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Mass School Shootings and the Short-Run Impacts on Use of School Security Measures and Practices: National Evidence from the Columbine Tragedy

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ABSTRACT

Following high-profile school shootings, policymakers and educators seek ways to prevent such shootings, but there has been little research on school-level responses in the immediate aftermath of such events. This study examines how school-level security measures and practices changed after the 1999 Columbine shooting using a nationally representative sample of elementary school principals from the Early Childhood Longitudinal Study ($N = 810$). Exploiting variation in the timing of survey completion relative to the Columbine shooting, we used regression analysis to examine the use of seven security measures and practices before and after Columbine. Elementary schools were 16 percentage points more likely to lock exits after Columbine and, over time, were more likely to use visitor sign in procedures. School racial/ethnic composition had a moderating effect in some models. Implications for policy and schools are discussed.

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School security; school violence; school shooting; natural experiment

Introduction

Following a series of school shootings in 2018, attention among policymakers, educators, and the general public has once again focused on enhancing students' safety (Blad, 2018; Curran, 2018a, 2018b). Such attention has similarities to the conversations sparked by prior high-profile tragedies such as the shooting at Columbine High School in 1999. As with prior shootings, efforts have focused on enhancing security, leading to proposals for increased law enforcement presence and security mechanisms like cameras or metal detectors (e.g., STOP School Violence Act, 2018).

The majority of attention, however, has focused on responses at the federal and state level (Curran, 2018a, 2018b; STOP School Violence Act, 2018). Comparatively, less attention has been given to the responses of schools themselves, despite the fact that schools may directly feel the pressure from parents to respond to such events and have the flexibility to move quickly in making some security changes – such as locking doors or changing visitor policies – in the immediate aftermath of a nationally prominent school shooting. Some prior work has explored changes in students' perceptions of fear and safety at school in the wake of high-profile shootings (Addington, 2003; Fisher, Nation, Nixon, & McIlroy, 2017), but quantitative research linking such high-profile events to short-term changes in security approaches by schools is limited (Birkland & Lawrence, 2009).

This study addresses these limitations by exploring the relationship between the Columbine shooting in 1999 and principals' reports of using specific security measures and practices. We drew on principal responses to a nationally representative survey fielded during a time period that overlapped the Columbine shooting. In doing so, we exploited variation in the timing of survey

completion that allowed us to explore principal responses immediately before and after the Columbine shooting. Our results provide evidence on how a nationally-prominent school shooting may affect short-run changes in the use of school security measures and practices.

School shootings as an impetus for change

Prominent narratives point to school shootings – particularly Columbine (Muschert, 2009; Muschert, Henry, Bracy, & Peguero, 2014) – as important for changes in schools' approaches to safety and security, but a surprisingly limited amount of research has examined the impacts of high-profile school shootings on school security. Although federal and state-level policies have addressed school safety following school shootings, passing legislation is slow and does not speak to more immediate school-level changes. Indeed, the media attention given to school shootings – in combination with an exaggerated perception of risk – has prompted school safety to become a prominent concern among parents and has prompted recent demonstrations and advocacy work among many students (PDK, 2018). Such pressure from stakeholders has led school and district leaders to make more localized changes to school security approaches in an effort to prevent potential tragedies (Madfis, 2016). Examining the influence of high-profile school shootings on these school policies is complicated by the shifting media narrative that follows the events. For example, the immediate media coverage of the Columbine shooting focused on it as a local story, but as time passed the reporting shifted to frame it as a symptom of a national problem (Muschert, 2009). Thus, any changes in schools' security measures and practices may not be driven by an immediate reaction to the event but by a delayed response to the media's shift in framing the event.

There are a wide range of approaches available to schools, including both visible security measures such as security cameras or metal detectors (Addington, 2009; Tanner-Smith, Fisher, Addington, & Gardella, 2018) and a variety of non-visible security measures and practices. Unfortunately, the evaluation evidence for both visible and non-visible security measures is lacking (Cook, Gottfredson, & Na, 2010; Petrosino, Guckenburg, & Fronius, 2012; Reingle Gonzalez, Jetelina, & Jennings, 2016), leaving schools to make decisions about school safety without clear guidance from research. Some of these changes are costly and difficult to implement, such as hiring school resource officers or installing metal detectors. By contrast, others might be quite inexpensive and easy to implement, such as requiring visitors to sign in or locking exterior doors. Schools may be particularly likely to use these easy-to-implement policies following high-profile school shootings.

