Article

Firearm Purchaser Licensing Laws and Firearm Deaths Among Adolescents and Emerging Adults

Youth & Society
2024, Vol. 56(8) 1522–1541

DOI: 10.1177/0044118X241273418
journals.sagepub.com/home/yas
Sage

Cassandra K. Crifasi[1], Rachel J. Topazian[1], Alex D. McCourt[1], Stephen N. Oliphant[2], April M. Zeoli[2], Katrina S. Kennedy[1], Elizabeth D. Wagner[1], and Mitchell L. Doucette[1]

Abstract

Research on firearm purchaser licensing laws has found population level reductions in firearm-related mortality. Limited research has been conducted specifically examining the impact of these laws among adolescents and emerging adults. We obtained death data from the National Center for Health Statistics from 1990 to 2019. We generated state-year rates of homicide and suicide, stratified by firearm involvement, for decedents aged 15 to 24. We stratified by race and ethnicity (white, Black, and Hispanic) to assess for differential policy effects. We used stacked difference-in-difference and augmented synthetic control modeling to estimate law repeal or adoption. Repeal of firearm purchaser licensing laws was associated with significantly higher rates of firearm homicide and suicide among those age 15 to 24. The adoption of these laws was associated with significantly lower rates of firearm homicide and suicide among this group. These laws are a

[1]Johns Hopkins Bloomberg School of Public Health, Baltimore, MD, USA
[2]University of Michigan, Ann Arbor, MI, USA

Data Availability Statement included at the end of the article.

Corresponding Author:
Cassandra K. Crifasi, Center for Gun Violence Solutions, Department of Health Policy and Management, Johns Hopkins Bloomberg School of Public Health, 750 E Pratt St, Baltimore, MD 20202-3142, USA.
Email: crifasi@jhu.edu

promising supply-side intervention to reduce firearm mortality among those with elevated violence vulnerability.

Keywords
policy evaluation, firearms, homicide, and suicide

Introduction

The burden of firearm death disproportionately impacts young people in the United States (US). According to provisional death certificate data for 2022 from the Centers for Disease Control and Prevention, there were 9,363 fatal firearm injuries among those ages 15 to 24 in the US: 5,814 firearm homicides and 3,246 firearm suicides (CDC, 2023b). This age group accounted for more than 19% of firearm fatalities in 2022 despite comprising only 13% of the US population (CDC, 2023b). But this burden is not distributed equally across adolescents and emerging adults due to issues such as structural racism, economic marginalization, residential segregation, and concentrated disadvantage (Sampson et al., 2002; Semenza et al., 2021). Black adolescents and emerging adults comprise only 15% of those age 15 to 24 in the US but account for 50% of fatal firearm injuries in this age group (CDC, 2023b). Comparatively, white adolescents and emerging adults comprise 73% of those age 15 to 24 but only 47% of fatal firearm injuries and Hispanic adolescents and emerging adults are 25% of the population and 18% of fatal firearm injuries in this age group (CDC, 2023b). While the number of firearm deaths among those age 15 to 24 in 2022 appears to be down slightly from the high in 2021, this burden has been increasing steadily since 2014 (Davis et al., 2023). Firearms were the leading cause of death among this age group—far surpassing the next leading causes of death: poisoning (6,955 deaths) and motor vehicle traffic (6,842 deaths) (CDC, 2023b).

Despite being a demographic group with high rates of firearm-related mortality, many adolescents cannot legally purchase firearms because of age restrictions for purchase or possession. Those who might be otherwise prohibited from buying firearms may get them through various mechanisms such as sales by private individuals, licensed dealers engaged in risky sales practices, or straw purchasing where a non-prohibited individual buys a gun on behalf of someone else (Braga & Kennedy, 2001). Even among emerging adults, who can often legally buy firearms, the concept of delaying impulsive firearm purchasing could lower firearm mortality. For example, research examining firearm acquisition in California found the risk of suicide peaked immediately after individuals acquired their first firearm (Studdert et al., 2020).

Fatal firearm injuries are a complex issue that require multifaceted prevention strategies at the individual, community, and societal levels (Fowler et al., 2015; Goldstick et al., 2019; Schmidt et al., 2022). Policy is one important tool to address this issue (Bugeja et al., 2011; Hawe & Potvin, 2009). Effective firearm policies can impact the availability of firearms among those who may be too risky to lawfully own them (RAND, 2023). Firearm purchaser licensing laws (also sometimes referred to as permit-to-purchase) are one state-level policy that have shown particular promise. These laws separate the screening and eligibility determination from the process of purchasing a firearm, particularly for first time gun purchasers, and go beyond federal background check requirements (JHCGVS, 2022). Firearm purchaser licensing laws complement the federal background check system by requiring prospective purchasers to apply for and obtain a firearm purchaser license from state or local law enforcement. The process varies across states, but generally consists of the following components: (1) a more thorough background check that involves local, state, and federal records, often facilitated by a fingerprint; (2) more time to complete the background check; and (3) a requirement that sellers, both licensed and private, can only sell to someone with a valid license (JHCGVS, 2022). Some laws also require first time firearm purchasers to undergo safety training. This system addresses several gaps in federal law by accessing records that might not yet have been reported into the federal system, affording more than the three business days allowed under federal law to complete a background check before selling a gun, and closing the background check exemption for private sales.

