

State-Level Changes in Firearm Laws and Workplace Homicide Rates: United States, 2011 to 2017

Erika L. Sabbath, ScD, Summer Sherburne Hawkins, PhD, and Christopher F. Baum, PhD

Objectives. To test whether year-over-year strengthening of state-level firearm laws is associated with decreases in workplace homicide rates.

Methods. In this time-series ecological study of working people in all 50 US states, we used federal data on workplace homicides by state and year from 2011 to 2017, linked to an index of state-year firearm laws, to characterize the regulatory environment (overall and within legislative categories). We used generalized linear regression to model associations between changes in firearm laws and changes in workplace homicide rates the following year.

Results. From 2011 to 2017, more than 3000 people died as a result of workplace homicides; over that period, 23 states strengthened firearm regulations and 23 weakened them. We modeled the impact of states strengthening laws within the interquartile range (IQR; equivalent to adding 20.5 firearm laws). This change was associated with a 3.7% reduction in the workplace homicide rate (95% confidence interval [CI]=−3.86, −3.51). Positive IQR changes in specific categories of firearm laws—concealed carry permitting (−5.79%; 95% CI=−6.09, −3.51), domestic violence-related restrictions (−5.31%; 95% CI=−5.57, −5.05), and background checks (−5.07%; 95% CI=−5.32, −4.82)—were also associated with significant reductions.

Conclusions. Strengthening state-level firearm laws may reduce the population-level mortality and morbidity burden posed by workplace homicides. (*Am J Public Health.* 2020;110:230–236. doi:10.2105/AJPH.2019.305405)

Gun violence is a public health crisis in the United States.¹ In 2017, 13 205 working-aged adults died from homicide by firearm, the ninth-leading cause of death in this age group.² Overall, mortality due to gun-related causes among individuals 18 to 64 years of age exceeds that of motor vehicle crashes.

Despite the mortality and morbidity burden attributable to firearms, the United States has passed little federal legislation to regulate their purchase, distribution, storage, or use. Most firearm-related legislative activity has occurred at the state level. Since the early 1990s, every state has passed policies either strengthening or weakening restrictions on the sale, possession, and use of firearms.³ On average, states have become slightly more restrictive in their firearm policies in the past 30 years,

particularly policies related to limitations on gun ownership among domestic violence offenders and other high-risk individuals, although many have become more permissive in areas such as “stand your ground” laws and concealed carrying of firearms.⁴

From a public health perspective, the same structural barriers that have inhibited federal legislation on gun violence also restrict research into its determinants.⁵ However, a growing evidence base has

documented the relationship between state-level firearm policy changes and firearm-associated homicide rates.⁶ These studies generally show that, at a population level, background checks⁷ and regulations for gun buyers (specifically permit to purchase)⁸ are associated with reductions in—although not elimination of—state-level firearm homicide rates, even after state-level social and demographic characteristics have been taken into account. There is less evidence of the relationship between firearm-related homicides and other types of gun control measures, such as limits on firearm trafficking or bans on assault weapons or high-capacity magazines.⁶ In addition, when states strengthen firearm policies intended to protect specific vulnerable populations (e.g., children, domestic violence victims), homicide rates in those groups tend to decline.^{9,10}

Each year, approximately 400 homicides by firearm occur when people are at work, accounting for about 9% of the approximately 4800 workplace fatalities occurring in the United States annually.¹¹ In addition to mortality among victims, workplace homicide can lead to broader morbidity in the form of long-term trauma among co-workers, who are often witnesses and survivors. This trauma is exacerbated by witnesses' need to return to the scene of the homicide each day to earn a living themselves.¹²

In most research on workplace homicides, national surveillance data have been used to

ABOUT THE AUTHORS

Erika L. Sabbath and Summer Sherburne Hawkins are with the School of Social Work, Boston College, Chestnut Hill, MA. Christopher F. Baum is with the Department of Economics, Boston College.

Correspondence should be sent to Erika L. Sabbath, ScD, Boston College School of Social Work, 140 Commonwealth Ave, Chestnut Hill, MA 02467 (e-mail: erika.sabbath@bc.edu). Reprints can be ordered at <http://www.ajph.org> by clicking the “Reprints” link.

