Economic insecurity and the rise in gun violence at US schools

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Frequent school shootings are a unique US phenomenon that has defied understanding[1,2]. Uncovering the aetiology of this problem is hampered by the lack of an established dataset[3,4]. Here we assemble a carefully curated dataset for the period 1990–2013 that is built upon an exhaustive review of existing data and original sources. Using this dataset, we find that the rate of gun violence is time-dependent and that this rate is heightened from 2007 to 2013. We further find that periods of increased shooting rates are significantly correlated with increases in the unemployment rate across different geographic aggregation levels (national, regional and city). Consistent with the hypothesis that increasing uncertainty in the school-to-work transition contributes to school shootings, we find that multiple indicators of economic distress significantly correlate with increases in the rate of gun violence when events at both K12 and post-secondary schools are considered.

Although there is extensive work on school shootings[1,2,4–10], the result is a patchwork of contradictory claims. Some studies report an insignificant increase in the rate of school shooting incidents or homicides over time[2,5–9], while others point to copycat effects and an increasing frequency in certain population segments and settings[4,10]. Going beyond these basic insights muddies the waters further, as the identification of sociological and risk factors related to being a shooter[11–14] are of doubtful predictive value because of their lack of specificity to individuals that commit gun violence at schools[2,15–18].

Resolving the differing perspectives on gun violence at schools is challenging for several reasons. Not least is the lack of a definitive data source with clear event inclusion criteria. Event counts of gun violence at schools vary dramatically across sources (Fig. 1a), which creates concern about the reliability of previous quantitative analyses. Even simple questions—such as whether the rate of shootings is increasing—are impossible to answer without valid data.

Multiple datasets with different inclusion criteria were used in previous research on mass killings, shootings and gun violence at schools (Fig. 1). To create a consistent dataset to investigate the phenomenon of gun violence at schools, we advance the following criteria for event inclusion: (1) the shooting must involve a firearm being discharged, even if by accident; (2) it must occur on a school campus; and (3) it must involve students or school employees, either as perpetrators, bystanders or victims. As an example, gang violence on a playground at night during the summer months would not be included since it violates the last criterion, while a student being shot at the school's baseball field after a game is included.

