Disproportionate sales of crime guns among licensed handgun retailers in the United States: a case control study

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Disproportionate sales of crime guns among licensed handgun retailers in the United States: a case–control study

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ABSTRACT

Objective: To determine risk factors among licensed firearm retailers for disproportionate sales of handguns that are later subjected to ownership tracing, generally after use in crime.

Design: Case–control; the study period was 1998–2003. Cases were all eligible firearm retailers whose handguns were later traced at a rate that significantly (p<0.05) exceeded the expected value. Controls were a 4:1 random sample of the remainder. Data were obtained from sales and tracing records for 1998–2003 and site visits conducted August–December, 2004.

Subjects and setting: 60 cases and 240 controls, from the 573 retailers in California selling ≥ 50 handguns annually during the study period.

Main outcome measure: Status as a case. Odds ratios were used to measure relative risk.

Results: In multivariate analyses, cases had larger sales volumes, sold inexpensive handguns more often, had a higher percentage of sales denied because the prospective purchasers were prohibited from owning firearms, and were more likely to be in an urban area, in or near a city with a policy of tracing all recovered crime guns. The effects of several risk factors, including status as a pawnbroker and sales to law enforcement personnel, appeared to be mediated by purchaser characteristics for which denied sales are a proxy measure.

Conclusions: A number of factors—most of them characteristics of the retailers or of their handgun purchasers, and most of them available in existing data—were linked to disproportionate sales of handguns that are later used in crime.

An estimated 348 910 violent crimes involving guns, including an estimated 11 512 homicides, were committed in the USA in 2007.[1 2] Firearms are used in an estimated 68% of all homicides in the US, and handguns in 73% of homicides involving firearms.[2]

American-made guns are also often used in crimes in other countries. Ninety percent of guns recovered by Mexican law enforcement agencies, and then successfully traced by the Bureau of Alcohol, Tobacco, Firearms and Explosives (ATF), are imported illegally into Mexico from the USA.[3] The same is true for most recovered crime guns in major Canadian cities.[4]

Federally licensed retailers are important sources of these guns.[5] Of persons incarcerated during the 1990s for gun crimes, 12–19% of those in state prisons[6] and 19% of those in federal prisons[7] purchased their guns personally from a gun dealer or pawnshop. Others use surrogate or "straw" purchasers and acquire guns from licensed retailers indirectly.[8] Licensed retailers who are themselves corrupt are linked to nearly half (48%) of guns that are trafficked—intentionally diverted into illegal commerce.[8]

A retailer's importance as a source of crime guns is often estimated by the number of guns it sells that are later subjected to ownership traces by ATF. Traces are performed at the request of law enforcement agencies worldwide on guns they have recovered, usually in connection with a crime. A completed trace ends with the gun's first retail sale. In 1998, just 1020 (1.2%) of 83 272 licensed retailers accounted for 57.4% of all traced guns.[9] In at least 17 major US urban areas, 10 or fewer retailers account for the majority of all traced crime guns.[10]

We previously found that the number of traced handguns linked to a retailer was not simply a function of the number of handguns that retailer had sold.[11] Increased risk of selling guns that were later traced was related chiefly to retailer-level characteristics such as licensure as a pawnbroker. Community variables, except for the local policy on gun tracing, were unimportant. That study was limited by its focus on the highest-volume retailers and reliance on data from existing records.[11]

This study extends our previous work, adding field observational data from site visits to records-based data and examining a broader retailer population. To our knowledge, no study involving observational data has previously been conducted. Given the exploratory nature of that portion of the work, our principal objective is to assess a wide variety of potential risk factors in the observational data to generate hypotheses for more focused investigation in the future. We do not derive a formal prediction instrument.

We also begin an exploration of why certain factors are associated with disproportionate sales of crime guns. A strong and seemingly paradoxical direct association exists between denials of gun purchase and sales of traced guns.[11 12] It raises the possibility that retailers who disproportionately sell guns that are later used in crime somehow attract purchasers who acquire guns with criminal intent. If this is the case, the effect of other risk factors might be mediated by the propensity for criminal activity of those purchasers.[13] Denials of gun purchase, a measure of previous criminal activity among prospecitve gun purchasers, may be a marker for that propensity. We therefore determine whether denials serve as a mediator variable for other risk factors identified by our analysis.

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METHODS

Study design, setting and participants

We used a case–control study design; the study period was 1998–2003.

The California Department of Justice (CDOJ) provided records of handgun sales by licensed retailers and of proposed sales that CDOJ denied under laws prohibiting felons, violent misdemeanants and certain others from purchasing firearms. (In California, almost all transfers of firearms, including those between private parties, must be processed by a licensed retailer.) ATF provided records of all gun traces initiated during the study period, regardless of the location of the requesting law enforcement agency. (Supplementary material on these records is available online.)

We identified the 573 retailers who sold handguns for at least 1 year during 1998–2003 and averaged at least 50 handgun sales annually for the years they were in business during that time. For these retailers, we identified all handguns sold and then linked the datasets to identify all traces of these handguns by ATF. (Supplementary material on linkage procedures is available online.)

Although ATF traces ordinarily terminate with a gun's first retail sale, at least 85% of recovered crime guns change hands again before their recovery by a police agency.[10] Some of these transfers involve licensed retailers. We used an established procedure to link each traced handgun to the retailer whose transfer of that gun most closely preceded its recovery.[11] [14] (Supplementary material on updating traces is available online.)

For all 573 retailers combined, we determined the rate at which handguns sold during 1998–2003 were later traced. This was expressed as traces per 1000 gun-years of exposure to the risk of being traced, analogous to person-years of exposure in a cohort study.[11] (Supplementary material on the calculation of gun-years at risk is available online.) We then used a binomial distribution to identify retailers for whom the actual number of traced handguns exceeded the expected number (predicted by the aggregate tracing rate) by a margin that achieved statistical significance ($p<0.05$). These 60 retailers were defined as cases. We then chose a random sample of 240 controls, for a 4:1 control/case ratio.

