ARTICLE

The headache of terror

A matched cohort study of adolescents from the Utøya and the HUNT Study

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Neurology® 2018;90:e111-118. doi:10.1212/WNL.0000000000004805

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Abstract

Objective

To elaborate the risk of headache among adolescent survivors exposed to terror.

Methods

On July 22, 2011, a lone man opened gunfire, killing 69 people at a summer camp for adolescents on the Utøya islet in Norway. All 358 adolescent survivors 13 to 20 years of age were invited to participate in the Utøya interview study. Among the 213 (59%) respondents, half (49%) were male, the mean age was 17.7 years, and 13 (6%) were severely injured. For each survivor, 8 matched controls were drawn from the population-based Young-HUNT3 Study, conducted between 2006 and 2008, with a participation rate of 73%. Recurrent migraine and tension-type headache (TTH) over the past 3 months served as main outcomes and were measured 4 to 5 months after the mass shooting with a validated headache interview, in accordance with the *International Classification of Headache Disorders*.

Results

After exposure to terror, the odds ratio for migraine was 4.27 (95% confidence interval 2.54–7.17) and for TTH was 3.39 (95% confidence interval 2.22–5.18), as estimated in multivariable logistic regression models adjusted for injury, sex, age, family structure and economy, prior exposure to physical or sexual violence, and psychological distress. The observed increased risk of headache in survivors was related largely to an increase in weekly and daily headaches.

Conclusions

Exposure to terror increases risk of persistent weekly and daily migraine and TTH in adolescent survivors, above expected levels. The terrors of other violence may similarly increase the risk of frequent headaches. After severe psychological traumas, interventions may need to address survivors' pain to hinder chronification.

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Go to Neurology.org/N for full disclosures. Funding information and disclosures deemed relevant by the authors, if any, are provided at the end of the article.

Glossary

CI = confidence interval; **TTH** = tension-type headache.

Terror attacks and other extreme violence pose major threats to the health and well-being of survivors worldwide.[1–3] Beyond the adverse impact of coinciding injuries,[1] harmful environmental exposure,[4] psychological distress,[5,6] and related psychosocial adversity,[7] the effect of such violent incidents on the somatic health of survivors is largely unknown. This lacuna could impede identification of the onset or exacerbation of frequent and disabling somatic complaints such as headaches[8,9] during the early phase of chronification, when interventions may be most fruitful.[10]

Nonviolent, stressful life events are potential triggers of migraine and tension-type headaches (TTHs).[11] There is a possibility that neuroendoimmunologic responses to severely adverse experiences[12] could affect central sensitization and pain modulation and perception, thereby increasing individual susceptibility to chronification of migraines and TTH over time.[10,13] If this is the case, we suspect life-threatening events such as a terror attack to be highly pathogenic in regard to triggering the onset or exacerbation of frequent headaches. Adolescents could be particularly vulnerable.[14]

In this study, we aimed to investigate the effect of terror on recurrent headache by type and frequency in adolescents. We compared headache among highly exposed adolescent survivors of a mass shooting (the Utøya Study) and matched controls from a general population study (the Young-HUNT3 Study). We hypothesized that exposure to terror would increase survivors' risk of frequent headaches, above expected levels, accounting for known risk factors, including injuries, age, sex, family structure and economy, prior physical violence, sexual abuse, and current psychological distress.