To build our dataset, we merged events from six original datasets pertaining to school violence (Fig. 1), resulting in 535 events. We cleaned the merged dataset and corrected dates using primary news sources, resulting in 529 events for potential inclusion. Three coders then independently evaluated each individual event against the defined criteria. If at least two coders agreed that an event should be included, then the event was added to the final consensus dataset. This process yielded 379 events meeting our strict criteria and two additional events found during the discovery process that were not present in any of the original six datasets.
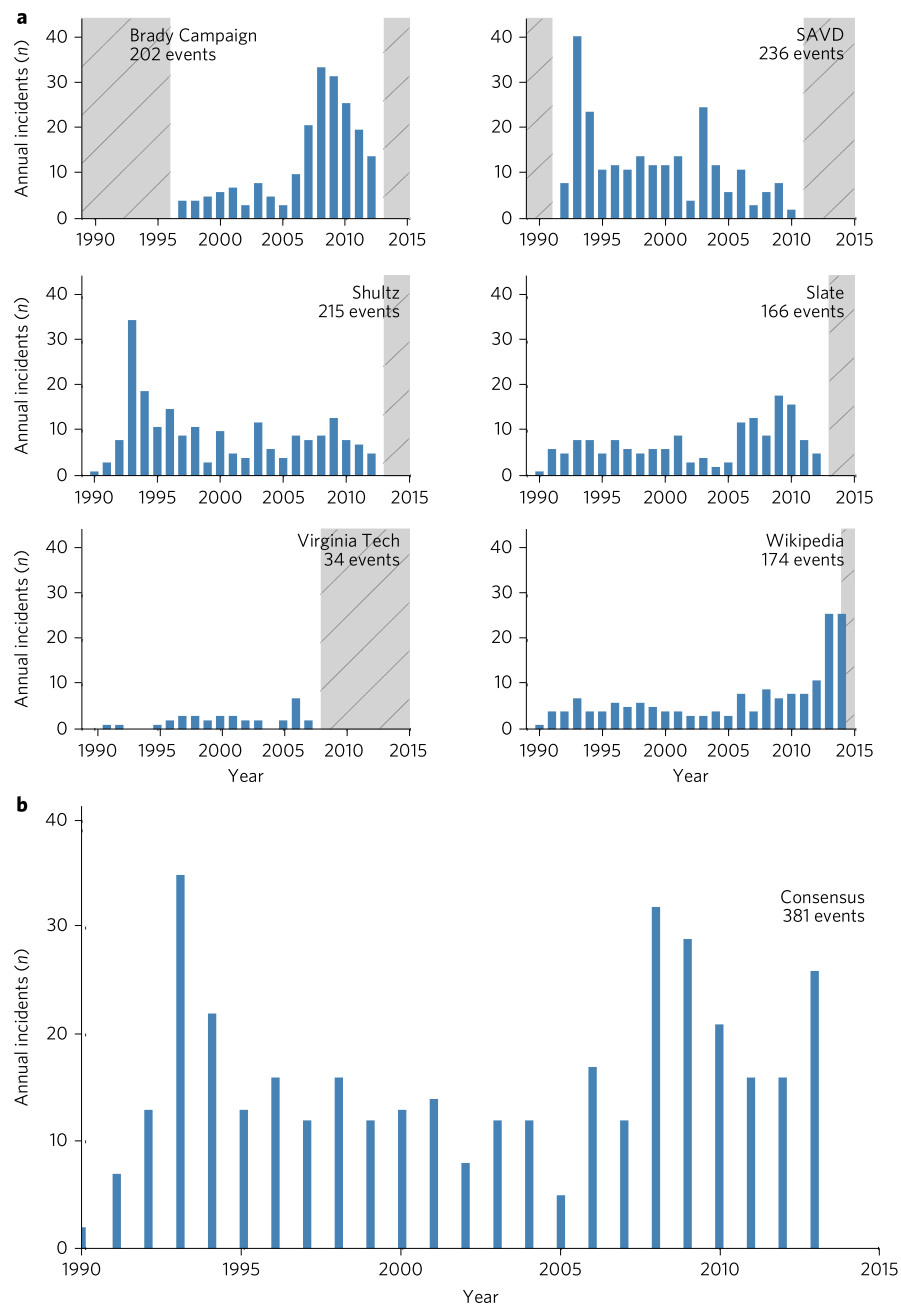
Our consensus dataset is positively correlated with all of the original datasets—demonstrating that our criteria do not exclude events from any one dataset at a noticeably higher rate than any of the others (Supplementary Fig. 2). We categorized the events within the consensus dataset to gain a more concrete understanding of what constitutes gun violence at schools (Fig. 2). Consistent with previous reports[3,19], we find that most events are targeted, that is, the shooter intends to harm a specific person.

In our dataset, gang-related violence constitutes 6.6% of all incidents; this is a much smaller fraction compared with what is observed for urban violence outside of schools[20]. The average number of fatalities per event is one and the number of incidents with three or more deaths constitutes 6.3% of included events. Moreover, gun violence at schools has not become more deadly over time (Fig. 3a and Supplementary Table 3).

It is also important to note that that this dataset is focused on all gun violence at schools and is not limited to mass shootings. Although there are notable mass shooting events on school campuses, most mass shootings happen at locations other than schools. Similarly, this dataset includes all instances of gun usage, whether someone dies in the course of the event or not, since the discharge of a gun is not permitted on school campuses (despite allowances 'to carry' on some state college campuses[21]). The inclusion of attempted violence distinguishes this dataset from other measures of violence, such as the homicide rate, since that rate is by definition only concerned with acts of violence resulting in a death.

