Firearm Acquisition and Criminal Use: Legal and Illegal Possession of Crime Guns in California (2010–2021)

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Abstract

Despite the importance of understanding how gun offenders obtain their firearms, data on acquisition pathways remains limited. Using records of guns recovered in crime in California (2010--2021; n=370,498), we examine rates of legal and illegal possession, and how they vary across offense types. Linking these "crime gun" records to firearm transactions in the state (n=5,247,348), we implement Cox Proportional Hazards models to identify characteristics associated with law enforcement recovery from an illegal versus legal possessor. We estimate separate models for violent crime recovery and conduct sex-stratified analyses. Among all recovered handguns, 61% were illegally possessed, 24% were legally possessed, and possession status was unknown for 15%. Legal possession varied substantially by crime type: for example, 56% of handguns recovered in threats were legally possessed, 37% in homicides and assaults, and 20% in robberies. Results from the survival analyses showed stolen firearms were associated with a 31-fold higher hazard of violent crime recovery with an illegal possessor compared to a hazard of 1.8 for legal possession recovery. Sex-stratified analyses provided evidence of potential straw purchasing: for example, female buyers with 12+ recent purchases had a 13-fold higher hazard of illegal possession recovery; there was no association with legal possession recovery. A purchaser's prior arrest history was associated with recovery, with larger hazards for legal possession. This study provides the first systematic examination of possession status by crime type. The considerable proportion of legally possessed crime guns, particularly in violent crimes, highlights the need for prevention strategies that address both legal and illegal acquisition pathways.

Key Words: Crime guns, firearm violence, firearm acquisition, legal possession, straw purchasing, firearm theft

INTRODUCTION

Gun violence remains a significant public health and public safety concern in the United States. In 2022, there were more than 48,000 firearm deaths, including nearly 20,000 firearm homicides (2024), and over 120,000 non-fatal assault-related firearm injuries. Understanding how gun offenders obtain firearms is critical for developing effective interventions, yet data available remains incomplete and fragmented.

Estimates of how frequently gun offenders legally acquire their firearms vary widely depending on the population and data source. For instance, prison and jail surveys indicate that, among those who report to have used guns in crimes, direct legal purchase from a federally licensed dealer (FFL) is rare. The most recent U.S. Department of Justice Survey of Inmates in State Correctional Facilities (SISCF), conducted in 2016, indicates that among individuals who used a gun in the crime for which they were incarcerated, only 7% purchased it directly from an FFL. Most obtained their firearms through the illicit or street market (43%) or from family

members or friends (25%) (Alper & Glaze 2019). Survey data from gang-involved individuals in Chicago jails suggest even lower rates of legal acquisition among this population: only 3% reported acquiring their guns directly from an FFL (Cook *et al.* 2015).

Administrative data from law enforcement on recovered firearms provides additional insights into acquisition patterns. Consistent with the survey data from Chicago jails, a study of guns confiscated from gang members in Chicago found that 3% had purchased their guns from an FFL (Cook *et al.* 2015). Crime gun trace data from the Bureau of Alcohol, Tobacco, Firearms and Explosives (ATF), which includes all firearms recovered in crimes, rather than just those from specific high risk populations, indicates 12% of recovered guns had the same first purchaser and possessor and 17% among crime guns with an identified possessor (29% of crime guns were recovered with an unknown possessor) (Bureau of Alcohol & Firearms 2002; 2023; The Bureau of Alcohol 2023). However, ATF trace statistics only include the first recorded legal purchase. Rates of legal ownership will be higher than indicated by ATF trace data insofar as there are subsequent sales or transfers. Given Tiahrt Amendment restrictions on ATF trace data (Krouse 2010), and the limited number of states with firearm transaction recordkeeping, there have been few studies providing estimates that account for subsequent legal transactions after the first purchase. Research done in Baltimore in the late 1990s suggests a higher rate of primary market reliance among illegal gun users than estimates from ATF and other sources: between 19%-28% of recovered guns with a known possessor had the same registered Maryland purchaser (possessor information was available for 63% of recoveries) (Koper 2014).

This study advances current knowledge of firearm acquisition for criminal use with two key contributions. First, using data on crime gun recovery reports in California from 2010 through October 2021, we provide the most comprehensive state-level estimates of legal and illegal possession among recovered crime guns. Unlike ATF trace data, which typically captures only the first recorded retail sale, California's integrated firearm data systems allow for the identification of all legal transfers after the first purchase and link these to individual-level prohibitions (e.g., criminal convictions, restraining orders) through the Armed and Prohibited Persons (APPS) system. This enables a more accurate determination of possession status at the time of recovery than is possible in most prior studies, which typically infer illegality based solely on whether the possessor differs from the original purchaser. Additionally, California's crime gun recovery data include the associated offense at the time of recovery, allowing us to examine possession status across specific crime types. To our knowledge, this represents a novel contribution and highlights important variation masked in aggregate crime gun statistics.

Second, building on our recent work that examined purchaser, handgun, and dealer characteristics associated with crime gun recovery in California (Robinson *et al.* 2024), we investigate how established predictors differ between legally and illegally possessed crime guns. Prior studies have documented a number of consistent risk factors for crime gun recovery. Handgun features such as low cost (Koper 2007; Wintemute 2009; Wright *et al.* 2010; Koper 2013; Braga *et al.* 2021; Robinson *et al.* 2024) and larger caliber (Koper 2007; Wright *et al.* 2010; Koper 2013; Robinson *et al.* 2024) have consistently been associated with increased recovery risk, as have sales from pawn dealers and from dealers with a high rate of denied sales following a background check (Wintemute *et al.* 2005; Pierce *et al.* 2006; Wintemute 2009; Wright *et al.* 2010; Robinson *et al.* 2024). Purchaser demographics including race and sex (Wright *et al.* 2010; Koper 2013; Robinson *et al.* 2024) have also been consistently identified as risk factors, as has purchaser criminal history (Robinson *et al.* 2024).

Extending this literature, we implement survival analysis models to identify handgun, transaction, purchaser, and dealer characteristics associated with time to recovery from an illegal possessor and from a legal possessor. We examine recovery in in any crime and in a violent crime, specifically. Additionally, we conduct sex-stratified analyses to examine evidence of straw purchasing. Research suggests women are more likely to purchase a firearm on behalf of a prohibited person or trafficker who does not want to be associated with the purchase (Koper 2007; Cook *et al.* 2014), with estimates indicating women account for as much as 80% of straw purchases (Moselle 2021).

California's comprehensive crime gun and firearm transfer records provide a unique opportunity to study how firearms used in crime are acquired and possessed. By distinguishing characteristics associated with recovery from legal versus illegal possessors, our study provides new insights into firearm acquisition pathways for criminal use. Our findings challenge the common narrative that gun offenders almost exclusively rely on the illicit market. This underscores the importance of prevention strategies that not only address diversion pathways such as straw purchasing and theft, but also target high-risk legal firearm acquisition.

METHODS

Data

Our descriptive analyses of legal and illegal crime gun possession rely on crime gun recovery records from 2010 through 2021 maintained by the California Department of Justice (CA DOJ) in their Automated Firearm System (AFS). Since the early 2000s, California has required that all firearms recovered by law enforcement be submitted to the CA DOJ for tracing through the Bureau of Alcohol, Tobacco, Firearms and Explosives (ATF) and that CA DOJ maintain the crime gun recovery records for at least ten years. The crime gun records include details on the firearm (make, model, caliber or gauge, and serial number), information on the date and type of crime in which the firearm was used and recovered, and information on whether the crime gun possessor was the legal owner of the firearm, illegally possessed the firearm, or it was unknown. The crime gun recovery database also includes statewide reports of firearms lost or stolen, and rows for guns held for evidence, found, held for safekeeping, under law enforcement observation, released by law enforcement, or destroyed.

