Firearm availability and firearm incidents: quasi-experimental analysis using start of US hunting seasons

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ABSTRACT

OBJECTIVE

To take advantage of the arbitrarily timed increase in firearm and ammunition availability brought on by the start of deer hunting seasons to study its impact on hunting, and importantly, non-hunting related firearm incidents.

DESIGN

Quasi-experimental analysis using start of hunting season in United States.

SETTING

Populations of US states with highest number of hunting accidents reported in the Gun Violence Archive for deer hunting seasons between 2016 and 2019.

PARTICIPANTS

10 US states (Alabama, Indiana, Michigan, Minnesota, Missouri, New York, Ohio, Pennsylvania, Texas, and Wisconsin).

MAIN OUTCOMES AND MEASURES

Average per capita weekly rates of firearm incidents overall and among specified categories of firearm incidents in the periods before, during, and after the opening of deer hunting seasons combined into a single analysis across four years and 10 states, adjusting for state fixed effects.

RESULTS

Compared with control periods before and after the opening period, the start of the hunting season was associated with a 12.3% relative increase in the rate of firearm incidents overall (absolute change 1.34-1.50 incidents per 10 million population; 95% confidence interval for relative change 3.0% to 21.6%, P<0.01). Relative increases were observed for incidents categorized as hunting incidents (absolute change <0.01-0.05 per 10 million; relative change 566%), suicide (0.70-0.77; 11.1%), incidents involving alcohol or other substances (0.07-0.13; 87.5%), domestic violence (0.13-0.16; 27.4%), defensive use (0.08-0.10; 27.8%), home invasion or robbery (0.13-0.17; 30.4%), and incidents related to firearm carry licenses (0.40-0.48; 19.4%). No differences were observed for incidents involving children or police officers.

CONCLUSIONS

The start of hunting season was associated with increased rates of hunting and non-hunting related firearm incidents, most plausibly because of the increased availability of firearms and ammunition. The results suggest that efforts to promote firearm safety at the beginning of hunting season could help reduce hunting and non-hunting related firearm incidents.

WHAT IS ALREADY KNOWN ON THIS TOPIC

Increased rates of gun ownership have been associated with increased rates of firearm injuries, homicide, and suicide in the United States, however causal links between availability of firearms in the community and firearm incidents are difficult to study

WHAT THIS STUDY ADDS

Because the beginning of popular deer hunting season is arbitrarily timed with respect to the baseline risk of firearm incidents, it offers a unique opportunity to quasi-experimentally study the impact of increased availability of firearms and ammunition in the community

In an event study analysis of four deer hunting seasons across 10 states, the start of deer hunting season (opener) was associated with increases in rates of hunting related and certain types of non-hunting related firearm incidents, including suicide, defensive use, and violent crimes

Findings suggest that increased community availability of firearms and ammunition might increase rates of firearm incidents

Several studies have shown associations between firearm ownership and adverse health related firearm incidents including homicide[1-3] and suicide,[4 5] but the causal association between firearm availability in the community and firearm incidents is difficult to study. Measuring the causal impact of the increased presence of firearms, at the geographical or person level, is challenging because the association between measures like firearm sales or ownership and firearm incidents could be confounded by measured and unmeasured factors that are also correlated with firearm incident risk.

However, when community firearm availability changes in a way that is as good as random, it creates a natural experiment for studying the impact of firearm availability that accounts for measured and unmeasured confounding factors. For example, in the five month period after the Sandy Hook Elementary School shooting in December 2012 where 26 children and adults were killed—a tragedy whose timing was arbitrary with respect to firearm availability and risk of firearm incidents—an estimated 3 million additional firearms above what would have been expected were sold in the United States. These sales were presumably out of fear of future restrictions on gun ownership and were associated with an estimated 57–66 additional accidental shooting deaths.[6] Another study estimated a 20.1% reduction in the national rate of firearm injuries during conventions of the National Rifle Association, arbitrarily timed events when attendees would be less likely to be using firearms recreationally and so less likely to be injured.[7]