Methods

Participants and procedure

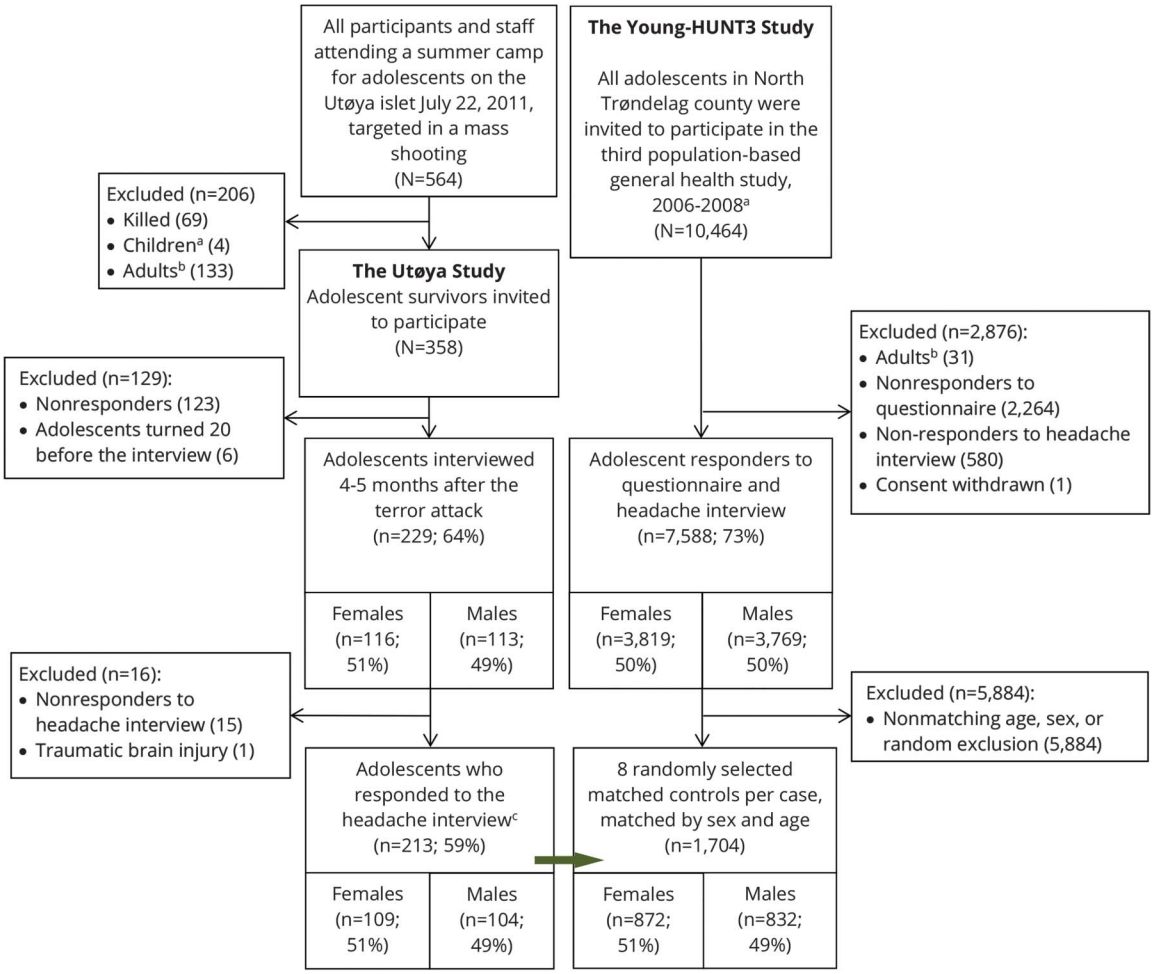
On July 22, 2011, there were 564 people on the Utøya islet for the yearly Norwegian Labor Party youth summer camp when a lone, ethnic Norwegian man, disguised as a policeman, opened fire, shot 69 people dead, and severely wounded 33 (hospitalized). Everyone present was highly exposed to terror. A high number of survivors witnessed the atrocities; many risked hypothermia and drowning trying to escape; and the majority lost friends.[3] Apart from 4 children <13 years of age, all survivors, including 358 adolescents, were invited to participate in the Utøya Study (figure). Among the 229 (64%) adolescent responders still <20 years of age at the time of the study, one was excluded because of traumatic brain injury and 15 did not respond to the headache interview, leaving us with 213 (59%) respondents, of whom 13 (6%) were severely injured and 104 (49%) were male. Trained personnel conducted semistructured interviews with the survivors, including a validated headache interview.[15] The first round of interviews (T1) took place 4 to 5 months after the terror attack, followed by T2 at 1.5 years and T3 at ≈3 years. At the end of each session, the interviewer assessed the survivors' current needs for health services and provided help in contacting the appropriate resources if required. Matched controls were drawn from the Young-HUNT3 Study cohort (https://www.ntnu.edu/hunt) (2006–2008), a population-based general health study encompassing a self-report questionnaire (http://www.ntnu.edu/hunt/data/que) and a clinical assessment by trained staff, including the validated headache interview.[15] A total of 7,588 (73%) of the 10,464 invited adolescents, of whom 3,769 (50%) were male, completed both the questionnaire and the headache interview. Eight Young-HUNT3 controls were matched to each Utøya case, according to sex and age, on the basis of a priori reasoning.[16] In total, 1,704 controls were included in the study, of whom 832 (49%) were male.