Law enforcement can establish ownership status at the time of recovery by searching for a firearm or an individual in the CA Law Enforcement Telecommunications system. The system integrates data from multiple California Department of Justice (CA DOJ) sources. This includes the California Dealer Records of Sale (DROS) database of all recorded legal firearms, cross-referenced with records identifying individuals who have become prohibited from owning or possessing firearms as well as additional databases containing criminal history and prohibiting conditions. A crime gun may also be classified as illegally possessed if the gun is determined to be prohibited under California law—for example, if it is a privately manufactured firearm (PMF), an unserialized firearm, or a model banned for sale or possession in the state. Over the study period, the possession status was marked as "unknown" for approximately 10% -15% of recovered crime guns. We excluded cases with unknown possession status from the survival analyses but present descriptive statistics on this category to provide a fuller picture of firearm recoveries.

Each crime gun recovery record includes a CA DOJ Uniform Offense Code. If multiple offenses were associated with the crime gun recovery, the most severe is typically recorded. We classified these into the following categories: homicide (09xx), kidnapping (10xx), robbery

(12xx), assault (13xx), sexual violence (including sexual assault (11xx) and sex offenses (36xx)), threats (16xx), burglary (22xx), larceny (23xx), stolen vehicle (24xx), stolen property (28xx), damage property (29xx), weapon (52xx), and drug (35xx) crimes. Categories for violent and property crimes were made by combining crime types (09xx, 10xx, 11xx, 12xx, and13xx for violent crime and 22xx, 23xx, 24xx, 28xx, 29xx, and 71xx for property crimes). A list of all offenses included in these crime categories are provided in the Appendix.

The second set of analyses examining handgun, purchaser, transaction and dealer characteristics associated with recovery from a legal possessor and recovery from an illegal possessor rely on California Dealer Records of Sale (DROS) records (2000-2021). We linked the firearm trace records to DROS records using the CA DOJ linkage number (OCA and Date of Transaction). California law requires that essentially all firearm transfers in the state, including private party and gun show transactions, be conducted through a licensed firearms retailer (FFL) and be subject to a background check and a mandatory 10-day waiting period between purchase and pick-up. DROS records contain all legal handgun transactions and transfers since 1996, and transactions for rifles and shotguns since 2014. We focus the survival analyses on handguns, as they account for most crime guns (70%) and long guns were not consistently recorded in DROS until 2014.

To purchase or transfer a firearm in California, individuals must submit an application to an FFL who then provides purchaser information to CA DOJ through electronic transfer. CA DOJ checks available state and federal records to determine whether the applicant has any legal disqualifications from purchasing or possessing firearms under state or federal law. DROS records include standard firearm purchases from an FFL, as well as legal private party transfers, gifts, loans, redemptions of pawned or consigned weapons, intra-familial transfers, collector reports, out-of-state registrations, and gun show sales. They contain details about the firearm, the date, time, and type of transaction (e.g., sale, denial, transfer, pawn), as well as identifiers for the seller. Purchaser information includes name, date of birth, sex, race and ethnicity, citizenship, country of origin, and address.

In addition to the purchaser information provided in DROS, we also included purchaser criminal history, maintained in the CA DOJ Automated Criminal History System (ACHS). These data contain information on offense code, disposition, arrest date, conviction date, and level of crime (i.e., infraction, misdemeanor, or felony), and additional modifiers and comments.

In total, we had records for 368,852 crime guns (258,615 handguns and 110,237 long guns). Among all crime guns, 54,440 handguns and 6,806 long guns were linked to a prior transaction record in DROS. Handguns that appeared only in the gun trace records without a corresponding DROS record within the specified time frame were not included in the survival analysis. Recovered firearms could not be linked to a DROS transaction for several reasons including out-of-state purchases, privately manufactured firearms, and data linkage issues such as missing serial numbers, purchase dates preceding DROS coverage (i.e., before 1996 for handguns and 2014 for long guns).

Descriptive and Time-to-Crime Analyses

For all recovered handguns, we conducted descriptive analyses examining the prevalence of legal and illegal possession among recovered crime guns over time and how possession status varied by the crime associated with the recovery. Findings for recovered long guns are presented in the Appendix (Table A3).

Using the linked handgun transaction and crime gun recovery records, we also analyzed the time from legal purchase to recovery in a crime, distinguishing among recoveries involving a legal possessor, an illegal possessor, or cases with unknown possession. A firearms "time-to-crime" is generally defined as the interval between a firearm's first retail sale and its recovery in a crime. A short time-to-crime —typically defined as one or three years — is a widely used indicator of potential trafficking or illicit transfer (The Bureau of Alcohol 2023; Stansfield *et al.* 2025). The literature has shown newer guns are disproportionately represented among crime guns, suggesting a rapid diversion after retail sale (Braga *et al.* 2021). We calculated median "time-to-crime" for firearms purchased in 2009, 2010, and 2011 to ensure a 10-year follow-up period for each purchase year. We also conducted a supplemental analysis of crime guns recovered between 2018-2021, assessing the percentage that had been recovered within one year of purchase.

Survival Analysis

We employed Cox Proportional Hazard models with handgun transactions as the unit of analysis to estimate the recovery risk associated with handgun characteristics, transaction and transfer events, and purchaser traits and prior criminal history. This approach accounts for the timing of recoveries and accommodates time-dependent covariates and censored observations.

Firearms were followed from their first DROS transaction (as early as 2000) until their recovery in a crime, their destruction by a law enforcement agency, or the end of administrative follow-up in 2021, whichever occurred first. To account for left truncation (i.e., the time between the most recent firearm purchase and the start of our crime gun recovery observation period in 2010), we specified the date of first purchase by the current purchaser as the entry time using PROC PHREG in SAS, which fits Cox proportional hazards models with time-dependent entry. All models accounted for clustering at multiple levels: transactions involving the same firearm-purchaser pair, the firearm, purchaser, dealership, and the purchaser's census tract. This multi-level clustering approach addresses potential non-independence of observations and provides more accurate standard error estimates.

We examined two distinct outcomes: (1) recovery in crime with a legal possessor and (2) recovery in crime with an illegal possessor. We also examined violent crime recovery specifically, again distinguishing between legal and illegal possessors. Finally, given evidence that women are overrepresented among straw purchasers, we also conducted additional stratified analyses by purchaser sex to examine potential differences in risk factors.

Predictors

To compare recovery pathways for legal versus illegal possessors, we first specified a large set of handgun-, transaction-, purchaser-, and dealer-level covariates. Predictors were derived from California's Dealer Record of Sale (DROS) database, either directly or through additional processing (e.g., geocoding purchaser address to census tract or calculating prior handgun purchases by the individual). A copy of the Dealer Record of Sale form, which is completed by dealers and submitted electronically to CA DOJ, is provided in Appendix Section A.

Candidate predictors were entered into the four initial Cox models: time to any recovery (illegal and legal possession) and time to violent-crime recovery (illegal and legal possession). For each outcome – any crime and violent crime recovery – we retained any predictor that reached statistical significance ($p < 0.05$) in at least one of the models for that outcome (i.e.,

significance in either the legal or illegal-possessor violent crime model). The resulting set of predictors were used in the final models and in the sex-stratified analysis to provide consistent comparisons between the relative importance of predictors in legal versus illegal possession recovery.