Deer hunting season offers a different, unique opportunity to study the impact of immediate changes in firearm availability in states with robust hunting seasons. The US Fish and Wildlife Service estimated

11.5 million hunters aged 16 and older dedicated 135 million days to hunting big game, predominantly deer, in 2022.[8 9] Deer hunting seasons vary by state, but they generally begin in fall or early winter, and are temporally accompanied by increases in sales of handguns and long guns nationwide.[10] Although short term increases in firearm availability and use at the start of hunting season might be expected to affect hunting related firearm injuries,[11 12] it is also possible that non-hunting related firearm incidents (eg, suicide and violent crime) could rise as more firearms are purchased and used. One important, recent study of rural counties in the US showed an increase in hunting incidents and non-hunting incidents brought on by the onset of hunting season.[13] However, with an estimated 75% of deer hunters living within metropolitan areas,[9] firearms might be more available wherever hunters live—mostly in urban or suburban communities—across the state. Furthermore, hunting season might bring about other changes that lead to increases in firearm availability among non-hunters or intermittent hunters, such as through increased marketing for firearms and ammunition that could lead to rises in non-hunting related firearm incidents across the state.

In a quasi-experimental event study analysis, we measured rates of different types of firearm incidents in the time period surrounding the beginning of deer hunting season in 10 US states. We hypothesized that while short term increases in firearm availability and use at the beginning of hunting season might be expected to affect hunting related firearm injuries,[11 12] non-hunting related firearm incidents (eg, suicide and violent crime) might also rise as more firearms are purchased and are present within the state.

Methods

Data sources

Data for hunting season start dates were obtained from several online sources, including state fish and wildlife services and local media. We defined the first day of hunting season in a given state and year as the first day when antlered buck hunting using firearms was permitted for the general population. Many states have different seasons and hunting days for hunting using different equipment (eg, archery, muzzleloaders), for special hunter populations (youth, paraplegic), or for hunting antlerless deer (a less popular target as they yield less meat and no trophy in the form of antlers, but one that is often important for population control). However, hunting for antlered bucks using firearms is the most popular hunting activity; the National Deer Association estimates that in 2021 approximately 6.9 million Americans hunted deer using firearms compared with 3.3 million using a bow or crossbow and 1.4 million using a muzzleloader.[14] The opening weekend of firearm season is by far the most popular time to hunt bucks. In Wisconsin, for example, about half of the season's bucks are killed during the opening weekend.[15]

Firearm incident data were obtained from the Gun Violence Archive (GVA), a publicly available database of gun violence incidents in the US, which has been validated and previously used for epidemiological research.[16-18] Each firearm related incident in the GVA includes information on the date, address, participants, number of victims (injuries or deaths) if any, and nature of the incident—which includes hunting, suicide, domestic violence, defensive use, home invasion or robbery, and other categories. GVA data are collected using automated online queries and manual searches of over 7500 sources, including media, police, and other governmental sources; each incident is reviewed and confirmed manually.[19] State population data were obtained from the US Census Bureau.[20]

Study population

We studied firearm incidents from 2016 to 2019 among the populations of 10 states. These states were selected as those with deer hunting seasons that had the highest number of hunting accidents reported in the GVA, a figure that serves as a proxy measure for hunting activity (and has previously been shown to correlate with the number of hunting licenses issued[13]). These data allow analysis of a group of states where firearms would most plausibly be more available in communities during hunting season. We assumed that any hunting season related changes in firearm behavior would probably be present in these states.

