reporting among some agencies, the LEO rate was calculated as the average number of sworn officers reported from 2011 to 2018 for every 1,000 people in the county. Counties that did not have reported counts of LEOs from any level agency (i.e., city, county, state, etc.) during that timeframe were removed from the analysis. This resulted in the removal of 18 counties. The affected counties all had fewer than 26,000 residents, with 12 counties comprised of fewer than 10,000 residents. Only one of these counties experienced the loss of an LEO during the study period.

To determine the effect of training on LEO firearm deaths, the number of hours required in the police academy for each state was obtained from individual state websites. This measure was converted to the number of 8-hour days of required training and included in the analysis. Doing so aligned this variable with the measurement of other variables, making the coefficient more interpretable without impacting the level of significance or the size of the variable's effect in the regression models. It is important to note that these hours only reflect a base level of training. Many

agencies have additional specific training requirements before joining the force as well as continuing education training that must take place each year. Because counties may contain multiple agencies with varied requirements, having a county-level measure was not feasible for the current study. Utilizing state training hours resulted in the removal of all five counties in Hawaii as state-level requirements could not be ascertained.

Due to the focus on officers killed with a gun, it is important to include measures of gun access in the current study. Gun data at the county-level is extremely rare, especially when analyzing the entire nation. As a result, proxies for gun availability are measured at the state level. An estimate of the household firearm ownership rate was obtained from the RAND Corporation. This estimate represents the percentage of adults in the state who live in a household with a firearm. To calculate this measure, the RAND Corporation combined data from 51 nationally representative surveys that specifically ask about firearm ownership with commonly used proxies of gun access in the state, such as permit to purchase laws, hunting licenses, background checks, firearm suicides, crimes committed with firearms (i.e., homicide, robbery, and assault), and subscriptions to gun magazines (Schell et al., 2020). Yearly estimates of the household firearm rate from 2011 to 2016 (the most recent year of data) were averaged and included in the analyses. Use of this variable resulted in the removal of Washington, D.C., from the analyses due to a lack of information for this variable.

A second gun measure is the average number of firearms recovered and traced per day in each state between 2011 and 2019. Raw data on the number of firearms recovered and traced annually were obtained from the ATF then converted to a daily average count. Each year, the ATF reports the number of firearms for which law enforcement agencies in each state requested a trace. These traces are only for criminal investigations in which the use of a firearm was confirmed or suspected. Tracing firearms allows law enforcement to link offenders to a gun used in a crime. It also assists with detecting traffickers of illegal guns and recognizing trends in the movement of those firearms. It is important to note that not all recovered guns are traced, though the ATF encourages agencies to do so (Bureau of Alcohol, Tobacco, Firearms and Explosives, 2019). Furthermore, it is recognized that not all guns used in crimes are illegally obtained. However, research has found the vast majority (90%) of prison inmates did not purchase guns used in the commission of their crimes from a licensed dealer. Nearly half obtained the weapon from the underground market or stole it (Bureau of Justice Statistics, 2019).

Control Variables

There are known correlates of crime that must be included in any model predicting violence. The first variable is the percent of the county population that is African American. Though African Americans make up about 13% of the U.S. population (U.S. Census Bureau, n.d.), they account for more than 27% of arrests each year (U.S. Federal Bureau of Investigation, 2018a). As a result, crime studies consistently control for the size of this population (Land et al., 1990). Additionally, criminological literature indicates that young people are more likely to be both victims and offenders of crime (Laub & Sampson, 2003). To account for this, the percent of the county population that is 15 to 24 years old is controlled. A third control variable is location. The South has a known history of violence (M. R. Lee et al., 2007) and has the highest murder rate in the United States (U.S. Federal Bureau of Investigation, 2018b). Research on the southern subculture of violence has shown that southern violence can be felt across the country as southerners have moved elsewhere, taking their culture with them (M. R. Lee et al., 2007). Additionally, research on LEO deaths has indicated that a regional effect may exist (Kaminski, 2008). As a result, the percent of the county population that was born in the South is controlled.[2] Data for these variables were obtained from the 2015 ACS five-year estimates.

