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Effects of Crime Gun Prevalence on Homicide Rates

by

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ABSTRACT

The paper explores the influence of "crime gun" prevalence on the risk of homicide. Reliance on measures of "crime guns" is a unique contribution of this paper that focuses the analysis, for the first time, on the subset of guns most likely to be used in violent street crimes rather than the general prevalence of guns in a community. The number of guns reported stolen, and the number of 911 calls reporting shots fired incidents, measure variations in the prevalence of "crime guns." Strong neighborhood variations in both the prevalence of "crime guns" and the levels of homicide are evident, with higher homicide rates in the same areas as higher levels of "crime gun" incidents. This cross-sectional relationship, however, may reflect general neighborhood differences in the propensity to violence and not necessarily any causal link between crime gun prevalence and homicides. Going beyond a simple cross-sectional relationship, the present analysis relies on a hazard model to estimate changes in the homicide risks in different neighborhoods as levels of crime gun prevalence change. Finding evidence a temporal relationship as the two variables change in value is a much stronger test of a direct link between greater access to crime guns and an increased risk of homicide. The influence of crime guns in raising the homicide risk is restricted to selected types of homicides, specifically homicides by gun, those involving youth (ages 12 to 24), and gang motivated homicides. No similar effect is found for other types of homicides, a result that is compatible with the general nature of homicides between family members and acquaintances where the general prevalence of legal guns in households is likely to have greater influence.

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BACKGROUND

Firearms are an important factor in violent crimes. Nationally, year-to-year changes in the homicide rate closely track annual changes in the percentage of homicides that involve firearms (Figure 1). As firearm involvement increases or decreases so does the overall homicide rate. This apparent similarity in trends between homicides and firearm use in homicides has sparked considerable debate about the relationship between gun prevalence and the incidence of violence. Central to this debate is whether increases in gun prevalence actually contribute to increases in violence levels, especially homicide deaths, or the coincidence in the two phenomena merely reflects the influence of some other underlying process, like changes in propensity for violence. While highly suggestive, it is difficult to sort out the direction and strength of any causal links that may exist using only highly aggregated annual national data. The analysis in this paper examines the spatial and temporal relationship between gun prevalence and homicide levels in one city in an effort to more precisely isolate any causal effects.

Gun prevalence may either increase or decrease violence, and the research literature provides plausible arguments for both types of effects. At the level of the individual encounter, firearms might have any of the following effects. *Facilitation:* Possession of a gun may facilitate an attack by weaker aggressors against stronger victims by shifting the balance of power in ways that increase the likelihood of a successful outcome and decrease the risk to the aggressor (Cook, 1982). It is also hypothesized that guns may facilitate attacks by allowing squeamish attackers to minimize contact with their victims (Newton & Zimring, 1969). *Triggering:* Experimental psychologists argue that the mere display of a weapon can elicit aggression in angered persons because of a learned association between weapons and aggressive behavior (Berkowitz & Lepage, 1967). However, research in this area finds that guns can inhibit as well as elicit aggression among subjects (Fischer, Kelm & Rose 1969, Fraczek & Macauley, 1971). *Escalation:* Encounters that may not otherwise have led to violence become excessively so due to the presence of a gun. Altercations that might have been settled by fist fights, or attempts at robbery that might have been abandoned, may result in injury or even death because of the extreme lethality of the weapon used. *Inhibition:* Attackers are aware that a gun significantly increases the probability of a lethal outcome, and are therefore less likely to escalate from threats with a gun to an actual attack (Kleck, 1991). *Redundancy:* Guns are used as a substitute for attack, rather than an instrument for attack. That is, brandishing guns gives attackers the power necessary to accomplish their objectives without resorting to further physical attacks (Kleck and McElrath, 1991).

At the community level, where the unit of analysis is a neighborhood or city, gun prevalence may again either increase or decrease violence. On the one hand, high gun prevalence may inhibit violence by serving as an instrument of social control and as a deterrent to attacks on armed victims. On the other hand, elevated levels of gun prevalence may accompany low levels of social control. When gun prevalence is high in areas where traditional forms of social control are weak, the combination of low social control and high gun prevalence may lead to increased violence.

Prior research that attempts to identify which of the above effects predominates can be broadly divided into three major types. First are studies that examine how guns affect outcomes in individual encounters. Other studies examine trends in violence and gun prevalence at an aggregate level, and the final class of studies evaluates gun control interventions. While the latter studies do not directly consider the influence of gun prevalence on higher violence levels, the results of gun control studies are worth noting because they provide information about indirect effects on violence outcomes. If gun control interventions—acting through their effects on gun prevalence—are effective in reducing violence rates, then a persuasive argument can be made for a causal relationship between gun prevalence and violence.

The evidence from individual-level studies suggests that firearm involvement in a crime incident significantly increases the probability of a death. A study using data from the National Crime Victimization Survey and the Supplemental Homicide Reports finds that when the offender has a gun, the probability that a threatening situation will result in a homicide is 176 in 10,000 incidents. This is five times higher than the overall risk of 36 homicides in 10,000 threatening situations (Kleck and McElrath, 1991). This study also found that a threatening situation is less likely to lead to an actual physical attack when the offender has a gun. Furthermore, when a threatening situation does escalate to an attack, there is a lower probability that the victim will sustain an injury if the offender used a firearm. These reductions in intermediate risks, however, are more than offset by a significantly higher probability that an injury will be fatal when the weapon is a firearm. An earlier study by Cook (1976) reports similar results for robbery.

These results highlight the complexity of the relationship between firearm use and violence. The evidence suggests that the effects of weapons vary at different stages in a violent encounter, and specifically that firearm use has opposite effects on the probabilities that an offender attacks, the attack is completed, and the attack results in injury and/or death.

Results from aggregate analyses of violence are fairly evenly divided between those that find significant effects of gun prevalence on violence and those that find no effects. When disaggregating by type of violence, however, analyses at the state and city level find that gun prevalence increases total homicide rates (Newton & Zimring, 1969; Fisher, 1976; Brill, 1976;

Kleck, 1979; Sloan *et al.*, 1988). Kleck (1991: 187), however, notes that these results are not conclusive because the majority of studies either fail to control for other determinants of violence or rely on very small sample sizes. With few exceptions, aggregate level analyses that examine the role of gun prevalence on other types of violence, such as assault and robbery, find no effects of gun prevalence. The results in aggregate data thus mirror those in individual level analyses where gun prevalence increases homicide rates but not assault or injury rates.

Gun control studies are primarily of two types—time series studies that examine monthly violence rates before and after some change in gun control within a single jurisdiction, and cross-sectional studies that compare areas with gun control laws to others without similar controls. The results are mixed with no consensus on whether or not gun control laws are effective. The results are weakened further by the fact that most studies suffer from methodological problems that prevent firm conclusions.

Time series studies do not adequately control for changes in other determinants of violence and very often do not take into account that gun control laws are usually implemented at, or very shortly after the time when the target problem has peaked (Kleck, 1993). In either case, there are alternative explanations for subsequent reductions in violence other than the change in gun laws. Cross-sectional studies generally rely on states as their unit of analysis. This confounds the results since states are large units that are heterogeneous with respect to both the levels of violence and the variables affecting violence. This heterogeneity within the unit of analysis makes it difficult to control for other determinants of violence and also leaves the study vulnerable to aggregation bias. In addition, very few of these studies assess whether gun control laws actually impact levels of gun prevalence.

For the purposes of this paper it is sufficient to note that the gun control literature does not provide overwhelming evidence that gun control reduces violence either directly, or indirectly through an effect on gun prevalence. One of the only studies to include a comprehensive evaluation of the effects of gun control on both gun prevalence and violence rates concludes that increased gun prevalence does not significantly increase levels of violence, except for suicide rates (Kleck and Patterson, 1993).

