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School-wide attendance rates and firearm-involved expulsions in Michigan K-12 public schools, 2018–2022

Rebeccah Sokol[a,b,*], **V. Medina Del Toro**[b], **M. Degli Esposti**[b], **P. D. Kernsmith**[c], **B. G. Victor**[d], **H.-F. Hsieh**[b], **J. E. Heinze**[b,e]

[a]School of Social Work, University of Michigan, Ann Arbor, USA;

[b]Institute for Firearm Injury Prevention, University of Michigan, Ann Arbor, Michigan, USA;

[c]Luskin School of Public Affairs, Department of Social Welfare, University of California-Los Angeles, Los Angeles, California, USA;

[d]School of Social Work, Wayne State University, Detroit, Michigan, USA;

[e]School of Public Health, University of Michigan, Ann Arbor, Michigan, USA

Abstract

This ecological study estimated associations between school-wide attendance and expulsions for student firearm possession using administrative data for Michigan public K-12 schools from 2018–2022 (N=2,866 schools). Between the 2018–19 and 2021–22 school years, 77 Michigan public schools (2.7%) expelled students for firearm possession. In unadjusted models, higher rates of on-track attendance (i.e., the proportion of students who attend ≥90% of school days) were associated with lower odds of the school having an expulsion for student firearm possession (OR=0.96; 95% CI=0.95, 0.97). This association remained after adjusting for student body demographics, school building characteristics, and school rates of student interpersonal violence and discipline (aOR=0.97; 95% CI=0.95, 0.98). Efforts to improve school-wide attendance may offer a primary and universal prevention avenue against student firearm possession.

Keywords

school; firearms; school violence; ecological study

Shootings at K-12 schools account for less than one percent of firearm-involved deaths in the United States,[1] but their incidence exceeds that of any other high-income country[2,3] and is rising.[4] In 2022, there were 46 shootings at K-12 schools in the United States, more than in any year since 1999.[4] When considering how to prevent shootings on school grounds, public attention often focuses on selective or indicated strategies that attempt to influence a small subgroup of students at risk for firearm possession rather than universal strategies that apply to an entire student body.[5] Further, such strategies overwhelmingly involve secondary

*1080 S University, Ann Arbor, MI 48103; rlsokol@umich.edu.

Conflicts of Interest

The authors report there are no competing interests to declare.

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prevention to identify and mitigate evolving risks or tertiary prevention to reduce harms of specific incidents rather than primary prevention that occurs prior to risk formation.[6,7]

Despite their widespread implementation, many existing efforts to prevent firearm violence in schools have little to no evidence of effectiveness. A 2019 meta-analysis of 693 studies found no associations between common target hardening practices (such as security cameras, metal detectors, and school resource officers or security personnel) and any form of school violence or victimization.[8] Identifying intervention avenues that apply to the entire student body (i.e., universal prevention) prior to students developing risk for bringing a firearm to school (i.e., primary prevention) may inform novel strategies to reduce school-based firearm violence.

In 2019, 3% of students reported carrying a weapon, including a firearm, to school.[9] Current students are the most common perpetrators of shootings at schools,[4] and so reducing school-based firearm violence requires identifying opportunities to decrease the likelihood that a student feels the need to bring a firearm to school. The few studies that have identified correlates of at-school firearm possession primarily focus on individual and interpersonal risk factors, including violence involvement,[10,11] having peers bringing firearms to school,[10] being male,[10–12] being older,[11] higher levels of fear,[12] gang membership,[11,12] and substance use.[11] Prioritizing individual and interpersonal risk factors often leads to interventions focused on selective/indicated and secondary/tertiary prevention rather than universal and primary prevention.

