

ORIGINAL ARTICLE

Risk factors among handgun retailers for frequent and disproportionate sales of guns used in violent and firearm related crimes

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Additional data can be found on our website.

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Objective: To determine the retailer and community level factors associated with frequent and disproportionate sales of handguns that are later used in violent and firearm related crimes (VFC handguns).

Design: Cross sectional. The authors used California records to identify all handguns sold by study subjects during 1996–2000 and federal gun tracing records to determine which of these guns had been recovered by a police agency in the US or elsewhere and traced by 30 September 2003.

Subjects and setting: The 421 licensed gun retailers in California selling at least 100 handguns annually during 1996–2000.

Main outcome measure: The number of VFC handguns per 1000 gun years of exposure. Differences are expressed as incidence rate ratios (RR) with 95% confidence intervals (CI).

Results: Subjects accounted for 11.7% of California retailers with handgun sales, 81.5% of handgun sales, and 85.5% of VFC handguns. Among subjects, the 3426 VFC handguns accounted for 48.0% of all traced handguns and 65.0% of those linked to a specified crime. The median VFC handgun trace rate was 0.5/1000 gun years (range 0–8.8). In multivariate analysis, this rate increased substantially for each single-point increase in the percentage of proposed sales that were denied because the purchasers were prohibited from owning guns (RR 1.43; 95% CI 1.32 to 1.56), and was increased for pawnbrokers (RR 1.26; 95% CI 1.02 to 1.55). Community level crime rates and sociodemographics had little predictive value.

Conclusions: Risk factors, largely determined at the retailer level, exist for frequent and disproportionate sales of handguns that are later used in violent and firearm related crimes. Screening to identify high risk retailers could be undertaken with data that are already available.

More than 291 000 violent crimes involving guns, including an estimated 10 657 homicides, were committed in the United States in 2004.^{1,2} Federally licensed retailers are an important source of the guns used in these crimes. Of people incarcerated during the 1990s for crimes involving guns, 12–19% of those in state prisons³ and 19% of those in federal prisons⁴ purchased their guns personally from a retail store or pawnshop. Corrupt licensed retailers are the immediate source of nearly half of all guns that are trafficked—diverted intentionally from legal to illegal commerce.⁵

Gun retailers in the US are also an important, if indirect, source of guns used in crime in other countries. An estimated 144 000 to 199 000 people die in firearm homicides worldwide each year (excluding deaths during armed conflict). More than half of these deaths occur in North America, Latin America, and the Caribbean.⁶ Some 80% of Mexico's illegal firearms and most recovered crime guns in major Canadian cities are imported illegally from the United States.⁷

A retailer's importance as a source of crime guns can be estimated by the number of recovered crime guns that retailer had previously sold. Linking crime guns to retailers is accomplished by gun tracing: reconstructing a gun's chain of ownership from manufacture to first retail sale. Gun traces are conducted by the Bureau of Alcohol, Tobacco, Firearms and Explosives (ATF), which received 240 651 trace requests in fiscal year 2002.⁸ With few exceptions, traced guns are known or suspected to have been used in crime.⁹

In 1998, just 1020 (1.2%) of 83 272 federally licensed retailers accounted for 57.4% of all guns traced by the ATF.¹⁰

Gun sales are also concentrated, however; approximately 15% of retailers request 80% of background checks on gun buyers conducted by the National Instant Criminal Background Check System (NICS).¹¹

It has therefore been argued that the number of crime guns traced to a retailer reflects nothing but that retailer's sales volume.¹² Preliminary evidence suggests that this is incorrect.¹³ If instead there are high risk retailers who sell a disproportionate number of guns that are later used in crimes, and if status as a high risk retailer can be predicted, then new, evidence based opportunities for preventing gun violence may follow. We test these hypotheses for licensed gun retailers in California, focusing on handguns linked to violent and firearm related crimes (VFC handguns).

METHODS

The California Department of Justice (CDOJ) provided records for all handgun sales by licensed retailers during the study period and for proposed sales that CDOJ denied under laws prohibiting felons, violent misdemeanants, and certain others from purchasing firearms (see <http://www.injuryprevention.com/supplemental> for additional material). ATF provided records for all gun traces initiated during the study period (see additional material as before).

Abbreviations: ATF, Bureau of Alcohol, Tobacco, Firearms and Explosives; CDOJ, California Department of Justice; IQR, interquartile range; NICS, National Instant Criminal Background Check System; VFC, violent and firearm related crime.

We linked the gun sales and gun trace datasets to identify all handguns that were sold by subject retailers and subsequently traced by ATF. We considered a match on gun manufacturer and serial number alone to be insufficient, as some manufacturers use serial numbers repeatedly. We declared a match when a handgun's manufacturer, serial number, type (for example, semiautomatic pistol), and caliber were identical. When one of the latter two variables was discordant, we compared records manually, reviewing handgun model designations if available and referring to standard catalogues^{14 15} when necessary, to determine whether the discordance was real or reflected an error in the data.

Though ATF traces terminate with a gun's first retail sale, at least 85% of recovered crime guns change hands after that sale and before their recovery by a police agency.⁹ To link each traced handgun to the retailer whose sale of the gun most closely preceded its recovery, we identified all sales of traced handguns occurring before the guns' recovery dates. Following an established procedure,¹⁶ we assigned a traced handgun to the retailer identified in the ATF trace when no subsequent sales were recorded. When there were subsequent sales, or when the trace record did not identify any seller and the sales records did, we assigned the gun to the most recent seller identified in the sales records (see <http://www.injuryprevention.com/supplemental>).

Additional variables addressed specifics of each retailer's handgun sales. First was sales of inexpensive handguns (defined in table 1), which figure prominently among crime guns^{9 16} and purchasers of which have an increased incidence of subsequent arrest.¹⁷ Second was sales at gun shows, which have been implicated as important sources of crime guns.^{5 18 19} Third was sales of multiple guns in a single transaction, considered a marker for gun trafficking.^{5 9} Fourth was sales to police agencies or personnel, expected to have a negative relation with sales of crime guns.