Prior research has documented robust public safety benefits associated with firearm purchaser licensing laws. States with these laws see lower rates of diversion of guns for use in crime (Crifasi et al., 2017; Li et al., 2023; D. Webster et al., 2013). These laws are also associated with lower rates of firearm homicide (Crifasi et al., 2018; Hasegawa et al., 2019; Rudolph et al., 2015; D. Webster et al., 2014), including mass shootings (D. W. Webster et al., 2020), firearm suicide (Crifasi et al., 2015; McCourt et al., 2020), and shootings by police (Crifasi et al., 2023). Less attention has been paid to the effectiveness of firearm purchaser licensing laws among specific populations or demographic subgroups such as adolescents and emerging adults who may be more vulnerable to violence involvement (Zeoli et al., 2019). However, firearm purchaser licensing laws may be particularly relevant for young people, some of whom cannot lawfully acquire firearms on their own, as more robust background check requirements might interrupt the pathways to unlawful firearm access. For example, prior research suggests minimum age laws for handgun purchase is associated with lower rates of adolescent suicide (Raifman et al., 2020);

and adolescents in states with comprehensive background checks had lower rates of self-reported gun carrying than those living in states without these laws. As firearm purchaser licensing laws ensure more robust background check processes to identify and screen out those prohibited from legally buying guns, a more thorough analysis of the impact of these laws on firearm mortality among adolescents and emerging adults is warranted. Additionally, limited prior research has examined whether policies have different effects across race and ethnicity. Identifying differential policy effects, whether beneficial or harmful, is a key step in understanding policy effects (Jones, 2001). Not simply because of disparities in firearm mortality, but also because policies might have heterogeneous effects across demographic groups based on social determinants of health and structural racism that influence vulnerability for violence involvement (Sampson et al., 2002; Semenza et al., 2021). Adjusting or controlling for race and ethnicity in statistical models is insufficient. To advance the field, we need to stratify across outcomes to understand if and how policies are affecting different groups to mitigate potential health inequities that might result from policy choices. Given the burden of firearm mortality among those age 15 to 24 in the US and prior research on the effectiveness of firearm purchaser licensing laws at the broader population level, this study sought to examine whether these laws were associated with firearm mortality outcomes among adolescents and emerging adults. Additionally, we sought to understand whether there were differential policy effects across race and ethnicity among this age group. To that end, we sought to answer three specific research questions:

1. What effect do firearm purchaser licensing laws have on firearm homicide among adolescents and emerging adults?
2. What effect do firearm purchaser licensing laws have on firearm suicide among adolescents and emerging adults?
3. Do the effects of firearm purchaser licensing laws differ when firearm mortality is stratified by race and ethnicity?

Methods

We conducted a quasi-experimental longitudinal study using two comparative interrupted time series designs—stacked difference-in-difference (DiD) and augmented synthetic control method (ASCM)—to assess the impact of adopting or repealing a firearm purchaser licensing law on homicide and suicide among those aged 15 to 24. Because of a lack of systematic nonfatal firearm injury data, this analysis was restricted to mortality.

Data and Measures

We obtained restricted access mortality data from the National Center for Health Statistics compiled from death certificate information across all 50 states from 1990 through 2019. Given the change in how race is coded that began in 2020, we could not extend the dataset beyond 2019 (CDC, 2023a). Because of missing data for Hispanic decedents, Oklahoma and New Hampshire were excluded from the analysis and data was interpolated for Louisiana for 1990. We generated rates of homicide and suicide which were stratified by firearm involvement (firearm vs. non-firearm) and indexed by state and year for those aged 15 to 24. Additionally, we generated outcome rates stratified by decedent race and ethnicity (white, Black, and Hispanic). We utilized non-firearm homicides and suicides as negative controls to test for unmeasured confounding in our models that might bias our estimates of effect.

Four states made changes to their firearm purchaser licensing policies during the study period. Two states adopted these laws: Connecticut (1995) and Maryland (2013). One state fully repealed: Missouri (2007). And one state partially repealed: Michigan (2012—In 2012, Michigan removed the requirement to get a firearm purchaser license when buying a firearm from a licensed dealer. Effective March 2024 those wanting to purchase a firearm in Michigan must obtain a firearm purchaser license for all firearm sellers). Recognizing that states may have implemented other laws that could impact our outcome of interest, we include other potentially relevant firearm laws in our stacked DiD models. In addition to firearm purchaser licensing, we included concealed carry weapons laws (i.e., May, Shall, Permitless), stand your ground, violent misdemeanor firearm prohibitions, final domestic violence restraining order firearm prohibitions, domestic violence misdemeanor firearm prohibitions, and child access prevention laws. Based on prior legal research (Doucette et al., 2022), we coded our policy variables as 1 in the first year in which the law was in effect for at least 6 months and each subsequent year that a state had a policy, and 0 otherwise.

We also adjusted for several state-level demographic characteristics that could influence whether states might have other protective policies in place and baseline rates of violence. Indexed by state-year, we included the following covariates: law enforcement officers per capita, gini coefficient, percent population living in a metropolitan statistical area, robbery rate, poverty rate, per capita income, unemployment rate, educational attainment (percentage of the population age 25 or older with a high school degree or equivalent), overdose rate, percent male, percent married, and percent veteran.

Analytic Methods

For both the stacked DiD and ASCM, we ran separate models for each of our outcomes, homicide and suicide by firearm, and our negative controls—homicide and suicide by other means. To assess whether there may be differential policy effects across groups, we also ran separate models for the stratified outcomes by race and ethnicity as noted above. To account for some states in the sample adopting firearm purchaser licensing laws ("Adopters"—Connecticut [1995] and Maryland [2013]) and others repealing PTP laws ("Repealers"—Missouri [2007]), we ran separate models estimating the effects of adoption and repeal. This resulted in eight firearm mortality models and eight negative control (non-firearm mortality) models for each in the stacked DiD and ASCM. Because Michigan partially repealed its PTP law (2012), we only included Missouri in the Repealer models for the stacked DiD presented in this paper. We estimated state-specific effects of Michigan's partial repeal in the ASCM.