In summary, prior studies find that there is evidence that gun prevalence does affect some types of violence. At the level of individual encounters, guns may actually reduce violence at some stages of the encounter, but overall they increase the probability of death. Aggregate-level studies also provide some evidence that gun prevalence increases homicide rates but not assault or robbery rates. Studies of gun control, which typically address gun prevalence only indirectly, generally fail to provide support for the argument that gun prevalence plays a role in violence levels.

Noticeably absent from the literature is any analysis of the effects of gun prevalence and violence at finer levels of spatial or temporal resolution. Aggregate level studies have, with a few exceptions, used states or cities as their unit of analysis. Smaller spatial and temporal units allow for better tests of a causal relationship than the gross levels of covariation examined in most aggregate-level analyses. Studies find that the impacts of drug markets and gangs are highly localized within neighborhoods (Block & Block, 1994; Cohen & Tita, 1998; Fagan, 1993; Klein, Maxson & Cunningham, 1991), and these localized effects can be substantially dampened in city wide trends. Similarly, the effects of gun prevalence on violence may also be highly localized, and using smaller units of analysis (e.g., neighborhoods within a city) will allow better estimation of place-specific effects, and any contagious spread between these places.

Measures of Gun Prevalence

Prior studies have used a variety of measures to capture gun prevalence. One common method relies on measures like the fatal gun accident rate, the number of subscriptions to hunting magazines, and contributors to gun owners groups such as the NRA and the Second Amendment Foundation. Legal gun ownership dominates these measures, and so they may be quite remote from criminal uses of guns. The measures also fail to correlate significantly with survey measures of gun ownership (Cook, 1979). Results from analyses that use these measures are mixed, with some studies finding significant relationships between gun prevalence and violence and other studies finding no relationship.

Another common measure relies on information on the manufacture, sales and import of guns to approximate the available stock of guns. These data actually represent the flow of new guns and are a poor proxy of the existing stock of guns. They are flawed by inaccuracies in the count of imports. More importantly, the data fail to include any accounting for exports, breakage, confiscation and other removals from the stock (Cook,1991). Studies that examine the effect of these "stock" measures on temporal movements in the homicide rate generally find a positive effect (Phillips, Votey and Howell, 1976; Kleck, 1979; Magddino and Metoff, 1984). One study finds no effect (Kleck, 1984).

One of the most widely used measures of gun prevalence is the percentage of violent acts that are committed with handguns. Cook (1979) created an index using the percentage of suicides and percentage of non-felony homicides by gun. The index was highly correlated with survey measures of urban household gun ownership. Kleck and Patterson (1993) used a principal components factor that included the percentages of suicides, non-felony homicides, aggravated assaults, and robberies committed with guns and the percentage of total dollar value of all stolen property reported to police that is due to firearm theft. In principal, these measures of the percentage by gun are likely to be better proxies of the prevalence of guns used in crimes than are measures of general prevalence of legally owned guns discussed above. They are, however, vulnerable to measurement error bias when estimating their relationship with violence rates. This is especially a problem in cross-sectional studies.

To illustrate, consider the case of assaults. It is very likely that victims report assaults to police at different rates in different jurisdictions. Furthermore, victims are more likely to report assaults that involve firearms than other types of assaults. If the percentage of assaults by gun is compared to the overall rate of reported assaults, cross-sectional variations in rates of under-reporting of non-gun assaults will induce a spurious bias in a negative direction in the estimated relationship. Such bias would reduce and might even offset a true positive relationship between the percentage of assaults by gun and the overall assault rate.

Figure 2 illustrates this measurement error bias problem. Consider a number of jurisdictions each with an identical population (P), the same number of actual gun assaults (G) and the same number of total actual assaults (A). If the true assault rate (A/P) is plotted against gun prevalence, as measured by the percent of assaults committed using firearms (G/A), all the jurisdictions will be located at the same point (A/P, G/A). If there is variation in the rates of victims reporting non-gun assaults to police, the observed assault rates will be lower than A/P and observed gun prevalence will be higher than G/A. The resulting measurement errors in the magnitude of the two variables are compounded when the rate of victim reports to police varies across the units of observation, and induces a spurious negative relationship between the percentage of assaults by gun and the total assault rate (see Figure 2). Such a spurious negative relationship will result in underestimates of any positive effect of gun prevalence on violence levels.[1]

Measures of Violence

Prior research has examined the effects of gun prevalence on different types of violence, such as rates of robbery, assaults, and homicides. Those studies that have examined effects on homicide do not differentiate by type of homicides and have restricted their analyses to comparisons of gun and non-gun homicides. While incidents such as assaults and robberies provide measures of a wider array of violence, the studies that rely on police counts of these crimes are vulnerable to measurement error biases due to variations in reporting these offenses to police. This is far less a problem in studies that use data from the National Crime Victimization Survey, but the latter are only available at the highly aggregated national level. Homicides are a more reliable indicator of violence levels across local jurisdictions because under-reporting is far less likely for both gun and non-gun homicides.

RESEARCH DESIGN

The analyses that follow depart from prior studies in several significant ways. First, the analyses examine variations in violence levels and gun prevalence at the level of local neighborhoods or communities within a city. This will permit estimates of effects at a level that is much closer to the presumed underlying behavioral responses of individuals to gun prevalence than prior global analyses that aggregate across larger and more heterogeneous population groups facing quite diverse gun prevalence and violence levels. Instead, we focus on estimating the impact of local variations in gun prevalence on violence levels in the same community.

[1] Blumstein, et al. (1978) discusses this same type of measurement error bias toward a spurious negative relationship in the context of estimating the deterrent effects of criminal justice sanctions on crime levels.

Largely because of data limitations, past analyses of firearms and violence rely primarily on indicators of the general prevalence of guns. These measures, however, include a very substantial number of guns that are never involved in criminal incidents, which can seriously distort results about the relationship of guns to crime. In a major departure from prior research, the analyses below focus on the impact of *crime guns*. A crime gun is any firearm that is readily available for criminal use, measured here by stolen gun reports and shots fired incidents. Reliance on measures of crime guns is a unique contribution that focuses the analysis, for the first time, on the subset of guns most likely to be used in violent street crimes rather than the general prevalence of guns in a community.

We also rely exclusively on homicides as our measure of violence. This avoids the measurement error bias that affects other forms of violence reported to police. In a departure from prior analyses, however, we distinguish among various types of homicide since we anticipate that crime guns are likely to be more important in some types of homicide and less so in others. Naturally, we expect crime gun prevalence to influence gun homicides and to have no effect on non-gun homicides. The strength of the effect on gun homicides will be an indication of the relative share of gun homicides that are directly influenced by crime guns. A strong effect of crime gun prevalence will indicate that crime guns are a major determining factor in a large share of gun homicides, while a weak or null effect on gun homicides indicates little effect of crime gun prevalence on the incidence of gun homicides.

Since it is illegal for persons under 21 to purchase handguns, access by youthful offenders to these guns, and especially to the newer, more powerful semiautomatic pistols, is likely to be much more dependent on crime guns. While crime guns are likely to be a factor in homicides by youth generally, they may be especially important in the gang and drug market activities of youth, where guns hold special significance for self protection, for maintaining order within these illegal enterprises, and as a basis for bestowing status.

The analyses also go beyond simple cross-sectional variations in the prevalence of crime guns and levels of homicide. Causal influences are difficult to sort out in cross-sectional relationships. Communities may experience higher levels of crime guns and homicide due to the presence of some other underlying factor like general neighborhood differences in the propensity to violence, and not because crime gun prevalence stimulates increased violence, or vice versa. The analyses below focus on temporal changes in homicide rates as the prevalence of crime guns changes in a community. Finding a similar temporal relationship across many different neighborhoods provides a much stronger test of a direct link between greater access to crime guns and an increased risk of homicide.