We included retailer type, as pawnbrokers are believed to be disproportionately involved in sales of crime guns,²⁰ and the number of study years during which each retailer sold handguns, as some corrupt retailers operate briefly, disappear, and resurface with a new identity (Pierce G, personal communication, 2000). We considered the percentage of purchasers who were male (males have higher crime rates than females do) and median purchaser age (criminal activity among adults generally decreases with age).

We also included the percentage of proposed sales that were denied by CDOJ. Most denials stem from previous

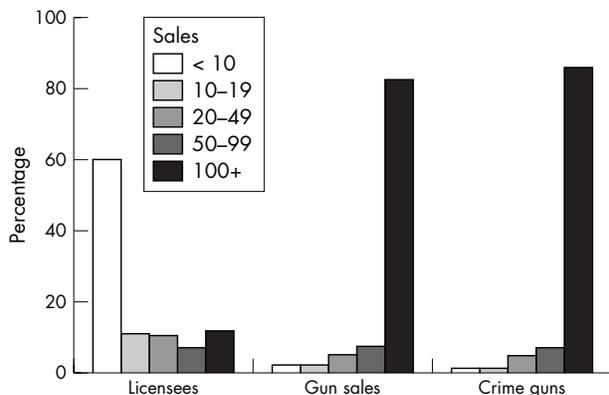


Figure 1 Percentages of federally licensed gun retailers, of handgun sales for 1996–2000, and of traces of handguns linked to violent and firearm related crimes for 1996–2003, that are attributable to retailers having specified average annual handgun sales. Retailers with approximately 100 sales annually are study subjects.

Table 1 Specific violent and firearm related crimes linked to 3426 handguns sold by study subjects

Crime	n (%)
Homicide	241 (7.0)
Assault	570 (16.6)
Robbery	144 (4.2)
Intimate partner or domestic violence	142 (4.1)
Rape or other sex crimes	18 (0.5)
Kidnapping	12 (0.4)
Firing a weapon in public	72 (2.1)
Carrying a concealed weapon	558 (16.3)
Illegal possession of a weapon	1596 (46.6)
Illegal gun commerce	49 (1.4)
Other*	24 (0.7)

*Resisting an officer (3), arson (2), riot (1), extortion (1), crimes against person (17).

criminal convictions,^{21 22} and a high denial percentage might therefore reflect a clientele at increased risk for committing crimes. For retailers linked to traced handguns, we added the median time between the traced guns' sales and their recoveries by police, known as time to crime; a short time to crime is a marker for gun trafficking and is common among retailers selling many traced guns.^{9 16 23}

We represented local police policy on gun tracing by a binary variable, coded 1 if the retailer's city had a policy of tracing all recovered guns; such a policy would increase the probability of a recovered gun's being traced (see <http://www.injuryprevention.com/supplemental>).

All other variables were measured at the county level. These included the number of firearm licensees with handgun sales per 100 000 adults in 2000, under the hypothesis that increased density would increase competition and thereby increase sales of crime guns. We evaluated year 2000 violent Crime Index crime rates, as higher rates might reflect an increased supply of crime guns for tracing.²⁴ We considered year 2000 arrest rates for weapons offenses, which are largely possession offenses (crime rates were not available, and arrest rates might also reflect police efforts to confiscate guns at risk for use in crimes).²⁴ Finally, we included year 2000 census data for seven sociodemographic variables shown to account for 60–70% of small area variation in serious violent crime rates^{25 26} (see <http://www.injuryprevention.com/supplemental>).

In addition to handguns linked to violent crimes, our outcome measure included handguns traced in connection with such crimes as illegally carrying a concealed weapon and illegal weapon possession. Such handguns are at increased risk of being used in violence, and police initiatives targeting such guns have reduced violent crime rates.^{27–29} We also included handguns linked to crimes involving illegal gun commerce, such as obliterating a serial number or trafficking.

Statistical analysis

Our primary outcome measure was the number of VFC handguns sold by each retailer. We conducted a separate analysis using all traced handguns.

We used medians and interquartile ranges (IQRs) to describe continuous variables. We used a binomial distribution to test the basic hypothesis that random variation alone could account for observed differences in our outcome measure.

The dependent variable in all regressions was the number of traced handguns linked to each retailer. Poisson regressions demonstrated overdispersion, and our analysis therefore relied on negative binomial regression.³⁰

In regression analysis we replaced each retailer's absolute sales volume with an estimate of gun years of exposure to the

Table 2 Descriptive statistics for count and continuous variables

Variable	Median	IQR	Range
Variables measured at the retailer level			
VFC handgun traces*, n	3	1–8	0–184
Total handgun traces, n	5	2–15	0–336
VFC traces per 1000 gun years of exposure	0.5	0.2–0.9	0.0–8.8
Total traces per 1000 gun years of exposure	1.1	0.6–2.0	0.0–14.2
Handgun sales, n	945	557–2002	108–24035
Gun years of exposure, n	4869	2862–10272	566–129906
Years with sales, n	5	4–5	1–5
Gun years from sales of inexpensive handguns, %†	2.6	1.0–6.9	0.0–75.7
Gun years from sales at gun shows, %‡	0.2	0.0–1.1	0.0–86.9
Gun years from police sales, %§	5.6	3.7–8.2	0.2–88.4
Gun years from sales of multiple guns, %¶	9.4	7.0–12.3	0.0–58.8
Denials, % (of sales + denials)	1.1	0.6–1.5	0.0–5.4
Median time to crime for VFC handguns, y**	2.4	1.8–3.3	0.1–7.2
Median age of purchasers, y	41	39–43	24–53
Male purchasers, %	93.3	91.5–94.6	79.6–99.2
Federal firearm licensees per 100 000 persons††,‡‡	8.1	4.5–14.3	0.3–58.3
Crime rates per 100 000 persons††			
Homicide	4.8	2.8–8.1	0.0–10.5
Rape	29.0	27.2–34.0	11.2–70.4
Robbery	118.9	88.3–209.3	10.6–448.0
Aggravated assault	345.2	297.9–516.8	129.3–607.8
Felony weapons offenses§§	46.2	44.5–59.2	20.6–113.5
Misdemeanor weapons offenses¶¶	12.6	11.2–18.7	3.7–41.4
Sociodemographics††			
Black population, %	5.7	1.9–9.8	0.3–14.9
Latino population, %	30.8	19.0–44.0	5.5–72.2
Males ages 20–29, as % of males ages 40–44	187	165–208	99–284
Unemployed people, % (of people ages ≥16)	4.4	3.4–5.0	1.9–7.8
Households headed by single females, %	12.2	10.9–14.7	3.9–17.1
Median household income, × \$1000	42.4	42.1–54.1	27.5–74.3
Households per 10000 persons	3292	3247–3566	2651–4322