We next evaluate the timing of these events to determine whether they follow a Poisson process. Since our dates cover an extended period of time, we allow for the possibility that the rate parameter, λ, varies over time in a stepwise manner. We fit models with an increasing number of change-points to the monthly time series of events and find that the best fit has four distinct periods separated by three change-points (see Supplementary Information for methods, parameter values and information criteria scores; Fig. 3a for model fit).
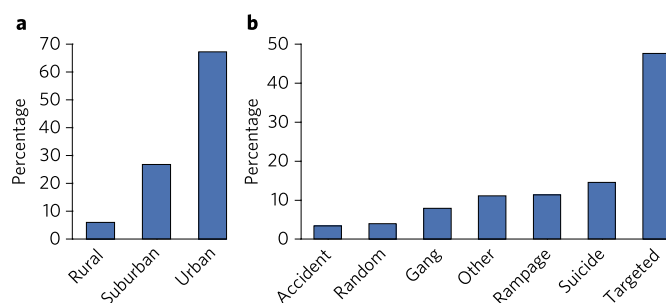
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Figure 1 | Comparison of annual shooting event counts in school-associated datasets for 1990–2013. a, The individual datasets differ dramatically in both the annual number (n) of events and the pattern over time. The School Associated Violent Deaths (SAVD) and Shultz datasets record a high number of events for 1993 and 1994 and display a decreasing trend in the number of events over time. In contrast, the Brady Campaign, Slate and Wikipedia datasets record the greatest number of events in the period 2006–2012 and display an increasing trend in the number of events over time. The Virginia Tech report has a relatively small number of recorded events during this time period, which makes it difficult to assess any trend over time. Years not covered in an individual dataset are shaded in grey to make it clear that the missing data is due to absence of coverage. **b**, Our curated consensus dataset comprises 381 events and displays a more complex trend over time than any of the independent datasets.

Distinct periods marked by different rates suggest a possible dependence on exogenous factors. An exogenous factor that may be considered a plausible cause of this phenomenon is gun availability, but changes in gun ownership do not align with periods of higher values of gun violence in schools (Supplementary Fig. 4). In contrast, there is a visual congruence between periods of increased unemployment and periods of elevated shooting rates at the national level (Fig. 3b).

The unemployment rate is particularly of interest, since it is a single aggregate statistic that captures the difficulties faced by older students in the school-to-work transition or by students' families[22]. Joblessness is related to lowered self-esteem, diminished status and detrimental behaviour[23]. There is also evidence that minors may be responsive to the unemployment of their parents[24,25] and that the attitudes of youths have a significant impact on their future employment prospects and earnings[26–29]. We posit that gun violence at schools is a response, in part, to the breakdown in the expectation that sustained participation in the educational system will improve economic opportunities and outcomes.

Figure 2 | Breakdown of urbanity and event type in the consensus dataset. a, The urbanity of the events mirrors the population distribution in the United States (6% rural, 26% suburban, 67% urban), with most events occurring in urban areas. **b**, Events categorized based on the reported outcome and shooter intent (when available). Targeted events (an attacker intending to shoot one or two others) is the primary event type.

National level

Since we hypothesize that increased school shootings are a response to increasing unemployment, we fit the data using Poisson regression:

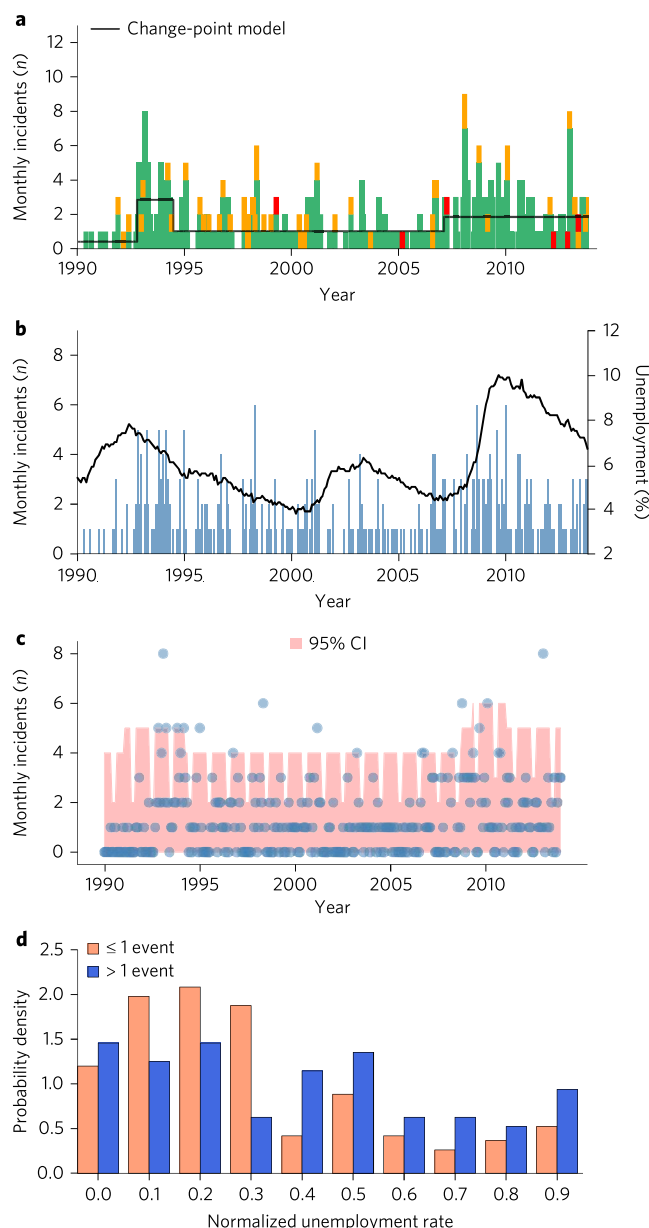$$E[S_m|u_m, m_s] = e^{\beta_0 + \beta_1 u_m + \beta_2 m_s} \qquad (1)$$

where S_m is the number of shootings per month, u_m is the monthly unemployment rate, m_s is a dummy variable that accounts for the summer months, E is the expected value, and β_0, β_1, and β_2 are the parameters being estimated. We find a significant ($P < 10^{-4}$, pseudo-$R^2 = 0.074$) relationship between the unemployment rate and number of incidents per month (95% confidence intervals (CIs) shown in Fig. 3c and Supplementary Table 8). Although the pseudo-R^2 value is low, this is largely due to the inherent noise in Poisson processes—the fit captures 53% of the maximum variance that would be expected for this number of observations even if there was a perfect correlation between unemployment and the number of incidents per month (Supplementary Fig. 5). The unemployment rate is still a significant predictor if we control for the change in student population over time (Supplementary Table 9).

To further confirm the robustness of this finding, we test our hypothesis in two additional ways. First, we model the relationship of the average time between events to unemployment. Using this formulation, we find again that there is a significant relationship between increasing unemployment and decreasing time between event incidences ($P = 0.011$, $R^2 = 0.10$; Supplementary Table 10). Second, we normalize the unemployment rate into the range [0,1] during the time period studied and categorize the months based on the number of shootings within each month. Since the period (1994–2007) with a lowered rate of shootings has an average of approximately one shooting per month, we use that number of shootings per month as a threshold to separate the two groups. If unemployment is a factor in school shootings then we would expect that months with more shootings would have a significantly larger mean normalized unemployment rate. This is indeed what we observe. We find that the two distributions are significantly different and that months with two or more events have a larger mean normalized unemployment rate (0.43 versus 0.35; Kolmogorov–Smirnov (K–S) two-sample test, $P = 0.006$; Fig. 3d).