Study measures and covariates

We calculated the average weekly per capita rate of firearm incidents in a three week period around the opening of deer hunting season as well as the three week periods before and after the opening day across the 10 states from 2016 to 2019, spanning 40 total state seasons. The opener was defined as the seven day period before and the 14 day period after the first legal day of firearm deer hunting season; that is, if the first day of hunting season is day 0, the period before was defined as days −28 to −8, the opener was defined as days −7 to +13, and the period after as days +14 to +34. This definition for the opener allows for the possibility that increased firearm incidents might be brought on by increases in access to and availability of firearms as hunters prepare for opening day and in the first two weeks of hunting season when firearm related hunting activity is probably greatest.[15]

We defined nine firearm incident categories (hunting, suicide, involving alcohol or other substance, domestic violence, defensive use, home invasion or robbery, carry license related (ie, incidents related to who can carry a firearm in public and how they do so), child involved, and officer involved) using the labels applied to each incident in the GVA, where several labels can be applied to a single incident. Supplementary table 1 in the appendix lists labels contained in each category. Because incidents can have several characteristic labels (eg, an incident could involve domestic violence and substance use), incident types are not mutually exclusive from one another except for hunting

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accidents, which were categorized only as hunting accidents even if other labels were present so that we could analyze incidents that were explicitly unrelated to hunting.

Overview of study design

Our goal was to examine whether the increased availability and use of firearms brought on by the opening of hunting season—the most popular time to hunt deer within the season—could lead to increases in both hunting related and non-hunting related firearm incidents across the state. We performed a quasi-experimental event study analysis, combining data across states and years into a single analysis.[21] Because the specific date of the beginning of deer hunting season is as good as random with respect to the background risk of firearm incidents, a natural experiment occurs at the onset of hunting season, permitting estimation of the effect of hunting season on firearm injuries. However, estimation using a time series approach relies on the assumption that there were no other events that could plausibly lead to changes in firearm behavior whose timing coincided with the onset of hunting season. For individual hunting seasons, therefore, it can be hard to separate the causal impact of hunting season on firearm injuries—including hunting accidents, which have previously been temporally associated with hunting seasons,[22-25] in addition to firearm incidents unrelated to hunting.

The primary advantage of the event study over an individual time series analysis is that, by combining all events into a single analysis, we could estimate an average effect across all included states while minimizing bias from any unobserved factors during the temporal control periods that might have influenced firearm incidents in any individual state hunting season. Therefore, causal inference from the event study design relies on the assumption that no events systematically lead to increased firearm incidents that temporally align with the start of hunting season across states and across years. Although it would be possible to include additional controls by comparing, for example, deer hunting states with neighboring states without hunting seasons during those time periods, this was not done because of the potential for spillover effects (eg, hunters might travel to a neighboring state to hunt, or marketing might cross state lines), which would violate the assumption that such states could serve as reasonable controls. Moreover, some neighboring states that could potentially serve as controls also had their own hunting seasons, which would again restrict their ability to serve as valid controls. Therefore, our empirical approach relied on a longitudinal comparison of firearm incidents within states where hunting is highly popular, before versus after the start of hunting season in each state. Although this event study approach might suggest a causal association between hunting season and firearm incidents, it does not pinpoint the specific causal mechanism between the two.

Statistical analyses

We calculated the average weekly per capita rate of firearm incidents across the 40 state seasons in the periods before, during, and after the beginning of deer hunting seasons using linear regression to adjust for state fixed effects. We measured incidence overall and by incident category. We estimated two versions of this model, differing only in how the control periods were combined. Firstly, to test for differences between the deer hunting opener and the surrounding periods combined into a single control group, we estimated a regression model with an indicator variable denoting weeks in the opener versus all other weeks in the periods before and after the opener. Secondly, to better assess the timing of any changes in firearm incidents associated with the opening of hunting season, we estimated an analogous model in which the opener was compared with the periods before and after separately (ie, fixed effect or indicator variables for each period were included in the model); this model was used to estimate the weekly rate of firearm incidents for each of the three time periods individually. Similar models were estimated for each subgroup based on incident type (eg, hunting incidents, suicide, etc). Finally, to test the sensitivity of our findings to alternative ways of defining the opener, and the periods before and after, we performed similar analyses to the primary analysis but using one, two, or three week durations for the time periods, defining the first week of firearm deer hunting season as week 0 (eg, the opener was defined as day 0–7, day 0–14, or day 0–21 for analyses using one, two, and three week durations, respectively). Two tailed α levels were set to 0.05. Analyses were performed using R (R Core Team). This study was approved by the Harvard Medical School institutional review board.

