Age-specific gun-related homicide rates in New York City: investigating the relative contribution of policing, cocaine markets, firearm availability, incarceration, and alcohol consumption to the homicide decline during the 1990s in different age groups

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Abstract

We assessed whether changes in neighborhood misdemeanor policing, cocaine consumption, incarceration rate, firearm availability and alcohol consumption had a different relationship with gun-related homicide among youth (15-24), young adults (25-34) and adults (35+) in New York City in the 1990s. We used cross-sectional time-series data for 74 police precincts in 1990-99, and estimated Bayesian hierarchical models. An increase in 5000 misdemeanor arrests was associated with fewer homicides among young adults (median [95% CI]: -18.77 [-27.26, -10.13]) and adults (-3.22 [-5.87, -0.54]). Decreased alcohol consumption was related to declining homicides for young adults and adults, while decreased firearm availability was only associated with decreased homicides for young adults. The only conditions associated with change in homicide among youth were changes in cocaine consumption (0.26 [0.08, 0.45]) and changes in the incarceration rate (0.04 [0.01, 0.06]). This study illustrates the importance of investigating age-specific patterns to understand the mechanisms underlying homicide trends.

Most large U.S. cities experienced a decline in homicide during the 1990s. However, nowhere was the decline more publicized or debated than in New York City (NYC) (1-4). The homicide drop in NYC after 1992 was the largest in the postwar history of the city (1): the number of homicides declined from 2,245 in 1990 to 633 in 1998—a drop of 72% over 8 years (2).

Two leading theoretical perspectives have guided interpretations of the mechanisms behind the decline in homicide. One of the most prominent theoretical perspectives is the theory of "broken windows" policing, formulated by James Q Wilson and George Kelling (5), which proposes that failure to control minor offenses such as prostitution and disorderly conduct destabilizes neighborhoods by creating a sense of public disorder, and encourages the proliferation of crime. This theory motivated the investment in misdemeanor policing during the 1990s. The second theoretical framework, the "crack cocaine" thesis, attributed the increase in homicide in the 1980s to the appearance of crack cocaine in drug markets of big cities (6-8). This phenomenon was accompanied by heavy recruitment of young males as dealers, creating the need for increased use of guns. Guns then diffused to the broader community. Blumstein proposed that the drop in homicide in the 1990s was due to a change in the drug markets, a police response to gun carrying by young males, efforts to decrease general access to guns, an increase in the prison population, and economic expansion (6, 7).

Building on these theoretical perspectives, explanations for the homicide decline in NYC have focused on five potential factors: 1) improvement in policing, particularly focused on the growth in the numbers of officers dedicated to the proactive crackdown of low-level, quality-of-life offenses (3, 4, 9-12); 2) the diminishing drug scene marked by

fewer turf wars between drug-dealing crews, after the ebbing of the crack/cocaine epidemic (6, 7, 13-15); 3) new anti-gun strategies (13, 16, 17); 4) the removal of dangerous persons from the streets with the institution of pro-incarceration policies (12, 13, 18, 19); and 5) a decline in alcohol consumption associated with the instatement of a consumption tax on beer and hard liquor (2).

The risk of homicide varies sharply by age (20-22). In addition, age-specific homicide victimization rates are not constant but are responsive to social change and these age-specific rates have shifted significantly over the course of the 20th century (12, 23, 24). Indeed, Zahn and McCall characterize the changes in the age structure of homicide as the "most pronounced shift" in homicide trends in their review of homicide trends over this period (24).

Regarding the specific case of NYC, researchers have observed that the dramatic drop in homicides in the 1990s benefited some age groups more than others (2, 25). People between the ages of 16 and 40 accounted for two-thirds to three-fourths of all murder victims in NYC in the 1980s and early 1990s. During the 1990s, teenagers between ages 16-19 and young adults in their twenties experienced the sharpest decrease in homicide of all age groups.

The marked difference in the timing and magnitude of homicide victimization rates by age group, historical evidence on the differential response that age-specific homicide rates have to social changes, as well as the fact that leading theories on the NYC homicide drop propose a particular impact of social changes on youth and young adults, suggest that to truly understand the determinants of the homicide drop, we should examine the determinants of change in age-specific homicide rates. Focusing on age-

specific rates rather than on overall population rates may allow us to understand the drivers of the homicide rate for those age groups that are causing the overall rates to rise and fall. Little investigation, however, has been carried out on the influence of these social changes on the risk of victimization in different age groups. Therefore, in this analysis, we examine the extent to which the previously documented social determinants of changes in total homicide levels in NYC (i.e., misdemeanor policing, cocaine consumption, firearm availability, incarceration rates, and alcohol consumption) had a differential impact on gun-related homicide rates among different age groups over time.