Descriptive Statistics and Data Reduction

To discuss the characteristics of officers shot and killed in the line of duty, several additional pieces of information were coded from the ODMP, including demographic characteristics of the officer and the officer's tenure within the agency. While the officer's age was specifically provided, the officer's sex and race were ascertained from the photograph provided on the website. It is recognized that this is not the most ideal way to determine the officer's race. Those whose race was not easily identifiable were coded as unknown. These demographic characteristics are only used for descriptive purposes and are not included in the analyses. The description of events was then read and used to code variables related to the circumstances under which the death occurred. These variables included the reason the officer was on the scene (i.e., call for service, traffic stop, serving a warrant, etc.), the number of offenders present, the type of gun used by the offender(s) (if known), and if the officer was alone during the incident. Of the 393 officers murdered by gunfire from 2011 to 2019, 95% were male (n = 374), and approximately 85% were white (n = 334). On average, these officers were 39 years old and had served 12 years on the police force. Nearly

38% were responding to a call for service (n = 148), and more than 34% were alone at the time of the incident (n = 135). Of the 235 cases where the type of gun was specified, 67.7% were murdered with a handgun (n = 159), including 17 incidents in which the officer's own gun was used against them.

These 393 officer deaths indicate approximately 44 officers are shot and killed each year. Over the nine-year timeframe, LEO firearm deaths fluctuated between a low of 28 (in 2013) and a high of 62 (in 2016). A closer examination of the counties in the current dataset shows that large, urban counties experienced the most LEO firearm deaths. Maricopa County (Arizona) had seven officers killed, while Los Angeles County (California) and Dallas County (Texas) each had six LEO firearm deaths. However, these counties tend to have more officers, and thus, lower rates of these deaths. The highest LEO firearm death rates are found in rural counties. Clay County (West Virginia) experienced the highest average death rate with 24.7 officers killed for every 1,000 sworn officers. Dillingham Census Area (Alaska) and Broadwater County (Montana) followed this, with each experiencing an average of approximately 11 LEO firearm deaths for every 1,000 sworn officers in the county.

Table 1 provides descriptive statistics for the dependent, explanatory, and control variables from the 3,118 counties analyzed in the current study. On average, counties had fewer than one officer killed in the line of duty over the nine-year timeframe. This statistic is not surprising given the rare nature of these events. When analyzing the rate of death per year, on average, approximately 10 officers were killed each year for every 100,000 officers in a county. The measures of socioeconomic status show that on average, 16.7% of the county population lives in poverty, 7.8% of the county's civilian labor force is unemployed, and 14.9% of the county population does not have a high school diploma. Most counties do not experience high levels of ethnic heterogeneity. On average, less than 5% of the county's population is foreign-born, and approximately 9% is Hispanic. Most county populations are relatively stable with only 13.6% of the population moving in the prior year, on average. Additionally, on average, 7.7% of households with children in the county are headed by females. The density measure shows that there are approximately 264 people per square mile in a county. Measures directly related to law enforcement show that, on average, there are only two officers for every 1,000 people in a county and that states require an average of approximately 74 8-hour days of training for their officers. The household firearm ownership rate indicates that, on average, nearly 41% of adults live in a household with a firearm. Finally, law enforcement agencies recovered and traced approximately 22 firearms each day, on average.

Table 1: Descriptive Statistics

	Mean	SD
Dependent Variable		
Leo Killed in Line of Duty Count	0.125	.496
Leo Killed in Line of Duty Rate (per 100,000 per year)	10.382	77.354
Explanatory Variables		
Percent of residents below poverty line	16.674	6.554
Percent of civilians 16+ unemployed	7.753	3.495
Percent of residents 18+ without HS diploma	14.871	6.374
Percent of residents foreign born	4.616	5.657
Percent of residents Hispanic or Latino	8.864	13.536
Percent of residents not living in same house as prior year	13.561	4.375
Percent of households headed by females	7.652	3.101
Number of people per square mile	264.031	1775.898
Average number of sworn officers per 1,000 people	2.092	1.235
Number of 8-hour training days	73.670	21.755
Average percent of adults with firearm in household	40.850	10.310
Average count of recovered and traced firearms	21.831	19.822
Control Variables		
Percent of residents who are black	8.894	14.254
Percent of residents 15 to 24	13.020	3.537
Percent of residents born in the South	39.589	38.335

Note: N=3,118

Several measures in this study are theoretically and statistically related to each other, measuring aspects of similar overarching concepts. Including these variables individually into statistical models produces issues of multicollinearity as these measures have shared variance. Correlation

coefficients, variance inflation factors (VIFs), condition indices, and variance proportions were analyzed to detect multicollinearity. The correlation matrix presented in Table 2 indicates statistically significant relationships between several of the independent variables. While these associations are not all strong, every variable is significantly correlated with at least one other variable in the study. Further analysis of the VIFs revealed relatively low values (all less than 4). Additionally, there were five condition indices greater than 15, with one exceeding 30. While condition indices greater than 15 are concerning, indices greater than 30 indicate a serious multicollinearity issue, especially when coupled with variance proportions greater than 0.50 on more than one variable (Myers & Well, 2003). Though there were condition indices greater than 15, none produced variance proportions greater than 0.50 on more than one variable.