*VFC denotes violent and firearm related crime.
 †Handguns manufactured by 7 companies—Bryco Arms/Jennings Firearms, Davis Industries, High Point Firearms, Lorcin Engineering, Phoenix Arms, Raven Arms, Sundance Industries—whose handguns all had suggested retail prices of approximately \$150 or less; almost no such handguns were manufactured by other companies during the study period.
 ‡Results are for 398 retailers with sales during one or more of the years 1997–2000, during which gun show sales were identified.
 §Sales to police agencies or individuals who were exempt, due to police employment, from California’s required basic firearms safety course.
 ¶Sales of more than one handgun in a single transaction.
 **The time between the dates of a gun’s sale and its recovery by police, in years. Results are for the 351 retailers with VFC handguns.
 ††Measured at the county level.
 ‡‡All licensees with handgun sales during the study period, regardless of sales volume.
 §§An arrest rate. Examples: unlawful possession of a weapon on the person, in a vehicle, or in a public place (charged as a felony); unlawful possession of weapon in public building; possession of short-barreled shotgun or rifle; possession of firearm by felon; carrying firearm with intent to commit felony; obliterating firearm serial number.
 ¶¶An arrest rate. Examples: unlawful possession of a weapon on the person, in a vehicle, or in a public place (charged as a misdemeanor); possession of weapon with intent to assault; knowingly filing false firearm purchase application; selling firearms without a license; possession of unregistered assault weapon; sale of ammunition to a minor.
 IQR, interquartile range.

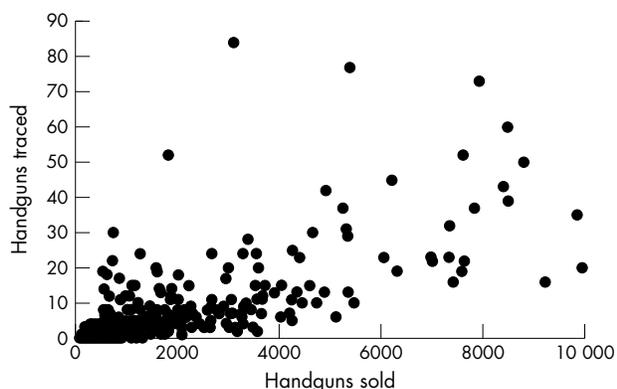


Figure 2 Number of handguns sold during 1996–2000, and number of traces of those handguns linked to violent and firearm related crimes during 1996–2003, for study subjects. (Six outlier observations have been removed: four with >16 000 sales and two with >200 traces. These observations were included in the regression analysis.)

risk of being traced for that retailer’s handguns, analogous to replacing a count of people with person years in a cohort study. Variables representing sales of inexpensive guns, of multiple guns, at gun shows, and to police personnel were expressed as percentages of total gun years of exposure. We included (gun years of exposure/1000) as an offset variable³⁰ (see <http://www.injuryprevention.com/supplemental>).

We first performed bivariate regressions. Variables with $p < 0.10$ in these regressions were entered into multivariate models in which community level variables were added in groups to variables measured at the retailer level. Reduced models were generated by removing variables from the full multivariate models in order of decreasing p until all remaining variables had $p < 0.10$. We exponentiated regression coefficients and expressed differences as rate ratios for traced handguns per 1000 gun years of exposure.

The study was approved by the UC Davis institutional review board.

RESULTS

Study subjects are the 421 California retailers, including 390 (92.6%) gun dealers and 31 (7.4%) pawnbrokers, who sold handguns during 1996–2000 and had average annual sales of

Table 3 Results of regressions on individual explanatory variables for traced handguns linked to violent and firearm related crimes, and for all traced handguns*

Variable	Handguns linked to violent and firearm related crimes			All traced handguns		
	RR	95% CI	p Value	RR	95% CI	p Value
Variables measured at the retailer level						
Gun years of exposure, ×1000	1.01	1.00–1.01	0.18	1.01	1.00–1.01	0.04
Years with handgun sales, n	1.06	0.98–1.16	0.16	1.06	0.99–1.14	0.12
Gun years from sales of inexpensive handguns, %	1.03	1.02–1.05	<0.0001	1.03	1.02–1.04	<0.0001
Gun years from sales at gun shows, %†	1.00	0.99–1.00	0.21	1.00	0.99–1.00	0.33
Gun years from police sales, %	0.98	0.97–0.99	<0.0001	0.98	0.98–0.99	<0.0001
Gun years from sales of multiple guns, %	1.03	1.01–1.04	0.004	1.02	1.01–1.04	0.004
Denials, % (of sales + denials)	1.81	1.66–1.97	<0.0001	1.71	1.59–1.85	<0.0001
Median time to crime for traced guns, y‡	0.83	0.77–0.90	<0.0001	0.85	0.79–0.91	<0.0001
Median age of purchasers, y	0.91	0.89–0.93	<0.0001	0.92	0.90–0.93	<0.0001
Male purchasers, %	0.92	0.90–0.95	<0.0001	0.93	0.91–0.96	<0.0001
Retailer type (pawnbroker = 1, gun dealer = 0)	1.75	1.28–2.38	0.0004	1.78	1.36–2.32	<0.0001
Variables reflecting local gun commerce and tracing policy						
Federal Firearm Licenses per 100 000 people§	0.94	0.92–0.95	<0.0001	0.94	0.93–0.95	<0.0001
Retailer's city traces all recovered guns (yes = 1)	3.05	2.25–4.14	<0.0001	2.82	2.14–3.70	<0.0001
Crime rates per 100 000 people§						
Homicide	1.16	1.14–1.19	<0.0001	1.15	1.12–1.17	<0.0001
Rape	1.00	0.99–1.02	0.97	1.00	0.99–1.02	0.58
Robbery	1.01	1.01–1.01	<0.0001	1.01	1.01–1.01	<0.0001
Aggravated assault	1.00	1.00–1.00	<0.0001	1.00	1.00–1.00	<0.0001
Felony weapons offenses¶	1.00	0.99–1.00	0.20	1.00	0.99–1.00	0.28
Misdemeanor weapons offenses¶	0.96	0.94–0.98	<0.0001	0.96	0.94–0.97	<0.0001
Sociodemographics§						
Black population, %	1.13	1.11–1.16	<0.0001	1.13	1.11–1.15	<0.0001
Latino population, %	1.03	1.03–1.04	<0.0001	1.03	1.02–1.03	<0.0001
Unemployed people, % (of people ages ≥16)	1.11	1.03–1.20	0.008	1.06	0.99–1.14	0.096
Households headed by single females, %	1.21	1.16–1.27	<0.0001	1.18	1.14–1.23	<0.0001
Males ages 20–29, as % of males ages 40–44	1.01	1.01–1.01	<0.0001	1.01	1.01–1.01	<0.0001
Median household income, ×\$1000	0.99	0.98–1.00	0.003	0.99	0.98–1.00	0.08
Households per 10000 people	1.00	1.00–1.00	<0.0001	1.00	1.00–1.00	<0.0001