Data

Homicides in Pittsburgh

We use census tract-level data from the city of Pittsburgh for the years 1990 through the end of 1995. The data on homicide incidents are based on detailed information on various attributes of individual homicides extracted from police case files.[2] These data include attributes of the offenders and victims and any relationships between them, the circumstances surrounding the incident, and the locations where the incident occurred and where offenders and victims reside. Circumstances include motive and other precipitating events, type of weapon, and any involvement of illicit drugs or gangs in the incident. Table 1 provides a breakdown of gun involvement by type of homicide. Most homicides involve guns for all types of homicides except non-youth homicides. Cohen and Tita (1998, 1999) provide thorough treatments of the

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[2] The homicide data were collected with funding from the National Institute of Justice (grant 95-IJ-CX-0005).

changing nature of homicides evident in these data. Some of the key features relating to age, drugs, and gangs are summarized briefly here.

Most homicides involve youthful participants—juveniles ages 12 to 17 and young adults through age 24—as either offenders or victims. Of 287 total homicides that occurred from 1991 to 1995 in Pittsburgh, only one-in-four failed to include at least one youthful participant and 7 in 10 involved youthful offenders. Guns also figure prominently in homicides, especially homicides involving youthful participants. While guns are used in 75% of homicides that involve youths as offenders, the same is true for only 49% of non-youth homicides.

Drug related homicides include incidents with any mention of illicit drugs. These homicides overwhelmingly involved drug trafficking activities (63%) and rarely involved drug use (under 1%). Another 34% occurred during robberies of drug dealers. Crack cocaine arrived in Pittsburgh during the latter half of 1989. It was accompanied by a substantial increase in drug arrests (up more than 100% from 1988 to 1989, and an additional 61% from 1989 to 1990), especially arrests of younger offenders through age 20 (up 4.7-fold from 1988 to 1989, and then almost 2-fold from 1989 to 1990). The arrival of crack apparently did not spawn an increase in drug related homicides which remained relatively constant in number over the study period. There was, however, an increase in the involvement of youth in drug related homicides—increasing 30 percentage points from 59 to 89%. A similar age shift to younger participants also occurred in non-drug homicides during the same period.

Gang-involved homicides include both gang motivated incidents (e.g., gang initiations or inter-gang rivalries) and incidents that involve gang members but no specific gang objectives. Throughout the study period, gang-motivated homicides were about two-thirds and member-only homicides one-third of all gang-involved homicides. The one exception was the end of the study period in 1995 when member-only homicides—usually involving domestic disputes and robberies—increased to become 68% of all gang-involved homicides. Inter-gang conflicts were the bulk of all gang-involved homicides (68%). There was very little intersection between gang-involved and drug-involved homicides, with only 21% of gang-involved homicides also being drug related. The emergence of violent youth gangs began in the latter half of 1991 and continued through 1992. This was accompanied by very large increases in the numbers of gang-involved homicides in the city.

Crime Gun Prevalence

We also rely on police data to measure crime gun prevalence, specifically reports to police of stolen guns and 911 calls reporting shots fired incidents. Like the homicide data, street addresses are available to identify the locations of these incidents.

Stolen Guns Stolen guns have been regarded as a potentially important source of crime guns (Wright and Rossi, 1986; Sheley and Wright, 1993). Gun thefts or purchases of stolen guns are effective means of circumventing restrictions on the legal acquisition of guns, and moving guns from legal ownership to criminal uses. Stolen gun reports are also potentially important as a means of concealing "straw purchases." Straw purchases involve individuals who legally purchase guns with the express purpose of transferring them to persons who can not legally purchase guns for themselves. Police data on guns reported stolen include the attributes of the gun and residential locations of owners. These data are available over the period 1985 through mid-1996 in the study site.

Shots Fired Data on 911 calls reporting shots fired incidents provide vital information on both the location and timing of these incidents. Shots fired are a unique measure that not only captures varying levels of access to crime guns, but also variations in willingness to use crime guns in a criminal manner. At its most trivial level, discharging a gun within city limits is by itself usually a criminal violation. Criminal use escalates in seriousness when the gun is fired to damage property, and reaches the highest levels of seriousness when the gun is fired to threaten or injure another person.

Previously used measures of gun prevalence are generally quite remote from the prevalence of crime guns and levels of *criminal* gun use. This is especially so when the indicators are dominated by legal gun ownership, e.g., numbers of hunting licenses issued, or subscriptions to gun publications, or memberships in sporting and gun advocacy organizations. Shots fired are not only more directly linked to crime guns, they are also highly visible indicators of the relative prevalence of crime guns in different communities. Incident-level data of 911 calls permit analyses of variations in crime gun prevalence across neighborhoods and over time.[3]

Estimating the Impact of Crime Gun Prevalence

Dependent Variable

The analysis relies on the timing of homicides at the census tract level over the years 1990-1995. Each tract is observed for repeated spells, each one week long, and the presence or absence of a homicide is noted. The dependent variable is the probability of observing a homicide in a tract during each one week interval. Separate homicide spells are obtained for several different types of homicide. These are noted in Table 2 along with the expected effects of crime gun prevalence on each type. Crime gun prevalence is expected to affect levels of gun-, gang-, and drug-related homicides, especially those in each type that involve youthful offenders ages 12 to 24.

[3] Because many observers will easily detect gun shots, shots fired are especially vulnerable to multiple reports of the same crime incident. We use time (≤ 5 minutes apart) and distance (≤ 2000 feet) filters to screen out potential duplicate calls for the same incident.

We do not attempt to distinguish between intention and instrumentality in the effects of crime guns on homicide. Crime gun prevalence may increase in order to facilitate the commission of a planned homicide. Alternatively, mere increases in crime gun prevalence, that occur without any specific homicide intentions, may increase the risk of homicide by emboldening actors to pursue confrontations and redress grievances using weapons with especially lethal consequences. Either effect would be detected as a direct effect with increases in crime gun prevalence followed by increases in the risk of homicide in the same neighborhood.

Gun Prevalence

The measures of crime guns capture two aspects of prevalence. Shots fired reflect both accessibility to crime guns and willingness to use these guns in a criminal manner. Stolen guns indicate changes in the potential supply of crime guns. The shots-fired variable is calibrated as a time dependent measure. Shots fired in a neighborhood represent an extremely visible indicator of crime gun prevalence that is expected to raise the threat of a homicide in the same neighborhood immediately after the incident.[4] The effect of shots fired then decreases as the time back to the last shot fired incident becomes more distant and this indicator of crime gun prevalence becomes less salient. The effect is expected to die out completely after a year and so we cap the time back variable at a maximum of 365 days.[5] Measuring the prevalence of shots fired in terms of the time since the last shot was fired allows us to capture the expected change in the effect of shots fired. Figure 3 graphically represents the expected effects.

The effect of time since shots were fired may be mediated by any prior shots fired history. A neighborhood that experiences frequent shots fired incidents may be subject to

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[4] The estimated effect excludes the influence of shots fired on a homicide occurring in the same incident. The estimated effect always looks to the time back to the immediately prior shots fired incident.

cumulative effects, with threat levels increasing each time shots are fired. Alternatively, the effects of a shot being fired may decrease when successive shots fired incidents are not followed by a homicide. To accommodate either form of cumulative effect, we include the average weekly number of shots fired incidents during the previous quarter.

The final indicator of crime gun prevalence is the average weekly number of guns reported stolen in a tract during the previous quarter. These stolen guns contribute to the local potential for converting non-crime guns to crime guns. Since they are not the exclusive source of crime guns in a tract, however, their effect may be mediated.

Control Variables

Time trend and Seasonality Effects

Since we are examining homicide rates over a 6-year period, exogenous citywide factors linked to time may affect the homicide risk across all census tracts. Including a separate dummy variable for each year in the model controls these citywide time trends. Significant yearly effects will capture years with exceptionally high or exceptionally low citywide homicide rates. The analysis also allows for a seasonal trend of increases or decrease in homicides that recur at the same time each year. Homicides, especially any homicides that are a consequence of drug dealing or gang activity, or those that involve youth, are likely to increase during the summer months when these precipitating activities occur at higher than usual rates (Tennenbaum & Fink, 1994). To control for these effects the model includes a seasonal dummy variable for each quarter.

