HANDGUN CARRYING PERMITS: A REACTION TO LOCAL VIOLENT CRIME AND NATIONALLY PUBLICIZED MASS MURDERS?

By

Brandon Turchan

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ABSTRACT

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Recently, there has been rapid growth in the number of people applying for handgun carrying permits (HCP). This research investigated monthly HCP application rates at the county-level in Tennessee from 2008 through 2012 to identify possible factors behind the dramatic increase. Two factors hypothesized to be associated with HCP application rates were local violent crime rates and the occurrence of nationally publicized mass murders. First, a concurrent time series design was used to test for a relationship between local rates of murder, robbery, aggravated assault rate, forcible rape, and motor vehicle theft with HCP application rates. A Granger causality test was used to investigate simultaneity between the two key variables. Second, an interrupted time series design tested whether there was a relationship between nationally publicized mass murders and HCP application rates. Local murder, forcible rape, and robbery rates were found to be unrelated to HCP application rates, with mixed results for aggravated assault and motor vehicle theft rates. Also, results were mixed regarding the relationship between nationally publicized mass murders and HCP application rates but evidence suggests that an association may exist. Results are discussed in terms of theory and policy implications.

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CHAPTER 1:

INTRODUCTION

Recently, there has been a surge in the number of citizens applying for permits to carry concealed handguns. In 2013, many states issued drastically larger numbers of handgun carrying permits (HCP) compared to previous years. (see Love, 2012; Nicas & Jones, 2013; Romboy & Evans, 2013). For example, from January to June 2013, Colorado experienced an 87% increase in HCP applications (Huffington Post, 2013). Kansas set a state record in 2013 when they received 50% more HCP applications than they did in 2012 (Plumlee, 2014). In the first six months of 2013, Tennessee, the focus of the present study, received a 113% increase in applications for HCPs compared to that same period the previous year (Humphrey, 2013).

The purpose of this research is to identify potentially influencing factors associated with these increases. Specifically, this research assesses the effects of local violent crime rates and nationally publicized mass murders on HCP application rates. Two questions are addressed: 1) is there a relationship between local violent crime rates and HCP application rates? and 2) is there a relationship between the occurrence of nationally publicized mass murders and HCP application rates? Understanding factors potentially associated with increasing HCP applications is important because of the implications concealed handgun permits may have on crime and public safety due to the seriousness and lethality of gun violence.

Currently, a limitation of existing research is that only a few studies have considered the effects of violent crime on HCPs. Past research has primarily focused on the number of permits issued rather than the number of HCP applications filed. Furthermore, no study has assessed whether mass murders influence HCP application rates. After reviewing existing literature and conducting their own analyses, the National Research Council (2005) concluded that a

combination of insufficient data and limitations of existing research impeded the ability to formulate adequate handgun carrying policies. Through the availability of monthly data for both crime and HCP applications from 2008 through 2012, this study aimed to fill these gaps in the literature. Using counties in Tennessee, this study was able to investigate whether the public's collective motivation to acquire HCPs is in response to local violent crime rates and/or the occurrence of nationally publicized mass murders.

The first section of this study defines terms that are used throughout this analysis. Second, this study reviews existing literature on HCPs' relationship with crime trends and nationally publicized mass killings. In the third section, theoretical frameworks used by proponents and opponents are examined. The importance of this issue is then noted, followed by a description of how the present study improves on existing research was detailed. Then, descriptions of statistical analyses used to test research questions in this study are outlined. After reviewing results, a discussion detailing the meaning and significance of this study's findings is offered.

Definitions

Because there is generally a lack of consensus on many terms that were used in this study, this section defines and clarifies each term. *Right-to-carry* (RTC) laws, also known as "*shall-issue*" policies, address the rights of concealed firearm carrying implemented on the state level (Aneja, Donohue, & Zhang, 2011; Kovandzic, Marvell, & Vieraitis, 2005). The most common state approach towards regulating firearm carrying is a "*shall-issue*" law. A "*shall-issue*" law means that any individual who applies for a concealed carry permit and meets all of the objective criteria set forth by that particular state (e.g., age, background check, or training) and federal restrictions, shall be issued a license (Vernick, 2013; Webster, Vernick, Ludwig, &

Lester, 1997). In some cases, states with shall-issue laws allow limited discretion for the issuing body to deny a permit to a qualified individual if the person is thought to pose a threat to society (Law Center to Prevent Gun Violence, 2012). For example, if a sheriff processing a concealed handgun permit application has documented reasonable suspicion that the applicant may harm himself or others, he or she may deny the concealed handgun permit application even if the applicant meets all the objective criteria. Currently, there are two other types of state laws addressing firearm carrying: "*may-issue*" laws generally require the applicant to justify a need for carrying a weapon and "*constitutional carry*" laws do not require an individual to have a permit for carrying of a firearm, concealed or openly (Vernick, 2013). The present study focuses on Tennessee, which is considered a "*shall-issue*" state.

Terminology applied to legally carrying a firearm varies across states. *Carrying a concealed weapon* (CCW) is not limited to the carrying of a firearm; for example in Florida it includes knives, tear gas guns, and slingshots (Florida Legislature, 2013). Tennessee uses the term "*handgun carrying permit*" (HCP) because permit holders in Tennessee are not legally required to conceal their handguns when carrying (Summers, Moore, & Hale, 2005). Because the majority of states require carrying permit holders to conceal their weapons and previous research tends to focus on concealed policies, the term concealed handgun permit was used to describe the legal carrying of a firearm when discussing previous research. Exceptions to this occur when the focus is specifically on Tennessee, at which point "*handgun carrying permit*" or "HCP" will be used.

Another term used in this study that does not have a consensus definition in the literature is "mass murder." This study uses the Federal Bureau of Investigations' definition for mass murder, which is a single incident with four or more fatal victims (Behavioral Analysis Unit,

2005). The FBI's definition for mass murder is also the most frequently used definition in previous research (Duwe, 2000; Duwe, Kovandzic, & Moody, 2002; Fox & Levin, 1998). For the present study, the types of mass murder included in this analysis are more narrowly defined in the methods chapter.

Literature Review

Crime and concealed handgun permits.

Studies regarding the effects of shall-issue laws on crime have drawn much criticism and have often produced conflicting results. Typically, prior research on concealed handgun permits has focused on the implementation and presence of RTC laws, rather than concealed handgun permit applications or the number of concealed handgun permits held by citizens. Early studies found no relationship between violent crime and the presence of shall-issue policies (Kleck & Patterson, 1993), and, more specifically, no effect of shall-issue policies on annual homicide levels (McDowall, Loftin, & Wiersema, 1995). Although these studies were among the first to evaluate the effects of RTC laws, attention given to RTC laws did not begin growing until the late-1990s.

Arguably the most well-known evaluation of shall-issue laws and crime is that of Lott and Mustard (1997). Using annual data, Lott and Mustard found that the presence of RTC laws significantly reduced violent crime at the state level, with the exception of robbery. They also found a positive association between RTC laws and property crime, which the authors hypothesized was likely due to a substitution effect. The conclusion drawn in this study, that shall-issue laws reduce violent crime, helped propel the debate over the effectiveness of RTC laws.

Black and Nagin (1998) were among the first to reanalyze the data used by Lott and Mustard (1997). After further analysis, Black and Nagin (1998) found no evidence of a significant relationship between RTC laws and violent crime, either positive or negative. Ludwig (1998) also reanalyzed Lott and Mustard's (1997) data and pointed to omitted variables, such as the crack epidemic, gang activity, and economic disparity, as leading to spurious findings. Ludwig (1998) demonstrated omitting these variables biased results through contrasting adult and juvenile homicide victimization, and finding no significant evidence that RTC laws reduce homicides.

Homicide has often been given greater attention as the dependent variable in research on RTC laws because it is considered the most reliably reported offense (McDowall et al., 1995; Olson & Maltz, 2001). Results from studies analyzing the effects of RTC laws on homicide have been mixed. A portion of the literature suggests RTC laws reduce homicide rates (Gius, 2014; Lott & Mustard, 1997; Olson & Maltz, 2001; Plassmann & Tideman, 2001). There is another portion of the literature, however, that suggests there is no association between RTC laws and homicide rates. These works suggested RTC laws and homicide are unrelated after controlling for omitted variables (Ayres & Donohue, 2003a; Ludwig, 1998), influential outliers (Black & Nagin, 1998), and regressions to the mean (Grambsch, 2008).

Still, robbery has been hypothesized to be the crime most likely affected by RTC laws because it is the violent crime most commonly committed in public (Kovandzic et al., 2005). In other words, robbery is the crime in which an offender would be most likely to encounter a legally armed citizen. Overall, research suggests no effect between RTC laws and robbery (Lott & Mustard, 1997; Kovandzic et al., 2005). Contrary to expectations, findings from two studies

have actually suggested a possible increase in robbery rates stemming from the passage of RTC laws (Kovandzic & Marvell, 2003; Rubin & Dezhbakhsh, 2003).

Although not unanimous across the literature (see Lott, 2002; Lott & Mustard, 1997), there has been a relatively frequent positive correlation found between assaults and RTC laws. Multiple studies have found RTC laws associated with an increase in assaults (Black & Nagin, 1998; Kovandzic et al., 2005; Moody & Marvell, 2008). To control for the increased number of assaults reported in the 1990s due to changed cultural attitudes towards domestic violence, Aneja and colleagues (2011) used state trends to differentiate between aggravated assaults with and without gun involvement. Results suggested a positive association between RTC laws and gun-related aggravated assaults, without diminishing RTC laws' effects on overall aggravated assault, but only at the <.10 level (Aneja et al., 2011).

Not only have studies revealed varying effects of RTC laws depending on the type of crime, evidence has also suggested RTC laws may have differing effects across geographical landscapes. Studies have shown RTC laws have heterogeneous effects among states, with some states experiencing reduced crime rates and others increased crime rates (Ayres & Donohue, 2003a; Black & Nagin, 1998; Plassmann & Tideman, 2001). Moody and Marvell (2008) found more states initially incurred greater financial burdens associated with crime than those that experienced benefits associated with crime reduction. More specifically, Louisiana and Tennessee sustained an estimated $10 billion in costs while Florida and Georgia combined experienced approximately $38 billion in benefits associated with the effects of adopting RTC laws (Moody & Marvell, 2008). These sharply contrasting experiences suggests intra-regional heterogeneity is a possible effect of RTC laws. Aneja and co-authors (2011) explained this difference by showing the sensitivity of results based on the selection of different levels of data

(state versus county) when assessing the effects of RTC laws. In addition to variations across states, Rubin and Dezhbakhsh (2003) suggested RTC laws may have differential effects among counties. In sum, research suggests that the effects of RTC laws are far from universal.

Indicators of HCP prevalence.

Two studies that examined whether crime was a driving factor in concealed handgun permit prevalence produced mixed results. Partial evidence was found by Kovandzic and Marvell (2003) suggesting that increased robbery and auto theft rates were positively associated with the number of active concealed handgun permits; however, no potential association was found with any other crime. Kovandzic and colleagues (2005) found no support for increasing crime rates leading citizens to react by acquiring concealed handgun permits for protection.

In addition to concealed handgun permits, some research has addressed potentially motivating factors in defensive gun ownership in general. The term defensive gun ownership means that an individual's primary reasoning for owning a gun is for protection (Cook & Ludwig, 1997; Smith & Uchida, 1988). The most common type of gun owned for protective purposes is a handgun (Cook & Ludwig, 1997), which is often the only type of gun permitted by RTC laws. Prior victimization has also been suggested to influence whether an individual carries a concealed firearm (May, 2001). Smith and Uchida (1988) found gun ownership is positively associated with someone in the respondents' household being previously victimized. Another factor associated with defensive gun ownership is whether the respondent perceives himself or herself at risk of being victimized (Smith & Uchida, 1988). Increased unemployment rates have been associated with greater numbers of motivated offenders (Cantor & Land, 1985), which in return may heighten people's perception of increased likelihood of criminal victimization and eventually defensive gun behavior. Studies have also found that crime affects rates of handgun

ownership (Kleck, Kovandzic, Saber, & Hauser, 2011) and, more specifically, market demand of guns for protective purposes (Kleck, 1991).

Research on who is most likely to have a concealed handgun permit reveals vast differences among various socio-demographic characteristics. Men have been found overwhelmingly more likely to possess concealed handgun permits than women (Hood & Neeley, 2000; Schwaner, Furr, Negrey, & Seger, 1999). Schwaner and colleagues (1999) surveyed people planning to apply for concealed handgun permits and found culture, demographics, and lifestyle may all influence the application decision. The prevalence of concealed handgun permits has been found to be positively associated with income, education, and percent of white residents in a community (Hood & Neeley, 2000). Stroud (2012) found concealed handgun permit holders were more likely to carry their handguns in areas they considered dangerous; however, these respondents implicitly associated danger with the prevalence of people in an area who were Black or African American.

Local police may also influence residents' defensive gun behaviors. Evidence suggests that people are more likely to have guns for defensive purposes when confidence in the police is low (Smith & Uchida, 1988). More specifically, Gau (2008) found concealed handgun permits were more prevalent in communities that considered police presence inadequate (Gau, 2008). Collectively, these studies post that greater confidence in and presence of police may make people less reliant on more personal measures for protection, such as HCPs.

Mass murder and concealed handgun permits.

Little attention in extant literature has been given to the relationship of mass murders with concealed handgun permits. Fox and DeLateur (2013) declared because mass murder is under-researched, the public has inaccurate perceptions of its prevalence. Due to a confluence of

reasons, such as media reporting and technology, Fox and DeLateur (2013) argued that the public perceived mass murders as increasing in frequency and severity, which is not actually the case. Two studies examined the effects of RTC laws on mass shootings. Lott and Landes (2000) found RTC laws significantly reduced the frequency and severity of mass shootings. In contrast, Duwe and associates (2002) found RTC laws had neither a positive nor negative association with mass shootings. Both studies assumed an increasing number of concealed handgun permits through a time trend dummy law variable, not the actual number of permits held by the public.

A review of existing research for this inquiry revealed no study has examined the influence of mass murders on concealed handgun permit applications. Although the influence of mass murders on concealed handgun permits is generally neglected in the literature, there is evidence that the incidents may have an effect on other forms of gun activity. For example, mass shooting is one type of mass murder that has been consistently followed by increased gun sales (Wahba & Forsyth, 2012), driven in part by consumers seeking self-protection (Feldmann, 2012; Winter, 2012). One day following a mass murder at a shopping mall in Tucson, Arizona, handgun sales increased by 60% in Arizona (Epstein, 2011). In the three days after the shooting in a movie theater in Aurora, Colorado that left 12 people dead and 58 wounded, there was a 40% increase on background check requests for gun sales in Colorado compared to that same period the previous year (Winter, 2012). By July 2013, seven months after a mass shooting at Sandy Hook Elementary School, the Newtown police department issued more applications for concealed handgun permits than they did the whole previous year (de Avila & Fox, 2013).

These statistics reflect the effects the mass shootings had on local gun-related activity but, because the incidents received national attention, it is reasonable to expect similar effects on gun demand across the United States. The Monday after the 2011 shooting in Arizona,

nationwide gun sales were five-percent higher than the year before, including a 65% increase in Ohio (Epstein, 2011). In King County, Washington, concealed handgun permit applications nearly doubled in the days after the 2012 mass shooting in Colorado compared to the previous year (Workman, 2012). Workman (2012) also noted that not only did original concealed handgun permit applications rise, so did concealed handgun permit renewals. In short, these findings suggests that the effects of mass shootings are not confined to local communities, but rather have national implications and may motivate people to apply for concealed handgun permits.

There is evidence that increased gun activity following a mass murder is not constant over time; instead, it eventually begins regressing toward the mean. In the months following the mass murder in an Aurora, Colorado, York County Sheriff's Office in Pennsylvania received 45-65 concealed handgun permit applications per day (Lee, 2013). After Sandy Hook, York County averaged 85 concealed handgun permit applications per day (Lee, 2013). These numbers eventually declined and by June 2013 (approximately six months after Sandy Hook), York country received 12 concealed handgun permit applications per day (Lee, 2013). In terms of more general gun activity, Smith (2014) noted the January after the mass shooting at Sandy Hook Elementary School, 2.5 million federal background checks were completed for gun sales. One year later, the number of federal background checks completed decreased to 1.7 million for the month of January. These fluctuating trends in gun activity surrounding mass murders may be reasonably expected to also be apparent in concealed handgun permit application trends around the country.

Countrywide fluctuations in gun activity following mass murders may be fueled by advancements in technology over the past two decades that have changed the reach and

immediacy of news reporting (Fox & DeLateur, 2013). The media has the ability to take a local criminal act, such as a mass murder, and give it national publicity making people across the country aware of the event. For example, after the Columbine shooting in 1999, TIME Magazine released a cover with the incident's shooters and the caption "Monsters Next Door" (Fox & DeLateur, 2013). This cover implied that anyone can be a victim of a mass murder and may have caused people thousands of miles away from where the incident to consider that possibility (Duwe, 2000). If people conclude a mass murder similar to the one being covered by the media could happen near them, they may respond by seeking a concealed handgun permit, presumably for self-protection.

Constant media coverage and updates may also influence people's emotions by making distant tragic events feel like they are happening in one's own neighborhood (Fox & DeLateur, 2013). In a 2012 Gallup Poll, 25% of respondents replied "very likely" and over 50% replied "somewhat likely" when asked how likely they thought a Sandy Hook Elementary-type shooting was to happen in their community (Saad, 2012). Because mass murder is a rare occurrence (Duwe, 2000), and one the magnitude of Sandy Hook even rarer, the results of this survey suggests factors other than purely objective analysis influence the public's perception of mass murder. Increased media coverage influences people's perceptions of mass murders, making them think mass murders are a growing problem when, in reality, mass murders have neither increased in frequency nor severity (Best, 2013).