Measures

Headache

A validated headache interview was used to assess recurrent headache by type and frequency in survivors at 4 to 5 months after the mass shooting (the Utøya Study, T1) and among matched controls (the Young-HUNT3 Study).[15] During the acute posttrauma phase of about a month,[17] survivors' psychological and physiologic reactions are called acute stress reactions, which are usually transient, may be considered normal,[18] and could temporarily affect headache prevalence among survivors. In collaboration with the authors of the original instrument, the text was therefore slightly modified in the Utøya Study, in which adolescents were asked to report headache over the past 3 months to ensure that the reported headache patterns represented persistent complaints, recurring for at least 3 months after the acute posttrauma phase. Adolescents in the Young-HUNT3 Study reported recurrent headache complaints during the past year. Both survivors and controls were asked whether they had experienced headaches not caused by a cold (infection) or other illness. In accordance with the *International Classification of Headache Disorders*, "yes" responders were read 2 descriptive texts of prototypic complaints for migraine and TTH[19] and asked whether either, both, or neither description resembled their own complaints. This recognition-based headache interview differentiating migraine and TTH in adolescents has previously been validated against diagnoses based on extensive semistructured interviews by neurologists. The overall chance-corrected agreement (Cohen κ) was 0.76 (95% confidence interval [CI] 0.66–0.86), which is considered good.[15] Furthermore, the adolescents were asked to specify the frequency of their head pain. Adolescents with any recurrent headache with migraine characteristics within the given time period were classified as

Figure Flowchart of the study sample, adolescent survivors, and matched controls



having migraine. No TTH or less than monthly TTH complaints were coded as no TTH, while reports of TTH on 1 to ≥3 d/mo were classified as TTH. Other headache was coded in a manner similar to TTH. The grand total of any reported frequencies of migraine, TTH, and other headaches formed the basis for the calculation of a headache frequency variable, ranging from none to less than monthly (less than once a month), monthly (1–3 d/mo), weekly (1–4 d/wk), or daily/chronic (>4 d/wk) headache complaints.

Terror

All adolescent survivors included in the Utøya Study had been directly exposed to the mass shooting incident on the Utøya islet on July 22, 2011,[3] and were coded 1 for terror. The matched controls from the Young-HUNT3 Study were coded 0. Information on gunshot wounds in survivors of the mass shooting was drawn from hospital records as part of the Utøya Study. Survivors diagnosed with traumatic brain injuries in the hospital records were excluded, while other injuries requiring hospitalization were called severe injury.

Sex and age

For both survivors and matched controls, information on sex and age at the time of interview was based on data from the Norwegian National Population Registry.

Socioeconomic factors

Family structure differentiated between living with 1 or both parents and living without either parent. In both studies, relative affluence of the family was measured by asking, "What is the economic status of your family in comparison to most others?" Answers were dichotomized as family economy below average, including worse or somewhat worse than most others, and all other categories of family economy, self-reported as average or better than average.