The study was approved by the UC Davis Institutional Review Board.

Variables and data collection

Variables fell into four classes: relating to the retailer, the retailer's handgun purchasers (including those who were denied), the local physical environment and the general socio-economic environment. Appendix table 1 (online) gives the rationale for the inclusion of each and its hypothesised relationship to status as a case.

The records-based variables from our previous study[11] are included along with variables based on data collected during site visits. Given the exploratory nature of the site visits, we were inclusive in identifying variables that might be related to status as a case. These variables were largely identified through a review of studies involving site visits to sellers of cigarettes,[15–19] alcohol[20–25] and guns[26 27] and preliminary visits to ~30 retailers in Northern California. A few variables were included following the first ~20 site visits conducted for the study. Where necessary, retailers were revisited to collect the additional data.

I conducted all site visits between August and December, 2004; I was unaware of retailers' status as cases or controls. I assessed the local physical environment and the exterior of the premises first; this required ~15 min. An interior inspection lasting 15–20 min was facilitated by a token purchase. Lastly, I made a subjective assessment of each retailer's status as a case or control. I recorded my observations immediately after the visit on a pre-printed form. I did this before leaving the vicinity, to allow a return to add missing data.

Complete site visit data could not be collected when retailers had moved or gone out of business, were on restricted military installations, or were at residences or non-retail commercial premises. Exterior variables were therefore divided into two groups: "fixed", not susceptible to modification by the occupant of the premises and likely to be valid at sites that were no longer occupied by the study subject (eg, proximity of nearest alcohol outlet); and "modifiable" (eg, security measures). Data for interior variables were collected only for retail premises that were still occupied by the study subject.

I prepared data for records-based variables for analysis. Site visit data were coded and entered by project staff, whom I trained. Dual data entry was used, with discrepancies resolved by me or a third staff member.

Statistical methods

As before,[11] we replaced each retailer's handgun sales volume with an estimate of gun-years of exposure to the risk of being traced during the study period for that retailer's handguns. Records-based variables for subsets of handgun sales were expressed as percentages of total gun-years of exposure.

Some records-based and site visit variables correlated highly, such as sales of inexpensive handguns as determined from records and the prevalence of inexpensive handguns during the site visit. In such cases, site-visit variables were used given the study's primary focus on the observational data. Many site visit variables were categorical. Given the relatively small number of study subjects, categories were combined in a manner that provided the best fit to the data.

Odds ratios (ORs) with 95% CIs were used to quantify relative risks. Regressions involving modifiable exterior variables were restricted to retailers who still occupied the premises; regressions involving interior variables were restricted to occupied premises for which an interior inspection could be performed. Forward stepwise regression was used to produce multivariate models, using entry and retention criteria of $p \leqslant 0.30$ and $p \leqslant 0.10$, respectively.

Terms for interactions between local policy on gun tracing and retailer licence type (dealer, pawnbroker) were added to the final multivariate models. A separate analysis was performed for retailers near a city with a policy of tracing recovered crime guns.

Logistic and linear regression were used to test whether denials met the criteria for status as a mediator for other variables that were associated with case status in bivariate regression.[13] (Further information on mediation is in the supplementary material available online.)

The Hosmer–Lemeshow test was used to assess goodness of fit for multivariate models.

RESULTS

Participants

The study population of 300 retailers (52.4% of 573 who met the eligibility criteria) included 60 cases and 240 controls (fig 1). We excluded 16 retailers at private residences, three at military installations, and one that could not be located. Residential retailers were less likely than others to be cases, but the difference was not statistically significant (OR 0.25, 95% CI

Figure 1 Flow diagram showing numbers of study subjects with data available for analysis, and numbers of and reasons for exclusions.
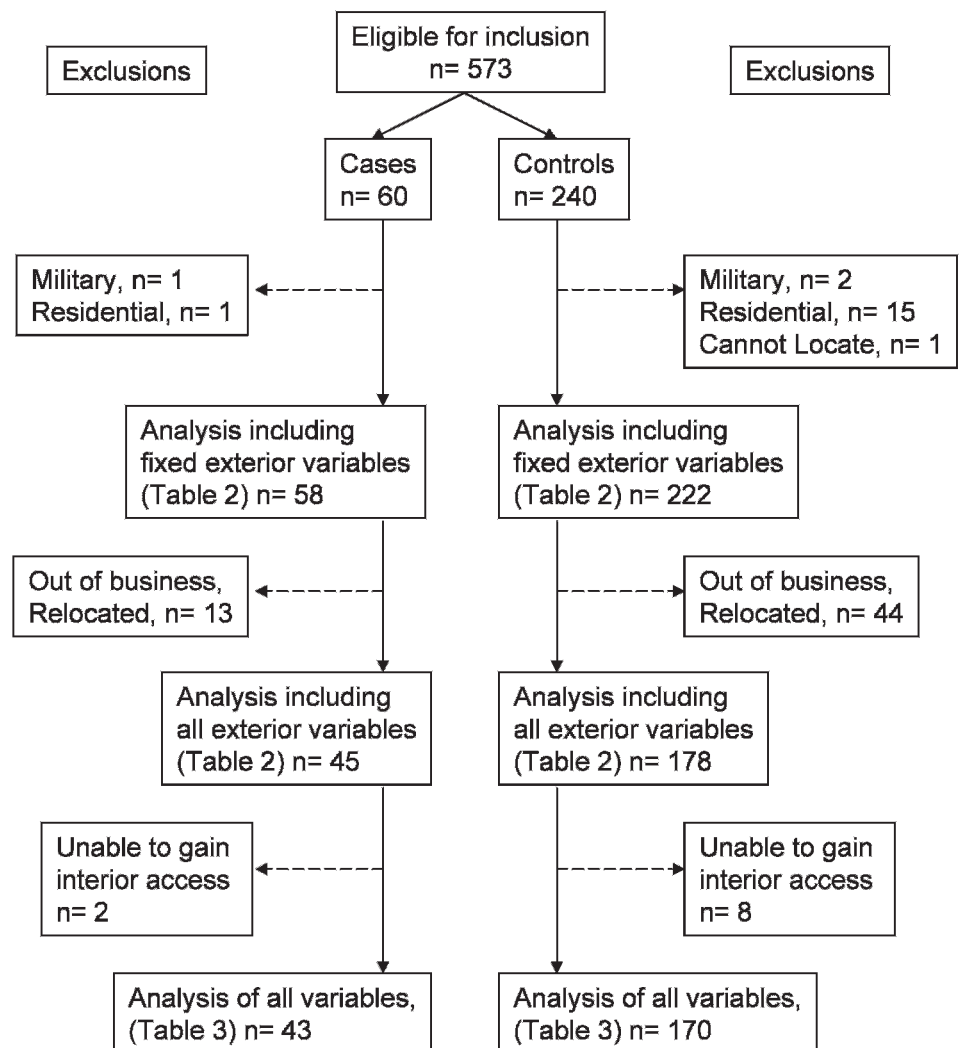
0.03 to 1.96). Additional restrictions applied to analyses including site visit data (fig 1).

