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Posttraumatic Stress Among Students After the Shootings at Virginia Tech

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On April 16, 2007, in the worst campus shooting incident in U.S. history, 49 students and faculty at Virginia Polytechnic Institute and State University (Virginia Tech) were shot, of whom 32 were killed. A cross-sectional survey of 4,639 Virginia Tech students was carried out the following summer/fall to assess PTSD symptoms using the Trauma Screening Questionnaire (TSQ). High levels of posttraumatic stress symptoms (probable PTSD) were experienced by 15.4% of respondents 3 to 4 months following the shooting. Exposure to trauma-related stressors varied greatly, from 64.5% unable to confirm the safety of friends to 9.1% who had a close friend killed. Odds ratios for stressors predicting high levels of posttraumatic stress symptoms were highest for losses (2.6–3.6; injury/death of someone close) and inability to confirm the safety of friends (2.5). Stressor effects were unrelated to age, gender, and race/ethnicity. The exposures that explained most of the cases of high posttraumatic stress symptoms were inability to confirm the safety of friends (30.7%); death of a (not close) friend (20.3%); and death of a close friend (10.1%). The importance of high-prevalence low-impact stressors resulted in a low

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concentration of probable cases of PTSD, making it difficult to target a small, highly exposed segment of students for mental health treatment outreach. The high density of student social networks will likely make this low concentration of probable PTSD a common feature of future college mass trauma incidents, requiring broad-based outreach to find students needing mental health treatment interventions.

Keywords: posttraumatic stress disorder, trauma, epidemiology, campus safety, college students, treatment

In the deadliest shooting incident by a single gunman in U.S. history, 49 students and faculty were shot (32 of whom were killed) at Virginia Polytechnic Institute and State University (Virginia Tech) on April 16, 2007 (Kaine, 2007). This was the 330th U.S. school shooting incident since 1992 (Washington Ceasefire, 2009). Although the literature on these incidents is not extensive (Brymer, 2007; Hattula, Orcutt, & Varkovitzky, 2008; Norris, 2007; Paludi, 2008; Pynoos et al., 1987; University of Montreal, 2009), broad predictions can be made about likely mental health effects on Virginia Tech students. Among the consequences that have been documented by other researchers are posttraumatic stress disorder (PTSD), depression, anxiety, grief, and anger. These reactions tend to occur in the immediate aftermath of the incidents and to decrease over time, but to persist for a minority. The nature and severity of trauma and loss exposure are strong determinants of these outcomes, although vulnerability factors (e.g., history of prior trauma and loss, history of psychopathology) also predict onset and persistence of these reactions (Galea et al., 2002; Norris, 2007; Norris et al., 2002; Pfefferbaum et al., 2001).

Existing studies of mass shootings, however, provide limited guidance in understanding the consequences of the Virginia Tech shootings, which occurred within a campus community with more than 30,000 people working and living on 2,600 acres with more than 100 buildings. Multiple shootings occurred in two episodes within a four-hour period that included periods of uncertainty about the safety of friends and loved ones, e-mail and loudspeaker warnings, a campus lockdown, extensive media coverage, and multiple levels of exposure across several dimensions (e.g., the shooting incidents themselves, physical proximity to victims, hearing shots and sirens, seeing wounded victims, SWAT teams' activities, etc.).

Studies of reactions to traumatic incidents indicate that posttraumatic stress reactions are experienced by individuals well beyond those directly exposed to trauma (Galea et al., 2003), but because of the unusual social and ecological context of the Virginia Tech shootings, it is unclear whether or what kinds of indirect exposure may have increased the probability of these reactions. In addition, the implications of widespread and multidimensional exposure for targeting treatment for likely cases of PTSD are unclear.

The immediate aftermath of the shootings included efforts by the university and community agencies to deal with the mental health consequences of the traumatic events. These efforts included providing mental health outreach services for the university community that were broadly consistent with the public mental health approach proposed by Pynoos, Groenjian, and Steinberg (1995) to deal with mental health problems in the immediate aftermath of disasters. Key parts of this program are described in the Virginia Tech Resilience Recovery Model (Jones, 2008) and, during the last three weeks of the semester, included providing services to those who had been most directly exposed to the shootings, organizing visits of professional mental health service providers to classes with special attention to classes held by departments who had lost students or faculty members in the shootings, and positioning mental health service providers in locations around campus where students could drop in for counseling.

