

# State firearm laws and workplace homicides in the United States

Erika Sabbath, Summer S Hawkins, Christopher F Baum

London Stata Meetings, 2019

August 22, 2019

# Introduction

Firearm regulations in the US have been featured in the media after the most recent tragic mass shootings in El Paso, Texas and Dayton, Ohio. One of the key aspects of legislation related to firearms is its wide variability over the 50 states and the District of Columbia. What is legal in one state may not be in another, and regulations change over time.

US firearm deaths—whether homicide, suicide or accident—have been characterized as a public health crisis (Bauchner et al., *JAMA Psychiatry*, 2017). Homicide by firearm is the ninth-leading cause of death among working-age adults (CDC) and gun-related deaths exceed those from motor vehicle accidents.

Public health research has been stymied by Congressional restrictions.

# Introduction

Firearm regulations in the US have been featured in the media after the most recent tragic mass shootings in El Paso, Texas and Dayton, Ohio. One of the key aspects of legislation related to firearms is its wide variability over the 50 states and the District of Columbia. What is legal in one state may not be in another, and regulations change over time.

US firearm deaths—whether homicide, suicide or accident—have been characterized as a public health crisis (Bauchner et al., *JAMA Psychiatry*, 2017). Homicide by firearm is the ninth-leading cause of death among working-age adults (CDC) and gun-related deaths exceed those from motor vehicle accidents.

Public health research has been stymied by Congressional restrictions.

# Introduction

Firearm regulations in the US have been featured in the media after the most recent tragic mass shootings in El Paso, Texas and Dayton, Ohio. One of the key aspects of legislation related to firearms is its wide variability over the 50 states and the District of Columbia. What is legal in one state may not be in another, and regulations change over time.

US firearm deaths—whether homicide, suicide or accident—have been characterized as a public health crisis (Bauchner et al., *JAMA Psychiatry*, 2017). Homicide by firearm is the ninth-leading cause of death among working-age adults (CDC) and gun-related deaths exceed those from motor vehicle accidents.

Public health research has been stymied by Congressional restrictions.

*After a deadly shooting, the debate always, it seems, breaks down like this: One side argues for gun control, and the other argues there is no research proving those measures work. There is, in fact, little research into gun violence at all—especially compared to other causes of death in the United States.*

*The modern origins of the impasse can be traced to 1996, when Congress passed an amendment to a spending bill that forbade the Centers for Disease Control and Prevention from using money to “advocate or promote gun control.”*

*The actual amendment sponsored by Jay Dickey, a congressman from Arkansas, did not explicitly forbid research into gun-related deaths, just advocacy. But the Congress also lowered the CDC’s budget by the exact amount it spent on such research. Message received. It’s had a chilling effect on the entire field for decades. (Atlantic, Feb. 15, 2018)*

A number of states have weakened regulations related to licensing, possession and the carrying of firearms over the last decade, while other states have imposed additional restrictions.

From an econometric perspective, this variability across states and over time makes it feasible to analyze several outcomes and their associations to firearms legislation. It also creates challenges: how are we to quantify the strength or weakness of a broad set of laws? Thankfully, prior research by Siegel and colleagues (*Am.J.Pub.Health*, 2017) has provided such an index, based on 133 regulations, grouped into 13 different types of state-level gun laws.

A number of states have weakened regulations related to licensing, possession and the carrying of firearms over the last decade, while other states have imposed additional restrictions.

From an econometric perspective, this variability across states and over time makes it feasible to analyze several outcomes and their associations to firearms legislation. It also creates challenges: how are we to quantify the strength or weakness of a broad set of laws? Thankfully, prior research by Siegel and colleagues (*Am.J.Pub.Health*, 2017) has provided such an index, based on 133 regulations, grouped into 13 different types of state-level gun laws.

In prior work, Ghiani, Hawkins and Baum (*Am.J.Epidemiology*, 2019) analyzed the prevalence of firearm suicides across the US over a 10-year period. More than half of all suicides (and a higher percentage of male suicides) are carried out with firearms. Likewise, over 60% of firearm-related deaths in the US (including homicides and accidents) are suicides. The firearm suicide rate has been rising since 1999.