Handgun characteristics

Handgun related predictors included caliber size, categorized as small (e.g., .22, .25, .32), medium (e.g., .38, 9mm), or large (e.g., .40, .44, .45) based on the firearm make, model, and caliber. This classification scheme follows prior research examining firearm lethality and crime gun risk (Koper 2014; Braga & Cook 2018). We generated a proxy indicator for "cheap" handguns, which we defined as the lowest quantile of median manufacture prices in the *Blue Book of Gun Values* using a Possibly Gapped Histogram method (Fushing & Roy 2018) We also included an indicator for semiautomatic weapons. As noted in the introduction, the crime gun literature has consistently found elevated recovery risk associated with inexpensive, larger caliber, and semiautomatic handguns (Wright *et al.* 2010; Koper 2014; Robinson *et al.* 2024)

Transaction characteristics

We included information on any previous transactions associated with the firearm. These included consignments, intrafamilial transfers, pawns, pawn redemptions, and whether the most recent transaction was a private party transfer. We also incorporated indicators for law enforcement holds, law enforcement releases, and any lost or stolen reports —fields captured in the crime gun database. Theft, in particular, represents a potentially important pathway by which legally acquired firearms enter the illicit market (Alper & Glaze 2019). Our recent analysis found handguns reported stolen were approximately nine times more likely to be later used in crime (Robinson *et al.* 2024). In contrast, law enforcement holds and a handgun being placed for pawn — periods in which a handgun is out of circulation—were inversely associated with crime gun recovery in our prior analysis (Robinson *et al.* 2024).

Purchaser characteristics

We included several characteristics related to the last recorded purchaser: age at the time of purchase, sex, citizenship status, place of birth (US or non-US), and race/ethnicity. We calculated the number of handguns purchased by the individual in the year prior to the transaction and binned this variable into five categories (0, 1, 2–5, 6–12, >12) to improve model stability. We also included an indicator for first-time buyers. Prior research has consistently found elevated risk of crime gun recovery associated with purchasers who are younger, non-white, female and who engage in multiple sale transactions (Koper 2014; Robinson *et al.* 2024).

To capture criminal history, we included indicators for any prior arrests within ten years for alcohol intoxication, firearm-related crimes, major violent crime, and major property crime. Criminal history has been shown to be a risk factor for violence among legal firearm purchasers (Kagawa *et al.* 2020; Laqueur *et al.* 2024), and was associated with elevated recovery risk in prior non-stratified analysis (Robinson *et al.* 2024).

Finally, we geocoded dealer and purchaser addresses to measure the distance traveled from purchaser to dealer, categorized as missing (10.6%), ≤5 miles, >5 –20 miles, or >20 miles. In our prior analysis, handguns purchased from nearby dealers (≤5 miles) were more likely to be recovered in crime, possibly reflecting access and availability in dense urban environments (Robinson *et al.* 2024). Related research has found that dealers located in urban areas are more

likely to sell crime guns (Wintemute 2017; Braga *et al.* 2022), and that greater dealer density is associated with higher rates of community violence (Semenza *et al.* 2022).

Community characteristics

To capture community characteristics, we included the social vulnerability index (SVI) subscales (socioeconomic status, racial/ethnic minority status, household characteristics, and housing type/transportation) associated with the purchasers' census tract. SVI measures relative vulnerability, with higher scores indicating greater vulnerability. We also included the 2010 Rural-Urban Commuting Area (RUCA) code, dichotomized as most urban (1) versus all other classifications (0). Neighborhood disadvantage and urbanicity have been consistently linked to higher rates of gun violence (Polcari *et al.* 2023; Henry *et al.* 2024), though they have not shown strong or consistent associations with crime gun recovery (Wintemute *et al.* 2005; Robinson *et al.* 2024)

Dealer characteristics

Finally, we included dealer characteristics, all lagged by one year: average sales, denial percentage, percentage of pawn-related sales (redemptions and pawns), percentage of guns that became crime guns in the year they were sold, and percentage of sales to police. Dealer-level factors including higher denial rates, greater sales volume, and higher proportion of sales that resulted in crime gun recovery have consistently been associated with increased risk of diversion (Wintemute *et al.* 2005; Wintemute 2009; Koper 2014).

RESULTS

Legal and illegal possession among all recovered crime guns

Our dataset contained a total of 370,498 crime gun recovery records from 2010 through 2021, 70% of which were handguns (n = 258,715). A total of 31,122 firearms (22,773 handguns and 8,349 long guns) were recovered in a violent crime. We focus our analyses on handgun recoveries; details on possession status for long guns are presented in Appendix Table A3.

Over the study period, among all recovered handguns, 24% were identified to be legally possessed, 61% illegally possessed, and 15% had unknown possession status (Table 1). Among handguns with a determined possession status, 28% were legally possessed (n = 62,699) and 72% were illegally possessed (n = 157,749), with legal possession rates ranging from 23% to 31% depending on the year. Overall, firearms recovered in association with violent crimes had highest rates of unknown possession (22%) with slightly lower rates of unknown possession for property crimes (14%). The fraction of crime guns with legal, illegal, and unknown possession also varied substantially depending on the city of recovery (Appendix Table A1).

INSERT TABLE 1 HERE

Figure 1 displays the rates of legal, illegal, and unknown possession by crime type. The rates vary significantly depending on the crime category: legal possession was highest in violent crimes (34%) compared to property crimes (26%), drug crimes (23%) or weapons offenses (17%). Within violent crime (Panel B), legal possession was highest when the firearm was recovered in association with threats (56%) and sexual assault (51%), followed by homicides (37%) and assaults (37%), and lowest for robberies (20%). Rates of legal possession were

particularly low in stolen vehicle recoveries (17%), and higher for burglary (27%) and larceny (24%). The patterns were similar for long gun recoveries (Appendix Table A3).

INSERT FIGURE 1 HERE

Possession status and time-to-crime among handguns with a DROS

A total of 54,440 recovered handguns linked to a prior DROS record (2000 – 2021). Among these handguns, rates of legal possession were somewhat higher (31%) and rates of unknown possession status somewhat lower (11%) compared to the complete set of crime guns described in the section above. Appendix Tables A1 and A2 provides additional statistics on possession status by crime type and across large California cities

Table 2 presents median time-to-crime (years) among handguns linked to prior California DROS records (2009–2011 purchases with 10-year follow-up), stratified by possession status (legal, illegal, unknown), purchaser sex, and crime type (any crime, violent crime). Overall, illegally possessed handguns had a longer median time-to-crime (4.08 years) compared to legally possessed handguns (2.81 years). For violent crime recoveries, time-to-crime was shorter for both groups and the difference between illegal and legal possession was smaller (3.87 vs. 3.12 years, respectively). Notably, handguns recovered in violent crimes with unknown possession status had an even shorter median time-to-crime (2.02 years), particularly among female purchasers (1.46 years). Consistent with these results, the proportion of firearms recovered rapidly among all crime guns 2018-2021 was higher among legal possession recoveries (31% recovered within a year) than illegally possessed crime guns (21% recovered within a year), a pattern that persisted for violent crime recoveries (32% vs. 23%, respectively).

INSERT TABLE 2 HERE

Risk factors for crime gun recovery

Descriptive characteristics

Table 3 presents select descriptive statistics for handguns with a DROS record, comparing characteristics of handguns never recovered, those recovered in crime with a legal possessor and those recovered in crime with an illegal possessor. A report that the handgun was stolen was far more common among illegally possessed crime guns (27.6%) than among legally possessed crime guns (4.9%) and non-crime guns (0.7%). Crime guns were also more likely to be low-cost: 7% for illegally possessed crime guns and 6% for legally possessed crime guns, compared to 2% for handguns that were not recovered in crime.