Cases were linked to more traced handguns than controls were, whether traces were expressed as counts (cases, median 15, interquartile range (IQR) 7–32; controls, median 2, IQR 0–4) or per 1000 gun-years of exposure (cases, median 5.6, IQR 4.0–8.1; controls, median 1.1, IQR 0.0–2.0).

Main results

A wide array of variables was associated with case status (table 1). Among retailer variables, particularly large and significant associations were seen with status as a pawnbroker, median elapsed time from sale to recovery for traced guns, and the prevalence of several specific weapon types (handguns, inexpensive or used handguns, assault rifles and fantasy knives or swords), among others. Strong associations were also seen with the percentage of sales that were denied and environmental characteristics including the nature and maintenance of the business premises, the general nature of the location, and, particularly, proximity to a jurisdiction with a comprehensive gun tracing policy (OR 6.78, 95% CI 3.52 to 13.04).

Retailers who no longer sold handguns were not more likely than others to be cases. Proximity to a retail alcohol outlet was unrelated to case status, as were retailer hours of operation and most safety and security measures.

Table 2 gives multivariate regression results for records-based and exterior site visit variables. Sales of inexpensive handguns, urban location, the robbery rate and local gun tracing policy were associated with case status, whether just fixed exterior variables or all exterior variables were included. Case status was substantially more likely for every percentage point increase in denied sales.

When interior variables were included (table 3), handgun sales became a risk factor for case status; sales volume, sales of inexpensive handguns (now approximated by observed prevalence at the premises), denied sales, urban location, the robbery rate and local tracing policy persisted as risk factors.

Other analyses

Adding terms for interactions between local tracing policy or licence type did not affect the results.

Adding elapsed time from sale to recovery and restricting the analysis to retailers with traces yielded nearly identical results for the variables in tables 2 and 3 (data not shown). Elapsed time from sale to recovery was inversely associated with case status in the models that included all exterior variables (per year of increase, OR = 0.54, 95% CI 0.26 to 1.09) and both exterior and interior variables (per year of increase, OR = 0.21, 95% CI 0.05 to 0.88).

Given the importance of local tracing policy as a risk factor, a separate analysis was conducted for the 109 subjects (43 cases,

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Table 1 Descriptive statistics and results of bivariate regressions for retailers at commercial sites

A Continuous variables

Variable	Cases Median (IQR)	Controls Median (IQR)	OR (95% CI)	p Value
Retailer characteristics				
Gun-years of exposure ($\times$1000)	2.5 (1.0–6.6)	1.6 (1.0–3.2)	1.05 (1.00 to 1.09)	0.030
Years with sales	5 (4–5)	5 (4–5)	1.05 (0.84 to 1.32)	0.651
Gun-years from sales of inexpensive handguns (%)*	2.1 (0.2–8.2)	1.4 (0.3–4.2)	1.07 (1.02 to 1.12)	0.004
Gun-years from sales at gun shows (%)	0.1 (0.0–0.4)	0.2 (0.0–2.1)	0.96 (0.91 to 1.01)	0.128
Gun-years from sales of multiple guns (%)†	9.0 (5.8–15.2)	7.5 (4.5–11.6)	1.05 (1.01 to 1.09)	0.020
Median time from sale to recovery (years)‡	1.1 (0.8–1.5)	1.4 (0.9–2.2)	0.57 (0.38 to 0.85)	0.006
Purchaser characteristics				
Gun-years from police sales (%)¶	4.4 (2.7–8.2)	6.7 (4.6–9.7)	0.88 (0.81 to 0.96)	0.002
Denials (% of (sales + denials))	2.4 (1.7–3.7)	1.6 (1.0–2.2)	2.25 (1.70 to 2.98)	<0.0001
Median age of purchasers (years)	40 (37–42)	43 (40–45)	0.83 (0.77 to 0.90)	<0.0001
Male purchasers (%)	91.8 (90.0–93.7)	92.8 (90.2–94.3)	0.90 (0.82 to 0.99)	0.023
General environmental characteristics§				
Federal firearm licensees (per 100 000 persons)	4.2 (4.2–8.1)	8.1 (5.0–14.8)	0.83 (0.76 to 0.91)	<0.0001
Homicide (per 100 000 persons)	9.5 (5.9–10.5)	4.6 (2.8–6.1)	1.34 (1.21 to 1.49)	<0.0001
Rape (per 100 000 persons)	29.0 (29.0–34.2)	29.0 (24.3–34.0)	1.02 (0.99 to 1.06)	0.195
Robbery (per 100 000 persons ($\times$10))	29.9 (20.0–29.9)	11.9 (8.5–20.0)	1.14 (1.10 to 1.18)	<0.0001
Aggravated assault (per 100 000 persons ($\times$10))	57.4 (37.7–60.8)	33.9 (23.4–48.6)	1.07 (1.05 to 1.10)	<0.0001
Felony weapons offenses (per 100 000 persons)**	46.2 (46.2–50.3)	46.2 (44.5–59.2)	0.99 (0.98 to 1.01)	0.511
Misdemeanour weapons offenses (per 100 000 persons)††	12.6 (12.6–16.1)	12.6 (10.9–18.9)	0.96 (0.91 to 1.01)	0.111
Black population (%)	9.8 (6.7–9.8)	5.3 (1.7–9.1)	1.27 (1.17 to 1.39)	<0.0001
Latino population (%)	44.6 (26.8–44.6)	30.8 (17.7–44.0)	1.05 (1.02 to 1.07)	0.0003
Males aged 20–29 (% of males aged 40–44)	208 (179–208)	184 (159–208)	1.01 (1.00 to 1.02)	0.014
Unemployed persons (% of persons aged ≥16)	5.0 (4.2–5.0)	4.4 (3.4–5.0)	1.18 (0.96 to 1.45)	0.125
Households headed by a single female (%)	14.7 (13.0–14.7)	11.8 (10.7–14.7)	1.45 (1.23 to 1.71)	<0.0001
Median household income ($\times$US$1000)	42.2 (42.2–47.1)	42.9 (38.7–55.9)	0.98 (0.96 to 1.01)	0.292
Households (per 10 000 persons ($\times$100))	32.9 (32.9–33.1)	32.9 (32.8–36.3)	0.90 (0.80 to 1.00)	0.059

