

Firearm ownership in California: A latent class analysis

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Received 29 July 2019

Revised 8 September 2019

Accepted 11 September 2019

Published Online First

10 October 2019

ABSTRACT

Objective To examine whether firearm ownership and ownership-related motivations and practices can be classified into reasonably distinct types.

Methods Cross-sectional data on firearm owners (n=429) were obtained from the 2018 California Safety and Well-Being Survey, a state-representative web-based survey. We conducted a latent class analysis using six self-reported indicators of firearm ownership: (1) number of firearms owned, (2) types of firearms owned, (3) primary reason for firearm ownership, (4) firearm storage, (5) loaded handgun carrying and (6) high-capacity magazine ownership.

Results We identified five markedly different classes of firearm ownership. There were two classes of single-firearm owners and three classes of multiple-firearm owners. Only members of one class (9% of owners) were likely to have carried a loaded handgun and to own high-capacity magazines or assault-type weapons. Members of this class were also likely to own 5+ firearms, own for protection against people, and store a firearm in the least secure manner (loaded and unlocked).

Conclusion There were distinct classes of firearm ownership in California, and all higher-risk behaviours studied were exhibited disproportionately by members of a single class. This latent class structure, which may help identify higher-risk groups of firearm owners, could inform future research on risk assessment and on focused interventions to reduce firearm injury and death.

INTRODUCTION

In 2017, almost 40 000 people died from firearm-related injuries in the USA; 37% of these deaths were homicides and 60% were suicides.¹ There are many more nonfatal injuries each year, resulting in physical disability, emotional trauma and significant financial burden.² The epidemiology of firearm injury varies substantially by intent and across geographical areas.³

Relatively little empirical work⁴⁻⁶ has focused on understanding patterns of firearm ownership. Most research has measured ownership with proxies,^{7,8} in broad terms^{9,10} or by variation in a single firearm-related behaviour (eg, firearm storage),¹¹ often making comparisons across various sociodemographic characteristics.⁹⁻¹¹ This approach may mask differences in ownership characteristics and practices, limiting our ability to fully understand firearm ownership and to design and implement appropriate violence prevention strategies.

Evidence from the 2015 National Firearms Survey, which provides the most comprehensive

and up-to-date data on firearm ownership in the USA, indicated that ownership is heterogeneous.⁴ Among the estimated 55 million firearm owners, there was notable variation in the number of firearms owned (ranging from 1 to 140), types of firearms owned (including rifles, shotguns, pistols and revolvers), reasons for ownership, storage practices and loaded handgun carrying.^{4,12,13} Ownership has also become more concentrated.⁴ In 1994, approximately 25% of Americans collectively owned 192 million firearms; in 2015, 22% of Americans owned 265 million firearms. Half of the country's firearm stock in 2015 was owned by 14% of owners, most of whom owned 10 or more firearms.⁴

These findings suggest that there are distinct typologies of ownership. If so, one-size-fits-all firearm violence prevention strategies may be less effective than approaches that consider this heterogeneity. For example, firearm owners have different reasons for ownership (eg, recreation vs desire for self-protection), and these varying motives may influence firearm type, use and related risk behaviours (eg, unsafe storage practices). Firearm violence prevention efforts may gain greater traction if messages and interventions are targeted according to patterns of ownership.^{14,15}

In this study, we conducted a latent class analysis (LCA) of firearm ownership and ownership-related motivations and practices (hereafter 'ownership') to empirically describe subgroups of firearm owners that have previously been described only conceptually and have not been comprehensively explored. Our findings will contribute to a more nuanced understanding of firearm ownership and can inform research on tailored interventions to prevent firearm violence.

In addition to using a novel approach to analyse patterns of firearm ownership, we focus on a single state—California—since the state level is where much difference resides,³ and it is the level at which significant firearm-related policies are often made.¹⁶

METHODS

Data

We used data from the 2018 California Safety and Well-Being Survey (CSaWS), a state-representative, web-based survey designed by our research group and administered between 14 September 2018 and 12 October 2018 by Ipsos (formerly the GfK Group).

CSaWS collected detailed information on firearm ownership and use, as well as exposure to violence and its consequences. The sample comprised members from the Ipsos KnowledgePanel, a



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To cite: Schleimer JP, Kravitz-Wirtz N, Pallin R, *et al.* *Inj Prev* 2020;**26**:456–462.

probability-based online panel that includes approximately 55 000 adult members, including roughly 6700 California residents. Members residing in California who were 18 years or older were eligible to participate. Of the 5232 eligible members who received an invitation to participate, 49% completed the survey (n=2558), a response rate comparable to that of the 2015 National Firearms Survey.⁴ CSaWS non-responders were more likely than responders to be young, female and Hispanic, and to have lower income, fewer years of education and children at home (see online supplementary table S7). The state-representative sample was generated with a respondent-specific weight, created from presample and study-specific poststratification weights. Additional information about how the sample was constructed and weighted is available in the online supplementary material.