*Gun years of exposure/1000 is employed as an offset variable; results are on a per 1000 gun year basis.

†Results are for retailers with sales during one or more of the years 1997–2000, during which gun show sales were identified.

‡Results for all retailers with traced handguns: 351 subjects in the case of VFC handguns and 392 for all traced handguns.

§Measured at the county level.

¶Arrest rate.

RR, rate ratio; CI, confidence interval.

at least 100 handguns during their year(s) in business. These retailers made up 11.7% of all 3611 California retailers selling handguns during that time but accounted for 81.5% of handgun sales (781 475 of 959 189) and 85.5% of handguns traced in connection with a violent or firearm related crime (3426 of 4006) (fig 1). VFC handguns accounted for 48.0% (3426 of 7133) of handguns traced to study subjects and

65.0% (3426 of 5271) of traced handguns linked to a specified crime (table 1).

Table 2 presents descriptive statistics. Of 421 retailers, 351 (83.4%) were linked to at least one VFC handgun, but just 10 retailers accounted for 29.2% of VFC handguns traced to study subjects. Thirty one subjects (7.4%) were in cities with mandatory tracing policies. Of the 3426 VFC handguns, 2926

Table 4 Results for reduced multivariate regression models for traced handguns linked to violent and firearm related crimes, and for all traced handguns*

Variable	Handguns linked to violent and firearm related crimes			All traced handguns		
	RR	95% CI	p Value	RR	95% CI	p Value
Variables measured at the retailer level						
Gun years from police sales, %	0.99	0.99–1.00	0.04	0.99	0.99–1.00	0.007
Gun years from sales of multiple guns, %				1.01	1.00–1.02	0.07
Denials, % (of sales + denials)	1.43	1.32–1.56	<0.0001	1.37	1.28–1.47	<0.0001
Median age of purchasers, y	0.95	0.94–0.97	<0.0001	0.95	0.94–0.96	<0.0001
Retailer type (pawnbroker = 1, gun dealer = 0)	1.26	1.02–1.55	0.03	1.30	1.10–1.53	0.002
Variables reflecting local gun commerce and tracing policy						
Federal Firearm Licenses per 100 000 people†	0.97	0.96–0.98	<0.0001	0.97	0.96–0.98	<0.0001
Retailer's city traces all recovered guns (yes = 1)	1.43	1.15–1.78	0.001	1.52	1.28–1.79	<0.0001
Crime rates per 100 000 people†						
Robbery	1.00	1.00–1.00	0.003	1.00	1.00–1.00	<0.0001
Sociodemographics†						
Latino population, %	1.01	1.00–1.02	0.07			

*Gun years of exposure/1000 is employed as an offset variable; results are on a per 1000 gun year basis. Time to crime was not incorporated in these models.

†Measured at the county level.

RR, rate ratio; CI, confidence interval.

(85.4%) were recovered in California; other leading recovery states were Texas (74 guns, 2.2%), New York (51 guns, 1.5%), Nevada (46 guns, 1.3%), and Arizona and Illinois (each with 29 guns, 0.8%).

The number of VFC handguns linked to retailers with similar sales volumes varied substantially (fig 2). Each handgun had probability $p = 0.00438$ (3426 traces/781 475 sales) of being traced as a VFC handgun under the hypothesis that this probability was the same for all handguns sold. Forty seven retailers (11.2%) had VFC handgun traces numerous enough to be inconsistent with this hypothesis ($p < 0.05$); accounting for 17.9% of sales and 46.1% of VFC handguns. The median VFC handgun trace rate for all retailers was 0.5/1000 gun years (IQR 0.2–0.9; range 0–8.8).

Table 3 presents bivariate regression results. Most retailer level variables were significant for both VFC handguns and all traced handguns, as were variables representing gun tracing policy and retailer density. Results for crime rates and sociodemographics were mixed. In multivariable models in which community level variables were added to retailer characteristics, effects of crime rates and sociodemographics were small and rarely significant (see supplementary table 1 at <http://www.injuryprevention.com/supplemental>).

In a reduced model (table 4), the VFC handgun trace rate increased substantially for every single point increase in the percentage of proposed sales that were denied (RR 1.43; 95% CI 1.32 to 1.56). Rates were increased for pawnbrokers (RR 1.26; 95% CI 1.02 to 1.55) and for retailers in cities with mandatory tracing policies (per year RR 1.43; 95% CI 1.15 to 1.78). The trace rate was inversely related to police sales, median purchaser age, and retailer density, but these effects were small. Crime rates and sociodemographics were not significant predictors of VFC handgun trace rates, except for a small increase with the robbery rate. Very similar results were obtained for all traced handguns (table 4).

For the 351 retailers with VFC handgun traces (see supplementary table 2 at <http://www.injuryprevention.com/supplemental>), trace rates were negatively, but not significantly, associated with time to crime (per year RR 0.95; 95% CI 0.90 to 1.01). The association with the percentage of male purchasers was negative and significant (per single point increase, RR 0.98; 95% CI 0.95 to 1.00). Results for other variables were little changed.