A key factor in generating the public's fear of mass murders is the media (Fox & DeLateur, 2013). Fox and Levin (1994) suggested the public's fear towards crime can be influenced by how media covers mass murders. The authors argued media increases fear among the public from mass murders by providing gruesome details about the incident. Additionally,

when mass murders occur in close temporal proximity to one another, media may suggest the problem is more widespread than it actually is (Fox & Levin, 1994). Duwe's (2000) findings revealed there is even variability in how the media reports different types of mass murders. The rarest form of mass murder, a random mass murder in a public setting, receives the most media attention when compared to other incident types (Duwe, 2000; Fox & Levin, 1998). In short, media coverage of mass murders is important to rates of concealed handgun permit applications because it has the ability to heighten people's sense of fear which may lead them to defensive gun activities.

The magnitude of attention these extremely infrequent events (Best, 2013; Duwe, 2000) receive was evident in a poll that was conducted by the Associated Press. According to the poll, mass shootings were voted the number one news story of 2012, ahead of the presidential election (Crary, 2012). Mass shootings were also voted a bigger news story than Superstorm Sandy, which caused over $60 billion in damages and killed more than three times the number of people in the United States than all mass shootings combined in 2012 (Crary, 2012). In short, evidence suggests mass murders may induce fear in the public and can affect the public's demand for guns. The existing evidence regarding mass murders being related to public fear and gun demand, leads the present research to hypothesize a possible association of mass murders and demand for concealed handgun permits.

Criminological Context

Both proponents for concealed handgun permits and opponents of concealed handgun permits ground their arguments in criminological frameworks. One criminological theory that has been used to support concealed carrying rights is routine activities theory. Routine activities theory argues that for a crime to occur, there must be a convergence between a motivated

offender and suitable target in the absence of a capable guardian (Cohen & Felson, 1979). Applying this theory to the present study, Schwaner and colleagues (1999) argued guns may assist people in serving as capable guardians through the prevalence of concealed handgun permits and the public's awareness of people being legally able to carry a concealed handgun. Additionally, concealed handgun permits may provide people an opportunity to act as capable guardians intervening in situations where crime is occurring. Supporters of concealed handgun permits are often against having "no-gun zones," locations where carrying of firearms is prohibited, because they believe it would increase citizens' vulnerability to crime in those areas (Fox & DeLateur, 2013). Put in terms of routine activities theory, a crime is more likely to occur in places where firearms are prohibited because of the absence of a capable guardian: an individually legally carrying a handgun.

Rational choice is a criminological theory drawn upon by both sides of the concealed handgun permit debate to explain whether potential offenders acknowledge the possibility of encountering a legally armed individual before engaging in crime. A rational choice perspective posits offenders conduct a cost-benefit analysis of a situation in order to decide whether engaging in crime is in their own best interests (Clarke & Cornish, 1985). Those in favor of RTC laws argue that concealed handgun permits increase the risks offenders associate with committing crime (Lott & Mustard, 1997), and adding to the cost side of the offender's situational evaluation.

Opponents argue RTC laws may not significantly alter an offender's calculated costs associated with a crime because of the low probability of encountering a concealed handgun permit. The Government Accountability Office (GAO) (2012) estimated there was slightly over eight million active concealed handgun permits in the United States by the end of 2011. Even

though permit prevalence has been rising, only a small minority of the population still possesses them. With a population of just over 311 million in 2011, GAO's (2012) estimated number of concealed handgun permits in the U.S. by the end of that year means permit holders represented approximately 2.6% of the country's total population. In addition to representing a relatively small percent of the population, not everyone with a concealed handgun permit carries a firearm on a regular basis. In a survey of gun owners in general, Cook and Ludwig (1997) found of all the respondents who carried guns, the majority (56%) carried less than 30 days in an entire year. These statistics showing the relatively small number of citizens who possess concealed handgun permits (Bird, 2000; Hill, 1997; Kleck, 1997), combined with even fewer carrying on any given day, suggest that informed offenders may not give much weight to concealed handgun permits when conducting their cost-benefit analysis.

RTC opponents more closely adhere to Clarke and Cornish's (1985) idea of an offender's "bounded rationality." Bounded rationality is the concept that offenders do not always know everything about a situation and make their decision to engage in crime based on limited knowledge (Clarke & Cornish, 1985). In accordance with the idea of offenders having bounded rationality, some people doubt whether potential offenders are knowledgeable of RTC laws and the local prevalence of concealed handgun permits (Duwe et al., 2002; Kovandzic & Marvell, 2003). The key premise of this argument is that if an offender is unaware of RTC laws and/or the number of people with concealed handgun permits in their locality, then those factors will not affect his or her decision to commit a crime.

The rational choice perspective implicitly assumes a rational offender, which may not always be the case. In the case of mass shootings, knowledge of concealed firearm prevalence among the public may not deter a mass shooter because they are often considered mentally ill or

suicidal (Levin & Fox, 1985). In fact, approximately one-fourth of mass murder offenders commit suicide (Duwe, 2000; Petee, Padgett, & York, 1997). Unnithan, Pogrebin, Stretesky, and Venor (2008) interviewed inmates convicted of gun offenses in Colorado to investigate whether their behavior would have changed due to the state's adoption of a "*shall-issue*" law making targeted victims potentially armed. The majority of inmates indicated there were times in their lives that nothing, including legally armed citizens, would have changed their violent behavior (Unnithan et al., 2008). This finding suggests that at least a portion of informed offenders are unaffected by the potential of encountering an armed victim or are irrational in thinking they will not face increased risks when engaging in crime.

In sum, both sides of the concealed handgun permit debate use criminological theory to support their arguments either in favor of or against RTC laws. The best way to test the legitimacy of each argument is through empirical evaluations. Basing firearm carrying policies on sound theoretical framework and empirical evidence is vital given the magnitude of risk factors associated with guns in society.

Present Study

The purpose of this study was to examine factors potentially associated with increases in handgun carrying permit (HCP) application rates. This study has two overarching hypotheses regarding factors potentially associated with HCP application rates. The first hypothesis is that local violent crime rates are positively associated with trends in HCP application rates. If beliefs towards or motives behind HCPs are constant, then rates of HCP applications should correspond with the number of people reaching the minimum age requirement. In contrast, if fluctuations in HCP application rates do not correspond with age, then increasing local violent crime rates may be responsible for altering individuals' views or attitudes toward HCPs.

The second hypothesis posed in this study is that the occurrence of nationally publicized mass murders are positively associated with HCP application rates. If rates of HCP applications are associated with nationally publicized mass murders, it is likely these decisions are more emotionally-based than objectively-driven given the low likelihood of being victimized by such infrequent events. Both hypotheses are based on principles of routine activities theory where HCPs would be expected to increase guardianship in response to local violent crime rates and nationally publicized mass murders.

Because of the possibility that concealed handgun permits have an effect on crime, it is important to know what motivates the public to apply for concealed handgun permits in order to formulate appropriate policies. Implicit in the decision to acquire a concealed handgun permit is that it will have the intended outcome of improving safety (Gau, 2008; Schwaner et al., 1999; Stroud, 2012). If safety is a motivation in applying for concealed handgun permits, then that anticipated effect should be empirically supported.

Research suggests one reason people may obtain concealed handgun permits is for protection of oneself and others, which ultimately reduces crime in general (Kleck et al., 2011; Stroud, 2012). If concealed handgun permits are associated with reductions in crime, then it would be expected that rising numbers of concealed handgun permits within a community would decrease future crime rates within that community. In contrast, if concealed handgun permits are not associated with a reduction in crime, then people who acquire concealed handgun permits for that purpose could be incurring costs without achieving their intended outcome. Concealed handgun permit applicants not only incur costs monetarily (e.g., permit fees), or, in some states, through time (e.g. required training), but concealed handgun permit holders may inherit unexpected health risks.

Previous research suggests that gun possession, which concealed handgun permits facilitate, comes at a cost of increased risk of injury or death (Stroebe, 2013). Cook (1991) and Zimring (1972) found that when a gun is present during a dispute, the odds of injury and death both increase. The severity of injury caused by guns was highlighted by Wintemute (2008), who found a 30% fatality rate for people who sustained gunshot wounds. On a more macro-level, gun-dense communities have been found to have more murders (Killias, 1993), robberies ending in fatalities (Cook, 1991), and firearm-related deaths (Bangalore & Messerli, 2013). In short, the presence of a gun during an altercation can have seriously injurious or lethal ramifications on all parties involved, including the concealed handgun permit holder.

Society also has an invested interest in the prevalence of concealed handgun permits because of the potential unintended consequences. Cook (2013) noted that gun violence has the ability to generate devastating effects on a community. Similar to the individual with the concealed handgun permit, society may also unknowingly inherit risks associated with gun carrying (Cook & Ludwig, 1997) and may become unwilling participants in someone else's gun-involved encounter. Opponents of RTC laws have argued innocent bystanders can become victims in a potential crossfire between the offender and concealed handgun permit defender (Fox & DeLateur, 2013). A counterargument posits that legally armed citizens promote safety and that the presence of people with concealed handgun permits reduces the severity of certain incidents (Lott & Landes, 2000).

In addition to physical health concerns, psychological effects are necessary considerations when evaluating gun carrying in public. Psychological factors may also influence whether people apply for concealed handgun permits; a person may feel safer if he or she has a concealed handgun permit (Cao, Cullen, & Link, 1997; Reid, Roberts, & Hilliard, 1998).

Although those who have concealed handgun permits may feel safer, the rest of their community may not feel the same way in response to gun carrying within their surroundings. Previous research suggests some people feel less safe with an increasing number of people carrying guns in their neighborhood (Hemenway, Azrael, & Miller, 2001; Smith, 2001). In other words, the psychological personal security of the few may threaten the psychological feeling of security for others. These feelings could potentially lead to a civil arms race (McDonald, 1999; Rubin & Dezhbakhsh, 2003) where greater numbers of people carrying guns make neighbors feel less safe by spurring further concealed handgun permit acquisitions among those who perceive themselves as at risk. Understanding what factors increase rates of concealed handgun permit applications is important because of the myriad of potential ramifications on the permit holder's well-being and community safety.

The stakes associated with gun carrying makes it important to advance existing literature on the topic. One improvement this study made to previous research is how the presence of RTC laws was measured. Early studies (Kleck & Patterson, 1993; McDowall et al., 1995) assigned a binary value to the presence of RTC laws. This method was expanded by using a time trend variable in combination with binary values to account for the hypothesized growing number of concealed handgun permits the longer laws were in effect (Ayres & Donohue, 2003a). These methods of measuring the presence of RTC laws assumed a homogenous effect of RTC laws across geographies and time, as well as an equal rate of concealed handgun permit acquisition in each jurisdiction. Using the number of concealed handgun permits intuitively seems to be a more accurate representation of the impact of RTC laws on permit acquisition. Lott and Mustard (1997) used the annual number of concealed handgun permits issued statewide per capita for three states and found mixed results. Specifically, the authors found partial support for

concealed handgun permits reducing violent crime in two states and no evidence of concealed handgun permits reducing crime in the third state. Kovandzic and Marvell (2003) used rates of active concealed handgun permits per county for each year of their study period when testing the effects of RTC laws on violent crime. Kirchgassner, Wolters, and Hassler (2013) cautioned that using observations encompassing a large period of time, such as an entire year, makes it difficult to attribute changes in a variable in a later time period to changes in a variable in previous observation periods. Monthly data is a more narrowed approach for observing sequences of time, or if one variable influences another variable at a later time (Kirchgassner et al., 2013). Following Kirchgassner and colleagues' approach, this study used monthly data for both crime and HCP statistics.

Monthly data was also beneficial when capturing how immediately crime rates and concealed handgun permit rates interacted with each other, which has been a deficiency in existing RTC research. Generally, there are two problems with the representation of time in past studies of RTC laws and crime. First, many studies, especially early-on, failed to consider any lagged effect on crime from the RTC law (see Kleck & Patterson, 1993; Lott & Mustard, 1997); instead only modeling an immediate effect. Second, when studies tested for a lagged effect of RTC laws on crime, they assigned the delayed effect a value of one year (see Hepburn, Miller, Azrael, & Hemenway, 2004; Kovandzic et al., 2005; Olson & Maltz, 2001). Using crime as the dependent variable, studies using a one-year lag period suggest the effects of RTC laws being implemented will be detectable in crime rates one year later. One study, Gau (2008), tested for a one-year lag with concealed handgun permit rates as the dependent variable. The explanation for accounting for a lag effect is that it takes time after a RTC law is implemented for citizens to be able to obtain concealed handgun permits, often 2 to 3 months (Plassmann & Tideman, 2001).

Because concealed handgun permit applications are processed within months, one full year is not an accurate representation of the process. Research using monthly data may more precisely captures the reactive nature of the hypothesized crime- concealed handgun permit application relationship.

Third, few previous studies considered the possibility of simultaneity when studying RTC laws and crime. Simultaneity is necessary to address due to the possible reciprocal relationship between crime rates and concealed handgun permits. In other words, crime rates may affect the rate at which people apply for concealed handgun permits, and the rate at which people obtain concealed handgun permits may, in return, affect crime rates. If these two variables are measured at the same time, the effect of one on the other is impossible to discern and model assumptions of independence are violated.

Lott and Mustard (1997) attempted to address this issue through a two-stage least-squares test, which requires the use of an instrumental variable in place of the variables involved in the potential feedback loop. An instrumental variable needs to be highly correlated with the endogenous variable while uncorrelated with the error term (Zohoori & Savitz, 1997). The ability to find an appropriate variable to satisfy the standards of an instrumental variable in the concealed handgun permit equation has been doubted in the literature (Kovandzic & Marvell, 2003; Manning, 2003). Two studies (Kovandzic & Marvell, 2003; Kovandzic et al., 2005) addressed simultaneity concerns without the use of instrumental variables by using a Granger causality test (Granger, 1969). Overall, however, simultaneity is often neglected in RTC research leading to potentially biased results (Kovandzic & Marvell, 2003). The present study compensated for simultaneity bias by using the Granger causality test, which is discussed further in the methods chapter of this thesis.

Historically, the effects of handgun carrying laws on crime have been studied while the effects of crime or mass murders on concealed handgun permits have been largely neglected in the literature; however, this study aims to reduce that disparity. When studies examined a variety of factors that potentially influence concealed handgun permit rates or defensive gun acquisitions, they did so primarily through the use of surveys (see Cook & Ludwig, 1997; Gau, 2008; Smith & Uchida, 1988; Stroud, 2012). These surveys often fail to identify what changes a people's minds to seek a concealed handgun permit when he or she previously did not have one. For instance, Schwaner and colleagues (1999) noted cultural and demographic characteristics influence concealed handgun permit application decisions. Because these are relatively static factors there must be something beyond cultural or demographic characteristics that influences the public's desires for concealed handgun permits, or else there would not be fluctuations in concealed handgun permit application rates. What these studies did not investigate was the point at which communities experience an increase in concealed handgun permit applications, as a proportion of the community decides they need to carry a gun.

Lastly, this study improves on the literature by using new data from a relatively recent period of time to examine the relationship between HCPs and local crime and mass murder. Many studies have used or modified Lott and Mustard's (1997) original dataset from 1977-1992 (see Benson & Mast, 2001; Bronars & Lott, 1998; Ludwig, 1998; Olson & Maltz, 2001; Rubin & Dezhbakhsh, 2003). Some studies have adjusted the dataset by controlling for state trends (Ayres & Donohue, 2003b; Black & Nagin, 1998; Moody & Marvell, 2008) or considering the growing number of concealed handgun permits over time (Ayres & Donohue, 2003a; Lott, 1998). Other studies have extended the time period of the original dataset additional years (Lott, 2000; Lott, 2002; Plassmann & Whitley, 2003). Despite these alterations, there is still a

disproportionate representation in the RTC literature of the same general time period and same general data. By examining the time period of 2008 through 2012, this study avoids obstacles faced in previous long-term RTC studies, such as the crack epidemic and surge in homicide of the late 1980s and early 1990s (Ayres & Donohue, 2009; Moody & Marvell, 2008; Ludwig, 1998) or RTC laws being implemented in response to crime (Donohue, 2003; Grambsch, 2008).

CHAPTER 2:

METHODS

Site Selection

This section provides relevant background on Tennessee, the focus of this analysis, and describes general requirements the state has for handgun carrying permit (HCP) applicants. Tennessee was selected for this study based on the availability of monthly crime and HCP data from 2008 through 2012 at the county level. In Tennessee, the public's ability to legally carry a handgun in public has undergone vast transformations in recent decades, generally towards a loosening of restrictions. Originally a limited open-carry state, Tennessee became a "may-issue" state in 1989 when county sheriffs were authorized to issue permits to citizens (Tennessee Firearms Association, 2009). Tennessee adopted a "*shall-issue*" law in 1994 that mandated a handgun carry permit be issued to any applicant meeting the required qualifications (State of Tennessee, 1994). Varying interpretations of the law by counties forced the Legislature to standardize the application process in 1996 (Tennessee Firearms Association, 2009). Despite Tennessee's efforts to correct previous obstacles, problems persisted in the HCP process. In response, the state tried streamlining the application review process by adopting legislation in 1997 requiring permits to be issued within 90 days, regardless of whether criminal background checks were completed (Tennessee Firearms Association, 2009).