Though little evidence exists about the school-level short-run changes to security measures and practices following school shootings at a national level, some related studies suggest there may be an effect. For example, examining national-level trends over time (including before and after Columbine), Addington (2009) found that schools continued their trend of increasing school security following Columbine, particularly in the use of security personnel, cameras, locking doors, requiring visitor sign-ins, and using identification badges. However, this study was unable to assess changes in schools' approaches to security until over a year after Columbine, leaving unclear the timing of these changes. Another study found that 63% of Colorado high schools tightened their security procedures following Columbine, 40% used stricter disciplinary procedures, 32% increased security presence, and 17% increased their use of locker checks (Crepeau-Hobson, Fliaccio, & Gottfried, 2005). However, given that Columbine took place in Colorado, it is unclear whether these increases in security were a localized reaction or one that extended nationally.

Theoretical framework

We draw on several theoretical perspectives to explain why a national event like Columbine might result in shifts in security measures and practices, why school level responses might be an important component of this response, and why such responses might vary by the demographics of students served. First, the use of school security measures and practices geared toward maintaining school

safety is often understood as a set of social control mechanisms that are meant to prevent violence (Cook et al., 2010; Muschert & Peguero, 2010; Noguera, 1995; Tanner-Smith & Fisher, 2016). Opportunity theories of crime – based on rational actor models in which criminal behavior occurs when the potential benefits outweigh the potential costs – suggest that these sorts of crime prevention policies and practices will deter violence because potential offenders will perceive that their violent behavior is likely to be detected and punished (Becker, 1968; Piliavin, Gartner, Thornton, & Matsueda, 1986). As such, increasing schools' ability to monitor potential offenders in and around the school – and ensuring that this monitoring is visible – is one approach to violence prevention that has been taken in many schools. Paired with a recent increase in schools adopting approaches used in criminal justice arenas, the likelihood that an event like Columbine could spark changes in security mechanisms is particularly salient (Hirschfield, 2008; Kupchik, 2016).

Next, policy implementation theory suggests that local actors, such as district and school leaders may have substantial impact on the enactment of security measures and practices (Datnow & Park, 2012). Such “street level bureaucrats,” in the terminology of policy implementation, exercise discretion in the enactment of local policies (Lipsky, 1981). Indeed, empirical evidence documents differences in approaches to security across a number of characteristics of schools. For example, schools in urban areas are more likely to have security personnel, more likely to use metal detectors, and more likely to have controlled access to schools than those in rural settings (Musu-Gillette et al., 2018). Similarly, high schools are more likely than elementary schools to use security cameras or metal detectors but less likely to control access to the building or require picture identification (Musu-Gillette et al., 2018). Differences might also be expected across public/private institutions and those that are secular or faith-based due to documented differences in rates of gang activity and other threats to safety across these contexts (Musu-Gillette et al., 2018). Such local differences across types of schools might theoretically be linked to bottom-up policy implementation, in which local actors influence and enact policy. This suggests that examining the responses of the schools themselves, particularly in the immediate aftermath of an event like Columbine, may yield insights into how approaches to security are altered by the actions of local leaders.

Finally, racial threat theory suggests that such disparities may be a direct response to the demographic makeup of these schools, reflecting efforts by the dominant social group to socially control racial minorities (Welch & Payne, 2010). Critical scholars point to the racially disproportionate way that social control is used in schools and implemented across locales. They argue that security measures and policies are themselves a mechanism of violence and part of a broader social trend toward surveilling students, particularly students of color (Henry, 2009; Noguera, 1995; Wacquant, 2001). In particular, nationwide there are more invasive and exclusionary forms of school security (e.g., metal detectors) used in schools with larger proportions of students of color (Musu-Gillette et al., 2018; Steinka-Fry, Fisher, & Tanner-Smith, 2016). This increased focus on surveillance has the potential to socialize students into lives where they expect to be monitored and face the threat of incarceration (Hirschfield, 2008; Wacquant, 2001). If high-profile school shootings change the landscape of school security measures and policies in racially disparate ways, this may help explain some of the existing racial differences in students' educational experiences.

Current study

Given the contradiction between the broad narratives that position high-profile school shootings as important events for shaping school policies and the dearth of research examining schools' responses to these events, the current study positions Columbine as a natural experiment to assess the extent to which schools responded by implementing various school security measures and policies. Drawing on methods from prior studies investigating the impacts of high-profile school shootings (Addington, 2003; Fisher et al., 2017), this study uses survey data from principals about their use of a variety of school security measures and practices. In particular, we address the following research questions:

- (1) How do schools' use of security measures and practices differ between the period immediately preceding a high-profile school shooting and the period immediately following such an event?
- (2) How do differences in the use of particular security measures and practices before and after a high-profile school shooting vary based on school racial/ethnic composition?