B Categorical variables

Characteristic	Cases N (%)	Controls N (%)	OR (95% CI)	p Value
Retailer characteristics: general and exterior				
Licensed as pawnbroker	19 (32.8)	45 (20.3)	1.92 (1.01 to 3.63)	0.046
"Closed": no continuing record of handgun sales in Department of Justice data	15 (25.9)	55 (24.8)	1.06 (0.55 to 2.05)	0.865
Nature of business‡‡				0.013
Pawnshop	22 (46.8)	45 (24.9)	2.91 (1.41 to 5.99)	
Sporting goods, other	8 (17.0)	35 (19.3)	1.36 (0.54 to 3.42)	
Gun dealer	17 (36.2)	101 (55.8)	Referent	
Size of establishment				0.803
Large	35 (60.3)	127 (58.5)	1.08 (0.60 to 1.95)	
Small	23 (39.7)	90 (41.5)	Referent	
External indication of gun sales‡‡	26 (57.8)	115 (65.0)	0.74 (0.38 to 1.44)	0.372
Guns visible from exterior‡‡	8 (17.8)	37 (20.9)	0.82 (0.35 to 1.91)	0.642
Exterior signage: products‡‡	17 (37.8)	99 (55.6)	0.48 (0.25 to 0.95)	0.034
Exterior signage: events‡‡	6 (13.3)	39 (21.9)	0.54 (0.22 to 1.39)	0.205
Exterior signage: political‡‡	7 (15.6)	47 (26.4)	0.51 (0.22 to 1.23)	0.135
Total hours open				0.436
0–19	14 (24.1)	51 (23.0)	0.85 (0.36 to 2.00)	
20–39	7 (12.1)	29 (13.1)	0.74 (0.26 to 2.09)	