In an effort to examine issues of exposure and posttraumatic stress reactions to the Virginia Tech shootings, and to provide information to the university administration for mental health treatment needs assessment, a web-based Virginia Tech student survey was carried out during the summer/fall after the shootings. The survey asked questions about exposure to the shootings and assessed posttraumatic stress symptoms, along with more general symptoms of anxiety, depression, and grief. This report presents the first results from that survey. We focus on the prevalence and associations between traumatic stressors and probable PTSD as indicated by a high level of posttraumatic stress symptoms.

The present paper focuses on (1) the prevalence of likely PTSD among Virginia Tech students; (2) the impacts of varying dimensions of exposure to the shootings on PTSD reactions; (3) how much of the PTSD reactivity among students was due to different kinds of exposure; and (4) how knowledge of patterns of exposure can be used to target treatment for likely cases of PTSD.

Method

Sample

The target sample included all Virginia Tech students at the Blacksburg campus (where the shootings occurred) on April 16, 2007. Each student had a Virginia Tech e-mail address. Virginia Tech also maintained student home phone numbers. An attempt was made to assess all students in an Internet survey and then to administer a shorter survey by telephone to a probability subsample of Internet survey nonrespondents.

The Internet survey was sent three months after the shootings. An advance email was sent several days earlier to notify students of the survey, encourage participation, assure confidentiality, and provide contact information for the Virginia Tech Counseling Center. The survey began with an informed consent script. Only students who provided consent were administered the survey. These recruitment and consent procedures were approved by the Virginia Tech Institutional Review Board (IRB). A total of 4,639 students from the population of 23,214 (20.0%) completed the Internet survey. The number who refused was extremely small (0.1%), raising the possibility that many nonresponding students did not monitor their Virginia Tech e-mail accounts over the summer.

An attempt was made to contact a probability subsample of 1,093 Internet survey nonrespondents with a shortened telephone

version of the survey. Verbal consent was obtained before questions were administered. These recruitment and consent procedures were approved by the Virginia Tech IRB. Many (38.3%) selected students could not be contacted in the survey time window. Others (9.1%) had nonworking phone numbers, while 89.9% of those contacted (52.5% of selected students) completed the survey. Only 11.1% of those contacted (5.9% of selected students) refused participation. The weighted response rate for the two modes of the survey combined (20.0% for the Internet survey plus 52.5% of the remaining 80.0% for the telephone survey) was 62.0%.

Comparison of survey responses found few meaningful differences between the two samples (detailed results available on request), although Internet survey respondents reported somewhat less psychological distress than telephone respondents, controlling for trauma exposure. Based on these results, we used a propensity score weighting approach (Weitzen, Lapane, Toledano, Hume, & Mor, 2004) to weight the 4,639 Internet survey responses to represent students who participated in either the Internet survey or the telephone survey on the variables in both surveys. We also applied a second weight to the Internet survey data to adjust for residual discrepancies with the student body on gender, race/ethnicity, and year in school. The results reported here are based on these weighted Internet survey data.

Measures

Trauma-related stressors. There were two attacks. The first occurred in a large (894 residents) dormitory (West Ambler Johnston Hall) at 7:15 a.m. The shooter killed two students in one dorm room and fled without attempting to enter other rooms. The second attack occurred two hours later, when the shooter entered Norris Hall, an engineering classroom building, chained the three entrance doors shut, and killed 30 students and faculty and wounded 17 others in four classrooms before shooting and killing himself. Approximately 120 other students were in the building at the time.

In the two hours between the two incidents, the Virginia Tech administration sent an e-mail to the Virginia Tech community informing them of the first shootings. Just as the second incident was ending, a second e-mail was sent stating that "a gunman is on the loose on campus. Stay in buildings until further notice. Stay away from all windows." This announcement was also broadcast on campus loudspeakers. School officials locked down many campus buildings and occupants could not get out for several hours. Subsequent administration e-mails instructed people to stay where they were, informed recipients of multiple victims and the arrest of a "shooter," and announced a search for a possible second shooter.

Live TV broadcasts of the rescue efforts and the injured occurred and were viewed by many students on lockdown. Two and a half hours later the university president rescinded the lockdown order, although residual concerns continued for some time about possible other shooters at large. These concerns subsided as more details emerged about the identity of the actual shooter and his social isolation from others in the university community.