Method

Data

We drew on nationally representative data from the Early Childhood Longitudinal Study – Kindergarten (ECLS-K). The ECLS-K was administered by the National Center for Education Statistics' Institute for Education Sciences. Although the ECLS-K is a longitudinal study beginning in 1998–99 and following a nationally representative set of kindergartners from that school year through eighth grade, this study focuses only on surveys completed in the base year between January and October of 1999. The ECLS-K used a multi-stage sampling design where the second stage of the design (after separating the United States into geographical sampling units and strata) randomly selected public and private schools that offer kindergarten programs.

We used a school-wide survey administered as part of ECLS-K that was completed by the principal (or their designee). The sample of principals ($N = 810$; rounded to comply with IES restricted data standards) is nationally representative of elementary schools with kindergartens in the 1998–99 school year. Surveys were provided to school principals in several different ways based on their preferences – through site visits prior to spring data collection, via mail, and during visits to the schools to administer student assessments. Once the survey was in hand, school administrators then completed the surveys at a time of their choosing (Tourangeau et al., 2009). The survey completion date (as marked by the completer of the survey) varied such that some principals completed the survey prior to Columbine whereas others completed the survey after Columbine. While such variation in the timing of the survey completion is not strictly random – early completers could differ from later completers – we argue that it provides a degree of random variation, and we address remaining selection bias through the use of observable controls and other approaches as described in our robustness checks.

Independent variables

Our primary independent variable was a binary indicator of whether the principal completed the survey after Columbine (April 20th, 1999). Out of 810 principals, 620 completed the survey post-Columbine and 190 completed the survey pre-Columbine.

Additionally, some specifications included a continuous measure of the number of days post-Columbine to assess delayed responses to Columbine. This approach accounts for the media's delayed shift in framing Columbine as a symptom of a national problem (Muschert & Carr, 2006) that might have led to a delayed uptake of security measures and practices.

Dependent variables

We focused on several dependent variables indicating the use of a particular security measure or practice. Principals responded to a question (0 = *No*, 1 = *Yes*) that asked “Does your school take any of the following measures to ensure the safety of children?” and included the following: security guards, metal detectors, locked exterior doors during the day, a requirement that visitors sign in, limits on going to the restrooms, teachers assigned to supervise the hallways, and hall passes required to leave class. We analyzed each of these security measures and practices individually.

Control variables

Although the timing of Columbine relative to principals' survey completion could be considered a random shock, we nevertheless included controls in our models for a variety of observable characteristics of both schools and principals. In particular, we controlled for school characteristics including school size, urbanicity, geographic location, racial composition of teachers and students, and the percent of students eligible for free or reduced-price lunch. We also controlled for characteristics of the principal including gender, race/ethnicity, experience, and education level. See Tables 1 and 2 for descriptive statistics on each control variable.

Missing data

The ECLS-K includes missing data that would have reduced our sample by a third if we had used listwise deletion. To prevent this loss of observations and to preserve the generalizability of the estimates, we used multiple imputation. We imputed the missing values on control variables with missing data, but we did not impute the values on any of the dependent or focal independent variables. We imputed using the multivariate normal approach in Stata creating ten imputed datasets. As described in the robustness and sensitivity check section, our primary results were generally robust to the use of listwise deletion and missing dummy variables as alternative means of addressing missing data.

Data analysis

Our identification strategy was based on the assumption that the date Columbine occurred was unrelated to whether or not a school had already completed the ECLS-K survey. This represented then a natural experiment in which schools who completed the survey before April 20th, 1999 served as a plausible comparison group to those who completed the survey afterward. The main assumption in this strategy is that the treatment schools (those completing the survey post-Columbine) and the comparison schools (those completing the survey pre-Columbine) are equal in expectation: the security measures and practices in both groups of schools would be the same on average in the absence of the Columbine shooting.

Our primary analytic approach involved estimation of an ordinary least squares (OLS) regression with a robust set of observable covariates to explore differences in the reported use of security measures and practices before and after Columbine. In particular, we estimated a model of the following form:

$$\text{SecurityMeasurePractice}_{sp} = \beta_0 + \beta_1 \text{AfterColumbine}_{sp} + \beta_2 \text{SchoolMeasures}_{sp} + \beta_3 \text{PrincipalMeasures}_{sp} + e \quad (1)$$

in which *SecurityMeasurePractice* is a binary indicator of whether the principal reported the use of a given security measure within the school, *AfterColumbine* is a binary indicator of whether the principal survey was completed after the occurrence of the Columbine shooting, *SchoolMeasures* is a vector of school level observable covariates, and *PrincipalMeasures* is a vector of observable principal characteristics. Our interest was in β_1 which represents the difference in the likelihood of a principal reporting the use of a given security measure or practice after Columbine as compared to before Columbine.