Identifying school-level correlates of student firearm possession may inform universal and primary prevention interventions. The United States Secret Service analyzed 41 incidents of targeted school violence at K-12 schools in the United States from 2008 to 2017, finding no patterns for the types of school that perpetrators had targeted with respect to school size, type, location, and teacher-to-pupil ratio.[13] Yet, education research has explored how other types of school conditions—including school climate,[14,15] student belongingness and alienation,[16,17] and student engagement[14,18]—can contribute to or prevent school violence.[19,20] School-wide attendance rates may capture these overlapping, multi-dimensional, and difficult to measure school conditions.[21–24] Indeed, researchers have demonstrated that high attendance rates within schools can both reflect and contribute to positive school climate,[22,23,25] student belonging,[26,27] and student engagement.[28] As such, low school rates of student attendance may signal underlying risk for school violence, including student firearm possession. We posit that school attendance rates inform and reflect underlying school conditions that influence a school's protection against student firearm possession at school. As such, improving attendance rates may be one promising mechanism for preventing school-based firearm violence.

In this ecological study, we estimate the association between school-wide attendance rates and school expulsions for student firearm possession in Michigan public K-12 schools using publicly available school-level administrative data from the Michigan Department of Education. We hypothesize that high rates of school-wide student attendance links to lower risks of student firearm possession at school.

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Methods

Data Source

The State of Michigan provides public access to student attendance, discipline data, student body demographic characteristics, and school building characteristics aggregated to the school building level. We used this publicly available data from the 2018–2019 to 2021–2022 academic years for all general education, in-person (i.e., non-virtual) Michigan K-12 schools that operated during all academic years of the study period (N=2,866 schools). We included schools that held virtual classes over the course of the COVID-19 pandemic but excluded schools that districts developed with the intent of providing online education in perpetuity. Supplemental Methods 1 provides specific definitions and collection details for each measure.

Measures

School-wide on-track attendance rate: The focal independent variable was school-wide on-track attendance rate. The school-wide on-track attendance rate is the number of students per 100 students in a school who attend 90% or more of possible school days in a given academic year. High school-wide on-track attendance rates indicate that a large proportion of the student body regularly attends school.

Firearm-involved expulsion: The primary outcome was whether a school expelled one or more students for firearm possession during the study period, academic years 2018–19 through 2021–22. The state of Michigan requires all public schools to report expulsions for all students, including the incident type that led to the expulsion. Michigan law requires schools to expel any student found in possession of a firearm on school grounds. We therefore considered expulsions that involved firearm possession as being firearm-involved expulsions.

Covariates: Supplemental Figure 1 provides our conceptual model and research-based assumptions regarding the relationships between potential covariates, student attendance rates (focal predictor), and firearm-involved expulsion (outcome). In accordance with our conceptual model, covariates included student body demographics, school building characteristics, school rates of student interpersonal violence, and school rates of discipline.

Student body demographic characteristics included the number of students who were economically disadvantaged per 100 students, the percent of the student body by gender, and the student body's diversity index. School building characteristics included school locale (rural, suburb or town, city), school level (elementary school, middle school, high school, mixed level), and total student enrollment. School rates of student interpersonal violence were the number of bullying incidents and the number of victimization incidents per 100 students. The number of non-firearm-involved expulsions per 100 students (for example, expulsion for alcohol or physical violence without a firearm) represented school rates of disciplinary action.

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Statistical Analyses

We aggregated data across all academic years included in the study, 2018–19 through 2021–22. Specifically, we averaged schools' annual on-track attendance rates, student body demographic characteristics, total student enrollment, and interpersonal violence rates over the study period. The outcome, firearm-involved expulsion, was whether a school expelled one or more students for firearm possession during any point in the study period. School locale and level did not change over time. Supplemental Table 1 provides a descriptive summary of schools stratified by academic year. Most school-level variables were stable over time (median intra-class correlation [ICC]: 0.97; range: 0.07–0.99), except for rare events (non-firearm expulsions, victimization, and bullying) and attendance rates during and immediately following the onset of the COVID-19 pandemic in 2020. As such, we conducted sensitivity analyses that excluded academic year 2020–2021 and that did not aggregate data across years (see Sensitivity analyses, below)

We first estimated bivariate associations between school characteristics and whether the school had a firearm-involved expulsion during the study period, academic years 2018–19 through 2021–22. We calculated effect sizes for all bivariate analyses. For continuous covariates, we calculated effect sizes for the differences in the means between schools that did not versus those that did have an expulsion for student firearm possession using Cohen's *d* with the Satterthwaite approximation. For categorical covariates, we calculated effect size using Cramer's *V*.