Stacked Difference-in-Difference (DiD). To avoid potential bias from comparing late to early adopters among Repealers and Adopters (Cengiz et al., 2019), we employed the stacked DiD approach. This method, illustrated in Cengiz et al (Cengiz et al., 2019), generates robust estimators for staggered treatment timing. Stacked DiD builds g number of stacks, or bundles, where g=the number of Adopter/Repealer groups. As an example, the Adopter models in this paper had two groups, 1995 (CT) and 2013 (MD). For each stack, the group is compared to the untreated group ($D_{it}=0$), excluding data from the other treatment groups by reconstructing the dataset into time relative to treatment centered on the first year of adoption. The method then appends all the treatment cohorts and their controls and estimates a conventional two-way fixed effects model controlling for group and time fixed effects, and included covariates, to produce an average treatment effect on the treated (ATT). To stabilize the variance and account for zero counts in some of the outcomes, we transformed the outcome variable by taking the natural logarithm of the rate plus one. Models were run using log + 1 rates per 100,000 population for overall and stratified outcomes. Results are initially reported using these transformed rates for precision. Results are presented as ATTs—the rate per 100,000 in the treated group compared to the counterfactual. ATTs greater than 0 indicate a higher rate in the "treated" group (i.e., the states experiencing the policy change). ATTs less than 0 indicate a lower rate in the treated group.

To facilitate interpretation, we also provided back-transformed results to approximate the additive differences in the actual rates. These are presented

as rates per 100,000 population. Analyses were conducted in Stata 16.1 using the command stackedev.

Synthetic Control Modeling (SCM) and Augmented Synthetic Control Method (ASCM). To understand the impact of state-specific impacts of changes to firearm purchaser licensing laws, we used the augmented synthetic control method (ASCM). This is an extension of the synthetic control method (SCM). The SCM generates a weighted combination of donor (i.e., untreated) units to minimize the pre-intervention difference between the synthetic and observed units which is then used to forecast the outcome. Adopters were compared to Never Treated and Repealers compared to Always Treated.

Adopters: Connecticut and Maryland

Never Treated: Alabama, Alaska, Arizona, Arkansas, California, Colorado, Delaware, Florida, Georgia, Idaho, Indiana, Kansas, Kentucky, Louisiana, Maine, Minnesota, Mississippi, Montana, Nevada, New Mexico, North Dakota, Ohio, Oregon, Pennsylvania, Rhode Island, South Carolina, South Dakota, Tennessee, Texas, Utah, Vermont, Virginia, Washington, West Virginia, Wisconsin, and Wyoming.

Repealers: Missouri and Michigan (partial)

Always Treated: Hawaii, Illinois, Iowa, Massachusetts, Nebraska, New Jersey, New York, North Carolina.

The difference between the synthetic forecast and the trend in the intervention unit (i.e., Repealer/Adopter) is the estimated policy effect. The ASCM introduces a penalty term through a ridge regression to reduce error and improve the pre-intervention fit between the synthetic and observed units. ASCM then leads to a better forecast and more precise estimate of policy effects. We used the synth and augsynth packages in *R* version 4.3.3 for the SCM and ASCM, respectively.

This research was reviewed and deemed not human subjects research by the Johns Hopkins Bloomberg School of Public Health Institutional Review Board.

Results

Stacked DiD

The estimated effects of repealing or adopting a firearm purchaser licensing law on firearm homicide and suicide among adolescents and emerging adults

Table 1. Stacked DiD Model Estimates of Repealing or Adopting a Firearm Purchaser Licensing Law on Firearm Homicide and Suicide Among those Aged 15 to 24.

Outcomes Stratified by Race and Ethnicity	Firearm homicide		Firearm suicide	
	ATT	*SE*	ATT	*SE*
Repeal				
Overall 15–24	**3.042**	**0.360**	**2.693**	**0.266**
Black 15–24	6.686	4.156	**5.390**	**1.423**
Hispanic 15–24	2.245	2.371	**3.656**	**1.727**
White 15–24	**1.224**	**0.564**	**2.025**	**0.412**
Adoption				
Overall 15–24	**−1.912**	**0.566**	**−0.867**	**0.326**
Black 15–24	−0.901	2.074	−2.653	1.416
Hispanic 15–24	−4.870	3.523	1.861	0.949
White 15–24	−0.547	0.670	**−0.637**	**0.281**

Note. Bold indicates significance at $p < .05$.

(15–24) are presented in Table 1. Overall, repeal of a firearm purchaser licensing law (i.e., Missouri) was associated with increased rates of firearm homicide. The ATT for firearm homicide among adolescents and emerging adults was 3.042 higher in Missouri compared to states that retained their law (*SE* = 0.360). This translates to a rate that was 19.95 per 100,000 higher in Missouri. Rates were significantly higher for white individuals in this age group (ATT = 1.224, *SE* = 0.564), corresponding to an increase of 2.4 per 100,000 population. Missouri's repeal was also associated with increased rates of firearm suicide among adolescents and emerging adults and across all demographic strata. Overall, the ATT for firearm suicide in this age group was 2.693 higher in Missouri post-repeal than states where the law remained in effect (*SE* = 0.266), indicating an increase of 13.78 per 100,000 population. Across demographic strata, the ATTs for firearm suicide were significantly higher for adolescents and emerging adults who were identified as Black (ATT = 5.390, *SE* = 1.423), Hispanic (ATT = 3.656, *SE* = 1.727), and white (ATT = 2.025, *SE* = 0.412). This translates to firearm suicide rates that were 218.20 per 100,000, 37.71 per 100,000, and 6.58 per 100,000 higher, respectively.

The adoption of firearm purchaser licensing laws was associated with decreased rates of firearm homicide for adolescents and emerging adults (age 15–24). The ATT for firearm homicide was 1.912 lower in adopting states (i.e., Connecticut and Maryland) compared to states that did not implement

Table 2. Stacked DiD Model Estimates of Repealing or Adopting a Firearm Purchaser Licensing Law on Non-Firearm Homicide and Suicide Among those Aged 15 to 24.