We also extended this specification in two ways. First, as some security measures and practices may have taken time to be implemented or may have been implemented in response to the evolving media narrative around Columbine, we estimated a model that included a measure of the number of days after Columbine in addition to the binary indicator of being after Columbine. Second, we explored the extent to which changes in security measures and practices varied by schools' racial/ethnic composition of students using the proportion of Black and Hispanic students as moderators. As a part of our moderator analysis, we explored interaction effects via testing of regions of

significance. Testing for regions of significance allows for an examination of the ranges at which interaction effects are significant, providing more nuanced interpretations than those provided by single coefficients (Preacher, Curran, & Bauer, 2006).

Results

Descriptive overview

As shown in Table 1, about a third of schools were private schools, and the teacher workforce was predominantly White. On average, about a quarter of students in a school qualified for free lunch, and half of schools were Title 1 designated. The student body was predominantly White, with schools averaging 13% Black students and 9% Hispanic students.

The principals responding to the survey were also representative of elementary principals nationally. As shown in Table 2, they were predominantly White, female, and had substantial experience as both a teacher and a principal. Most principals held a master's degree.

As our analytic approach relied in part on the assumption that the timing of completion of the principal survey was unrelated to the timing of Columbine, we compared descriptive statistics for school and principal characteristics for the period before and after Columbine (columns 2 and 3 of Tables 1 and 2). In column 4, we indicate statistically significant differences using a Welch's *t*-test. As shown, we observed relatively good balance on observable covariates across time periods. Although there were some statistically significant differences (e.g., the regionality of the schools), the demographic composition, and the size of the schools, the magnitude of the differences was in most cases relatively small.

Table 1. Means and standard errors of school-level covariates by time period.

	Full Sample	Before Columbine	After Columbine	Significant ($p < .05$) Before-After Difference
	(1)	(2)	(3)	(4)
Northeast Region	0.21 (0.01)	0.17 (0.03)	0.22 (0.02)	
Midwestern Region	0.26 (0.02)	0.32 (0.04)	0.24 (0.02)	
Western Region	0.22 (0.02)	0.14 (0.04)	0.25 (0.02)	*
Private School	0.36 (0.02)	0.39 (0.04)	0.35 (0.02)	
Mid-size City	0.21 (0.03)	0.20 (0.05)	0.22 (0.03)	
Large Suburb	0.26 (0.02)	0.22 (0.04)	0.28 (0.03)	
Mid-size Suburb	0.07 (0.01)	0.05 (0.02)	0.08 (0.02)	
Large Town	0.03 (0.01)	0.04 (0.02)	0.02 (0.01)	
Small Town	0.09 (0.01)	0.14 (0.03)	0.08 (0.01)	
Rural	0.17 (0.02)	0.21 (0.05)	0.15 (0.02)	
School Enrollment is 0–149	0.24 (0.02)	0.27 (0.05)	0.24 (0.02)	
School Enrollment is 150–299	0.27 (0.02)	0.31 (0.04)	0.26 (0.02)	
School Enrollment is 300–499	0.24 (0.02)	0.20 (0.03)	0.25 (0.02)	
School Enrollment is >750	0.07 (0.01)	0.05 (0.01)	0.08 (0.01)	*
Observations	810	190	620	

Table 1. Continued. Means and standard errors of school-level covariates by time period.

	Full Sample	Before Columbine	After Columbine	Significant ($p < .05$) Before-After Difference
	(1)	(2)	(3)	(4)
Proportion White Teachers	0.86 (0.01)	0.91 (0.01)	0.85 (0.01)	*
Proportion Black Teachers	0.06 (0.01)	0.05 (0.01)	0.06 (0.01)	
Proportion Hispanic Teachers	0.04 (0.01)	0.02 (0.01)	0.04 (0.01)	
Number of Teachers	14.73 (0.40)	13.95 (0.87)	14.98 (0.47)	
Proportion LEP	0.05 (0.01)	0.04 (0.01)	0.05 (0.01)	
Title I School	0.50 (0.02)	0.51 (0.04)	0.50 (0.02)	
School Prop. Black Students	0.13 (0.01)	0.10 (0.02)	0.14 (0.01)	
School Prop. Hispanic Students	0.09 (0.01)	0.07 (0.01)	0.10 (0.01)	*
School Includes Middle Grades	0.50 (0.03)	0.59 (0.04)	0.47 (0.03)	*
School Includes High School Grades	0.08 (0.01)	0.15 (0.05)	0.06 (0.01)	
Attendance	94.93 (0.16)	95.05 (0.32)	94.89 (0.18)	
Proportion Gifted Students	0.06 (0.01)	0.09 (0.03)	0.05 (0.01)	
Proportion of Free Lunch Students	0.26 (0.01)	0.22 (0.02)	0.27 (0.01)	
School Prop. Minority Students	0.30 (0.02)	0.26 (0.04)	0.31 (0.02)	
Observations	810	190	620	

Estimates weighted and adjusted for the complex sampling design of the ECLS-K.