Female-headed households and Black, though not direct measures of socioeconomic status, commonly load with measures of economic or resource disadvantage (Land et al., 1990; McCall et al., 2010) because these households are more likely to be impoverished than other household types (Semega et al., 2017). Additionally, Table 2 indicates that all variables in this factor are significantly related with either a moderate or a strong association. Ethnic heterogeneity is the second factor, composed of measures of the foreign-born and Hispanic populations in the county.[3] According to Table 2, these variables have a strong and significant relationship (r = 0.681). Finally, the unstable population factor consists of the residential instability and age structure variables. Table 2 shows that these variables have a moderate and significant relationship (r = 0.552). This association may be explained by the fact that young

Table 2: Correlation Matrix of Dependent, Explanatory, and Control Variables

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
LEO Firearm Death Count	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Percent of residents below poverty line	.044*	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Percent of civilians 16+ unemployed	.081**	.651**	1	-	-	-	-	-	-	-	-	-	-	-	-	-
Percent of residents 18+ without HS diploma	-.013	.636**	.461**	1	-	-	-	-	-	-	-	-	-	-	-	-
Percent of residents foreign born	.253**	-.057**	-.008	.181**	1	-	-	-	-	-	-	-	-	-	-	-
Percent of residents Hispanic or Latino	.128**	.090**	.017	.398**	.681**	1	-	-	-	-	-	-	-	-	-	-
Percent of residents not living in same house as prior year	.114**	.086**	.018	-.135**	.210**	.138**	1	-	-	-	-	-	-	-	-	-
Percent of households headed by females	.150**	.636**	.571**	.497**	.116**	.166**	.085**	1	-	-	-	-	-	-	-	-
Number of people per square mile	.199**	-.003	.026	-.024	.332**	.083**	.045*	.070**	1	-	-	-	-	-	-	-
Average number of sworn officers per 1,000 people	.032	.093**	.035	.044*	.112**	.123**	.051**	.075**	.227**	1	-	-	-	-	-	-
Number of 8-hour training days	.035*	-.034	.050**	.053**	.167**	.173**	.015	-.045*	.062**	-.069**	1	-	-	-	-	-
Average percent of adults with firearm in household	-.107**	.176**	-.068**	.098**	-.374**	-.233**	.004	.019	-.174**	-.008	-.206**	1	-	-	-	-
Average count of recovered and traced firearms	.136**	.122**	.207**	.319**	.370**	.432**	.083**	.166**	.036*	.028	.248**	-.501**	1	-	-	-
Percent of residents who are black	.131**	.462**	.453**	.345**	.000	-.103**	.006	.637**	.091**	.144**	-.151**	.015	.121**	1	-	-
Percent of residents 15 to 24	.091**	.271**	.105**	-.062**	.158**	.106**	.552**	.224**	.042*	-.007	.014	-.061**	.061**	.143**	1	-
Percent of residents born in the South	-.003	.442**	.329**	.561**	-.063**	.044*	-.047**	.422**	-.041*	.093**	.120**	.216**	.309**	.534**	.049**	1

Note: *$p \leq .05$; **$p \leq .01$

Based on the significant relationships shown in the correlation matrix, an obliquely rotated principal components factor analysis was performed on conceptually similar variables (see Table 3). Each factor includes variables with loading scores greater than 0.50 and eigenvalues greater than 1. The first factor, resource disadvantage, consists of the variables for poverty, female-headed households, unemployment, high school dropouts, and Black.

adulthood tends to be the most mobile time of life for individuals (Clark, 2018). Furthermore, these variables have been found to load together in prior analyses (Kaminski et al., 2003). Diagnostic analyses for multicollinearity conducted after the creation of these factors indicated improvement in these statistics. VIFs were reduced to less than 2.5, and all condition indices were below 30.

Analytic Methods

Negative binomial regression techniques were utilized in the current study to estimate predictors of LEOs being shot and killed in the line of duty. These deaths are statistically rare with most counties not experiencing an LEO firearm death in any given year. This can result in skewed distributions and potentially non-linear relationships (Long & Freese, 2014; Osgood, 2000; Osgood & Chambers, 2000). Statistical methods that do not rely on the assumption of linearity must be employed as results from normal regression techniques are at risk of being highly distorted. Negative binomial regression is one of these statistical methods. To analyze data using this technique, the dependent variable must be measured as a count outcome indicating the number of occurrences of a particular phenomenon (Long & Freese, 2014). A likelihood-ratio test for overdispersion revealed that negative binomial regression was appropriate for use with these data. Cluster estimation was used to produce robust standard errors clustered by state. Doing so adjusts for heterogeneity and within state correlated errors (Long & Freese, 2014). Additionally, this command essentially treats the model as a multilevel model, taking into consideration variables that are measured at the state level (i.e., state training, household firearm rate, and recovered and traced firearms). Finally, models were offset by the log of the population at risk (LEOs) to adjust for the likelihood of these murders taking place and to allow the coefficients to be interpreted as a change in the rate, rather than counts (Cameron & Trivedi, 2013; Gardner et al., 1995).