Outcomes Stratified by Race and Ethnicity	Non-firearm homicide		Non-firearm suicide	
	ATT	*SE*	ATT	*SE*
Repeal				
Overall 15–24	−0.263	0.151	−0.714	0.601
Black 15–24	**−2.586**	**0.514**	−0.252	1.156
Hispanic 15–24	**−2.938**	**1.152**	−1.791	1.956
White 15–24	0.119	0.113	−0.081	0.643
Adoption				
Overall 15–24	0.005	0.094	−0.452	0.280
Black 15–24	**−1.213**	**0.491**	**1.701**	**0.751**
Hispanic 15–24	1.284	0.779	**2.244**	**0.402**
White 15–24	**0.541**	**0.110**	**−0.931**	**0.211**

Note. Bold indicates significance at $p < .05$.

firearm purchaser licensing requirements ($SE = 0.566$). This translated to a rate of firearm homicide that was 5.77 per 100,000 lower. The adoption of firearm purchaser licensing laws was also associated with decreased rates of firearm suicide among adolescents and emerging adults. The ATT for firearm suicide was 0.867 lower for states that adopted firearm purchaser licensing compared to those that did not ($SE = 0.326$), indicating a rate that was 1.38 per 100,000 population lower. There were significantly lower rates of firearm suicide for white adolescents and emerging adults (ATT = −0.637, $SE = 0.281$), translating to a rate that was 0.89 per 100,000 population lower.

Table 2 provides estimates of repealing or adopting a firearm purchaser licensing law on non-firearm homicide and suicide among adolescents and emerging adults (age 15–24) as a negative control. Overall, there was no effect on non-firearm homicide among this age group in Missouri post-repeal. However, the rate of non-firearm homicide was significantly lower among Black and Hispanic Americans adolescents and emerging adults. Missouri's repeal was not significantly associated with non-firearm suicide among adolescents and emerging adults.

Overall, the adoption of firearm purchaser licensing did not significantly affect the rate of non-firearm suicide among adolescents and emerging adults. However, there were higher rates of non-firearm suicide for Black and

Hispanic adolescents and emerging adults and a lower rate for white adolescents and emerging adults.

SCM and ASCM

Output from the SCM analyses was not substantively different from the ASCM; therefore, only results from the ASCM models are presented.

The ASCM estimated effects of repealing or adopting a firearm purchaser licensing law on firearm homicide and suicide among adolescents and emerging adults (15–24) are presented in Table 3.

Repeal: Overall, rates of firearm homicide increased in Missouri following the repeal of the state's firearm purchasing law (ATT = 0.458, *SE* = 0.068; an increase of 0.58 per 100,000 population). This was driven by significant increases in firearm homicide among adolescents and emerging adults who were identified as white (ATT = 0.460, *SE* = 0.072; 0.584 per 100,000 higher) and Hispanic (0.644, *SE* = 0.285; 0.904 per 100,000 higher). There were no significant impacts of Michigan's partial repeal on firearm homicide. Overall, rates of firearm suicide increased in Missouri following its repeal (ATT = 0.308, *SE* = 0.030; 0.36 per 100,000 higher); rates increased significantly among white adolescents and emerging adults (ATT = 0.274, *SE* = 0.037; 0.32 per 100,000 higher). Rates of firearm suicide also increased significantly in Michigan after its partial repeal (ATT = 0.215, *SE* = 0.038; 0.24 per 100,000 higher). Across demographic strata, rates of firearm suicide were significantly higher for adolescents and emerging adults who were identified as white (ATT = 0.212, *SE* = 0.038; 0.24 per 100,000 higher), Black (ATT = 0.239, *SE* = 0.043; 0.27 per 100,000 higher), and Hispanic (ATT = 0.610, *SE* = 0.224; 0.84 per 100,000 higher).

Adoption: Overall, rates of firearm homicide in Connecticut declined significantly following the passage of its firearm purchase licensing law (ATT = −0.545, *SE* = 0.231; 0.73 per 100,000 lower). This was driven by significant declines for adolescents and emerging adults who were identified as white (ATT = −0.584, *SE* = 0.120; 0.79 per 100,000 lower) and Hispanic (ATT = −0.739, *SE* = 0.127; 1.09 per 100,000 lower). There were no significant impacts of Maryland's passage on firearm homicide. Overall, rates of firearm suicide significantly declined in Connecticut following its passage (ATT = −0.445, *SE* = 0.124; 0.56 per 100,000 lower). Rates were significantly lower for adolescents and emerging adults who were identified as white (ATT = −0.541, *SE* = 0.093; 0.72 per 100,000 lower) and Hispanic (ATT = −0.654, *SE* = 0.177; 0.92 per 100,000 lower). Following Maryland's passage, overall rates of firearm suicide showed a non-significant decline. Across demographic strata, rates of firearm suicide were significantly lower

Table 3. ASCM Estimates of Repealing or Adopting a Firearm Purchaser Licensing Law on Firearm Homicide Among those Aged 15 to 24.