Currently, Tennessee requires HCP applicants to be at least 21 years of age, have no felony convictions or disqualifying misdemeanors, be a U.S. citizens, mentally stable, not have a history of abusing drugs or alcohol, and not be the subject of a restraining order (State of Tennessee, 2013). The applicant is required to provide photo identification and be finger printed when he or she submits his or her HCP application (State of Tennessee, 2013). Prior to filing

their HCP applications, applicants must complete a pre-approved handgun safety course (State of Tennessee, 2013). There is a $115 application fee and $50 renewal fee for HCPs, and permits last four years (State of Tennessee, 2013). Tennessee law does not require an individual with a HCP to have his or handgun concealed (Summers et al., 2005). In other words, individuals with HCPs may carry their handguns either openly or concealed, in non-restricted areas. Tennessee does not legally allow the carrying of a concealed weapon on college campuses (National Conference of State Legislatures, 2014).

The total number of active HCPs in Tennessee at the beginning of 2008 was 191,208 (Locker & Smith, 2010). By the start of 2009, there were 218,004 active permits and 268,711 the following year (Locker & Smith, 2010). In November 2011, Tennessee had 340,689 and over 382,000 by the end of 2012 (Smith, 2013). This steady increase in the number of HCPs continued into 2013, where Tennessee saw a 113% increase in the number of HCP applications they received for the first six months compared to the previous year (Humphrey, 2013). During the time period of this study, Tennessee enacted five laws that pertained to HCPs that, in general, favored the rights of HCP holders (State of Tennessee, 2013). See Table 1 for descriptions of these laws.

Dependent Variable

The dependent variable for the present study was the monthly rate of HCP applications per 100,000 residents by county. Data used for this variable came from annual reports on handgun carrying permit statistics produced by Tennessee's Department of Safety and Homeland Security. These reports provided monthly, county level statistics on the number of HCPs issued that were original, renewed, duplicated, free, and for new residents, as well as the number of HCPs suspended, revoked, and denied. This study only included HCP categories where

individuals were required to proactively take action in obtaining a unique permit. Permit categories included in the HCP application rates variable for this study were the number of original HCPs issued, HCPs renewed, HCPs issued to new residents, and HCPs denied. These four categories were added together into one variable that measured the monthly number of HCP applications a county received.

Tennessee's HCP reports presented statistics based on when the permit-issuing authority made a decision on an application. In other words, these statistics reflected the end result of HCP applications and not when applicants initially submitted. Because HCPs are not issued instantaneously upon submission of an application, the number of days it takes to process an application needed to be taken into account. From 2008 through 2012, the average number of days for the decision to issue or deny an HCP application was 43.18 days. Based on this average processing time, two months were subtracted from the month HCPs were issued or denied in order to capture when applications were originally submitted.

To transform the HCP application variable into a rate, the number of HCP applications in each county was divided by the county's population who were 21 years of age or older. The county's 21 years of age or older population was used because Tennessee law requires individuals to be at least 21 years old when applying for HCPs; thus, only people who meet the minimum age requirement can be expected to react to local violent crime rates or the occurrence of nationally publicized mass murders by applying for HCPs. After dividing the total number of HCP applications by population, the resulting number was then multiplied to create a standard rate of "per 100,000 residents." This final number was used for the HCP application rate variable (see Table 2).

Independent Variables

Local violent crime rates.

The first hypothesis was that local violent crime rates would be positively associated with HCP application rates. This study only focused on violent crime for two reasons. The first reason was because HCPs are hypothesized to be most likely associated with violent crime compared to other types of crime (Kovandzic & Marvell, 2003). Second, tests were limited to violent crime because property crimes, such as burglary or malicious destruction of property, do not require a homeowner to have an HCP in order to legally have a gun in that setting. Local violent crimes evaluated in this study included: homicide, robbery, forcible rape, and aggravated assault, and all were tested as rates per 100,000 residents (see Table 2).

One additional crime variable examined was motor vehicle theft because Kovandzic and Marvell (2003) found partial evidence that the number of concealed handgun permits may increase as a response to increasing rates of motor vehicle theft per 100,000 residents. Motor vehicle thefts were also tested because under Tennessee law, an individual with an HCP is legally allowed to possess a loaded rifle or shotgun in a privately owned vehicle (State of Tennessee, 2013). In other words, people with HCPs legally have the ability to possess guns other than handguns in situations particular to motor vehicles. This is important to consider because gun possession in vehicles has been found to increase driver aggression and lead to dangerous driving tactics (Hemenway, Vriniotis, & Miller, 2006).

Data for county-level violent crime was obtained from the Tennessee Bureau of Investigations. Each of the five violent crime types was represented by separate variables to establish whether the public's reactions varied depending on the type of violent crime. For the variables, all crime counts were converted into rates by dividing each crime by the county's total

population and then multiplied to form a rate of "per 100,000 residents" (see Table 2). The crime rate variables were tested for normality, a test that they failed. Transformations to increase the normality of the variables were considered, the only promising of which was a log transformation. Ultimately, the log transformation was rejected because the majority of observations would have been lost in the analyses due to many county-months with rates of zero for each crime type.

Nationally publicized mass murders.

Mass murder, is defined as a single event that results in four or more fatalities. In this study, the occurrence of nationally publicized mass murders was coded as a count variable with a value of "1" for each mass murder that occurred in that month. The severity of nationally publicized mass murder was also tested in order to determine whether changes in HCP application rates were associated with the actual occurrence of the incident or its severity. Severity was expressed as a count variable that measured the number of fatalities from nationally publicized mass murders in months that the incidents occurred. .For the purposes of this study, eligible instances of mass murder were narrowed to only encompass scenarios where someone with an HCP could be reasonably argued to have intervened. Two components of the mass murder definition that then needed to be addressed were location and weapon. In terms of location, not all mass murders occur in a setting that would require someone to have an HCP to legally intervene with a gun. For example, most mass murders occur in private residences (Duwe, 2000). Incidents that occurred in a home were excluded from this analysis because an HCP is not legally required for an individual to possess a gun in his or her place of residence. Although mostly occurring in a private setting, all mass murders that involved familial relationships were also excluded from this study because research suggests these events receive

less attention relative to those involving strangers (Duwe, 2000). In short, only mass murders that occurred in a setting that would have required a HCP to legally intervene with a gun were included in this analysis.

The second component of mass murder critical to this analysis was the weapon used by the offender during the incident. Mass murder can be carried out in a variety of ways, including stabbing, shooting, blunt force, bombing, and arson. However, not all of these methods of executing mass murder could be prevented or interrupted by someone with an HCP. Two methods of executing mass murder excluded from the present study were bombing and arson. I posit HCPs cannot be reasonably assumed to prevent a planned explosion and cannot intervene in such an incident given its immediate nature with extremely limited intervention opportunities. Also, I do not believe HCPs are not a reasonable way to prevent or reduce the severity of an ongoing fire stemming from arson. Fox and Levin (1994) also excluded incidents involving fire from their mass murder analysis. Due to the unlikelihood of HCPs being useful tools in these two scenarios, I chose to only include mass murders where offenders shot, stabbed, or beat victims to death. In other words, this study only used situations where offenders were required to be physically present at the scene of the crime when the mass murder occurred.

Beyond limitations on the setting and method of a mass murder, a third restriction in need of explanation was determining what constitutes "nationally publicized." Duwe (2000) found not all types of mass murders receive equal media coverage, with some remaining relatively local stories and never receiving any national attention. Due to the disproportionate media coverage of different types of mass murder, there needed to be a systematic way to determine whether a mass murder received national publicity. To represent national media, popular nationwide news websites were selected to examine if a particular mass murder received national

attention. In order to account for changes in what sources people relied on for their news over the course of the study period, the most popular news websites (based on unique visits per month) from 2008 (Seward, 2009) and 2012 (Nielsen, 2012) were compared for commonalities. The comparison revealed three common news websites: Los Angeles Times, New York Times, and USA Today. This study categorized a mass murder as "nationally publicized" if it was reported in all three of these news sources.

Numerous steps were taken to identify incidents that qualified as nationally publicized mass murders. To begin, a list from USA Today (2013) with all mass murders (four or more fatal victims) from 2006 through 2013 was used. The list of mass murders was formulated using a combination of the FBI's Supplementary Homicide Reports and local news reports for years where the FBI's Supplementary Homicide Reports were unavailable. This original list was first reduced to include only incidents that occurred from 2008 through 2012. Then, the list of mass murders was filtered down further to only include incidents qualifying for this analysis based on location and method (as outlined above). Each nationally publicized mass murder served as an intervention in the time series observations of HCP application rates.

After applying the previously specified criteria for mass murders, 19 incidents qualified for this study. See Table 3 for overviews of each qualified nationally publicized mass murder. No nationally publicized mass murders during the study period occurred within the geographic focus of this study, Tennessee. Except for February 2008, there was never more than one-nationally publicized mass murder that occurred in a month. This study tested the occurrence of nationally publicized mass murders in two different ways. First, all mass murders were regressed against HCP application rates as a single variable. Second, each nationally publicized mass murder was regressed against the dependent variable individually, while controlling for all

other incidents. One limitation encountered in this process was being unable to effectively differentiate between the individual effects of the three nationally publicized mass murders that occurred in February 2008. For this month, all three nationally publicized mass murders were tested as one incident with the variable's value being "3" because that was the number of incidents that occurred in that month (see Table 2).

The severity of mass murder variables represented the number of fatal victims resulting from an incident. Controlling for the severity of nationally publicized mass murders allows for a distinction to be made between whether it was the actual occurrence of the incident or the number of people killed in a particular incident that influenced HCP application rates. Similar to the occurrence of nationally publicized mass murders, severity was tested two different ways in this study. First, the victims from all nationally publicized mass murders were regressed as one variable against the dependent variable. Second, the severity of each incident was tested separately against HCP application rates, while controlling for other potentially influential variables.

Control variables.

Control variables used in this model were unemployment rate, income per capita, law enforcement officers, race, educational attainment, and changes in HCP-related laws. As previously outlined, unemployment rate, income per capita, educational attainment, and changes in HCP-related laws may be positively associated with increases in HCP application rates. Research also suggests confidence in law enforcement and race may also be related to HCP application rates. See Table 2 for sources for these data.

Two economic variable were included in this study because of the financial costs associated with applying for an HCP. Unemployment rate was one economic variable included,

and represented the county level unemployment rate by month. Monthly unemployment rate data was obtained from the United States Bureau of Labor Statistics. The second economic control variable was annual income per capita by county. Annual, county level statistics for income per capita were retrieved from the United States Bureau of Economic Analysis. Diagnostics tests for this variable revealed a skewed distribution. To reduce asymmetry, income per capita was expressed as its inverse.

The yearly number of law enforcement officers per county was controlled for as a measure of police presence. The presence of law enforcement officers has been expressed in past literature as police per 100,000 residents (Stahura & Sloan, 1988). In order to accurately represent local police presence, the number of county-level law enforcement officers was combined with the number of city-level law enforcement officers for cities located in that particular county. For cities that overlapped more than one county, the number of officers for that city was allocated evenly among each county. If dividing officers among counties resulted in a fraction, the number was rounded to the nearest whole number. Once the total number of law enforcement officers in each county was determined, the variable was divided by the county's total population and then converted into a rate of "per 100,000 residents." Diagnostics tests on the law enforcement variable revealed a positively skewed distribution. After analyzing possible transformation strategies to improve the normality of the distribution, this variable was transformed into one divided by the square root of its original value to counterbalance skewness. Data used for the law enforcement variable was obtained from the FBI's Uniform Crime Reports.

A fourth variable controlled for in this study was race. In this study, race was represented as the percentage of individuals by county who identified themselves as one race and Black or

African American. Reliable county level data on racial composition was only found from 2009 through 2012. County level race percentages from 2009 were duplicated for the missing 2008 data. Diagnostics tests for the race variable revealed a highly and positively skewed distribution. To counteract this asymmetric distribution, the race variable was transformed by taking the square root of itself. The newly transformed variable did not generate an ideally normal distribution, but did reduce the extent of asymmetry relative to the original race variable.

The fifth control variable in this study was educational attainment. Educational attainment represented the percentage of a county's population 25 years of age or older who possessed a Bachelor's Degree in a given year. Reliable data for educational attainment was obtained from 2010 through 2012. For the missing 2008 and 2009 data, county level values from 2010 were used. Diagnostics results on the educational attainment variable showed a moderately and positively skewed distribution. Asymmetry was reduced by expressing the variable as one divided by the square root of its original value.

Finally, one variable was used to control for changes in laws pertaining to HCPs. In 2009, Tennessee enacted five laws over approximately a four-month period that pertained to HCPs. Binary values were assigned to months before and after the first of these five laws were enacted. All months prior to the first full month (May 2009) the first new law was enacted were assigned a value of "0" and all following months were assigned a value of "1" demonstrating a change in restrictions.

Statistical Analyses

The statistical software program Stata was used to conduct all statistical tests in this study. Bivariate regressions were run on the data before building the multivariate regression models. Collinearity between the independent variables was considered by examining variance

inflation factors. After reducing collinearity within models, statistical analysis was conducted on the multivariate models for leverage and influential outliers. Specifically, months and counties were investigated for possible unduly influential observations. Tests revealed no evidence that influential outliers existed to skew model results. Based on the lack of influential outliers, all observations remained in the multivariate regression models.

The statistical models used in this section were time series models that observed all 95 Tennessee counties for a period of five years, from 2008 through 2012. Because the repeated measures on counties in the analysis break the linear regression assumption of independence, the data were modeled with generalized estimating equations, specifying county and month as the unit and time variables. Generalized estimating equations are population-averaged models and an exchangeable correlation structure was specified. A time series design was the best approach for answering the question of whether HCP application rates and local violent crime are related because the design allows for high frequencies of observations over time to examine the potential interactive variability between two key variables (Shadish, Cook, & Campbell, 2001). Significance was determined at the level of $p < .05$.

Granger causality test.

Given that some studies have found evidence suggestive of HCPs affecting crime rates, it is possible that both HCPs and crime are endogenous variables within the proposed model. An endogenous variable is a variable that is partially determined by other variables in the model being tested (Zohoori, 1997). Due to this potential threat to the model, it is necessary to test for a potential feedback effect between local violent crime rates and HCP application rates. This study used the Granger causality test to investigate a possible reciprocal relationship between HCPs and local violent crime. In addition to testing for a reciprocal relationship, the Granger

causality test's ability to control for lagged effects of both variables makes it intuitively applicable when examining a possible HCP-crime relationship. Typically, crime data is unavailable to the public until after the month is completed. This means people who are applying for HCPs in response to officially reported crime rates would base their decision on crime in the previous month(s). In other words, one could reasonably expect a lag of at least one month if HCPs applications are in response to officially reported crime because that is how long it takes to obtain that data.

The multiple lag values that can be modeled strengthens the utility of the Granger causality test even further when testing whether HCP applications are a response to local violent crime. For example, applying for HCPs may not be in response to a one month spike in crime but rather a growing trend extending over multiple prior months. After a person decides he or she wants to apply for an HCP, another lag effect can take place. Many states, including Tennessee, require applicants to complete a training course prior to submitting their HCP applications. These training courses typically last one day, but it may take time for an applicant to find and enroll in an available training session. This requirement could potentially delay the submission of a HCP application from occurring for another month, if not more.

When examining the reverse relationship, a delayed effect is also likely to occur. Because the amount of time between deciding to apply for a HCP and actually submitting the application can last several months, if HCPs were to affect crime, crime would more likely be influenced by the number of HCPs issued than the number of HCP applications filed. For example, Tennessee denied 574 HCP applications in 2012 and revoked or suspended an additional 1,389 HCPs (Tennessee Department of Safety, 2013). In other words, it is reasonable

to expect any effects on crime (in either direction) will likely be delayed some time period after the HCP application is originally submitted.

Used in time-series analyses, the Granger causality test is a linear regression model that examines the potential causal relationship between two time series (Russo, 2009). Two central components of defining causality are temporal precedence (X must occur before Y) and physical influence (changes in X cause changes in Y) (Eichler, 2012). The first principle of Granger causality is that one time-series precedes the other (Granger, 1969), which adheres to one of the central elements of causality. Addressing the second essential component of causality, Granger causality is when time-series "X" improves the predictive results of time-series "Y" (Granger, 1969). A variable (X) is considered Granger causal to another variable (Y), if past values of X can improve predictions of future Y values more than only using past values of Y (Russo, 2009). Since X in Granger causality is meant to improve the prediction of Y, the term "Granger causal" is typically used instead of "causal" to imply the distinction of the Granger causality results from absolute causality. Kirchgassner and colleagues (2013) equated Granger causal to "incremental predictability" because the emphasis is on improving forecasts of Y, rather than determining total causality (pp. 96).

The null hypothesis for Granger causality is X does not cause Y. If the null hypothesis cannot be rejected, the distribution of Y is only conditioned on past values of Y and previous values of X do not affect Y values (Russo, 2009). The null hypothesis can be represented as the following:

$$Y_t \perp\!\!\!\perp X_{t-1} | Y_{t-1}$$

In the above equation, "$\perp\!\!\!\perp$" stands for independence and " | " denotes a conditional relationship. This equation reads that Y is independent of the historical values of X conditional

on the history of Y (Russo, 2009), or in other words, when past values of Y are considered, X no longer is valuable in predicting Y.