Because county boundaries simply serve as identifiers of geographical space, crime that occurs in one county may be influenced by crime occurring elsewhere. As a result, the potential for spatial dependence must be recognized. Moran's I is a standard statistic used for assessing this issue. When this value exceeds 0.20, there is evidence of significant spatial autocorrelation among geographic units (Anselin, 1988). To test for this, both a first-order rook and queen contiguity weight matrix were created in GeoDa. Neither weight matrix produced a Moran's I value greater than 0.08, indicating spatial autocorrelation is not a concern in the models.

Results

Table 4 presents the results for models predicting LEOs shot and killed in the line of duty. Variables are presented in a stepwise approach to ascertain if there are any mediating relationships. Model 1 predicts LEO firearm deaths using standard social disorganization variables. This model indicates

Table 3: Obliquely Rotated Principal Components Factor Pattern Matrices

	Factor Loading Scores		
Resource Disadvantage			
Percent of residents below poverty line	.862		
Percent of households headed by females	.848		
Percent of civilians 16+ unemployed	.794		
Percent of residents 18+ without HS diploma	.736		
Percent of residents who are black	.721		
Ethnic Heterogeneity			
Percent of residents foreign born		.917	
Percent of residents Hispanic or Latino		.917	
Unstable Population			
Percent of residents not living in same house as prior year			.881
Percent of residents 15 to 24			.881
Eigenvalue	3.154	1.681	1.552

that resource disadvantage and ethnic heterogeneity are significantly related to LEOs killed by gunfire. However, the ethnic heterogeneity measure is opposite the predicted direction. To determine the strength of the coefficients, the incidence-rate ratios (IRR) are presented. Incidence-rate ratios are calculated as the exponential of the unstandardized coefficients and represent a percent change in the dependent variable for each unit increase in the independent variable, holding all other variables constant (Piza, 2012). Based on this calculation, each unit increase in resource disadvantage results in an approximately 42.4% increase in the rate of LEO deaths by gunfire. Additionally, there is a 12.1% decrease in the rate of LEO firearm deaths for each unit increase in ethnic heterogeneity.

Model 2 utilizes measures specific to law enforcement in predicting LEO deaths by gunfire. Each of these variables is negative and significantly related to these homicides. There is a 15.2% decrease in the LEO firearm death rate for each unit increase in the rate of LEOs in a county. Furthermore, every unit increase in the number of 8-hour training days

required by the state results in an approximately 0.8% decrease in the LEO firearm death rate.

Model 3 includes the two measures of gun availability to predict LEO firearm deaths. Both variables are positive and significantly related to these homicides. Specifically, a one unit increase in the household firearm ownership rate results in a 3.2% increase in the rate of LEOs killed by firearms. Additionally, each unit increase in the average number of guns recovered and traced each day results in a 0.8% increase in the LEO firearm death rate.

The full model (Model 4) includes the social disorganization, law enforcement, and gun measures, along with the control variables. In this model, all measures of social disorganization are significant. Resource disadvantage and ethnic heterogeneity retained their significance from Model 1, while the unstable population and density measures reached statistical significance in this model. The effects of both resource disadvantage and ethnic heterogeneity slightly increased. Each unit increase in resource disadvantage results in a 45.5% increase in the LEO firearm death rate. Ethnic heterogeneity decreases the rate of LEOs killed by gunfire 15.4% for each unit increase in this measure. Additionally, there is an 8.1% increase in the rate of LEOs killed by gunfire for each unit increase in the unstable population. Regarding density, the incidence-rate ratio is unable to accurately show the effect of this measure on the LEO firearm death rate, as it appears to have a value of 1 (due to rounding). To provide a meaningful interpretation, a standardized percent change was calculated instead. To do so, the unstandardized coefficient for density (b = 0.000037) was multiplied by its standard deviation (from Table 1) and then the exponent of this product was taken. This value is converted to a percent by subtracting one and multiplying by 100. This calculation indicates that each standard deviation increase in density results in a 6.8% increase in the rate of LEOs killed by gunfire.