MATERIALS AND METHODS

Data for this study were collected from five principal sources: the Office of the Chief Medical Examiner (OCME) of New York City, the NYC Police Department (NYPD), the NYC Human Resources Administration, the NYC Mayor's Management Office, and the United States Census Bureau. The units of analysis used for this research were NYC police precincts (herein referred to as precincts). Police precincts were considered the most appropriate unit of analysis to study the impact of broken-windows policing, since law enforcement is organized at the precinct level (19). Precincts 33 and 34, covering the Washington Heights and Inwood areas, were treated as one precinct because they were split only in 1994. The Central Park Precinct (Precinct 22) was excluded because no one resides in this precinct, and thus no population denominator was available to estimate the rates of homicide and misdemeanor arrests.

Homicide

The homicide measures of interest were gun-related homicide rates for the following age groups: 1) 15-24; 2) 25-34; and 3) 35 years and older. We focus on gun-related homicides because (a) previous research has demonstrated distinct trends for gun vs. non-gun homicide in NYC, and (b) the overall trend for gun-related homicide is more compatible with theoretical arguments about the impact of changes in policing and cocaine markets (1). All cases of homicides in NYC from 1990 to 1999 were identified through standardized manual review and abstraction of medical files in the OCME of NYC. The OCME is responsible for investigating all deaths of people believed to have died from unnatural causes. Thus, all homicide deaths in NYC are reviewed by the OCME and would have been included in the charts used for data extraction. In addition, the Chief Medical Examiner has been the same person from 1990 to the current time in New York City, so the classification of cases, toxicology, policies, and other aspects of the OCME have remained the same over the time period covered in this study.

Data regarding cause of death, circumstances of death (including use of a gun), and toxicology were collected from the OCME files by trained abstractors using a standardized protocol and data collection forms. The OCME investigators used the decedent's medical history, the circumstances and environment of the death, autopsy findings, and laboratory data, to attribute the cause of death to each case reviewed. All OCME cases from 1990 to 1999 were then geocoded to the precinct level by address of injury using ArcGIS software, version 9.0 (ESRI, Redlands, CA). Only cases with a valid address of injury were included in the analysis. Homicide rates were calculated per 100,000 population using data from the 1990 and 2000 Census. The total population in

each precinct in each year was estimated using a linear interpolation for the years between Census population estimates of 1990 and 2000.

Misdemeanor policing

The NYPD routinely collects data on all police arrests for various causes by precinct. Data were collected from the NYPD on all misdemeanor arrests by precinct from 1990-1999 to represent "broken windows" oriented policing, consistent with prior research (3, 9, 11, 26). Misdemeanor arrest rates were expressed as rates per 100,000 population using year-specific population counts.

Cocaine consumption

The level of cocaine use in each precinct was measured as the % of accident decedents whose toxicology results were positive for cocaine in each precinct in each year from 1990-1999, recorded from OCME data.

Firearm availability

We used % of suicide deaths where guns were used per precinct each year from 1990-1999, recorded from OCME data, as a proxy for precinct firearm availability. This measure has been shown to correlate highly with survey-based measures of firearm availability (27).

Incarceration rate

Incarceration rate per 100,000 population was operationalized as the number of prison admissions by precinct of arrest from 1990-1999. This measure was originally obtained from the New York State Division of Criminal Justice Services.[1]

[1] This measure was kindly provided to us by Richard Rosenfeld in a personal communication.

Alcohol consumption

The level of alcohol consumption in each precinct was measured as the % of accidental deaths with toxicology results positive for alcohol in each precinct in each year from 1990-1999, recorded from OCME data.

Potential confounders

The selection of control variables was informed by the prior research by Messner et al. (3) to facilitate replication. These controls included a wide range of socio-demographic characteristics of precincts that have been linked with homicide rates in past macro-level research (28). We first present time-varying confounders and then follow with covariates only available at baseline.

Felony arrests. Felony arrest data were collected from the NYPD by police precinct from 1990-1999. Felony arrest rates were expressed as rates per 100,000 population, once again using population counts interpolated from the 1990 and 2000 Census as the relevant denominator. This variable was included to assess whether increased police activity at all levels was responsible for the decline in homicides rather than increased broken windows policing specifically.

Police manpower. The indicator of manpower was the number of police officers assigned to each police precinct from 1990-1999 by the NYPD.

Public assistance. We used public assistance as a measure of time-varying neighborhood disadvantage: it has been previously shown to correlate highly with other indicators of disadvantage, such as the concentration of poverty and unemployment (29-32). The annual proportion of the precinct population receiving public assistance was obtained from the NYC Human Resources Administration.

Data for the following variables were available only for decennial years, and thus they were measured as time invariant fixed at the 1990 Census year. The specific measures were as follows:

% male. % persons in a given precinct who were male.

% under age 35. % persons in a given precinct under age 35.

% black. % persons in a given precinct who were black.

% Hispanic. % persons in a given precinct who were Hispanic.

% of population foreign-born. % persons in a given precinct who were foreign-born.

% unemployed. % persons in a given precinct who were unemployed.

Concentrated poverty: Composite of % of persons below 200 % of the poverty line, % with less than a high school education, and % female-headed households.