Interpersonal violence

Among survivors, lifetime exposure to physical violence before the mass shooting on Utøya islet was measured as "was subjected to violence (beaten or injured)" (yes or no). Lifetime exposure to sexual abuse before the mass shooting was

measured by asking whether the participant "was subjected to unpleasant/disagreeable sexual acts" (yes or no). We avoided screening of prior interpersonal violence in the early aftermath (T1) on the basis of ethical and clinical considerations concerning the survivors' well-being and the appropriate length and content of the interview. Data were therefore collected during the following waves (T2 and T3). The Young-HUNT3 Study included questions on lifetime exposure to physical violence and sexual abuse, similar to the questions used in the Utøya Study, although sexual abuse was measured with 2 items differentiating the perpetrator, peer vs adult. A sum score (0–2) of the 2 Young-HUNT3 items on sexual abuse formed the basis for dichotomization between no sexual abuse (0) and sexual abuse (1–2), comparable to the single, dichotomous item of the Utøya Study.

Psychological distress

The level of posttraumatic psychological distress in survivors and psychological distress in matched controls was measured with a validated, 5-item short version[20] of the 25-item Hopkins Symptom Checklist subscale on anxiety and depression, assessing fear or anxiety, tension/distress or restlessness, hopelessness, dejection or sadness, and excessive worry over the past 14 days. Cronbach α was 0.82 for survivors and 0.83 for matched controls.

Data analyses

Analysis of variance and exact Pearson χ^2 tests were used to assess group differences in continuous and categorical variables between cases and controls for each sex separately. Logistic regression models were used to obtain adjusted odds ratios and 95% CIs that estimated the likelihood of experiencing recurrent headache, migraine, and TTH according to exposure to terror within complete case samples. No migraine and no monthly or more frequent TTH/other headache served as the reference category for all 3 outcomes. Ordinal logistic regression was used to estimate the likelihood of survivors experiencing more frequent headaches compared to matched controls. The analyses of headache frequency were based on an a priori assumption of proportional odds. We estimated 3 multivariable logistic regression models, hierarchically adjusting for increasing numbers of risk factors, based on a priori reasoning. Risk for headache by type and higher frequency, in relation to exposure to terror, was estimated in multiple logistic regression analyses and adjusted for sex, age, socioeconomic factors, and severe injury (model 1).[11,16,21] In model 2, childhood exposure to physical violence and sexual abuse was added.[13,22] Model 3 also included a measure of level of current posttraumatic psychological distress in survivors and psychological distress in matched controls.[21,23] All tests were 2 tailed, with a significance level of $p \leq 0.05$. The analyses were performed with IBM SPSS statistics version 22 in combination with R version 3.1.2 (The R Foundation for Statistical Computing, Vienna, Austria).

Standard protocol approvals, registrations, and patient consents

Both the Utøya Study and the Young-HUNT3 Study were based on written informed consent from participants ≥16 years of age and from the parents of individuals <16 years of age. The current matched cohort study of adolescents from the Utøya Study and the Young-HUNT3 Study was approved by the Norwegian Regional Committee for Medical and Health Research Ethics in Norway (document 551224, 2011/1625; 2014/246).

Results

Survivors of terror were found to be comparable to matched controls in regard to background factors (table 1). Adolescent girls and boys exposed to terror experienced more recurrent headaches than their nonexposed peers (table 2). As expected,

Table 1 Age, socioeconomic factors, and prior exposure to physical violence and sexual abuse in 213 adolescents exposed to terror at the Utøya islet and the 1,704 matched controls, by sex[a]

	Girls					Boys				
	Survivors (n = 109)		Controls (n = 872)			Survivors (n = 104)		Controls (n = 832)		
	No.	n (%)/mean (SD)	No.	n (%)/mean (SD)	*p* Value	No.	n (%)/mean (SD)	No.	n (%)/mean (SD)	*p* Value
Age	109	17.8 (1.1)	872	17.6 (1.0)	0.172[b]	104	17.6 (1.4)	832	17.4 (1.2)	0.258[b]
Socioeconomic factors										
Living without either parent	106	22 (21)	830	154 (19)	0.585[c]	104	18 (17)	791	114 (14)	0.434[c]
Family economy below average	93	13 (14)	844	90 (11)	0.332[c]	91	12 (13)	774	68 (9)	0.170[c]
Prior physical violence	89	13 (15)	848	82 (10)	0.142[c]	89	20 (22)	785	120 (15)	0.080[c]
Prior sexual abuse	87	8 (9)	847	101 (12)	0.450[c]	92	3 (3)	787	26 (3)	0.983[c]