This study was restricted to personal firearm owners (n=429), 14.4% of the total CSaWS sample, based on affirmative responses to two items: 'Do you or does anyone else you live with currently own any type of gun?' and 'Do you personally own a gun?'

CSaWS received institutional review board approval from the University of California, Davis, and respondents received a standard consent page online before starting the survey.

Measures

We included six variables that describe features of firearm ownership (table 1). Variables were selected for their conceptual importance and ability to characterise firearm ownership as a latent construct. For each variable, missingness due to non-response was less than 2.3%. Specific survey questions are reported in the online supplementary material.

Number of firearms owned

Firearm owners were first asked if they own one gun or more than one gun. Those who reported owning more than one were asked how many handguns and long guns they owned, respectively. We created three categories from the sum of reported handguns and long guns: 1, 2–4 and 5+.

Types of firearms owned

Respondents were asked 'Which of the following types of guns do you own?' and indicated 'handguns', 'long guns such as rifles or shotguns' or both. Later, those who reported owning at least one rifle or who reported owning a long gun but refused to report the specific type were asked whether they owned any rifles or long guns 'of the type sometimes called "assault rifles," "modern sporting rifles" or "modern tactical rifles." Examples include AR rifles, AK rifles and SKS rifles'. We created four mutually exclusive and exhaustive categories, first classified by assault-type weapon ownership and then by ownership of other types: (1) assault-type weapons and other guns (includes handguns and non-assault-type long guns), (2) handguns and long guns other than assault-type weapons, (3) handguns only and (4) long guns other than assault-type weapons only. Other possible categories did not apply to any respondent in our sample. We created these categories to optimise conceptual distinctions,¹⁷ policy relevance,¹⁸ and the size of each group (see online supplementary table S8).

Primary reason for firearm ownership

Respondents were asked to report the single most important reason for ownership for each type of firearm owned. Response options included 'for protection against people', 'for protection against animals', 'for hunting', 'for sporting use (other than hunting)', 'for a collection' and 'for some other reason'. We created two groups—those

Table 1 Characteristics of firearm owners, 2018 California Safety and Well-Being Survey

	Unweighted (n)	Weighted (%)
Total	429	100
Age (years)		
18–29	7	6.5
30–44	45	17.5
45–59	99	33.2
60+	278	42.9
Race/ethnicity		
NH white	318	64.1
NH black	16	4.4
Hispanic	71	20.4
NH other or 2+ races	24	11.1
Gender		
Male	301	72.9
Female	128	27.1
Number of firearms owned		
1	165	37.5
2–4	143	33.9
5+	113	27.3
Type(s) of firearm(s) owned*		
Assault-type weapon(s) and other firearms†	36	9.6
Handgun(s) and long gun(s) other than assault-type weapons	175	40.7
Handgun(s) only	133	30.6
Long gun(s) other than assault-type weapons only	81	18.5
Reason for firearm ownership		
Any owned primarily for protection against people	217	48.7
None owned primarily for protection against people	203	50.1
Firearm storage		
Least secure‡	78	17.8
Moderately secure§	175	36.8
Most secure¶	132	34.8
Any stored at work/someplace else	32	8.4
Loaded handgun carrying (past 30 days)		
Yes, primarily for protection against people	26	8.5
Yes, not primarily for protection against people	21	8.5
No	376	82.4
Own high-capacity (>10) magazine		
Yes	49	12.7
No	370	85.4

Columns may not sum to total because of missing values.

*Categories are mutually exclusive and exhaustive. Other possible categories did not apply.

†Includes individuals who owned assault-type weapons and handguns only, and those who owned assault-type weapons, handguns and long guns other than assault-type weapons.

‡Any firearm loaded and not locked up in/around the home, no firearms stored at work or someplace else.

§No firearms loaded and not locked up, but at least one firearm loaded and locked or unloaded and unlocked in/around the home; no firearms stored at work or someplace else.

¶All firearms locked and unloaded in/around the home, no firearms stored at work or someplace else.

NH, non-Hispanic.

who owned any firearm primarily for protection against people and those who did not—as owning primarily for protection against people carries distinct implications for firearm-related risk.^{6 19}

Firearm storage

Individuals were asked to specify, by type and number, how they usually store their firearms: 'unloaded and locked up (with a trigger lock, cable lock, in a lock box or safe or in some other

way); 'unloaded and not locked up'; 'loaded and locked up'; and 'loaded and not locked up'. We created a three-level variable characterising storage in and around the home: any firearm stored unlocked and loaded ('least secure'); no firearms stored unlocked and loaded but at least one firearm stored locked and loaded, or unlocked and unloaded ('moderately secure') or all firearms stored locked and unloaded ('most secure'). Secure storage has been linked to reduced injury risk.²⁰ Individuals who stored any firearm at work or someplace else (8.4%) were categorised separately due to an error in the survey prompt that precluded us from accounting for all the ways in which firearms were stored in and around the home for these respondents.