In that work, the authors analyzed the associations of firearm suicides with the Siegel et al. index of firearms legislation, and found significant effects for a number of its subindices as well as for the overall index.



In prior work, Ghiani, Hawkins and Baum (*Am.J.Epidemiology*, 2019) analyzed the prevalence of firearm suicides across the US over a 10-year period. More than half of all suicides (and a higher percentage of male suicides) are carried out with firearms. Likewise, over 60% of firearm-related deaths in the US (including homicides and accidents) are suicides. The firearm suicide rate has been rising since 1999.

In that work, the authors analyzed the associations of firearm suicides with the Siegel et al. index of firearms legislation, and found significant effects for a number of its subindices as well as for the overall index.

# Workplace homicides and firearms legislation

In this paper, currently being revised and resubmitted to *American Journal of Public Health*, we look at an important subset of firearms deaths: those related to the workplace. These events, usually involving a coworker, represent over 400 deaths per year for the last decade, and have involved a number of mass shootings such as the tragedy at a municipal building in Virginia Beach, Virginia last May 31, instigated by a “longtime public utilities employee.” (*New York Times*, May 31, 2019)

# *12 Killed in Rampage at Municipal Center in Virginia*



Police officers remained outside the Virginia Beach Municipal Center after a gunman killed 12 people there on Friday. Benjamin Donald Boshart for The New York Times

Despite the burden of disease attributable to gun-related causes, the US has had little federal legislation to regulate purchasing, distribution, storage, or use of firearms.

Most firearm-related legislative activity has occurred at the state level. Since the early 1990s, every state has passed policies either tightening or weakening restrictions on the sale, possession, and use of firearms.

On average, states have become slightly more restrictive in their firearm policies in the past 30 years, particularly related to limitations on gun ownership for 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.

Despite the burden of disease attributable to gun-related causes, the US has had little federal legislation to regulate purchasing, distribution, storage, or use of firearms.

Most firearm-related legislative activity has occurred at the state level. Since the early 1990s, every state has passed policies either tightening or weakening restrictions on the sale, possession, and use of firearms.

On average, states have become slightly more restrictive in their firearm policies in the past 30 years, particularly related to limitations on gun ownership for 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.

Despite the burden of disease attributable to gun-related causes, the US has had little federal legislation to regulate purchasing, distribution, storage, or use of firearms.

Most firearm-related legislative activity has occurred at the state level. Since the early 1990s, every state has passed policies either tightening or weakening restrictions on the sale, possession, and use of firearms.

On average, states have become slightly more restrictive in their firearm policies in the past 30 years, particularly related to limitations on gun ownership for 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.

Each year, approximately 400 homicides by firearm occur when people are at work, accounting for about 9% of the approximately 4,800 workplace fatalities occurring in the U.S. annually.

In addition to mortality of the victim, workplace homicide can lead to broader morbidity in the form of long-term trauma to coworkers, who are often witnesses and survivors.

To our knowledge, there has been no research on how the state-level policy environment is associated with likelihood of being killed by another individual at work.

In this study, we tested whether tightening of state-level firearm policies from 2011 through 2017 were associated with decreases in state-level workplace homicide rates. We also tested for associations between changes in sub-categories of firearm policies and workplace homicide rates.

Each year, approximately 400 homicides by firearm occur when people are at work, accounting for about 9% of the approximately 4,800 workplace fatalities occurring in the U.S. annually.

In addition to mortality of the victim, workplace homicide can lead to broader morbidity in the form of long-term trauma to coworkers, who are often witnesses and survivors.

To our knowledge, there has been no research on how the state-level policy environment is associated with likelihood of being killed by another individual at work.

In this study, we tested whether tightening of state-level firearm policies from 2011 through 2017 were associated with decreases in state-level workplace homicide rates. We also tested for associations between changes in sub-categories of firearm policies and workplace homicide rates.



Each year, approximately 400 homicides by firearm occur when people are at work, accounting for about 9% of the approximately 4,800 workplace fatalities occurring in the U.S. annually.