Patient and public involvement

This study was a retrospective observational study. No patients were involved in setting the research question or the outcome measures, nor were they involved in developing plans for design or implementation of the study. No patients were asked to advise on interpretation or writing up of results. The study was unfunded and therefore no funding was available for patient and public involvement.

Results

Based on information from state fish and wildlife agencies and other sources, well defined firearm deer hunting seasons were identified in 32 states. Seasons typically began between late October and early December, with most occurring in early to mid November. Of these 32 states, those with the highest number of hunting accidents reported in the GVA between 2016 and 2019—that is, the states with the most hunting activity—were Alabama, Indiana, Michigan, Minnesota, Missouri, New York, Ohio, Pennsylvania, Texas, and Wisconsin. The start of hunting varied across states and over time, reflected in supplementary figure 1. Across these 10 states over

Table 1 | Adjusted weekly rate of firearm incidents during hunting season opening period and surrounding periods

Firearm incident category	Hunting season opening		Surrounding weeks		Adjusted absolute rate difference* (95% CI)	Adjusted relative difference, % (95% CI)	P value
	No of incidents	Adjusted rate*	No of incidents	Adjusted rate*			
Overall incidents	2551	1.50	3109	1.34	0.16 (0.04 to 0.29)	12.3 (3.0 to 21.6)	<0.01
Hunting incidents	73	0.05	21	<0.01	0.04 (0.04 to 0.05)	566 (479 to 653)	<0.01
Suicide incidents	1129	0.77	1368	0.70	0.08 (0.01 to 0.15)	11.1 (1.1 to 21.2)	0.03
Alcohol substance use incidents	268	0.13	252	0.07	0.06 (0.03 to 0.09)	87.5 (43.4 to 131.4)	<0.01
Child involved incidents	62	0.04	67	0.03	0.01 (−0.01 to 0.02)	28.0 (−19.1 to 76.4)	0.26
Officer involved incidents	160	0.08	232	0.09	−0.01 (−0.04 to 0.01)	−11.4 (−37.8 to 15.1)	0.41
Defensive use incidents	133	0.10	140	0.08	0.02 (0.00 to 0.04)	27.8 (1.1 to 54.7)	0.04
Domestic violence incidents	204	0.16	210	0.13	0.03 (0.01 to 0.06)	27.4 (6.9 to 48.0)	<0.01
Home invasion or robbery incidents	322	0.17	357	0.13	0.04 (0.01 to 0.07)	30.4 (7.0 to 53.8)	0.01
Carry license incidents	756	0.48	870	0.40	0.08 (0.03 to 0.13)	19.4 (6.6 to 32.1)	<0.01

Adjusted firearm incident rates were calculated at weekly level and estimated from a linear regression model that adjusted for fixed effects for state and fixed effect for control periods before and after opener combined. Opener was defined as the three week period starting seven days before and ending 14 days after the first day of firearm deer hunting season. This definition was chosen because increases in firearm availability might be greatest in the days before and shortly after opening day. Periods before and after opening period were defined as three weeks before and three weeks after opening period. Incident types are not mutually exclusive except for hunting incidents. Included states are Alabama, Indiana, Michigan, Minnesota, Missouri, New York, Ohio, Pennsylvania, Texas, and Wisconsin.
*Per 10 million population.

four years, the hunting season opener was associated with an average 12.3% (95% confidence interval 3.0% to 21.6%, P<0.01) relative increase in firearm incidents compared with the three weeks before and after in the model comparing the opener to the surrounding control periods combined (table 1).