In all analyses, interactions between retailer type and other retained variables were not significant (results not shown).

DISCUSSION

These findings suggest that handgun retailers' sales of guns that are later used in violent and firearm related crimes can be predicted, largely by factors measured at the retailer level.

There is a strong relation between sales of crime guns and prospective sales that are denied following a background check. This suggests that retailers who sell disproportionate numbers of crime guns also deal disproportionately with people who are at high risk of committing crimes with guns. Some of these people are prohibited from purchasing guns, usually because they have been convicted of serious crimes, and their detection by a background check increases denied sales for these retailers.

But others at high risk would not be prohibited people. Prior offenders are one such group. In much of the US, one can have an extensive criminal record involving lesser offenses and still purchase handguns. Handgun buyers with criminal records are at substantially increased risk of committing crimes subsequently, including violent and firearm related crimes.³¹ Still others who purchase from these retailers may be surrogates ("straw purchasers") for prohibited individuals or gun traffickers.⁵ Purchases by high risk,

non-prohibited individuals and by surrogates would link these retailers to disproportionate sales of crime guns.

Some of our findings were unexpected. Gun show sales were not a risk factor for sales of crime guns in these data. California regulates gun shows to a unique degree, however, which may have reduced their otherwise considerable importance as sources of crime guns.^{18 19} Sales of crime guns were inversely related to the percentage of purchasers who were male—a finding that persisted in multivariate analysis for retailers linked to VFC handguns. Women may be more likely than men to act as surrogates; of straw purchasers working with gun trafficking operations, 18% were girlfriends or spouses of the traffickers.⁵ The negative relation between crime gun sales and licensee density may reflect the higher density in rural counties³² than in urban areas where most gun traces originate.

Sociodemographics and local crime rates were generally not important predictors of crime gun sales. This could occur if most crime guns were recovered in communities distant and different from those where the retailers were located. But most crime guns are recovered close to their places of origin.^{9 16 23} The results suggest that most important predictors of crime gun sales, other than local gun tracing policy, reflect characteristics of the retailers themselves.

We cannot state definitively whether retailers who sell a disproportionate number of crime guns do so through their own behavior or from circumstances beyond their control. Important factors could include practices that encourage patronage by high risk people, but also unmeasured attributes of the retailer's clientele (prior criminal history, for example) or location, the guns sold, or other matters.

Retailers who deliberately participate in illegal gun commerce are likely to be disproportionate sources of crime guns. Some such retailers may be missed in a records based study such as this; characteristics of corrupt retailers, such as selling guns without records, may represent clandestine behavior.^{19 33}

Other limitations deserve mention. We could not include rifles and shotguns; CDOJ cannot archive records for these guns. The classification of handguns as inexpensive was based on manufacturer, as selling prices were unavailable. This classification would preferably have been restricted to new handguns, as used guns from other manufacturers could be inexpensive, but sales records did not reliably indicate whether guns were new or used.

Most importantly, these traced handguns are necessarily a subset of handguns sold by our subjects during 1996–2000 and used in crime. Not all crime guns are recovered, and not all recovered guns are traced. Police agencies vary in the likelihood that they will request gun traces, which affects the number of traced guns linked to individual retailers. In addition, selection bias may result if some guns are more likely to be traced than others.³⁴ Most traced guns in California come from cities with mandatory tracing policies, so within-jurisdiction selection bias should be minimal.¹⁶ Handguns traced by these cities are similar to those from others in the state;¹⁶ selection bias may not be a major factor.

Some have argued that gun traces are inappropriate for research on gun related crime, as not all traced guns are linked to a specific crime.^{35 36} Our results for all traced handguns were similar to those obtained for handguns linked to known violent and firearm related crimes. Such concern may not be justified.

The US Department of Justice has recently stressed the need to identify retailers who are disproportionate sources of crime guns.⁸ Our results confirm earlier suggestions that pawnbrokers merit special attention,²⁰ though the mechanism for their increased sales of crime guns remains unclear.

Nationwide comprehensive tracing of recovered crime guns would be valuable but will not occur soon. Our findings suggest that data already collected at the federal level could help identify these retailers. For each retailer, the Department of Justice could compare the number of background check queries submitted to the NICS with the number of denials to compute a denial percentage.³⁷ (The number of queries would not equal the number of sales, as a transaction involving multiple guns generates one query, but the two would be closely correlated. Sales of multiple guns are reported separately to ATF.)

This denial percentage may be a useful initial screening tool, because sales of crime guns increase rapidly as it increases. Such screening and the focused enforcement efforts that result could help disrupt illegal gun commerce without unduly affecting the legitimate gun market in the US.

As part of global efforts to prevent violence involving small arms and light weapons, an international agreement is being negotiated to uniquely identify all firearms during manufacture and trace those that are recovered after illicit use.³⁸ Our results show that gun tracing can help identify important sources of guns used in violent crimes and could have an international impact on the public's health and security.^{39 40}

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Key points

- Just over 1% of licensed gun retailers sell nearly 60% of guns later used in crime; why this occurs has not been known. It has been argued that the number of crime guns sold by a retailer only reflects retailer's sales volume.
- Among licensed retailers of handguns in California, the number of guns sold was an inadequate predictor of the number of guns subsequently linked to violent and firearm related crimes.
- Important risk factors for having a high rate of crime related handguns per 1000 gun years of exposure included licensure as a pawnbroker and the percentage of sales denied because the purchasers were prohibited from owning guns.
- Other than local policy on tracing recovered crime guns, community level factors (crime rates and socio-demographics) were of little predictive value.
- Data already gathered at the federal level would permit screening and tentative identification of handgun retailers whose guns are disproportionately likely to be involved in violent and firearm related crimes.

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Competing interests: none.

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reported. The measures described are largely those that have been implemented in Europe and North America. I hope that future revisions of this book will include studies examining measures being implemented in developing countries. This is a challenge to researchers working in developing countries to evaluate and publish findings on road safety measures that have been implemented in these countries.