This article was accepted September 18, 2019.

doi: 10.2105/AJPH.2019.305405

identify trends in rates and subgroups of workers at particular risk.^{13,14} A few small studies of employer-level determinants of workplace homicide have shown that homicides are more likely to occur at workplaces that permit weapons on site¹⁵ and under working conditions such as solo work at night or poor exterior lighting.¹⁶ However, higher-level determinants of workplace homicide are unknown. Specifically, to our knowledge, there has been no research on how the state-level policy environment is associated with the likelihood of being killed by another individual at work.

In this study, we assessed whether strengthening of state-level firearm laws from 2011 through 2017 was associated with decreases in state-level workplace homicide rates. Also, we tested for associations between changes in subcategories of firearm laws and workplace homicide rates.

METHODS

This study was a time-series ecological investigation. Participants were any people who worked for pay in each of the 50 US states between 2011 and 2017.

Workplace Homicide Rates

Our outcome variable was workplace homicide rates. We identified all workplace homicides occurring in the United States between 2011 and 2017 by state and year using the Census of Fatal Occupational Injuries (CFOI).¹⁷ CFOI, the national surveillance system for tracking all occupational fatalities occurring within the country, is a federal-state cooperative program administered through the US Department of Labor's Bureau of Labor Statistics. CFOI is considered the definitive record of occupational fatalities in the United States.

After a death occurs at work, information about the fatality is compiled via data including death certificates and records from workers' compensation, media, the Occupational Safety and Health Administration, and the company at which the event took place. Two independent sources must confirm the work relatedness of a fatality if it is to be entered into CFOI. CFOI classifies each verified work-related fatality according to the

Occupational Injury and Illness Classification System to document the nature, source, secondary source, and event or exposure that led to the fatality.¹⁷ Only fatalities experienced by workers are included in CFOI counts, even if a single event led to casualties among both workers and patrons or clients.

Fatalities categorized as "intentional injury by person" are classified by the Occupational Injury and Illness Classification System as homicides. The subcategories included in this definition are as follows: intentional shooting by another person; stabbing, cutting, slashing, or piercing; hitting, kicking, beating, or shoving; strangulation by another person; bombing or arson; and multiple violent acts by another person.¹⁷

We generated state and year workplace homicide rates by dividing the number of workplace homicides (publicly available from CFOI) by the number of people (in 100 000s) employed in the state during the year in question. The latter data are publicly available through the Current Population Survey, administered by the US Census Bureau.¹⁸

Firearm-Related Legislation

We obtained information on firearm laws from the State Firearm Laws Database, a publicly available, nonpartisan, comprehensive database on the presence of firearm laws in each state from 1990 to the present; we used data from 2011 to 2017.^{3,4} The database has been employed in a number of empirical studies of firearm policies and population health.^{7,19}

The database contains dichotomous indicators on the presence or absence of each of 132 firearm-related legislative provisions for each state-year combination during the study period. Each of the 132 laws is coded so that 1 refers to more restrictive gun access and 0 refers to more liberal access. The law indicators are then summed to create a measure of the overall firearm policy environment in a given state, with higher scores equivalent to stronger firearm regulations.

The 132 firearm laws each fit into one of 13 policy subcategories according to type of law (e.g., laws related to restrictions on domestic violence offenders, laws related to concealed carry permitting). These subcategories contain between one law ("stand your ground" provisions) and 21 laws

(laws related to domestic violence). Within each subcategory, the number of law indicators is summed and coded so that higher scores are equivalent to stronger firearm regulations.

Covariates

Using publicly available data from a variety of sources, we adjusted for covariates associated with state-level variation in homicide, suicide, and accidental firearm mortality rates.²⁰ All covariates were measured according to state and year. We initially adjusted for unemployment rate,²¹ percentage of residents below the federal poverty line,²² racial/ethnic composition (percentage Black, percentage Hispanic),¹⁸ percentage of residents with a college education,¹⁸ percentage of male residents,¹⁸ violent crime rate (exclusive of homicide),²³ population density,²⁴ and percentage of the population that is of working age (18–64 years).⁶ Percentage of Hispanic residents, population density, and proportion of the population 18 to 64 years of age were not significantly associated with workplace homicide rates in any models and thus were not retained in our analyses.