Following bivariate analyses, we estimated unadjusted and adjusted logistic regression models to identify associations between school-wide attendance rates and firearm-involved expulsions. In accordance with the conceptual model, adjusted models included student body demographics, school building characteristics, school rates of student interpersonal violence, and school rates of discipline. We included cluster robust standard errors by school district in both unadjusted and adjusted models to account for nesting of school buildings within school districts. The area under the receiver operating characteristic curve (AUC) evaluated model fit.

Among the 2,866 non-virtual, general education Michigan public K-12 schools operating between 2018–19 and 2021–22, 70 schools had incomplete information on covariates. As this missingness accounted for less than 3% of schools in the state, we performed complete case analyses (Supplemental Figure 2).

We performed all data management and analyses in R v4.2, and we used the miceadds R package (v3.16–18) to estimate all logistic regression models. The University of Michigan Institutional Review Board approved this study (HUM00224140).

Sensitivity analyses: Starting March 13, 2020, Executive Order 2020–5 closed schools to reduce the spread of the SARS-CoV-2 virus, and subsequent orders closed in-person instruction for the remainder of the academic year.[29] Michigan public K-12 could return to in-person instruction in Fall 2020, with many schools transitioning to some form of online teaching and learning during academic year 2020–21. As such, we conducted sensitivity analyses that removed this year from the aggregated dataset (Supplemental Table 2). We also

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conducted sensitivity analyses on school-by-year data (i.e., not aggregated across the study period) that estimated mixed effects regression models that included random intercepts for school building and school district (Supplemental Table 3).

Results

Table 1 provides a descriptive comparison of Michigan public K-12 schools that did and did not have an expulsion for student firearm possession during the 2018–2019 through 2021–2022 school years. During the study period, 77 Michigan public schools (2.7%) had an expulsion for student firearm possession. The median school-wide on-track attendance rate (averaged over the study period) for schools with a firearm-involved expulsion (67.8; inter-quartile range [IQR]: 47.2–77.3) was lower than that among schools without a firearm-involved expulsion (79.2; IQR: 69.1–85.5; Cohen's d=0.76). The median student enrollment (700 [IQR: 424–1030] versus 401 [IQR: 286–552]; Cohen's d=0.80) and rate of students (per 100 students) with non-firearm expulsions (0.08 [IQR: 0.02–0.22] versus 0 [IQR: 0–0.03]; Cohen's d=0.72) were also higher among school with versus without a firearm-involved expulsion.

In the unadjusted model, higher rates of school-wide on-track attendance (i.e., the proportion of students who attend ≥90% of school days) were associated with lower odds of the school having an expulsion for student firearm possession (odd ratio [OR] = 0.96; 95% confidence interval [CI] = 0.95, 0.97; AUC = 0.71 [0.65, 0.77]). After adjusting for student body demographic characteristics, school building characteristics, and rates of student interpersonal violence and school disciplinary action, higher rates of school-wide on-track attendance remained associated with lower odds of the school having a firearm-involved expulsion (adjusted odds ratio [aOR] = 0.97; 95% CI = 0.95, 0.98; AUC = 0.87 [0.83, 0.90]). Specifically, the odds of having a school expulsion for student firearm possession reduced by three percent for every one percent increase in students who achieve on-track attendance.

Figure 1 displays the average marginal predicted probabilities of schools having an expulsion involving student firearm possession at different rates of school-wide on-track student attendance. The average marginal predicted probability of having a firearm-involved expulsion in schools where half of students achieve on-track attendance was 4.5%. This marginal predicted probability decreased to 2.2% in schools where three-quarters of students achieve on-track attendance and 1% in schools where ≥95% of students achieve on-track attendance (Figure 1).

Sensitivity analyses

The findings from our adjusted logistic regression model of the association between school-wide attendance rates and firearm-involved expulsions were robust to sensitivity checks that removed the 2020–21 academic year from the aggregated dataset (Supplemental Table 2) and that involved mixed effects regression models that included random intercepts for school building and school district (Supplemental Table 3).