INSERT TABLE 3 HERE

Purchaser characteristics also varied, with crime guns more likely to have been most recently bought by younger individuals, non-white purchasers, and those with prior criminal arrests. The median purchaser age was 35.8 years for both legally and illegally possessed crime guns, compared to 43.5 years for handguns never recovered in crime. Male purchasers accounted for the majority in all groups, though the percentage of female purchasers was higher among illegally possessed handguns (16.1%) than legally possessed crime guns (11.9%) and non-crime guns (10.9%). White purchasers were the majority across all groups, though Black and Hispanic purchasers accounted for a larger share of crime gun purchases: among illegally possessed crime

guns, 16.9% were originally purchased by Black individuals, 28.3% by Hispanic individuals, and 45.8% by White individuals, compared to 4.1% Black, 17.4% Hispanic, and 64.8% White for handguns never recovered in crime. Purchasers' prior criminal history differed substantially across groups. For example, for handguns that were never recovered, 4% of purchasers had a prior alcohol intoxication arrest comparted to 10% for illegally possessed crime guns and 12% for legally possessed crime guns.

A full table of descriptive statistics for all predictors included in the survival models is provided in Appendix Table A6.

Hazard Ratios

Table 4 and Table 5 present select results from the multivariable survival analyses examining any crime gun recovery and violent crime gun recovery, respectively. Tables 6 and 7 show select results from the sex-stratified analyses, examining any crime gun recovery and violent crime gun recovery, respectively. The full set of results with all variables included in each model, including non-significant associations and those not highlighted below, are shown in Appendix Tables A7, A8, A9, and A10.

INSERT TABLES 4 AND 5 HERE

Stolen and lost firearms

The survival analyses showed several significant differences in recovery hazard depending on whether the crime gun possessor was in legal or illegal possession of the gun. By far the largest risk factor for illegal possession recovery was a stolen report following a firearm transaction or transfer. Compared to firearms not reported stolen, those with a stolen report had a 22-fold higher hazard of recovery from an illegal possessor (95% CI: 20.72–22.58) (4) and 31-fold higher hazard for recovery in a violent crime involving an illegal possessor (CI: 26.00–36.02) (Table 5). In contrast, firearms reported stolen had a 2.7-fold higher risk of being recovery from a legal possessor (CI: 2.45–2.96) and 1.8-fold higher risk of violent crime recovery from a legal possessor (CI: 1.37–2.38). Firearms reported lost were also significantly associated with violent crime recovery from an illegal possessor (HR: 7.06, CI: 4.37–11.39), but there was no significant association violent crime recovery with a legal possessor (Table 5).

Female purchasers

The survival analyses revealed distinct patterns for female purchasers, suggestive of potential straw purchasing. Firearms purchased by females had a 45% higher hazard of being recovered in a crime from illegal possessors (CI: 1.39–1.51) but showed no significant increase in risk of recovery from a legal possessor (HR: 1.02, CI: 0.97–1.08) (Table 4). In the sex-stratified analyses (Table 6), handguns purchased by a female who had purchased 12 or more firearms in the past year had a 13-fold increase in risk of illegal possession recovery (CI: 9.23–18.30), but this was not significantly associated with recovery from a legal possessor. For violent crime recoveries (Table 7), a low-cost handgun purchased by a female was associated with a close to 3-fold higher hazard of illegal possession recovery (HR: 2.87, CI: 1.82–4.52). There was no significant association for male purchasers. Finally, the risk associated with purchasing from a dealer who had a higher fraction of short time-to-crime sales was greater for female purchasers compare to male purchasers and was significant for illegal possession recovery but not recovery from a legal possessor. For example, among female buyers, risk of recovery in a violent crime with an illegal possessor was an estimated 44% higher (CI: 1.15, 1.80) for every 1 percentage

point increase in a dealer's past year one-year crime gun sales; this association was not significant for recoveries involving legal possessors (Table 7).

INSERT TABLES 6 AND 7 HERE

Criminal history

A history of criminal arrests for the last known purchaser was consistently associated with firearm recovery, with larger associations observed for recoveries involving legal owners. Handguns purchased by an individual with a prior violent crime arrest had roughly twice the hazard of recovery from a legal possessor CI: 1.85–2.28) compared to a more modest 40% higher hazard of recovery from an illegal possessor (95% CI: 1.26–1.54) (Table 4). This pattern persisted for violent crime recovery, where prior violent arrest was associated with a 245% higher hazard of recovery from a legal possessor (CI: 1.91–3.14), compared to a 45% higher hazard of recovery from an illegal possessor (Table 5). Similar patterns were observed for other prior criminal arrests, though the differences were generally smaller.

Handgun and transaction characteristics

Several handgun and transaction characteristics were significant predictors of recovery, with larger associations for legal possession recovery than illegal possession recovery. Medium and large caliber handguns (compared to small) were associated with a roughly 40% higher risk of crime gun recovery from a legal possessor (medium: HR 1.4, CI: 1.30–1.51; large caliber: HR: 1.42, CI: 1.32–1.54) (Table 4), and smaller increases of 11% (CI: 1.05–1.18) and 19% (CI: 1.12–1.26) for illegal possession recovery.

For violent crime recoveries (Table 5), medium and large caliber handguns were linked to a 64% (CI: 1.34–2.01) and 96% (CI: 1.30, 1.97) higher hazard of recovery from a legal possessor, respectively. The associations for illegal possession recoveries were just above 25% (medium: HR: 1.27, CI: 1.01–1.59; large: HR: 1.26, CI: 1.00–1.60).

Low-cost handguns were also associated with increased recovery risk, with larger associations for legal possession recovery. Compared to other handguns, low-cost handguns were associated with a 54% higher hazard of recovery from an illegal possessor (CI: 1.43–1.64) and 80% higher hazard for legal possession recovery (CI: 1.66–1.95). This pattern persisted for violent crime recoveries, with low-cost handguns associated with a 55% higher risk of illegal possession recovery (CI: 1.22, 1.59) and 84% increased risk for legal possession recovery (CI: 1.51, 2.25).

Several transaction-related characteristics were associated with lower recovery risk. Private party transfers were associated with 17% lower hazard of recovery with a legal possessor (CI: 0.78-0.88) and a 28% lower hazard of violent crime recovery with a legal possessor (CI: 0.62-0.84), with no significant association for illegal possession recoveries. Previous pawn transactions were linked to reduced risk for both legal possession (HR: 0.60, CI: 0.50-0.71) and illegal possession (HR: 0.67, CI: 0.57-0.77) recoveries, but there was not significant relationship between pawn transactions and violent crime recovery.

Finally, a previous law enforcement hold was associated with lower risk of illegal possession recovery, with a 61% lower hazard for any crime recovery (HR: 0.39, CI: 0.36-0.44) and a 58% lower hazard for violent crime recovery (HR: 0.42, CI: 0.29-0.60). There was no significant association between law enforcement holds and legal possession recoveries. By contrast, a law enforcement *release* was associated with a higher risk of recovery from a legal

possessor for both any crime (HR: 1.36, CI: 1.17-1.60) and violent crime (HR: 1.65, CI: 1.12-2.44), but there was no significant association for illegal possession recoveries.

DISCUSSION

This study provides insight into rates of legal and illegal possession among perpetrators of gun-related crimes. Our findings indicate that a substantial proportion of crime-involved firearms were legally possessed at the time of recovery, including firearms used in violent crimes such as homicides and assaults. This challenges the common narrative that gun crimes are almost entirely committed with illegally obtained weapons and highlights the need for prevention strategies that address both illicit market diversion pathways as risks among legal purchasers.