Statistical Analysis

We examined associations between state-level firearm laws and state-level workplace homicide risk factors. We used a generalized linear model approach to take into account that the dependent variable, the state-year workplace homicide rate, is strictly positive. We fit the model with a log link and γ -distributed errors using robust standard errors clustered by state. We specified a log- γ model because the log- γ technique (unlike the Gaussian regression commonly used in log-linear models) requires no external transformation, it is more straightforward to interpret, and its residuals allow evaluations of model fit.²⁵

In the estimated model, the key variable explaining a state's workplace homicide rate was the preceding year's firearm law index in that state. We included this lag in the firearm law index to reduce potential error caused by laws being in effect for parts but not all of a given year, as our workplace homicide data were available only annually. Models were adjusted for state-level time-varying characteristics (unemployment rate, percentage of

residents below the federal poverty line, percentage of Black residents, percentage of residents with a college education, percentage of male residents, and nonhomicide violent crime rate) as well as year fixed effects to control for time trends.

The generalized linear model was specified as $\log(\text{homrate}_{i,t}) = \beta_0 + \beta_1 \text{lawtotal}_{i,t-1} + \beta_2 \text{povertyrate}_{i,t} + \beta_3 \text{pctmale}_{i,t} + \beta_4 \text{pctcollege}_{i,t} + \beta_5 \text{violentcrimerate}_{i,t} + \beta_6 \text{pctblack}_{i,t} + \beta_7 \text{unemployrate}_{i,t} + \Phi Y_t + \eta_{i,t}$ for $i = 1, 50$ and $t = 2012, 2017$. Y_t values are indicator variables for the years 2013 to 2017, with coefficients in the Φ vector. The covariate of interest was the preceding year's firearm index value for state i , $\text{lawtotal}_{i,t-1}$.

Subsequently, we examined 13 subcategories of firearm laws⁴ involving at least one state policy change in the given subcategory over the study period. One policy subcategory (immunity from prosecution for gun manufacturers) included in the State Firearms Law Database did not meet this criterion and was therefore not analyzed in regression models. We modeled each subcategory of firearm laws and workplace homicide rates separately to avoid multicollinearity.

We present parameter estimates (b values) as well as average marginal effects to describe the predicted change in workplace mortality rates in response to an interquartile range (IQR) positive increase in the state-level policy environment. An IQR change across

all policy areas is interpreted as the number of firearm laws that a state would need to add or strengthen to move from being in the weakest firearm law quartile to the strongest quartile. Across all policy areas, this would mean strengthening 20.5 firearm laws on average. We also modeled the effect of an IQR change within specific policy areas (e.g., for concealed carry permitting, this is equivalent to a state strengthening or adding 2 concealed carry laws). We used Stata version 15.1 (StataCorp LLC, College Station, TX) in conducting all of our analyses.

RESULTS

There were 3131 workplace homicides during the study period, ranging from a low of 404 in 2013 to a high of 500 in 2016, which translated to an average of 0.31 homicides per 100 000 workers. On average, workplace homicides accounted for 9% of all workplace fatalities (Table 1).

Over the study period, the Occupational Injury and Illness Classification System classified 2474 (79%) homicides as “intentional shooting of another person.” Of these homicides, 61% involved a handgun and 12% involved a rifle; other weapons were not reported. Seven percent of assailants were family members or intimate partners of the victim; 11% were customers, clients, or patients; and 15% were current or former

coworkers (Table 1). Retail sales workers, cashiers, and police officers were most likely to be killed by another person while at work.¹¹

The 2011 through 2017 period was an active one for the enactment and implementation of firearm regulations (Table 2). Across all years of the study period, the average state had 26 laws restricting firearms (range = 3–104), with an IQR of 20.5; states in the 25th percentile of firearm policies had 10 firearm-restricting laws, and states in the 75th percentile had 30.5 such laws.

Overall, 23 states strengthened firearm regulations, 23 weakened regulations, and 9 did not change firearm laws during the study period. Five states appeared on both the “strengthened” and “weakened” lists because they either strengthened regulations in one subcategory of laws but weakened them in another (South Carolina, Virginia, and West Virginia) or weakened and then strengthened laws within the same subcategory (Idaho and Oklahoma). The legislative subcategories with the most activity were domestic violence-related laws (17 states strengthened and 3 states weakened regulations), possession regulations (4 states strengthened and 10 states weakened regulations), and concealed carry permitting (6 states strengthened and 8 states weakened regulations).