Granger (1969) offered three definitions for causality. The first definition of causality is simple Granger causality, where variable X is Granger causal to variable Y if:

$$\sigma^2(Y_{t+1}) < \sigma^2(Y_{t+1} \mid I_t\text{-}\bar{x}_t)$$

In this equation, σ^2 is the variance of the corresponding forecast error, t is the time of the most recent selected observation period, $\bar{x}$ is the mean of all past and current values up to time "t" for variable X, and I_t is all available information up until time t (Kirchgassner et al., 2013). Putting this equation into words: if removing information found in X_t from all available information at the time selected results in a larger forecast error variance than only using all available information to predict future values of Y, then X is Granger causal to Y. Variable X Granger causes Y because information held by X_t improves the predictability of future Y values.

A second definition Granger (1969) used for causality is instantaneous Granger causality. Instantaneous Granger causality is when future values of Y are better predicted when considering past, current, and future values of X (Granger, 1969). This is represented as:

$$\sigma^2(Y_{t+1} \mid \{I_t , X_{t+1}\}) < \sigma^2(Y_{t+1} \mid I_t)$$

Translating this equation into words, if only considering all available information up until selected time t results in a larger forecast error variance when predicting Y than when also considering future values of X, then X is instantaneously Granger causal to Y (Kirchgassner et al., 2013).

The third definition of causality according to Granger (1969) is feedback between X and Y. In feedback causality, X causes Y and Y causes X. A feedback effect can be determined if the null hypothesis can be rejected in both directions (Kirchgassner et al., 2013). More

specifically, the null hypotheses "X does not cause Y" and "Y does not cause X" are both rejected.

Thus far, only one lagged period has been represented in equations presented when discussing Granger causality. The Granger causality test, however, is not restricted to using only a single lagged variable. Multiple lagged values can be used for both variables when testing for Granger causality. Below are representations of historical values for X and Y, with "k" representing the total number of lagged values:

$$X = (X_t, X_{t-1}, X_{t-2}, Xt_{-3}, \ldots X_{t-k})$$

$$Y = (Y_t, Y_{t-1}, Y_{t-2}, Y_{t-3}, \ldots Y_{t-k})$$

In these equations, "t" stands for "time" and represents all observations of time up until that point. When the variable is followed by "t-1," that represents one lagged period in time for that variable. In other words, if observations are made monthly, then "t-1" represents the value of that variable one month prior to the current observation time of that variable, or "t." When the variable is followed by "t-2" the lag time is two months, and so on.

Not all historical values for X and Y are pertinent in determining Granger causality, so a process is used to determine which lagged values are to be included. The first step in the Granger causality test is lagging the dependent variable against itself (Southwick, 1997). This initial lag is represented as:

$$Y_t = \alpha + \alpha_1 Y_{t-1}$$

In this equation, "α" represents the estimated Y-intercept and the number that follows it represents the lagged observation period. After lagging the dependent variable against itself, a second lag is determined by regressing the dependent variable against two lagged versions of itself (Southwick, 1997). The second lagged version of the dependent variable is represented as:

$$Y_t = \alpha + \alpha_1 Y_{t-1} + \alpha_2 Y_{t-2}$$

The Akaike Information Criterion is used to assess if the equation with two lagged time periods provides additional information that better predicts the value of Y_t than the first equation with only one lagged version of the dependent variable (Judge et al., 1985). If the second lag adds predictive value and is statistically significant, then another dependent variable lag can be tested (Southwick, 1997). An F test is used to determine if lagged values are statistically significant (Kirchgassner et al., 2013). Only lags that are statistically significant are included in the analysis (Marvell & Moody, 1996). Once the number of lagged versions of the dependent variable with explanatory significance is determined, the next step is to add a lagged version of the causal variable to the equation. Adding a lagged value for the causal variable is represented as:

$$Y_t = \alpha + \alpha_1 X_{t-1} + b_1 X_{t-1}$$

If $b_1=0$, then there is no relationship between X and Y (Bachman & Paternoster, 2009). The Akaike Criterion is used to test if $b_1 X_{t-1}$ improves the predictability of Y_t (Southwick, 1997). If the lagged X value improves the predictability of Y_t and b_1 is statistically significant, then the null hypothesis (no relationship between X and Y) can be rejected. This result also means a second X lag can be tested to try improving the predictability of Y_t even further. The second X lag is represented as:

$$Y_t = \alpha + \alpha_1 X_{t-1} + b_1 X_{t-1} + b_2 X_{t-2}$$

If $b_2 X_{t-2}$ does not add to the predictability of Y_t, as determined by the Akaike Criterion, or is not statistically significant then the number of lags is limited to one for the X time series.

To test for reverse causation, or a feedback effect, the variables are switched in the equation (Kirchgassner et al., 2013). In other words, Y becomes the independent variable and X

becomes the dependent variable. The same steps outlined above are then repeated to test if Y is Granger causal to X. Once one Granger causal direction is established (in this case X → Y), the next step is to regress X against a lagged version of itself. This is represented as:

$$X_t = \alpha + \alpha_1 X_{t-1}$$

After the initial lag is established, X is regressed against two lagged versions of itself simultaneously:

$$X_t = \alpha + \alpha_1 X_{t-1} + \alpha_2 X_{t-2}$$

The Akaike Criterion is then used to determine if adding the second lagged version of X improves the predictability of X_t beyond only using the initial lag. If $\alpha_2 X_{t-2}$ does not add information or is not statistically significant, then no further lagged versions of X need to be tested. After the number of appropriate lagged versions of X are established, then lagged values of Y are considered. This is done be regressing a lagged version of Y against X, which is represented as:

$$X_t = \alpha + \alpha_1 X_{t-1} + b_1 Y_{t-1}$$

If b_1 is statistically significant and $b_1 Y_{t-1}$ adds to the predictability of X_t, then the null hypothesis (Y does not cause X) can be rejected. In other words, Y Granger causes X. Since both tests revealed a Granger causal relationship in both directions, a feedback effect is present. Both equations together can be represented as:

$$\sigma^2(Y_{t+1}) < \sigma^2(Y_{t+1} \mid I_t\text{-}\bar{x}_t) \cap \sigma^2(X_{t+1}) < \sigma^2(X_{t+1} \mid I_t\text{-}\bar{y}_t)$$

Although commonly critiqued as only being a bivariate test, in actuality the Granger causality test has capabilities beyond two-variable analysis (Eichler, 2012). In defining causality, Granger (1969) noted X has a causal relationship with Y when X provides predictive

information for Y that is not found in all other information in the universe. These two information variables are represented as:

I(t)…all information up to the designated time

I-x(t)…all information excluding that held by X values up to the designated time

Eichler (2012) pointed out the practical limitations of the abstract nature of "I(t)." For practical purposes, another measurement of other possibly influencing factors needed established. A vector labeled "Z" can be used to encompass possible explanatory variables for changes in Y (Patriota, Sato, & Achic, 2014). Since only lagged X and Y values are being considered in the test, whether Z variables are endogenous or exogenous will not matter (Kirchgassner et al., 2013). Expanding Granger causality beyond two variables can be represented as:

$$Y_t \perp\!\!\!\perp X_{t-1} \mid (Y_{t-1}, Z_t)$$

This equation translates to: Y is independent of the history of X when the history of Y and variables encompassed in vector Z are considered. The findings section of this paper will detail the number of appropriate lagged values and whether Granger causal relationships were found in both directions for the variables being tested.

The Granger causality has been criticized for having its limitations, but these limitations have ways of being addressed. One criticism of the Granger causality test is the influence of variables unaccounted for in the model (Russo, 2009). Marvell and Moody (1996) addressed this potential issue by using proxy variables for omitted lag effects. Kovandzic and Marvell (2003) also controlled for five potentially causal variables when testing for a concealed handgun permits-crime relationship using the Granger causality test. A second criticism towards the Granger causality test is that when more lags are added to the model making it more complex,

lagged values may become endogenous themselves and correlated with error terms (Zohoori & Savitz, 1997). This concern is minimized in the present study by restricting the number lagged values included to only those that have explanatory power at a statistically significant level.

Another criticism towards the Granger causality test is it assumes a linear relationship (Eichler, 2012). Tests have been developed to test for nonlinear Granger causality, but their application is limited to small-scale models (Eichler, 2012). An additional criticism of Granger causality is that it underestimates contemporaneous relationships between the two key variables (Eichler, 2012; Marvell & Moody, 1996). The instantaneous Granger causality test (Granger, 1969) addresses this issue. Nonetheless, this concern is not applicable to the present study because of the unavoidable delays in the HCP application process. Lastly, the Granger causality test has been criticized for over-anticipating the causal relationship between two variables (Marvell & Moody, 1996; Russo, 2009). This is unlikely a problem for the present study because it would imply people are applying for HCPs in anticipation of local violent crime increasing.

CHAPTER 3:

RESULTS

The dependent variable in this study was monthly HCP application rates at the county-level. From 2008 through 2012, counties in Tennessee averaged 188.55 HCP applications per month (See Table 4). Statewide, HCP application rates peaked in April 2009; however, overall monthly HCP application rates were highly volatile over the five-year study period in Tennessee (see Figure 1). Independent variables in this study included nationally publicized mass murders and local violent crime rates. With the exception of February 2008, in which three separate mass murders occurred, there was never more than one nationally publicized mass murder in a month from 2008 through 2012. There were a total of 17 nationally publicized mass murders during this study period. The number of victims in these nationally publicized mass murders ranged from four to 27. The majority of incidents (n=11) had between four and six victims, and only three incidents had 10 or more fatalities (see Table 3).

There were substantial variations in frequencies for local violent crimes from 2008 through 2012 (see Table 4). Murder was the least common crime during the study period with an average of less than 0.50 incidents per 100,000 residents. Forcible rape and robbery were also both relatively rare events averaging 2.00 and 3.65 incidents per 100,000 residents, respectively. The most frequently occurring local violent crime during the study period was aggravated assault, which averaged more than 27 incidents per 100,000 residents. The second most common crime in this study was motor vehicle theft with 14.62 incidents per 100,000 residents.

Bivariate regression results showed that the severity of all nationally publicized mass murders was statistically significantly and positively related to HCP application rates, but the variable indicating the occurrences of all nationally publicized mass murders was not

significantly related to HCP application rates (see Table 5). Of the five local crimes that were tested, the only statistically significant bivariate relationship was between motor vehicle theft rates and HCP application rates, in the negative direction (see Table 5). All six control variables had statistically significant associations with HCP application rates in bivariate regression models (see Table 5) which suggests that all were appropriate to include in multivariate regression models.

Bivariate regression results for the occurrence of each nationally publicized mass murder against HCP application rates revealed a statistically significant relationship for 13 of 17 incidents. Seven of the 13 significant incidents were positively correlated with HCP application rates while the remaining six incidents were negatively related to HCP application rates (see Table 6). For the severity of each nationally publicized mass murder, the same 13 incidents were statistically significantly related to HCP application rates and in the same directions as their corresponding occurrence variables (see Table 7).

During multivariate model development, the variables were tested for collinearity. Collinearity concerns were present when using the same model to test the occurrence of individual nationally publicized mass murders and individual mass murder severity variables. To correct for this issue, individual mass murder incidents were tested in a separate model from the incidents' corresponding individual severity variables. For aggregated nationally publicized mass murder variables, confounding effects were avoided by testing occurrence and severity variables separately. In total, four separate multivariate regression models using generalized estimating equations and exchangeable correlation structures were used to test whether local violent crime rates and the occurrence of nationally publicized mass murders were associated

with HCP application rates. See Tables 8, 9, 10 and 11 for variance inflation factors for these models.

Model 1 examined the effects of the occurrence of all nationally publicized mass murders, local murder, forcible rape, robbery, aggravated assault, and motor vehicle theft rates on HCP application rates, in addition to controlling for unemployment, income per capita, law enforcement, race, educational attainment, and HCP law changes (see Table 12). The variable representing all nationally publicized mass murders ($\beta = 4.08$, $p = 0.029$) was statistically significantly and positively related to HCP application rates. Aggravated assault ($\beta = 0.17$, $p = 0.012$) and motor vehicle theft ($\beta = -0.28$, $p = 0.005$) were the only two local crime rates statistically significantly related to HCP application rates. Local aggravated assault rates were positively associated with HCP application rates while local motor vehicle theft rates were negatively related to HCP application rates. In Model 1, there were four control variables found to have statistical significant relationships with HCP application rates. Both unemployment rates ($\beta = 14.00$, $p < 0.001$) and changes in laws pertaining to HCPs ($\beta = 14.48$, $p < 0.001$) were positively associated with HCP application rates. Because income per capita ($\beta = -6734153$, $p < 0.001$) was expressed in the model as its inverse, results actually estimated a positive correlation with HCP application rates. The percent of county populations who identify themselves as Black or African American ($\beta = -16.98$, $p < 0.001$) was negatively associated with HCP application rates.

Model 2 tested whether the severity of nationally publicized mass murder, five local crime rates, and six control variables were correlated with HCP application rates (see Table 13). The severity of all nationally publicized mass murders ($\beta = 4.09$, $p < 0.001$) was significantly and positively associated with HCP application rates. Again, local aggravated assault rates were

positively correlated with and motor vehicle theft rates were negatively correlated with HCP application rates. Unemployment rate, income per capita, race, and law changes were all statistically significantly related to HCP application rates and in the same directions as the previous model.

Model 3 regressed rates of local murder, forcible rape, aggravated assault, robbery, motor vehicle theft, individual instances of nationally publicized mass murders, and six control variables against HCP application rates (see Table 14). Unlike the two previous models, local aggravated assault and motor vehicle theft rates were no longer estimated to be statistically significant predictors of HCP application rates. No category of local violent crime had a statistically significant correlation with HCP application rates. Of the 17 mass murder incidents that were tested, 12 were statistically significant in relation to HCP application rates. However, six incidents revealed a positive association and six incidents revealed a negative association with HCP application rates. In additional to the same four control variables being statistically significant as prior models, educational attainment ($\beta = -115.70$, $p = 0.035$) was significantly and negatively related to HCP application rates.

Model 4 examined whether local murder, forcible rape, aggravated assault, robbery, motor vehicle theft rates, and the severity of individual nationally publicized mass murders, as well as six control variables were related to HCP application rates (see Table 15). Similar to Model 2, no local violent crime rates were statistically significantly correlated with HCP application rates. The severity variables for 12 of the 17 nationally publicized mass murders were significantly associated with HCP application rates. Six severity variables were positively related and six severity variables were negatively related to HCP application rates. These 12 statistically significant individual severity variables and their directional association with HCP

applications matched their corresponding occurrence variables in Model 3. Coinciding with results from Model 3, unemployment rate and changes in HCP-related laws were estimated to be positively associated with HCP application rates at a statistically significant level. Inverse income was negatively and significantly related to HCP application rates, meaning that as income increased, HCP application rates also increased. Finally, race and educational attainment were both statistically significantly related to HCP application rates in the negative direction.

There were consistencies in the results from the four statistical models that were tested. In each model, no significant relationship was found between local rates of murder, forcible rape, or robbery and HCP application rates. Results for four control variables were also consistent across each model tested. Unemployment rates, HCP-related law changes, and income per capita were found to be positively associated to HCP application rates, while the percentage of a county's Black or African American population was estimated to have a negative effect on HCP application rates. The only control variable not found to be statistically significantly related to HCP application rates in any of the four models was law enforcement officers per 100,000 residents.

Discrepancies in the results were found between models with the aggregated mass murder variables and models with the disaggregated nationally publicized mass murder variables. One variation in results was whether estimates for local aggravated assault and motor vehicle theft rates met the significance threshold. When the occurrence and the severity of nationally publicized mass murders were controlled for collectively, local aggravated assault and motor vehicle theft rates were statistically significantly related to HCP application rates; however after controlling for the occurrence and severity of nationally publicized mass murders individually, these crimes were not significant. The second difference found was the effect of educational

attainment on HCP application rates. In Models 1 and 2, educational attainment was unrelated to HCP application rates. However, in Models 3 and 4, educational attainment was statistically significantly and negatively associated with HCP application rates.

Granger Causality Test

The Granger causality test was used to test for the lagged effects of local crime rates on HCP application rates and to examine possible endogeneity. Three counties were individually examined using the Granger causality test and were selected based on population. Relative to all counties in Tennessee, County 1 (Pickett County) had the smallest population, County 2 (Obion County) had the median population level, and County 3 (Shelby County) had the largest county population in the state. Four lagged values for each independent variable were tested to determine whether they improved the predictability of HCP application rates. Each lagged time value equated to one month. For example, two lags demonstrated the effects of a particular variable's value from two months prior on the current value of the dependent variable.

The first use of the Granger causality test in this study was to examine the effects of lagged rates for local murder, forcible rape, aggravated assault, robbery, and motor vehicle theft on HCP application rates. Results for the lagged effects of local crime rates on HCP applications varied across both county and type of crime (see Table 16). For County 1, none of the lagged crime values were statistically significantly associated with HCP application rates. The statistical software Stata omitted the murder rate variable from Granger causality results in County 1 due to collinearity. Murder rates were collinear in County 1 because no murders occurred in the county from 2008 through 2012. In County 2, there were no statistically significant crime values for the first two lags. The third and fourth lagged values of motor vehicle theft rates were statistically significant in improving the predictability of the dependent

variable. Additionally, for County 2, all five crimes taken as a whole were significant in improving the predictability of HCP applications in both the third and fourth lags. For the first three lagged periods in County 3, no crime was estimated to have a statistically significant relationship with HCP application rates. The fourth lagged values for motor vehicle theft rates and all local crimes collectively were found to have a significant effect on HCP application rates in County 3.