Turning to security measures and practices (Table 3), we found that there was great variation in use across measures/practices. For example, 78% of schools required visitors to sign-in whereas 5% or fewer used security guards or metal detectors. Across time periods, we observed a statistically significant difference in the use of locked exits and the presence of security guards, with the prevalence of each being greater after Columbine than before. In particular, after Columbine schools were 53% more likely to report locked exits and 100% more likely to report the use of security guards (though the magnitude of this difference, three percentage points, was quite small). Although suggestive of changes in response to Columbine, these differences could also be driven by systematic differences in the schools that responded at each time period. We turn next to results of our regression models that accounted for observable differences in schools.

Schools locked exits more frequently after columbine

Table 4 Panel A presents results of our primary regression models which predict the presence of a security measure or practice from the indicator of being after Columbine. Each column represents a different security measure or practice and all of the models controlled for the observable school and principal covariates. As shown, we found that after Columbine the probability of a school locking exits was .164 higher than prior, a 48% higher likelihood compared to the baseline probability. Estimates for the other security practices and procedures were statistically nonsignificant.

Table 2. Means and standard errors of principal-level covariates by time period.

	Full Sample	Before Columbine	After Columbine	Significant ($p < .05$) Before-After Difference
	(1)	(2)	(3)	(4)
Hispanic Principal	0.03 (0.01)	0.00 (0.00)	0.03 (0.01)	*
Black Principal	0.07 (0.01)	0.03 (0.01)	0.08 (0.01)	*
Native American Principal	0.01 (0.00)	0.01 (0.01)	0.01 (0.01)	
Asian Principal	0.02 (0.01)	0.01 (0.01)	0.02 (0.01)	
Female Principal	0.61 (0.02)	0.51 (0.05)	0.64 (0.02)	*
Overall Principal Experience (Years)	10.42 (0.30)	11.24 (0.61)	10.17 (0.38)	
Years as Principal at This School	6.62 (0.27)	6.30 (0.42)	6.72 (0.32)	
Principal's Teacher Experience (Years)	12.11 (0.33)	11.18 (0.59)	12.41 (0.39)	
Principal Highest Degree is a BA	0.10 (0.01)	0.09 (0.02)	0.11 (0.02)	
Principal Highest Degree is a Doctorate	0.08 (0.01)	0.11 (0.03)	0.07 (0.01)	
Principal Highest Degree is Other	0.03 (0.01)	0.02 (0.01)	0.04 (0.01)	
Observations	810	190	620	

Estimates weighted and adjusted for the complex sampling design of the ECLS-K.

Schools phased in sign-in procedures following Columbine

Although we observed no relationship with security measures and practices outside of locking exits in our primary models, it is possible that Columbine's impact on their use could have been delayed. To account for this, we examined models that included both an indicator for the time period after Columbine and a measure of the number of days since Columbine, allowing for a mean shift as well as a change in the use of measures and practices over time.

As shown in Table 4 Panel B, our primary finding regarding locking exits remained but we also detected a delayed impact on requiring visitors to sign in. In particular, for each day after Columbine, schools were approximately 0.001 percentage points more likely to require visitor sign-in. Although the coefficient on Columbine was actually negative, this time-specific impact suggests that after about two and a half months, schools were more likely to require visitors to sign-in than they were before Columbine. Considering that the Columbine shooting took place in late April, this finding likely indicates schools waited until the following school year to implement sign-in procedures.

Moderating effects of school racial/ethnic composition

Finally, we examined differences in responses across schools serving different racial/ethnic compositions of students. Table 4 Panel C shows results from models in which the Columbine indicator was interacted with the proportion of Black students and the proportion of Hispanic students in the school. The findings suggest that, overall, responses to Columbine were similar regardless of the demographics of the student body served.

That said, it is possible for a regression model to indicate no significant interaction term, but for there to still be certain regions of the interaction over which there was a significant effect. Using the online utility accompanying Preacher et al. (2006), we plotted these regions of significance (see

Table 3. Means and standard errors of security measures by time period.