In analyses by incident type subgroup, season opening was associated with large increases in hunting incidents (relative increase of 566%, 95% confidence interval 479% to 653%, P<0.01), in keeping with the assumption that the beginning of hunting season is the most popular time to hunt. However, there were also increases in non-hunting related incidents, including suicide (11.1%, 1.1% to 21.2%, P=0.03), incidents involving alcohol or other substances (87.5%, 43.4% to 131.4%, P<0.01), domestic violence (27.4%, 6.9% to 48.0%, P<0.01), defensive use (27.8%, 1.1% to 54.7%, P=0.03), home invasion or robbery (30.4%, 7.0% to 53.8%, P=0.01), and incidents related to firearm carry licenses (19.4%, 6.6% to 32.1%, P<0.01). There were no differences in incidents involving children (P=0.26) or police officers (P=0.41).

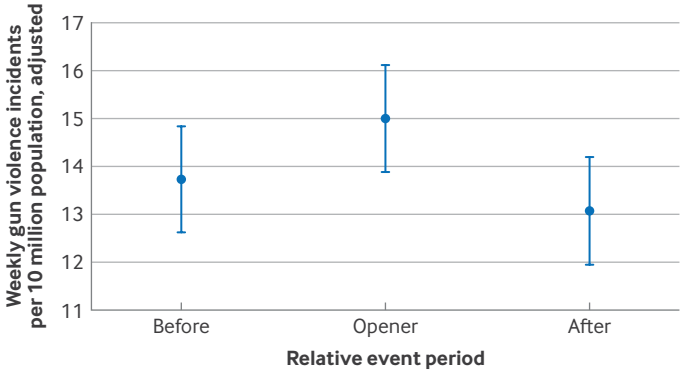

Fig 1 | Total firearm incident rates before, during, and after opening of deer hunting season in 10 states. Adjusted firearm incident rates were calculated at weekly level and estimated from linear regression model that adjusted for fixed effects for state and fixed effects for period relative to hunting season opener. Opener was defined as three week period starting seven days before and ending 14 days after first day of firearm deer hunting season. This definition was chosen because increases in firearm availability might be greatest in the days before and shortly after opening day. Periods before and after opener were defined as three weeks before and three weeks after opening period, allowing for comparison of three mutually exclusive three week periods. Error bars represent point estimates' 95% confidence intervals; estimates and statistical tests comparing periods before and after opener are reported in table 1. Incident types are not mutually exclusive except for hunting incidents. Included states are Alabama, Indiana, Michigan, Minnesota, Missouri, New York, Ohio, Pennsylvania, Texas, and Wisconsin

Similar results were observed when considering the time periods before and after the opener separately in the alternative regression model, with significant increases during the season opener for the overall incident rate (fig 1) and for the same incident categories as in the primary model (fig 2). For example, adjusted overall firearm incident rates increased from 13.7 incidents per 10 million population per week in the period before the opener to 15.0 incidents per 10 million population per week in the opener, a relative increase of 9.3% (P=0.058 for difference). Adjusted overall incident rates then decreased to 13.1 incidents per 10 million population per week in the period after the opener (P≤0.01 for difference compared with opener). Similarly, adjusted hunting firearm incident rates increased from 0.0 incidents per 10 million population per week in the period before the opener to 0.51 incidents per 10 million population per week in the opener, a relative increase of 1265% (P≤0.01 for difference), falling to 0.1 incidents per 10 million population per week in the period after the opener. At the same time, home invasion or robbery firearm incidents increased from 1.24 incidents per 10 million population per week in the period before the opener to 1.75 in the opener, a relative increase of 41.3% (P≤0.01 for difference), falling to 1.42 in the period after the opener. Firearm incidents categorized as defensive use—an often legally permissible use of firearms in the community—also increased from 0.71 incidents per 10 million population per week during the period before the opener to 0.97 during the opener, before falling back down to 0.83 in the period after the opener.