Outcomes Stratified by Race and Ethnicity	Firearm homicide					Firearm suicide				
	ATT	RMSE	*SE*	95% CI		ATT	RMSE	*SE*	95% CI	
Repeal										
Missouri										
Overall	**0.458**	**0.121**	**0.068**	**0.324**	**0.592**	**0.308**	**0.088**	**0.030**	**0.248**	**0.368**
White	**0.460**	**0.128**	**0.072**	**0.318**	**0.602**	**0.274**	**0.087**	**0.037**	**0.201**	**0.348**
Black	0.303	0.175	0.201	−0.091	0.698	0.321	0.291	0.172	−0.016	0.657
Hispanic	**0.644**	**0.785**	**0.285**	**0.084**	**1.203**	0.424	0.982	0.344	−0.250	1.098
Michigan										
Overall	−0.031	0.109	0.116	−0.258	0.196	**0.215**	**0.107**	**0.038**	**0.141**	**0.288**
White	−0.001	0.094	0.105	−0.208	0.205	**0.212**	**0.111**	**0.043**	**0.128**	**0.295**
Black	−0.259	0.128	0.262	−0.773	0.256	**0.239**	**0.293**	**0.102**	**0.039**	**0.439**
Hispanic	0.006	0.346	0.158	−0.303	0.316	**0.610**	**0.573**	**0.224**	**0.171**	**1.049**
Adoption										
Connecticut										
Overall	**−0.545**	**0.075**	**0.231**	**−0.997**	**−0.093**	**−0.445**	**0.019**	**0.124**	**−0.689**	**−0.201**
White	**−0.584**	**0.052**	**0.120**	**−0.818**	**−0.349**	**−0.541**	**0.040**	**0.093**	**−0.723**	**−0.358**
Black	−0.309	0.129	0.269	−0.836	0.217	−0.310	0.393	0.252	−0.804	0.184
Hispanic	**−0.739**	**0.252**	**0.127**	**−0.987**	**−0.491**	**−0.654**	**0.637**	**0.177**	**−1.000**	**−0.307**
Maryland										
Overall	−0.043	0.088	0.156	−0.348	0.262	−0.303	0.011	0.647	−1.571	0.966
White	0.268	0.005	1.751	−3.164	3.701	**−0.166**	**0.170**	**0.039**	**−0.242**	**−0.090**
Black	−0.119	0.140	0.081	−0.277	0.039	**−0.468**	**0.252**	**0.101**	**−0.665**	**−0.271**
Hispanic	0.240	0.630	0.199	−0.150	0.631	**0.290**	**0.625**	**0.143**	**0.009**	**0.570**

Note. Bold indicates significance at $p < .05$.

for adolescents and emerging adults who were identified as white (ATT = −0.166, *SE* = 0.039; 0.18 per 100,000 lower) and Black (ATT = −0.468, *SE* = 0.101; 0.6 per 100,000 lower); however, there was a significant increase among those identified as Hispanic (ATT = 0.290, *SE* = 0.143; 0.34 per 100,000 higher).

The ASCM estimated effects of repealing or adopting a firearm purchaser licensing law on non-firearm homicide and suicide among adolescents and emerging adults (15–24) are presented in Table 4.

Repeal: Overall, only Missouri's repeal showed a significant impact on non-firearm homicide (ATT = −0.151, *SE* = 0.054; 0.16 per 100,000 lower). This was driven by a significant decline in non-firearm homicide among Black adolescents and emerging adults in the state (ATT = −0.430, *SE* = 0.084; 0.54 per 100,000 lower). Only Michigan's partial repeal was associated with a significant impact on non-firearm suicide (ATT = 0.093, *SE* = 0.031; 0.1 per 100,000 higher). This was driven by a significant increase in non-firearm suicide among white adolescents and emerging adults (ATT = 0.115, *SE* = 0.037; 0.12 per 100,000 higher).

Adoption: Overall, there were no significant associations between adoption of firearm purchaser licensing and non-firearm homicide. However, there was a small but significant increase found for non-firearm homicide among white adolescents and emerging adults following Connecticut's law passage (ATT = 0.178, *SE* = 0.193; 0.2 per 100,000 higher). Overall, only Connecticut's adoption was associated with a decrease in non-firearm suicide among adolescents and emerging adults (ATT = −0.168, *SE* = 0.129; 0.18 per 100,000 lower). There were no significant differences for any sub-groups. For Maryland, the law overall was not associated with changes in non-firearm suicide. However, there was a small but significant decline in non-firearm suicide among white adolescents and emerging adults (ATT = −0.042, *SE* = 0.070; 0.04 per 100,000 higher).

Discussion

Our study assesses the impact of firearm purchaser licensing laws on homicide and suicide among adolescents and emerging adults while also examining whether differential policy effects were present across race and ethnicity. Across both modeling strategies, for those aged 15 to 24, firearm purchaser licensing laws were associated with lower rates of firearm homicide and suicide. We found fairly consistent protective effects associated with adoption for both firearm homicide and suicide and harmful effects associated with repeal. The examination of state specific policy effects across different strata of race and ethnicity revealed that, for those age 15 to 24, while there were

Table 4. ASCM Estimates of Repealing or Adopting a Firearm Purchaser Licensing Law on Non-Firearm Homicide and Non-Firearm Suicide Rates per 100,000 Among those Aged 15 to 24.

Outcomes Stratified by Race and Ethnicity	Non-firearm homicide					Non-firearm suicide				
	ATT	RMSE	*SE*	95% CI		ATT	RMSE	*SE*	95% CI	
Repeal										
Missouri										
Overall	**−0.151**	**0.124**	**0.054**	**−0.257**	**−0.151**	0.012	0.131	0.069	−0.122	0.147
White	0.012	0.152	0.056	−0.098	0.012	−0.056	0.123	0.086	−0.224	0.112
Black	**−0.430**	**0.360**	**0.084**	**−0.596**	**−0.430**	0.110	0.507	0.077	−0.041	0.260
Hispanic	−0.078	1.073	0.136	−0.345	−0.078	−0.129	0.940	0.133	−0.388	0.131
Michigan										
Overall	0.010	0.147	0.041	−0.071	0.010	**0.093**	**0.103**	**0.031**	**0.033**	**0.153**
White	0.002	0.148	0.091	−0.176	0.002	**0.115**	**0.114**	**0.037**	**0.043**	**0.188**
Black	−0.001	0.248	0.079	−0.156	−0.001	−0.015	0.268	0.089	−0.189	0.159
Hispanic	0.008	0.619	0.117	−0.221	0.008	0.038	0.485	0.064	−0.088	0.165
Adoption										
Connecticut										
Overall	0.083	0.068	0.091	−0.095	0.083	**−0.168**	**0.026**	**0.129**	**−0.420**	**0.084**
White	**0.178**	**0.193**	**0.031**	**0.117**	**0.178**	−0.152	0.129	0.055	−0.260	−0.045
Black	−0.105	0.169	0.163	−0.424	−0.105	0.057	0.197	0.173	−0.283	0.396
Hispanic	0.111	0.188	0.130	−0.144	0.111	0.029	0.349	0.080	−0.128	0.185
Maryland										
Overall	0.351	0.003	2.544	−4.635	0.351	−0.048	0.086	0.040	−0.126	0.030
White	0.284	0.007	0.365	−0.431	0.284	**−0.041**	**0.122**	**0.070**	**−0.178**	**0.096**
Black	0.029	0.261	0.104	−0.174	0.029	−0.017	0.234	0.093	−0.199	0.165
Hispanic	0.970	0.022	3.623	−6.132	0.970	−1.244	0.016	3.748	−8.590	6.102