Within the context of this complex set of events, students were exposed in varying degrees to numerous dangers, traumatic events, and losses. To tap these different exposures, the survey included a chronological set of questions based on focus groups about the most stressful aspects of the incident. Responses were used to construct measures of exposure to five incident dimensions: awareness of the events, close proximity to the events, exposure to potentially traumatizing features of the events, indirect exposure, and loss. Measures of 18 component stressors were created to tap these dimensions.

The *awareness* indicators included hearing campus announcements, watching TV reports about the events as they unfolded, awareness of police presence, and being in lockdown. *Close proximity* indicators included being in a building where a shooting took place or in a nearby building or close enough to hear shots. *Trauma exposure* indicators included exposure to persons injured or killed, witnessing students fleeing or the SWAT teams or medic teams, and personally being injured. These objective features of exposure do not fully capture the subjective perception or appraisal of danger, a functioning of awareness, which may also contribute to the severity of posttrauma distress. The *indirect exposure* indicators included being outside on campus during lockdown and becoming aware of the shootings only after entering a building, missing a scheduled class in Norris Hall at the time of the shootings, having a class in Norris Hall at some contiguous time, and trying unsuccessfully to confirm the safety of a close friend during lockdown. The *loss* indicators included death, injury, and escape of someone close, less close (a friend/acquaintance), or known distantly.

The exposure variables used in the present study were coded as dummy variables, with those who were exposed coded 1 and those who were not exposed coded 0. For example, on the variable indicating awareness to the first incident at Ambler-Johnston Hall, those reporting any of the awareness experiences indicated above were coded 1, and others were coded 0.

Posttraumatic stress symptoms. Posttraumatic stress symptoms were assessed with the Trauma Screening Questionnaire (TSQ) (Brewin et al., 2002), a validated screen for PTSD, which we modified so that content-specific items referred to the April 16th shootings at Virginia Tech. An analogous version of the TSQ was used in a prior study of the survivors of Hurricane Katrina (Galea, Brewin, Jones, King, & King, 2007; Kessler, Galea, Jones, & Parker, 2006). A clinical reappraisal study in the Katrina sample documented excellent concordance of diagnoses of *DSM–IV* PTSD based on this scale with independent diagnoses based on blinded clinical reappraisal interviews using the Non-Patient Version of the Structured Clinical Interview for *DSM–IV* (First, Spitzer, Gibbon, & Williams, 2002). Sensitivity was .89, specificity .93, and area under the receiver operating characteristic curve .91.

Our indicator of high posttraumatic stress includes items in the TSQ that tap three PTSD *DSM–IV* criterion B symptoms (reexperiencing), five criterion C symptoms (avoidance/numbing), and three criterion D symptoms (arousal; American Psychiatric Association, 2000). To categorize a respondent as having experienced high levels of posttraumatic stress, we required that a respondent report one criterion B symptom, two criterion C symptoms, and one criterion D symptom 2–3 days a week or more in the two weeks prior to the survey and indicate that the tragedy caused upsetting memories or inability to work (criterion F) "some," "a lot," or "extremely" in the two weeks prior to the survey. This variable was coded as a dummy variable, with those experiencing high posttraumatic stress coded 1, and others coded 0.

Sociodemographic control variables used in the analyses below include gender (females coded 1 and males coded 0), age, and race/ethnicity (4 dummy variables for African American, Hispanic, Asian, and other, with White serving as the comparison category).

Statistical Analysis

Simple cross-tabulations were used to examine stressor distributions and high posttraumatic stress. Multiple logistic regression (Hosmer & Lemeshow, 2000) was used to examine joint associations of stressors with high posttraumatic stress. Logistic regression coefficients and their standard errors were exponentiated and are presented here as odds ratios (ORs) with 95% confidence intervals (95% CIs). We began with a separate model for each stressor plus sociodemographic controls and then estimated an additive multivariate model and more complex nonadditive models. The Akaike Information Criterion (Burnham & Anderson, 2002) was used to evaluate model fit. All significance tests for logistic regression coefficients were evaluated using .05-level two-sided tests. As the data were weighted, design-based standard errors were estimated based on the Taylor series linearization method (Wolter, 1985) implemented in the SAS 9.1 software system (SAS Institute Inc., 2002).