[5] The cap simply means that observed intervals longer than 365 days are reset to the maximum of 365 days for estimation purposes. The influence of these longer intervals is indistinguishable from that at the cap of 365 days.

Neighborhood Fixed Effects

We expect that each census tract has a distinct base rate of homicide that is associated with various individual- and neighborhood-level characteristics of a tract, e.g. economic and social disadvantages that increase the risk of violence, or the presence of youth gangs in a neighborhood. To control for time-stationary, cross-tract differences in these base rates of homicide, the analysis includes separate fixed effects for each tract. These fixed effects will capture stable cross-sectional variation in homicide risk across different tracts.[6]

Prior Homicides

To further control for changes in homicide rates that are due to factors other than crime gun prevalence we include information on prior homicides. To allow for contagion of violence within a tract, we use a measure of the time since the last homicide to capture time-dependent effects of prior homicides. This measure is formulated in the same manner as time since last shot was fired. We expect that if occurrence of homicide has an effect on the risk of a subsequent homicide, this effect will dampen with increasing time back to the last homicide. Like shots fired, the duration since the last homicide is also capped at 365 days.

Estimating Effects

A logit model provides estimates of the magnitude of the effects of crime guns on homicide risk.[7] The estimated model of the probability of a homicide in census tract i, during week t, Pr(H=1), is:

where:

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[6] Once estimated, the fixed effect coefficients can be regressed on social and demographic characteristics to obtain estimates of factors associated with differences in the base rate.

[7] The results of a logit analysis on discreet time intervals are indistinguishable from more complicated continuous time hazard model estimates when the length of the discreet time spells is small enough to approximate the process in continuous time. The one-week long intervals used here are short enough in relation to the usual intervals between homicides.

$$\Pr(H_{it}=1) = f(\alpha_i + \sum_{1}^{4}\beta_j yr_t + \sum_{5}^{7}\beta_k qt_t$$
$$+ \beta_8 d\hom_{it} + \beta_9 dshot_{it} + \beta_{10} avgshot_{it} + \beta_{11} avgstgun_{it})$$

f = logistic function Pr(H=1)= exp(**X**β)/(1 + exp(**X**β)),

α_i = census tract-level fixed effects for each tract *i*,

yr_t = time trend fixed effects for each year *t*,

qt_t = quarterly fixed effects for each season,

$d\text{hom}_{it}$ = duration since last homicide in days,

$d\text{shot}_{it}$ = duration since last shot was fired in days,

$avgshot_{it}$ = average number of shots fired per week during previous quarter,

$avgstgun_{it}$ = average number of guns stolen per week during previous quarter.

The winter quarter and year 1991 are the omitted variables. We do not include 1990 in the analysis since this is the base year for the calculation of the lagged variables.

For each type homicide, the model is estimated only for those tracts that have at least one homicide of that type between 1991 and 1995. Table 3, examines the demographic characteristics of tracts with and without at least one homicide during the study period. Most of the population risk factors are significantly higher in tracts with homicides and these social and economic disadvantages are likely to contribute to very different base levels of homicide across tracts. To control for potentially important omitted variables that produce large differences in risk we exclude tracts with no homicides from the analysis.

RESULTS

The model estimation yields compelling evidence of a causal link between changes in access to crime guns and changes in levels of gun violence that goes beyond simple co-occurrence of both crime guns and homicides in the same neighborhoods. Table 4 summarizes the estimated impacts of the two indicators of crime gun prevalence on the subsequent risk of homicide. The individual coefficient estimates for each type of homicide are in Table 5.

Impact of Shots-Fired

The coefficients of time back to the previous shots fired incident are in the expected direction and significant only for those types of homicides expected to vary with prevalence of crime guns, notably gun homicides, gang homicides, and the subsets of gun and gang homicides by youthful offenders. (Tables 4a and 5). There are no corresponding significant effects of time back to shots fired on non-gun and non-gang homicides, even when these homicides involve youthful offenders. Also, the average weekly rate of shots fired during the previous quarter is never significant, suggesting that there is no cumulative effect of shots fired that mediates or augments the impact of a recent incident.

Table 6 reports the estimated impact of time back to a shots-fired incident on the weekly probability of a homicide. The table reports both the estimated constant base rate of weekly homicide probability after a year without a shots fired incident, and the estimated spike upward in this homicide probability immediately after a shots fired incident. Only the time back to the previous shots-fired incident varies while all other variables are set to the mean value observed in the data (means are in Table 7). To calculate the base rate, time back to a shots fired incident is set to 365 days. This is compared to the calculated probability when a new incident occurs and time back resets to 1 day. The probability estimates are given for the median tract (i.e., the tract that falls in the middle of the estimated values of the tract fixed effects) and the worst tract (i.e., the tract with the largest estimated value of the tract fixed effects).

When the coefficient for time back to a shots-fired incident is significant, the impact on the weekly probability of a homicide is substantial in magnitude (Table 6). For gun homicides in a median tract, a shots fired incident raises the weekly risk of a gun homicide in that tract 44-fold, from a prevailing base rate of .00014 (one homicide in every 137 years—[1/.00014]/52—or essentially zero risk) to .00621 (one homicide every 3 years).[8] In the worst tract, a shots-fired incident raises the weekly risk of a gun homicide from a base rate of .00128 (one homicide every 15 years) to .05330(one homicide every 19 weeks).[9] Similarly significant impacts are detected for youth-gun homicides, and for gang and youth-gang homicides.

Figure 4 illustrates the estimated effect of shots-fired incidents on the risk of youth-gang homicides. Shots fired increases the weekly risk of homicide from essentially zero to .00606 (one homicide every 3.2 years) in a median-risk tract. The corresponding effect in the worst-risk tract is an increase to .02508 (one homicide every 40 weeks). The influence of shots fired on youth gang homicides then falls off very quickly reaching half the maximum after 33 days and dropping back to near-zero (one homicide every 50 years) in about 6 months in all tracts.

Impact of Stolen Guns

The results for the impact of stolen guns on homicides are similarly selective (Table 4b). The estimated coefficients for stolen guns are significant and positive for homicides involving youthful offenders, guns, and youthful offenders in gun and gang-involved homicides. In each case an increase in the weekly average number of guns reported stolen in a tract during the previous quarter increases the weekly probability of that type of homicide in the same tract. The other coefficients are generally as expected—not significant for non-youth, non-gun, and non-gang homicides. The one exception is a combination of a significant positive effect of stolen guns on gun homicides and a significant negative effect of stolen guns on non-gun homicides.

[8] All else being equal, a median tract has an estimated fixed effect and associated base-level homicide risk that falls at the median level of all tracts.

[9] In the worst tract, the estimated fixed effect yields the highest base level of homicide risk, all else being equal.

This suggests a substitution effect where gun homicides replace non-gun homicides as access to stolen guns increases in a tract.

Null Effects

The results largely confirm the expected effects of rising crime gun prevalence in increasing the subsequent risk of certain types of homicide. The expected effects on homicides by youthful offenders and drug homicides, however, are not observed. The null effect for drugs is consistent with the overall pattern of no change in drug-related homicides in the study city, despite the arrival of crack markets and increasing involvement of younger offenders in these markets. The weak or null effects for youth homicides suggests that offender age alone is not a determining factor in the influence of crime guns on homicide risk and other features of homicides by youth are important.

Impact of Previous Homicides

Contrary to expectation, time back to a previous homicide of the same type is significant for most types of homicide investigated here. (Tables 5 and 8). Furthermore, these significant effects are not in the expected direction—on the contrary, the probability of another homicide of the same type in a tract *declines* immediately after a homicide and then increases back to the base rate as the previous homicide becomes more distant in time. At first, this *suppression* effect following a homicide seems at odds with the expectation of retaliation following gang-motivated homicides. It is less surprising, however, if the gangs involved in a homicide are located in different tracts so that retaliatory incidents are more likely to occur somewhere else.