Using generalized linear models (Table 3), we first tested overall associations between changes in state-level firearm laws and

TABLE 1—Characteristics of Workplace Homicides in the United States From 2011 to 2017

	2011	2012	2013	2014	2015	2016	2017	All
Overall characteristics								
Total number of workplace homicides	468	475	404	409	417	500	458	3131
Workplace homicide rate per 100 000 workers	0.337	0.337	0.283	0.282	0.282	0.332	0.300	0.307
Workplace fatalities classified as homicides, %	10	10	9	8	9	10	9	9
Workplace homicides classified as “intentional shooting of another person,” %	78	80	80	75	85	79	77	79
Type of weapon used, %^a								
Handgun	56	56	58	63	63	66	66	61
Rifle	14	10	14	10	12	13	10	12
Relationship of assailant to victim, %								
Family member or intimate partner	8	7	7	7	8	9	6	7
Coworker or former coworker	10	13	18	15	16	13	17	15
Client, customer, or patient	11	12	9	12	11	9	12	11

Source. Data for this table were drawn from multiple sources.^{11,17,18}

^aWeapon was not reported for all shootings.

TABLE 2—Summary of Changes in State-Level Firearm Laws: United States, 2011–2017

Policy Subcategory	Explanation of Policy Area	Total Possible Laws, No.	Laws per State, Mean No.	Laws in 25th Percentile, No.	Laws in 75th Percentile, No.	States That Strengthened Gun Control During 2011–2017	States That Weakened Gun Control During 2011–2017
Concealed carry permitting	Restrictions to concealed carrying of firearms	7	4.01	3	5	ID, LA, MI, MO, NC, OH	ID, IL, KS, ME, MO, NH, ND, WV
Domestic violence–related laws	Laws aimed at preventing those with a history of domestic violence from purchasing or owning firearms	21	4.16	0	6.5	AL, CA, CO, CT, DE, HI, IL, IN, LA, ME, MD, MN, NV, NJ, NY, OR, UT	AL, AR, VA
Background checks	Background checks for all sales	11	2.33	0	4.5	CO, DE, NV, NY, OR, WA	...
Dealer regulations	Regulations around dealer recordkeeping, licensing, and reporting	17	2.68	0	5	CO, DE, NY, WA	AL, GA, SC
Child safety provisions	Regulations around locking and storage of firearms around minors	11	1.63	0	3	CA	...
Gun trafficking	Protections against purchasing with intent to resell or purchase without background checks or resell to persons prohibited from gun ownership	7	0.76	0	2	CA, IN, MN	...
Buyer regulations	Age, permitting, and training requirements for gun purchase	17	2.35	0	3	CA, CT, DE, MD, WA	MI, VA, WI
Ammunition regulations	Restrictions on purchasing age, recordkeeping, and licensing for sale of ammunition	7	0.69	0	1	CT	...
High-risk gun owner prohibitions	Prohibitions on gun possession by people with a history of certain mental health problems, substance use, or criminal activity	10	3.06	1	5	AL, CT, DE, NV, OR, SC	AL, RI
Possession regulations	Restrictions on possession of guns among young people and restrictions on carrying firearms in some areas	12	2.62	1	3	CA, CT, OK, WA	AR, GA, IL, MS, MO, OK, SD, TN, TX, WV
Assault weapons and large-capacity magazines	Ban on purchase, transfer, and possession of assault weapons and large-capacity magazines	8	0.67	0	0	CA, CO, CT, MD, NY	...
No preemption	No laws that prohibit local governments from passing firearm regulations that are more stringent than those at the state level	3	0.41	0	0	...	IL
No “stand your ground” laws	No “stand your ground” legislation in place	1	0.54	0	1	...	MO
Total	...	132	26.24	10	30.5	CA, CO, CT, DE, HI, ID, IN, LA, ME, MD, MN, NV, NJ, NY, NC, OH, OK, OR, SC, VT, VA, WA, WV	AL, AK, AR, GA, ID, IL, IA, KS, MI, MS, MO, NH, ND, OK, RI, SC, SD, TN, TX, UT, VA, WV, WI

Source. State Firearm Laws Project³ and Siegel et al.⁴

TABLE 3—Adjusted Associations Between Changes in State-Level Firearm Laws and Workplace Homicide Rates: United States, 2011–2017