The data source for these socio-demographic control variables was the U. S. Census Summary File 3 (SF3). Infoshare Online (www.infoshare.org) was used to provide Census data at the tract level, which were aggregated to the precinct level. We conducted principal component analysis to construct the composite measure of concentrated poverty, using data from the US Census 1990. The composite score for concentrated poverty was created by summing the % of persons living below 200 % of the poverty line, the % with less than a high school education, and the % of female-headed households, each weighted by its factor loading. Higher scores indicated greater levels of concentrated poverty. All time-invariant control variables were standardized to have a mean of 0 and a standard deviation of 1 to improve convergence and to enhance comparability and ease of interpretation.

Statistical Analyses

All analyses were based on "change" Bayesian hierarchical models (33, 34). The models used incorporated the spatial dependence of risk for homicide in nearby areas through the use of spatial proximity measures. Spatial models were first chosen after determining that there was sizable spatial autocorrelation, according to the Moran's I estimates of spatial autocorrelation under assumptions of constant risk (using the Poisson distribution) for homicide rates, averaging across years for two time periods (1990-1994 and 1995-1999). Once spatial dependence was established, the Moran's I estimates for spatial error and spatial lag model residuals were compared in order to select the appropriate type of spatial model. A spatial error model was chosen since the magnitude of residual spatial autocorrelation was markedly lower when spatial dependence was accounted for in the model error term rather than in a spatial lag.

In this model, the likelihood of the observed values was modeled as a Normal distribution, where ΔY_{it} is the change in gun-related homicide between times *t* and *t+1* for the precinct i for time period t. The change in homicides was modeled as specified below:

$$\Delta Y_{it} = \alpha_i + \beta_{it}\Delta X_{it} + \mathrm{XB}_i + \lambda_i$$

$\lambda \sim$ CARNormal (W, τ_λ)

$\tau_\lambda \sim$ Gamma (0.5, 0.0005)

The model presented above is a fully-adjusted model, where $\beta_{it}\Delta X_{it}$ represents a vector of the parameters estimating change in the age-specific rate of gun-related homicide, corresponding to a unit change in the independent variables of interest and time-varying control variables for the i^{th} precinct in the t^h time interval, and XB_i is a

vector of the parameters estimating the association between change in age-specific gun-related homicide and time-invariant baseline demographic characteristics measured in 1990 for the i^{th} precinct. λ_i is the random spatially-structured effect accounting for the rate of age-specific homicide in adjacent neighborhoods (33).

The spatial random effect was modeled with a prior that has a conditionally autoregressive distribution (CAR), with weights for first-order adjacent neighbors set at 1 ("neighbors" defined as precincts sharing a border) (34, 35). The conditional distribution of each neighborhood random effect was normal with a mean equal to the average of the random effects of its "neighbors": in this way, the information from adjacent areas could be used to reduce random variation unrelated to the underlying risk of homicide. The prior precision parameter had a hyperprior with a gamma distribution, following the recommendation of Richardson et al. (35). This type of model was chosen after a comparison of model fit between different types of model specifications for spatial clustering, based on the Deviance Information Criterion (DIC), indicated that this model provided the best fit to the data. Our inferences were robust to the choice of hyperprior for the variance in the CAR model.

All models were estimated with Winbugs (Version 1.4.1, Imperial College, UK, 2004), with two parallel Markov chain Monte Carlo (MCMC) chains. Models were run for 100,000 iterations, with the first 50,000 iterations discarded as burn-in, and thinning every ten iterations, for a total of 10,000 samples. Convergence was assessed by visually inspecting the trace histories for each of the parameters of interest (precision parameters, intercept, and parameters for each covariate); in all cases, there was complete overlap between the two chains, indicating adequate convergence.

The predictors of neighborhood homicide rates were examined separately for each homicide victim age group (15-24, 25-34, 35+). For each age group, a model including the exposures of theoretical interest was first estimated. Next, the time-varying control variables (change in the size of the welfare population, change in felony arrest rate and change in police manpower) were introduced into the model. Finally, the time-invariant control variables were included in Model 3.

RESULTS

Of 14,186 homicides that occurred in New York City between 1990 and 1999, 2,027 (14.3%) were missing precinct of injury information, leaving a total of 12,159 homicides classified by precinct of injury. Of these, 8,820 (72.5%) were firearm-related and were thus used in the analysis. Firearm homicide decedents who were excluded from the analysis because of missing precinct of injury information were more likely than those included to be female (8.10% of excluded vs. 7.54% of included), and were more likely to be White (9.27% of excluded vs. 7.66% of included decedents) or other race (4.93% of excluded vs. 3.66% of included), but were less likely to be Black (48.51% of excluded vs. 52.14% of included). There were no differences in the age of decedents included and excluded from the analysis. Homicide counts geocoded by precinct based on the data obtained from the Medical Examiner correlated between 0.85 and 0.95 (depending on the year) with the homicide counts obtained from the NY Police Department.