Population attributable risk proportion (PARP) was computed for each stressor. PARP is the proportion of observed cases of probable PTSD (high levels of posttraumatic stress symptoms) that would not have occurred in the absence of exposures to one or more focal stressors based on the assumption that the coefficients in the best-fitting regression model are due to causal effects of the stressors (Rothman & Greenland, 1998). The simulations used to estimate PARP generated individual-level predicted probabilities of probable PTSD twice from the coefficients in the best-fitting model: the first time using all the coefficients in the model and the second time assuming that the coefficients (logits) associated with the stressor(s) of interest were all zero. One minus the ratio of the mean predicted probabilities in the two specifications was then used to define PARP.

Results

Stressor Exposure

Table 1 presents the distribution of stress exposure among Virginia Tech students in the total sample and among men and women. Gender differences in stress exposure are evaluated using odds ratios (ORs). In the present study, the ORs indicate the change in the odds (or likelihood) of an outcome that is associated with a change from 0 to 1 on a predictor variable. For example, the OR of 1.4 for awareness of the first incident at Ambler-Johnston Hall in Table 1 indicates that women were 1.4 times (or 40%) more likely to have reported awareness of this incident than men were.

The majority of respondents (76.7%) were aware of the first incident at the dormitory (West Ambler Johnston Hall) in the two hours after it occurred. Awareness was somewhat higher among women than men (80.2% vs. 74.1%, $\chi^2_1 = 17.8$, $p < .001$).

Table 1
Distribution and Gender Differences in Traumatic Stress Exposure

	Total		Male		Female		Female:Male	
	%	(*SE*)	%	(*SE*)	%	(*SE*)	OR	(95% CI)
I. First incident at Ambler-Johnston Hall								
Awareness	76.7	(0.8)	74.1	(1.1)	80.2	(0.9)	1.4[a]	(1.2–1.7)
Close proximity	4.6	(0.3)	4.1	(0.4)	5.2	(0.5)	1.3	(0.9–1.7)
Trauma exposure	20.8	(0.6)	21.1	(0.9)	20.5	(0.8)	1.0	(0.8–1.1)
II. Second incident at Norris Hall								
Awareness	98.4	(0.2)	98.4	(0.3)	98.5	(0.3)	1.1	(0.6–1.8)
Close proximity	9.1	(0.4)	10.7	(0.6)	6.8	(0.4)	0.6[a]	(0.5–0.7)
Trauma exposure	35.6	(0.8)	37.3	(1.2)	33.2	(1.0)	0.8[a]	(0.7–1.0)
III. Indirect exposure								
Could not contact close friends	64.5	(0.8)	60.9	(1.2)	69.6	(1.0)	1.5[a]	(1.3–1.7)
Changed campus locations	11.0	(0.5)	11.4	(0.8)	10.4	(0.7)	0.9	(0.7–1.1)
Should have/might have been at Norris Hall	14.7	(0.6)	16.7	(0.9)	11.8	(0.7)	0.7[a]	(0.6–0.8)
IV. Knew someone who was killed								
Someone close	9.1	(0.5)	8.9	(0.7)	9.3	(0.6)	1.0	(0.8–1.3)
Friend or acquaintance	63.7	(0.9)	60.7	(1.3)	67.9	(1.1)	1.4[a]	(1.2–1.6)
Someone distant	79.1	(0.8)	76.1	(1.1)	83.2	(0.8)	1.6[a]	(1.3–1.8)
V. Knew someone who was injured								
Someone close	6.0	(0.4)	5.8	(0.6)	6.4	(0.6)	1.1	(0.8–1.5)
Friend or acquaintance	29.1	(0.8)	26.3	(1.1)	33.2	(1.1)	1.4[a]	(1.2–1.6)
Someone distant	44.8	(0.9)	40.5	(1.2)	50.9	(1.2)	1.5[a]	(1.3–1.7)
VI. Knew someone who escaped uninjured								
Someone close	9.5	(0.5)	9.8	(0.7)	9.0	(0.7)	0.9	(0.7–1.2)
Friend or acquaintance	27.3	(0.8)	25.6	(1.1)	29.7	(1.0)	1.2[a]	(1.1–1.4)
Someone distant	28.1	(0.8)	25.1	(1.1)	32.3	(1.1)	1.4[a]	(1.2–1.6)
	(4,639)		(2,107)		(2,532)			

Note. CI = confidence interval; *SE* = standard error of the prevalence estimate.
[a] Significant gender difference at the .05 level, two-sided design-based test.