Three of the four remaining independent variables of interest maintain their significance in the final model. LEO presence has a larger effect than seen in Model 2, indicating a 23.4% decrease in the LEO firearm death rate for each unit increase in the LEO rate. Though maintaining significance, the household firearm rate has a reduced effect on the rate of LEOs killed with a firearm, indicating that a one unit increase in this measure results in a 2.3% increase in the LEO firearm death rate. Lastly, the recovered and traced firearms measure appears to have an identical effect as in Model 3. However, this is primarily the result of rounding. A closer examination of the IRR (= 1.00754) shows a slightly reduced effect in the final model, with a 0.75% increase in the LEO

Table 4: Negative Binomial Regression Models Predicting Law Enforcement Officers Killed by Gunfire in U.S. Counties (N = 3,118 in all models)

	Model 1		Model 2		Model 3		Model 4	
Resource Disadvantage	1.424***	(0.084)					1.455***	(0.109)
Ethnic Heterogeneity	0.879**	(0.033)					0.846***	(0.044)
Unstable Population	1.068	(0.049)					1.081*	(0.043)
Number of people per square mile[a]	1.000	(0.000)					1.000**	(0.000)
Average number of sworn officers per 1,000 people			0.848***	(0.033)			0.766***	(0.028)
Number of 8-hour training days			0.992*	(0.004)			0.998	(0.002)
Average percent of adults with firearm in household					1.032***	(0.007)	1.023***	(0.006)
Average count of recovered and traced firearms					1.008***	(0.002)	1.008***	(0.002)
Percent of residents born in the South							0.998	(0.002)
Sworn Officers (offset)	1.000		1.000		1.000		1.000	

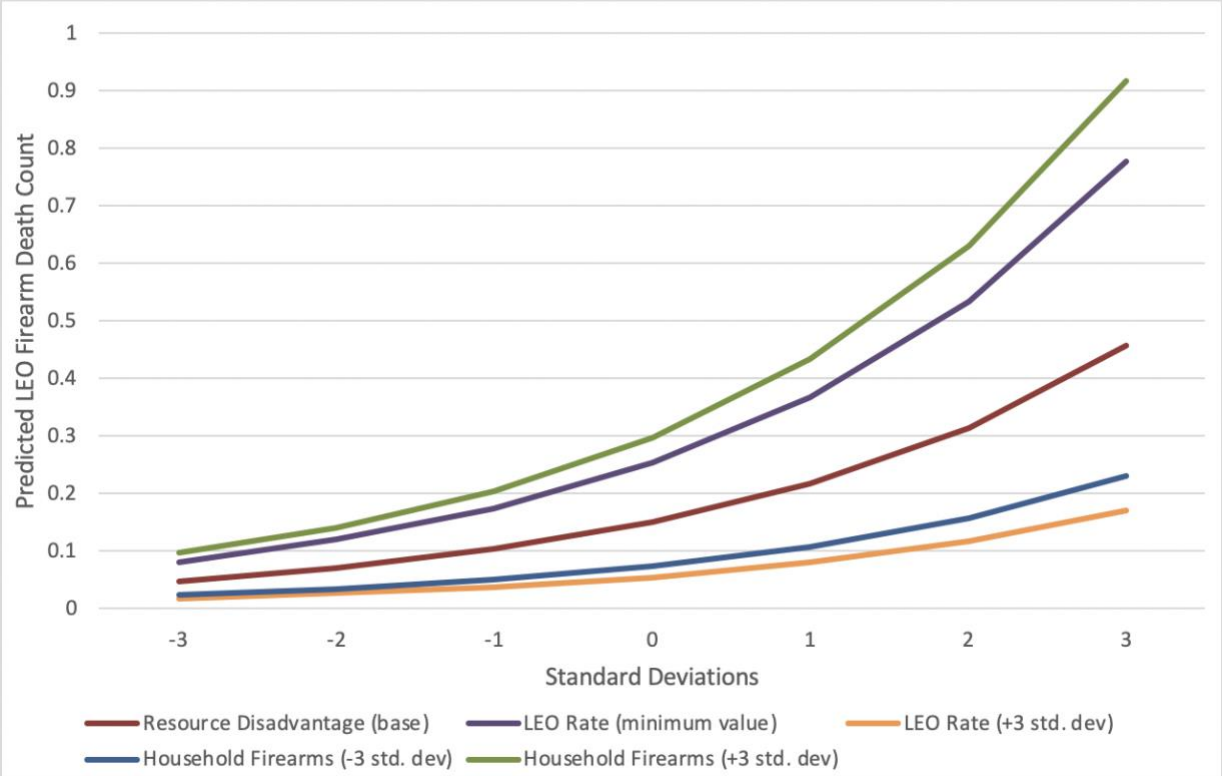
Note*:* Incidence-rate ratios reported with robust standard error in parentheses
[a] Zero values for standard error due to rounding
†$p \leq .10$; *$p \leq .05$; **$p \leq .01$; ***$p \leq .001$

firearm death rate for each unit increase in this measure.