Cohen, et al. (1998) found evidence of a similar suppression effect immediately following drug homicides in St Louis neighborhoods, and following gang homicides in both St Louis and Chicago neighborhoods. The authors suggest various potentially self-limiting processes that would account for the observed suppression effects. Sustained high levels of violence are likely to be a disruptive factor in sustaining the economic viability of illegal drug markets as both customers and vendors avoid dangerous market locales. Increased law enforcement presence and visibility in the immediate aftermath of a homicide may also suppress visible street violence in the affected area. Finally, the visibly tragic human consequences of a homicide for family and friends of both the victim and offender no doubt also serve to suppress risky behavior in the affected community.

CONCLUSION

Using incident-level data of the spatial and temporal distribution of homicides and other offending related to guns, the analysis explores the influence of "crime gun" prevalence on the risk of homicide. The use of "crime gun" measures is a unique contribution of this paper that focuses the analysis, for the first time, on the subset of guns most likely to be used in violent street crimes rather than the general prevalence of guns in a community. The number of guns reported stolen and the number of 911 calls reporting shots-fired incidents measure variations in the prevalence of crime guns. Strong neighborhood variations in both the prevalence of crime guns and the levels of homicide are evident, with higher homicide rates observed in the same locations as higher levels of crime-gun incidents. This cross-sectional relationship, however, may reflect general neighborhood differences in the propensity to violence and not necessarily any causal link between crime gun prevalence and homicides.

Going beyond a simple cross-sectional relationship, the present analysis relies on a hazard model to estimate changes in homicide risks in different neighborhoods as levels of crime gun prevalence change. Finding evidence a temporal relationship as the two variables change in value is a much stronger test of a direct link between greater access to crime guns and an increased risk of homicide. Overall, the effects of crime gun prevalence are as expected—increases in crime gun prevalence are followed by increases in homicide risk.

These effects occur selectively only for those types of homicide where access to crime guns is expected to be a factor, specifically homicides by gun and those involving gang motives, and especially the subsets of these homicides that involve youthful (ages 12 to 24) offenders. No similar effects are found for non-youth homicides, or for non-gun and non-gang homicides even when the latter types involve youthful offenders. The one exception is a significant effect in the opposite direction for stolen guns on non-gun homicides—as the number of stolen guns increases, homicides by gun increase while non-gun homicides decline, suggesting a substitution effect with guns replacing other weapons when the prevalence of stolen guns increases.

These results are important evidence of a direct influence of crime gun prevalence on the likelihood of homicides. The selective nature of the effects further highlights the types of homicides that are most likely to be impacted by interventions that disrupt access to crime guns—those involving youth with guns and youth in gangs.

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Figure 1. Offense Rate and Percent Firearms: Homicide in U.S.