Rates of legal possession documented in the California crime gun data are higher than prior estimates, most of which have been derived from ATF trace data, which typically stops at the first recorded purchase. As a result, firearms transferred legally after their initial sale are misclassified as illegally possessed. In our data, approximately 14% of handguns had a second recorded transfer after the first recorded purchase. Prior research that has incorporated subsequent legal transactions, done in Maryland in the late 1990s, reported higher rates of legal possession than estimates derived from ATF trace data, though these estimates were still slightly lower than our findings from California's more recent crime gun data (19%-28% among crime guns with a known possessor in Maryland, compared to 23%-31% in our dataset). Additionally, the rate of unknown possession was substantially higher in the Maryland (37% had unknown possessor compared to 15% in the California data) (Koper 2014).

Our estimates of legal possession are also notably higher than estimates reported in survey-based studies involving individuals incarcerated in jails or prisons. For example, self-reported data from incarcerated persons indicate that only 3%-7% purchased their firearms from a licensed dealer, depending on the survey (Cook 2018; Alper & Glaze 2019). The difference likely reflects the broader population of gun-involved individuals captured at the point of law enforcement recovery, whereas survey-based studies of incarcerated individuals captures a population with more extensive criminal histories and greater reliance on illicit channels. Our findings suggest that there are populations legally acquiring firearms for criminal use.

We found substantial variation in rates of legal possession depending on the crime associated with the recovery. For example, 33% of handguns recovered in violent crimes were legally possessed (44% illegally possessed and 22% unknown). Even assuming all recovered guns with unknown possession status had been used by someone who was not in legal possession, this still suggests a substantial fraction of guns being used in assaults and homicides that were in the hands of the legal owner. Over half of guns recovered in association with sexual violence and threats were legally possessed. Overall, we see lower rates of legal possession for property crimes (25%). This likely reflects, in part, arrests for crimes such as burglary or auto theft that included the theft of the gun in the act. For example, only 17% of handguns recovered in association with auto theft were marked as legally possessed (65% were illegally possessed and 19% had unknown possession status).

These relatively high rates of legal possession, especially in association with threats, sexual violence, homicides and assaults, suggest that legally owned firearms contribute substantially to gun violence. This finding is especially notable given California's stringent

firearm laws governing who is eligible to purchase and possess a firearm and how firearms may be legal transferred (in addition to restrictions on firearm types, storage and public carry). These include disqualifications from purchase for 10 years following a misdemeanor violence conviction and requirements that all transfers, including those between private parties and gun show transactions, be conducted through a licensed dealer and subject to a background check (Castillo-Carniglia *et al.* 2019). Similar analyses conducted in states with more permissive gun laws where private sales are allowed without background checks and there are fewer disqualifications for firearm possession would likely reveal even higher rates of legally possessed crime guns.

Our finding that legally possessed crime guns had shorter median time-to-crime compared to illegally possessed ones may initially seem counterintuitive, as shorter time-to-crime typically serves as an indicator of trafficking or illicit diversion. We do, however, find that violent crime guns with *unknown* possession status (22% of recoveries) had a substantially shorter time-to-crime (2.02 years) than those recovered with an illegal possessor (3.9 years) or legal possessor (3.1 years), and even shorter median time-to-crime when possession status was unknown, and the purchaser was female (1.46 years). The relatively short time-to-crime for handguns recovered in violent crime with an unknown possessor may reflect cases in which the gun was rapidly diverted to an unauthorized possessor but recovered without someone present (e.g., abandoned at a crime scene). It is also possible that some cases involve firearms that are difficult to trace, such PMFs or defaced weapons, though such guns would typically be considered illegally possessed under California law.

The relatively longer time-to-crime for illegally possessed crime guns compared to legally possessed crime guns could reflect that fact that diversion from legal commerce through mechanisms like theft or trafficking networks adds time to a firearms trajectory. In contrast, when legal purchasers use their own firearms in crimes, the pathway is more direct. This may also suggest instances where firearms were acquired legally with criminal intent. The differences could also reflect biases in using crime gun recovery data, which is not representative of all guns used in crime. Some guns may be used in crime very soon after purchase and then rapidly discarded such that they are no longer at risk of recovery by law enforcement.

Our survival analysis highlighted the distinct pathways and risk factors for legally and illegally possessed crime guns. Firearms reported stolen showed dramatically higher risk of recovery from illegal possessors, suggesting theft is an important diversion pathway and strengthening theft prevention policies—such as secure storage requirements and mandatory theft reporting—could help reduce firearm diversion (Vernick *et al.* 2006; Webster *et al.* 2009; Crifasi 2018). It is important to note that some fraction of the risk associated with a stolen report could reflect straw purchasing rather than actual theft. A straw purchaser buying on behalf of someone else may falsely report a firearm stolen to disassociate their name with the weapon before it is used in crime. A randomized experiment in Los Angeles mailed letters to a random subset of new gun buyers with a public safety message notifying them of their criminal liability if the gun was later involved in a crime, and found that letter recipients were significantly more likely to report their guns stolen, though it was not clear whether this reflected true theft or a desire to disassociate with the weapon (Ridgeway *et al.* 2011). While false reporting is a possibility, it likely does not account for most of the association between stolen reports and

illegal possession recovery. This is supported by our sex stratified analyses: a stolen report was associated with a 35-fold increase in risk of recovery in a violent crime with an illegal possessor when the purchaser was male and a 14-fold increase when the purchaser was female. Given women are estimated to account for approximately 80% of straw purchases (Moselle 2021), we would expect to see a stronger association among female purchasers if false reporting were the primary driver of our finding.

The distinct patterns observed for female purchasers, particularly the substantially elevated risk of recovery with an illegal possessor associated with many purchases within the prior year, provides evidence of potential straw purchasing. Though California has some of the nation's most stringent firearm regulations, it is not one of the twelve states with a "permit-to-purchase" law (Violence 2025). Such laws require prospective buyers to apply for a permit in person before purchasing a firearm and to undergo an enhanced background check and fingerprinting. Research suggests that permit-to-purchase laws are associated with reductions in diversion of guns for use in crime and that the application process itself may deter potential straw purchasers (Crifasi *et al.* 2017; Crifasi *et al.* 2019; Crifasi *et al.* 2023).

The point of purchase represents an opportunity for intervention, not only to deter straw purchasing and trafficking but also to potentially identify and discourage high-risk legal purchasers. Purchasers with prior arrests showed higher risk of having their legally purchased firearms recovered in crimes compared to those with no prior arrests, with a larger magnitude of risk associated with legal possession recoveries than for illegal possession recoveries. These findings align with prior longitudinal studies of legal handgun purchasers in California, which found a 2-to 4-fold elevated risk of subsequent violent crime among those with prior convictions (Laqueur *et al.* 2019; Kagawa *et al.* 2020; Shev *et al.* 2023). This, along with the shorter time-to-crime for legal possession recoveries and the greater risk associated with recovery of low-cost and larger caliber firearms among legal possessors (compared to illegal possessors), suggests that some handguns may be purchased with criminal intent. Together, these findings highlight opportunities for enhanced screening at the point of sale or potential refinements to eligibility criteria for legal firearm purchaser.

Limitations

This study has several limitations that should be considered when interpreting the findings. Our analysis relies on crime guns recovered by law enforcement, which represent only a subset of firearms used in crime. Crime reporting patterns and law enforcement practices likely influence which incidents result in firearm recovery, potentially affecting estimates of legal and illegal possession across different crime types.

Possession status was recorded by law enforcement, and misclassification is possible. We are not able to independently verify possession status, as identifiers for the crime gun possessor were unavailable. In the survival analysis, while crime guns classified as legally possessed were likely in the hands of their last recorded purchaser, we cannot confirm this.