Figure 1 illustrates the changes in the age-specific homicide rates over the decade. Throughout the years, the 15-24 year-old group had the highest rates of homicide, while the adults aged 35 and older had the lowest rates of homicide. All age groups experienced

a comparable level of decrease, although the absolute change seemed steeper for those aged 15-24 and 25-34, as they initially showed markedly higher rates of gun-related homicide. Gun-related homicide rates among youth aged 15-24 dropped to a rate 77% lower in 1999 than in 1990, while young adults aged 25-34 experienced a decline of 74% from the rate in 1990, and adults 35 and older showed a drop of 76% in the ten years under study.

Table 1 presents the average demographic characteristics for the total sample, as well as at two key points of the study: the beginning of the decade (1990) and the end of the decade (1999). Although baseline measures were standardized for model estimation purposes, here they are presented in their original distribution, in order to provide readers with an understanding of their actual mean and range. Concomitant to the homicide drop, a series of social characteristics also shifted. Proxy indicators of cocaine use and alcohol use (the proportion of deaths in the precinct with a positive toxicology report for cocaine and alcohol use), for example, also decreased, from 8.6 to 5.2% and 19.5 to 16.2%, respectively. The average proportion of residents receiving public assistance diminished, from 12.3 to 9.3 over the decade. The misdemeanor arrest rate, by contrast, increased from 4013.9 to 4954 per 100,000 persons.

Tables 2 – 4 present the models used to test the association between the change in the precinct-level characteristics purported to have been associated with the homicide decline and the change in age-specific rates of homicide. Table 2 presents models for the youth aged 15-24. Model 3 indicates that, independent of basic sociodemographic characteristics assessed at baseline and the level of homicide in adjacent neighborhoods, a unit increase in the level of cocaine consumption was associated with a 0.26-unit

increase in the rate of homicide. Moreover, a unit increase in the incarceration rate was associated with a 0.04-unit increase in the homicide rate.

Table 3 shows comparable models for the 25-34 young adult victims of homicide. Controlling for baseline covariates and independent of the change in the rate of felony arrests and police manpower (Model 3), change in the rate of misdemeanor arrests was modestly and negatively associated with a change in the homicide rate: an increase of 5000 arrests (approximately a standard deviation from the mean of arrests) was associated with 18.8 fewer homicides (95% CI: -27.26, -10.13) per 100,000 population. In contrast, change in the level of alcohol consumption (posterior median: 0.14; 95%CI: 0.03, 0.25) and change in firearm availability (posterior median: 0.08; 95% CI: 0.01, 0.14), were positive predictors of homicide. Change in the proportion of public assistance receipt had a negative association with change in homicide (posterior median: -100.6; 95% CI: -172.3, -29.37).

Table 4 shows models for the effects of the predictors of the homicide decline among adults aged 35 years and older. As with youth, the increase in misdemeanor arrests (posterior median: -3.22; 95% CI: -5.87, -0.54), as well as a change in the rate of public assistance (posterior median: -33.55; 95%: -56.02, -11.26) had a negative association with homicide. Changes in the level of cocaine consumption (posterior median: 0.073; 95% CI: 0.026, 0.120) and of alcohol use (posterior median: 0.04; 95% CI: 0.002, 0.07) were positive predictors of changes in homicide.

DISCUSSION

This study provides one of the first examinations of the impact that key social changes had on the gun-related homicide decline among specific age groups in New York

City in the 1990s. In an analysis based on pooled, cross-sectional time series data for 74 NYC police precincts from 1990-1999 we found that there was a different relation between social and policy changes and homicide rates in three different age groups during a time of dramatic overall decrease in homicide rates citywide. Among youth aged 15-24, a decline in the cocaine markets was associated with a lower homicide rate. Several of the leading predictors of the homicide decline were associated with the homicide drop among young adults aged 25-34 years: an increased investment in misdemeanor policing and increased concentration of welfare receipt in the precinct population were associated with a reduction in homicide. Decreased levels of alcohol consumption, as well as a removal of firearms from the population, were also associated with a reduced rate in this group. Finally, among the older adults, investment in misdemeanor policing and welfare receipt played a role in reducing levels of homicide, although to a lesser extent than for young adults. Declining levels of both alcohol and cocaine consumption also contributed to the reduction in gun-related homicides in this age group.

The potential impact of declining levels of cocaine consumption on the youth is consistent with the crack cocaine thesis, which implies that youth should be particularly susceptible to the influence of changes in the drug markets. To respond to the demand for crack, drug dealers recruited young males from the inner city to act as sellers, and armed them to protect themselves from attacks from rival dealers and street robbers (25). The decline in the crack/cocaine trade, as well as the transformation of the trafficking market away from open-air, free-for-all competitive arenas into a structured, underground economy that took place in protected closed spaces between people who knew each other,

removed the need for highly-armed, and potentially violent youth (2). The potential impact of cocaine consumption on the older adults, in contrast, may reflect a decline in the number of older adults who developed crack/cocaine dependence, with its accompanying risk of engaging in violent acts (and of becoming a victim of a violent act), as well as a decrease in the level of violence associated with the drug trade, which would likely be run by hard-core criminals who were also cocaine-dependent.