Loaded handgun carrying in the past 30 days

All owners were asked whether, and if yes, why they have carried a loaded handgun in the past 30 days, with response options: 'for protection against people', 'for protection against animals', 'for transporting the gun to or from work', 'for use at work', 'for transporting the gun to or from a shooting range' and 'for some other reason'. We grouped respondents into three categories: yes, primarily for protection against people; yes, not primarily for protection against people; and no. We did this because handgun carrying regulations vary greatly by state,²¹ and though interpersonal self-defense is a primary motivator for carrying, research suggests that most defensive firearm use may not be legal or socially desirable.¹⁹

High-capacity magazine ownership

Individuals who reported owning at least one rifle or semiautomatic pistol, or who refused to report the specific types of firearm(s) owned, were asked if they owned detachable ammunition magazines, and, if yes, the number of rounds their largest-capacity magazine could hold. Magazines holding >10 rounds (vs ≤10) were classified as high capacity.²² Respondents for whom the question was not applicable (ie, did not own a firearm that accepts a high-capacity magazine) were included in the ≤10 level under the assumption that the decision to own a high-capacity magazine is predicated on the decision to buy a firearm capable of accepting one.

Statistical analysis

We conducted an LCA using the SAS procedure PROC LCA, developed by The Methodology Centre at Penn State.²³ LCA is a mixture model designed to characterise an underlying categorical latent variable within a population into mutually exclusive and meaningful subgroups. Latent variables are not directly observed, but instead inferred from relationships between measured indicators.²³ It is an intuitive, parsimonious way of describing relationships between many observed characteristics²⁴ and is often used to describe complex, multidimensional constructs.²⁵

The LCA model estimates class membership probabilities and item-response probabilities as a function of class membership. Class membership probabilities reflect the prevalence of each class; item-response probabilities indicate the likelihood of endorsing an item, conditional on class membership. The researcher interprets item-response probabilities to derive a conceptual understanding of the classes. PROC LCA accounts for survey weights with the pseudo-maximum likelihood approach and handles missing data with the assumption of missing at random.²⁶

We compared models with one to seven classes. As recommended,²⁶ we applied a ρ prior of 1 to improve estimation of

probabilities close to 0 or 1 and allowed the model to be fit with multiple random starts to reach optimal estimation. Model selection was based primarily on Bayesian information criterion, which prioritises parsimony, and conceptual interpretability. We also considered other standard fit statistics, including likelihood-ratio G^2 , Akaike's information criterion and entropy (see online supplementary material).

Lastly, we used the maximum-probability assignment rule to describe class membership according to respondents' gender, race/ethnicity and age. Specifically, posterior probabilities of class membership were used to group respondents into the class in which they had the highest probability of belonging.^{23,27} Class prevalence (ie, the proportion assigned to each class), which can be easily derived after maximum-probability assignment, will not necessarily equal the class membership probabilities estimated by the LCA model, although correspondence between the two is an indicator of model accuracy.²⁷

Analyses were conducted in SAS V.9.4 and STATA V.15.1. An example of a SAS code for the LCA is presented in the online supplementary material.

Sensitivity analyses

We assessed the sensitivity of our findings to variable operationalisations, the inclusion of other variables and the number of classes. For example, we regrouped types of firearms owned into three categories (handguns only, long guns only, and both handguns and long guns), number owned into four categories (1, 2–4, 5–9 and 10+) and reasons for ownership into three categories (firearms owned primarily for protection against people, for protection against animals or for hunting/sporting, or for collection or other reason). We also regrouped individuals who did not own a firearm capable of accepting a high-capacity magazine into a third 'not applicable' category. Lastly, we examined how well our final model corresponded to the data by calculating the average posterior probability of class assignment for each class, classification probabilities for the most likely latent class and the odds of correct classification (see online supplementary tables S4–S6).²⁷

RESULTS

Descriptive

Our sample comprised 429 firearm owners, who were mostly over 30 years old (mean age 55.7), non-Hispanic white and male (table 1). A majority (71.4%) owned either one firearm (37.5%) or two to four firearms (33.9%). A plurality (40.7%) owned both handguns and long guns other than assault-type weapons. Approximately half owned primarily for protection against people. Almost 18% stored at least one firearm in the least secure manner. Most (85.4%) did not own high-capacity magazines. Approximately one in five owners (17.0%) had carried a loaded handgun for any reason in the past 30 days; almost 1 in 10 owners (8.5%) had carried primarily for protection against people.