Additionally, we observed substantial variation in rates of legal, illegal, and unknown possession across jurisdictions (Appendix Table A1), which warrants further investigation. These differences may reflect local enforcement practices, regional gun ownership cultures, and/or differences in how law enforcement agencies determine possession status.

This study is restricted to firearms recovered in California. Firearms purchased in-state and used in crime across state lines would not appear in our data, though research suggests that crime guns are more often trafficked into California from states with more permissive gun laws than from California to other states (Knight 2013). More importantly, as a California-specific study, findings may not generalize to states with different regulatory environments. States with less stringent firearm laws may, for example, have higher rates of legally possessed crime guns due to fewer prohibitions on firearm purchases and less oversight of private or gun show sales.

The analysis of risk factors is also limited to crime guns that had at least one recorded legal transaction in California. Although California's DROS database offers a more complete record of in-state firearm transfers than is provided by standard ATF trace data, it does not include out-of-state transactions. According to ATF summary reports, during our study period, roughly one-third of firearms recovered in California had been originally purchased in another state (when a source state was identified) (Laqueur *et al.* 2023). Further, we were able to link less than a quarter of recovered handguns to a prior DROS record. Beyond out-of-state purchases, this also likely reflects purchases made in California before DROS coverage, recovered PMFs that were not registered and assigned a serial number, and incomplete data entry.

Finally, some covariates in the survival analysis, such as prior reports of firearm theft, were relatively infrequent, and low event counts may produce unstable or inflated hazard ratio estimates.

Conclusions

Supply-side intervention strategies focused on reducing gun access to high-risk individuals are an important component of gun violence prevention efforts (Cook *et al.* 2015), however, these strategies require understanding how gun offenders obtain their weapons and data have historically been limited and fragmented. This study leverages comprehensive crime gun recovery and firearm transaction data to provide new insights into firearm recovery patterns. We find a considerable proportion of crime guns were legally possessed, particularly those used in certain violent crimes. This highlights the need for targeted prevention strategies that reduce the risk associated with legal firearm access among high-risk individuals, as well as efforts to prevent diversion into the illicit market. For example, policies such as requiring a permit-to-purchase could help to disrupt straw purchasing as well as to potentially deter legal purchasers acquiring firearms with criminal intent. Policies aimed at expanding eligibility restrictions based on criminal history could also help reduce access and criminal use among legal owners. Finally, efforts to strengthen firearm theft prevention could help reduce the diversion of legally acquired guns into illicit markets. Future research is needed to examine these patterns in states with different regulatory environments and to evaluate the impact of specific policies on both legal and illegal crime gun possession to further inform evidence-based prevention strategies.

Tables and Figures

Table 1. Possession Status among recovered handguns in California (2010-2021)

	Illegally possessed handguns recovered in crimes	Legally possessed handguns recovered in crimes	Possession status unknown
	n (%)	n (%)	n (%)
Overall	157,749 (61.0)	62,699 (24.2)	38,167 (14.8)
Year			
2010	9905 (59.0)	4229 (25.2)	2656 (15.8)
2011	10,260 (55.4)	4673 (25.2)	3604 (19.4)
2012	11,440 (56.9)	5037 (25.1)	3624 (18.0)
2013	12,133 (61.4)	4724 (23.9)	2906 (14.7)
2014	12,648 (60.7)	5362 (25.8)	2816 (13.5)
2015	13,194 (60.6)	5090 (23.4)	3503 (16.1)
2016	14,738 (63.5)	5233 (22.5)	3256 (14.0)
2017	15,795 (63.2)	6137 (24.6)	3063 (12.3)
2018	15,517 (61.3)	6540 (25.8)	3277 (12.9)
2019	16,049 (61.7)	6675 (25.7)	3300 (12.7)
2020	18,216 (62.2)	6615 (22.6)	4455 (15.2)
2021 (partial year)	7854 (65.8)	2384 (20.0)	1707 (14.3)

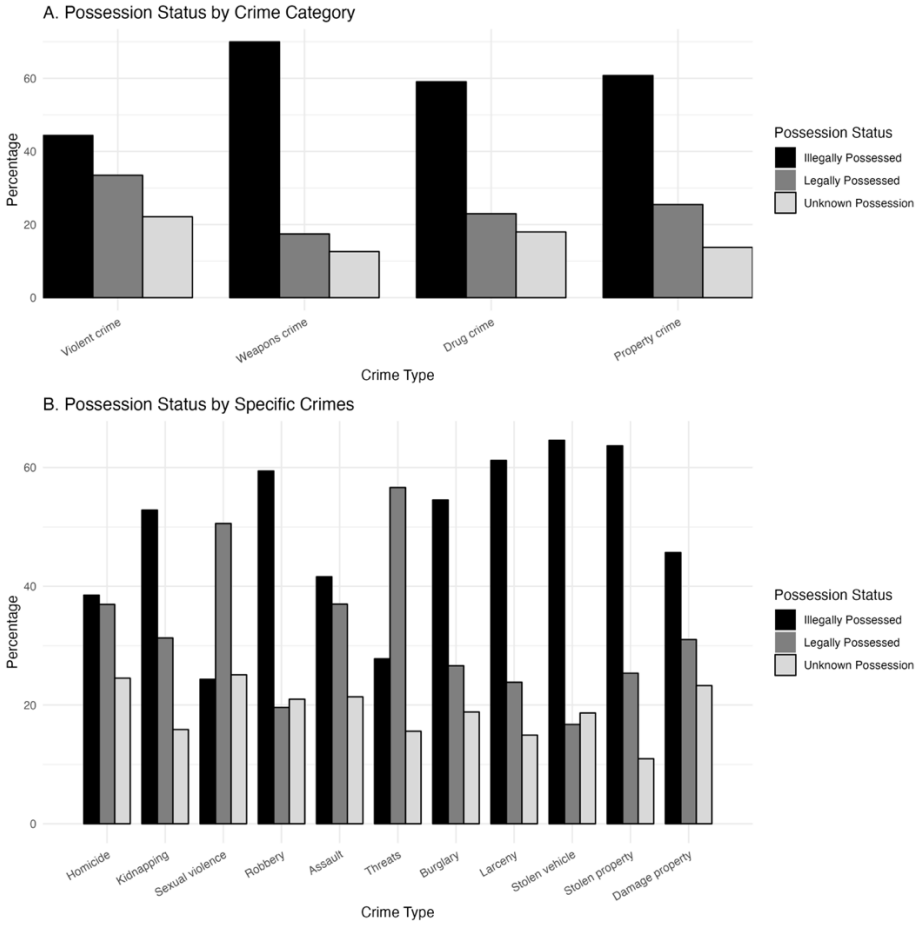


Figure 1. Possession Status by Handgun Recovery Crime Type

Table 2. Time to crime among guns purchased in 2009, 2010, and 2011 with 10 years follow-up

	Illegally possessed		Legally possessed		Possession unknown	
Median time to crime	**n**	**Median (Q1, Q3)**	**n**	**Median (Q1, Q3)**	**n**	**Median (Q1, Q3)**
All crimes	3,872	4.08 (1.95, 6.41)	2,077	2.81 (0.97, 5.69)	791	2.96 (1.09, 5.72)
Male purchasers, all crimes	3,343	4.16 (2.02, 6.47)	1,881	2.84 (0.99, 5.69)	692	3.06 (1.10, 5.72)
Female purchasers, all crimes	529	3.35 (1.46, 5.98)	196	2.25 (0.72, 5.68)	99	2.33 (1.00, 5.58)
Violent crime	250	3.87 (1.72, 6.16)	311	3.12 (1.20, 5.57)	122	2.02 (0.54, 4.41)
Male purchasers, violent crime	216	3.91 (1.73, 6.19)	273	3.13 (1.22, 5.60)	103	2.20 (0.68, 4.50)
Female purchasers, violent crime	34	3.67 (1.69, 5.26)	38	2.86 (0.81, 5.22)	19	1.47 (0.24, 3.14)