The Granger causality test was also used to examine whether endogeneity occurred between the dependent and independent variables. Similar to the results of the lagged effects of local crime on HCP applications, results when testing for reverse relationships also varied across county and crime. In these tests, HCP application rates were the independent variable and each type of local crime rate served as the dependent variables. Stata again omitted the murder rate variable in County 1 due to collinearity. None of the first three lagged HCP application rates were estimated to improve the predictability of any local violent crime rates. For County 1, the only significant lagged value of HCP application rates when predicting local aggravated assault rates was its fourth lag (see Table 17). In County 2, neither one-month nor three-month lagged values of HCP application rates were statistically significant in improving the predictability of any of the five local crimes examined. The second lagged value of HCP application rates, however, was statistically significant in improving the predictability of motor vehicle theft rates. The fourth lag of HCP application rates was statistically significantly related to local murder and aggravated assault rates in County 2 (see Table 18). Consistent with the two previous counties, a one-month lag of HCP application rates in County 3 was not found to have a statistically significant association with any category of local crime rates. The second and third values of HCP applications were significantly related to local murder rates. Additionally, the third and

fourth lags of HCP application rates were statistically significantly associated with local forcible rape rates (see Table 19).

CHAPTER 4:

DISCUSSION

The purpose of this study was to determine whether violent crime rates and/or the occurrence of nationally publicized mass murders were associated with the relatively recent and drastic increases in handgun carrying permit (HCP) applications. Previous research has relied on annual crime rates and concealed handgun permit issuance data to test for a possible relationship between the two variables. However, past research has primarily focused on the effects of HCP laws, and in some cases permits, on crime and not whether crime influences HCP application rates. Through the use of monthly, county-level violent crime and HCP application data in Tennessee from 2008 through 2012, this study tested whether local violent crime rates and the occurrence of nationally publicized mass murders influenced HCP application rates. Lagged crime effects and endogeneity were both considered in this study through the use of the Granger causality test. Results for aggravated assault in two models was the only evidence found supporting the hypothesis that local violent crime rates are positively related to HCP application rates. Empirical support was found for the second hypothesis in this study that nationally publicized mass murders are associated with HCP application rates.

Local Violent Crime Rates

Estimates for local aggravated assault rates partially supported the hypothesis, while no other crimes were found to have the hypothesized relationship with HCP application rates. It is surprising that rates of homicide, a serious crime that people are arguably likely to be made aware of through local news or social networks, had no discernable impact on HCP application rates. One possible reason no relationship was found may be due to homicide being a relatively rare event in this study. Specifically, there were 2.40 murders per 100,000 residents annually

statewide during the study period. Furthermore, 31 counties experienced less than one murder per year during that same timeframe. There simply may not have been enough murders for people to perceive a need for HCPs because of them. Another possible explanation for this null finding may pertain to victim characteristics. For example, Pizarro, Zgoba, and Jennings (2011) found that over three-fourths of homicide victims in Newark, NJ had criminal or deviant lifestyles. If the public perceives that these victim characteristics are applicable to Tennessee, it may suggest that potential HCP applicants do not anticipate their lifestyles leading them to criminal encounters that could result in homicide. Also, because homicide victims largely have criminal or deviant pasts consisting of violence or drug activity (Pizarro et al., 2011), those most likely victimized by the crime may be legally prohibited from reacting to changes in homicide rates by acquiring HCPs.

Possible discrepancies between the public's perception of crime and actual crime rates may explain why some local violent crime rates were found to be unrelated to HCP application rates. O' Connell and Whelan (1996) found the public's perception of crime was independent of official crime statistics. Instead of actual crime rates, the portrayal of crime in the media may be more influential in shaping public perception and contributing to the public's overall awareness of local crime. Indeed, past research suggests a link between newspaper readership and how individuals perceive crime in their community (O' Connell & Whelan, 1996). Additionally, Hanslmaier (2013) found fear of victimization among people who read local newspapers was positively related to county crime rates while those who did not read local newspapers were unaffected by changes in local crime rates.

Fear of crime or victimization has been found to be influential in defensive gun ownership (Hauser & Kleck, 2013; Smith & Uchida, 1988), which may be constructed by the

media. More specifically, media coverage may explain why local forcible rape rates were found to be unrelated to HCP application rates. At times, media has been found to portray rape victims in a way that generates feelings of victim blaming or perpetuates rape myths, both ultimately diminish the significance of the crime (Merz & Miller, 2009). If the victim is viewed as being at least partially responsible for the crime, it may be possible that the crime may not increase the public's fear of victimization and therefore is not associated with defensive gun behavior (Smith & Uchida, 1988), such as applying for HCPs. Another possible explanation for a lack of relationship between local rates of forcible rape and HCP applications may be related to what types of rapes get reported in the media. It is possible that serial rapists, of which there were at least three in Tennessee during the study period, may be more important to HCP application rate trends than actual local forcible rape rates. For example, the presence of a serial rapist may be reported more prominently in local media than general rape rates and may increase the public's sense of vulnerability to rape in a way general rates may not.

Kovandzic and colleagues (2005) hypothesized that robbery was the violent crime most likely to be affected by right-to-carry laws because it most often occurs in a public setting. However, results from the present study align with those of past research (Kovandzic et al., 2005) that found people are unlikely to react to increases in reported robbery rates by seeking HCPs. It is possible that relatively few people followed the local news to be aware of fluctuations in robbery rates (see Figure 2) causing them to perceive themselves as more likely to be victimized and have greater fear of crime. Awareness of spikes in local robbery rates and heightened feelings of potential victimization may have led to defensive gun behaviors. Conversely, it could be that the population does not view the defensive gun carrying allowed by HCPs as a viable strategy for avoiding robbery victimization.

Because conflicting findings for local aggravated assault rates are highly tied to model specification, specifically how nationally publicized mass murders were modeled, no firm conclusions can be made about the crime's relationship with HCP application rates. An examination of statewide aggravated assault rates over the study period suggests that the offense is subjected to the affects of seasonality (see Figure 3). The fluctuations in aggravated assault rates generally do not match changes in HCP application rates from 2008 through 2012 in Tennessee (see Figure 1), however, this suggests that modeling seasonal changes would not lead to an increase in the explanatory power of the model. If people react to increased local aggravated assault rates by applying for HCPs, it may be due to aggravated assault being the violent crime in which people are most likely victimized by in this study. In contrast, if people do not respond to increased rates of local aggravated assault it may be because they were unaware of changes in its frequency.

Finally, results were also inconclusive for whether motor vehicle theft rates were associated with increased HCP application rates. The fact that victims of motor vehicle theft are not typically present when the offense occurs may explain both sides of this study's contradictory findings. Specifically, carjacking is the only form of motor vehicle theft where victims are present, but only accounts for approximately two percent of motor vehicle thefts (Bureau of Justice Statistics, 1994). If motor vehicle theft rates are negatively related to HCP application rates, this may suggest that people are investing in defensive strategies other than HCPs that are more suited to combating motor vehicle theft. In other words, the public may perceive that the victim is not likely to be present when a motor vehicle theft occurs, and therefore may not view gun carrying as an effective protective measure against it. Similar to other violent crimes, public perception may explain why HCP application rates were unrelated to

motor vehicle theft rates. Grohe, DeValve, and Quinn (2012) found that the public perceived itself as unlikely to be victimized by an auto-related crime; a perception that did not accurately reflect the actual prevalence of that crime in the city.

Nationally Publicized Mass Murders

The second hypothesis in this study was that HCP application rates are positively influenced by the occurrence of nationally publicized mass murders. Nationally publicized mass murders collectively, as well as six incidents individually, were statistically significant predictors of HCP application rates in the hypothesized positive direction. Counterintuitively, six nationally publicized mass murders had statistically significant negative relationships with HCP application rates. Given that previous evidence has suggested gun sales and defensive gun activity spike following mass murders (Feldmann, 2012; Wahba & Forsyth, 2012), there is no reasonable explanation as to why HCP application rates would decrease as the result of such an event. These findings altogether point to omitted variables influencing HCP application rates.

Further supporting the notion of omitted variables being influential in this study was the overall volatility of HCP application rates over the study period. Evidence suggests that the volatility of HCP application rates during this time period was not unique to Tennessee. Trends in concealed handgun permit application rates in Colorado generally reflected the same drastic fluctuations that Tennessee experienced from 2008 through 2012 (see Figures 1 and 4). Rates of concealed handgun permits in Kansas also revealed volatility on a monthly basis. Contrary to Tennessee and Colorado, however, results for Kansas showed a more consistent and generally upwards trend in concealed handgun permits during the same five years (see Figure 5).

Volatility was also evident in overall gun demand, as shown by National Instant Criminal Background Check System (NICS) statistics on record-setting firearm background check

requests. Two mass murders, each with four victims, occurred on February 20, 2014 (outside of the study period). These two incidents may have contributed in some degree to the number of requests for gun purchasing background checks submitted to the NICS in the ensuing three consecutive weeks that were among the top ten weeks for most requests since 1998 (FBI, 2014). Both the week of and the week following the mass murder in Newtown, CT that left 27 people dead were among the top ten highest weeks for NICS background check requests. Interestingly, two weeks (February 4th-10th, 2013 and February 11th-17th, 2013) among the highest total background check requests were from a month without the occurrence of a mass murder in the United States. In short, these statistics suggest that other factors in addition to the occurrences of mass murders contribute to the volatility of overall gun demand.

A host of factors not examined in this study may have had mediating effects on whether nationally publicized mass murder variables were statistically significant predictors of HCP application rates. Examining detailed characteristics of mass murder incidents could increase our understanding of the influence of those mass murders on HCP application rates. No consistent patterns emerged when examining available demographic characteristics of mass murder victims from incidents in this study, gathered from online newspaper reports. For example, HCP application rates were statistically significantly and positively influenced by the January 2011 mass murder of all white victims in Tucson, AZ. All victims in the Parkland, WA November 2009 mass murder were white, but, in this case, HCP application rates did not have a statistically significant relationship with the incident, either positive or negative. Inconsistencies also existed when using incidents where victims were racial minorities to predict whether HCP application rates were affected by nationally publicized mass murders. HCP application rates were estimated to increase in response to the April 2009 Binghamton, NY and August 2012 Oak

Creek, WI mass murders in which the majority of victims were minorities. Victims in Oakland, CA of the April 2012 mass murder were also racially diverse, but HCP application rates were found to be unrelated to this incident. In short, examining the racial composition of the mass murder victims does not appear to add value to predicting HCP application rates.

Considering the socioeconomic setting of where the mass murder occurred did not reveal a noticeable trend in predicting HCP application rates. Carthage, NC was the location of a nationally publicized mass murder in March 2009 and classified as a lower middle class area (Zip Data Maps, 2014). This incident was statistically significantly and positively associated with HCP application rates. A similar middle class characterization was given to Medford, NY, the site of the June 2011 mass murder that ended with four people dead. The relationship between this incident and HCP application rates was also statistically significantly but in the opposite direction. Taking into account the economic prosperity of the city where a mass murder occurred does not initially appear to enhance the predictability of HCP application rates. In short, factors beyond mass murder victim characteristics or a city's level of economic prosperity were likely affecting HCP application rates. It is possible that characteristics of the mass murders, from victim race and age to perpetrator motivation to socioeconomic status of the geographic area, interact to have an effect on HCP application rates. Given the small number and variability of mass murders, these interactions cannot be tested.

The date when nationally publicized mass murders occurred may explain some of the larger estimated relationships, negative and positive, between the incidents and HCP application rates. The first nationally publicized mass murder that was significantly and negatively related to HCP application rates, the February 2008 mass murders with a total of 16 victims, occurred early in the study period (see Figure 6). Monthly HCP application rates in the first year of the

study were generally lower than they were in the following four years. HCP application rates in the first year of this study may have been unusually low and caused the negative correlation between the two variables. The three nationally publicized mass murders that occurred in February 2008, however, did not correspond with higher HCP application rates than months without mass murders within that same year.

The extent of certain positively estimated relationships between certain mass murders and HCP application rates may have been inflated due when the incident occurred. The largest positive coefficient for HCP application rates significantly affected by a nationally publicized mass murder was the April 2009 incident in Binghamton, NY (see Table 14). This incident happened only five days after a positive and significant March 2009 nationally publicized mass murder in Carthage, NC. These incidents had corresponding fatality counts of 8 and 13, and both severity variables were statistically significant. Due to closeness in temporal proximity, it is possible a spillover effect from the previous month magnified the estimates of the next mass murder on HCP application rates.

Despite discrepancies in the overall findings, there is evidence that suggests that nationally publicized mass murders may influence HCP application rates. First, the three incidents with the highest number of victims, December 2012 in Newtown, CT (27 victims), April 2009 in Binghamton, NY (13 victims), and July 2012 in Aurora, CO (12 victims) were statistically significantly and positively related to HCP application rates. These three mass murders were the only incidents in this study that had greater than 10 fatalities. Second, in terms of publicity, the three mass murders that received arguably the most attention over the five-year study period were January 2011 in Tucson, AZ, July 2012 in Aurora, CO, and December 2012 in Newton, CT. All three of these incidents were found to be statistically significantly and

positively associated with HCP application rates. These findings suggest that fatalities and the intensity of national media coverage may be important considerations when predicting changes in HCP application rates following these events.

Granger Causality Test

The Granger causality test was used to determine whether lagged independent variables influence HCP application rates and whether an endogenous relationship between violent crime and HCP application rates existed in this study. No consistent evidence was found demonstrating either effect was present. Variations across counties, crimes, and lagged values in relation to HCP application rates suggest that within-state heterogeneity existed.

Although variations existed across county and crime, a few notable results were found when examining the effects of lagged crime variables on HCP applications. First, none of the three counties tested had a statistically significant crime rate associated with HCP application rates in the first two lagged periods. Coupled with findings from the previous multivariate regression models, this suggests that HCP application rates were not affected by the local violent crime rates in the current or the two previous months, with the possible exception of aggravated assault. Second, in two of the three counties, the fourth lagged values of motor vehicle theft rates and all five crimes together were statistically significant in relation to HCP application rates. This finding suggests that it is possible that individual types of local crime may not alter HCP application rates, but various types of local crime collectively over time may result in changes in HCP application rates. Lastly, the type of crime that had the relatively most frequent statistically significant values was motor vehicle theft rates; however, its significant values were not evenly distributed across counties or lags. As a whole, accounting for the effects of lagged local violent crime rates did not appear to improve the predictability of HCP application rates.

Similarities emerged when examining reciprocal relationships between local violent crime rates and HCP application rates. First, in all three counties a one-month lag of HCP application rates did not have a statistically significant relationship with any type of crime. This finding intuitively makes sense because HCP applications typically take at least one month to be processed and issued, if approved. Second, none of the four lagged HCP application rate values had a significant relationship with local robbery rates, which was the crime hypothesized to be most likely affected by HCPs (Kovandzic & Marvell, 2003). Examining the reverse relationship generally showed that endogeneity was not likely a threat to the statistical models used in this study. There was only partial evidence suggesting that HCP applications influence certain types of crime, but outcomes were not consistent across counties or lags. It is important to note that lagged HCP application rates did not have homogenous effects across all three counties or any category of local violent crime.

Control Variables

Overall, results from this study suggests HCP application rates are greater in counties with higher unemployment rates, higher income per capita, larger white populations, and less college educated residents. Results for unemployment rates align from a theoretical perspective with past research suggesting increased unemployment rates are positively linked to perceived potential for crime (Cantor & Land, 1985). Estimates from this study suggesting HCP applications are more prevalent in higher income areas and areas with smaller minority populations are consistent with previous research (Hood & Neeley, 2000). Contrary to Hood and Neeley (2000), however, this study found a significant and negative relationship between educational attainment and HCP application rates.

Changes in state laws pertaining to HCPs were also consistently positively related to HCP application rates. After the first law was enacted in 2009, the lessened restrictions or burdens on HCP holders were estimated to increase HCP application rates. This finding that firearm legislation affected gun-related activity is not a novel one. Past research has found that changes in national gun laws have impacted gun demand (Koper & Roth, 2002). An important implication drawn from this finding is that gun legislation has the potential to change gun-related activity.

The final control variable in this study, law enforcement officers per 100,000 residents, was not statistically significantly correlated with HCP application rates in any model. This lack of relationship is in contrast with previous literature that established an inverse relationship between community confidence in police and defensive gun behaviors (Gau, 2008; Smith & Uchida, 1988). Gau (2008) found that perceptions of local police were more influential in fear of victimization than actual crime rates. If police are considered ineffective, then people may rely on other measures for protection. Because this study did not measure perception of police, this possible effect on HCP application rates was unable to be determined.

Theory and Policy Implications

Drawing on criminological theory may further enhance our understanding of this study's results. Drawing on routine activities theory, the presence and possible presence of HCPs have been argued to enhance people's guardianship capabilities (Schwaner et al., 1999). Evidence was found suggesting that HCPs may have been expected to help strengthen guardianship in response to increased local aggravated assault rates; however, contradictory findings makes this theoretical relationship less certain. Although results were not unanimous, partial evidence

suggests that using HCPs as guardians may have decreased in response to increased rates of local motor vehicle theft.

There was evidence that suggests certain nationally publicized mass murders may cause more people to apply for HCPs as a means of increasing guardianship. Lethality and media coverage for some nationally publicized mass murders may invoke the public's perceived need to increase guardianship through personal defensive gun activities. This argument, however, does not extend to nationally publicized mass murders that were estimated to decrease HCP applications rates. As previously discussed, omitted factors were likely influential on all nationally publicized mass murder variables.