	b (95% CI)	Policies in IQR, ^a No.	Effect of IQR Change on Homicide Rate, % (95% CI)
Overall effect of firearm policies	-0.0055 (-0.0087, -0.0023)	20.5	-3.68 (-3.86, -3.51)
Legislative subcategories			
Concealed carry permitting	-0.0913 (-0.144, -0.0385)	2	-5.79 (-6.09, -5.50)
Domestic violence related	-0.0256 (-0.0391, -0.0121)	6.5	-5.31 (-5.57, -5.05)
Background checks	-0.0351 (-0.0584, -0.0119)	4.5	-5.07 (-5.32, -4.82)
Dealer regulations	-0.0304 (-0.0508, -0.0100)	5	-4.88 (-5.11, -4.65)
Child safety provisions	-0.0407 (-0.0699, -0.0116)	3	-3.99 (-4.18, -3.80)
Gun trafficking	-0.0584 (-0.113, -0.0034)	2	-3.82 (-4.00, -3.64)
Buyer regulations	-0.0276 (-0.0498, -0.0054)	3	-2.75 (-2.88, -2.62)
Ammunition regulations	-0.068 (-0.122, -0.0138)	1	-2.28 (-2.38, -2.17)
High-risk gun owner prohibitions	-0.028 (-0.0580, 0.0020)	4	-3.67 (-3.85, -3.50)
Possession regulations	-0.0195 (-0.0507, -0.0118)	2	-1.32 (-1.39, -1.26)
Assault weapon bans	-0.0115 (-0.0554, 0.0325)	0	0.00 (0.00, 0.00)
No preemption	-0.0623 (-0.142, 0.0174)	0	0.00 (0.00, 0.00)
No “stand your ground” law	0.0225 (-0.123, 0.168)	1	0.79 (0.75, 0.83)

Note. CI = confidence interval; IQR = interquartile range. Units for parameter estimates are interpreted as the change in workplace homicides per 100 000 working people associated with a 1-unit increase in the firearm laws index the preceding year. Values were adjusted for the following variables by state and year: unemployment rate, percentage of residents below the federal poverty line, percentage of Black residents, percentage of residents with a college education, percentage of male residents, and nonhomicide violent crime rate. Data include year fixed effects.

^aInterquartile range refers to the effect of adding or strengthening laws at the state level. The IQR is interpreted as the number of laws in a given area that a state would need to add to become one of the strongest, rather than one of the weakest, states with respect to firearm-restricting laws in that area.

changes in workplace homicide rates. In adjusted models, we found a negative association between strengthening of firearm laws and homicide rates; that is, as laws became more restrictive, homicide rates decreased ($b = -0.005$; 95% confidence interval [CI] = $-0.0087, -0.0023$; $P = .001$). An IQR positive increase in state firearm laws (adding 20.5 laws) was associated with, on average, a 3.68% decrease in the workplace homicide rate.

We then modeled the associations between 13 subcategories of firearm policies and workplace homicide rates. We found that, in 8 of the 13 subcategories, strengthening laws was associated with statistically significant reductions ($P < .05$) in workplace homicide rates. Strengthening concealed carry permitting legislation was associated with a 5.79% reduction (equivalent to strengthening 2 laws); domestic violence–related restrictions, with a 5.31% reduction (strengthening 6.5 laws); background checks, with a 5.07% reduction (strengthening 4.5 laws); dealer regulations, with a 4.88% reduction (strengthening 5

laws); child safety provisions, with a 3.99% reduction (strengthening 3 laws); gun trafficking restrictions, with a 3.82% reduction (strengthening 2 laws); buyer regulations, with a 2.75% reduction (strengthening 3 laws); and ammunition regulations, with a 2.28% reduction (strengthening 1 law).

There were no statistically significant associations between workplace homicide rates and high-risk gun owner prohibitions, possession regulations, assault weapons bans, preemption, or “stand your ground” laws.

In sensitivity analyses, we found that the association between state firearm policy changes and workplace homicides did not vary meaningfully by the number of state firearm policies at baseline (Table A, available as a supplement to the online version of this article at <http://www.ajph.org>).

DISCUSSION

Using state-level data on workplace homicides, we tested whether year-over-year

strengthening of firearm laws was associated with lower rates of workplace homicides. We found that as states strengthened regulations related to firearms, workplace homicide rates decreased. Although other studies have shown that stronger firearm laws reduce overall homicide rates, this study provides some of the first evidence that workplace homicide rates are also sensitive to changes in state firearm laws. More broadly, it provides further evidence that strengthening certain firearm restrictions may be an effective tool for reducing homicide rates in a variety of settings, including workplaces.

Several of the legislative subcategories associated with reductions in workplace homicide rates are meaningful in a workplace context. One is strengthening restrictions on gun possession among domestic violence offenders. We found that strengthening 6.5 laws, the IQR for policies related to firearm possession among these offenders, would be associated with a 5.31% reduction in workplace homicides. About 7% of workplace homicides are committed by a relative or intimate partner of the victim (Table 1).