[a] Because of rounding, percentages may not total 100.
[b] Analysis of variance.
[c] Pearson χ^2 test.

adolescents reported mainly recurrent TTHs and migraines, and headache prevalence was generally lower among boys. The survivors consistently reported more frequent headaches than matched controls regardless of sex. Three times more survivors reported weekly or daily headache complaints than matched controls, while headaches recurring less than monthly seemed to maintain at a stable, low level across exposure and sex. Thus, the elevated prevalence of headache observed in survivors was largely and significantly related to an increase in frequent headaches. Level of posttraumatic psychological distress in survivors was higher than reported psychological distress among controls.

Test of parallel lines suggested no significant deviation from the proportional odds assumption ($p = 0.199$). Logistic regression revealed strong, consistent, and significant relationships between exposure to terror and migraine, TTH, and higher frequency of headache complaints, despite adjustment for severe injury, age, sex, and family structure and economy (model 1, table 3). Additional adjustment for prior exposure to physical violence or sexual abuse did not alter risk estimates substantially (model 2). When posttraumatic psychological distress was added as a covariate, exposure to terror remained significantly and consistently associated with all outcomes (model 3). Adjustment for psychological distress seemed to bring about an attenuation of risk estimates, although the 95% CIs remained overlapping.

Taken together, the estimates of the effect of exposure to terror on headache in survivors remained robustly high across the headache types. In particular, all multivariable ordinal logistic regression models revealed a strong and significant relationship between exposure to terror and higher headache frequency (models 1–3).

Prior physical violence and sexual abuse were significantly and independently linked to headache (model 3). As expected, higher levels of psychological distress were associated with increased risk of headache (model 3).

Discussion

Our study shows that exposure to terror increases the risk of recurrent or chronic headaches in survivors. The findings may

Table 2 Headache type and frequency and psychological distress in the 213 adolescents exposed to terror and the 1,704 controls, by sex[a,b]

	Girls					Boys				
	Survivors (n = 109)		Controls (n = 872)			Survivors (n = 104)		Controls (n = 832)		
	No.	n (%)/mean (SD)	No.	n (%)/mean (SD)	*p* Value	No.	n (%)/mean (SD)	No.	n (%)/mean (SD)	*p* Value
Headache	109		872			104		832		
No headache		29 (27)		547 (63)	<0.001[c]		61 (59)		674 (81)	<0.001[c]
Headache		80 (73)		325 (37)			43 (41)		158 (19)	
By type										
Migraine		36 (33)		101 (12)	<0.001[c]		14 (13)		36 (4)	<0.001[c]
With TTH or other		21 (19)		26 (3)	<0.001[c]		6 (6)		7 (1)	<0.001[c]
TTH		54 (50)		196 (22)	<0.001[c]		29 (28)		87 (10)	<0.001[c]
Other headache		7 (6)		16 (2)	<0.001[c]		5 (5)		7 (1)	0.001[c]
By frequency					<0.001[c]					<0.001[c]
Less than monthly		5 (5)		50 (6)			5 (5)		50 (6)	
Monthly		26 (24)		157 (18)			22 (21)		78 (9)	
Weekly		36 (33)		100 (11)			11 (11)		25 (3)	
Daily		13 (12)		12 (2)			5 (5)		5 (1)	
Psychological distress	109	2.29 (0.70)	857	1.74 (0.63)	<0.001[d]	104	1.95 (0.66)	807	1.41 (0.48)	<0.001[d]

Abbreviation: TTH = tension-type headache.
[a] Definitions of headache follow the third *International Classification of Headache Disorders*. Migraine encompasses recurrent migraine attacks of any frequency. TTH and other headaches encompass headaches recurring more than monthly. Current psychological distress is a 5-item scale, 1 to 4.
[b] Because of rounding, percentages may not total 100.
[c] Pearson χ^2 test.
[d] Analysis of variance.