Latent classes

A five-class model fit the data best (Bayesian information criterion 663.43) (see online supplementary table S1). Fit statistics, a discussion of model selection and the next best-fitting models (four-class and six-class) are presented in the online supplementary material.

Members of class 1 (31% of owners) were likely to own 5+ firearms, own both handguns and long guns other than assault-type weapons, own primarily for a reason other than protection

Table 2 Five-class model: probability of endorsing item given latent class membership and firearm owners, 2018 California Safety and Well-Being Survey

	Class 1	Class 2	Class 3	Class 4	Class 5
Class membership probabilities	0.31	0.26	0.21	0.14	0.09
Number of firearms owned					
1	<0.01	0.73	0.91	<0.01	<0.01
2–4	0.48	0.27	0.09	0.79	<0.01
5+	0.52	<0.01	<0.01	0.21	>0.99
Type(s) of firearm(s) owned*					
Assault-type weapon(s) and other firearms†	0.16	<0.01	<0.01	<0.01	0.53
Handgun(s) and long gun(s) other than assault-type weapons	0.84	<0.01	<0.01	0.77	0.46
Handgun(s) only	<0.01	0.38	0.87	0.23	<0.01
Long gun(s) other than assault-type weapons only	0.01	0.62	>0.13	<0.01	<0.01
Reason for firearm ownership					
Any owned primarily for protection against people	0.28	<0.01	>0.99	0.93	0.79
None owned primarily for protection against people	0.72	>0.99	<0.01	0.07	0.22
Firearm storage					
Least secure‡	0.05	<0.01	0.08	0.71	0.59
Moderately secure§	0.36	0.45	0.53	0.23	0.13
Most secure¶	0.52	0.45	0.37	<0.01	0.04
Any stored at work/someplace else	0.08	0.10	0.02	0.06	0.25
Loaded handgun carrying (past 30 days)					
Yes, primarily for protection against people	<0.01	<0.01	0.03	0.14	0.67
Yes, not primarily for protection against people	0.04	0.12	<0.01	0.20	0.17
No	0.96	0.88	0.98	0.65	0.16
Own high-capacity (>10) magazine					
Yes	0.09	0.09	0.07	0.05	0.65
No	0.91	0.91	0.93	0.95	0.35

Bold indicates probabilities greater than or equal to 0.50.

*Categories are mutually exclusive and exhaustive. Other possible categories did not apply.

†Includes individuals who owned assault-type weapons and handguns only, and those who owned assault-type weapons, handguns and long guns other than assault-type weapons.

‡Any firearm loaded and not locked up in/around the home, no firearms stored at work or someplace else.

§No firearms loaded and not locked up, but at least one firearm loaded and locked or unloaded and unlocked in/around the home; no firearms stored at work or someplace else.

¶All firearms locked and unloaded in/around the home, no firearms stored at work or someplace else.

NH, non-Hispanic.

against people and store all firearms in the most secure manner (table 2). Members of class 2 (26%) were likely to own one non-assault-type long gun primarily for a reason other than protection against people. Those in class 3 (21%) were likely to own one handgun primarily for protection against people, stored in the moderately secure manner. Members of class 4 (14%) were likely to own two to four firearms, own both handguns and long guns other than assault-type weapons, own a firearm primarily for protection against people and store at least one firearm in the least secure manner. Members of classes 1–4 were highly unlikely

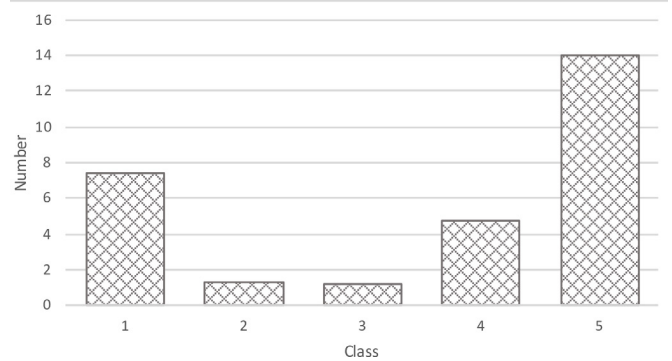


Figure 1 Five-class model: average number of firearms owned by latent classes of firearm ownership, 2018 California Safety and Well-Being Survey. Note: counts were weighted. Firearm owners were grouped into the class in which they had the highest probability of belonging. Class 1 was defined by owning 5+ firearms, handguns and long guns other than assault-type weapons, not owning any firearm primarily for protection against people and storing all firearms in the most secure manner. Class 2 was defined by owning one long gun, not primarily for protection against people. Class 3 was defined by owning a single handgun, stored moderately secure, primarily for protection against people. Class 4 was defined by owning two to four firearms, handguns and long guns other than assault-type weapons, owning a firearm primarily for protection against people and storing at least one firearm in the least secure manner. Class 5 was defined by owning 5+ firearms, including assault-type weapons, owning a firearm primarily for protection against people, storing at least one firearm in the least secure manner, carrying a loaded handgun in the past 30 days for protection against people and owning high-capacity magazines.