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CALENDAR

2006 RoSPA Road Safety Congress: The road to safer behaviour

27 February to 1 March 2006, Blackpool, England. Visit www.rospa.com/road/index.htm for further information.

Ontario Injury Prevention Conference 2006

5 – 7 March, 2006, Toronto, Canada. The theme of the conference is "Injury Prevention through the Ages". Visit www.oipc.org for more information.

XII International Winter Road Congress

27 – 30 March 2006, Torino, Italy. Visit www.aipcr2006.it for further information for this meeting, organised by the World Road Association.

Reducing Firearm-Related Mortality and Morbidity: Data to Action

31 March – 1 April 2006, Durban, South Africa. The objectives of the conference are to

examine how the collection and linkage of accurate and relevant data can assist in developing policies aimed at the prevention and reduction of firearm-related death and injuries, giving examples of good practice in this regard and identifying limitations and obstacles; and to examine how data is translated into action to prevent firearm related death and injury, giving examples of good practice, exploring the ways in which the social, political and economic environment either inhibits or facilitates the translation of data into action. Further information: <http://tinyurl.com/as2rr>.

6th International Conference on Measuring the Burden of Injury

1 April 2006, Durban, South Africa. The conference objectives are to promote the understanding, use and development of interdisciplinary health status and injury outcomes measures; to provide a forum for injury scientists from around the world to discuss emerging issues in the measurement of injury outcomes; and to encourage a harmonized approach to injury outcomes research. For further information contact: Stephen Luchter, sluchter@earthlink.net.

8th World Conference on Injury Prevention and Safety Promotion

2 – 5 April 2006, Durban, South Africa. Further information and key dates: www.safety2006.info.

International Society for Child and Adolescent Injury Prevention (ISCAIP) Bi-Annual Conference

5 – 6 April 2006, Durban, South Africa. Further information: www.iscaip.net

2nd International Seminar on Injury Research Methods

6 – 7 April 2006, Cape Town, South Africa. Organised by ECOSA-Eurosafe and the

Medical Research Council. More information from Saakje Mulder, s.mulder@consafe.nl, url: and www.mrc.ac.za/conference/ecosa/index.htm.

15th International Safe Communities Conference: Creating a safer environment

9 – 11 April 2006, Cape Town, South Africa. Visit www.tinyurl.com/dn3sr for further information.

1st European Conference on Injury Prevention and Safety Promotion. Challenges for a Safer Europe

25 – 27 June 2006, Vienna, Austria. Further information: www.ecosa.org/csi/ecosa2003.Dnsf/events. Secretariat: Mrs Joke Broekhuizen, tel: + 31 20 5114 513, [www.secretariat@eurosafe.eu.com](mailto:secretariat@eurosafe.eu.com)

Australian Injury Prevention Network 8th National Injury Prevention Conference

27 – 29 September 2006, Sydney, Australia. Visit www.aipn.com.au/conference.html for further information.

CORRECTION

An error occurred in the paper by Wintemute *et al* in last month's issue of the journal (*Inj Prev* 2005;11:357–63). The last sentence of the legend for figure 1 should read "Retailers with at least 100 sales annually are study subjects" and not "Retailers with approximately 100 sales annually are study subjects".

SUPPLEMENTAL METHODS TEXT

California Department of Justice handgun sales data

We excluded from the study a private club that sold only to police personnel.

Records for both sales and denials included identifiers for the gun (manufacturer, type, caliber, model, and serial number); the retailer selling the gun (name, address, and license number); and the prospective purchaser. For completed sales, records included the date of sale and indicated whether the gun was sold at a gun show or to police personnel.

Criteria for denial of handgun purchase

The California Department of Justice conducts a criminal and mental health records background check for all purchases of firearms unless the purchaser is specifically exempted from the background check requirement.

Under federal law (18 USC 922), firearms may not be possessed by a person who:

- Is under indictment for, or has been convicted of, a crime punishable by imprisonment for more than one year;
- Is a fugitive from justice;
- Is an unlawful user of, or is addicted to, any controlled substance;
- Has been adjudicated as a mental defective or committed to a mental institution;
- Is an illegal alien or has been admitted to the United States under a nonimmigrant visa;
- Was discharged from the US Armed Forces under dishonorable conditions;
- Has renounced US citizenship;
- Is subject to a court order restraining him or her from harassing, stalking, or threatening an intimate partner or child;
- Has been convicted in any court of a misdemeanor crime of domestic violence.

In addition, federal law prohibits most transfers of handguns to people under 21.

Many states have enacted additional prohibitions; California, for example, denies transfers of firearms to people convicted of a wide array of violent misdemeanors.

Most denials are due to previous criminal convictions. Denials for domestic violence restraining orders account for 4% of denials nationally and 7% in California.

Further information on denial nationwide is available in Bowling M. Background checks for firearm transfers, 2004. Bureau of Justice Statistics 2005. NCJ 210117. Available at <http://www.bjs.gov>.

Additional information on denial in California is available in Handgun Commerce in California 2000. Sacramento: Violence Prevention Research Program. Available at <http://www.ucdmc.ucdavis.edu/vprp/> (accessed October 2005).

Gun traces by the Bureau of Alcohol, Tobacco, Firearms and Explosives

An ATF gun trace begins with a request from a police agency. The trace request includes identifiers for the gun and its possessor at the time of recovery, if any; the recovery date and location; and, at the submitting agency's option, the most serious crime to which the gun was linked. ATF attempts to reconstruct the initial chain of ownership of the gun, beginning with its manufacturer. Absent special

circumstances, traces are terminated when the first retail purchaser is identified. Completed traces contain identifiers for the gun's manufacturer, wholesaler, first retail seller, and first retail purchaser. The most recent data on the success of gun tracing are for the 77,250 traces initiated by ATF in 2000 as part of its Youth Crime Gun Interdiction Initiative: 70.8% identified the federal firearm licensee who first sold the gun at retail (typically a gun dealer or pawn shop, occasionally a distributor or manufacturer), and 61.5% identified the gun's first retail purchaser. Further information is available in Bureau of Alcohol Tobacco and Firearms. *Crime gun trace reports (2000)*. Washington, DC: Bureau of Alcohol, Tobacco and Firearms, 2002, available at <http://www.atf.gov>

Linking gun sales records to gun trace records

Before linking the gun sales and gun trace datasets, we excluded 619 duplicate sales records and 10123 records of sales from one licensee to another.