Overall and for categories where incidents increased during the opener compared with the period before,

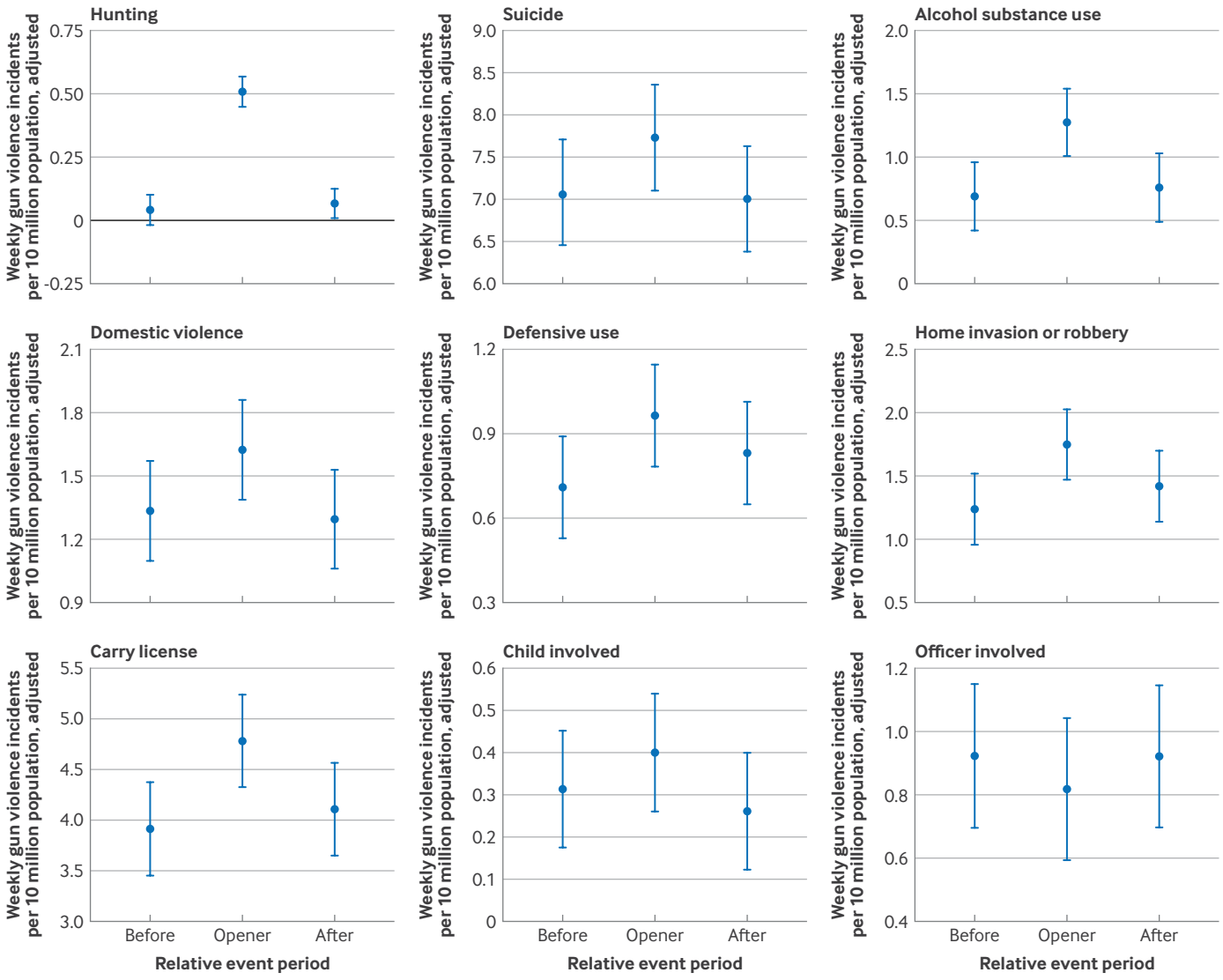

Fig 2 | Firearm incident rates before, during, and after opening of deer hunting season in 10 states by category. Adjusted firearm incident rates were calculated at weekly level and estimated from linear regression model that adjusted for fixed effects for state and fixed effects for period relative to hunting season opener. Separate regressions were estimated by category. Opener was defined as three week period starting seven days before and ending 14 days after first day of firearm deer hunting season. This definition was chosen because increases in firearm availability might be greatest in the days before and shortly after opening day. Periods before and after opener were defined as three weeks before and three weeks after opening period, allowing for comparison of three mutually exclusive three week periods. Error bars represent point estimates' 95% confidence intervals; estimates and statistical tests comparing periods before and after opener are reported in table 1. Incident types are not mutually exclusive except for hunting incidents. Included states are Alabama, Indiana, Michigan, Minnesota, Missouri, New York, Ohio, Pennsylvania, Texas, and Wisconsin

the incident rate fell during the period after the opener when deer hunting activity falls off, suggesting the changes seen during the season opener would not be explained by a broader trend. Patterns for overall incidents were similar when repeating the primary analysis using different durations for the opener, and the periods before and after (supplementary figure 2).

Discussion

Principal findings

The deer hunting season opener—when firearms and ammunition are more available in states with major deer hunting seasons—was associated with increases in both hunting and non-hunting related firearm incidents, including violent crime, defensive use, and suicide. Although increases in hunting related incidents are to be expected in these states at the onset of hunting season, increases in non-hunting related firearm incidents are less obviously so, indicating the potential general effect of greater firearm availability on several different types of firearm incidents.

Under the assumption that the specific timing of deer hunting season opening is arbitrary with respect to the baseline risk of firearm injury, this event study suggests a potential link between the start of hunting season and changes in the rate of firearm incidents. Although this study cannot pinpoint a precise causal mechanism, one hypothesis is a greater presence of

firearms and ammunition in communities around the time of deer hunting season openers, when firearms and ammunition will be removed from secure storage areas or newly purchased. While other hypothetical mechanisms could contribute to the observed effect (eg, alcohol use or partying might rise, which could increase the risk of firearm incidents), increases in firearm availability is logically plausible—firearm incidents cannot occur without firearms and ammunition available for use.