In addition to mortality of the victim, workplace homicide can lead to broader morbidity in the form of long-term trauma to coworkers, who are often witnesses and survivors.

To our knowledge, there has been no research on how the state-level policy environment is associated with likelihood of being killed by another individual at work.

In this study, we tested whether tightening of state-level firearm policies from 2011 through 2017 were associated with decreases in state-level workplace homicide rates. We also tested for associations between changes in sub-categories of firearm policies and workplace homicide rates.

Each year, approximately 400 homicides by firearm occur when people are at work, accounting for about 9% of the approximately 4,800 workplace fatalities occurring in the U.S. annually.

In addition to mortality of the victim, workplace homicide can lead to broader morbidity in the form of long-term trauma to coworkers, who are often witnesses and survivors.

To our knowledge, there has been no research on how the state-level policy environment is associated with likelihood of being killed by another individual at work.

In this study, we tested whether tightening of state-level firearm policies from 2011 through 2017 were associated with decreases in state-level workplace homicide rates. We also tested for associations between changes in sub-categories of firearm policies and workplace homicide rates.

# Workplace homicide data

We identified all workplace homicides occurring in the US between 2011 and 2017 by state and year using the Census of Fatal Occupational Injuries (CFOI) maintained by the Department of Labor's Bureau of Labor Statistics. Only fatalities experienced by workers are included in CFOI counts, even if a single event led to casualties of both workers and patrons or clients.

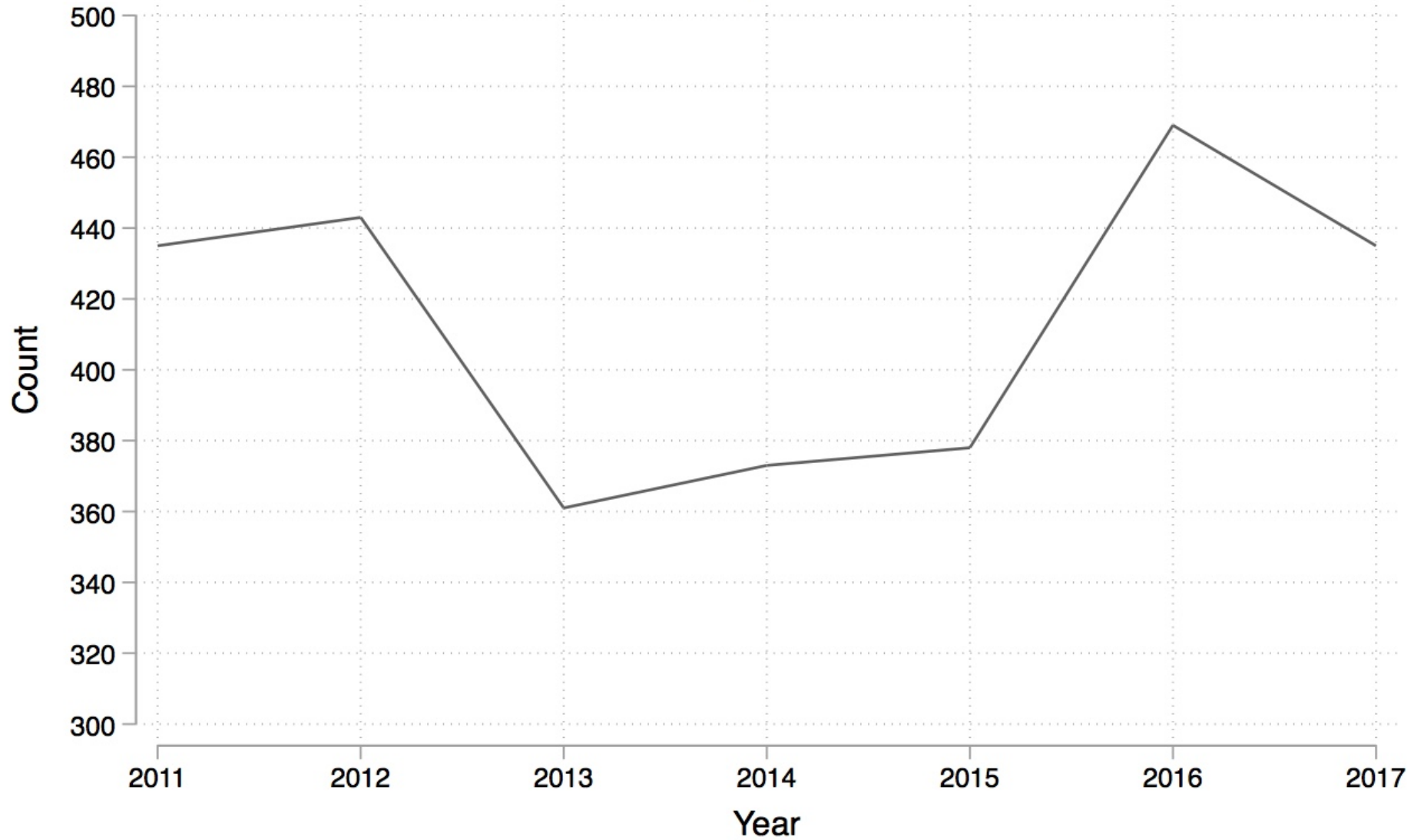
We generated state-year workplace homicide rates by dividing the number of workplace homicides by the number of persons in 100,000s employed in the state that year.