Results for unemployment rate and law enforcement variables also have larger implications based on the routine activities perspective. From 2008 through 2012 in Tennessee, it appears that the public associated higher unemployment rates with a larger number of motivated offenders causing them to react defensively by applying for HCPs. Pertaining to the role of law enforcement, results from this study may suggest that the mere presence of police does not generate capable guardianship from the public's perspective and that police per capita does not mediate the likelihood of people seeking HCPs.

Results from this study also have larger implications from a rational choice perspective. Increased HCP application rates in response to local aggravated assault rates and certain mass murders may suggest that applicants assume potential offenders would be aware of the increasing number of people potentially acquiring HCPs. The increasing number of HCP applications also suggests that applicants may expect potential offenders associate an increased presence of HCPs in their county with higher risks when contemplating engaging in future crimes.

Policy issues pertaining to gun control and gun rights are often controversial, but there are important policy considerations that can be drawn from the results of this study. Vernick, Hodge, and Webster (2007) noted the push and pull between individual freedom and the rights of society collectively when determining firearm policies. This study was ecologically focused, meaning the purpose of this study was not to determine why individuals apply for HCPs in response to local crime or nationally publicized mass murders. Miles-Doan (1998) posited environmental characteristics effect levels of violence. Through a macro-level approach, this research examined if the public's general reaction to these events was manifested through greater demand for HCPs. It is important to study this issue from an ecological perspective because the risks associated with handgun carrying do not only apply to the individual, but extend to others in society as well (Vernick et al., 2007). Carrying guns in public has the potential to create situations where an individual exercising personal freedom is compromising the safety and well-being of others. Because society inherits physical risks (Fox & DeLateur, 2013) and sustains psychological tolls (Hemenway et al., 2001) when people carry guns in public, gun carrying policy should require that people demonstrate a compelling need for HCPs. This policy recommendation aligns with "*may-issue*" laws, which currently exist in nine states (Law Center to Prevent Gun Violence, 2012). A "*may-issue*" policy requires an applicant to justify a need for carrying a handgun in public (Vernick, 2013).

The difference between how "*may-issue*" and "*shall-issue*" policies impact the number of people with concealed handgun permits is demonstrated by a recent policy change in Iowa. In 2011, Iowa went from having a "*may-issue*" policy on concealed handgun permits to a "*shall-issue*" policy on concealed handgun permits (Love, 2012). One year after loosening restrictions, Iowa experienced a 154% increase in the number of people with concealed handgun permits

(Love, 2012). According to standards of "*may-issue*" policies, this drastic increase in Iowa likely means that there is now a large portion of citizens carrying handguns in public without valid justifications.

In addition to justifying a need for carrying handguns in public, HCP applicants should also be required to complete appropriate training prior to receiving their permits. Currently, slightly over half of states issuing concealed handgun permits require applicants to complete some type of training (Law Center to Prevent Violence, 2012). Because of the physical harms that could potentially be imposed on innocent bystanders, it is reasonable to require HCP applicants to prove knowledge and proficient use, including live-firing, of handguns they would be carrying. Also due to the seriousness of gun violence, HCP applicants should be required to complete safety courses to ensure that the responsibilities accompanying gun carrying in public are well-known and respected.

When applying for HCPs, people should be made aware of the personal risks inherited by gun carrying, as wells as the harms they impose on others. For example, people should be alerted of the increased lethality of situations involving firearms (Vernick et al., 2007; Wintemute, 2008) prior to completing the HCP application process. To address the effects of nationally publicized mass murders on HCP application rates, informational campaigns should enlighten the public about the infrequency of such incidents (Fox & DeLateur, 2013) and that HCPs are not necessarily the most effective way of reducing future mass murders. In sum, relaying pertinent information to the public could be used to help prospective HCP applicants recognize the personal and societal costs associated with carrying handguns in public.

Future Research

There are a plethora of avenues for future research on HCPs. First, this study did not differentiate between effects of the actual mass murders on HCP applications versus effects of the often-polarizing gun control debates that sometimes follow mass murders. Evidence has shown that debates over gun control are often sparked by mass shootings (Duwe, 2000) and can drive demand for guns and ammunition (Wahba & Forsyth, 2012). This may have confounded results if it was actually the presence or absence of a national gun control debate that drove HCP application rates. Future research should develop an appropriate measure of gun control debate or perceived threats to gun rights that may help make the distinction as to whether applying for HCPs is a response to the occurrence of mass murders or a response to the intensified focus on gun control following an incident.

On the state level, legislative changes and debates also need to be considered when examining factors potentially associated with HCP application rates. Changes in gun legislation have been found to affect demand for firearms and prices for such weapons (Koper & Roth, 2002). Although this study controlled for the five laws pertaining to HCPs that were enacted in 2009, it is possible that other legislative-related issues may have also had an impact. Regardless of whether laws were passed, additional legislative debates on HCP rights intensified at various points throughout this study's time frame (Tennessee Firearms Association, 2009). The National Rifle Association's (NRA) intervention into Tennessee state politics and successful campaign to replace a state representative who opposed NRA-backed legislation (Locker, 2012) is another example of a possible influential political factor not captured in this analysis. Because gun control debates and legislation on the national level have been found to influence gun demand (Ingram, 2012), it is reasonable to suspect that the same issues on the state level may produce

similar effects. It is important that future research include measures of the political environment and debate surrounding guns at the national, state, or even local levels in assessments of correlations with HCP application rates.

Accurately representing monthly HCP application rates is critical to determining whether changes in such rates are in response to fluctuations in local violent crime rates or the occurrence of nationally publicized mass murders. Application rates were determined by combining HCP issuance and denial data, and lagging that information by two months. A two-month lag was chosen because the average HCP processing time during the five-year study period was 43.18 days; however, the monthly average number of days for HCPs to be processed varied greatly. The standard lag value of two months was chosen after it was determined that using different lag values based on average processing time for each month would have resulted in overlapping HCP application values for some months and gaps for others. Obtaining daily HCP application rates data would strengthen the accuracy of the variable in future statistical analyses.

An additional challenge in terms of determining the appropriate length of HCP application lags was due to the timing of certain nationally publicized mass murders. For mass murders that occurred near the end of the month, it was possible that a number of HCP applications filed in response to that incident did not happen until the following month, and thus failed to be adequately captured by the current dependent variable. Of the 17 mass murders included in this study, the three incidents most likely to have been affected by this because each occurred within four days of the end of the month. The March 2009 and September 2012 mass murders were tested in the actual month in which the incidents occurred. The March 2009 mass murder in Carthage, NC was positively related to HCP application rates at a statistically significant level, while the September 2012 incident in Minneapolis, MN was found to be

unrelated to HCP application rates. The November 2009 mass murder in Parkland, WA occurred just one business day prior to the end of the month and was tested in the following month. After adjusting the month, HCP application rates were not statistically significantly associated with this event. Daily data would minimize concerns regarding the effects of mass murders on HCP application rates spilling over into another observation period.

Future research should also reconsider how best to operationalize the concept of "nationally publicized" when classifying mass murders. Although three of the most popular online news sources were used in this study to determine whether a particular mass murder received national attention, this measurement was not comprehensive in terms of other mediums in which people obtain their news or the extensiveness of media coverage. For example, research has identified television as the most common way in which people obtain their news (Pew Research, 2012). People also get their news from other outlets including print materials, such as newspapers and magazines, and the radio. Additionally, an increasing number of people are getting their news through their cell phones and social media websites (Pew Research, 2012). A measure of "nationally publicized" would likely be more representative if it encompassed all different forms of news outlets. Furthermore, incorporating popular news sources particular to each state being examined into measures of publicity may help generate a more accurate depiction of the public's awareness of events outside of their own state. Beyond capturing various modes of news communication, it is also important to account for the intensity of media attention to a particular mass murder. Past research has noted that media attention to mass murders varies (Duwe, 2000). Given this possibility, it is reasonable to speculate that larger proportions or prolonged periods of media coverage dedicated to a particular mass murder may increase the likelihood of that incident influencing HCP application rates.

In this study, the severity of mass murders was measured strictly based on number of fatalities and not the overall number wounded. Oftentimes, the total number of people wounded in a mass murder differs drastically from the number of fatalities. For example, the mass murder in an Aurora, CO movie theater in 2012 left 58 people wounded in addition to 12 deceased. It is possible that considering the total number of people injured in a mass murder may enhance the predictability of HCP application rates over only considering the number of people killed in the incident. Furthermore, Duwe (2000) found that the number wounded in a mass murder was a strong predictor in the level of media coverage. Including the number of people wounded in future analyses may explain changes in HCP application rates through more people being aware of the incident via increased media coverage.

An assumption made in this study was that the effects of crime rates in one county did not spillover over into neighboring counties. Studies on crime displacement and diffusion of benefits demonstrate that spatial crime patterns do not adhere to abstractly established geographic borders, such as county lines. This limitation is challenging to overcome in quasi-experimental research. Media and technology has demonstrated the ability to connect people with distant events and influence their emotions (Duwe, 2000). In other words, knowledge of and reaction to events or crimes is not restricted to a narrowly defined geographic location. Methods of modern day communication make controlling for this effect in future studies difficult.

Caution should be used when interpreting the results from the Granger causality tests. Lagged and endogenous effects were examined for only three of the ninety-five counties in the study. For the purposes of this study, the Granger causality test was only used to determine whether lagged variable values and possible reciprocal relationships could have had intervening

effects in multivariate regression models. Although the three counties used were selected to represent a wide range of county populations, this is still only a small sample of the whole study population. More counties should be tested using the Granger causality test to improve the generalizability of the results from this study.

Future research should examine whether fear of crime is a better predictor of HCP application rates than actual local crime rates. Focusing on fear and perception of crime could utilize principles of social disorganization theory by considering structural influences on the community level that could mediate fear of crime. Past research has suggested that community level factors and social relationships may influence fear of crime (Porter, Rader, & Cossman, 2012), which may, in return, affect HCP application rates. Considering neighborhood characteristics may provide insight on mediating factors that could explain why people collectively resort to similar defensive behavioral tactics, such as applying for HCPs.

The present study did not differentiate among characteristics of HCP applicants. This presents another avenue for future research. Past research has found females to be more likely than men to own guns for primarily protective purposes (Cook & Ludwig, 1997). Future studies should test whether women are more likely to apply for HCPs when rates increase for crimes in which they are most likely victimized by compared to men, such as forcible rape (Brennan & Taylor-Butts, 2008). Being able to differentiate among populations who is more likely to apply for HCPs in response to various circumstances would allow interventions to more directed and steer people towards safer alternatives.

Lastly, future research should evaluate whether there are correlations between HCP application rates and local crime rates or nationally publicized mass murders in other states. Research has suggested that heterogeneity exists across ecological units when testing for the

effects of RTC laws (Rubin & Dezhbakhsh, 2003). Comparisons should be made among states based on, but not limited to, cultural influences. A more pro-gun culture in the south (Vernick et al., 2007) may make people more prone to apply for HCPs than other regions. Additionally, research should compare HCP application rates between "*shall-issue*" and "*may-issue*" states to determine whether laws alter the likelihood of people applying for HCPs following changes in local crime rates or the occurrence of nationally publicized mass murders.

Conclusion

Results were mixed regarding whether local aggravated assault rates are positively related to HCP application rates, while no evidence was found suggesting that local rates of murder, forcible rape, robbery, or motor vehicle theft were associated with HCP application rates. Whether HCP applications were a reaction to nationally publicized mass murders likely depends on the mass murder incident. It is likely that factors beyond the scope of this study were responsible for the mixed associations found between the two variables. In terms of structural characteristics, HCP applications were more prevalent in counties with higher unemployment rates, greater economic prosperity, smaller minority representation, and lesser proportions of college educated residents.

People who apply for HCPs in response to changes in local aggravated assault rates or certain nationally publicized mass murders may believe HCPs will allow them to exert increased guardianship. HCP applicants for these two categories of crime may also assume that potential offenders are rational and are aware of HCP prevalence, and that more HCPs increase the risks offenders consider when contemplating future criminal activity. The presence of guns in public could have potentially seriously injurious, or even lethal, outcomes. Because of the stakes involved with gun carrying, policies should require HCP applicants to have legitimate

justifications for doing so and restrict permits to only those who have demonstrated proficient knowledge and use of handguns, as well as handgun safety.

APPENDICES

APPENDIX A:

TABLES

Table 1: Changes in laws related to handgun carrying permits in Tennessee from 2008-2012

Enacted	Law	Description
April 27, 2009	*Handgun Information Privacy*	prohibits any safety course from requiring permit applicants to provide any identifying information about his or her handgun
June 12, 2009	*Handguns in Parks*	permits individuals with handgun carrying permits to possess a handgun in any state, county, or city park (with a few exceptions); local governments are allowed to legislate restrictions on local parks
June 12, 2009	*Loaded Rifles and Shotguns in Vehicles*	permits an HCP holder to have a loaded rifle or shotgun in his or her privately owned vehicle
July 1, 2009	*Orders of Protections*	requires anyone who has a protection order issued against him or herself to legally dispose of his or her firearms within 48 hours but once the order ceases to exist, the individual may continue carrying a firearm
July 9, 2009	*Guns in Refuges/Wildlife Areas*	permits an HCP holder to carry a firearm in a refuge area, public hunting area, wildlife management area, or on national forest land

*Information retrieved from Tennessee Department of Safety (2013)

Table 2: Descriptions of variables and their sources

Dependent Variable		
Variable	*Variable Description*	*Source*
HCP Application Rates	The number of monthly HCP applications per 100,000 residents by county	Tennessee Department of Safety and Homeland Security
Independent Variables		
Variable	*Variable Description*	*Source*
Violent Crime	The number of monthly reported murders, forcible rapes, aggravated assaults, robberies, and motor vehicle thefts per 100,000 residents by county; each category of crime was tested individually	Tennessee Bureau of Investigations
Mass Murder	The total number of qualifying mass murders in a month with 4 or more victims that occurred outside of the home and in the U.S.; coded as a count variable	USA Today
Control Variables		
Variable	*Variable Description*	*Source*
Unemployment Rate	Monthly unemployment rate by county	Bureau of Labor Statistics
Income per capita	The annual per capita personal income by county	Bureau of Economic Analysis
Law Enforcement	The annual number of law enforcement officers per 100,000 residents by county	F.B.I. Uniform Crime Reports
Race	The annual percent of population who identifies as only Black or African American by county	U.S. Census Bureau (2009-2012)
Education	The annual percent of population over 25 years of age and older who possess a Bachelor's degree by county	U.S. Census Bureau (2010-2012)
Severity	The number of nationally publicized mass murder victims	USA Today
Law Change	A binary variable that assigns a value of "1" to all observations the first full month after the first pertinent HCP law was enacted starting in May 2009.	Tennessee Department of Safety and Homeland Security

Table 3: Nationally publicized mass murder overviews (N=19)

Date	City	State	Location	Fatalities
February 2, 2008	Tinley Park	IL	Store	5
February 7, 2008	Kirkwood	MO	City Council Meeting	6
February 14, 2008	Dekalb	IL	University	5
September 2, 2008	Alger	WA	Outside	6
November 2, 2008	Long Beach	CA	Homeless camp	5
March 29, 2009	Carthage	NC	Nursing Home	8
April 3, 2009	Binghamton	NY	Immigration Services Center	13
November 29, 2009	Parkland	WA	Restaurant	4
August 3, 2010	Manchester	CT	Workplace	8
January 8, 2011	Tucson	AZ	Parking Lot	6
June 19, 2011	Medford	NY	Pharmacy	4
September 6, 2011	Carson City	NV	Restaurant	4
October 12, 2011	Seal Beach	CA	Beauty Salon	8
April 2, 2012	Oakland	CA	University	7
May 20, 2012	Seattle	WA	Coffee Shop	5
July 20, 2012	Aurora	CO	Movie Theater	12
August 5, 2012	Oak Creek	WI	Temple	6
September 27, 2012	Minneapolis	MN	Workplace	6
December 14, 2012	Newtown	CT	School	27

* The November 5, 2009 mass murder at Fort Hood, TX was excluded because an HCP would not have permitted a citizen to have possessed a gun in that setting.

