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

G J Wintemute, P J Cook, M A Wright

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.


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.
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 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. 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, 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 and purchasers of which have an increased incidence of subsequent arrest. Second was sales at gun shows, which have been implicated as important sources of crime guns. Third was sales of multiple guns in a single transaction, considered a marker for gun trafficking. 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, 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 criminal convictions, 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 gun’s 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.

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.

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). 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 (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. 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.

In regression analysis we replaced each retailer’s absolute sales volume with an estimate of gun years of exposure to the...
These observations were included in the regression analysis.

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...
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>
<thead>
<tr>
<th>Variable</th>
<th>Handguns linked to violent and firearm related crimes</th>
<th>All traced handguns</th>
</tr>
</thead>
<tbody>
<tr>
<td>RR</td>
<td>95% CI</td>
<td>p Value</td>
</tr>
<tr>
<td>Gun years of exposure, ×1000</td>
<td>1.01</td>
<td>1.00–1.01</td>
</tr>
<tr>
<td>Years with handgun sales, n</td>
<td>1.06</td>
<td>0.98–1.16</td>
</tr>
<tr>
<td>Gun years from sales of inexpensive handguns, %</td>
<td>1.03</td>
<td>1.02–1.05</td>
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<tr>
<td>Gun years from sales at gun shows, %</td>
<td>1.00</td>
<td>0.99–1.00</td>
</tr>
<tr>
<td>Gun years from police sales, %</td>
<td>0.98</td>
<td>0.97–0.99</td>
</tr>
<tr>
<td>Gun years from sales of multiple guns, %</td>
<td>1.03</td>
<td>1.01–1.04</td>
</tr>
<tr>
<td>Denials, % (of sales + denials)</td>
<td>1.81</td>
<td>1.66–1.97</td>
</tr>
<tr>
<td>Median time to crime for traced guns, y</td>
<td>0.83</td>
<td>0.77–0.90</td>
</tr>
<tr>
<td>Median age of purchasers, y</td>
<td>0.91</td>
<td>0.89–0.93</td>
</tr>
<tr>
<td>Male purchasers, %</td>
<td>0.92</td>
<td>0.90–0.95</td>
</tr>
<tr>
<td>Retailer type (pawnbroker = 1, gun dealer = 0)</td>
<td>1.75</td>
<td>1.28–2.38</td>
</tr>
<tr>
<td>Variables reflecting local gun commerce and tracing policy</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Federal Firearm Licensees per 100 000 people†</td>
<td>0.94</td>
<td>0.92–0.95</td>
</tr>
<tr>
<td>Retailer’s city traces all recovered guns (yes = 1)</td>
<td>3.05</td>
<td>2.25–4.14</td>
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<tr>
<td>Crime rates per 100 000 people†</td>
<td>1.16</td>
<td>1.14–1.19</td>
</tr>
<tr>
<td>Homicide</td>
<td>1.00</td>
<td>0.99–1.02</td>
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<tr>
<td>Rape</td>
<td>1.01</td>
<td>1.01–1.01</td>
</tr>
<tr>
<td>Robbery</td>
<td>1.01</td>
<td>1.00–1.00</td>
</tr>
<tr>
<td>Aggravated assault</td>
<td>1.00</td>
<td>0.99–1.00</td>
</tr>
<tr>
<td>Felony weapons offenses†</td>
<td>1.06</td>
<td>1.02–1.09</td>
</tr>
<tr>
<td>Misdemeanor weapons offenses†</td>
<td>0.96</td>
<td>0.94–0.98</td>
</tr>
<tr>
<td>Variables measured at the retailer level</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Black population, %</td>
<td>1.13</td>
<td>1.11–1.16</td>
</tr>
<tr>
<td>Latino population, %</td>
<td>1.03</td>
<td>1.03–1.04</td>
</tr>
<tr>
<td>Unemployed people, % (of people ages &gt;16)</td>
<td>1.11</td>
<td>1.03–1.20</td>
</tr>
<tr>
<td>Households headed by single females, %</td>
<td>1.12</td>
<td>1.16–1.27</td>
</tr>
<tr>
<td>Males ages 20–29, as % of males ages 40–44</td>
<td>1.01</td>
<td>1.01–1.01</td>
</tr>
<tr>
<td>Median household income, $10000</td>
<td>0.99</td>
<td>0.98–1.00</td>
</tr>
<tr>
<td>Households per 10000 people</td>
<td>1.00</td>
<td>1.00–1.00</td>
</tr>
</tbody>
</table>

*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.

RR, rate ratio; CI, confidence interval.

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

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<td>Median age of purchasers, y</td>
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<tr>
<td>Retailer type (pawnbroker = 1, gun dealer = 0)</td>
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<td>0.96–0.98</td>
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</tr>
<tr>
<td>Retailer’s city traces all recovered guns (yes = 1)</td>
<td>1.00</td>
<td>1.00–1.00</td>
</tr>
<tr>
<td>Crime rates per 100 000 people†</td>
<td>1.01</td>
<td>1.00–1.02</td>
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RR, rate ratio; CI, confidence interval.
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 1.53) 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. Still others who purchase from these retailers may be surrogates (“straw purchasers’) for prohibited individuals or gun traffickers. 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. 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 girls, friends or spouses of the traffickers. The negative relation between crime gun sales and licensee density may reflect the higher density in rural counties than in urban areas where most gun sales 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. 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.

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. Most traced guns in California come from cities with mandatory tracing policies, so within-jurisdiction selection bias should be minimal. Handguns traced by these cities are similar to those from others in the state; 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. 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. Our results confirm earlier suggestions that pawnbrokers merit special attention, 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.31 (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.32 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.33 34

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REFERENCES

33 Ricker RA. Declaration in support of plaintiffs’ opposition to defendant manufacturers’ motion for summary judgment in People et al v Arcadia Foundation, and grants from The Joyce Foundation and The Richard and Rhoda Goldman Fund. The study sponsors played no role in study design; in collection, analysis, and interpretation of data; in the writing of the report; or in the decision to submit the paper for publication.

Competing interests: none.

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 inaccurate 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.
Predicting sales of crime guns


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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.

M Khayesi
Injuries and Violence Prevention Department,
World Health Organization;
khayesim@who.int

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

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

15th International Safe Communities Conference: Creating a safer environment

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

Australian Injury Prevention Network 8th National Injury Prevention Conference

2006 RoSPA Road Safety Congress: The road to safer behaviour

Ontario Injury Prevention Conference 2006

XII International Winter Road Congress

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.

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”.

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