# Workplace homicide data

We identified all workplace homicides occurring in the US between 2011 and 2017 by state and year using the Census of Fatal Occupational Injuries (CFOI) maintained by the Department of Labor's Bureau of Labor Statistics. Only fatalities experienced by workers are included in CFOI counts, even if a single event led to casualties of both workers and patrons or clients.

We generated state-year workplace homicide rates by dividing the number of workplace homicides by the number of persons in 100,000s employed in the state that year.

### Total US workplace homicides



# State-level firearm laws

We obtained firearm policies from the State Firearm Law Database, a publicly-available, nonpartisan, comprehensive database on the presence of firearm policies in each state from 1991 to the present published by Siegel et al. (*AJPH*, 2017) at <http://statefirearmlaws.org/resources>

The database contains dichotomous indicators on the presence or absence of each of 133 firearm-related legislative provisions for each state-year combination during the study period. Each of the 133 laws is coded so that 1 equals more restrictive gun access and 0 equals more liberal gun access. The laws are then summed to create a measure of the overall firearm policy environment within the state, with higher scores equivalent to tighter gun control.

# State-level firearm laws

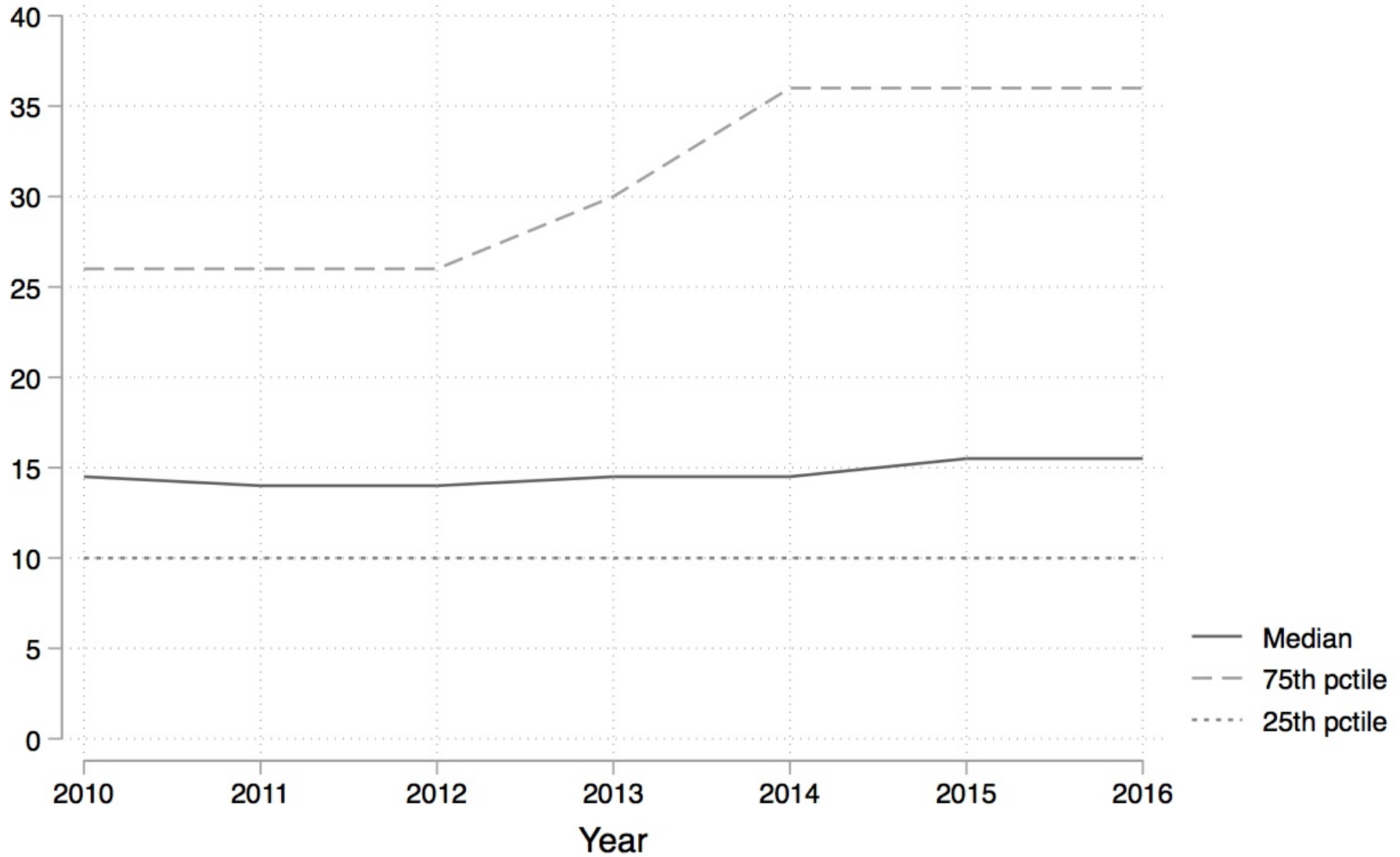
We obtained firearm policies from the State Firearm Law Database, a publicly-available, nonpartisan, comprehensive database on the presence of firearm policies in each state from 1991 to the present published by Siegel et al. (*AJPH*, 2017) at <http://statefirearmlaws.org/resources>

The database contains dichotomous indicators on the presence or absence of each of 133 firearm-related legislative provisions for each state-year combination during the study period. Each of the 133 laws is coded so that 1 equals more restrictive gun access and 0 equals more liberal gun access. The laws are then summed to create a measure of the overall firearm policy environment within the state, with higher scores equivalent to tighter gun control.