Continued

Table 1 Continued

B Categorical variables

Characteristic	Cases N (%)	Controls N (%)	OR (95% CI)	p Value
40–49	12 (20.7)	71 (32.0)	0.52 (0.22 to 1.25)	
50–59	12 (20.7)	31 (14.0)	1.19 (0.48 to 2.97)	
≥60	13 (22.4)	40 (18.0)	Referent	
Open evenings	15 (25.9)	51 (23.0)	1.17 (0.60 to 2.28)	0.645
Open Monday	39 (67.2)	137 (61.7)	1.27 (0.69 to 2.35)	0.438
Security: pylons‡‡	11 (24.4)	39 (20.7)	1.15 (0.54 to 2.48)	0.716
Security: lighting‡‡	6 (13.3)	16 (9.0)	1.56 (0.57 to 4.24)	0.385
Security: alarm‡‡	5 (11.1)	20 (11.2)	0.99 (0.35 to 2.79)	0.981
Security: camera‡‡	1 (2.2)	11 (6.2)	0.35 (0.04 to 2.75)	0.315
Security: window bars‡‡	19 (42.2)	91 (48.9)	0.70 (0.36 to 1.35)	0.287
Security: small or absent windows‡‡	12 (26.7)	21 (11.8)	2.72 (1.22 to 6.07)	0.015
Security: other barrier‡‡	12 (26.7)	10 (5.6)	6.11 (2.44 to 15.30)	0.0001
Security: signage‡‡	2 (4.4)	24 (13.5)	0.30 (0.07 to 1.31)	0.110
Security: total measures observed‡‡				0.487
2	17 (37.8)	55 (30.9)	1.62 (0.72 to 3.62)	
≥3	15 (33.3)	55 (30.9)	1.43 (0.63 to 3.25)	
0–1	13 (28.9)	68 (38.2)	Referent	
Retailer characteristics: interior				
Interior improvements				0.644
Immediately noticeable	6 (14.0)	30 (17.7)	0.65 (0.23 to 1.82)	
Average	20 (46.5)	85 (50.0)	0.76 (0.37 to 1.58)	
None	17 (39.5)	55 (32.4)	Referent	
Empty space				0.516
Immediately noticeable	3 (7.0)	23 (13.5)	0.47 (0.12 to 1.88)	
Average	29 (67.4)	107 (62.9)	0.99 (0.45 to 2.16)	
None	11 (25.6)	40 (23.5)	Referent	
Number of guns visible				0.169
>250	9 (20.9)	26 (15.3)	0.83 (0.31 to 2.24)	
51–250	12 (27.9)	74 (43.5)	0.39 (0.16 to 0.94)	
1–50	9 (20.9)	39 (22.9)	0.55 (0.21 to 1.46)	
0	13 (30.2)	31 (18.2)	Referent	
Handguns (% of guns)				0.014
>50%	15 (50.0)	37 (26.6)	2.76 (1.23 to 6.19)	
≤50%	15 (50.0)	102 (73.4)	Referent	
Used handguns	19 (79.2)	66 (57.4)	2.82 (0.99 to 8.08)	0.053
Inexpensive handguns (<US$200) (% of handguns)				0.035
≥10%	7 (26.9)	13 (10.7)	3.06 (1.08 to 8.66)	
<10%	19 (73.1)	108 (89.3)		
Assault-type rifles	14 (46.7)	42 (30.2)	2.02 (0.91 to 4.51)	0.086
Paintball equipment	3 (7.0)	12 (7.1)	0.99 (0.27 to 3.67)	0.985
Airguns	2 (4.7)	9 (5.3)	0.87 (0.18 to 4.20)	0.865
Fantasy knives and/or swords	6 (14.0)	9 (5.3)	2.90 (0.97 to 8.65)	0.056
Antique guns	1 (2.3)	12 (7.1)	0.31 (0.04 to 2.48)	0.272
Consignment guns	1 (2.3)	10 (5.9)	0.38 (0.05 to 3.06)	0.364
All guns secured	29 (69.1)	119 (73.9)	0.79 (0.38 to 1.66)	0.528
Locks displayed	7 (16.3)	15 (8.8)	2.01 (0.76 to 5.29)	0.158
Safety materials on display	2 (4.7)	18 (10.6)	0.41 (0.09 to 1.85)	0.247
Interior signage: products	20 (46.5)	110 (64.7)	0.47 (0.24 to 0.93)	0.031
Interior signage: events	6 (14.0)	62 (36.5)	0.28 (0.11 to 0.71)	0.007
Interior signage: security	5 (11.6)	22 (12.9)	0.89 (0.32 to 2.49)	0.817
Interior signage: legal information	30 (69.8)	131 (77.1)	0.69 (0.33 to 1.44)	0.322
Interior signage: "Don't Lie" campaign	5 (11.6)	22 (12.9)	0.89 (0.32 to 2.49)	0.817
Interior signage: political	10 (23.3)	60 (35.3)	0.56 (0.26 to 1.21)	0.137
Number of staff				0.030
≥3	18 (41.9)	44 (25.9)	3.62 (1.40 to 9.41)	
2	18 (41.9)	64 (37.7)	2.49 (0.97 to 6.38)	
1	7 (16.3)	62 (36.5)	Referent	
Uniforms for staff	6 (14.3)	19 (11.3)	1.31 (0.49 to 3.51)	0.595
Nature of business: shooting range	3 (7.0)	20 (11.8)	0.56 (0.16 to 1.99)	0.372

Table 1 Continued

B Categorical variables

Characteristic	Cases N (%)	Controls N (%)	OR (95% CI)	p Value
Nature of business: gunsmith	4 (9.3)	38 (22.4)	0.36 (0.12 to 1.06)	0.064
Purchaser characteristics				
Number of other customers				0.084
≥5	9 (20.9)	16 (9.4)	2.20 (0.86 to 5.64)	
2–4	12 (27.9)	68 (40.0)	0.69 (0.32 to 1.49)	
≤1	22 (51.2)	86 (50.6)	Referent	
Other customers: females	11 (25.6)	34 (20.0)	1.38 (0.63 to 3.00)	0.424
Other customers: possibly gang or juvenile	4 (9.3)	3 (1.8)	5.71 (1.23 to 26.54)	0.026
Other customers: hangers-out	4 (9.3)	19 (11.2)	0.82 (0.26 to 2.53)	0.724
Local environmental characteristics				
Nature of site				0.0007
Business block	34 (58.6)	73 (33.0)	4.66 (2.10 to 10.33)	
Freestanding	15 (25.9)	58 (26.2)	2.59 (1.06 to 6.30)	
Mall, business/industrial park	9 (15.5)	90 (40.7)	Referent	
Site maintenance‡‡				0.412
Poor	5 (11.1)	11 (6.2)	2.47 (0.65 to 9.33)	
Fair	33 (73.3)	129 (72.5)	1.39 (0.56 to 3.39)	
Good	7 (15.6)	38 (21.4)	Referent	
Nearest alcohol outlet				0.287
Same premises, next door, same block	25 (44.6)	80 (36.9)	1.38 (0.76 to 2.50)	
Farther away	31 (55.4)	137 (63.1)	Referent	
Nature of nearest street/road				
Commercial (≥4 lanes)	45 (77.6)	143 (64.4)	1.91 (0.97 to 3.76)	0.060
Commercial (2 lanes), residential, other	13 (22.4)	79 (35.6)	Referent	
Located at intersection	13 (22.4)	45 (20.4)	1.13 (0.56 to 2.27)	0.732
General environmental characteristics				
In or <25 miles from city with comprehensive tracing	43 (74.1)	66 (29.7)	6.78 (3.52 to 13.04)	<0.0001
Nature of location				<0.0001
Centre city, other urban	31 (53.5)	47 (21.2)	4.28 (2.33 to 7.85)	
Suburban, small town, rural	27 (46.6)	175 (78.8)	Referent	
Overall assessment				
Site observer's assignment of case status	18 (31.0)	18 (8.1)	5.10 (2.44 to 10.65)	<0.0001

Variables are grouped by the entity they describe: the retailer, the retailer's handgun purchasers, the local physical environment or the general socioeconomic environment. Variables derived from handgun sales and trace records, and not from site visits, are in italics. Because their descriptive statistics differ, continuous variables and categorical variables are listed separately. Additional definitional information and the rationale for including these variables are in Appendix table 1.