Next, we test our hypothesis at different levels of spatial aggregation to assess whether this relationship is conditional on location or might arise from an ecological fallacy[30].
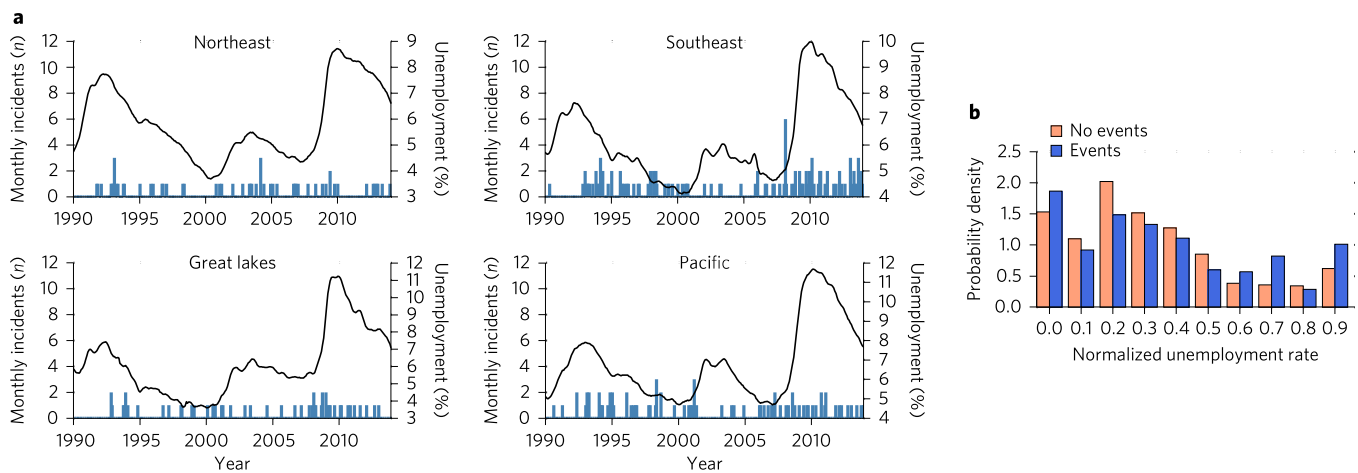
Regional level

We partition the continental United States into seven regions according to geography and socioeconomic similarity (Fig. 4a and Supplementary

Figure 3 | The rate of school shootings is time-dependent and correlated with increasing unemployment above 'normal' levels. a, The monthly number of events categorized based on number of fatalities (green 0–1, orange 2–5 and red >5). We fit Poisson process change-point models to the monthly incident time series and find that the best fit model has four distinct periods (see Supplementary Table 7). **b**, National unemployment rate peaks (black line) qualitatively align with periods of elevated rates of school shootings (blue bars). **c**, Confidence intervals for the fit of national unemployment rate to monthly shootings (blue dots) (see Equation (1)). **d**, The distributions of normalized unemployment in months with ≤1 and >1 event differ significantly and months with >1 shooting have a larger mean normalized unemployment.

Fig. 7). We examine the distribution of normalized unemployment rates, with each region having its unemployment normalized into the range [0,1] individually. Due to the lower frequency of events at a regional scale, we partition months into those with no shootings and those with shootings. As before, we find that months with one or more shootings have a normalized unemployment rate distribution that significantly differs with a larger mean normalized unemployment rate (0.41 versus 0.37; K–S two-sample test, $P = 0.017$; Fig. 4b).