to have carried a loaded handgun in the past 30 days or to own high-capacity magazines or assault-type weapons. In contrast, members of class 5 (9%) commonly carried a loaded handgun for protection against people, owned high-capacity magazines, owned 5+ firearms (14 on average, figure 1), including assault-type weapons, and stored at least one firearm in the least secure manner.

Class 1 membership was most common among men, whites and individuals of 2+ races or other race, and those 45 years and older (table 3); their firearms accounted for approximately 50% of the sample's firearm stock (figure 2). Membership in class 2 was most common among blacks and Hispanics and those aged 18–44 years. Class 3 membership was most common among women. Classes 4 and 5 were generally the least common; men were more likely to belong to both classes than were women. Class 4 membership was more prevalent among non-Hispanic whites and those aged 18–29 years compared with other races and other age groups, whereas class 5 membership was relatively more common among individuals of 2+ races or other race and those over 60 years old.

Assessments of model accuracy indicated that the five-class model fit the data well (see online supplementary tables S4–S6). Alternative variable definitions or the inclusion of additional variables did not substantially improve model fit, and the observed patterns were generally robust to these changes.

DISCUSSION

This is the first study to our knowledge to empirically describe patterns of firearm ownership with LCA. Using a landmark, state-representative survey conducted in 2018, we identified five distinct

Table 3 Five-class model: characteristics of firearm owners by most-likely latent class membership, 2018 California Safety and Well-Being Survey

	Class 1*	Class 2†	Class 3‡	Class 4§	Class 5¶	Total
Total, unweighted n (weighted %)	136 (31.0)	107 (25.6)	95 (20.8)	63 (14.4)	28 (8.2)	429 (100)
Gender, unweighted n (weighted %)						
Male	99 (32.8)	75 (26.1)	53 (15.2)	49 (15.1)	25 (10.9)	301 (100)
Female	37 (26.3)	32 (24.1)	42 (36.1)	14 (12.5)	3 (1.0)	128 (100)
Race/ethnicity, unweighted n (weighted %)						
NH white	108 (32.8)	75 (23.3)	64 (20.1)	51 (16.3)	20 (7.6)	318 (100)
NH black	3 (14.9)	3 (45.6)	9 (36.2)	1 (3.3)	0 (0.0)	16 (100)
NH other or 2+ races	11 (33.4)	4 (21.5)	5 (17.8)	2 (8.8)	2 (18.6)	24 (100)
Hispanic	14 (27.7)	25 (30.7)	17 (21.5)	9 (13.9)	6 (6.2)	71 (100)
Age (years), unweighted n (weighted %)						
18–29	1 (10.1)	3 (52.7)	0 (0.0)	3 (37.3)	0 (0.0)	7 (100)
30–44	6 (12.8)	19 (42.6)	17 (33.8)	1 (2.2)	2 (8.7)	45 (100)
45–59	39 (36.9)	16 (16.5)	24 (20.3)	15 (18.1)	5 (8.2)	99 (100)
60+	90 (37.1)	69 (21.5)	54 (19.1)	44 (13.0)	21 (9.2)	278 (100)

Firearm owners were grouped into the class in which they had the highest probability of belonging.

*Class 1 was defined by owning 5+ firearms, handguns and long guns other than assault-type weapons, not owning any firearm primarily for protection against people and storing all firearms in the most secure manner.

†Class 2 was defined by owning one long gun, not primarily for protection against people.

‡Class 3 was defined by owning a single handgun, stored moderately secure, primarily for protection against people.

§Class 4 was defined by owning two to four firearms, handguns and long guns other than assault-type weapons, owning a firearm primarily for protection against people and storing at least one firearm in the least secure manner.

¶Class 5 was defined by owning 5+ firearms, including assault-type weapons, owning a firearm primarily for protection against people, storing at least one firearm in the least secure manner, carrying a loaded handgun in the past 30 days for protection against people and owning high-capacity magazines.