Prior studies have shown that laws requiring domestic violence offenders to relinquish their firearms are associated with decreases in firearm-related intimate partner homicide.¹⁰ Such policies may reduce workplace homicides in 2 ways. First, they may directly reduce domestic abusers’ ability to kill their intimate partner (and the partner’s coworkers) while the partner is at work. Second, perpetrators of domestic violence are more likely than the general population to exhibit behaviors (especially stalking) that may be precursors to homicides involving people other than the intimate partner.²⁶ Removing guns from abusers may therefore protect their other potential victims.

An IQR increase in concealed carry policies (strengthening 2 laws) was associated with a 5.7% decrease in workplace homicides. Some, but not all, prior research has revealed that when states or cities liberalize concealed carry permitting from “may issue” (in which local law enforcement can deny a permit even if a person has passed a background check) to “shall issue” (in which law enforcement does not have this discretion), firearm homicide rates increase.²⁷ In addition to permitting, concealed carry regulations also dictate places in which people are allowed to carry a

concealed weapon, including schools, colleges, houses of worship, bars, hospitals or medical facilities, prisons, and public sporting events.⁴ Each of these locations represents someone's workplace, as well as a public space. Therefore, changing policies to allow unrestricted concealed carrying of firearms in these settings may increase the risk of homicide for people who work there.

We also found associations between workplace homicides and strengthening of laws surrounding background checks, buyer regulations, dealer regulations, and limits on firearm trafficking, with effect sizes ranging from a 2.75% reduction (buyer regulations) to a 5% reduction (background checks). These policy changes may have been associated with decreases in workplace homicide by reducing gun ownership or the number of firearms in circulation; research has shown a positive relationship between state-level gun ownership rates and state-level homicide rates.²⁸

We did not adjust for gun ownership, as it is likely a mediator of the relationship between the latter categories of firearm laws (background checks, buyer regulations, dealer regulations, and limits on firearm trafficking) and workplace homicide rates. Including this mediating factor in our models could have led to overadjustment and erroneous conclusions that the laws are ineffective.²⁹ Furthermore, consistency between findings in these 4 policy domains as well as areas in which the observed associations are not plausibly driven by gun ownership (concealed carry permitting, child safety laws) suggests that the overall patterns revealed in our analysis are not solely attributable to ownership.

Strengthening of child safety policies was significantly, and unexpectedly, associated with decreases in workplace homicide rates. We hypothesize that an unintended effect of making firearms less accessible to children is that the same firearms are less accessible to theft or misuse by adults other than the original owner. Further research involving other data sets (e.g., individual-level data) will help elucidate potential mechanisms for such associations.

Strengthening of 4 subcategories of firearm laws—possession regulations, assault weapon bans, preemption, and stand-your-ground laws—was not significantly (or nearly significantly) associated with reductions in workplace homicide rates. Not enough states

changed assault weapon or preemption laws to allow us to test effects of policy changes on workplace homicide rates (the IQR for both policy areas was 0). Both possession and stand-your-ground regulations are tangential to workplace homicide risk factors. Possession regulations consist mostly of restrictions on gun ownership to individuals 18 years (or 21 years) and older and restrictions on guns at schools or colleges,⁴ but most working adults are older than 21 years and are not employed in educational settings. Stand-your-ground defenses are typically invoked in conflicts occurring at someone's home, making them less relevant in a workplace context.

Limitations and Strengths

To protect the confidentiality of victims, CFOI provides data only by year and one other characteristic. Because our study design necessitated collecting data by state and year, we were unable to further stratify by other characteristics that could have been informative. These characteristics include events involving firearms versus other kinds of weapons and whether events involved one or multiple victims. With regard to the latter, 79% of workplace homicides during the study period were classified as shootings; non-shooting homicides likely contributed to random error and biased results toward the null. With respect to mass shootings, aggregate CFOI data reveal that only 5% to 8% of workplace homicides involve more than one victim, making mass shootings an unlikely driver of our results.³⁰

Although the Centers for Disease Control and Prevention tracks nonfatal workplace injuries (including homicides) in a separate database, there is insufficient detail in publicly available surveillance data by state and year to capture physical and psychological morbidity related to nonfatal firearm injuries. This limitation is compounded by known underreporting of nonfatal workplace injuries.³¹

Other limitations relate to our study design. We used state-level policy changes and homicide rates; the ecological fallacy is therefore a threat to the validity of our findings. However, the majority of studies of firearm policies and homicide are ecological.⁶ We also cannot account for implementation; policies in some states may be more strictly enforced than policies in other states. Level of

enforcement of firearm policies may be related to unobserved confounders at the state level.