Virtually all respondents (98.4%) were aware of the later shootings in Norris Hall near the time they occurred. Few respondents were in close proximity to the two incidents (4.6% and 9.1%). Exposure to potentially traumatizing elements of the incidents (e.g., witnessing activities of the SWAT teams, seeing injured or dead people) was more common than close proximity (20.8% and 35.6%). Close proximity and exposure to the second incident were higher among men than women (Close proximity: 10.7% vs. 6.8%, $\chi^2_1 = 26.6$, $p < .001$; Exposure: 37.3% vs. 33.2%, $\chi^2_1 = 7.1$, $p = .008$), presumably because Norris Hall was an engineering building that would have had more male students than female students. Indirect exposure was also common, with nearly two thirds (64.5%) of respondents trying unsuccessfully to confirm the safety of close friends, 11.0% on campus between the incidents, and 14.7% either missing a Norris Hall class at the time of the shootings there or having a class there at another time. Inability to confirm the safety of close friends was reported by more women than men (69.6% vs. 60.9%, $\chi^2_1 = 28.7$, $p < .001$), while having a class in Norris Hall was reported by more men than women (16.7% vs. 11.8%, $\chi^2_1 = 18.0$, $p < .001$).

The proportion of respondents close to someone killed (9.1%) is approximately 65 times as large as the number of people killed (0.14% of the student body), suggesting that the social networks of Virginia Tech students were very extensive, that respondents exaggerated their closeness to the victims, or that the shared traumatic experience increased students' perceived closeness to the victims. A somewhat smaller percentage (6.0%) of respondents reported being close to someone injured and a larger percentage (9.5%) close to someone who narrowly escaped. The majority of respondents (63.7%; 455 times the number of students who were killed) reported having either (not close) friends or acquaintances killed. Smaller numbers reported having (not close) friends or acquaintances who were injured (29.1%) or who narrowly escaped (27.3%). Much higher proportions reported distantly knowing someone who was killed (79.1%), or injured (44.8%), or who narrowly escaped (28.1%). Higher proportions of women than men (odds ratios of 1.2–1.6) reported having (not close) friends, acquaintances, and people they distantly knew who were killed or injured or who narrowly escaped ($\chi^2_1 = 7.5$–36.7, $p = .006$ – $<.001$).

Associations of Stressors With High Posttraumatic Stress

We estimate that 15.4% (95% CI: 14.2–16.7%) of respondents experienced probable PTSD (a high level of posttraumatic stress) at the time of the survey. Prevalence was significantly higher among women than men (23.2% vs. 9.9%, $\chi^2_1 = 96.5$, $p < .001$).

Table 2 presents bivariate and multivariate analyses. The bivariate analyses include 18 different models, each including a single stressor predicting posttraumatic stress with controls for gender, age, and race/ethnicity. The multivariate analysis includes all

Table 2
*Bivariate and Multivariate Associations (Odds Ratios) of Traumatic Stress Exposure With Probable PTSD (High Posttraumatic Stress) (*n *= 4,639)*[a]

	Bivariate		Multivariate	
	OR	(95% CI)	OR	(95% CI)
I. First incident at Ambler-Johnston Hall				
Awareness	1.1	(0.9–1.4)	—	—
Close proximity	1.7[b]	(1.2–2.3)	1.3	(0.9–2.0)
Trauma exposure	1.7[b]	(1.4–2.1)	1.5[b]	(1.2–1.9)
II. Second incident at Norris Hall				
Awareness	1.2	(0.6–2.6)	—	—
Close proximity	1.3	(1.0–1.6)	—	—
Trauma exposure	1.4[b]	(1.2–1.7)	1.1	(0.9–1.4)
III. Indirect exposure				
Could not contact close friends	2.5[b]	(1.9–3.1)	1.9[b]	(1.5–2.4)
Changed campus locations	1.2	(0.9–1.5)	—	—
Should have/might have been at Norris Hall	1.4[b]	(1.1–1.9)	1.2	(0.9–1.6)
IV. Knew someone who was killed				
Someone close	3.6[b]	(2.8–4.8)	2.8[b]	(2.1–3.7)
Friend or acquaintance	1.9[b]	(1.5–2.4)	1.5[b]	(1.2–1.9)
Someone distant	1.2	(0.9–1.5)	—	—
V. Knew someone who was injured				
Someone close	2.6[b]	(1.9–3.7)	1.8[b]	(1.2–2.6)
Friend or acquaintance	1.4[b]	(1.2–1.7)	1.1	(0.9–1.4)
Someone distant	1.3[b]	(1.1–1.6)	1.3[b]	(1.0–1.5)
VI. Knew someone who escaped uninjured				
Someone close	1.7[b]	(1.3–2.3)	1.2	(0.8–1.6)
Friend or acquaintance	1.1	(0.9–1.4)	—	—
Someone distant	1.2	(1.0–1.5)	—	—