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Discussion

The present findings suggest that a modifiable school condition—attendance—is associated with firearm possession in schools. Specifically, high student attendance rates were associated with fewer student expulsions for firearm possession at school. Although high on-track attendance rates may indicate school protection against student firearm possession at school, student absences likely are not the causal forces that produce the outcome. Still, school attendance rates may be a promising universal and primary prevention intervention focus for reducing student firearm possession at school and improving school safety.

Interventions do not need to act directly on the proximal causes of a problem to be effective. Even though school-wide attendance rates likely are not directly creating risk for student firearm possession, attendance rates both reflect and contribute to school conditions known to influence school safety, including school climate,[14,15] student belongingness and alienation,[16,17] and student engagement.[14,18] Given these bi-directional associations, improving school attendance might in turn influence additional school conditions (e.g., creating norms around the importance of school attendance, facilitating student belongingness, reducing student alienation from peers and teachers) that support overall school safety.

The association between school attendance rates and student expulsion for firearm possession at school was small. The probability of a school having an expulsion for student firearm possession dropped 2.3 percentage points between schools where half of students and three-quarters of students achieve on-track attendance. This small association, however, is meaningful given the rarity, but potential severity, of student firearm possession at school.

Being chronically absent from school can be the product of multiple factors across the social ecology—including individual, peer, family, school, and community circumstances—that combine to make attending school difficult or not a priority.[30] In the multivariable analysis, we sought to account for other individual, peer, family, and community circumstances that may influence school-wide attendance rates (Supplemental Figure 1)—including student body demographic characteristics, school locale and size, and rates of peer violence. Additional family, neighborhood, and community factors not included in the present analyses (e.g., community violence) may be common causes of both the exposure (school-wide attendance rates) and the outcome (firearm-involved expulsion), and their exclusion from the present analyses may bias estimates. Yet, we expect these unmeasured factors to correlate strongly with the included covariates based on prior research.[31,32] Our preliminary findings suggest that underlying school conditions can influence student firearm possession at school, and future work that accounts for confounders at multiple levels of the social ecology would indicate the robustness of these findings.

This study did not identify the specific underlying school conditions that school-wide attendance rates reflect, but prior literature suggests school conditions may contribute to firearm violence in schools. Indeed, in an analysis of school shootings in the United States between 1966 and 2009, scholars proposed that school characteristics that foster alienation among students may contribute to conditions associated with fatal school

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shootings.[33] Future studies that propose and test models of the associations between school conditions and school risk for student firearm possession would further inform school-based interventions to promote school safety.

A competing rationale for the observed association between school-wide attendance rates and risk for student firearm possession is a compositional one. A compositional rationale posits that the types of students that compose the school, not the school context, create risk for at-school firearm possession.[34] Following this logic, school attendance does not reflect underlying school conditions, but rather attendance is an individual-level correlate of a student's propensity to carry a firearm to school; as such, schools that have more of these students with low attendance have a higher likelihood of expelling a student for at-school firearm carriage. Empirical literature, however, supports the idea that school context —beyond school composition—influences various student outcomes, including violence perpetration,[35] violence victimization,[36] and general student misbehavior (i.e., fighting, suspension, and/or trouble for not following school rules).[37] Furthermore, as we conducted all analyses at the school-level, it would be an ecological fallacy—drawing inaccurate conclusions about individuals based on group-level findings—to infer that students with more absences are more likely to carry a firearm to school compared to students with fewer absences. Future multilevel analyses are required to tease apart the compositional and contextual effects of schools on school risk for student firearm possession.