Figure 4 | Elevated unemployment is correlated with an increased rate of school shootings at the regional level. a, Average unemployment (black lines) and school shooting incidents (blue bars) for the four most active regions (all eight regions shown in Supplementary Figure 7). **b**, When the distributions of these normalized unemployment rates are compared, we find that there is a significant difference and months with shootings have an over-representation of months with a high normalized unemployment rate.
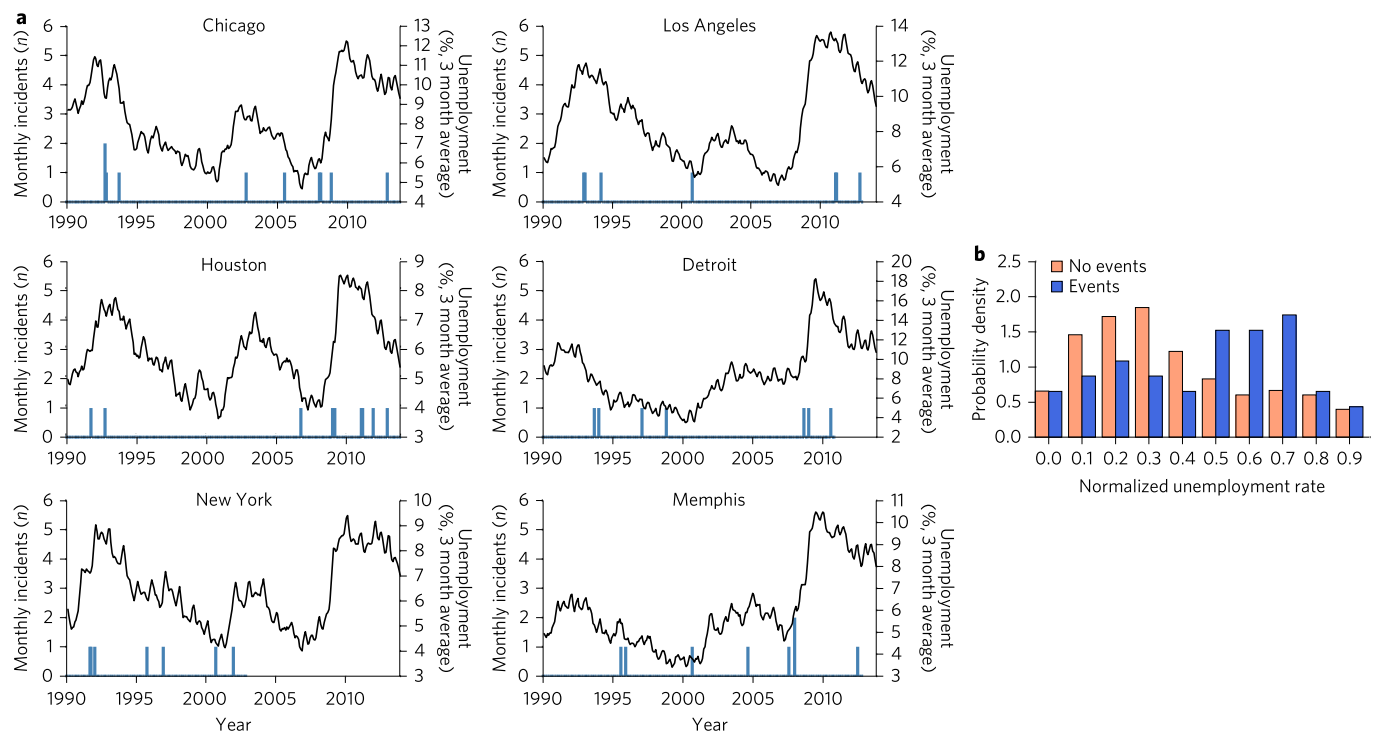
City level

We analyse the six cities with the most gun violence at schools: New York City, Detroit, Chicago, Memphis, Los Angeles and Houston (Fig. 5a). As for the national and regional levels, we find that months with one or more shootings have a normalized unemployment rate distribution that significantly differs and has a larger mean normalized unemployment rate (0.51 versus 0.41; K–S two-sample test, $P=0.005$; Fig. 5b).