Note. CI = confidence interval; OR = odds ratio.
[a] Based on bivariate (one stressor in each equation) or multivariate (all stressors in a single equation) logistic regression models with controls for gender, age, and race-ethnicity. Only the significant stressors from the bivariate models were used in the multivariate model. [b] Significant at the 0.05 level, two-sided design-based test.

stressors that were statistically significant in the bivariate models included in a single model with controls for gender, age, and race/ethnicity. All 18 stressors were positively related to high posttraumatic stress in bivariate models. Eleven of the 18 were statistically significant, with ORs of 1.3–3.6 (see Table 2). The highest ORs were associated with losses (2.6–3.6 injury/death of someone close) and being unable to contact someone close to confirm their safety (2.5) rather than with personal danger (1.1–1.7) or other aspects of direct trauma exposure (1.4–1.7).

A simple multivariate additive model with significant bivariate stressors found all ORs to be greater than 1.0 and significant as a set ($\chi^2_{11} = 190.2, p < .001$). Six ORs were individually significant. As in bivariate models, the strongest predictors were injury/death of someone close (1.8–2.8) and being unable to contact someone close to confirm their safety (1.9). More complex models were estimated that added information about either number of stressors experienced, interactions between number and type of stressors, and differential effects of particular types as a function of number of stressors. (Detailed results are available on request.) None of these more complex models improved on the simple additive multivariate model.

Subsample Variation in Stressor Effects

We evaluated interactions of stressors with age, gender, and race/ethnicity (non-Hispanic White vs. all others). No significant global interactions were found ($\chi^2_{18} = 13.6–24.5, p = .14–.76$). Only two individual interactions out of 54 (i.e., 18 stressors interacted with each of three sociodemographic variables) were significant, a proportion (3.7%) no higher than expected by chance using .05-level significance tests.

Population Attributable Risk Proportion

The population attributable risk proportion (PARP) associated with the additive multivariate model found 68.6% of probable PTSD (high posttraumatic stress) associated with the 11 significant stressors (see Table 3). The most important stressors in terms of explained prevalence were inability to contact a close friend (30.7%), death of a (not close) friend/acquaintance (20.3%), and death of a close friend (10.1%).

Multivariate Risk Profiles

We created multivariate risk profiles (profiles based on combinations of possible exposures) by using the coefficients from the additive multivariate model to generate predicted probabilities of probable PTSD (high posttraumatic stress) and then categorize respondents into relatively homogeneous categories based on these probabilities. The highest risk category included 5.0% of respondents. With a 45.2% prevalence, these students included 14.6% of all those with probable PTSD (see Table 4). The screening efficiency ratio (SER; the number of students screened to find one with probable PTSD) was 2.2. Prevalence decreased to 31.7% and 23.2% in the next two highest risk categories, which together with the highest category captured over half (57.1%) of the students with probable PTSD, while SER increased in these categories to 3.2 and 4.3. The proportion of all students in one of the three highest risk categories was 29.6%. The concentration of cases of probable PTSD in these categories was relatively low because the relevant stressors were highly prevalent and the ORs associated with these stressors were relatively modest in magnitude.

Table 3
Population Attributable Risk Proportions of Probable PTSD (High Posttraumatic Stress) Associated With Each of the Traumatic Stressors (n = *4,639*)[a]

	PARP[b]
I. First incident at Ambler-Johnston Hall	
Awareness	—[c]
Close proximity	—[c]
Trauma exposure	10.2
II. Second incident at Norris Hall	
Awareness	—[c]
Close proximity	—[c]
Trauma exposure	3.1
III. Indirect exposure	
Could not contact close friends	30.7
Changed campus locations	—[c]
Should have/might have been at Norris Hall	—[c]
IV. Knew someone who was killed	
Someone close	10.1
Friend or acquaintance	20.3
Someone distant	—[c]
V. Knew someone who was injured	
Someone close	3.6
Friend or acquaintance	—[c]
Someone distant	8.3
VI. Knew someone who escaped uninjured	
Someone close	—[c]
Friend or acquaintance	—[c]
Someone distant	—[c]
VII. All stressors combined	68.6

Note. PARP = Population Attributable Risk Proportion.
[a] Estimated from simulations based on the best-fitting multivariate prediction equation. [b] The PARPs for the individual stressors do not sum to equal the PARP for all stressors combined because each individual PARP represented the expected effect of removing one and only one stressor. The sum of PARPs would equal the PARP of removing all stressors combined in such a situation only if all stressors were completely unrelated to each other, which is not the case here. [c] Missing entries indicate that the stressor was not a significant predictor of high posttraumatic stress.