Although we observed large relative increases overall and among several types of firearm incidents, including violent crime and suicide, firearm incidents are fortunately relatively rare compared with other injury mechanisms, and so absolute differences in rates of firearm incidents were small. Nevertheless, this study sheds light on the important policy question of whether increased availability of firearms and ammunition can lead to increases in firearm incidents.

Comparison with other studies

This study adds to the existing literature by showing increases in several types of non-hunting firearm incidents associated with a time when greater availability of firearms is expected during hunting season. Previous smaller studies have shown expected temporal associations between hunting season and hunting related firearm incidents that occur among those participating in hunting activities.[11 25] Firearms and ammunition used for hunting are of course present in the community when hunters are not actively engaged in hunting, creating the potential for incidents that occur because of hunting season, but not because of hunting activity specifically. In Maryland, for example, long guns typically used for hunting were found to be more often used in suicides during hunting season.[24] The observed increases in this study in firearm incidents related to suicide, alcohol and substance related incidents, domestic violence, defensive use, home invasion or robberies, and carry licenses could all plausibly be explained by increased availability of firearms and ammunition in the community.

This study also adds to the growing body of quasi-experimental studies of firearm related outcomes, including providing a statewide analysis of several incident types that replicates and complements findings of a recent, important study evaluating the impact of hunting season on firearm incidents in rural counties.[13] In contrast to that study, which similarly used a longitudinal analysis to study changes in firearm incidents at the start of hunting season,[13] our study was not limited to rural counties, which is important because an estimated 75% of deer hunters live within metropolitan areas.[9] This implies that any increase in firearms brought about by hunting season might have effects in rural areas and wherever hunters live—mostly in urban or suburban communities—across the state. Moreover, hunting season could lead to increases in firearm availability among non-hunters or intermittent hunters, such as through increased marketing for firearms and ammunition, which could lead to rises in non-hunting related firearm incidents in rural areas and across the state.