Table 3 Multivariate logistic regression analyses for headache by type and higher frequency in relation to exposure to terror, prior physical violence, and sexual abuse[a,b,c]

	Recurrent headache (n = 447)		Migraine (n = 157)		TTH (n = 309)		Headache frequency[d] (n = 519)	
	OR (95% CI)	*p* Value	OR (95% CI)	*p* Value	OR (95% CI)	*p* Value	OR (95% CI)	*p* Value
Terror								
Unadjusted	3.86 (2.75–5.44)	<0.001	4.86 (3.10–7.60)	<0.001	4.00 (2.57–5.81)	<0.001	4.15 (5.67–3.04)	<0.001
Model 1[e]	4.38 (3.04–6.32)	<0.001	5.73 (3.52–9.33)	<0.001	4.67 (3.12–6.98)	<0.001	4.55 (3.28–6.31)	<0.001
Model 2[e]	4.38 (3.03–6.34)	<0.001	6.10 (3.73–9.99)	<0.001	4.67 (3.12–7.00)	<0.001	4.51 (3.25–6.26)	<0.001
Model 3[e]	3.26 (2.22–4.79)	<0.001	4.27 (2.54–7.17)	<0.001	3.39 (2.22–5.18)	<0.001	3.39 (2.41–4.77)	<0.001

Abbreviations: CI = confidence interval; OR = odds ratio; TTH = tension-type headache.
[a] Study definitions and measures are defined in tables 1 and 2.
[b] Reference categories: no migraine and no monthly or more frequent TTH/other headache is the reference category in analyses with recurrent headache, any migraine, and TTH as an outcome; terror, no terror; prior physical violence/sexual abuse, no exposure; and sex, male.
[c] Complete case analyses (n = 1,667).
[d] Ordinal logistic regression analyses.
[e] Model 1 includes terror, severe injury, age, sex, and socioeconomic factors. Model 2 also includes prior exposure to physical violence and sexual abuse. Model 3 also includes current psychological distress. For the sake of clarity, assessed risk factors other than exposure to terror were omitted from the table.

have implications for emergency preparedness planning, surveillance, and clinical interventions.

Strengths of this study are the matched cohort design and high participation rates; other studies after large-scale traumatic incidents usually face sampling problems[24] and lack comparison data. The high, relatively homogeneous exposure among the survivors[3] contrasts with most other studies, in which great variation in severity, duration, and frequency of individual violence exposure may weaken the validity and reliability of results.[25] Exposure to the mass shooting did not coincide with exposure to toxicants, irritants, or other harmful environmental factors, which is often the case in other terror or disaster studies[4] and studies assessing the effect of violence exposure on health in vulnerable subgroups of populations.[7,26] Clinical relevancy of the outcome measure[15] may also be helpful in terms of interpreting the findings and anticipating potential, meaningful interventions. Because headache and related risks were measured similarly and independently in the Utøya Study and the Young-HUNT3 Study, we were able to account for a comprehensive range of known risk factors and thereby attenuate the risk of confounding. On the other hand, the span of 3 to 5 years between the collection of data in the Young-HUNT3 Study and the Utøya Study could affect the results; survivors and matched controls could vary in confounding factors that were not accounted for; and the retrospective, cross-sectional study design hinders causal inference. Adjustment for concurrent psychological distress, which may represent a confounder or mediator of the assessed relationship between exposure to terror and headache, could have led to an underestimation of the strength of associations. The lower response rate among survivors with high symptom levels could have led to an underestimation of associations,[24] and the lower response rate among marginalized adolescents in both studies could have affected results either way.[27] Our measures of prior physical violence and sexual abuse lack event-specific information on the perpetrator, severity, and duration. Our measure of psychological distress did not capture avoidance or re-experience reactions, although general distress is highly correlated with specific posttraumatic reactions.[3]