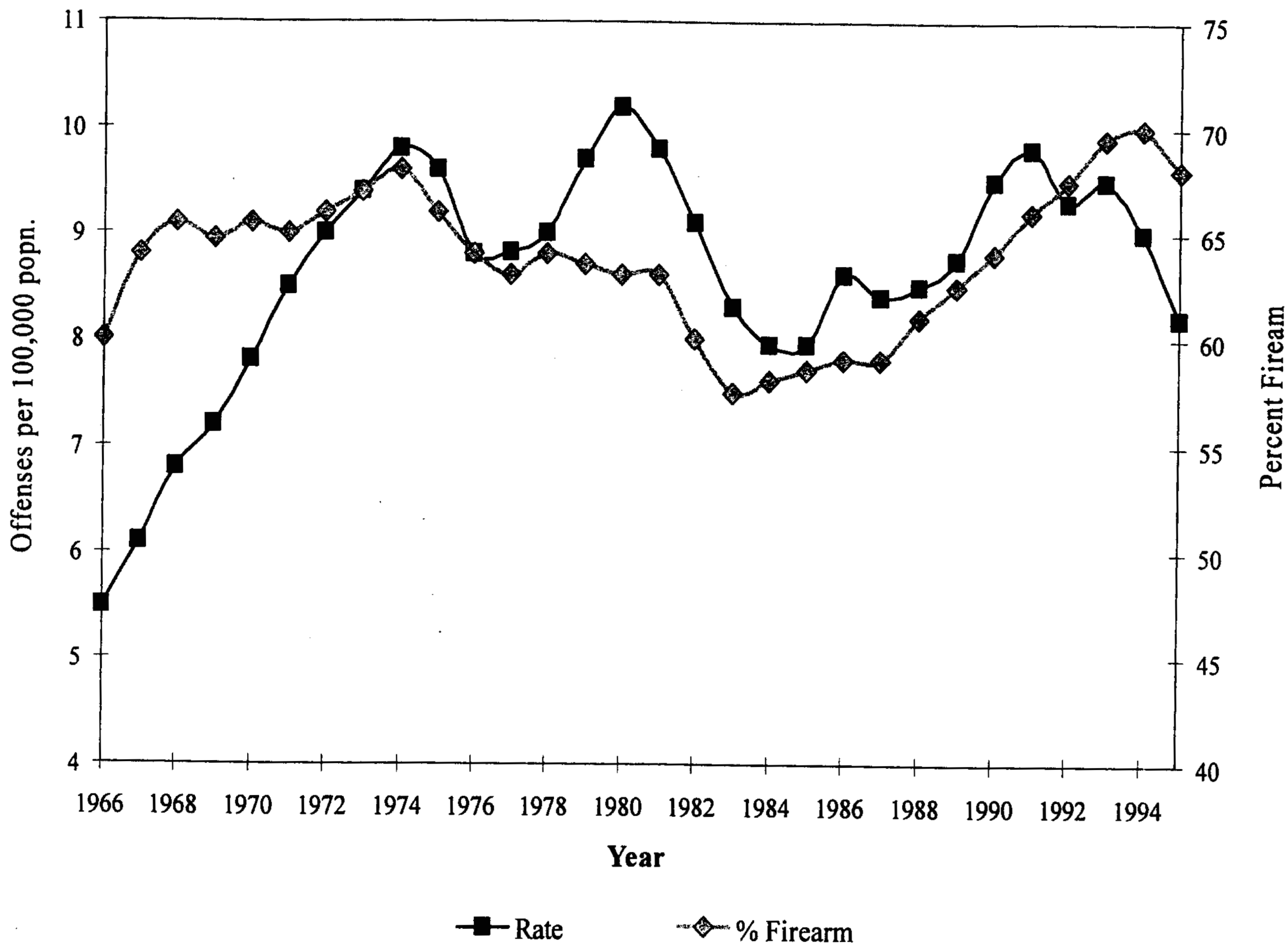

Figure 2: Effects of measurement error

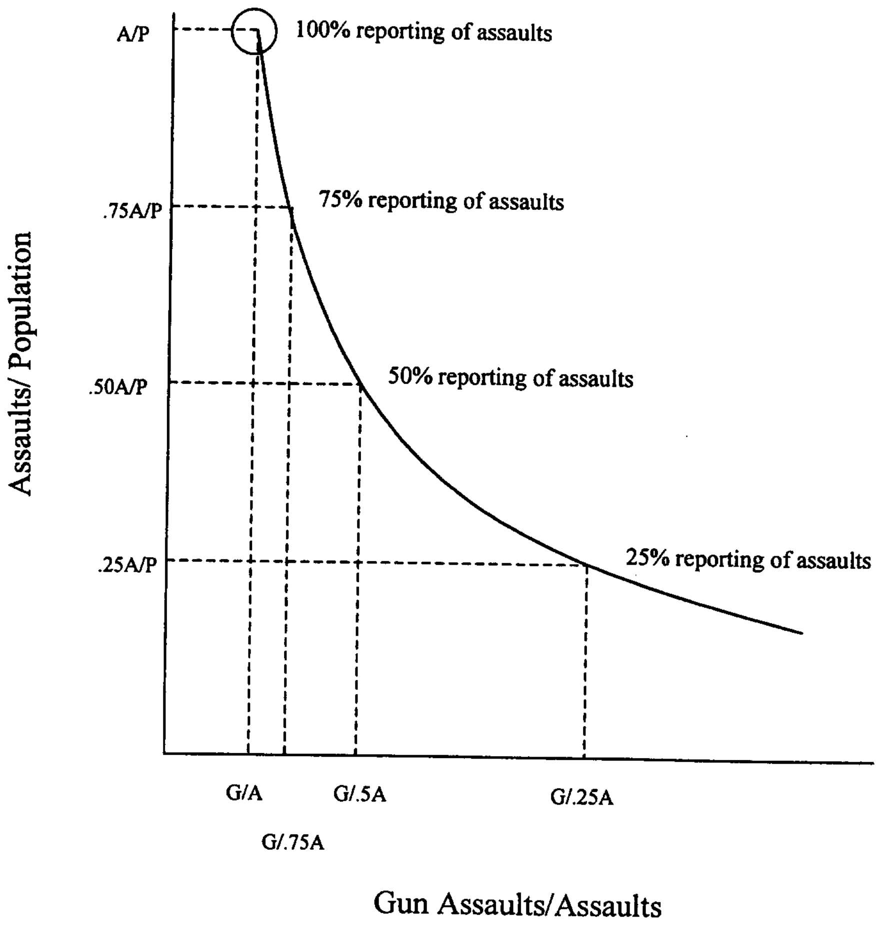

Figure 3. Effect of Shots Fired on Probability of Homicide

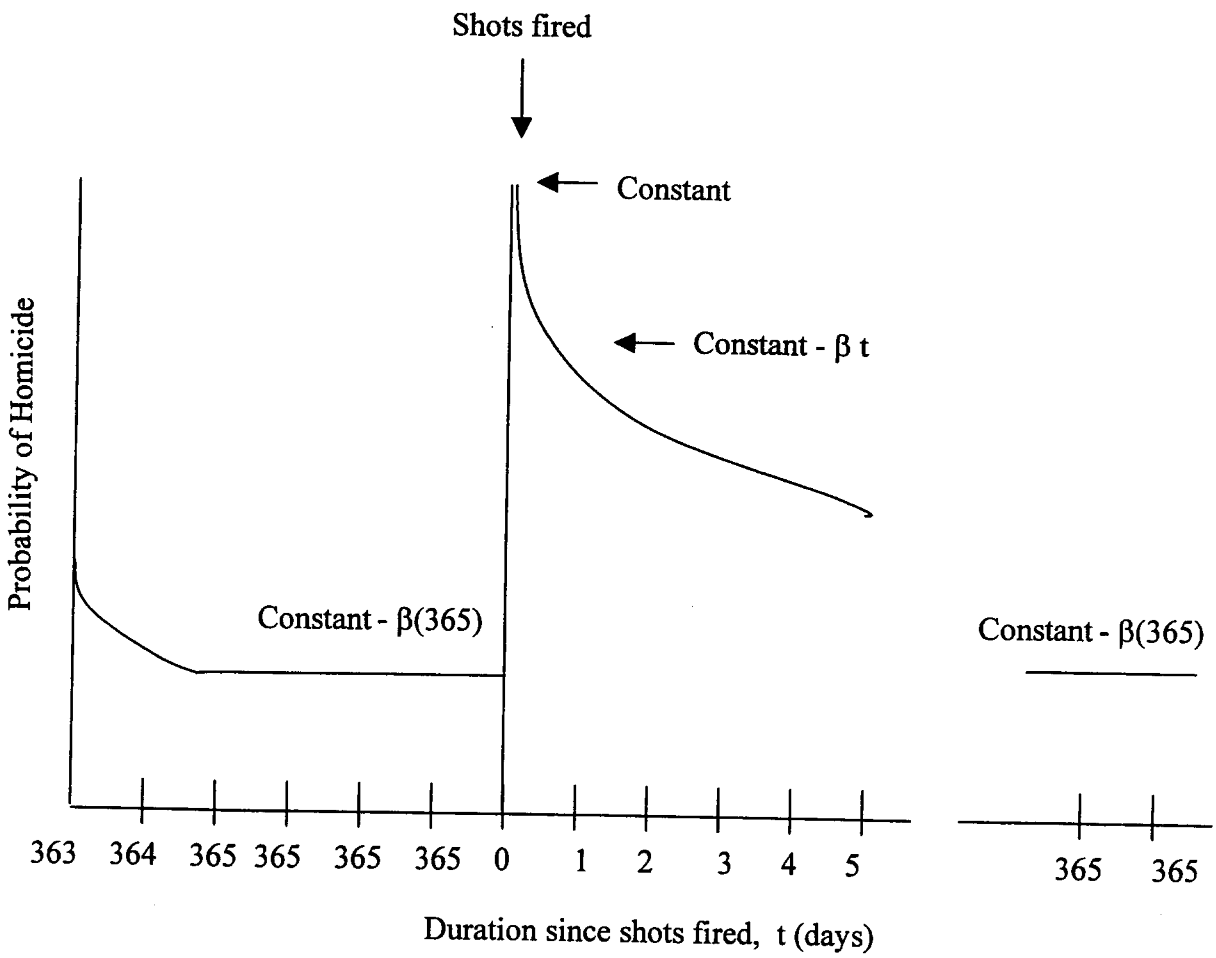

Figure 4. Impact of Shots Fired Incidents on Weekly Risk of Youth-Gang Homicides

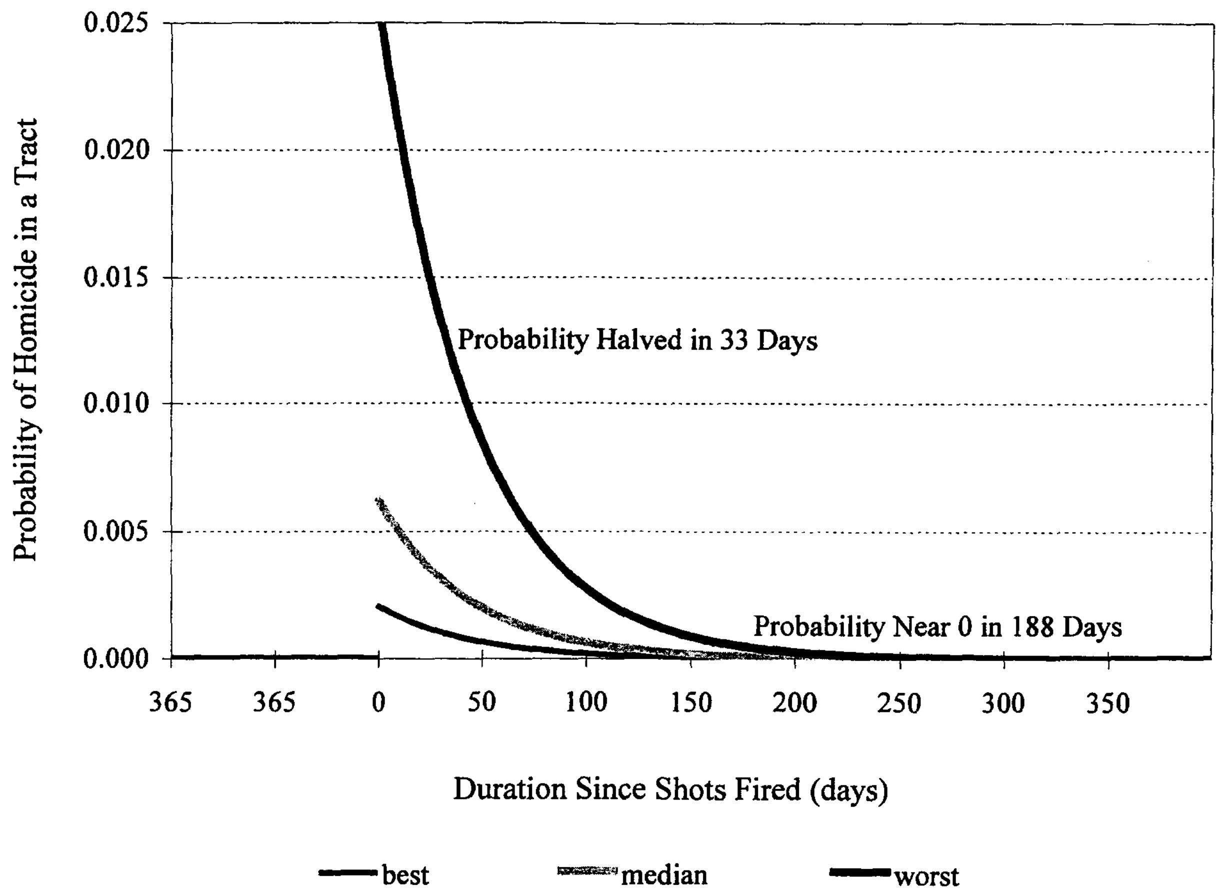

Table 1. Counts of Homicides Disaggregated by Type

Homicide Type	Gun	No Gun	Total	Percent by Gun
Total Homicides	206	121	327	63.0
Youth Homicides	161	60	221	72.8
Non-Youth	45	61	106	42.5
Gang	70	1	71	98.6
Drug	56	12	68	82.4

Table 2. Expected Effects of Crime Guns by Type of Homicide

Types with Expected Effect	Types with No Expected Effect
	All Homicides
Youth	Non-Youth
Gun	Non-Gun
Youth-Gun	Youth-Non-Gun
Gang	Non-Gang
Youth-Gang	Youth-Non-Gang
Drug	Non-Drug

Table3. Attributes of Tracts by Presence of Homicides

Population Attribute	Mean in Tracts with Homicides N = 100	Mean in Tracts with No Homicides N = 74	t statistic	p value (2 tail)
% Black in Population	40.78	14.13	5.46	.0001
% Female-Headed Households	22.08	13.37	4.80	.0001
% Households on Public Assistance	19.20	10.14	4.55	.0001
% Not High School Graduates in Population 18 to 25	30.86	23.77	3.48	.0007
% Unemployed in Civilian Labor Force	13.20	7.59	4.21	.0000
% Population Below Poverty	28.26	16.33	4.61	.0000
% At-Risk Ages 12 to 24 in Population	15.61	14.94	0.48	.6311

Table 4. Expected and Observed Impact of Crime Guns on the Weekly Risk of Homicide in a Census Tract: Variations by Type of Homicide [a]

a. Impact of Time Back to Previous Shots Fired Incident in Same Tract

Expected: Negative and Significant [b]		Expected: Not Significant	
Homicide Type	Obs	Homicide Type	Obs
		All Homicides	√
Youth		Non-Youth	√
Gun	√	Non-Gun	√
Youth-Gun	√	Youth-Non-Gun	√
Gang	√	Non-Gang	√
Youth-Gang	√	Youth-Non-Gang	√
Drug		Non-Drug	√

b. Impact of Average Weekly Count of Guns Reported Stolen During Previous Quarter in Same Tract

Expected: Positive and Significant [c]		Expected: Not Significant	
Homicide Type	Obs	Homicide Type	Obs
		All Homicides	√
Youth	√	Non-Youth	√
Gun	√	Non-Gun	-[d]
Youth-Gun	√	Youth-Non-Gun	√
Gang		Non-Gang	√
Youth-Gang	√	Youth-Non-Gang	√
Drug		Non-Drug	√

[a] Types of homicide are separated by the expected effect of each crime gun measure on the weekly probability of a homicide. A check mark appears when the observed effect estimated from the data matches that expected in sign and significance.

[b] Immediately after a shots fired incident, the homicide risk increases from the prevailing level. This risk then *decreases* again as time back to the shots fired incident *increases*. Hence the expected effect of time back is *negative*.

[c] As the number of stolen guns increases in a tract, the homicide risk also increases. Hence the expected effect of stolen guns is *positive*.

[d] The effect estimated from data is significant and negative (i.e., an increase in access to stolen guns *decreases* the risk of non-gun homicides. A significant positive effect of crime guns on the risk of gun homicides, combined with a significant negative effect of crime guns on the risk of non-gun homicides, suggests a substitution effect where gun homicides replace non-gun homicides as access to stolen guns increases in a tract.