To aid in interpreting the results presented above, the predicted counts of LEO firearm deaths were plotted under varied county characteristics. Because resource disadvantage has the largest effect on these deaths, it serves as the base model for the plots. Predicted LEO firearm death counts were obtained as resource disadvantage varies from three standard deviations below to three standard deviations above the mean (holding all other variables at their means). As shown in Figure 1, when moving from less to more disadvantaged counties, the predicted number of LEO firearm deaths increases from 0.05 to 0.46. While these numbers are small (a fraction of a death), it is important to remember these deaths are rare, with an average of 0.125 LEO firearm deaths over the nine-year timeframe. Thus, highly disadvantaged counties experience nearly four times the average count of these deaths.

From this base model, the rate of LEOs in a county was varied by setting it to its minimum value as well as to three standard deviations above its mean (all other variables held to their means). The minimum value was chosen (rather than three standard deviations below the mean) because counties cannot have negative LEO rates, nor can they experience an LEO firearm death if there are no LEOs. As displayed in Figure 1, having a lower LEO rate in a county increases LEO firearm deaths regardless of the level of resource disadvantage. However, this impact is greater in more disadvantaged counties. Conversely, increasing the LEO rate reduces the expected counts across all levels of resource disadvantage, with the greatest reduction evident in highly disadvantaged counties. These results show that the impact of the rate of LEOs on LEO firearm deaths increases as counties experience more resource disadvantage.

Figure 1: Predicted LEO Firearm Death Counts



The final manipulation examines how LEO firearm deaths in low to high resource disadvantage counties are affected by having firearms in the household. Of the gun measures, this variable had a stronger effect on LEO firearm deaths. The household firearm rate was set to three standard deviations below and above the mean (holding all other variables at their means). Figure 1 indicates that having lower household firearm rates reduces the expected LEO firearm death count across all levels of resource disadvantage. The negative impact on LEO firearm deaths is more evident when examining the household firearm rate at three standard deviations above the mean. Having a greater percentage of households with access to firearms increases these counts across all levels of resource disadvantage. Furthermore, these

predicted counts show that having more firearms is more detrimental than having fewer officers regardless of the level of disadvantage in a county.

Additional Tests and Diagnostics

Several additional steps were taken to ensure model fit and accuracy. As mentioned above, negative binomial regression is utilized when there is evidence of overdispersion. However, misspecification of the Poisson model could result in overdispersion (Long & Freese, 2014). Tests for interaction effects and outliers were conducted to ensure these were not causes for misspecification. No interaction effects were identified in the models. Based on diagonals from the hat matrix, Los Angeles County (California), New York County (New York), and Philadelphia County (Pennsylvania) were identified as potentially high-leverage counties. However, removal of these counties from the analyses did not produce substantively different results in the final model. Additionally, the likelihood-ratio test for overdispersion remained significant even after these counties were removed. Model misspecification can also occur when relevant variables are excluded from the analyses. Failing to account for potentially important predictors could introduce bias into the model. Because of the potential relationship between the overall occurrence of crime on LEO firearm deaths, both the violent and property crime rates were included as control variables. Neither of these variables, however, produced significant effects on LEO firearm deaths in the full model.

Discussion

Conclusions and Implications

With millions of police-citizen interactions each year, understanding the conditions in which these encounters turn fatal is crucial for protecting all parties involved. Though one of the most dangerous occupations, the literature on officers being murdered in the line of duty is lacking in both the number of studies conducted as well as the consistency of their findings. The current study aimed to contribute to the literature by examining the influence of social disorganization, law enforcement presence, law enforcement training, and gun availability measures on LEO firearm deaths in U.S. counties.

The results show that multiple components of social disorganization theory have the same impact on LEO firearm deaths as they do on crime in general. Resource disadvantage, the unstable population factor, and density significantly predict an increase in the LEO firearm death rate. The findings regarding resource disadvantage are not unexpected as prior research has consistently found that these measures significantly increase LEO deaths (among others, see Fridel et al., 2020; Kaminski, 2008). Furthermore, resource disadvantage has been linked to higher crime rates overall (see McCall et al., 2010 among others), which may result in increased contact between law enforcement and potential offenders that could turn deadly. Research has also shown that higher levels of disadvantage tend to coincide with a distrust of law enforcement (Panditharatne et al., 2018) and reduced levels of police legitimacy (Gau et al., 2012). While law enforcement agencies cannot change the structural conditions of the neighborhoods they patrol, they can adjust their approach based on these conditions.