We found a positive association between alcohol consumption and homicide rates for adults 25 years of age and older, so that an increase in alcohol use was associated with an increase in gun-related homicide rates. These results may suggest that adults are more vulnerable to victimization when they were under the influence of alcohol intoxication. Prior studies found that alcohol was responsible for an important proportion of gun-related homicides in New York City (36-38), and this has been attributed to increased impulsivity and cognitive impairment (39). The relation between changes in alcohol consumption and changes in homicide fits in with a previously documented decrease in the consumption of hard liquor from the mid-1980s until the mid-1990s, which took place after Mayor Koch imposed a special tax on hard liquor and beer (2).

Investment in misdemeanor arrests seemed to be associated with changes in homicide rates among adults 25 years of age and older, rather than on youth. This is consistent with a police strategy of targeting adults above the legal age for conviction, thus removing them not only from committing offenses, but from the opportunity be victimized. The association was independent of alternative measures of policing, including felony arrests and police manpower, which indicates that misdemeanor arrests may have tapped into the unique contribution of policing quality-of-life offenses, rather

than the overall level of policing invested in more violent neighborhoods. The results confirm the substantive findings from recent work on the influence of policing on overall homicide rates in NYC (3, 4, 14).

Change in welfare receipt also was associated with change in homicide rates among the older age groups, but the sign of the association was opposite to that predicted: increases in the relative size of the population on welfare were associated with declines in homicide. This unexpected finding may reflect the salutary effect of a welfare safety net, conditional on baseline levels of disadvantage. Consistent with these speculations, prior research at the sub-national and national level has suggested that more generous and expansive social welfare policies reduce stressors in the environment and strengthen institutional controls, thereby reducing levels of lethal violence (40-42). The distinctive association of welfare with the older age groups is consistent with the notion of an "aging out of crime" process, as people in their twenties are more likely to be on the road to desistance from crime and in the process of forming families, so that income supplements could help get them out of situations that make them more vulnerable to victimization.

The relation between change in incarceration and change in homicide also was in the opposite direction than that hypothesized: an increase in the incarceration rate was associated with an increase in homicide among youth aged 15-24. This result stands in contrast to prior work by McCall et al. (12) as well as Levitt (18), who found a small but significant relationship between increases in the use of prisons and decreases in crime. Our findings may reflect endogeneity, whereby imprisonment rates actually reflect underlying rates of crime. This is a particular concern given Karmen's parallel analysis of imprisonment rates and homicide rates in the 1990s, which indicates that the high rate of

imprisonment did not imply a selective incapacitation of highly active criminals, but rather an unselective imprisonment of low-level drug sellers and chronic abusers, and that after 1993, the fraction of felony arrestees that received harsh prison sentences declined instead of increasing (2).

The study was subject to several limitations. The use of a non-experimental design invariably raises concerns about endogeneity and unobserved confounding. We addressed concerns about the rate of misdemeanor arrests reflecting a response to underlying levels of violence by including controls for levels of police manpower and felony arrests. However, we cannot conclusively differentiate the impact of misdemeanor policing from other policing practices or correlated measures that may have taken place at the same time in NYC neighborhoods. Indeed, it is important to note that the spatial error term was associated with changes in homicide in all models suggesting that there were factors related to homicide that were omitted from the models and that exhibited a spatial imprint. Although incorporation of the spatial term in the models dealt with the statistical problems of autocorrelation effectively, the mechanisms underlying the decline in homicide will not be fully understood until these omitted variables are identified and explicitly modeled, driving the spatial error term to non-significance.

Despite these limitations, this study makes an important contribution to the understanding of the impact of social changes on homicide by clarifying the ways in which changes in social conditions had differential impacts on the respective age groups in NYC. While the decline in crack/cocaine markets played a role in the homicide decline among the group with the highest rates of homicide (youth aged 15-24), misdemeanor policing, alcohol/cocaine consumption, and public assistance contributed to changes in

homicide among the older age groups. The heterogeneity in homicide rates by age group, as well as the secular shifts in the age structure of homicide, underscores the need to examine age-specific patterns to understand more fully the processes that drive aggregate trends in homicide.

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Figure 1. Average Gun-related Homicide Rate per 100,000 Population by Age Group, New York City, 1990-99