Table 4: Statistical overview for test variables (N=5700)

Variable	Mean (SD)	Min	Max
HCP Application Rate	188.55 (90.02)	0	875.89
Mass Murder	0.32 (0.56)	0	3
Mass Murder Severity	2.43 (4.89)	0	27
Murder Rate	0.37 (1.36)	0	25.74
Forcible Rape Rate	2.00 (3.18)	0	51.15
Aggravated Assault Rate	27.79 (20.06)	0	167.4
Robbery Rate	3.65 (5.94)	0	53.22
Motor Vehicle Theft Rate	14.62 (12.30)	0	383.63
% Unemployed	10.36 (2.91)	3.7	29.8
Income Per Capita	30414.78 (5763.97)	19441	66195
Officers per 100,000 residents	200.14 (87.77)	85.11	1025.06
% Black or African American	7.23 (10.43)	0	52.1
% 25+ years of age with Bachelor's Degree	13.04 (6.58)	4.7	51.8

Table 5: Bivariate regression results of local violent crime rates and nationally publicized mass murders on HCP application rates in Tennessee from 2008-2012

Variable	Coef.	[95% Conf. Interval]		Wald chi2
All Mass Murders	-3.23	-7.16	0.70	2.60
All Mass Murder Victims	3.54**	3.10	3.99	246.82**
Murder	-0.17	-1.82	1.48	0.04
Forcible Rape	-0.22	-0.96	0.51	0.36
Aggravated Assault	0.01	-0.13	0.15	0.03
Robbery	-0.47	-1.06	0.12	2.40
Motor Vehicle Theft	-0.61**	-0.82	-0.40	33.36**
Unemployment Rate	13.05**	12.08	14.02	695.57**
Income Per Capita^	-4491009**	-5416367	-3565650	90.48**
Law Enforcement^	-576.86*	-1103.46	-50.27	4.61*
Race^	-6.23**	-10.00	-2.46	10.50**
Educational Attainment^	-291.82**	-379.17	-204.48	42.88**
Law Change	52.58**	47.77	57.38	459.56**

* = p<.05 , ** = p<.01 , ^ = transformed variable , "HCP" = Handgun Carrying Permit

Table 6: Bivariate regression results of individual nationally publicized mass murders on HCP application rates in Tennessee from 2008-2012

Variable	Coef.	[95% Conf.	Interval]	Wald chi2
All February 2008	-35.54**	-41.22	-29.86	150.30**
September 2, 2008	-68.48**	-85.66	-51.30	61.05**
November 2, 2008	-52.60**	-69.82	-35.39	35.86**
March 29, 2009	28.50**	11.24	45.76	10.48**
April 3, 2009	226.49**	210.27	242.71	748.84**
November 29, 2009	22.07*	4.81	39.33	6.28*
August 3, 2010	-15.52	-32.78	1.75	3.10
January 8, 2011	61.94**	44.75	79.14	49.85**
June 19, 2011	-36.51**	-53.75	-19.26	17.21**
September 6, 2011	-68.18**	-85.36	-51.00	60.51**
October 12, 2011	-50.44**	-67.66	-33.22	32.96**
April 2, 2012	4.75	-12.52	22.02	0.29
May 20, 2012	4.23	-13.04	21.50	0.23
July 20, 2012	45.67**	28.44	62.90	26.98**
August 5, 2012	43.86**	26.63	61.09	24.88**
September 27, 2012	-12.21	-29.48	5.06	1.92
December 14, 2012	158.16**	141.39	174.93	341.78**

* = p<.05 , ** = p<.01, "HCP" = Handgun Carrying Permit

Table 7: Bivariate regression results of individual nationally publicized mass murder victims on HCP application rates in Tennessee from 2008-2012

Variable	Coef.	[95% Conf.	Interval]	Wald chi2
All February 2008 Victims	-6.66332**	-7.7286	-5.59803	150.3**
September 2, 2008 Victims	-11.4135**	-14.2766	-8.55046	61.05**
November 2, 2008 Victims	-10.5207**	-13.964	-7.0774	35.86**
March 29, 2009 Victims	3.562468**	1.405537	5.719398	10.48**
April 3, 2009 Victims	17.42221**	16.17437	18.67005	748.84**
November 29, 2009 Victims	5.517196*	1.201721	9.832672	6.28*
August 3, 2010 Victims	-1.93952	-4.09787	0.21883	3.1
January 8, 2011 Victims	10.32348**	7.457599	13.18936	49.85**
June 19, 2011 Victims	-9.12649**	-13.4378	-4.81521	17.21**
September 6, 2011 Victims	-17.0447**	-21.3395	-12.7499	60.51**
October 12, 2011 Victims	-6.30515**	-8.45777	-4.15252	32.96**
April 2, 2012 Victims	0.6785	-1.7888	3.145803	0.29
May 20, 2012 Victims	0.846133	-2.60811	4.300376	0.23
July 20, 2012 Victims	3.805429**	2.369583	5.241274	26.98**
August 5, 2012 Victims	7.31019**	4.437964	10.18242	24.88**
September 27, 2012 Victims	-2.0345	-4.9126	0.843603	1.92
December 14, 2012 Victims	5.85786**	5.236827	6.478893	341.78**

* = p<.05 , ** = p<.01, "HCP" = Handgun Carrying Permit

Table 8: Collinearity results for local crime rates and the occurrence of all nationally publicized mass murders

Variable	VIF	1/VIF
Income Per Capita^	3.05	0.33
Educational Attainment^	2.93	0.34
Robbery	1.64	0.61
Unemployment Rate	1.61	0.62
Race^	1.57	0.64
Aggravated Assault	1.36	0.74
Law Change	1.24	0.80
Motor Vehicle Theft	1.16	0.86
Law Enforcement^	1.13	0.89
Forcible Rape	1.05	0.95
Mass Murder	1.03	0.97
Murder	1.01	0.99

^ = transformed variable

Table 9: Collinearity results for local crime rates and all nationally publicized mass murder victims

Variable	VIF	1/VIF
Income Per Capita^	3.06	0.33
Educational Attainment^	2.93	0.34
Robbery	1.64	0.61
Unemployment Rate	1.61	0.62
Race^	1.57	0.64
Aggravated Assault	1.36	0.74
Law Change	1.24	0.81
Motor Vehicle Theft	1.16	0.86
Law Enforcement^	1.13	0.89
Forcible Rape	1.05	0.95
Mass Murder Victims	1.02	0.98
Murder	1.01	0.99

^ = transformed variable

Table 10: Collinearity results for local violent crime rates and individual nationally publicized mass murders

Variable	VIF	1/VIF
Income Per Capita^	3.09	0.32
Educational Attainment^	2.95	0.34
Unemployment Rate	1.89	0.53
Law Change	1.81	0.55
Robbery	1.65	0.60
Race^	1.58	0.63
Assault	1.38	0.73
Motor Vehicle Theft	1.16	0.86
Mass Murder 03/29/09	1.14	0.87
Law Enforcement^	1.13	0.89
Mass Murder 04/03/09	1.12	0.89
Mass Murder 02/2008	1.08	0.92
Mass Murder 09/02/08	1.08	0.93
Mass Murder 11/02/08	1.07	0.93
Forcible Rape	1.06	0.95
Mass Murder 09/27/12	1.03	0.97
Mass Murder 04/02/12	1.03	0.97
Mass Murder 05/20/12	1.03	0.97
Mass Murder 12/14/12	1.03	0.97
Mass Murder 01/08/11	1.03	0.98
Mass Murder 08/05/12	1.03	0.98
Mass Murder 11/29/09	1.02	0.98
Mass Murder 07/20/12	1.02	0.98
Mass Murder 10/12/11	1.02	0.98
Mass Murder 08/03/10	1.02	0.98
Mass Murder 09/06/11	1.02	0.98
Mass Murder 06/19/11	1.02	0.98
Murder	1.02	0.98

^ = transformed variable

Table 11: Collinearity results for local violent crime rates and the severity of individual nationally publicized mass murders

Variable	VIF	1/VIF
Income Per Capita^	3.09	0.32
Educational Attainment^	2.95	0.34
Unemployment Rate	1.89	0.53
Law Change	1.81	0.55
Robbery	1.65	0.60
Race^	1.58	0.63
Assault	1.38	0.73
Motor Vehicle Theft	1.16	0.86
Mass Murder Victims 03/29/09	1.14	0.87
Law Enforcement^	1.13	0.89
Mass Murder Victims 04/03/09	1.12	0.89
Mass Murder Victims 02/2008	1.08	0.92
Mass Murder Victims 09/02/08	1.08	0.93
Mass Murder Victims 11/02/08	1.07	0.93
Forcible Rape	1.06	0.95
Mass Murder Victims 09/27/12	1.03	0.97
Mass Murder Victims 04/02/12	1.03	0.97
Mass Murder Victims 05/20/12	1.03	0.97
Mass Murder Victims 12/14/12	1.03	0.97
Mass Murder Victims 01/08/11	1.03	0.98
Mass Murder Victims 08/05/12	1.03	0.98
Mass Murder Victims 11/29/09	1.02	0.98
Mass Murder Victims 07/20/12	1.02	0.98
Mass Murder Victims 10/12/11	1.02	0.98
Mass Murder Victims 08/03/10	1.02	0.98
Mass Murder Victims 09/06/11	1.02	0.98
Mass Murder Victims 06/19/11	1.02	0.98
Murder	1.02	0.98

^ = transformed variable

Table 12: Multivariate regression results of local violent crime rates and nationally publicized mass murders on HCP application rates for 95 counties in Tennessee from 2008-2012

Variable	Coef.	[95% Conf. Interval]	
All Mass Murders	4.08*	0.42	7.75
Murder	-0.31	-1.81	1.20
Forcible Rape	-0.38	-1.05	0.29
Aggravated Assault	0.17*	0.04	0.30
Robbery	0.04	-0.54	0.63
Motor Vehicle Theft	-0.28**	-0.47	-0.09
Unemployment Rate	14.00**	12.87	15.13
Income Per Capita^	-6734153**	-8181295	-5287011
Law Enforcement^	-255.27	-790.81	280.26
Race^	-16.98**	-21.67	-12.30
Educational Attainment^	-104.59	-229.35	20.16
Law Change	14.48**	8.66	20.29

^ = transformed variable , * = p<.05 , ** = p<.01 , "HCP" = Handgun Carrying Permit , Wald chi^2 = 1151.98**

Table 13: Multivariate regression results of local violent crime rates and nationally publicized mass murder victims on HCP application rates for 95 counties in Tennessee from 2008-2012

Variable	Coef.	[95% Conf. Interval]	
All Mass Murders Victims	4.09**	3.68	4.50
Murder	-0.20	-1.66	1.25
Forcible Rape	-0.28	-0.93	0.37
Aggravated Assault	0.17**	0.04	0.30
Robbery	0.12	-0.45	0.68
Motor Vehicle Theft	-0.19*	-0.38	-0.01
Unemployment Rate	14.24**	13.15	15.33
Income Per Capita^	-5198230**	-6599103	-3797358
Law Enforcement^	-140.77	-657.25	375.70
Race^	-15.05**	-19.55	-10.55
Educational Attainment^	-98.48	-218.80	21.85
Law Change	20.24**	14.63	25.86

^ = transformed variable , * = p<.05 , ** = p<.01 , "HCP" = Handgun Carrying Permit , Wald chi^2 = 1610.12**

Table 14: Multivariate regression results of local violent crime rates and individual nationally publicized mass murders on HCP application rates for 95 counties in Tennessee from 2008-2012

Variable	Coef.	[95% Conf. Interval]	
Murder	-0.19	-1.49	1.10
Forcible Rape	-0.28	-0.86	0.30
Aggravated Assault	0.11	-0.01	0.22
Robbery	0.11	-0.39	0.62
Motor Vehicle Theft	-0.08	-0.25	0.08
Unemployment Rate	8.72**	7.62	9.82
Income Per Capita^	-3482697**	-4752278	-2213116
Law Enforcement^	99.60	-359.14	558.34
Race^	-13.42**	-17.43	-9.42
Educational Attainment^	-115.70*	-223.32	-8.08
Law Change	45.97**	40.02	51.91
All February 2008 Mass Murders	-10.92**	-15.62	-6.21
September 2, 2008 Mass Murder	-4.36	-18.38	9.65
November 2, 2008 Mass Murder	4.74	-9.27	18.74
March 29, 2009 Mass Murder	48.64**	33.84	63.45
April 3, 2009 Mass Murder	249.56**	235.01	264.12
November 29, 2009 Mass Murder	3.51	-10.23	17.24
August 3, 2010 Mass Murder	-21.91**	-35.58	-8.24
January 8, 2011 Mass Murder	30.61**	16.84	44.39
June 19, 2011 Mass Murder	-56.95**	-70.61	-43.28
September 6, 2011 Mass Murder	-78.92**	-92.57	-65.26
October 12, 2011 Mass Murder	-57.00**	-70.69	-43.31
April 2, 2012 Mass Murder	0.58	-13.28	14.44
May 20, 2012 Mass Murder	-2.24	-16.09	11.60
July 20, 2012 Mass Murder	30.75**	16.97	44.52
August 5, 2012 Mass Murder	33.20**	19.39	47.00
September 27, 2012 Mass Murder	-14.87*	-28.75	-1.00
December 14, 2012 Mass Murder	149.39**	135.56	163.23

^ = transformed variable , * = p<.05 , ** = p<.01 , "HCP" = Handgun Carrying Permit , Wald chi^2 = 3566.03**

Table 15: Multivariate regression results of local violent crime rates and individual nationally publicized mass murder victims on HCP application rates for 95 counties in Tennessee from 2008-2012

Variable	Coef.	[95% Conf. Interval]	
Murder	-0.19	-1.49	1.10
Forcible Rape	-0.28	-0.86	0.30
Aggravated Assault	0.11	-0.01	0.22
Robbery	0.11	-0.39	0.62
Motor Vehicle Theft	-0.08	-0.25	0.08
Unemployment Rate	8.72**	7.62	9.82
Income Per Capita^	-3482697**	-4752278	-2213116
Law Enforcement^	99.60	-359.14	558.34
Race^	-13.42**	-17.43	-9.42
Educational Attainment^	-115.70*	-223.32	-8.08
Law Change	45.97**	40.02	51.91
All February 2008 Victims	-2.05**	-2.93	-1.16
September 2, 2008 Victims	-0.73	-3.06	1.61
November 2, 2008 Victims	0.95	-1.85	3.75
March 29, 2009 Victims	6.08**	4.23	7.93
April 3, 2009 Victims	19.20**	18.08	20.32
November 29, 2009 Victims	0.88	-2.56	4.31
August 3, 2010 Victims	-2.74**	-4.45	-1.03
January 8, 2011 Victims	5.10**	2.81	7.40
June 19, 2011 Victims	-14.24**	-17.65	-10.82
September 6, 2011 Victims	-19.73**	-23.14	-16.31
October 12, 2011 Victims	-7.13**	-8.84	-5.41
April 2, 2012 Victims	0.08	-1.90	2.06
May 20, 2012 Victims	-0.45	-3.22	2.32
July 20, 2012 Victims	2.56**	1.41	3.71
August 5, 2012 Victims	5.53**	3.23	7.83
September 27, 2012 Victims	-2.48*	-4.79	-0.17
December 14, 2012 Victims	5.53**	5.02	6.05

^ = transformed variable , * = p<.05 , ** = p<.01 , "HCP" = Handgun Carrying Permit , Wald chi^2 = 3566.03**

Table 16: Granger causality F-statistic results for lagged crime rates on HCP application rates in three Tennessee counties from 2008-2012

	Variable	Small County	Median County	Large County
Lag 1	Murder	--	1.12	0.27
	Forcible Rape	0.20	0.61	0.27
	Aggravated Assault	0.71	3.40	0.24
	Robbery	0.02	0.27	0.09
	Motor Vehicle Theft	1.28	0.85	0.53
	All	0.51	1.35	0.32
Lag 2	Murder	--	0.56	1.97
	Forcible Rape	0.15	0.34	1.35
	Aggravated Assault	0.71	2.12	1.70
	Robbery	0.07	0.71	0.27
	Motor Vehicle Theft	1.01	0.84	1.09
	All	0.42	1.04	1.71
Lag 3	Murder	--	0.59	0.68
	Forcible Rape	0.31	0.82	0.79
	Aggravated Assault	0.52	3.35	1.62
	Robbery	0.78	0.30	1.48
	Motor Vehicle Theft	0.60	3.30*	1.14
	All	0.58	1.98*	1.67
Lag 4	Murder	--	1.86	1.26
	Forcible Rape	0.56	2.23	0.54
	Aggravated Assault	0.30	2.14	2.04
	Robbery	0.56	2.53	2.13
	Motor Vehicle Theft	0.53	5.01**	3.70*
	All	0.51	3.10**	2.41*

* = p<.05 , ** = p<.01 , "--" = omitted due to collinearity , "HCP" = Handgun Carrying Permit , “Small” means smallest total population of any Tennessee county (Pickett County) , “Median” means a median county population (Obion County) relative to all Tennessee counties , “Large” means the largest county population (Shelby County) relative to all Tennessee counties

Table 17: Reverse relationship between crime rates and HCP application rates for Small County in Tennessee from 2008-2012

	Murder		*Rape*		*Assault*		*Robbery*		*Motor Vehicle Theft*	
	F	Prob > F	F	Prob > F	F	Prob > F	F	Prob > F	F	Prob > F
Lag 1	--	--	0.20	0.654	1.34	0.253	0.16	0.687	0.00	0.946
Lag 2	--	--	0.15	0.862	1.19	0.313	0.12	0.889	0.76	0.475
Lag 3	--	--	1.10	0.359	0.94	0.430	1.20	0.323	0.65	0.588
Lag 4	--	--	1.25	0.307	5.50	0.002	0.93	0.458	0.96	0.440

"HCP" = Handgun Carrying Permit , "- -" = omitted due to collinearity, "Small" means smallest total population of any Tennessee county , results in this table are for Pickett County

Table 18: Reverse relationship between crime rates and HCP application rates for Median County in Tennessee from 2008-2012

	Murder		*Rape*		*Assault*		*Robbery*		*Motor Vehicle Theft*	
	F	Prob > F	F	Prob > F	F	Prob > F	F	Prob > F	F	Prob > F
Lag 1	0.28	0.599	0.35	0.558	1.04	0.312	0.93	0.339	1.30	0.260
Lag 2	1.68	0.198	2.23	0.120	1.86	0.168	0.31	0.734	3.27	0.047
Lag 3	0.65	0.590	0.94	0.433	2.78	0.054	0.20	0.898	1.29	0.293
Lag 4	2.69	0.049	2.17	0.096	3.62	0.016	0.47	0.759	1.26	0.305

"HCP" = Handgun Carrying Permit , "Median" means a median county population relative to all Tennessee counties , results in this table are for Obion County