*Handguns manufactured by seven 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 ~US$150 or less; almost no such handguns were manufactured by other companies during the study period.

†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 58 cases and 165 controls with handgun traces.

¶Sales to police agencies or individuals who were exempt, because of police employment, from California's required basic firearms safety course.

§For the county in which the retailer is located.

**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-barrelled 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 misdemeanour), possession of weapon with intent to assault, knowingly filing false firearm purchase application, selling firearms without a licence, possession of unregistered assault weapon, sale of ammunition to a minor.

‡‡An external characteristic that was subject to alteration by the occupant. Data for these variables were included only for the 223 retailers who still occupied the premises listed in California Department of Justice's records.

IQR, interquartile range; OR, odds ratio.

66 controls) located in or near a jurisdiction with a comprehensive tracing policy. Results were again similar (data not shown).

Table 4 summarises the mediation analysis. Of the variables that were associated with case status in a bivariate regression, seven met criteria for at least partial mediation.

DISCUSSION
Key results
Several factors are strongly associated with handgun retailers' risk of disproportionate sales of guns that are later used in crimes. Most are measured at the retailer level and describe the retailers themselves or their purchasers. Some, including status

Table 2 Variables associated with case status for 280 retailers in a model using records-based and fixed exterior site visit variables, and for 223 retailers in a model using records-based and all exterior site visit variables

Variable	Records-based and fixed exterior variables (n = 280*)		Records-based and all exterior variables (n = 223†)	
	aOR (95% CI)	p Value	aOR (95% CI)	p Value
Retailer characteristics				
Gun-years of exposure (×1000)			1.09 (0.99 to 1.21)	0.084
Gun-years from sales of inexpensive handguns (%)	1.08 (1.02 to 1.15)	0.014	1.07 (1.00 to 1.15)	0.060
Security: small or absent windows			4.73 (1.28 to 17.53)	0.020
Purchaser characteristics				
Denials (% of (sales + denials))	2.39 (1.59 to 3.59)	<0.0001	3.09 (1.80 to 5.31)	<0.0001
General environmental characteristics				
Robbery (×10)	1.09 (1.04 to 1.14)	0.001	1.11 (1.04 to 1.18)	0.001
In or <25 miles from city with comprehensive tracing	6.99 (2.47 to 10.73)	0.0002	8.75 (2.44 to 31.31)	0.0009
Nature of location		0.0002		0.002
Centre city, other urban	5.01 (2.13 to 11.75)		5.53 (1.86 to 16.42)	
Suburban, small town, rural	Referent		Referent	

Records-based variables are in italics.
*Hosmer–Lemeshow statistics: $\chi^2 = 10.47$, p = 0.23.
†Hosmer-Lemeshow statistics: $\chi^2 = 11.66$, p = 0.17.
aOR, adjusted odds ratio.

as a pawnshop, denied sales, sales of inexpensive handguns, multiple-gun sales, urban location and a short elapsed time from sale to recovery for traced guns, have been identified repeatedly.[11 12 26 28 29] Some of the risk factors identified in the observational data, including urban location and prevalence of inexpensive handguns, are available or have near analogues in the existing records.

The relationship to denied sales is particularly strong. The two models based on the most complete data also identify overall sales volume as a risk factor for disproportionate, not just frequent, sales of traced guns. As before,[11] characteristics of the general socioeconomic environment seem to be less

Table 3 Predictors of case status for 213 retailers in a model using records-based and both exterior and interior site visit variables

Variable	aOR (95% CI)	p Value
Retailer characteristics		
Gun-years of exposure (×1000)	1.29 (1.08 to 1.52)	0.004
Handguns (% of guns)		0.089
>50%	5.19 (0.78 to 34.54)	
⩽50%	Referent	
Inexpensive handguns (<US$200) (% of handguns)		0.023
⩾10%	21.86 (1.53 to 312.32)	
<10%	Referent	
Interior signage: political	0.02 (<0.001 to 0.39)	0.010
Purchaser characteristics		
Denials (% of (sales + denials))	9.13 (2.06 to 40.44)	0.004
General environmental characteristics		
Robbery	1.02 (1.01 to 1.03)	0.003
In or <25 miles from city with comprehensive tracing	26.57 (1.91 to 370.21)	0.015
Nature of location		0.071
Centre city, other urban	5.73 (0.86 to 38.11)	
Suburban, small town, rural	Referent	

Records-based variables are in italics.
Hosmer–Lemeshow statistics: $\chi^2 = 3.35$, p = 0.91.
aOR, adjusted odds ratio.

Table 4 Summary of results of testing the hypothesis that the percentage of sales that are denied (or some factor for which it is a proxy measure) acts as a mediator for other variables associated with case status

Meets criteria for mediation	Does not meet criteria for mediation
Retailer characteristics	
Gun-years from sales of inexpensive handguns (%)	*Gun-years of exposure*
Licensed as pawnbroker	*Gun-years from sales of multiple guns* (%)
Inexpensive handguns (<US$200) (% of handguns)	*Median time from sale to recovery* (years)
Interior signage: products	Nature of business
Interior signage: events	Security: other barrier
	Security: small or absent windows
	Handguns (% of guns)
	Number of staff
Purchaser characteristics	
Gun-years from police sales (%)	*Median age of purchasers* (years)
Male purchasers (%)	Other customers: high risk
Local environmental characteristics	
	Nature of site
General environmental characteristics	
	Federal firearm licensees (per 100 000 persons)
	Homicide (per 100 000 persons)
	Robbery (per 100 000 persons)
	Aggravated assault (per 100 000 persons)
	Black population (%)
	Latino population (%)
	Males aged 20–29 (% of males aged 40–44)
	Households headed by a single female (%)
	Nature of location
	In or <25 miles from city with comprehensive tracing

See text for details. Records-based variables are in italics. Variables that appear in the multivariate models (tables 2, 3) are in bold. "Interior signage: political" is in the model displayed in table 3 and meets criteria for mediation. It is not included in the table because it is not a predictor of case status in a bivariate regression (p = 0.137, table 1).