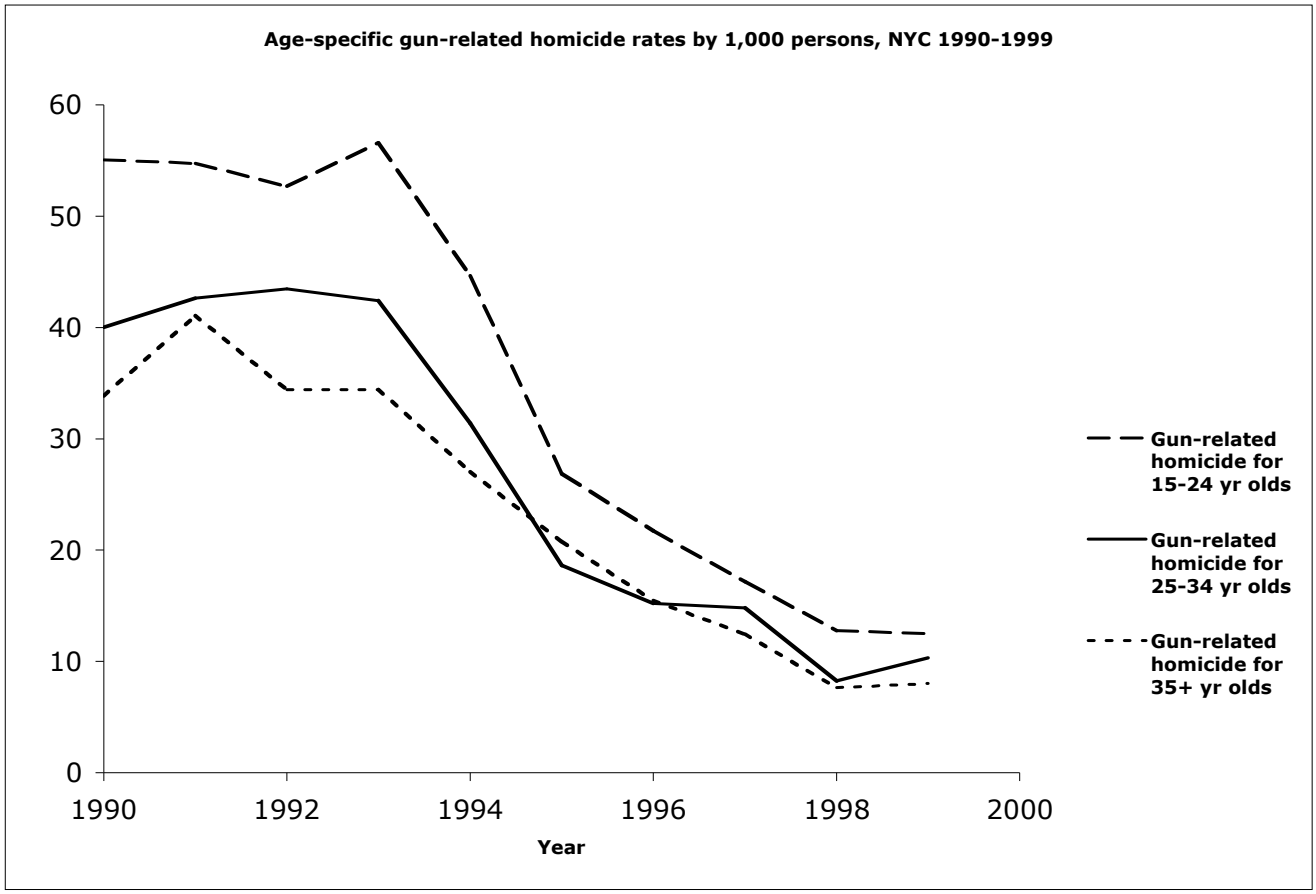

Table 1. Descriptive Statistics for New York City Police Precincts, by Year, 1990-1999

	Average, 1990-99 N = 74		1990 N = 74		1999 N = 74	
	Mean	(SD)	Mean	(SD)	Mean	(SD)
Total gun-related homicide rate (per 100,000 population)[a]	15.12	(15.58)	22.73	(19.22)	5.56	(4.42)
Youth (15-24) gun-related homicide rate (per 100,000 population)[a]	35.47	(40.50)	55.06	(49.86)	12.49	(15.09)
Young adult (25-34) gun-related homicide rate (per 100,000 population)[a]	26.71	(35.38)	40.04	(42.19)	10.31	(15.65)
Adult (35+) gun-related homicide rate (per 100,000 population)[a]	8.26	(10.74)	11.78	(13.33)	2.89	(3.67)
Exposures of interest						
Misdemeanor arrest rate (per 100,000 population)[a]	4748.43	(5074.7)	4013.96	(4882.18)	4954.13	(4082.39)
Proportion of accident decedents positive for cocaine toxicology[a]	7.97	(10.17)	8.56	(8.74)	5.24	(9.97)
Proportion of accident decedents positive for alcohol toxicology[a]	17.31	(13.13)	19.51	(12.97)	16.18	(16.99)
Proportion of suicide deaths caused by firearms[a]	18.83	(20.55)	16.89	(17.22)	14.79	(19.64)
Incarceration rate (per 100,000 population)[a]	304.70	(413.73)	322.77	(474.91)	231.36	(286.95)

Control variables

% receiving public assistance[a]	13.18	(10.11)	12.27	(9.74)	9.30	(7.72)
Felony arrest rate (per 100,000 population)[a]	2448.88	(2167.98)	2834.60	(2838.29)	2001.50	(1594.50)
Size of police force[a]	219.67	(60.52)	181.86	(47.93)	227.91	(59.32)
% of population male[b]	46.97	(2.28)				
% of population under 35 years of age[b]	52.1	(7.55)				
% of population black[b]	27.49	(27.37)				
% of population Hispanic[b]	23.76	(18.1)				
% of population foreign-born[b]	26	(12.21)				
% of population unemployed[b]	4.53	(1.17				
Concentrated poverty[b,c]	91.05	(42.01				