In bivariate analyses, student enrollment and a non-firearm expulsion rate were higher in schools with versus without firearm-involved expulsions. Although descriptively informative, these bivariate analyses do not provide an unbiased estimate of the associations between school characteristics and firearm-involved expulsions. For example, it may be that larger schools were more likely to have a firearm-involved expulsions because they schools have more students—and thus more opportunities for a student to possess a firearm at school—rather than intrinsic differences between schools of different sizes. Future work to understand relationships between different school characteristics and firearm-involved expulsions will require considering the unique potential confounders operating in each association.[38]

Limitations

The use of administrative data restricted the possible constructs to adjust for and explore in our models. Future studies that obtain multiple measures—particularly student self-report data—of school alienation, school climate, and their associations with student firearm possession at school would expand understanding of the present findings. Another limitation of the study is that school discipline data (including bullying, victimization, and non-firearm expulsions) reflect underlying racial biases within school systems, and data systems may not formally capture all such incidents.[39,40] Yet, expulsion decisions for student firearm possession may be less subjective compared to other behaviors, as the Gun-Free Schools Act of 1994 mandates that student firearm possession at school result in expulsion. We expect findings to generalize beyond Michigan, as the Gun-Free Schools Act applies to schools in all states. Additional state policy, social, and economic landscapes, however, may influence results and so similar analyses replicated in other states would inform the generalizability

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of findings beyond Michigan. Finally, as a cross-sectional study, our analyses are subject to reverse-causation, whereby student expulsion for firearm possession results in fewer students attending school—in response to fear, for example—rather than the relationship acting in the opposite direction. In our analysis, we attempted to control for student safety by controlling for bullying, victimization, and non-firearm-involved expulsion incidents.

Conclusions

Attendance is a modifiable school condition that is associated with firearm possession in schools. Although this association is small, it is potentially meaningful given the rarity but potential severity of student firearm possession at school. Efforts to improve student attendance may offer both a primary and universal prevention avenue against student firearm possession at school and an opportunity to shift the entire school population distribution risk for involvement in school-based firearm violence downward.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Biographies

Rebeccah Sokol, PhD, is an assistant professor in the School of Social Work at the University of Michigan and Institute for Firearm Injury Prevention. In Dr. Sokol's scholarship, she considers some of the largest threats to youth safety and how inequities root these threats.

Mr. Medina Del Toro is a Research Area Specialist at the University of Michigan Institute for Firearm Injury Prevention. His work focuses on understanding how individuals make sense of their lives in precarious structural contexts. He completed his master's degree in Global Criminology at Utrecht University.

Dr. Degli Esposti is a Research Assistant Professor with the Institute for Firearm Injury Prevention. Dr. Degli Esposti's research focuses on understanding violence and mental health at the population level, with a specific interest in firearm violence in the United States.

Poco Kernsmith is Professor and Chair of the Department of Social Welfare in the Luskin School of Public Affairs at the University of California-Los Angeles. Dr. Kernsmith's research focuses on the etiology and prevention of perpetration of violence among peers, in families, and intimate relationships.

Bryan Victor, Ph.D. is an associate professor in the Wayne State University School of Social Work. Dr. Victor specializes in the use of data science methods and administrative

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records research to better understand system operations and drive data-informed decision-making in child welfare practice.

Dr. Hsieh is a research associate professor at the Institute for Firearm Injury Prevention. Dr. Hsieh's research also seeks to identify behavioral, interpersonal, and community factors that promote resilience among communities shouldering the unjust burden of violence and racism and therefore inform preventive efforts.

Dr. Heinze is currently an associate professor in the Department of Health Behavior and Health Education in the School of Public Health. Dr. Heinze's research investigates how schools influence disparities in violence and other risk outcomes from an ecological perspective that includes individual, interpersonal, and contextual influences on development.