Discussion

This is the first systematic large-scale survey of college students after a mass shooting incident on a university campus. As this was the deadliest such incident in U.S. history, we might expect PTSD prevalence to be high relative to previous studies. However, between-incident variation in PTSD prevalence is importantly influenced by differences in exposure profiles (i.e., the extent to which members of the affected populations are exposed to extreme life threat; serious injury; and witnessing injury, death, and destruction [Pynoos & Steinberg, 2006]), which in the current case included only a relatively small proportion of students who experienced the death of a close friend or were in close physical proximity to the shootings. Most cases of high levels of posttraumatic stress symptoms were associated with loss of a nonclose friend/acquaintance and short-term uncertainty about the safety of a close friend. The

Table 4
The Concentration of Probable PTSD (High Posttraumatic Stress) as a Function of Traumatic Stress Exposure (n = *4,639)*

	Population Proportion[b]				PTSD Prevalence[c]				PTSD Proportion[d]				Screening Efficiency Ratio[e]	
	Category		Cumulative		Category		Cumulative		Category		Cumulative			
Risk category[a]	%	(*SE*)	%	(*SE*)	%	(*SE*)	%	(*SE*)	%	(*SE*)	%	(*SE*)	Category	Cumulative
1 (Highest)	5.0	(0.3)	5.0	(0.3)	45.2	(3.2)	45.2	(3.2)	14.6	(1.3)	14.6	(1.3)	2.2	2.2
2	10.0	(0.5)	15.0	(0.5)	31.7	(2.3)	36.1	(1.9)	20.5	(1.7)	35.1	(2.0)	3.2	2.8
3	14.6	(0.6)	29.6	(0.8)	23.2	(1.9)	29.7	(1.3)	22.0	(1.8)	57.1	(2.2)	4.3	3.4
4	20.3	(0.7)	49.9	(0.9)	15.3	(1.4)	23.9	(1.0)	20.1	(1.8)	77.3	(1.9)	6.5	4.2
5	19.5	(0.7)	69.5	(0.9)	10.7	(1.3)	20.2	(0.8)	13.6	(1.6)	90.8	(1.4)	9.3	5.0
6	10.5	(0.6)	80.0	(0.8)	7.0	(1.5)	18.4	(0.7)	4.7	(1.0)	95.6	(1.0)	14.3	5.4
7 (Lowest)	20.0	(0.8)	100.0	(0.0)	3.4	(0.8)	15.4	(0.6)	4.4	(1.0)	100.0	(0.0)	29.4	6.5

Note. *SE* = standard error.
[a] Estimated by collapsing respondents with similar predicted probabilities of high posttraumatic stress based on the best-fitting multivariate prediction equation. [b] The proportion of the sample in each risk category (Category) and cumulatively from the highest risk category through the risk category defined by the row (Cumulative). For example, 5% of respondents are in the highest risk category and 15% in the highest two risk categories. [c] The prevalence of high posttraumatic stress in each risk category (Category) and cumulatively from the highest risk category through the risk category defined by the row (Cumulative). For example, 45.2% of respondents in the highest risk category and 36.1% of those in the highest two risk categories combined had high posttraumatic stress at the time of interview. [d] The proportion of all cases of high posttraumatic stress in each risk category (Category) and cumulatively from the highest risk category through the risk category defined by the row (Cumulative). For example, 14.6% of all cases of high posttraumatic stress in the sample were in the highest risk category, while 35.1% of all cases of high posttraumatic stress were in either the highest or second highest risk categories. [e] The number of respondents in the risk category (Category) or cumulatively from the highest risk category through the risk category defined by the row (Cumulative) who would have to be screened to detect one case of high posttraumatic stress in the category. For example, one out of every 2.2 respondents in the highest risk category and one out of every 2.8 respondents in the two highest risk categories combined had high posttraumatic stress at the time of interview.