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important, except for urban location (a large effect) and the robbery rate (a small effect). One further and important exception is local policy on gun tracing, which would disappear as a risk factor under the desired condition that all communities traced recovered crime guns.

Several risk factors that might represent a retailer's attractiveness to high-risk purchasers also satisfy the computational criteria for mediation by the percentage of sales that are denied. These include sales of inexpensive handguns, licensure as a pawn broker, sales to women (who may act as straw purchasers[8]) and sales to law enforcement (intuitively a deterrent, and a protective factor in these data). Others, including multiple-gun sales, do not.

Such findings are consistent with the suggestion that the effects of some risk factors may be mediated by purchaser characteristics for which denied sales are a proxy measure. How might this occur? Retailers having certain characteristics may attract prospective purchasers who are at high risk of committing gun crimes themselves or who provide guns to others who have criminal intent. Such retailers might be described as "bad guy magnets." To the extent that their prospective purchasers are prohibited from purchasing guns, their denied sales increase; denied sales become a measure of "bad guy magnetism." Simultaneously, to the extent that the purchasers are not prohibited persons—with the results that their gun purchases are approved, with some of those guns being used in crime, and some of those crime guns being recovered and traced—these retailers risk becoming disproportionate sources of crime guns.

Factors we could not assess may also determine which retailers are disproportionate sources of crime guns. One may be word of mouth. Like other consumers, gun purchasers with criminal intent may rely on recommendations from peers (or superiors, in organised trafficking enterprises).[30] Past performance is another; trafficking investigations often document long-term relationships between illegal buyers and sellers.[8 30 31]

Limitations

Our findings are subject to several limitations. This is a single-state study, and generalisability may be limited. California has its own licensing and inspection programme; its handgun retailers may not be representative. Sales of handguns that fail specified safety tests, which tend to be inexpensive, were prohibited beginning in 2001. The sale of multiple handguns to an individual in any 30-day period became illegal in 2000. These changes may have affected our results for those variables. Only one set of site visit observations was collected, and by a single observer; the interobserver reliability and stability over time of the site visit data are unknown. For a variety of reasons, data were sometimes missing. We could not include long guns in the analysis, as CDOJ cannot retain sales records for them. (Such data might well show that another risk factor identified during site visits, handguns as a proportion of guns on display, could also be approximated from existing records.) The traced handguns used for our outcome measure are necessarily a subset of handguns sold by our subjects during 1998–2003 and used in crime. Most traced guns in California come from cities with comprehensive tracing policies, however, reducing the potential for selection bias.[14 32]

Perhaps most important, we made no observational assessment of the sales practices of the retailers, and particularly of their willingness to engage in illegal sales such as straw purchases. Previous research suggests that such willingness is widespread.[33] Other corrupt behaviours, such as willingness to sell guns without records, would also have been missed.[31 34]

What is already known on this subject

► Nationwide, 1.2% of licensed gun retailers sell 57% of guns that are later used in crime, a concentration only partly accounted for by differences in total numbers of handguns sold.
► Previous records-based research found relationships between characteristics of handgun retailers or their clienteles and disproportionate sales of guns that were later used in crime; community-level variables were less important.

What this study adds

► Even when observational data from site visits are available, most risk factors for disproportionate sales of crime guns can be identified from existing records.
► Some risk factors may act indirectly by attracting (or deterring) purchasers who acquire guns with criminal intent or whose guns are at high risk of diversion to criminal use.
► Data already collected for individual retailers at the federal level—the number of background checks requested and the number of denied sales—would permit screening to identify those who may be disproportionate sellers of guns that will be used in crime.

These limitations notwithstanding, our findings may assist efforts to prevent gun violence. The US Department of Justice stresses the need to identify retailers who are disproportionate sources of crime guns.[35] Denied sales may be a useful initial screening tool, if paired with the number of background check queries to the National Instant Criminal Background Check System as a surrogate for gun sales.[36] These data are available.

Screening and focused enforcement could help disrupt illegal gun commerce without unduly affecting the legitimate gun market. A focus on high-risk retailers can be effective,[28–30 37 38] although results may be only temporary (D Webster, personal communication, 2007). Given the importance of the United States as a source of crime guns elsewhere, such actions could have benefits in many countries.

Further research will be necessary to identify firmly risk factors for disproportionate sales of crime guns, particularly those involving retailer behaviour, and their mechanisms of action.