Period of follow up

The study period was initially defined as 1996–2000. After that analysis was completed, ATF and CDOJ provided records for January 1, 2001 through September 30, 2003. We extended our follow up to include the new data. We excluded from our new analysis 92 handguns that were traced during 2001–03 after having been sold during those years by a retailer other than the one to which they had been assigned using the 1996–2000 sales records.

Local police policy on gun tracing

California cities with comprehensive tracing policies were Anaheim, Compton, Long Beach, Los Angeles, Oakland, Salinas, San Jose, Santa Ana, and Stockton. This was represented by a binary variable, coded as 1 if at any time during the study period the city in which the retailer was located had participated in the ATF's comprehensive training program, the Youth Crime Gun Initiative. A more complex specification using the number of years during the study period that each city performed comprehensive tracing did not provide a better fit to the data.

Selection of sociodemographic variables

In our initial exploration of the data we included a binary variable coded 1 if the county in which the retailer was located was part of a Metropolitan Statistical Area. This variable was not significant in a preliminary multivariate analysis including the retailer level variables or in a separate analysis including only the other sociodemographic variables, and it was not included in the final analysis of the data.

Calculation of gun years and use of gun years as an offset variable

As our period of exposure was January, 1996 through September, 2003, we estimated gun years for each retailer by a mid-interval approach as $7.25 \times (1996 \text{ sales}) + 6.25 \times (1997 \text{ sales}) + 5.25 \times (1998 \text{ sales}) + 4.25 \times (1999 \text{ sales}) + 3.25 \times (2000 \text{ sales})$. So few handguns were traced, relative to those sold, that we did not censor gun years as of trace dates but calculated gun years as if all guns had remained at risk for tracing until the end of the study period. Similarly, so few guns were recorded as having been sold more than once that we did not censor gun years attributable to first retailer to sell a gun as of the date of a subsequent sale. We verified the suitability of gun years for use as an offset variable by a regression of traces on the natural logarithm of (gun years/1000), which yielded $\beta=1.09$, $SE=0.05$, $p<0.0001$.

Appendix Table 1A Results for regression models containing variables for which $p < 0.10$ in a bivariate regression, for handguns linked to violent and firearm related crimes*

Variable	Model 1 retailer variables			Model 2 retailer and commerce/tracing variables		
	RR	95% CI	p Value	RR	95% CI	p Value
Variables measured at the retailer level						
Gun years from sales of inexpensive handguns, %	0.98	0.97–1.01	0.001	0.99	0.98–1.00	0.17
Gun years from police sales, %	0.99	0.98–1.00	0.02	0.99	0.98–1.00	0.007
Gun years from sales of multiple guns, %	1.04	1.02–1.05	<0.0001	1.02	1.00–1.03	0.01
Denials, % of (sales + denials)	1.73	1.57–1.92	<0.0001	1.50	1.36–1.65	<0.0001
Median time to crime for traced guns, y						
Median age of purchasers, y	0.92	0.91–0.94	<0.0001	0.94	0.92–0.95	<0.0001
Male purchasers, %	1.00	0.97–1.03	0.99	0.97	0.94–1.00	0.08
Retailer type (pawnbroker=1, gun dealer=0)	1.13	0.88–1.45	0.03	1.17	0.94–1.46	0.16
Variables reflecting local gun commerce and tracing policy						
Federal Firearm Licensees per 100000 people†				0.96	0.95–0.97	<0.0001
Retailer's city traces all recovered guns (yes=1)				1.37	1.10–1.72	0.006

Variable	Model 3: retailer and commerce/tracing variables and crime rates			Model 4: retailer and commerce/tracing variables, crime rates, and sociodemographics		
	RR	95% CI	p Value	RR	95% CI	p Value
Variables measured at the retailer level						
Gun years from sales of inexpensive handguns, %	1.00	0.99–1.01	0.51	1.00	0.99–1.01	0.40
Gun years from police sales, %	0.99	0.99–1.00	0.03	0.99	0.99–1.00	0.03
Gun years from sales of multiple guns, %	1.01	1.00–1.02	0.06	1.01	1.00–1.02	0.08
Denials, % (of sales + denials)	1.42	1.28–1.56	<0.0001	1.42	1.29–1.57	<0.0001
Median time to crime for traced guns, y						
Median age of purchasers, y	0.95	0.93–0.96	<0.0001	0.95	0.93–0.97	<0.0001
Male purchasers, %	0.98	0.96–1.01	0.14	0.98	0.96–1.01	0.16
Retailer type (pawnbroker=1, gun dealer=0)	1.19	0.97–1.47	0.10	1.19	0.97–1.48	0.100
Variables reflecting local gun commerce and tracing policy						
Federal Firearm Licensees per 100000 people†	0.97	0.96–0.99	0.002	0.98	0.96–1.01	0.12
Retailer's city traces all recovered guns (yes=1)	1.40	1.13–1.73	0.002	1.47	1.18–1.83	0.001
Crime rates per 100000 people†						

Variable	Model 3: retailer and commerce/tracing variables and crime rates			Model 4: retailer and commerce/tracing variables, crime rates, and sociodemographics		
	RR	95% CI	p Value	RR	95% CI	p Value
Homicide	1.00	0.95–1.05	0.89	0.97	0.91–1.04	0.40
Robbery	1.00	1.00–1.00	0.03	1.00	1.00–1.01	0.01
Aggravated assault	1.00	1.00–1.00	0.40	1.00	1.00–1.00	0.53
Misdemeanor weapons offenses‡	0.99	0.98–1.01	0.47	0.99	0.97–1.01	0.22
Sociodemographics†						
Black population, %				1.00	0.96–1.05	0.97
Latino population, %				1.01	0.99–1.03	0.18
Unemployed people, % (of people ages ~16)				0.97	0.81–1.15	0.71
Households headed by single females, %				1.02	0.93–1.12	0.64
Males ages 20–29, as % of males ages 40–44				1.00	1.00–1.00	0.92
Median household income, × \$1000				1.00	0.98–1.01	0.51
Households per 10000 people				1.00	1.00–1.00	0.79

*Gun years of exposure/1000 is employed as an offset variable; results are on a per 1000 gun year basis.