Prior research indicates that exposure to extreme violence in the form of combat[21] or childhood maltreatment, encompassing sexual abuse and other violence from caregivers,[13] increases the risk of chronic headache in adults. These associations may be largely attributable to related accumulating, synergetic risk factors, including genetic susceptibility;[28] head injuries;[26] exposure to other adverse physical, economic, or psychosocial conditions; development of posttraumatic psychological distress;[29] and co-occurring lifestyle-related health problems.[30] Similarly, posttraumatic stress disorder has been linked to a range of somatic disorders in young girls in a large, cross-sectional, case-control study based on existing service-use data.[6] This finding was supported by results from a recent retrospective, cross-sectional study in which posttraumatic mental health problems mediated the relationship between self-reported interpersonal violence and subsequent onset of frequent headaches and back and neck pain in adolescents.[23] Conversely, findings from an early study of adolescent girls and women admitted to hospital after forcible rape indicate that headache may be among the first health complaints to emerge in the acute posttrauma phase.[31] To what degree the reported headaches were related to inflicted head injury or acute psychological distress and whether complaints persisted beyond the acute posttrauma phase were not elaborated. However, the indication of a more direct relationship between exposure to violent events and headache is not totally unprecedented because children and adolescents exposed to disaster[32] and transitory displacement during war[33] have also reported headache and pain, co-occurring with psychological distress, in the early aftermath of exposure.

Disentangling the pathogenicity of exposure to the terror of a specific event is a challenging task, given the tendency of accumulation of risk within individuals, families, and communities.[7,26,30] However, combining recent advances in headache research and the psychiatric, epigenetic, and neuroimmunologic fields may lend some support to our findings. Childhood maltreatment during periods of high developmental plasticity seems to trigger modifications in genetic expression, neural circuits, immunologic functioning, and related physiologic stress responses.[12,28,34] It is plausible that exposure to interpersonal violence could induce functional, neuroendoimmunologic alterations, affecting central sensitization and pain modulation and perception.[10] Central sensitization, expressed as hypersensitivity to visual, auditory, olfactory, and somatosensory stimuli, has long been thought to play a key role in the pathogenesis and chronification of migraine.[11,35,36] There is suggestive evidence that such sensitization may be related to higher severity and frequency of headaches rather than specific headache diagnoses.[37] One plausible pathway linking severe adversity to increased excitability could be fear-related elevated amygdalar metabolic activity. Such increased amygdalar activity was recently linked to a higher risk of the development of cardiovascular disease in humans over time, plausibly mediated through inflammatory processes, particularly arterial inflammation.[38] Migraine is known to co-occur with cardiovascular and neurovascular disorders,[16] and there is an ongoing debate as to whether migraine is a disease of vascular or neurologic dysfunction.[39] If these adolescents' frequent headaches relate in part to fear-induced physiologic adaptations or maladaptations, their head pain could represent early, modifiable predictors of later severe illness such as cardiovascular disease.[17] Exposure to physical violence and sexual abuse could play a similar fueling role.[13]

Despite their limitations, it is likely that the findings of our study may be applicable to other young survivors affected by terror. Children and adolescents exposed to other violence such as armed hostility or gun violence in their communities or interpersonal violence among close relations may also be at risk of developing recurrent or chronic headaches. Because migraines and TTH are among the most common causes of functional impairment in adolescents and adults alike,[9] it is likely that frequent complaints would add to the burden of survivors, affecting their ability to function and cope. In general populations indirectly exposed to terror and other atrocities, physical proximity, psychological closeness, and event-specific stigmatization are known to increase the risk of adverse psychological outcomes.[40] Headaches could distribute across similar patterns, adding to the burden of highly exposed or vulnerable subgroups within the wider population.

Exposure to terror and other extreme violence increases the risk of recurrent or chronic headache complaints, over and above the effect of psychological distress and other known risk factors. Emergency preparedness planning, surveillance, and interventions may need to address survivors' headaches to hinder chronification and to facilitate recovery.

Author contributions

S.Ø.S. carried out the data processing, analyzed the data, performed the statistical analysis, and drafted and revised the paper. She is the guarantor. G.D. and J.-A.Z. contributed to the integration of the headache interview and measures of victimization in the Young-HUNT3 Study. G.D. and S.Ø.S. wrote the original study protocol and further participated in the epidemiologic modeling, analysis and writing of the manuscript. G.D. applied for and received the grant for the study. T.W.-L. contributed to the statistical analysis. J.-A.Z. participated in the design of the study and helped to write the manuscript. All authors, external and internal, had full access to all of the data (including statistical reports and tables) in the study and take responsibility for the integrity of the data and the accuracy of the data analysis. All authors have read and approved the final version of the manuscript. S.Ø.S. had full access to all the data in the study and had the final responsibility for the decision to submit for publication.