	Full Sample	Before Columbine	After Columbine	Significant ($p < .05$) Before-After Difference
	(1)	(2)	(3)	(4)
Requires Sign In	0.78 (0.02)	0.78 (0.03)	0.78 (0.02)	
Hallways Monitored	0.44 (0.02)	0.46 (0.04)	0.43 (0.02)	
Locked Exits	0.48 (0.02)	0.34 (0.04)	0.52 (0.03)	*
Security Guards	0.05 (0.01)	0.03 (0.01)	0.06 (0.01)	*
Metal Detectors	0.01 (0.01)	0.01 (0.01)	0.01 (0.01)	
Hall Passes	0.40 (0.02)	0.41 (0.04)	0.40 (0.02)	
Restroom Limits	0.40 (0.02)	0.34 (0.04)	0.41 (0.02)	
Observations	810	190	620	

Estimates weighted and adjusted for the complex sampling design of the ECLS-K.

Table 4. Coefficients and standard errors from regressions.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Requires Sign-In	Hallways Monitored	Locked Exits	Security Guards	Metal Detectors	Hall Passes	Restroom Limits
Panel A: Predicting use of security practices and procedures from indicator of time after Columbine							
After Columbine	−0.041 (0.033)	0.001 (0.045)	0.164** (0.043)	0.024 (0.014)	−0.003 (0.008)	−0.013 (0.043)	0.052 (0.036)
Panel B: Predicting use of security practices and procedures from indicator of time after Columbine and # of days after Columbine							
After Columbine	−0.073* (0.036)	0.016 (0.049)	0.128* (0.053)	0.023 (0.018)	−0.005 (0.007)	−0.033 (0.047)	0.081 (0.044)
# Days After	0.001* (0.000)	−0.000 (0.001)	0.001 (0.001)	0.000 (0.000)	0.000 (0.000)	0.001 (0.001)	−0.001 (0.001)
Panel C: Predicting use of security practices and procedures from indicator of time after Columbine interacted with racial composition of schools							
After Columbine	−0.047 (0.038)	−0.002 (0.057)	0.145** (0.054)	0.035* (0.018)	0.008 (0.007)	−0.004 (0.053)	−0.018 (0.047)
After Columbine * Prop. Black	0.299 (0.155)	0.040 (0.249)	0.273 (0.226)	−0.017 (0.096)	−0.110 (0.058)	−0.007 (0.199)	0.409* (0.187)
After Columbine * Prop. Hispanic	−0.375* (0.153)	−0.025 (0.264)	−0.150 (0.257)	−0.148 (0.128)	0.020 (0.037)	−0.141 (0.291)	0.376 (0.269)
Prop. Black	0.097 (0.205)	−0.334 (0.292)	0.146 (0.264)	0.037 (0.109)	0.127* (0.059)	−0.079 (0.232)	−0.551* (0.215)
Prop. Hispanic	0.332 (0.192)	−0.093 (0.288)	0.477 (0.286)	0.072 (0.143)	0.011 (0.054)	0.194 (0.295)	−0.306 (0.286)
Observations	810	810	810	810	810	810	810

Standard errors in parentheses. All models include school and principal observable controls. Estimates are weighted and adjusted to account for the complex sampling design of the ECLS

** $p < .01$, * $p < .05$

Figure 1). After examining the regions of significance for all of the interaction terms, we found that six models had significant moderating effects over some or all of the possible range of values of the moderator, and that three of those had meaningful variation.

First, the proportion of Black students in the school was a significant moderator of the relationship between Columbine and locking exits at all possible values in the model. Specifically, the impact

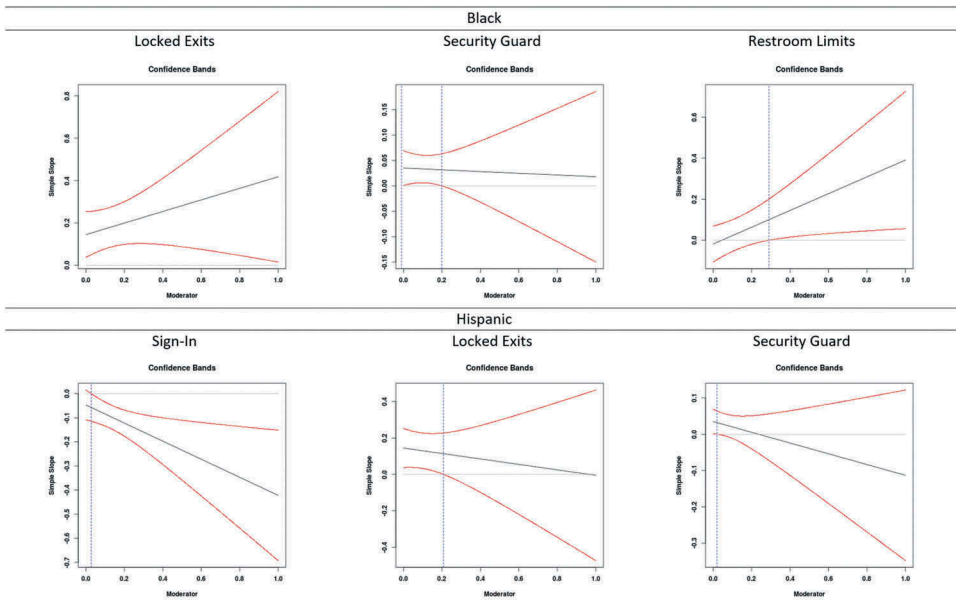


Figure 1. Significant regions of significance of interactions between after Columbine indicator and interaction with school proportion of Black students (top panel) and school proportion of Hispanic students (bottom panel).