Strengths of our study were 7 years of both policy and homicide data, the substantial amount of policy change activity over the study period, the lack of missing data, the use of a comprehensive policy assessment tool, the robust outcome measure, and the lack of conflict of interest that could come from funding by either gun-rights or gun-control entities. All of these factors have been identified as weaknesses of prior research on firearm policies and homicide.²⁹

Conclusions

Our findings add to a growing body of evidence indicating that although firearm legislation cannot prevent every gun-related death, strengthening such policies is associated with reductions in homicide rates at a population level.^{6,9,10} Our effect sizes were modest, but the pattern we observed is consistent with the population approach to improving public health: small shifts in disease rates as a consequence of policy or practice changes can have a meaningful impact on population health over time.³² With the addition of this study, we have evidence that workplace homicides are another category of outcomes sensitive to changes in firearm policies.

Originally, smoking bans in restaurants and bars were implemented as an occupational health precaution for bartenders and servers.³³ Over time, these policies were shown to benefit respiratory health not only among workers but also patrons.³⁴ Following a similar model, unions, industry groups, and other worker advocates could lobby for more restrictive firearm policies at the state level to protect the health of their workforces and the lives of those they serve. Our findings suggest that strengthening the state-level firearm policy environment within our interquartile range (adding 20.5 firearm laws) would save, on average, the lives of 16 workers each year who would have died from workplace homicides, with further benefits extending to their families, coworkers, and employers. **AJPH**

CONTRIBUTORS

E. L. Sabbath drafted the article and assembled the data. E. L. Sabbath and C. F. Baum designed the study.

C. F. Baum analyzed the data. All of the authors contributed to interpreting the results and editing the article for intellectual content.

ACKNOWLEDGMENTS

We thank Marco Ghiani for his work in managing the policy data.

CONFLICTS OF INTEREST

The authors declare no conflicts of interest.

HUMAN PARTICIPANT PROTECTION

No protocol approval was needed for this study because no human participants were involved.