Educational attainment

Our results strongly support the hypothesis that a breakdown in the school-to-work transition contributes to an increase in gun
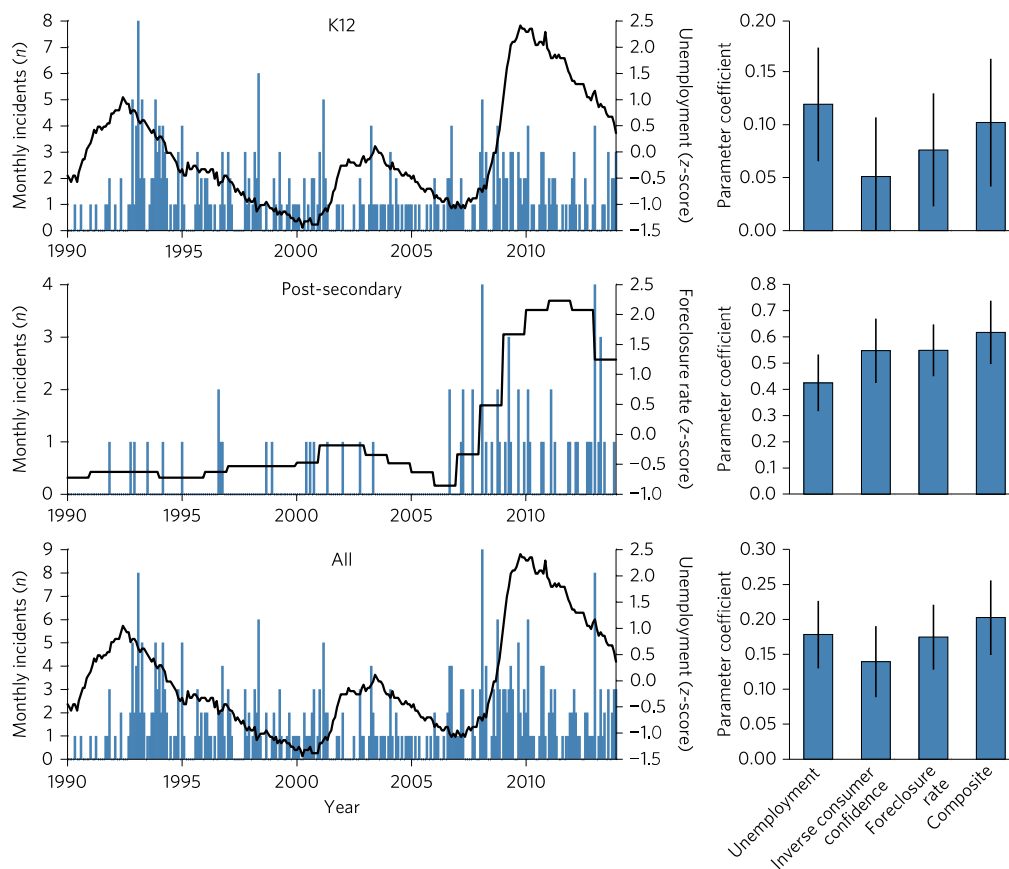
violence at schools. Taking this hypothesis a step further, we would expect that there would be a shift in the temporal location of these shootings during the period when post-secondary education has increasingly supplanted high school in determining successful school-to-work transitions[31,32]. When we analyse the post-secondary event series separately, we do find that the rate of gun violence is elevated from November 2005 to December 2013 (Supplementary Fig. 8 and Supplementary Table 15).

When these individual time series are fit against corresponding unemployment metrics ('less than high school' unemployment levels for K12 schools and 'some college' unemployment for

Figure 5 | Elevated unemployment is significantly correlated with an increased rate of school shootings in the most active cities. a, The city-wide unemployment rate (black lines) and school shooting incidents (blue bars) for the six cities with the most events. **b**, The distributions of normalized unemployment rates between months with and without a shooting differ significantly and months with a shooting have a larger mean normalized unemployment rate.

Figure 6 | A broad range of economic indicators significantly correlate to gun violence in post-secondary and all schools. Left: all economic indicators (black lines) are normalized according to their mean and standard deviation to make the parameter coefficients comparable across indicators. The consumer confidence is inverted so it is instead a measure of the lack of consumer confidence in the economy. The composite measure is a naive linear combination of all three economic indicators. Monthly incidents (blue bars) in K12 schools and the entire dataset are best described with the national unemployment rate, while the foreclosure rate best describes events in post-secondary schools. Right: with the exception of consumer confidence with K12 schools, all of the economic indicators are comparable in magnitude within K12, post-secondary and all schools (error bars are standard errors).

post-secondary schools), we again find unemployment as a significant predictor of shootings ($P = 0.007$, pseudo-$R^2 = 0.068$ for K12 schools and $P < 10^{-3}$, pseudo-$R^2 = 0.072$ for post-secondary schools; Supplementary Tables 17 and 18).