Our study also relates to other studies that have focused on long term impacts of firearm regulations rather than the immediate changes in availability of firearms and ammunition plausibly brought on by hunting seasons. For example, large studies of policies focused on restricting sales and ownership of firearms in varying ways suggest they can be effective in reducing firearm deaths.[26 27] Meanwhile, limited studies of gun buyback programmes aimed at reducing the number of firearms in communities suggest they might not decrease firearm deaths,[28 29] though additional research into this intervention is needed.

Strengths and limitations of this study

Despite the quasi-experimental design, a significant limitation of our study design is that it cannot point to a specific mechanism by which hunting season might lead to increased non-hunting firearm incidents. However, there are several plausible mechanisms. When hunting season arrives, hunters take firearms out of storage, purchase new firearms, and purchase ammunition, all of which increase firearm availability in some way to themselves and those immediately around them—in the home, in vehicles, or on their person. This lowers barriers for firearms to be used in suicide attempts or against others. Hunting season opening might also be accompanied by increased interest in firearms and ammunition by non-hunters, such as through the news, social media, marketing campaigns for hunting equipment, or interactions with others who are hunters—any of which could increase availability of a variety of types of firearms in a variety of communities. These potential mechanisms are hypothetical; further research is needed to establish precise possible causal pathways.

There are several additional limitations to this study. Despite the quasi-experimental study design, our analysis relies on the assumption that the hunting season opener is not systematically temporally associated with other events that could increase availability of firearms across the states and years studied, and residual confounding is possible. For example, the observed increase in alcohol and substance use related firearm incidents could reflect an overall increase in incidents, but might also signify an increase in alcohol and substance use that occurs around the time of hunting season that might be due to hunting season but nevertheless accounts for some fraction of increased firearm incidents. Additionally, although the GVA has been validated for epidemiological use, labels characterizing the incidents used to categorize them in this study are subject to classification errors as cases evolve or are updated over time; however, because any misclassification errors are unlikely to be correlated with the timing of hunting season, this would be unlikely to lead to bias. Increases in firearm incidents for violent crime reported in this study do not necessarily represent increases in the number of crimes committed, but

rather the involvement of firearms. Finally, this study analyzed 10 states with deer hunting seasons where hunting related firearm incidents were most common; the impact in other states or the impact of other types of hunting seasons are probably different, limiting its generalizability.

Conclusions

In a quasi-experimental study of the impact of deer hunting season openers on firearm incidents, we observed a significant increase in both hunting and non-hunting related firearm incidents, including violent crime and suicide. Risk reduction efforts timed to coincide with hunting season onset might help curb hunting related firearm injuries and those related to violent crime and suicide.

Contributors: All authors contributed to the design and conduct of the study, data collection and management, analysis, interpretation of the data; and preparation, review, or approval of the manuscript. ABJ supervised the study and is the guarantor. The corresponding author attests that all listed authors meet authorship criteria and that no others meeting the criteria have been omitted.

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Ethical approval: This study was approved by the Harvard Medical School Institutional Review Board.

Data sharing: No additional data available.

Transparency: The lead author (the manuscript's guarantor) affirms that the manuscript is an honest, accurate, and transparent account of the study being reported; that no important aspects of the study have been omitted; and that any discrepancies from the study as planned (and, if relevant, registered) have been explained.

Dissemination to participants and related patient and public communities: The results of this work will be disseminated to the public through institutional press release, ensuing news articles, and an opinion piece authored by the study's authors that describe the study's findings for the public.

Provenance and peer review: Not commissioned; externally peer reviewed.

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Web appendix: Supplementary appendix