Table 5. Estimated Coefficients in Models of the Weekly Risk of Homicide in a Census Tract [a]

Variables[b]	All Homicides	Drug Homicides	Non-Drug Homicides	Gang Homicides	Non-Gang Homicides	Gun Homicides	Non-Gun Homicides
dhom	0.002589 ***	0.002197	0.001907 **	0.003983 **	0.002227 **	0.003443 ***	0.001737
dshot	-0.002481	-0.008705	-0.001692	-0.022153 *	-0.001347	-0.010388 **	0.001333
avgshot	0.107134	0.223256	0.046055	0.171326	0.055798	0.124965	0.033335
avgstgun	0.837512	2.439023	0.622571	2.712564 +	-0.550464	1.780219 +	-5.363690 +
qt2	-0.084219	-0.010708	-0.095543	-0.578774	0.000982	-0.224939	0.176624
qt3	-0.099033	-0.174870	-0.044638	-0.124202	-0.095755	-0.077862	-0.158951
qt4	-0.121858	-0.783947 +	0.058195	0.183238	-0.264854	-0.118780	-0.109571
yr3	0.023232	-0.146308	0.064163	0.928248	-0.153086	0.258506	-0.343338
yr4	0.650354 **	-0.082658	0.775228 ***	1.772963 **	0.342323	0.852745 **	0.473681
yr5	0.312035	-0.044959	0.358935	1.426338 *	0.041831	0.652894 *	-0.254396
yr6	0.184613	0.433391	0.070833	0.627710	0.165200	0.505651 +	-0.110266

Variables[b]	All Homicides	Youth [c] Homicides	Non-Youth Homicides	Youth-Gang Homicides	Youth Non-Gang	Youth-Gun Homicides	Youth Non-Gun
dhom	0.002589 ***	0.002519 ***	0.001228	0.003422 *	0.002655 **	0.003291 ***	0.002386
dshot	-0.002481	-0.004071	-0.000567	-0.022450 *	-0.002025	-0.011447 *	0.001562
avgshot	0.107134	0.095523	0.052838	0.240789	0.016162	0.158461	-0.237269
avgstgun	0.837512	1.929135 +	-4.756085	3.079176 +	0.904315	2.439673 *	-2.756508
qt2	-0.084219	0.028761	-0.375602	-0.480154	0.166796	-0.021082	0.207389
qt3	-0.099033	-0.094299	-0.075808	-0.040707	-0.157316	-0.033180	-0.332720
qt4	-0.121858	-0.048771	-0.205825	0.153051	-0.216723	0.028371	-0.244838
yr3	0.023232	0.340443	-0.429273	0.882168	0.178397	0.550176	-0.147655
yr4	0.650354 **	1.011375 ***	0.131223	1.542259 **	0.729941 *	1.033711 **	1.199804 *
yr5	0.312035	0.685425 *	-0.241759	1.195665 +	0.434898	0.949222 **	-0.141028
yr6	0.184613	0.622062 *	-0.310333	0.523233	0.666040 *	0.797998 *	0.381146

[a] The logit model takes the general form $Pr(H=1) = exp(\mathbf{XB})/(1+exp(\mathbf{XB}))$ for independent variables **X** and coefficients **B**. As the value of a variable increases, positive coefficients increase the weekly probability of a homicide in a tract and negative coefficients decrease that probability. Coefficients are significant (two-tail t-test) at levels: + $p \leq .100$, * $p \leq .050$, ** $p \leq .010$, and *** $p \leq .001$

[b] The variables are: dhom=duration (in days) since last homicide of the same type in same tract, dshot=duration (in days).since last shots fired incident in same tract, avgshot=average number of shots fired per week in same tract during previous quarter, avgstgun=average number of guns stolen per week in same tract during previous quarter, qt2 to qt4= seasonal effects of quarters in a year, yr3 to yr6=citywide time trend effects of years 1992 to 1995.