Note. Bold indicates significance at $p < .05$.

overall increases in firearm homicide and suicide associated with Missouri's repeal, this was not experienced equally across groups. Effects among this age group were driven by increases in firearm deaths among white adolescents and emerging adults. Firearm suicide in Michigan was driven by increases across all strata of race and ethnicity in this age group. For adopting states, Connecticut experienced significant declines in both firearm homicide and suicide, driven by declines among white and Hispanic adolescents and emerging adults. In Maryland, while there were no significant effects for firearm homicide or suicide overall, there were significant declines in firearm suicide for white and Black adolescents and emerging adults.

Adolescents are a demographic subgroup with high vulnerability for violence involvement (CDC, 2023a, 2023b); many of whom cannot legally purchase firearms. Prior research has documented the ways that young people might illegally obtain firearms such as through unlicensed sales, bad actor licensed sellers, or straw purchasing (Braga & Kennedy, 2001), all of which are pathways that are diminished or deterred by firearm purchaser licensing (Crifasi et al., 2017; D. Webster et al., 2013). Emerging adults also experience greater vulnerability for violence involvement (CDC, 2023a, 2023b) but most can legally acquire at least some types of firearms. In addition to making it harder to potentially acquire a firearm through illicit sources, the built in waiting period while an application for a firearm purchaser license is processed, and access to additional records to ensure any prohibiting conditions are identified, may delay impulsive acquisition of firearms that could be used to harm self or others (JHCGVS, 2022). For firearm suicide, we also found that firearm purchaser licensing law repeal was associated with harmful effects and adoption with protective effects, at least for some groups. Young people buying their first gun in a state with firearm purchaser licensing would have a different experience—more thorough screening and a wait while the application is processed—than those in states without these policies who might be able to immediately acquire a new gun. As discussed above, data from California found that risk of suicide death among new purchasers spiked after their first firearm purchase (Studdert et al., 2020) and law that implement purchase delays have been associated with lower rates of firearm suicide among adults age 21 to 34 (Donohue et al., 2023). This is consistent with the concept that delaying impulsive firearm acquisition has important implications for suicide prevention. The overall findings of our work are consistent with prior research finding lower rates of firearm mortality associated with firearm purchaser licensing laws (Crifasi et al., 2015; McCourt et al., 2020; Rudolph et al., 2015). The subgroup findings demonstrate that policies can affect groups differently. It is imperative that researchers conduct stratified analyses to

better elucidate policy effects across demographic groups to better understand both protective effects and potential unintended consequences.

Our ASCM models did not find significant effects of adopting firearm purchaser licensing on firearm homicide among adolescents and emerging adults in Maryland. This could be impacted by an important historical confounder for Maryland with the in-custody death of Freddie Gray (NPR, 2020). Prior research examining Maryland's adoption found increases in firearm homicide, but sensitivity analyses that excluded Baltimore rendered that result insignificant (McCourt et al., 2020). Finding no effect of Maryland's law among a high-risk age group is counter to prior research but could suggest that gun access among this age group may be more sensitive to policies that create supply-side constraints. An analysis of crime gun recoveries in Baltimore post-adoption found declines in in-state recoveries, meaning that more guns were being recovered in crime in Baltimore that originated in sales outside of Maryland (Crifasi et al., 2017). This supports the need for stronger policies that limit the flow of firearms across state lines (Andrade et al., 2020; Collins et al., 2018).

There were some mixed effects on non-firearm mortality. Some of the race and ethnicity strata contained small sample sizes for this outcome. There could also be some unmeasured confounders in the model. Prior research has largely explored overall population effects on non-firearm mortality; however, some of the traditional confounders included in these models might not be as appropriate for assessing non-firearm mortality among adolescents and emerging adults. Future research should explore specific risk and protective factors for non-firearm mortality among this age group. However, taken in aggregate these findings suggest that the adoption of firearm purchaser licensing laws was associated with beneficial effects and repeal was associated with harmful effects among adolescents and emerging adults in the US.

These findings should be considered in the context of some limitations. Because this is quasi-experimental research, we could not randomize states to adopt or repeal firearm purchaser licensing. However, the use of stacked DiD models allowed us to create more robust comparisons to estimate policy effects by mitigating the bias present when treatment adoption occurs with staggered timing. This method is not without limitations. Its primary limitation is that it assumes a homogenous treatment effect across the g number of stacks, which may or may not be true. We addressed this issue by complementing our analyses with ASCM to elucidate whether the treatment effects of firearm purchaser license laws were indeed homogenous across treatment groups/states. Our ASCM models indicated this was not the case as there were differences between states across Adopters and Repealers, and within states across race and ethnicity strata.