Agencies working in disadvantaged communities should focus on rebuilding relationships with citizens by promoting community engagement so that officers are seen as community-builders rather than just law enforcers. Furthermore, involving residents in how community crime issues are handled would foster greater trust in the police as well as social cohesion among members (Clamp & Paterson, 2017). Once trust is established, officers could serve as a resource that connects community members with necessary services (outside of law enforcement) to resolve the issues that led to the need for police involvement in the first place. These actions may work to reduce not only LEO deaths but also overall rates of crime and violence.

While the resource disadvantage component performed as hypothesized and expected based on prior research, the remaining measures of social disorganization are either contradictory to the literature or the study hypotheses. The unstable population factor is positive and significantly related to LEO firearm deaths as hypothesized, though these findings contradict prior research. Other works utilizing this measure either failed to find significance and/or the variable operated in a direction opposite what was predicted (among others, see Fridel et al., 2020; Kaminski, 2008). One explanation for the current finding is the inclusion of the age structure variable as a measure of instability. While not traditionally included in an instability factor, prior research has found a marginally significant effect of "transitional areas" (a factor consisting of 15-29-year-olds, density, and reverse coded residential stability) on police assaults (Kaminski et al., 2003). Because young people are in a more transitional phase of life than older adults (Clark, 2018), incorporating age structure into an instability factor provides a more complete measure of this concept.

Another contradictory finding is the significant decrease in LEO firearm deaths related to increased ethnic heterogeneity. Prior research has provided mixed results that either indicate a positive

association (as was hypothesized in the current study) or fail to find a significant effect. These studies primarily measured racial (rather than ethnic) heterogeneity through use of either a diversity index or a single measure for percent Black (Fridel et al., 2020; Kaminski, 2008; Kaminski et al., 2003). Utilizing a measure that captures the foreign-born (immigrant) population may account for this discrepancy. It is important to note that focusing on this group falls in line with the original intention of Shaw and McKay (1942) in their specification of heterogeneity. Though this group has been expected to coincide with increased crime, research has shown declines in crime in areas with larger foreign-born or immigrant populations (Ferraro, 2015; Sampson, 2008). Furthermore, the recency of migration plays a role in criminality. Sampson and colleagues (2005) found that third-generation Americans were more likely to engage in violence than first-generation immigrants. With approximately 52% of the current immigrant population in the United States having entered the country after the year 2000, it stands to reason that counties included in these analyses are primarily comprised of the less crime prone first- and second-generation immigrants.

The final social disorganization measure, density (a measure of urbanization), is found to positively impact LEO firearm deaths as hypothesized. Prior literature analyzing measures of urbanization, however, is contradictory to this finding. Few studies on LEO deaths or assaults indicate either a negative or insignificant relationship (Jacobs & Carmichael, 2002; Kaminski, 2008; Kaminski et al., 2003; Peterson & Bailey, 1988), while others fail to account for this potential effect altogether (Swedler et al., 2015). Choosing to use density as the measure of urbanization may partially account for these findings, as many studies utilize percent urban to operationalize this concept. While both can capture urbanization, a density measure touts a few advantages. Density accounts for individuals living within a boundary (i.e., counties) that is uniform and unlikely to change over time. This provides a consistency to the measure and its definition. The U.S. Census Bureau's measure of urban areas, on the other hand, is based on how things look "from the air." Urbanized areas or urban clusters are based on where the population tends to accumulate, which grows over time. In fact, the percent of the U.S. population that lives in an urban area has increased dramatically since the 1950s, though most of the land mass of the United States (97%) remains rural (U.S. Census Bureau, 2017). Density is able to capture the fact that there are more people living on the same area of land. Furthermore, a portion of the "rural" population (which would not be accounted for in a percent urban measure) lives within a metro area (Ratcliffe et al., 2016). Though distinct from "urban," it can be argued that these populations are different from the truly rural population that does not have as easy access to urban amenities.

Law enforcement presence is one of the most significant measures predicting the LEO firearm death rate. Each additional officer for every 1,000 individuals in a county decreases the rate of these deaths by approximately 23%. This finding lends support for the deterrent and/or protective effect of officers, whether by reducing crime in general or deterring criminals from responding violently in encounters with multiple officers on the scene. Additionally, it gives merit to increasing the LEO rate in a county. Having more officers per capita would give departments the ability to instate two-officer patrols when deemed necessary, which may reduce the risk of assault against officers (Fridell & Pate, 2001). Furthermore, it may allow for faster response times to calls for backup, providing assistance in potentially deadly situations. Unfortunately, budget constraints and recent movements to "defund" the police have made it difficult for departments to recruit new and retain experienced officers. Training, on the other hand, is not statistically significant in the final model, which supports prior research (Fridell et al., 2009; Kaminski, 2004). Unlike the work of Fridell and colleagues (2009), these results indicate a negative (albeit insignificant) relationship between training and LEO firearm deaths. The measurement of this variable could play a role in this finding (see limitations section below).