15.4% probable PTSD prevalence found here is considerably lower than in some other school shooting studies (Brymer, 2007; Norris, 2007; Pynoos et al., 1987), although the 31.7–45.2% prevalence among students at highest exposure levels is consistent with earlier studies of students directly exposed to school shootings.

The finding that women had more probable PTSD than men is consistent with previous research (Gavranidou & Rosner, 2003). That research suggests the higher female than-male PTSD is due to differences in types of trauma experienced (especially sexual assault), cognitive reactions (most notably, higher perceived risk and lack of control), and stronger short-term psychological and psycho-physiological reactions among women than men (Olff, Langeland, Draijer, & Gersons, 2007). It is consequently noteworthy that we failed to find significant interactions between stressors and gender in predicting probable PTSD. The elevated female:male OR was due largely to significantly higher female losses in secondary networks (i.e., deaths, injuries, close calls of people considered not close). The high female prevalence of such stressors is consistent with previous evidence that women have more extensive secondary social networks than men (Kendler, Thornton, & Prescott, 2001; Kessler & McLeod, 1984). However, previous research also has found that secondary network losses have more adverse emotional effects on women than men. That this was not found here might be due to our study focusing on traumatic stressors and probable PTSD, whereas earlier studies focused on nontraumatic stressors and depression. Finally, the finding of increased probable PTSD among women may be linked to losses in secondary networks characterized by extended periods of worry or periods of perceived danger or harm in the absence of information.

The finding that component stressors vary in effects on probable PTSD is consistent with previous studies (Jones & Ollendick, 2005; La Greca, Silverman, Vernberg, & Prinstein, 1996; Pynoos, Steinberg, & Brymer, 2007; Pynoos, Steinberg, & Wraith, 1995). Based on prior research (Brymer, 2007; Pynoos & Nader, 1988), we anticipated that losses and short-term inability to confirm the safety of friends would be significant aggregate stressors as reflected in the high prevalence of these stressors in the sample. As the events at Virginia Tech were associated with high media coverage, repeated false alarms, heightened security, and the spread of rumors and misconceptions, there may have been exacerbated worries and concerns over perceived danger to self and others (Pynoos, Steinberg, Schreiber, & Brymer, 2006). The centrality of high-prevalence, low-impact stressors led to a low concentration of probable PTSD.

The finding that links the extent of an individual's social network to the impact of the event highlights the important role of extended periods of worry and fear over the safety of others. This finding has important implications for the content of postevent screening and intervention. Risk screening should include gathering information not only about direct exposure to trauma, loss, and injury to self and others, but also should include information about the extent and severity of worry about the safety of loved ones and friends. Setting up Internet forums for students and staff to make contact quickly and to find opportunities for mutual support is an important intervention for the college population (Vicary & Fraley, 2010). Other strategies include providing resources to students and staff to make effective emergency preparedness and communication plans to facilitate contact in the event of a subsequent emergency. For those individuals with lingering worries, there are

several skill-building strategies to help manage these distressing reactions (Berkowitz et al., 2010). Finally, assisting students in recruiting family and social support can facilitate recovery (Grills-Taquechel, Littleton, & Axsom, 2011; Vieno, Santinello, Pastore, & Perkins, 2007).

The present findings have important implications for planning mental health treatment outreach, as it would be extremely difficult to target a small subset of directly exposed students to find most cases of probable PTSD. Indeed, the students under direct threat (i.e., survivors in the Norris Hall classes where shootings occurred), who received specialized services as described in the Virginia Tech Resilience Recovery Model (Jones, 2008), constituted only a small fraction of all those with probable PTSD. The large number of students with probable PTSD was reached through universal educational programs about warning signs of PTSD coupled with contact information for the Virginia Tech Counseling Center sent repeatedly and through numerous channels to all Virginia Tech students and staff.

Our results are limited in several ways. First, probable PTSD was assessed with a screening scale rather than with clinical interviews. Despite good psychometric properties of the scale (Brewin et al., 2002), caution is needed in interpreting the results regarding prevalence. Second, the retrospective nature of the stressor questions may have led to recall bias. Third, the low survey response rate limits external validity. Despite these limitations, the results show clearly that probable PTSD occurred with significant prevalence and wide dispersion among Virginia Tech students. These results suggest that the nature of college student social networks is such that future college mass trauma incidents will likely have similarly wide dispersion of PTSD and require outreach efforts that go well beyond narrow targeting of the (presumably) small proportion of students with direct trauma exposure.

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