This analysis was also limited to four law changes during the study period. There will be future opportunities to examine the effect of firearm purchaser licensing law changes, as Iowa and North Carolina repealed their firearm purchaser licensing laws in 2021 and 2023, respectively. Oregon passed a ballot initiative adopting licensing in 2022, Minnesota adopted requirements for private handgun transfers in 2023, Michigan restored its full purchaser licensing system in 2024, and Delaware passed a firearm purchaser licensing system in 2024. This study was also limited in which race and ethnicity groups could be included due to small sample sizes. Future research should consider if and how firearm purchaser licensing laws are associated with mortality in other groups, perhaps using different methodologies. Finally, this analysis was restricted to examining firearm mortality as longitudinal, systematic, and comprehensive state-level non-fatal firearm injury data is not readily available. As efforts are made to address this data gap, future research that includes data on non-fatal firearm injuries would strengthen these analyses.

This study found overall protective effects associated with adoption of firearm purchaser licensing laws on firearm mortality among adolescents and emerging adults and harmful effects associated with repeal. There were some significant differences in effects across race and ethnicity strata suggesting the need to evaluate additional firearm policies for differential effects. Firearm purchaser licensing laws appear to be an effective supply-side strategy associated with a lower burden of firearm-related mortality among young people in the US.

Data Availability Statement

All data used in this study were publicly available or accessible by request from the National Center for Health Statistics.

Declaration of Conflicting Interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Funding

The author(s) disclosed receipt of the following financial support for the research, authorship, and/or publication of this article: This research was supported by a grant from the Centers for Disease Control and Prevention to Dr. Crifasi (1U01CE003368-1). The authors also want to acknowledge support from the National Institute for Occupational Safety and Health to the Johns Hopkins Education and Research Center (T42OH0008428) and the Eunice Kennedy Shriver National Institute of Child Health and Human Development (T32HD108054). The content is solely the responsibility of

the authors and does not necessarily represent the official views of the funding agencies.

ORCID iDs

Cassandra K Crifasi https://orcid.org/0000-0001-6748-5389

Katrina S. Kennedy https://orcid.org/0000-0003-4937-695X

References

Andrade, E. G., Hoofnagle, M. H., Kaufman, E., Seamon, M. J., Pah, A. R., & Morrison, C. N. (2020). Firearm laws and illegal firearm flow between US states. *Journal of Trauma and Acute Care Surgery*, *88*(6), 752–759. https://doi.org/10.1097/ta.0000000000002642

Braga, A. A., & Kennedy, D. M. (2001). The illicit acquisition of firearms by youth and juveniles. *Journal of Criminal Justice*, *29*(5), 379–388. https://doi.org/10.1016/S0047-2352(01)00103-9

Bugeja, L., McClure, R. J., Ozanne-Smith, J., & Ibrahim, J. E. (2011). The public policy approach to injury prevention. *Injury Prevention*, *17*(1), 63–65. https://doi.org/10.1136/ip.2010.030619

CDC. (2023a, May 12). *Multiple cause of death 1999–2020*. https://wonder.cdc.gov/wonder/help/mcd.html

CDC. (2023b). *Multiple cause of death - provisional*. https://wonder.cdc.gov/mcd.html

Cengiz, D., Dube, A., Lindner, A., & Zipperer, B. (2019). The effect of minimum wages on low-wage jobs. *The Quarterly Journal of Economics*, *134*(3), 1405–1454.

Collins, T., Greenberg, R., Siegel, M., Xuan, Z., Rothman, E. F., Cronin, S. W., & Hemenway, D. (2018). State firearm laws and interstate transfer of guns in the USA, 2006–2016. *Journal of Urban Health*, *95*(3), 322–336. https://doi.org/10.1007/s11524-018-0251-9

Crifasi, C. K., Buggs, S. A. L., Choksy, S., & Webster, D. W. (2017). The initial impact of Maryland's Firearm Safety Act of 2013 on the supply of crime handguns in Baltimore. *RSF: The Russell Sage Foundation Journal of the Social Sciences*, *3*(5), 128–140.

Crifasi, C. K., Merrill-Francis, M., McCourt, A., Vernick, J. S., Wintemute, G. J., & Webster, D. W. (2018). Correction to: Association between firearm laws and homicide in urban counties. *Journal of Urban Health*, *95*(5), 773–776.

Crifasi, C. K., Meyers, J. S., Vernick, J. S., & Webster, D. W. (2015). Effects of changes in permit-to-purchase handgun laws in Connecticut and Missouri on suicide rates. *Preventive Medicine*, *79*, 43–49.

Crifasi, C. K., Ward, J., McCourt, A. D., Webster, D., & Doucette, M. L. (2023). The association between permit-to-purchase laws and shootings by police. *Injury Epidemiology*, *10*(1), 28.

Davis, A., Kim, R., & Crifasi, C. (2023). *U.S. Gun Violence in 2021: An accounting of a public health crisis*. https://publichealth.jhu.edu/sites/default/files/2023-06/2023-june-cgvs-u-s-gun-violence-in-2021.pdf

Donohue, J., Cai, S. V., & Ravi, A. (2023). *Age and suicide impulsivity: Evidence from handgun purchase delay laws*. National Bureau of Economic Research. https://doi.org/10.3386/w31917

Doucette, M. L., Ward, J. A., McCourt, A. D., Webster, D., & Crifasi, C. K. (2022). Officer-involved shootings and concealed carry weapons permitting laws: Analysis of gun violence archive data, 2014–2020. *Journal of Urban Health*, *99*(3), 373–384.