Table 3. Select characteristics of recovered handguns, stratified by illegal and legal possession

	Not a crime gun		Illegally possessed crime guns		Legally possessed crime guns	
	n (%)	**Mean (SD)**	**n (%)**	**Mean (SD)**	**n (%)**	**Mean (SD)**
Characteristics of the firearm						
Low-cost manufacturers	100,166 (2.1)		1,377 (6.5)		774 (5.9)	
Caliber size						
Small	499,685 (10.6)		1,737 (8.3)		911 (7.0)	
Medium	2,426,468		10,305		6,780	
Large	1,800,019		8,983 (42.7)		5,389	
Firearm History						
Stolen report	31,853 (0.7)		5,807 (27.6)		646 (4.9)	
Any previous lost	4,958 (0.1)		242 (1.2)		58 (0.4)	
Demographic characteristics of						
Age, per 10 years		43.5 (13.8)		35.8 (12.6)		35.8 (12.6)
Female sex	513,682 (10.9)		3,388 (16.1)		1,558	
Race and ethnicity						
Asian	524,139 (11.1)		1,576 (7.5)		910 (7.0)	
Black	192,399 (4.1)		3,550 (16.9)		1,975	
Hispanic	823,775 (17.4)		5,944 (28.3)		3,768	
White	3,065,919		9,237 (43.9)		5,990	
Prior criminal arrests						
Alcohol intoxication, past 10	196,547 (4.2)		2,161 (10.3)		1,537	
Firearm-related, past 10 years	27,938 (0.6)		636 (3.0)		348 (2.7)	
Major violent crime, past 10 years	36,726 (0.8)		764 (3.6)		518 (4.0)	
Major property crime, past 10	19,685 (0.4)		604 (2.9)		323 (2.5)	

Table 4. Multivariable adjusted characteristics associated with crime gun recovery, stratified by illegal and legal possession[1]

	Illegally possessed handguns recovered in crimes		Legally possessed handguns recovered in crimes	
Characteristic	**Hazard Ratio (95% CI[2])**	**P-value**	**Hazard Ratio (95% CI)**	**P-value**
Characteristics of the firearm				
Low-cost manufacturers	1.54 (1.43, 1.64)***	<0.0001	1.80 (1.66, 1.95)***	<0.0001
Semiautomatic	1.25 (1.19, 1.30)***	<0.0001	1.05 (0.99, 1.10)	0.09
Caliber size				
Small	Reference		Reference	
Medium	1.11 (1.05, 1.18)***	0.0002	1.40 (1.30, 1.51)***	<0.0001
Large	1.19 (1.12, 1.26)***	<0.0001	1.42 (1.32, 1.54)***	<0.0001
Any previous law enforcement holds	0.39 (0.36, 0.44)***	<0.0001	0.99 (0.88, 1.11)	0.82
Any previous lost	4.47 (3.71, 5.39)***	<0.0001	1.85 (1.40, 2.46)***	<0.0001
Any previous pawn	0.67 (0.57, 0.77)***	<0.0001	0.60 (0.50, 0.71)***	<0.0001
Any previous stolen	21.63 (20.72, 22.58)***	<0.0001	2.69 (2.45, 2.96)***	<0.0001
Last transaction was a private party transfer	0.96 (0.92, 1.00)	0.08	0.83 (0.78, 0.88)***	<0.0001
Characteristics of the purchaser				
Age, per 10 years	0.76 (0.75, 0.78)***	<0.0001	0.73 (0.72, 0.74)***	<0.0001
Female sex	1.45 (1.39, 1.51)***	<0.0001	1.02 (0.96, 1.08)	0.50
Race/ethnicity				
Asian	0.97 (0.91, 1.03)	0.32	0.75 (0.70, 0.81)***	<0.0001
Black	2.73 (2.60, 2.86)***	<0.0001	2.98 (2.82, 3.15)***	<0.0001
Hispanic	1.44 (1.39, 1.50)***	<0.0001	1.29 (1.23, 1.35)***	<0.0001
Native American/Pacific Islander	1.53 (1.38, 1.69)***	<0.0001	1.30 (1.14, 1.47)***	0.0001
Other	1.37 (1.21, 1.55)***	<0.0001	1.45 (1.25, 1.67)***	<0.0001
White	Reference		Reference	
Handguns bought in the last year				
0	Reference		Reference	
1	1.01 (0.96, 1.07)	0.66	0.87 (0.81, 0.94)***	0.0001
2-5	0.78 (0.73, 0.83)***	<0.0001	0.69 (0.63, 0.76)***	<0.0001
6-12	0.64 (0.56, 0.75)***	<0.0001	0.55 (0.45, 0.67)***	<0.0001
>12	1.39 (1.19, 1.63)***	<0.0001	1.70 (1.42, 2.04)***	<0.0001
Criminal history, arrests				
Alcohol intoxication, past 10 years	1.53 (1.46, 1.61)***	<0.0001	1.90 (1.80, 2.01)***	<0.0001
Firearm-related, past 10 years	1.46 (1.30, 1.63)***	<0.0001	1.62 (1.43, 1.84)***	<0.0001
Major violent crime, past 10 years	1.39 (1.26, 1.54)***	<0.0001	2.05 (1.85, 2.28)***	<0.0001
Major property crime, past 10 years	1.82 (1.64, 2.02)***	<0.0001	1.98 (1.75, 2.24)***	<0.0001

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

[1]Tables 4 shows select significant variables from the full models. Complete models with all variables included in the final multivariate Cox models are available in Appendix Table A7.

Table 5. Multivariable adjusted characteristics associated with violent crime gun recovery, stratified by illegal and legal possession[1]

	Illegally possessed handguns recovered in violent crime		Legally possessed handguns recovered in violent crime	
Characteristic	**Hazard Ratio (95% CI[2])**	**P-value**	**Hazard Ratio (95% CI)**	**P-value**
Characteristics of the firearm				
Low-cost manufacturers	1.55 (1.22, 1.97) ***	0.0004	1.84 (1.51, 2.25***)	<0.0001
Semiautomatic	1.15 (0.97, 1.37)	0.11	1.35 (1.16, 1.57) ***	<0.0001
Caliber size				
Small	Reference		Reference	
Medium	1.27 (1.01, 1.59) *	0.04	1.64 (1.34, 2.01) ***	<0.0001
Large	1.26 (1.00, 1.60) *	0.05	1.60 (1.30, 1.97) ***	<0.0001
Any previous law enforcement holds	0.42 (0.29, 0.60) ***	<0.0001	0.84 (0.62, 1.14) ***	0.25
Any previous lost	7.06 (4.37, 11.39) ***	<0.0001	1.90 (0.94, 3.85)	0.07
Any previous stolen	30.61 (26.00, 36.02) ***	<0.0001	1.81 (1.37, 2.38) ***	<0.0001
Last transaction was a private party transfer	0.99 (0.84, 1.17)	0.89	0.72 (0.62, 0.84) ***	<0.0001
Characteristics of the purchaser				
Age, per 10 years	0.77 (0.73, 0.81) ***	<0.0001	0.76 (0.73, 0.80) ***	<0.0001
Female sex	1.41 (1.21, 1.65) ***	<0.0001	1.15 (1.01, 1.32) *	0.04
Race/ethnicity				
Asian	1.15 (0.92, 1.44)	0.21	0.92 (0.76, 1.12)	0.40
Black	2.78 (2.31, 3.35) ***	<0.0001	3.76 (3.27, 4.33) ***	<0.0001
Hispanic	1.31 (1.11, 1.53) **	0.001	1.55 (1.38, 1.76) ***	<0.0001
Native American/Pacific Islander	1.89 (1.32, 2.71) ***	0.0006	1.34 (0.95, 1.89)	0.10
Other	1.32 (0.80, 2.17)	0.28	1.83 (1.29, 2.59) ***	0.0007
White	Reference		Reference	
Handguns bought in the last year				
0	Reference		Reference	
1	1.15 (0.93, 1.42)	0.20	0.77 (0.64, 0.93) **	0.007
2-5	0.89 (0.68, 1.16)	0.37	0.86 (0.69, 1.06)	0.15
6-12	0.76 (0.43, 1.37)	0.36	0.19 (0.08, 0.46) ***	0.0002
>12	0.30 (0.07, 1.19)	0.09	0.19 (0.05, 0.77) *	0.02
Criminal history, arrests				
Alcohol intoxication, past 10 years	1.41 (1.17, 1.72)	0.0004***	1.70 (1.46, 1.97) ***	<0.0001
Firearm-related, past 10 years	1.47 (1.01, 2.15)	0.04*	1.34 (0.96, 1.87)	0.09
Major violent crime, past 10 years	1.45 (1.04, 2.02)	0.03*	2.45 (1.91, 3.14) ***	<0.0001
Major property crime, past 10 years	1.69 (1.17, 2.43)	0.005**	2.46 (1.86, 3.27) ***	<0.0001