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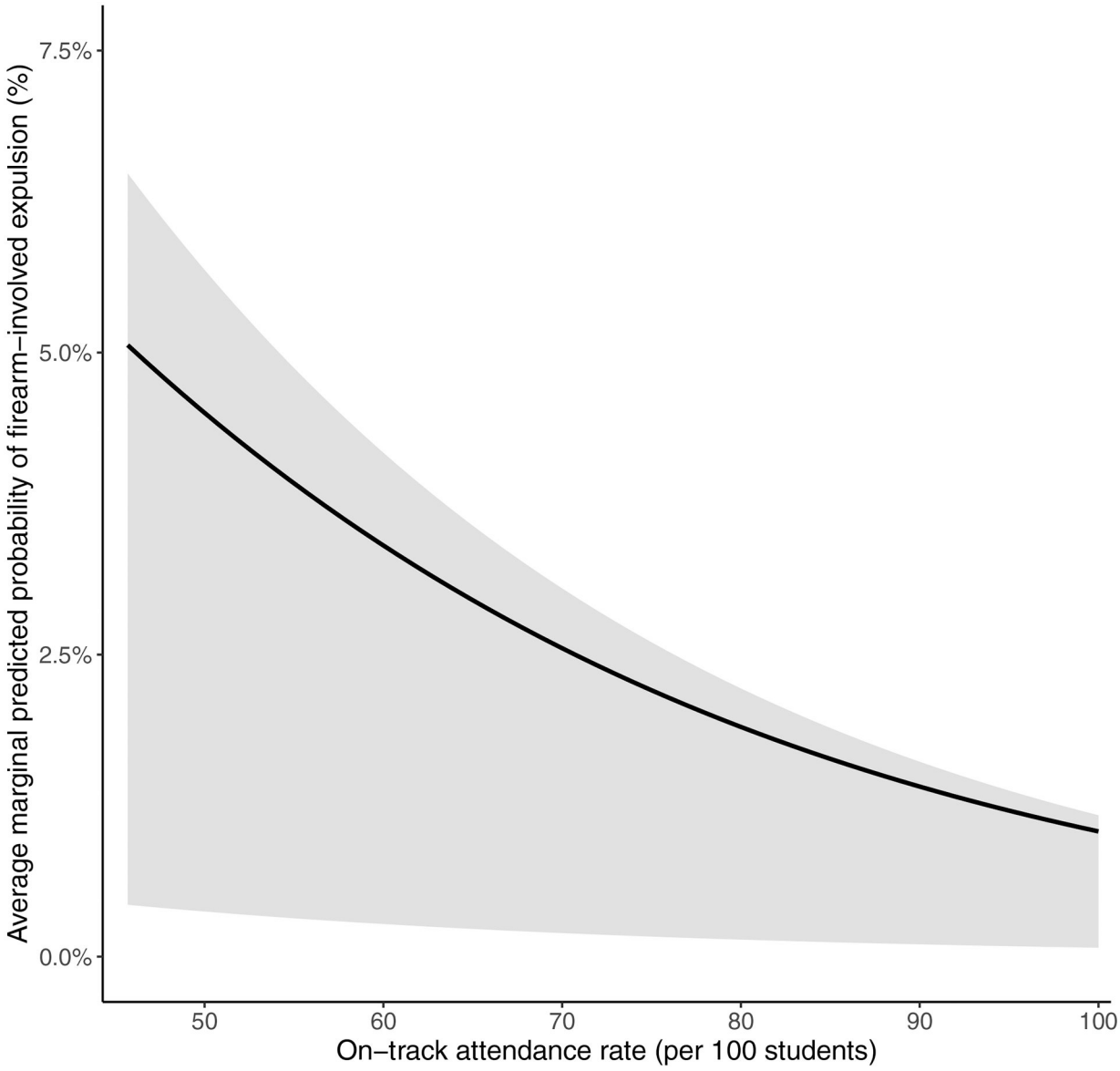


Figure 1.

The average marginal predicted probability of a Michigan public K-12 school having an expulsion due to student firearm possession at different rates of school-wide on-track student attendance, academic year 2018–19 through 2021–22.

Notes: Black line depicts average marginal predicted probability of having an expulsion involving student firearm possession at school and shaded area depicts the 25th and 75th percentiles of the marginal predicted probabilities. School-wide on-track attendance rate defined as the number of students that attend ≥90% of school days, per 100 students. The model used to estimate the average marginal predicted probabilities was a logistic regression model that adjusted for: school level; school locale; and annual average school total enrollment, student body by sex, school diversity index, school bullying rate, school non-firearm expulsion rate, and school victimization rate over the study period, 2018–2022.

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Table 1.

Descriptive comparison of Michigan public K-12 schools that did (n=77) and did not (n=2789) have an expulsion for student firearm possession during the 2018–2019 through 2021–2022 school years.