The 133 laws each fit into one of 13 policy sub-categories according to the sub-category of firearms law (e.g., laws related to restrictions on domestic violence offenders, or concealed carry permitting). Those sub-categories contain between 1–21 laws. Within each sub-category, the number of laws is summed, coded so that higher scores are equivalent to stronger firearm regulations.



### Percentiles of firearms index



# Covariates

We adjusted for covariates associated with state-level variation in homicide, suicide, and accidental firearm mortality rates, including unemployment rate, percentage of residents below the federal poverty line, racial/ethnic composition (percent Black, percent Hispanic), percent college-educated, percent male, violent crime rate (exclusive of homicide), population density, and proportion of the population that is of working age (18-64).

Percent Hispanic, population density, and proportion of population aged 18-64 were not significantly associated with workplace homicide rates in any models and so were not retained for analysis.

# Covariates

We adjusted for covariates associated with state-level variation in homicide, suicide, and accidental firearm mortality rates, including unemployment rate, percentage of residents below the federal poverty line, racial/ethnic composition (percent Black, percent Hispanic), percent college-educated, percent male, violent crime rate (exclusive of homicide), population density, and proportion of the population that is of working age (18-64).

Percent Hispanic, population density, and proportion of population aged 18-64 were not significantly associated with workplace homicide rates in any models and so were not retained for analysis.