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

[1]Tables 5 shows select significant variables from the full models. Complete models with all variables included in the final multivariate Cox models are available in Appendix Table A8.

Table 6. Select multivariable adjusted characteristics associated with any crime gun recovery, stratified by possession and sex[1]

	Males			
	Illegally possessed handguns recovered in crimes		**Legally possessed handguns recovered in crimes**	
	Hazard Ratio (95% CI[2])	**P-value**	**Hazard Ratio (95% CI)**	**P-value**
Dealer Characteristics				
Average % sales in calendar year that became crime guns that year	1.20 (1.14, 1.27) ***	<0.0001	1.20 (1.14, 1.27) ***	<0.0001
Characteristics of the firearm				
Low-cost manufacturers	1.50 (1.39, 1.62) ***	<0.0001	1.75 (1.61, 1.91) ***	<0.0001
Caliber size				
Small	Reference		Reference	
Medium	1.09 (1.03, 1.16) **	0.004	1.41 (1.30, 1.53) ***	<0.0001
Large	1.13 (1.06, 1.20) ***	0.0002	1.41 (1.29, 1.53) ***	<0.0001
Any previous lost	4.26 (3.40, 5.33) ***	<0.0001	1.86 (1.37, 2.54) ***	<0.0001
Any previous stolen	23.84 (22.76, 24.98) ***	<0.0001	2.70 (2.43, 2.99) ***	<0.0001
Purchaser characteristics				
Handguns bought in the last year				
0	Reference		Reference	
>12	1.10 (0.91, 1.31)	0.33	1.76 (1.46, 2.12) ***	<0.0001
Criminal history, arrests				
Major violent crime	1.38 (1.24, 1.54) ***	<0.0001	2.01 (1.80, 2.25) ***	<0.0001
	Females			
	Illegally possessed handguns recovered in crimes		**Legally possessed handguns recovered in crimes**	
	Hazard Ratio (95% CI)	**P-value**	**Hazard Ratio (95% CI)**	**P-value**
Dealer Characteristics				
Average % of sales in calendar year that become crime guns that year	1.43 (1.30, 1.56) ***	<0.0001	1.35 (1.16, 1.58) ***	0.0001
Characteristics of the firearm				
Low-cost manufacturers	1.77 (1.52, 2.05) ***	<0.0001	2.10 (1.71, 2.57) ***	<0.0001
Caliber size				
Small	Reference		Reference	
Medium	1.21 (1.07, 1.38) **	0.003	1.37 (1.13, 1.65) **	0.001
Large	1.60 (1.39, 1.83) ***	<0.0001	1.54 (1.25, 1.88) ***	<0.0001
Any previous lost	4.74 (3.43, 6.56) ***	<0.0001	1.79 (0.89, 3.63)	0.10
Any previous stolen	13.06 (11.71, 14.57) ***	<0.0001	2.65 (2.08, 3.38) ***	<0.0001
Purchaser characteristics				
Handguns bought in the last year				
0	Reference		Reference	
>12	13.00 (9.23, 18.30) ***	<0.0001	0.79 (0.11, 5.67)	0.82
Criminal history, arrests				
Major violent crime	1.46 (1.08, 1.96) *	0.01	2.65 (1.86, 3.78)	6.16

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

[1]Tables 6 shows select significant variables from the full models. Complete models with all variables included in the final multivariate Cox models are available in Appendix Table A9.

Table 7. Select multivariable adjusted characteristics associated with violent crime gun recovery, stratified by possession and sex[1,2]

	Males			
	Illegally possessed handguns recovered in violent crime		**Legally possessed handguns recovered in violent crime**	
Characteristic	**Hazard Ratio (95% CI[2])**	**P-value**	**Hazard Ratio (95% CI)**	**P-value**
Dealer Characteristics				
Average % sales in calendar year that became crime guns that year	1.19 (1.11, 1.28) ***	<0.0001	1.19 (1.12, 1.26) ***	<0.0001
Characteristics of the firearm				
Low-cost manufacturers	1.26 (0.95, 1.69)	0.11	1.84 (1.48, 2.29) ***	<0.0001
Caliber size				
Small	Reference		Reference	
Medium	1.23 (0.96, 1.60)	0.11	1.63 (1.31, 2.03) ***	<0.0001
Large	1.18 (0.91, 1.53)	0.22	1.58 (1.26, 1.98) ***	<0.0001
Any previous lost	6.80 (3.94, 11.73) ***	<0.0001	2.13 (1.00, 4.54) *	0.05
Any previous stolen	35.80 (30.04, 42.66) ***	<0.0001	1.97 (1.46, 2.65) ***	<0.0001
Criminal history, arrests				
Major violent crime	1.40 (0.97, 2.03)	0.07	2.36 (1.81, 3.07) ***	<0.0001
	Females			
	Illegally possessed handguns recovered in violent crime		**Legally possessed handguns recovered in violent crime**	
Characteristic	**Hazard Ratio (95% CI)**	**P-value**	**Hazard Ratio (95% CI)**	**P-value**
Dealer Characteristics				
Average % sales in calendar year that became crime guns that year	1.44 (1.15, 1.80) **	0.001	0.81 (0.45, 1.43)	0.46
Characteristics of the firearm				
Low-cost manufacturers	2.87 (1.82, 4.52) ***	<0.0001	1.86 (1.14, 3.03) *	0.01
Caliber size				
Small	Reference		Reference	
Medium	1.43 (0.86, 2.37)	0.17	1.76 (1.08, 2.85) *	0.02
Large	1.85 (1.07, 3.20) *	0.03	1.77 (1.04, 3.00) *	0.04
Any previous lost	6.99 (2.53, 19.30) ***	0.0002	1.00 (0.14, 7.42)	1.00
Any previous stolen	14.04 (9.38, 21.02) ***	<0.0001	1.12 (0.53, 2.37)	0.78
Criminal history, arrests				
Major violent crime	2.26 (0.97, 5.23)	0.06	3.41 (1.65, 7.04) ***	0.0009

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

[1]Tables 7 shows select significant variables from the full models. Complete models with all variables included in the final multivariate Cox models are available in Appendix Table A10.

[2]The sample size was insufficient to include the number of prior purchases in the past year.

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