[c] All varieties of youth homicides involve offenders ages 12 to 24.

Table 6. Estimated Impact of Shots Fired Incident on the Weekly Risk of Homicide in a Census Tract [a]

			Median Tract [c]			Worst Tract [d]		
Type of Homicide	Coeff [b]	Pseudo R^2	Base Level P(Homicide)[e]	Shots Fired Multiplier [f]	Maximum P(Homicide)[g]	Base Level P(Homicide)[e]	Shots Fired Multiplier [f]	Maximum P(Homicide)[g]
All	-.00248	.085	.00286	2.47	.00702	.02815	2.37	.06669
Youth Offender	-.00407	.078	.00115	4.38	.00502	.00959	4.26	.04088
Non-Youth	-.00057	.039[ns]	.00303	1.23	.00372	.01900	1.22	.02325
Gun	-.01039***	.086	.00014	43.60	.00621	.00128	41.58	.05330
Non-Gun	.00133	.047[ns]	.00550	.62	.00339	.03796	.62	.02372
Youth-Gun	-.01145**	.080	.00010	64.10	.00643	.00060	62.14	.03739
Youth-Non-Gun	.00156	.047[ns]	.00508	.57	.00288	.03078	.57	.01767
Gang	-.02215**	.089	.000002	3158.88	.00556	.000008	3093.27	.02622
Non-Gang	-.00135	.068	.00261	1.63	.00426	.03501	1.60	.05592
Youth-Gang	-.02245**	.084	.000002	3518.79	.00606	.000007	3451.45	.02508
Youth Non-Gang	-.00203	.060[ns]	.00192	2.09	.00401	.01938	2.05	.03967
Drug	-.00871	.057[ns]	.00022	23.66	.00509	.00073	23.39	.01704
Non-Drug	-.00169	.067	.00242	1.85	.00446	.02160	1.82	.03926

[a] The weekly probability of a homicide is given by the logit function, $Pr(H=1) = exp(\mathbf{XB})/(1+exp(\mathbf{XB}))$ for independent variables **X** and coefficients **B**. This probability can be translated to the average number of weeks between homicides by calculating the inverse quantity [1/Pr(H=1)]. The probabilities associated with some common intervals between homicides are:

Probability	.077	.038	.019	.0096	.0064	.0038	.0019	.00096
Weeks Between	13	26	52	104	156	260	520	1040

[b] The significance levels (two-tail t-test) of the estimated coefficients are: * $p \leq .100$, ** $p \leq .050$., and *** $p \leq .010$.

[c] The median tract falls at the middle of the estimated values of the fixed effects of tracts. All else being equal, the base-level homicide risk in the median tract falls at the median of the distribution of risk levels across the tracts.

[d] The worst tract has a fixed effect that yields the highest base-level homicide risk of any tract (all else being equal).

[e] The base level probability is the weekly risk of a homicide for a tract with mean values on all control variables and time back to the previous shots fired incident of 365 days or more. This is the risk level when there is no influence of previous shots fired incidents.

[f] The multiplier indicates the ratio between the homicide risk immediately after a shots fired incident and the prevailing base level of risk. A multiplier value of 2, for example, indicates a doubling in the weekly homicide risk.

[g] The maximum probability is also calculated for a tract with mean values on all the control variables. The maximum level is the risk immediately after a shots fired incident when time back to a shots fired incident is one day. This elevated probability declines from the maximum back toward the base level as time back to a shots fired incident increases, and disappears entirely after 365 days.

Table 7. **Variable Means for Models of the Weekly Risk of Homicide in a Census Tract** [a]

Variables[b]	All Homicides	Drug Homicides	Non-Drug Homicides	Gang Homicides	Non-Gang Homicides	Gun Homicides	Non-Gun Homicides
dhom	289.6261	317.9696	295.8314	312.1495	297.8562	299.9342	310.1275
dshot	44.3951	24.9319	44.7335	24.6863	44.7633	34.7509	46.1236
avgshot	0.5693	0.9406	0.5972	0.9845	0.5787	0.6755	0.7210
avgstgun	0.0191	0.0238	0.0196	0.0252	0.0192	0.0221	0.0188
qt2	0.2539	0.2538	0.2539	0.2538	0.2539	0.2538	0.2539
qt3	0.2538	0.2540	0.2538	0.2538	0.2538	0.2539	0.2538
qt4	0.2500	0.2499	0.2500	0.2500	0.2500	0.2500	0.2500
yr3	0.2000	0.2000	0.2000	0.2001	0.2000	0.2000	0.2000
yr4	0.2000	0.2000	0.2000	0.2000	0.2000	0.2000	0.2000
yr5	0.1999	0.2000	0.1999	0.1999	0.2000	0.1999	0.2000
yr6	0.2000	0.2000	0.2000	0.2000	0.2000	0.2000	0.2000

Variables[b]	All Homicides	Youth [c] Homicides	Non-Youth Homicides	Youth-Gang Homicides	Youth Non-Gang	Youth-Gun Homicides	Youth Non-Gun
dhom	289.6261	298.3531	316.7840	313.5304	308.6488	302.7883	322.0800
dshot	44.3951	38.7150	40.3029	25.0469	38.4670	31.4566	43.5937
avgshot	0.5693	0.6581	0.7290	0.9841	0.7015	0.7557	0.7845
avgstgun	0.0191	0.0204	0.0192	0.0254	0.0207	0.0227	0.0211
qt2	0.2539	0.2539	0.2538	0.2538	0.2539	0.2538	0.2540
qt3	0.2538	0.2538	0.2538	0.2538	0.2538	0.2539	0.2537
qt4	0.2500	0.2500	0.2500	0.2500	0.2499	0.2499	0.2500
yr3	0.2000	0.2000	0.2000	0.2001	0.2000	0.2001	0.2000
yr4	0.2000	0.2000	0.2000	0.2000	0.2001	0.2001	0.2000
yr5	0.1999	0.1999	0.2000	0.1999	0.1999	0.1999	0.2000
yr6	0.2000	0.2000	0.2000	0.2000	0.2000	0.2000	0.2000

[a] The logit model takes the general form $Pr(H=1) = exp(\mathbf{XB})/(1+exp(\mathbf{XB}))$ for independent variables **X** and coefficients **B**. As the value of a variable increases, positive coefficients increase the weekly probability of a homicide in a tract and negative coefficients decrease that probability. This table contains mean values of the variables, **X**.. Coefficients are in Table A2.

[b] The variables are: dhom=duration (in days) since last homicide of the same type in same tract, dshot=duration (in days).since last shots fired incident in same tract, avgshot=average number of shots fired per week in same tract during previous quarter, avgstgun=average number of guns stolen per week in same tract during previous quarter, qt2 to qt4= seasonal effects of quarters in a year, yr3 to yr6=citywide time trend effects of years 1992 to 1995.

[c] All varieties of youth homicides involve offenders ages 12 to 24.

Table 8. **Expected and Observed Impact of Time Back to Previous Homicides on Weekly Risk of Homicide: Variations by Type of Homicide [a]**

Expected: Positive and Significant [b] Homicide Type	Obs	Expected: Not Significant Homicide Type	Obs
		All Homicides	+
Youth	+	Non-Youth	
Gun	+	Non-Gun	
Youth-Gun	+	Youth-Non-Gun	
Gang	+	Non-Gang	+
Youth-Gang	+	Youth-Non-Gang	+
Drug		Non-Drug	+