REFERENCES

- Bauchner H, Rivara FP, Bonow RO, et al. Death by gun violence—a public health crisis. *JAMA Psychiatry*. 2017;74(12):1195–1196.
- Centers for Disease Control and Prevention. CDC-WISQARS: 10 leading causes of death, United States 2017. Available at: <https://www.cdc.gov/injury/wisqars>. Accessed November 20, 2019.
- State Firearm Laws Project. State Firearm Laws Database and codebook 2018. Available at: <http://statefiremlaws.org/resources>. Accessed November 20, 2019.
- Siegel M, Pahn M, Xuan Z, et al. Firearm-related laws in all 50 US states, 1991–2016. *Am J Public Health*. 2017;107(7):1122–1129.
- Metzl JM. Repeal the Dickey amendment to address polarization surrounding firearms in the United States. *Am J Public Health*. 2018;108(7):864–865.
- Lee LK, Flegler EW, Farrell C, et al. Firearm laws and firearm homicides: a systematic review. *JAMA Intern Med*. 2017;177(1):106–119.
- Siegel M, Pahn M, Xuan Z, Flegler E, Hemenway D. The impact of state firearm laws on homicide and suicide deaths in the USA, 1991–2016: a panel study. *J Gen Intern Med*. 2019;34(10):2021–2028.
- Rudolph KE, Stuart EA, Vernick JS, Webster DW. Association between Connecticut's permit-to-purchase handgun law and homicides. *Am J Public Health*. 2015;105(8):e49–e54.
- Safavi A, Rhee P, Pandit V, et al. Children are safer in states with strict firearm laws: a national inpatient sample study. *J Trauma Acute Care Surg*. 2014;76(1):146–150.
- Díez C, Kurland RP, Rothman EF, et al. State intimate partner violence-related firearm laws and intimate partner homicide rates in the United States, 1991 to 2015. *Ann Intern Med*. 2017;167(8):536–543.
- Bureau of Labor Statistics. Injuries, illnesses, and fatalities: workplace homicides. Available at: <https://www.bls.gov/iif/oshwc/cfoi/workplace-homicides.htm>. Accessed November 20, 2019.
- Blake RA, Lating JM, Sherman MF, Kirkhart MW. Probable PTSD and impairment in witnesses of work-related fatalities. *J Loss Trauma*. 2014;19(2):189–195.
- Loomis D, Wolf SH, Runyan CW, Marshall SW, Butts JD. Homicide on the job: workplace and community determinants. *Am J Epidemiol*. 2001;154(5):410–417.
- Konda S, Tiesman HM, Hendricks S, Gurka KK. Non-robbery-related occupational homicides in the retail industry, 2003–2008. *Am J Ind Med*. 2014;57(2):245–253.
- Loomis D, Marshall SW, Ta ML. Employer policies toward guns and the risk of homicide in the workplace. *Am J Public Health*. 2005;95(5):830–832.
- Loomis D, Marshall SW, Wolf SH, Runyan CW, Butts JD. Effectiveness of safety measures recommended for prevention of workplace homicide. *JAMA*. 2002;287(8):1011–1017.
- Bureau of Labor Statistics. Census of Fatal Occupational Injuries. Available at: <https://www.bls.gov/iif/oshfat1.htm>. Accessed November 20, 2019.
- US Census Bureau. Current Population Survey table creator. Available at: <https://www.census.gov/cps/data/cpstablecreator.html?#>. Accessed November 20, 2019.
- Ghiani M, Hawkins SS, Baum CF. Gun laws and school safety. *J Epidemiol Community Health*. 2019;73(6):509–515.
- Price JH, Thompson AJ, Dake JA. Factors associated with state variations in homicide, suicide, and unintentional firearm deaths. *J Community Health*. 2004;29(4):271–283.
- Iowa Community Indicators Program. Annual unemployment rates by state. Available at: <https://www.icip.iastate.edu/tables/employment/unemployment-states>. Accessed November 20, 2019.
- US Census Bureau. Historical poverty tables: people and families—1959 to 2017. Available at: <https://www.census.gov/data/tables/time-series/demo/income-poverty/historical-poverty-people.html>. Accessed November 20, 2019.
- Federal Bureau of Investigation. Crime Data Explorer. Available at: <https://crime-data-explorer.fr.cloud.gov/downloads-and-docs>. Accessed November 20, 2019.
- RAND State Statistics. Historical population density (states only). Available at: [https://www.randstatestats.org/us/stats/historical-population-density-\(states-only\).html](https://www.randstatestats.org/us/stats/historical-population-density-(states-only).html). Accessed November 20, 2019.
- Hardin JW, Hilbe JM. *Generalized Linear Models and Extensions*. College Station, TX: Stata Press; 2007.
- Aldridge ML, Browne KD. Perpetrators of spousal homicide: a review. *Trauma Violence Abuse*. 2003;4(3):265–276.
- Hamill ME, Hernandez MC, Bailey KR, Zielinski MD, Matos MA, Schiller HJ. State level firearm concealed-carry legislation and rates of homicide and other violent crime. *J Am Coll Surg*. 2019;228(1):1–8.
- Monuteaux MC, Lee LK, Hemenway D, Mannix R, Flegler EW. Firearm ownership and violent crime in the US: an ecologic study. *Am J Prev Med*. 2015;49(2):207–214.
- Santaella-Tenorio J, Cerdá M, Villaveces A, Galea S. What do we know about the association between firearm legislation and firearm-related injuries? *Epidemiol Rev*. 2016;38(1):140–157.
- Bureau of Labor Statistics. Census of fatal occupational injuries, 2017. Available at: <https://www.bls.gov/iif/oshwc/cfoi/cfoi-chart-data-2017.htm>. Accessed November 20, 2019.
- Gray W, Mendeloff J. *Fatality Rates in Construction Vary 3-Fold by State: Do OSHA and Workers' Compensation Play a Role?* Silver Spring, MD: Center for Construction Research and Training; 2019.
- Rose G. Sick individuals and sick populations. *Int J Epidemiol*. 2001;30(3):427–432.
- Eisner MD, Smith AK, Blanc PD. Bartenders' respiratory health after establishment of smoke-free bars and taverns. *JAMA*. 1998;280(22):1909–1914.
- Pickett MS, Schober SE, Brody DJ, Curtin LR, Giovino GA. Smoke-free laws and secondhand smoke exposure in US non-smoking adults, 1999–2002. *Tob Control*. 2006;15(4):302–307.