# Empirical methodology

To model annual state-level workplace homicides, a non-negative integer variable, we evaluated random-effects multiple regression, random-effects Poisson regression and generalized linear models (GLM). For the GLM approach, the workplace homicide rate (per 100,000) was the outcome variable.

The GLM is fit with a log link and gamma-distributed errors, using robust standard errors clustered by state. We specified a log-gamma model because it requires no external transformation and is more straightforward to interpret.

Following Hardin and Hilbe (*Generalized Linear Models and Extensions*, 2007), the AIC and BIC criteria indicated that the log-gamma GLM produced the best fit.

# Empirical methodology

To model annual state-level workplace homicides, a non-negative integer variable, we evaluated random-effects multiple regression, random-effects Poisson regression and generalized linear models (GLM). For the GLM approach, the workplace homicide rate (per 100,000) was the outcome variable.

The GLM is fit with a log link and gamma-distributed errors, using robust standard errors clustered by state. We specified a log-gamma model because it requires no external transformation and is more straightforward to interpret.

Following Hardin and Hilbe (*Generalized Linear Models and Extensions*, 2007), the AIC and BIC criteria indicated that the log-gamma GLM produced the best fit.

# Empirical methodology

To model annual state-level workplace homicides, a non-negative integer variable, we evaluated random-effects multiple regression, random-effects Poisson regression and generalized linear models (GLM). For the GLM approach, the workplace homicide rate (per 100,000) was the outcome variable.

The GLM is fit with a log link and gamma-distributed errors, using robust standard errors clustered by state. We specified a log-gamma model because it requires no external transformation and is more straightforward to interpret.

Following Hardin and Hilbe (*Generalized Linear Models and Extensions*, 2007), the AIC and BIC criteria indicated that the log-gamma GLM produced the best fit.

The key variable explaining workplace homicide rate was the prior year's firearm laws index in that state. We included a lag in the firearm index to reduce potential error caused by policies only being in effect for parts of a given year, as our workplace homicide data are only available annually.

Using the same model, we examined 13 sub-categories of firearm policies that had at least one state policy change in that sub-category over the study period.

The key variable explaining workplace homicide rate was the prior year's firearm laws index in that state. We included a lag in the firearm index to reduce potential error caused by policies only being in effect for parts of a given year, as our workplace homicide data are only available annually.

Using the same model, we examined 13 sub-categories of firearm policies that had at least one state policy change in that sub-category over the study period.



We present average marginal effects to describe the predicted change in the probability of 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 policies that a state would need to add or strengthen to move from being in the weakest quartile of firearm policies to the strongest quartile. Across all policy areas, this would mean adopting 20.5 firearm laws.

We present average marginal effects to describe the predicted change in the probability of 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 policies that a state would need to add or strengthen to move from being in the weakest quartile of firearm policies to the strongest quartile. Across all policy areas, this would mean adopting 20.5 firearm laws.

From 2011 through 2017 was an active period for the enactment and implementation of firearm regulation. Across all years of the study period, the average state had 26 policies restricting firearms. Overall, 23 states strengthened firearm regulations, 23 states weakened regulations, and nine states did not change firearm policies during this period.

The legislative sub-categories with the most activity were domestic violence-related policies (17 states strengthened and three states weakened regulations), possession regulations (four states strengthened and 10 states weakened regulations), and concealed carry permitting (six states strengthened and eight states weakened regulations).

From 2011 through 2017 was an active period for the enactment and implementation of firearm regulation. Across all years of the study period, the average state had 26 policies restricting firearms. Overall, 23 states strengthened firearm regulations, 23 states weakened regulations, and nine states did not change firearm policies during this period.

The legislative sub-categories with the most activity were domestic violence-related policies (17 states strengthened and three states weakened regulations), possession regulations (four states strengthened and 10 states weakened regulations), and concealed carry permitting (six states strengthened and eight states weakened regulations).

# Findings

We found a negative association between strengthening firearm policies and homicide rates. As policies became more restrictive, homicide rates were lower ( $\beta = -0.005$ , 95% CI  $-0.0087$  to  $-0.0023$ ,  $p=0.001$ ).