	Median (25th-75th percentile) or n (%)		Effect size
	Schools with a firearm-involved expulsion (N=77)	Schools without a firearm-involved expulsion (N=2789)	
On-track attendance rate[a]	67.8 (47.2–77.3)	79.2 (69.1–85.5)	**0.76**
Total enrollment	700 (424–1030)	401 (286–552)	**0.80**
School level			0.17
Elementary school	2 (2.6%)	1219 (43.7%)	
High school	36 (46.8%)	401 (14.4%)	
Middle School	13 (16.9%)	336 (12.0%)	
Mixed	26 (33.8%)	833 (29.9%)	
Locale			0.05
City	24 (31.2%)	596 (21.4%)	
Rural	12 (15.6%)	789 (28.3%)	
Suburb or town	41 (53.2%)	1379 (49.4%)	
Student body by sex			
% Male	51.3 (50.1–52.5)	51.3 (49.8–52.9)	0.01
% Female	48.7 (47.5–49.9)	48.7 (47.1–50.2)	
Student body by race			
% American Indian	0.27 (0.10–0.48)	0.21 (0.06–0.46)	0.11
% Asian American	0.69 (0.08–1.59)	0.68 (0.18–1.94)	0.27
% African American or Black	16.4 (1.94–64.5)	3.00 (0.90–17.9)	0.55
% Hispanic	4.90 (2.24–9.56)	4.91 (2.72–8.52)	0.12
% Hawaiian or Pacific Islander	0.04 (0–0.10)	0 (0–0.10)	0.15
% White	55.9 (10.5–84.6)	79.8 (49.9–89.5)	0.53
% Two or more races	3.88 (1.82–6.19)	3.79 (2.06–6.49)	0.03
Diversity index[b]	31.0 (15.8–54.6)	28.1 (16.6–50.6)	0.05
Disadvantaged rate[c]	65.6 (41.7–83.9)	53.9 (34.4–73.1)	0.34
Bullying rate[d]	0.48 (0.12–1.01)	0.30 (0.06–0.89)	0.08
Non-firearm expulsion rate[e]	0.08 (0.02–0.22)	0 (0–0.03)	**0.72**
Victimization rate[f]	0.02 (0–0.10)	0 (0–0)	0.39

Notes: Effect sizes quantify differences between schools that did versus did not have an expulsion for student firearm possession using Cohen's *d* with the Satterthwaite approximation (for continuous variables) and Cramer's V (for categorical variables). Bold indicates effect sizes ≥0.60.

[a]On-track attendance rate is the number of students (per 100 students) who attend ≥90% of schools days each year, averaged over 2018–19 through 2021–22.

[b]Diversity index is the probability (0–1) that two people chosen at random from the same school and year will be from different racial groups, averaged over 2018–19 through 2021–22.

[c]Disadvantaged rate is the number of students (per 100 students) who meet disadvantaged criteria each year, averaged over 2018–19 through 2021–22.

[d] Bullying rate is the number of bullying incidents per 100 students each year, averaged over 2018–19 through 2021–22. Bullying includes any written, verbal, physical act, or electronic communication intended to harm one or more students.

[e] Non-firearm expulsion rate is the number of not-firearm-involved expulsion events per 100 students in each year, averaged over 2018–19 through 2021–22.

[f] Victimization rate is the number of victimization events per 100 students each year, averaged over 2018–19 through 2021–22. Victimization incidents include when there is an official written complaint that a student was the victim of a violent criminal offense at school or at a school-sponsored activity.

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Table 2.

Logistic regression results for the association between school rates of on-track attendance and expulsion for student firearm possession during the 2018–2019 through 2021–2022 school years in Michigan public K-12 schools (N=2,796).

	Odds ratio (95% confidence interval) for having an expulsion for student firearm possession	
	Unadjusted	Adjusted[a]
On-track attendance rate	0.96 (0.95, 0.97)	0.97 (0.95, 0.98)

Notes: Model includes cluster robust standard errors by school district.

[a]Adjusted odds ratio is adjusted for school level; school locale; and annual average school total enrollment, student body by sex, school diversity index, school bullying rate, school non-firearm expulsion rate, and school victimization rate over the study period, 2018–2022.