[a] Measures available each year, 1990-1999

[b] Measures available at one point in time (1990)

[c] Concentrated poverty includes the following socioeconomic characteristics aggregated to the police precinct level: % less than high school education, % less than 200 % of the poverty line, and % female-headed households; higher scores indicate higher levels of concentrated poverty

Table 2. Bayesian Hierarchical Models, Including Space Random Effect, Predicting Change in Youth (15-24) Gun-related Homicide Rate, Including Control Variables, New York City Police Precincts, 1990-1999[a]

	Model 1			Model 2			Model 3		
	median	95% CI		median	95% CI		median	95% CI	
Exposures of interest									
Change in misdemeanor arrest rate (per 5000 arrests)[b]	-2.80	-12.96	7.52	-3.91	-14.69	6.79	-3.03	-13.57	7.68
Change in cocaine consumption[d]	0.26	0.08	0.46	0.26	0.08	0.45	0.26	0.08	0.45
Change in firearm availability[i]	-0.02	-0.10	0.07	-0.02	-0.10	0.07	-0.02	-0.10	0.07
Change in alcohol consumption	-0.02	-0.16	0.11	-0.02	-0.16	0.11	-0.02	-0.15	0.12
Change in incarceration rate[b]	0.03	0.01	0.06	0.03	0.00	0.06	0.04	0.01	0.06
Control variables									
Change in % on welfare				36.59	-50.69	124.40	16.49	-72.11	104.30
Change in felony arrest rate[b]				0.00	0.00	0.01	0.00	0.00	0.01
Change in manpower[g]				0.06	-0.10	0.21	0.06	-0.10	0.21
% male[e]							-0.12	-2.88	2.73
% under age 35 years[e]							-1.51	-7.12	4.51
% black[e]							-0.92	-6.77	4.71
% population Hispanic origin[e]							1.61	-3.88	7.02
% population foreign-born[e]							-0.14	-2.80	2.53
% unemployed[e]							1.69	-4.69	8.27
Concentrated poverty[e, f]							-3.51	-9.25	2.30
Residential stability[h]							-0.14	-4.39	4.51
Random effects									
Total standard deviation	30.00	28.45	31.72	30.07	28.50	31.78	30.11	28.54	31.80
Space CAR effect (standard deviation)	0.04	0.01	0.59	0.05	0.01	0.57	0.04	0.01	0.64
Intercept	-4.26	-6.51	-1.90	-4.07	-1.45	-6.65	-4.30	-1.73	-6.88

Abbreviation: CI, credible interval

[a] Models based on 50,000 to 100,000 iterations (10,000 samples)

[b] Misdemeanor arrest, felony arrest, and incarceration rates were expressed per 100,000 population before calculating annual change

[c] % receiving public assistance in 1990 at the police precinct level was approximated from the community district level; 1993 public assistance data are a linear interpolation between 1992 and 1994 data

[d] Annual change in % accident decedents with positive cocaine toxicology

[e] 1990 Census variables were standardized to have mean of 0 and standard deviation of 1

[f] Concentrated poverty includes the following socioeconomic variables aggregated to the police precinct level: % less than high school education, % less than 200 % of the poverty line, and % female-headed households; higher scores indicate higher levels of concentrated poverty

[g] Annual change in size of police force in precinct

[h] Composite of the proportion of people who lived in the neighborhood for more than 5 years and the proportion of owner-occupied housing

[i] Annual change in % suicides where guns were used

Table 3. Bayesian Hierarchical Models, Including Space Random Effect, Predicting Change in Young Adults (25-34) Gun-related Homicide Rate, Including Control Variables, New York City Police Precincts, 1990-1999[a]

	Model 1			Model 2			Model 3		
	median	95% CI		median	95% CI		median	95% CI	
Exposures of interest									
Change in misdemeanor arrest rate (per 5000 arrests)[b]	-25.44	-33.83	-16.91	-19.88	-28.63	-11.15	-18.77	-27.26	-10.13
Change in cocaine consumption[d]	0.04	-0.11	0.20	0.02	-0.13	0.17	0.02	-0.13	0.17
Change in firearm availability[i]	0.08	0.00	0.15	0.07	0.01	0.14	0.08	0.01	0.14
Change in alcohol consumption	0.13	0.02	0.24	0.13	0.02	0.25	0.14	0.03	0.25
Change in incarceration rate[b]	-0.02	-0.05	0.00	-0.01	-0.03	0.01	-0.01	-0.03	0.02
Control variables									
Change in % on welfare				-74.34	-145.10	-2.69	-100.60	-172.30	-29.37
Change in felony arrest rate[b]				-0.01	-0.01	0.00	-0.01	-0.01	-0.01
Change in manpower[g]				0.01	-0.12	0.13	0.01	-0.12	0.13
% male[e]							-0.30	-2.54	2.00
% under age 35 years[e]							-0.57	-5.17	4.36
% black[e]							1.36	-3.33	5.90
% population Hispanic origin[e]							1.37	-3.14	5.74
% population foreign-born[e]							0.72	-1.47	2.90
% unemployed[e]							-2.93	-8.10	2.41
Concentrated poverty[e, f]							-2.52	-7.16	2.17
Residential stability[h]							-0.63	-4.09	3.14
Random effects									
Total standard deviation	24.78	23.49	26.19	24.42	23.16	25.81	24.31	23.04	25.67
Space CAR effect (std deviation)	0.04	0.01	0.57	0.05	0.01	0.52	0.04	0.02	0.59
Intercept	-2.94	-4.80	-0.99	-4.51	-2.38	-6.62	-4.88	-2.82	-6.97