An IQR positive increase in state firearm policies (adding 20.5 firearm policies) was associated with, on average, a 3.68% decrease in the workplace homicide rate.

We modeled the associations between 13 sub-categories of firearm policies and workplace homicide rates. We found that, in eight of the 13 sub-categories, strengthening policies was associated with statistically significant reductions in workplace homicide rates.

# Findings

We found a negative association between strengthening firearm policies and homicide rates. As policies became more restrictive, homicide rates were lower ( $\beta = -0.005$ , 95% CI  $-0.0087$  to  $-0.0023$ ,  $p=0.001$ ).

An IQR positive increase in state firearm policies (adding 20.5 firearm policies) was associated with, on average, a 3.68% decrease in the workplace homicide rate.

We modeled the associations between 13 sub-categories of firearm policies and workplace homicide rates. We found that, in eight of the 13 sub-categories, strengthening policies was associated with statistically significant reductions in workplace homicide rates.

# Findings

We found a negative association between strengthening firearm policies and homicide rates. As policies became more restrictive, homicide rates were lower ( $\beta = -0.005$ , 95% CI  $-0.0087$  to  $-0.0023$ ,  $p=0.001$ ).

An IQR positive increase in state firearm policies (adding 20.5 firearm policies) was associated with, on average, a 3.68% decrease in the workplace homicide rate.

We modeled the associations between 13 sub-categories of firearm policies and workplace homicide rates. We found that, in eight of the 13 sub-categories, strengthening policies was associated with statistically significant reductions in workplace homicide rates.

**Table 1:** Effects of policy strengthening on workplace homicide rate

	$\hat{\beta}$	Policies in IQR	Effect of $\Delta$ IQR
Overall index	-0.0055	20.5	-3.68%
Concealed carry	-0.0913	2	-5.79%
Domestic violence	-0.0256	6.5	-5.31%
Background checks	-0.0351	4.5	-5.07%
Dealer regulations	-0.0304	5	-4.88%
Child safety	-0.0407	3	-3.99%
Gun trafficking	-0.0584	2	-3.82%
Buyer regulations	-0.0276	3	-2.75%
Ammunition regulations	-0.0680	1	-2.28%



A caveat regarding mass shootings: 79% of workplace homicides during the study period were classified as shootings. However, only 5–8% of workplace homicide events involve more than one victim, making mass shootings an unlikely driver of our results.

# Summary findings

These findings add to a growing body of evidence that, although firearm legislation cannot prevent every gun-related death, the policies are associated with reductions in homicide rates at a population level. With the addition of this study, we have evidence that workplace homicides are another category of outcomes sensitive to changes in firearm policies.

Our findings suggest that strengthening the state-level firearm policy environment within the interquartile range (adding 20.5 firearm policies) would save, on average, 16 workers' lives each year who would have died from homicides in the workplace, with further benefits extending to their families, coworkers, and employers.

The effect sizes are modest, but the pattern we observe 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.

# Summary findings

These findings add to a growing body of evidence that, although firearm legislation cannot prevent every gun-related death, the policies are associated with reductions in homicide rates at a population level. With the addition of this study, we have evidence that workplace homicides are another category of outcomes sensitive to changes in firearm policies.

Our findings suggest that strengthening the state-level firearm policy environment within the interquartile range (adding 20.5 firearm policies) would save, on average, 16 workers' lives each year who would have died from homicides in the workplace, with further benefits extending to their families, coworkers, and employers.

The effect sizes are modest, but the pattern we observe 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.

# Summary findings

These findings add to a growing body of evidence that, although firearm legislation cannot prevent every gun-related death, the policies are associated with reductions in homicide rates at a population level. With the addition of this study, we have evidence that workplace homicides are another category of outcomes sensitive to changes in firearm policies.

Our findings suggest that strengthening the state-level firearm policy environment within the interquartile range (adding 20.5 firearm policies) would save, on average, 16 workers' lives each year who would have died from homicides in the workplace, with further benefits extending to their families, coworkers, and employers.

The effect sizes are modest, but the pattern we observe 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.