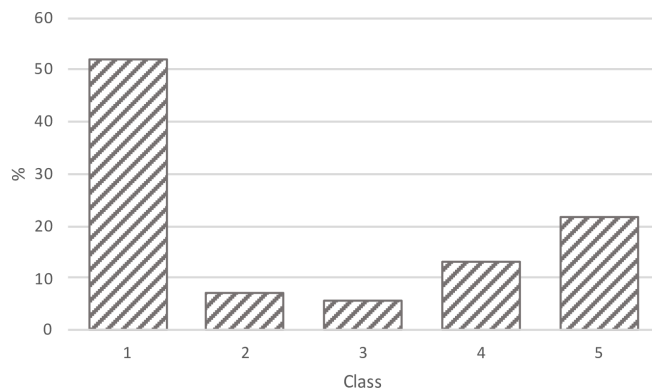


Figure 2 Five-class model: share of firearms owned by classes of firearm ownership, 2018 California Safety and Well-Being Survey. Note: percentages are weighted. Firearm owners were grouped into the class in which they had the highest probability of belonging. Class 1 was defined by owning 5+ firearms, handguns and long guns other than assault-type weapons, not owning any firearm primarily for protection against people and storing all firearms in the most secure manner. Class 2 was defined by owning one long gun, not primarily for protection against people. Class 3 was defined by owning a single handgun, stored moderately secure, primarily for protection against people. Class 4 was defined by owning two to four firearms, handguns and long guns other than assault-type weapons, owning a firearm primarily for protection against people, and storing at least one firearm in the least secure manner. Class 5 was defined by owning 5+ firearms, including assault-type weapons, owning a firearm primarily for protection against people, storing at least one firearm in the least secure manner, carrying a loaded handgun in the past 30 days for protection against people and owning high-capacity magazines.

classes of firearm ownership in California, indicating that ownership is heterogeneous and can be empirically distinguished by key features.

Those who owned a single handgun (class 3) did so primarily for protection against people, and this pattern was most common among women, whereas those who owned a single long gun (class 2) did so primarily for some other reason. These findings are consistent with prior research.⁴ Regardless of the number and type of firearms owned, owning for protection against people was associated with unsecure firearm storage (ie, unlocked and/or loaded). As secure firearm storage has been associated with lower risk of firearm injury and death,^{20,28} our findings suggest that interventions to increase secure firearm storage may need to consider and align with individuals' actual or perceived need for self-protection. For example, those who own firearms for protection may be more likely to use personalised firearms, which can only be fired by an authorised user,²⁹ and devices that function with relative ease and speed.¹⁵

There was substantial variability among owners of more than one firearm (classes 1, 4 and 5). Other than owning multiple firearms, there was no indicator on which all three of these classes aligned. Members of class 5 were uniquely likely to own high-capacity magazines and assault-type weapons—two features of ownership that have been associated with crime and mass violence,³⁰ and strictly regulated by federal¹⁸ and state law³¹—and to carry a loaded handgun in the past 30 days for protection against people. Unlike members of class 1, those in classes 4 and 5 commonly stored a firearm in the least secure manner.

Firearm ownership generally has been associated with firearm injury^{28,32} and risk behaviours such as heavy alcohol use^{33,34} and criminal activity,⁶ though the level of risk may vary across patterns of ownership. For example, Hemenway and Richardson³⁵ found that owners of automatic and semiautomatic firearms were more likely to binge drink compared with other owners. Analyses of

the Behavioural Risk Factor Surveillance System have shown that alcohol-related risk behaviours were most common among people (including firearm owners) who lived in homes where firearms were not stored securely^{33 36} and among owners who carried a firearm for protection against people.³³ Firearm carrying has also been associated with dangerous and aggressive driving³⁷ and an increased probability of having a firearm stolen,³⁸ which is considered a primary pathway to the illegal market and future crime.

The latent classes that we identified could inform future research on risk assessment, as these indicators may help identify higher-risk groups of firearm owners, and on focused interventions to reduce firearm injury and death. For example, secure storage tools and messaging can be targeted to the groups of owners most likely to benefit. With a more nuanced understanding of firearm ownership in California—and the association between ownership patterns and firearm violence risk—public health and safety efforts can be additionally tailored to owners' differing practices and risks. It is therefore of high priority to assess how the classes described herein relate to attitudes towards firearm policies, perceptions of safety, risk behaviours, violence, injury and crime.

Limitations

CSaWS may be subject to social desirability and non-response bias—which could have resulted in the under-reporting of highly regulated (eg, high-capacity magazine ownership) or higher-risk (eg, unsafe firearm storage) characteristics of ownership—as well as recall and selection bias. Differences between those who chose to complete the survey and those who did not may affect the generalisability of our findings. However, CSaWS sampling and weighting schemes sought to minimise selection bias and improve state representativeness, and the initial firearm ownership questions had low refusal rates (<1%). Moreover, online probability surveys have been shown to yield the least biased results compared with telephone and non-probability online surveys,³⁹ and responses to surveys about firearm ownership have been previously validated.⁴⁰ Lastly, because of the relatively small number of firearm owners within our larger sample, we restricted the number of variables included in the model and the level of detail with which variables were defined to retain statistical power and preserve model parsimony.