Acknowledgment

The authors thank all participants. They also thank their employers, the Norwegian Centre for Violence and Traumatic Stress Studies and the Division of Clinical Neuroscience, Oslo University Hospital, and the HUNT Research Centre, for their collaboration and funding. The Nord-Trøndelag Health Study (The HUNT Study), which is a collaboration among the HUNT Research Centre (Faculty of Medicine, Norwegian University of Science and Technology NTNU), Nord-Trøndelag County Council, Central Norway Health Authority, and Norwegian Institute of Public Health, planned, organized and financed the data collection.

Study funding

Supported by the Norwegian Directorate of Health and the Norwegian Research Council, project 228917/H10. The funder had no role in study design, data collection and analysis, interpretation, or writing the report.

Disclosure

The authors report no disclosures relevant to the manuscript. Go to Neurology.org/N for full disclosures.

Received June 16, 2017. Accepted in final form September 10, 2017.

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SOURCE ARTICLE NPub.org/kbwv4i

The headache of terror

A matched cohort study of adolescents from the Utøya and the HUNT Study

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Neurology® 2018;90:59. doi:10.1212/WNL.0000000000004805

Study question

Does exposure to terrorism increase the risk of headaches among adolescents?

Summary answer

Survivors of terror are at increased risk of frequent migraines and tension-type headaches.

What is known and what this paper adds

Exposure to terrorism and other extreme violence causes serious psychological distress in survivors, but its effects on somatic health, beyond injury, are poorly understood. This study provides evidence that such events increase the risk of frequent headaches in survivors, far above expected levels and accounting for related risks such as psychological distress.

Participants and setting

In this study 213 of the 358 adolescent survivors of the 2011 Utøya massacre participated. All were highly exposed to the terror, and each was matched on the basis of sex and age to 8 nonexposed subjects from the Young-HUNT3 Study cohort, with a response rate of 73%.

Design, size, and duration

The survivors and control participants underwent a validated headache interview. The survivors were interviewed 4 to 5 months after the massacre. The controls had been interviewed 3 to 5 years earlier. The authors used multivariable logistic regression models to calculate adjusted odds ratios (ORs) for how terrorism exposure affected the risk of headaches.

Main results and the role of chance

The survivors were more likely to experience weekly or daily headaches than the control participants (girls 45% vs 13%, boys 15% vs 4%). Logistic regression analyses revealed strong relationships between terrorism exposure and migraines, tension-type headaches, and higher frequency of headaches ($p < 0.001$ for all) after adjustment for age, sex, socioeconomic factors, injury, prior exposure to physical or sexual violence, and current psychological distress. The table presents fully adjusted ORs for increased headache complaints in survivors.

Complaint	OR (95% confidence interval)
Migraine	4.27 (2.54–7.17)
Tension-type headache	3.39 (2.22–5.18)
Headache frequency	3.39 (2.41, 4.77)

Bias, confounding, and other reasons for caution

The data collection for the Utøya Study occurred 3 to 5 years after data collection for the Young-HUNT3 Study, and the survivors and matched control subjects may have varied in ways that were unaccounted for. Furthermore, the retrospective, cross-sectional nature of the study hindered analyses of causal relationships.

Generalizability to other populations

The results of this study are probably applicable to young survivors of other extremely violent events.

Study funding/potential competing interests

This study was funded by the Norwegian Directorate of Health and the Norwegian Research Council (project 228917/H10). The authors declare no conflicts of interest. Go to Neurology.org/N for full disclosures.

A draft of the short-form article was written by M. Dalefield, a writer with Editage, a division of Cactus Communications. The authors of the full-length article and the journal editors edited and approved the final version.