REFERENCES

1. **Rand MR.** *Criminal victimization, 2007*. Report No NCJ 224390. Washington, DC: Bureau of Justice Statistics, 2008.
2. **Federal Bureau of Investigation**. *Crime in the United States, 2007*. Washington, DC: Federal Bureau of Investigation, 2008.
3. Statement of William Newell before the Committee on Appropriations, Subcommittee on Commerce, Justice, Science and Related Agencies, United States House of Representatives. Washington, DC. 24 March 2009.
4. **Graduate Institute of International Studies**. *Small arms survey 2002: counting the human cost*. Oxford: Oxford University Press, 2002.
5. **Braga AA,** Cook PJ, Kennedy DM, *et al*. The illegal supply of firearms. In: Tonry M, ed. *Crime and justice: a review of research*. Chicago, IL: The University of Chicago Press, 2002:319–52.
6. **Harlow CW.** *Firearm use by offenders*. Report No NCJ 189369. Washington, DC: Bureau of Justice Statistics, 2001.
7. **Scalia J.** *Federal firearm offenders. 1992–98*, Report No NCJ 180795. Washington, DC: Bureau of Justice Statistics, 2000.
8. **Bureau of Alcohol Tobacco and Firearms**. *Following the gun: enforcing federal laws against firearms traffickers*. Washington, DC: Bureau of Alcohol, Tobacco and Firearms, 2000.
9. **Bureau of Alcohol Tobacco and Firearms**. *Commerce in firearms in the United States*. Washington, DC: Bureau of Alcohol, Tobacco and Firearms, 2000.
10. **Bureau of Alcohol Tobacco and Firearms**. *Crime gun trace reports (2000)*. Washington, DC: Bureau of Alcohol, Tobacco and Firearms, 2002.
11. **Wintemute GJ,** Cook P, Wright MA. Risk factors among handgun retailers for frequent and disproportionate sales of guns used in violent and firearm related crimes. *Inj Prev* 2005;**11**:357–63.
12. **Pierce GL,** Braga AA, Hyatt RRJ, *et al*. Characteristics and dynamics of illegal firearms markets: implications for a supply-side enforcement strategy. *Justice Quarterly* 2004;**21**:391–422.
13. **Baron RM,** Kenney DA. The moderator-mediator variable distinction in social psychological research: conceptual, strategic, and statistical considerations. *J Pers Soc Psychol* 1986;**51**:1173–82.
14. **Wintemute GJ,** Romero MP, Wright MA, *et al*. The life cycle of crime guns: a description based on guns recovered from young people in California. *Ann Emerg Med* 2004;**43**:733–42.
15. **Altman DG,** Foster V, Rasenick-Douss L, *et al*. Reducing the illegal sale of cigarettes to minors. *JAMA* 1989;**26**:80–4.
16. **Arday DR,** Klevens RM, Nelson DE, *et al*. Predictors of tobacco sales to minors. *Prev Med* 1997;**26**:8–13.
17. **Erickson AD,** Woodruff SI, Wildey MB, *et al*. A baseline assessment of cigarette sales to minors in San Diego, California. *J Community Health* 1993;**18**:213–24.
18. **Centers for Disease Control and Prevention**. Minors' access to smokeless tobacco — Florida, 1994. *MMWR Morb Mortal Wkly Rep* 1995;**44**:839–41.
19. **Forster JL,** Hourigan M, McGovern P. Availability of cigarettes to underage youth in three communities. *Prev Med* 1992;**21**:320–8.
20. **Freistler B,** Gruenewald PJ, Treno AJ, *et al*. Evaluating alcohol access and the alcohol environment in neighborhood areas. *Alcohol Clin Exp Res* 2003;**27**:477–84.
21. **Forster JL,** Murray DM, Wolfson M, *et al*. Commercial availability of alcohol to young people: results of alcohol purchase attempts. *Prev Med* 1995;**24**:342–7.
22. **Forster JL,** McGovern PG, Wagenaar AC, *et al*. The ability of young people to purchase alcohol without age identification in northeastern Minnesota, USA. *Addiction* 1994;**89**:699–705.
23. **Preusser DF,** Williams AF. Sales of alcohol to underage purchasers in three New York counties and Washington, DC. *J Public Health Policy* 1992;**13**:306–17.
24. **Wolfson M,** Toomey TL, Forster JL, *et al*. Characteristics, policies and practices of alcohol outlets and sales to underage persons. *J Stud Alcohol* 1996;**57**:670–4.
25. **Wolfson M,** Toomey TL, Murray DM, *et al*. Alcohol outlet policies and practices concerning sales to underage people. *Addiction* 1996;**91**:589–602.
26. **Bureau of Alcohol Tobacco and Firearms**. *Operation Snapshot: an analysis of the retail regulated firearms industry*. Washington, DC: Bureau of Alcohol, Tobacco and Firearms, 2000.
27. **Sanguino SM,** Dowd MD, McEnaney SA, *et al*. Hangun safety: what do consumers learn from gun dealers? *Arch Pediatr Adolesc Med* 2002;**156**:777–80.
28. **Koper CS.** Federal Legislation and gun markets: how much have recent reforms of the federal firearms licensing system reduced criminal gun suppliers? *Criminol Public Pol* 2002;**1**:151–78.
29. **Webster D,** Vernick J, Bulzacchelli M. Effects of a gun dealer's change in sales practices on the supply of guns to criminals. *J Urban Health* 2006;**83**:778–87.
30. **Mayors Against Illegal Guns**. *Inside straw purchasing: how criminals get guns illegally*. http://www.mayorsagainstillegalguns.org/downloads/pdf/inside-straw-purchases.pdf (accessed 22 Jun 2009).
31. **Braga AA,** Kennedy DM. Gun shows and the illegal diversion of firearms. *Georgetown Public Pol Rev* 2000;**6**:7–24.
32. **Cook PJ,** Braga AA. Comprehensive firearms tracing: strategic and investigative uses of new data on firearms markets. *Ariz Law Rev* 2001;**43**(Summer):277.
33. **Sorenson SB,** Vittes K. Buying a handgun for someone else: firearm dealer willingness to sell. *Inj Prev* 2003;**9**:147–50.
34. **Ricker RA.** Declaration in support of plaintiffs' opposition to defendant manufacturers' motion for summary judgment in People *et al* v Arcadia Machine and Tool, Inc., *et al*.San Diego: Superior Court of California; Judicial Counsel Coordination Proceeding No 4095, 2003.
35. **US Department of Justice, Office of the Inspector General, Evaluation and Inspections Division**. *Inspections of firearms dealers by the Bureau of Alcohol, Tobacco, Firearms and Explosives*, Report No I-2004-005. Washington, DC: US Department of Justice, 2004.
36. **General Accounting Office**. Gun control: potential effects of next-day destruction of NICS background check records. Washington, DC: General Accounting Office, 2002.
37. **Braga A,** Pierce GL. Disrupting illegal firearms markets in Boston: the effects of Operation Ceasefire on the supply of new handguns to criminals. *Criminol Public Pol* 2005;**4**:717–48.
38. **Webster D,** Bulzacchelli M, Zeoli A, *et al*. Effects of undercover police stings of gun dealers on the supply of new guns to criminals. *Inj Prev* 2006;**12**:225–30.