of Columbine on locking exits was stronger in schools with larger proportions of Black students. Second, the proportion of Black students in the school was a significant moderator of the relationship between Columbine and using restroom limits in schools with a proportion of Black students between 0.29 and 1.00. Specifically, the impact of Columbine on using restroom limits was stronger in schools at the higher end of this range. Interestingly, however, these schools were less likely than schools with more White students to limit restrooms prior to Columbine, suggesting that Columbine may have served to increase the prevalence of this practice to a level more in line with other schools. Third, the proportion of Hispanic students in the school was a significant moderator of the relationship between Columbine and using visitor sign-in procedures in schools with a proportion of Hispanic students between 0.03 and 1.00. Specifically, the impact of Columbine on using visitor sign-in procedures was weaker in schools at the higher end of this range.

Robustness checks

In addition to our primary models, we conducted a number of analyses to check the robustness of our primary findings to various specifications and analytic decisions. First, we demonstrated that our results were robust to two other missing data approaches (results available by request). When using missing dummy indicators and listwise deletion in the primary models, we observed a similar pattern of statistical significance and effect sizes as with multiple imputation. Results for models including the number of days after Columbine were also qualitatively similar, though the coefficient on days after predicting requiring sign-in was nonsignificant when using listwise deletion. Likewise, results for models with racial/ethnic demographic interactions were also similar though we did observe a positive and significant interaction on the proportion of Black students predicting locked exits when using missing dummy variables and a positive and significant main effect on the use of security guards when using listwise deletion.

Next, we examined the robustness of our primary models to the inclusion of an overall time trend variable. We found that the magnitude and significance on locked exits remained in these

specifications; however, the coefficient on requiring visitors to sign in was actually negative and statistically significant (results available by request). This suggests that the delayed effect on requiring sign-in seen in the primary models may have been an artifact of a general time trend.

Finally, we estimated versions of the primary model and the model with race/ethnicity interactions using a limited bandwidth of schools around the Columbine shooting date (results available by request). This approach, which borrows from the strategy used in regression-discontinuity designs, provides plausibly more comparable schools; however, it sacrifices statistical power and, in the case of this study, is less suited for detecting effects that may have taken weeks or months to implement. Perhaps as a result of the limited statistical power, the results of this approach in our base model showed no significant relationships, though the magnitude of the coefficient on locking exits was similar to that in our primary models. There was, however, a significant relationship with requiring sign-in for schools serving greater proportions of Black students.

Discussion

Although highly publicized school shootings are often cited as galvanizing events in conversations about school security nationwide, little research has empirically examined their impact on the use of school security measures and practices, particularly the easy-to-implement efforts that are likely to require less time and money. This study's findings indicated that following Columbine, schools were more likely to lock the building's exits and implement sign-in procedures for visitors. Findings were largely similar across schools of varying racial compositions, although schools with larger proportions of Black students were more likely to increase the use of locking exits and limiting restroom visits and schools with larger proportions of Hispanic students were less likely to use visitor sign-in policies.

Although much of the focus on schools' security efforts following high-profile school shootings has been on state and federal policy (Curran, 2018a, 2018b; STOP School Violence Act, 2018), this study found that local schools and districts have made changes of their own in response to school shootings, particularly ones that were relatively easy to implement in terms of time and money. Given the changes in security following Columbine in other Colorado high schools (Crepeau-Hobson et al., 2005) and more generalized shifts in security uptake (Addington, 2009), this study's findings suggest that, consistent with theory, highly publicized school shootings may function as a window of opportunity for street level bureaucrats (e.g., school and district leaders) to make changes to school environments.

These windows of opportunity, in turn, may be coupled with political pressure to make changes in order to demonstrate a responsiveness to the event, particularly pressures from parents and, increasingly, students themselves. Notably, these changes are not necessarily in response to the particular elements of a given shooting – in Columbine, the shooting occurred during lunch, not a bathroom break, and in Parkland – a shooting that prompted calls for more SROs in schools – there was an SRO already stationed at the school. In fact, most of the changes being made to schools are made in the absence of evidence about their effectiveness or potential unintended consequences (Cook et al., 2010; Fisher & Hennessy, 2016; Petrosino et al., 2012; Reingle Gonzalez et al., 2016). A more useful approach – at least from an empirical perspective – might be to test different strategies using rigorous research designs to evaluate their effectiveness in preventing violence in schools, examine any unintended consequences, and make policy and practice decisions accordingly. Thus, when various actors feel compelled to respond to highly-publicized school shootings, rather than relying on initiatives with some degree of public support but a lack of empirical evidence (e.g., arming teachers), they will have a body of evidence upon which to base any changes they decide to make.