California may be unique, and the typologies we identified could vary across states. This approach could be reasonably

replicated in other states, since, compared with nationally representative surveys, such state-level data may be more feasible to collect. However, several findings from CSaWS (eg, mean number and types of firearms owned) were similar to those from the 2015 National Firearms Survey,⁴ indicating the potential generalisability of the latent class structure we identified.

CONCLUSION

There are discernible subtypes of firearm owners in California according to the number and types of firearms owned and ownership-related motivations and practices. Previously documented higher-risk firearm-related behaviours were concentrated among a relatively small number of owners. Further research should examine whether interventions tailored to these distinct classes are valuable as part of a more comprehensive approach to prevent firearm injury and death.

Contributors JPS conceived the research question and study design, conducted the analyses and drafted the manuscript. GJW, NK-W and RP designed the survey instrument. NK-W and RP oversaw data acquisition and management. All authors contributed content expertise and to the conception and design of the work, interpretation of results, and drafting and critical revision of the manuscript. All authors have given final approval of the manuscript for submission.

Funding This research was supported by University of California Firearm Violence Research Center with funds from the State of California. Additional support came from the California Wellness Foundation (award no. 2014-255), the Heising-Simons Foundation (award no. 2017-0447), the Langeloth Foundation (award no. 1824) and the University of California, Davis, Violence Prevention Research Program.

Competing interests None declared.

Patient consent for publication Not required.

Provenance and peer review Not commissioned; externally peer reviewed.

Data availability statement No data are available.

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REFERENCES

- Centers for Disease Control and Prevention. Web-Based injury statistics query and reporting system (WISQARS). fatal injury data. Available: <https://www.cdc.gov/injury/wisqars/fatal.html> [Accessed 22 June 2019].
- Gani F, Sakran JV, Canner JK. Emergency department visits for firearm-related injuries in the United States, 2006–14. *Health Aff* 2017;36:1729–38.
- Wintemute GJ. The epidemiology of firearm violence in the twenty-first century United States. *Annu Rev Public Health* 2015;36:5–19.
- Azrael D, Hepburn L, Hemenway D, et al. The stock and flow of U.S. firearms: results from the 2015 national firearms survey. *RSF Russell Sage Found J Soc Sci* 2017;3:38–57.
- Hepburn L, Miller M, Azrael D, et al. The US gun stock: results from the 2004 national firearms survey. *Injury Prevention* 2007;13:15–19.
- Cook P, Ludwig J. *Guns in America: results of a comprehensive national survey on firearms ownership and use*. Washington, DC: The Police Foundation, 1996.
- Azrael D, Cook PJ, Miller M. State and local prevalence of firearms ownership measurement, structure, and trends. *J Quant Criminol* 2004;20:43–62.
- Siegel M, Ross CS, King C. Examining the relationship between the prevalence of guns and homicide rates in the USA using a new and improved state-level gun ownership proxy. *Inj Prev* 2014;20:424–6.
- Oraka E, Thummalapally S, Anderson L, et al. A cross-sectional examination of US gun ownership and support for gun control measures: sociodemographic, geographic, and political associations explored. *Prev Med* 2019;123:179–84.
- Ikeda RM, Dahlberg LL, Kresnow M-j, et al. Studying "exposure" to firearms: household ownership v access. *Inj Prev* 2003;9:53–7.
- Hamilton D, Lemeshow S, Saleska JL, et al. Who owns guns and how do they keep them? the influence of household characteristics on firearms ownership and storage practices in the United States. *Prev Med* 2018;116:134–42.
- Rowhani-Rahbar A, Azrael D, Lyons VH, et al. Loaded handgun carrying among US adults, 2015. *Am J Public Health* 2017;107:1930–6.
- Azrael D, Cohen J, Salhi C, et al. Firearm storage in Gun-owning households with children: results of a 2015 national survey. *J Urban Health* 2018;95:295–304.
- Sidman EA, Grossman DC, Koepsell TD, et al. Evaluation of a community-based handgun safe-storage campaign. *Pediatrics* 2005;115:654–61.

What is already known on the subject

- ▶ Firearm ownership is prevalent in the USA.
- ▶ Recent estimates indicate that there is substantial variation in characteristics of firearm ownership and ownership-related motivations and practices.

What this study adds

- ▶ There are five distinct typologies of firearm ownership in California.
- ▶ Specific firearm-ownership characteristics (eg, assault-type weapon ownership) and higher-risk behaviours (eg, loaded handgun carrying) are concentrated among a relatively small number of owners.