†Measured at the county level.

‡Arrest rate.

RR, rate ratio; CI, confidence interval.

Appendix Table 1B Results for regression models containing variables for which $p < 0.10$ in a bivariate regression, for all traced handguns*

Variable	Model 1: retailer variables			Model 2: retailer and commerce/tracing variables		
	RR	95% CI	p Value	RR	95% CI	p Value
Variables measured at the retailer level						
Gun years of exposure/1000	1.01	1.00–1.01	0.008	1.00	1.00–1.01	0.095
Gun years from sales of inexpensive handguns, %	0.99	0.98–1.00	0.004	1.00	1.00–1.01	0.51
Gun years from police sales, %	0.99	0.99–1.00	0.01	0.99	0.99–1.00	0.001
Gun years from sales of multiple guns, %	1.03	1.02–1.04	<0.0001	1.01	1.00–1.02	0.006
Denials, % (of sales + denials)	1.64	1.50–1.80	<0.0001	1.41	1.30–1.53	<0.0001
Median age of purchasers, y	0.93	0.92–0.95	<0.0001	0.95	0.93–0.96	<0.0001
Male purchasers, %	1.01	0.98–1.03	0.59	0.98	0.96–1.00	0.05
Retailer type (pawnbroker=1, gun dealer=0)	1.25	1.02–1.53	0.03	1.28	1.08–1.53	0.006
Variables reflecting local gun commerce and tracing policy						
Federal Firearm Licensees per 100000 people†				0.96	0.95–0.97	<0.0001

Variable	Model 1: retailer variables			Model 2: retailer and commerce/tracing variables		
	RR	95% CI	p Value	RR	95% CI	p Value
Retailer's city traces all recovered guns (yes=1)				1.49	1.24–1.78	<0.0001
Variable	Model 3: retailer and commerce/tracing variables and crime rates			Model 4: retailer and commerce/tracing variables, crime rates, and sociodemographics		
	RR†	95% CI	p Value	RR	95% CI	p Value
Variables measured at the retailer level						
Gun years of exposure, n	1.00	1.00–1.01	0.07	1.00	1.00–1.01	0.07
Gun years from sales of inexpensive handguns, %	1.00	0.99–1.01	0.93	1.00	0.99–1.01	0.87
Gun years from police sales, %	0.99	0.99–1.00	0.005	0.99	0.99–1.00	0.003
Gun years from sales of multiple guns, %	1.01	1.00–1.02	0.09	1.01	1.00–1.02	0.07
Denials, % (of sales + denials)	1.34	1.24–1.46	<0.0001	1.35	1.24–1.46	<0.0001
Median age of purchasers, y	0.95	0.94–0.97	<0.0001	0.95	0.94–0.97	<0.0001
Male purchasers, %	0.99	0.97–1.01	0.19	0.99	0.97–1.01	0.20
Retailer type (pawnbroker=1, gun dealer=0)	1.30	1.10–1.54	0.002	1.31	1.10–1.55	0.002

Variable	Model 3: retailer and commerce/tracing variables and crime rates			Model 4: retailer and commerce/tracing variables, crime rates, and sociodemographics		
	RR†	95% CI	p Value	RR	95% CI	p Value
Variables reflecting local gun commerce and tracing policy						
Federal Firearm Licensees per 100000 people†	0.97	0.96–0.99	<0.0001	0.98	0.96–1.00	0.01
Retailer’s city traces all recovered guns (yes =1)	1.54	1.30–1.83	<0.0001	1.57	1.31–1.89	<0.0001
Crime rates per 100000 people†						
Homicide	1.01	0.97–1.05	0.55	0.99	0.94–1.04	0.62
Robbery	1.00	1.00–1.00	0.13	1.00	1.00–1.00	0.19
Aggravated assault	1.00	1.00–1.00	0.23	1.00	1.00–1.00	0.44
Misdemeanor weapons offenses‡	0.99	0.98–1.00	0.10	0.99	0.97–1.00	0.09
Sociodemographics†						
Black population, %				1.02	0.99–1.06	0.21
Latino population, %				1.00	0.99–1.02	0.83
Unemployed persons, % (of persons ages ~16)				0.99	0.87–1.13	0.89
Households headed by single females, %				1.00	0.93–1.08	0.99

Variable	Model 3: retailer and commerce/tracing variables and crime rates			Model 4: retailer and commerce/tracing variables, crime rates, and sociodemographics		
	RR†	95% CI	p Value	RR	95% CI	p Value
Males ages 20–29, as % of males ages 40–44				1.00	1.00–1.00	0.74
Median household income/\$1000				1.00	0.99–1.01	0.72
Households per 10000 people				1.00	1.00–1.00	0.72

*Gun years of exposure/1000 is employed as an offset variable; results are on a per 1000 gun year basis.

†Measured at the county level.

‡Arrest rate.

RR, rate ratio; CI, confidence interval.

Appendix Table 2 Results for reduced multivariate regression models for 351 retailers with handguns linked to violent and firearm related crimes*

Variable	RR	95% CI	p Value
Variables measured at the retailer level			
Gun years from police sales, %	0.99	0.98–1.00	0.006
Denials, % (of sales + denials)	1.34	1.23–1.46	<0.0001
Median time to crime for traced guns, y	0.95	0.90–1.01	0.08
Median age of purchasers, y	0.96	0.95–0.97	<0.0001

Variable	RR	95% CI	p Value
Male purchasers, %	0.98	0.95–1.00	0.04
Retailer type (pawnbroker=1, gun dealer=0)	1.24	1.01–1.52	0.04
Variables reflecting local gun commerce and tracing policy			
Retailer's city traces all recovered guns (yes=1)	1.52	1.26–1.84	<0.0001
Crime rates per 100000 people†			
Robbery	1.00	1.00–1.00	<0.0001
Misdemeanor weapons offenses	0.99	0.97–1.00	0.10
Sociodemographics†			
Latino population, %	1.01	1.01–1.02	0.0007
Unemployed persons, % (of persons ages ≥16)	0.93	0.86–1.00	0.05

*Gun years of exposure/1000 is employed as an offset variable; results are on a per 1000 gun year basis.

†Measured at the county level.

RR, rate ratio; CI, confidence interval.