While racial threat theory suggests that changes to security might vary by the racial/ethnic demographics of schools, most of this study's findings were invariant across different racial compositions of schools. Schools' racial composition was a meaningful moderator in some models. Interestingly, the direction of the moderating effect differed for the proportion of Black and Hispanic students; schools with larger proportions of Black students were more likely to use security measures and practices (i.e., locked exits and

restroom limits) whereas schools with larger proportions of Hispanic students were less likely to do so (i.e., visitor sign-ins). Viewing these findings through the lens of social control, these findings provide mixed evidence for the possibility that schools used Columbine as an opportunity to exert more control over students of color. Limiting students' restroom access during the school day does not appear on its face to be a useful technique for preventing school shootings, but instead limits the activity in hallways during classes. The fact that restroom limits increased following Columbine in particular within schools with larger proportions of Black students is suggestive of additional social control without a direct link to preventing school shootings (although it should be noted that restroom limits were still used less frequently than in schools with predominantly White students and that restroom limits could be useful for mitigating loss of life in the case of a school shooting). However, the other outcomes that differed by race – locked exits and visitor sign-ins – are more likely to affect the experiences of people from outside the school trying to enter, not increasing social control of the students themselves. Given that Columbine is often pointed to as a critical turning point for national conversations about school safety, it is possible that subsequent school shootings may have had different impacts on schools, and future research would benefit from exploring these dynamics with a particular eye toward schools' racial composition.

Limitations

Although our study provides some of the first quantitative estimates of the impact of a mass school shooting on schools' use of short-run security measures and practices, it nevertheless is limited in several ways. First, we were limited to examining security measures and practices included in the ECLS-K survey. It is plausible that schools may have implemented other security measures and practices that fell outside the purview of the survey. For example, some schools may have implemented practices like requiring clear backpacks, eliminating the availability of school lockers, or instituting dress code changes such as bans on trench coats. Our data did not allow us to explore the impact of Columbine on security measures and practices such as these.

Next, given the nature of the ECLS-K, our sample of schools was restricted to schools that contained kindergarten classrooms. Given that the Columbine shooting occurred in a high school setting, its impact on elementary schools may have been different than its impact on high schools. It is conceivable that the more recent school tragedies, such as that at Sandy Hook, which occurred in elementary settings, could have a differential impact on elementary schools' security measures and practices.

Next, our research design and research questions focused specifically on short-run responses to Columbine. As detailed in our background section, Columbine has remained a part of the national conversation around school safety for decades following the event. Our research questions and analytic approach were not designed to address these longer-run impacts on school security measures and practices.

Finally, although our research design exploits variation in the timing of survey completion along with a robust set of control variables, we cannot definitely preclude the potential for omitted variable bias. As discussed, principals completed surveys on their own time. Ideally, we would have had data on the same schools before and after Columbine; however, such data were not collected as part of the ECLS-K. We note that, while the timing of Columbine could not have been anticipated, differences in early completers and later completers could exist. That said, we saw few such differences in observable characteristics, and controlled for these characteristics in our models to address this concern. Our empirical design provides some of the most rigorous quantitative evidence on these research questions to date and addresses many possible sources of selection bias.

Conclusion

As school safety continues as a national priority, better understanding how schools respond to high-profile shootings will be informative for prevention efforts. Our work points to the need for

policymakers and practitioners to actively consider school security outside of high-profile events. While the political pressure of a high-profile shooting may provide a window of opportunity to enact new policy or interventions, policymakers and school leaders would benefit from having deliberative, research-based considerations of policy options ahead of time, in the absence of pressure to act quickly. Our work also points to the need to consider school-level administrators as important policy actors. Given that schools can implement immediate responses to high-profile school shootings, local actors should be empowered with the knowledge of effective practices and the resources to effectively respond.

Going forward, there is a need for research on effective practices for preventing school shootings. Our study shows that schools may respond to such shootings, but not always in evidence-based ways, largely due to a lack of research in this area. Evaluations that identify the causal effects of specific security measures and how they impact the broader school climate are important. Such evidence, in turn, can ensure students are safer in school and that future tragedies like Columbine might be prevented.

Disclosure statement

No potential conflict of interest was reported by the authors.

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