Broader economic indicators

Although unemployment is one proxy for the breakdown in the school-to-work transition and for economic insecurity, there are other plausible measures that could be used to model this breakdown, especially given the changes in the US economy over the last 25 years. Two other metrics that may provide a proxy for economic insecurity of families are the foreclosure rate and consumer confidence. We assess the ability of these two measures, unemployment and a composite indicator (an equal weighting of foreclosures, inverse consumer confidence and unemployment) to describe the incidence of gun violence events at K12 schools, post-secondary schools and across all schools (Fig. 6). We find that correlations with these indicators are significant at post-secondary schools and across all schools, while only unemployment is strongly significant at K12 schools. Further, the magnitude of the parameters are comparable for a given setting after normalizing the indicators, suggesting that this is a generalizable phenomenon that can be robustly measured with a variety of measures of economic insecurity.

In the last 25 years, there have been two periods of elevated gun violence at schools in the United States and the timing of these

periods significantly correlates with increased economic insecurity. With the unemployment rate as an indicator, this effect persists at the national, regional and city levels of geographic aggregation. Further, we find that this effect is measurable across several economic indicators, which underscores the robustness of our findings.

In accordance with the theory that gun violence is associated with a breakdown in the school-to-work transition, we find that where these events occur has shifted in the last 20 years. The 2007–2013 period of elevated gun violence is largely due to events at post-secondary schools, while the 1992–1994 period more often involves events at K12 schools. Given the nature of the school-to-work transition, it is predictable that more violence would occur closer to the last link in the chain from education to employment. An implication of our findings is that as economic prospects improve, the frequency of shootings in K12 schools should remain relatively stable, with declines at post-secondary schools.

The far-reaching impact of job loss, short-term unemployment, under-employment and long-term idleness is well established in the research literature[23], with results including numerous detrimental behaviours, such as drug and alcohol consumption. This literature explains that job loss and unemployment negatively impact well-being, self-esteem and sense of control, resulting in diminished socio-economic status and societal position. This decrease in status and position can exacerbate already apparent differences between students and further increase feelings of ostracism, isolation and failure.

This suggests that other factors that also increase the isolation of individuals should be considered as research continues in this area. Although the increasing fragility in the school-to-work transition can explain, at least in part, an increase in the frequency of school shootings, it does not explain why such a large basal rate of gun violence should exist at all in the United States.

Materials

Data. The Shultz[3] dataset was obtained from the corresponding author. The official reports from the Virginia Tech Review Panel[33] and the National School Safety Council on School Associated Violent Deaths[34] were used. Events were downloaded from Slate[35], the Brady Campaign to Prevent Gun Violence[36] and Wikipedia[37]. When constructing the consensus dataset, the inter-coder agreement across the three coders was 88%, 89% and 84%.

School population data were collected from the National Center for Education Statistics (https://nces.ed.gov/) using the ELSi tool for K12 schools and the Integrated Postsecondary Education Data System (IEPDS) tool for post-secondary schools.

National, regional and educational attainment unemployment rates were obtained from the St. Louis Federal Reserve (https://fred.stlouisfed.org/). City unemployment rates were obtained from the Bureau of Labor Statistic's Local Area Unemployment Statistics (www.bls.gov/lau). Foreclosure rates were obtained from the Mortgage Banker's Association (www.mba.org) and consumer confidence was obtained from the Organisation for Economic Co-operation and Development[38].

Data availability. The dataset presented in this manuscript is available at https://amaral.northwestern.edu/school_gun_violence/.

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Author contributions

A.R.P., J.H. and L.A.N.A. developed the research question. A.R.P., A.L.J., A.J., K.A. and A.J.H. collected, validated and annotated the data. A.R.P. and A.L.J. conducted the initial analyses. A.R.P. conducted the primary analyses and supporting analyses. A.R.P. and L.A.N.A. wrote the manuscript. A.R.P., J.H., A.J.H. and L.A.N.A. edited the manuscript.

Additional information

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Competing interests

The authors declare no competing interests.