Finally, both gun availability measures are significantly related to increases in LEO firearm deaths. Specifically, where there is a higher rate of household firearm access and more guns recovered and traced each day, there are more LEOs shot and killed in the line of duty. Prior research (Fridel et al., 2020; Swedler et al., 2015) had comparable results, indicating a positive relationship between gun access and LEO fatalities. These findings imply that officers in communities with greater access to guns should be aware of the increased risk of interactions turning fatal. Thus, one may deduce that reducing gun availability would provide further protection for officers. Additional analyses show that when a state's household firearm rate is one standard deviation below the average, there is an approximately 20.6% reduction in the LEO firearm death rate. These results appear to support research indicating that the presence of guns increases the likelihood of interactions turning violent (Phillips & Maume, 2007). One way to address the gun availability issue is through legislation. However, caution must be taken when deciding which gun laws are implemented as they can

have differing impacts on gun homicides. Research has found that right to carry/shall issue laws increased homicides, while banning those with violent misdemeanors from having guns reduced these crimes (Crifasi et al., 2018; Siegel et al., 2019). An examination of other laws (such as stand your ground or assault weapons bans) has found either mixed or insignificant impacts on homicide (Crifasi et al., 2018; Siegel et al., 2019). The effects of these laws on felonious police deaths specifically have not been as widely evaluated. Limited research, however, has found a reduction in these deaths in states with concealed carry laws (Mustard, 2001).

Limitations and Directions for Future Research

There are several data limitations in the current study that may help guide the direction of future research. One such limitation is the measurement of training, which only reflects the overall minimum state-mandated training hours required to join the police force. The focus on overall training may contribute to the lack of significance of this measure. It is possible that the content of the training plays an important role in preventing these deaths. Furthermore, most agencies require additional training beyond the state minimums, including yearly training hours. Revisiting what was learned in after-hire or required yearly training could prove beneficial as officers may be out of practice with some of the techniques learned at the beginning of their careers. Research by Andersen and Gustafsberg (2016) highlights the importance of additional, specific training. Their study found that officers who received supplementary training as part of a training intervention group were more likely to make correct use of force decisions than officers in the control group. Unfortunately, because this is a county-level analysis, obtaining agency-specific information on the amount and type of training was not feasible for the current study. Future research should examine the effect of training in specific content areas to determine what impact, if any, that may have on officer fatalities. Furthermore, as highlighted above, the recent calls for police reform (Eder et al., 2021) warrant researchers to continue to monitor the effect of training to ascertain if any changes made have significant impacts on future LEO deaths.

Another data limitation surrounds the flaws in the gun availability measures, even though the findings of the current study are as expected based on prior research. The RAND Corporation's household firearm rate conflates actual gun ownership with proxies for gun access, some of which include the illegal use, and potentially the illegal possession, of firearms. Even the ATF data, though intended to measure illegal firearms, does not distinguish illegally owned firearms from those legally owned, but illegally used. Prior research has indicated the importance of separating legal from illegal firearm access. Doucet et al. (2016) found that illegal firearm possession (measured as weapons violations) significantly increased the homicide rate in New Orleans census tracts, while legal firearm possession (measured as concealed carry permits) decreased the homicide rate. Future research should attempt to ascertain if there are differential impacts of legal and illegal gun possession on LEO firearm deaths.

LEO deaths will remain an issue faced by agencies into the future. It is the hope that insights from this study will assist law enforcement with making policy changes that protect their officers and instill confidence among individuals considering joining the profession.

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Endnotes

[1] Because the New York City Police Department covers five counties/boroughs, these officers were also apportioned out to each of the five boroughs based on their population size.

[2] The southern regional effect found to be significant in Kaminski (2008) was based on a dummy-coded categorical variable, with the northeast as the reference category. The born in the South measure used in the current analysis was replaced with a dummy coded variable (1=South, 0=non-South) based on the Census definition of southern states. Measuring the regional effect in this way also failed to attain statistical significance in the full model. Further analysis revealed that this measure did not improve the model fit. As such, born in the South was retained to represent a regional effect.

[3] The ethnic heterogeneity factor was replaced with Blau's dissimilarity index as an alternative measure. However, it failed to attain statistical significance and did not improve the model fit. An analysis of BIC' showed the model fit was better when utilizing the original measure of ethnic heterogeneity (percent foreign born and percent Hispanic), rather than Blau's dissimilarity index. As a result, the original measures were retained for the analysis.