Table 19: Reverse relationship between crime rates and HCP application rates for Large County in Tennessee from 2008-2012

	Murder		*Rape*		*Assault*		*Robbery*		*Motor Vehicle Theft*	
	F	Prob > F	F	Prob > F	F	Prob > F	F	Prob > F	F	Prob > F
Lag 1	0.19	0.661	3.94	0.053	1.71	0.196	0.25	0.623	0.03	0.870
Lag 2	3.40	0.042	2.86	0.067	1.62	0.209	0.28	0.756	0.36	0.697
Lag 3	3.02	0.042	5.29	0.004	1.81	0.163	0.52	0.671	0.67	0.575
Lag 4	2.50	0.063	5.14	0.003	0.70	0.601	0.43	0.787	0.65	0.633

"HCP" = Handgun Carrying Permit , "Large" means the largest county population relative to all Tennessee counties , results in this table are for Shelby County

APPENDIX B:

FIGURES

Figure 1: Handgun carrying permit applications per 100,000 residents in Tennessee from 2008-2012

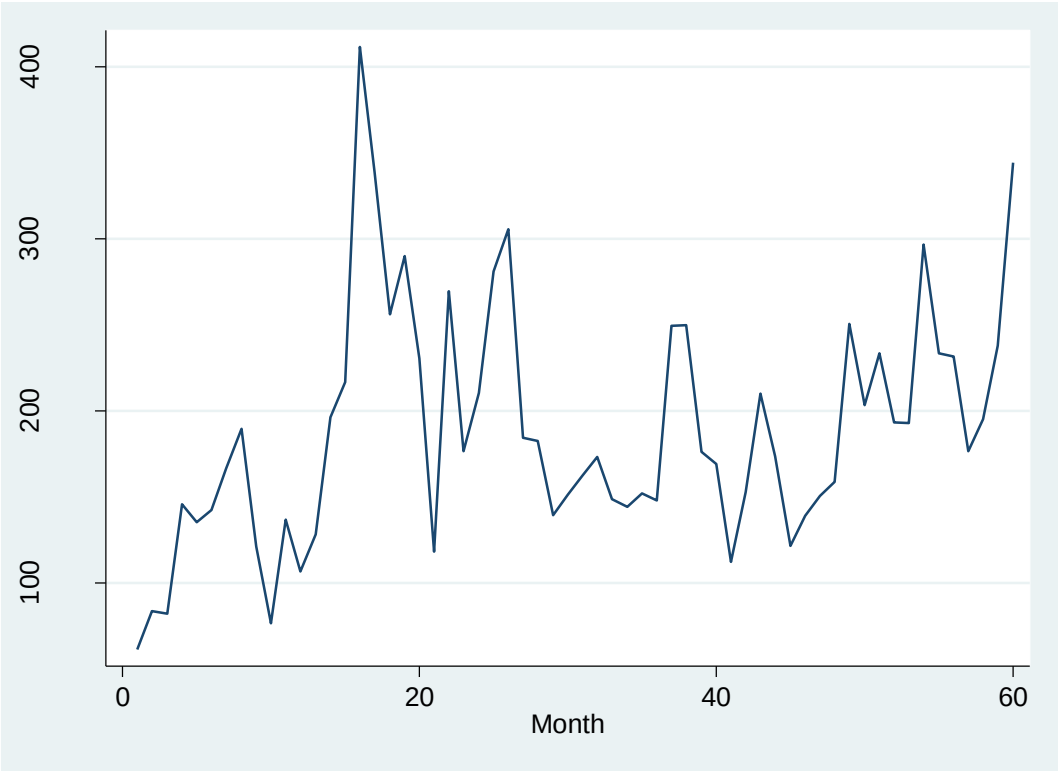


Figure 2: Statewide aggravated assault rates per 100,000 residents in Tennessee from 2008-2012

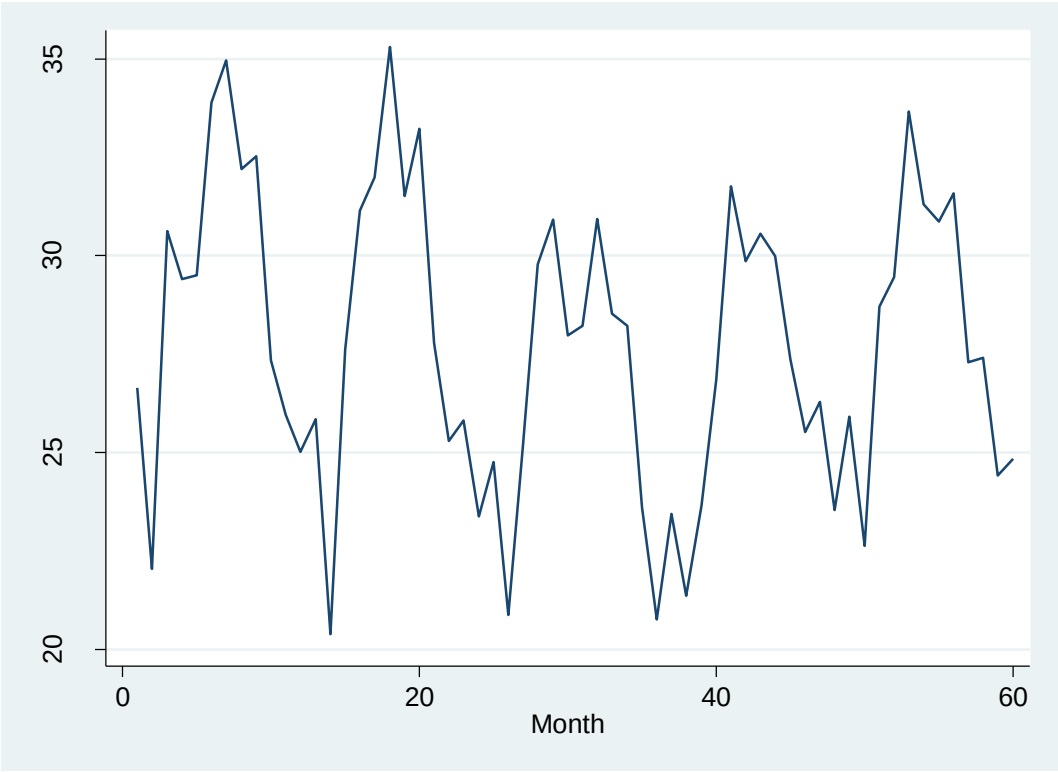


Figure 3: Statewide robbery rates per 100,000 residents in Tennessee from 2008-2012

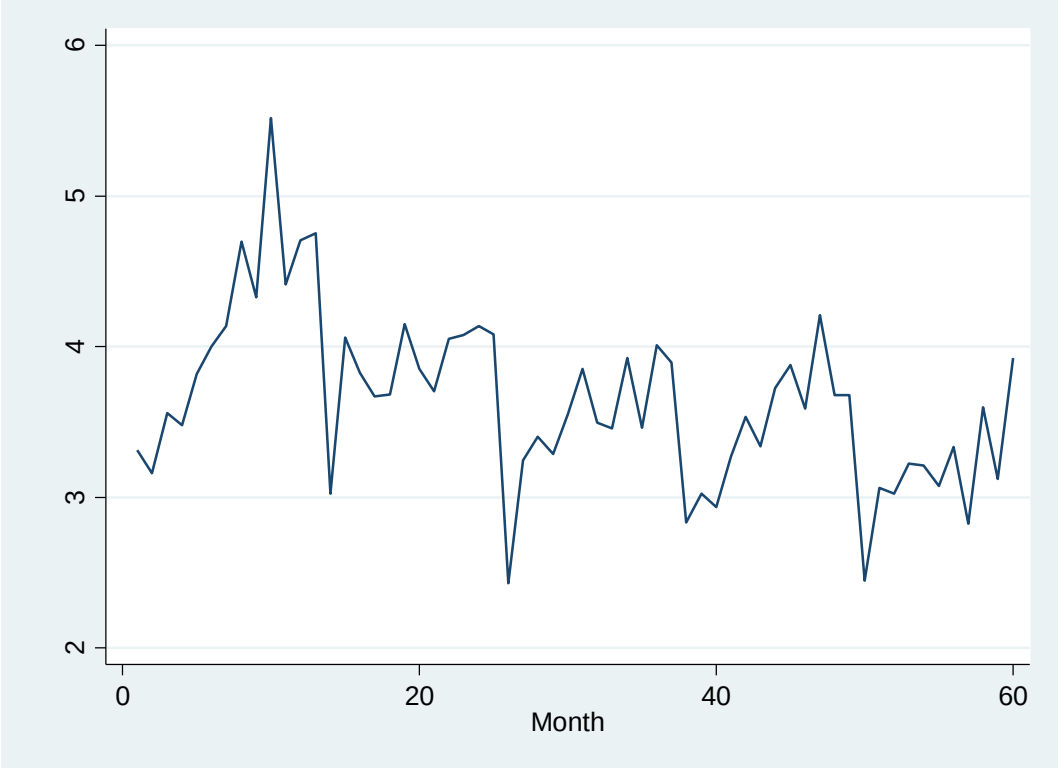


Figure 4: Handgun carrying permit applications per 100,000 residents in Colorado from 2008-2012

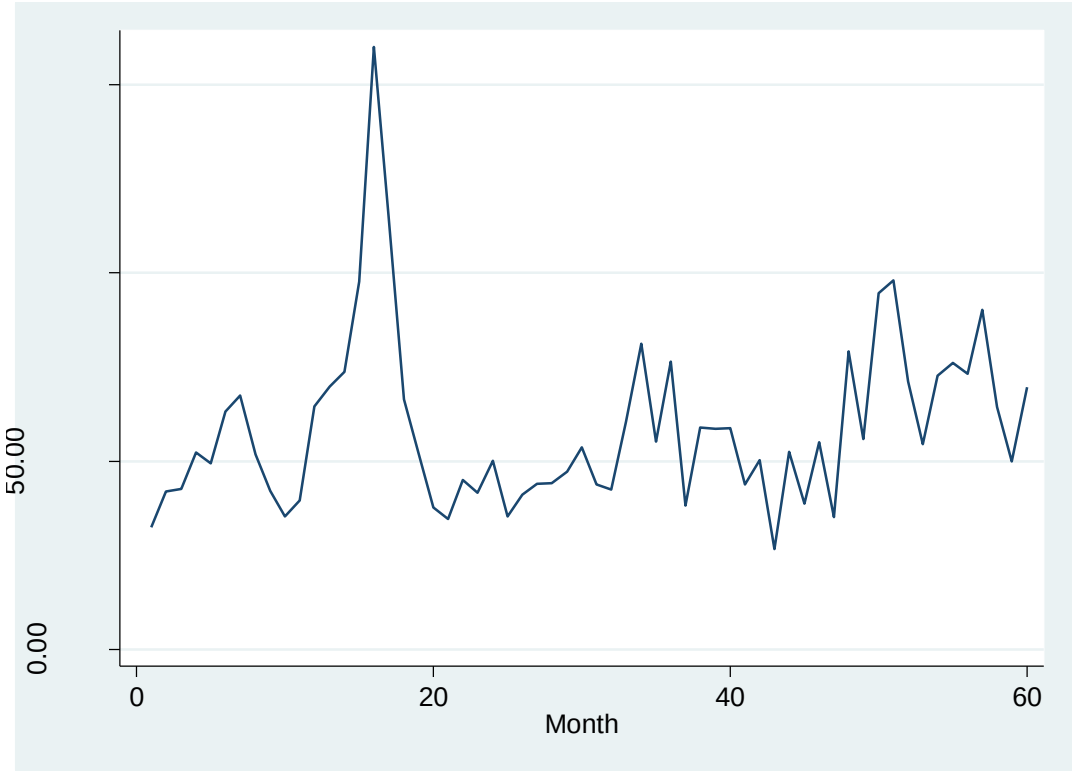


Figure 5: Handgun carrying permit applications per 100,000 residents in Kansas from 2008-2012

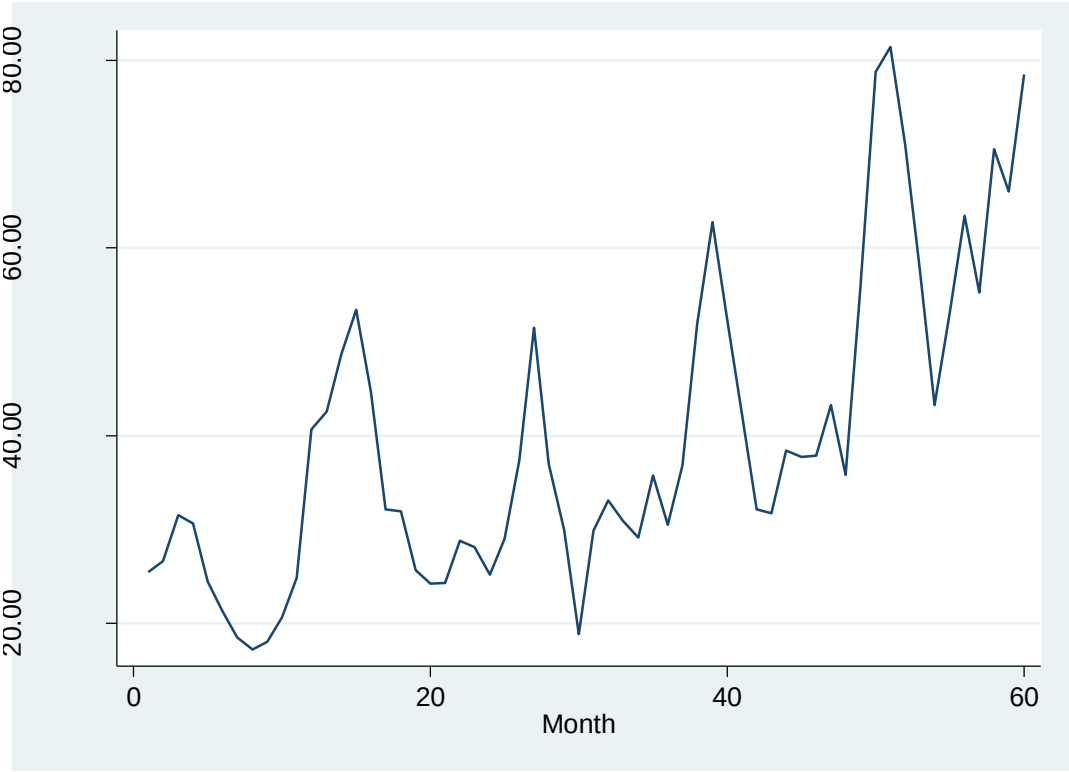
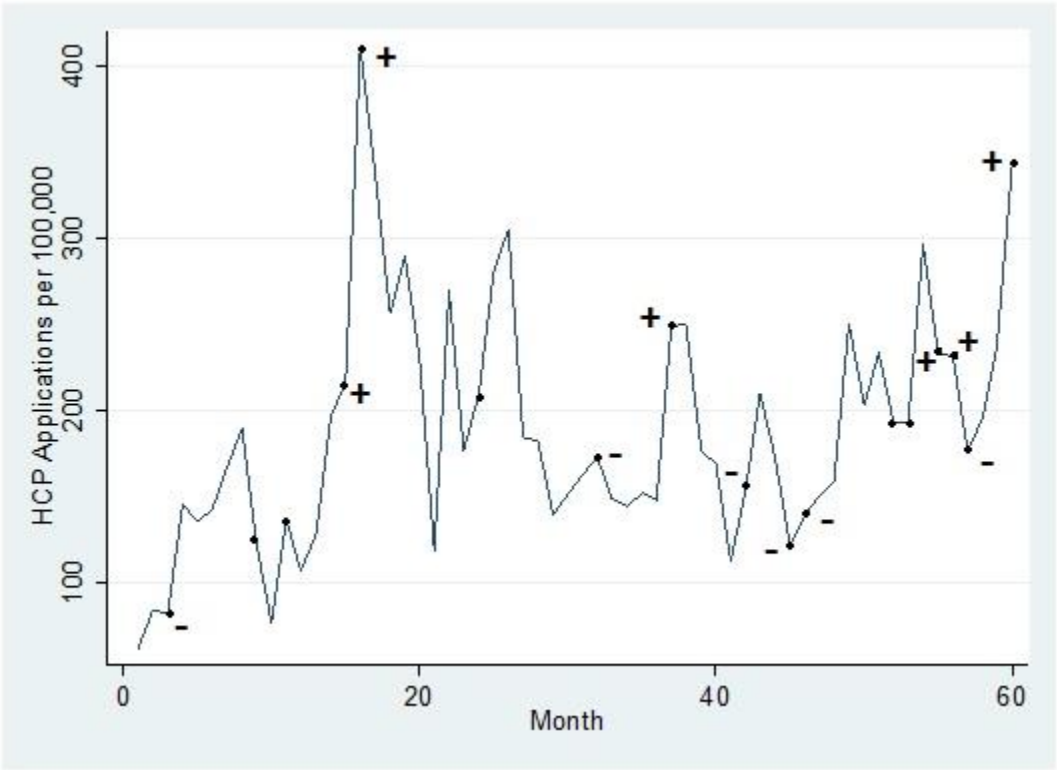


Figure 6: Handgun carrying permit applications in Tennessee from 2008-2012 with nationally publicized mass murders



● = Nationally publicized mass murder , "+" = nationally publicized mass murder that is statistically significantly and positively related to HCP application rates , "-" = nationally publicized mass murder that is statistically significantly and positively related to HCP application rates

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