- 15 Simonetti JA, Simeona C, Gallagher C, *et al.* Preferences for firearm locking devices and device features among participants in a firearm safety event. *West J Emerg Med* 2019;20:552–6.
- 16 Santaella-Tenorio J, Cerdá M, Villaveces A, *et al.* What do we know about the association between firearm legislation and firearm-related injuries? *Epidemiol Rev* 2016;38:140–57.
- 17 Hanlon TJ, Barber C, Azrael D, *et al.* Type of firearm used in suicides: findings from 13 states in the National violent death reporting system, 2005–2015. *J Adolesc Health* 2019;65:366–70.
- 18 Koper CS, Roth JA. The impact of the 1994 federal assault weapon ban on gun violence outcomes: an assessment of multiple outcome measures and some lessons for policy evaluation. *J Quant Criminol* 2001;17:33–74.
- 19 Hemenway D, Azrael D, Miller M. Gun use in the United States: results from two national surveys. *Inj Prev* 2000;6:263–7.
- 20 Grossman DC, Mueller BA, Riedy C, *et al.* Gun storage practices and risk of youth suicide and unintentional firearm injuries. *JAMA* 2005;293:707–14.
- 21 Giffords Law Center to Prevent Gun Violence. Concealed carry: state by state. Available: <https://lawcenter.giffords.org/gun-laws/state-law/50-state-summaries/concealed-carry-state-by-state/> [Accessed 31 Aug 2019].
- 22 California Legislative Information. California Penal code Sec. Available: https://leginfo.ca.gov/faces/codes_displaySection.xhtml?lawCode=PEN§ionNum=16740 [Accessed 29 Jul 2019].
- 23 Lanza ST, Collins LM, Lemmon DR, *et al.* Proc LCA: a SAS procedure for latent class analysis. *Struct Equ Modeling* 2007;14:671–94.
- 24 Lanza ST, Rhoades BL, Greenberg MT, *et al.* Modeling multiple risks during infancy to predict quality of the caregiving environment: contributions of a person-centered approach. *Infant Behav Dev* 2011;34:390–406.
- 25 Rhoades BL, Greenberg MT, Lanza ST, *et al.* Demographic and familial predictors of early executive function development: contribution of a person-centered perspective. *J Exp Child Psychol* 2011;108:638–62.
- 26 Lanza ST, Dziak JJ, Huang L, *et al.* *PROC LCA & PROC LTA Users' Guide Version 1.3.2*, 2015: 54.
- 27 Nagin DS. *Group-Based Modeling of Development*. Cambridge, MA and London, England: Harvard University Press, 2005.
- 28 Kellermann AL, Rivara FP, Simes G, *et al.* Suicide in the home in relation to gun ownership. *N Engl J Med* 1992;327:467–72.
- 29 Vernick JS, O'Brien M, Hepburn LM, *et al.* Unintentional and undetermined firearm related deaths: a preventable death analysis for three safety devices. *Inj Prev* 2003;9:307–11.
- 30 Koper CS, Johnson WD, Nichols JL, *et al.* Criminal use of assault weapons and high-capacity Semiautomatic firearms: an updated examination of local and national sources. *J Urban Health* 2018;95:313–21.
- 31 Giffords Law Center to Prevent Gun Violence. Assault weapons. Available: <https://lawcenter.giffords.org/gun-laws/policy-areas/hardware-ammunition/assault-weapons/> [Accessed 30 Jun 2019].
- 32 Grassel KM, Wintemute GJ, Wright MA, *et al.* Association between handgun purchase and mortality from firearm injury. *Inj Prev* 2003;9:48–52.
- 33 Wintemute GJ. Association between firearm ownership, firearm-related risk and risk reduction behaviours and alcohol-related risk behaviours. *Inj Prev* 2011;17:422–7.
- 34 Miller M, Hemenway D, Wechsler H. Guns at College. *J Am Coll Health* 1999;48:7–12.
- 35 Hemenway D, Richardson E. Characteristics of automatic or semiautomatic firearm ownership in the United States. *Am J Public Health* 1997;87:286–8.
- 36 Morgan ER, Gomez A, Rowhani-Rahbar A. Firearm ownership, storage practices, and suicide risk factors in Washington state, 2013–2016. *Am J Public Health* 2018;108:882–8.
- 37 Miller M, Azrael D, Hemenway D, *et al.* 'Road RAGE' in Arizona: armed and dangerous. *Accid Anal Prev* 2002;34:807–14.
- 38 Hemenway D, Azrael D, Miller M. Whose guns are stolen? the epidemiology of gun theft victims. *Inj Epidemiol* 2017;4.
- 39 Chang L, Krosnick JA. National surveys via RDD telephone interviewing versus the Internet: comparing sample representativeness and response quality. *Public Opin Q* 2009;73:641–78.
- 40 Rafferty AP, Thrush JC, Smith PK, *et al.* Validity of a household gun question in a telephone survey. *Public Health Rep* 1995;110:282–8.