Fowler, K. A., Dahlberg, L. L., Haileyesus, T., & Annest, J. L. (2015). Firearm injuries in the United States. *Preventive Medicine*, *79*, 5–14. https://doi.org/10.1016/j.ypmed.2015.06.002

Goldstick, J. E., Zeoli, A., Mair, C., & Cunningham, R. M. (2019). US firearm-related mortality: National, state, and population trends, 1999–2017. *Health Affairs*, *38*(10), 1646–1652. https://doi.org/10.1377/hlthaff.2019.00258

Hasegawa, R. B., Webster, D. W., & Small, D. S. (2019). Evaluating Missouri's handgun purchaser law: A bracketing method for addressing concerns about history interacting with group. *Epidemiology*, *30*(3), 371–379. https://doi.org/10.1097/EDE.0000000000000989

Hawe, P., & Potvin, L. (2009). What is population health intervention research? *Canadian Journal of Public Health*, *100*(1), I8–I14. https://doi.org/10.1007/BF03405503

JHCGVS. (2022). *Firearm purchaser licensing*. https://publichealth.jhu.edu/departments/health-policy-and-management/research-and-practice/center-for-gun-violence-solutions/solutions/permit-to-purchase-laws

Jones, C. P. (2001). Invited commentary: "race," racism, and the practice of epidemiology. *American Journal of Epidemiology*, *154*(4), 299–304; discussion 305–296. https://doi.org/10.1093/aje/154.4.299

Li, M., Small, D., Ye, T., Lin, Y., & Webster, D. (2023). Examining a hypothesized causal chain for the effects of the 2007 repeal of the permit-to-purchase licensing law in Missouri: Homicide guns recovered in state and within a year of purchase. *Journal of Urban Health*, *100*(3), 425–430. https://doi.org/10.1007/s11524-023-00739-6

McCourt, A., Crifasi, C., Stuart, E., Vernick, J., Kagawa, R., Wintemute, G., & Webster, D. (2020). Purchaser licensing, point-of-sale background check laws, and on firearm homicide and suicide in 4 US states, 1985–2017. *American Journal of Public Health*, *110*(10), 1546–1552.

NPR. (2020). *Freddie Gray's death, 5 years later*. https://www.npr.org/2020/04/24/844562979/freddie-grays-death-baltimore-five-years-later

Raifman, J., Larson, E., Barry, C. L., Siegel, M., Ulrich, M., Knopov, A., & Galea, S. (2020). State handgun purchase age minimums in the US and adolescent suicide rates: Regression discontinuity and difference-in-differences analyses. *BMJ*, *370*, m2436. https://doi.org/10.1136/bmj.m2436

RAND. (2023). *Gun policy in America*. https://www.rand.org/research/gun-policy.html

Rudolph, K. E., Stuart, E. A., Vernick, J. S., & Webster, D. W. (2015). Association between Connecticut's permit-to-purchase handgun law and homicides. *American Journal of Public Health*, *105*(8), e49–e54.

Sampson, R. J., Morenoff, J. D., & Gannon-Rowley, T. (2002). Assessing "neighborhood effects": Social processes and new directions in research. *Annual Review of Sociology*, *28*(1), 443–478.

Schmidt, C. J., Rauk, L., Cunningham, R. M., Zimmerman, M. A., Roche, J. S., & Carter, P. M. (2022). How multi-disciplinary research centers and networks can advance the science of firearm injury prevention. *The ANNALS of the American Academy of Political and Social Science*, *704*(1), 242–266.

Semenza, D. C., Stansfield, R., Steidley, T., & Mancik, A. M. (2021). Firearm availability, homicide, and the context of structural disadvantage. *Homicide Studies*, *27*(2), 208–228.

Studdert, D. M., Zhang, Y., Swanson, S. A., Prince, L., Rodden, J. A., Holsinger, E. E., Spittal, M. J., Wintemute, G. J., & Miller, M. (2020). Handgun ownership and suicide in California. *New England Journal of Medicine*, *382*(23), 2220–2229.

Webster, D. W., McCourt, A. D., Crifasi, C. K., Booty, M. D., & Stuart, E. A. (2020). Evidence concerning the regulation of firearms design, sale, and carrying on fatal mass shootings in the United States. *Criminology & Public Policy*, *19*(1), 171–212.

Webster, D., Crifasi, C. K., & Vernick, J. S. (2014). Erratum to: Effects of the repeal of Missouri's handgun purchaser licensing law on homicides. *Journal of Urban Health*, *91*(3), 598–601.

Webster, D., Vernick, J., McGinty, E., & Alcorn, T. (2013). Preventing the diversion of guns to criminals through effective firearm sales laws. In D. Webster & J. Vernick (Eds.), *Reducing gun violence in America: Informing policy with evidence and analysis* (pp. 109–122). The Johns Hopkins University Press.

Zeoli, A. M., Goldstick, J., Mauri, A., Wallin, M., Goyal, M., Cunningham, R., & For the, F. C. (2019). The association of firearm laws with firearm outcomes among children and adolescents: A scoping review. *Journal of Behavioral Medicine*, *42*(4), 741–762. https://doi.org/10.1007/s10865-019-00063-y

Author Biographies

Cassandra K. Crifasi, PhD, MPH is an Associate Professor in the Department of Health Policy and Management at the Johns Hopkins Bloomberg School of Public Health and Co-Director of the Center for Gun Violence Solutions.

Rachel J. Topazian, PhD, is an Assistant Professor at the Center for Bioethics and Humanities at the University of Colorado School of Medicine.

Alex D. McCourt, JD, PhD, MPH is an Assistant Professor in the Department of Health Policy and Management at the Johns Hopkins Bloomberg School of Public Health and core faculty at the Center for Gun Violence Solutions.

Stephen N. Oliphant, PhD, MPP is a Post-Doctoral Fellow at the University of Michigan Institute for Firearm Injury Prevention.

April M. Zeoli, PhD, MPH is an Associate Professor in the Department of Health Management and Policy at the University of Michigan School of Public Health and Policy Core Director at the Institute for Firearm Injury Prevention.

Katrina S. Kennedy, MPH is a Doctoral Candidate in the Department of Health, Behavior, and Society at the Johns Hopkins Bloomberg School of Public Health.

Elizabeth D. Wagner, ScM is a Senior Research Data Analyst in the Department of Health Policy and Management at the Johns Hopkins Bloomberg School of Public Health and biostatistician for the Center for Gun Violence Solutions.

Mitchell L. Doucette, PhD, MS is a Faculty Associate in the Department of Health Policy and Management at the Johns Hopkins Bloomberg School of Public Health.