Abbreviation: CI, credible interval

[a] Models based on 50,000 to 100,000 iterations (10,000 samples)

[b] Misdemeanor arrest, felony arrest, and incarceration rates were expressed per 100,000 population before calculating annual change

[c] % receiving public assistance in 1990 at the police precinct level was approximated from the community district level; 1993 public assistance data are a linear interpolation between 1992 and 1994 data

[d] Annual change in % accident decedents with positive cocaine toxicology

[e] 1990 Census variables were standardized to have mean of 0 and standard deviation of 1

[f] Concentrated poverty includes the following socioeconomic variables aggregated to the police precinct level: % less than high school education, % less below 200 % of the poverty line, and % female-headed households; higher scores indicate higher levels of concentrated poverty

[g] Annual change in size of police force in precinct

[h] Composite of the proportion of people who lived in the neighborhood for more than 5 years and the proportion of owner-occupied housing

[i] Annual change in % suicides where guns were used

Table 4. Bayesian Hierarchical Models, Including Space Random Effect, Predicting Change in Adults (35+) Gun-related Homicide Rate, Including Control Variables, New York City Police Precincts, 1990-1999[a]

	Model 1			Model 2			Model 3		
	median	95% CI		median	95% CI		median	95% CI	
Exposures of interest									
Change in misdemeanor arrest rate (per 5000 arrests)[b]	-4.61	-7.17	-1.99	-3.44	-6.16	-0.74	-3.22	-5.87	-0.54
Change in cocaine consumption[d]	0.08	0.03	0.12	0.07	0.03	0.12	0.07	0.03	0.12
Change in firearm availability[i]	0.02	-0.01	0.04	0.02	-0.01	0.04	0.02	-0.01	0.04
Change in alcohol consumption	0.03	0.00	0.07	0.03	0.00	0.07	0.04	0.00	0.07
Change in incarceration rate[b]	0.00	-0.01	0.01	0.00	-0.01	0.01	0.00	-0.01	0.01
Control variables									
Change in % on welfare[c]				-26.03	-48.25	-3.67	-33.55	-56.02	-11.26
Change in felony arrest rate[b]				0.00	0.00	0.00	0.24	-0.45	0.91
Change in manpower[g]				-0.01	-0.05	0.03	-0.01	-0.05	0.03
% male[e]							-0.49	-1.19	0.23
% under age 35 years[e]							-0.15	-1.64	1.39
% black[e]							-0.13	-1.59	1.30
% population Hispanic[e]							0.03	-1.39	1.45
% population foreign-born[e]							0.24	-0.45	0.91
% unemployed[e]							0.02	-1.61	1.68
Concentrated poverty[e, f]							-0.79	-2.24	0.66
Residential stability[h]							0.10	-1.05	1.25
Random effects									
Total standard deviation	7.62	7.22	8.05	7.58	0.02	8.01	7.56	7.17	7.99
Space CAR effect (standard	0.04	0.01	0.36	0.04	0.01	0.35	0.04	0.01	0.38

deviation)									
Intercept	-0.88	-1.46	-0.29	-1.23	-0.56	-1.87	-1.32	-0.68	-1.97

Abbreviation: CI, credible interval

[a] Models based on 50,000 to 100,000 iterations (10,000 samples)

[b] Misdemeanor arrest, felony arrest, and incarceration rates were expressed per 100,000 population before calculating annual change

[c] % receiving public assistance in 1990 at the police precinct level was approximated from the community district level; 1993 public assistance data are a linear interpolation between 1992 and 1994 data

[d] Annual change in % accident decedents with positive cocaine toxicology

[e] 1990 Census variables were standardized to have mean of 0 and standard deviation of 1

[f] Concentrated poverty includes the following socioeconomic variables aggregated to the police precinct level: % less than high school education, % below 200 % of the poverty line, and % female-headed households; higher scores indicate higher levels of concentrated poverty

[g] Annual change in size of police force in precinct

[h] Composite of the proportion of people who lived in the neighborhood for more than 5 years and the proportion of owner-occupied housing

[i] Annual change in % suicides where guns were used