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Predictors of early adulthood insomnia following exposure to a single mass violence attack during adolescence: 7–13 year follow-up from the Utøya and HUNT studies

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ABSTRACT

Background: The long-term impact of mass violence attacks is practically unknown, especially in children and adolescents. In a previous study, we found that 8.5 years after a terror attack targeting mainly adolescents, nearly half of the survivors met diagnostic criteria for insomnia.

Objectives: The aims of this study were to investigate: (1) whether exposure to a single mass violence event during adolescence increases the risk of insomnia almost a decade later above that expected for a non-exposed population; and (2) whether prior interpersonal violence exposure and early post-traumatic reactions predict later insomnia.

Method: Participants were survivors of the 2011 Utøya Island terrorist attack ($n = 279$) and controls from the HUNT Norwegian general population study ($n = 35,664$). Early adulthood insomnia was assessed using four items from the Karolinska Sleep Questionnaire 8.5 years after the attack. Participants who had also completed earlier data collection waves for both studies ($n = 116$ and 2382 , respectively) were included in logistic regression models testing the associations between predictors during adolescence and later insomnia.

Results: Nearly a decade after the Utøya attack, 38.4% ($n = 56$) of the survivors reported symptoms of insomnia indicative of probable insomnia compared to 20.5% ($n = 5771$) of controls. Terror exposure during adolescence was a significant predictor of later insomnia [odds ratio (OR) = 3.18, 95% confidence interval (CI) = 2.05–4.87, $p < .001$]. Early post-trauma symptoms of anxiety and depression (OR = 1.34, 95% CI = 1.02–1.76, $p = .033$) and weekly headaches (OR = 1.64, 95% CI = 1.08–2.47, $p = .018$) were also significant predictors while controlling for background factors and other predictors.

Conclusion: Long-term assessment and treatment are needed for survivors of mass violence to improve resilience and recovery.

Predictores del insomnio en la edad adulta temprana tras la exposición a un único ataque de violencia masiva durante la adolescencia: Seguimiento de 7 a 13 años de los estudios Utøya y HUNT

Antecedentes: El impacto a largo plazo de los ataques violentos masivos es prácticamente desconocido, especialmente en niños y adolescentes. Recientemente hemos encontrado que 8,5 años después de un ataque terrorista dirigido principalmente a adolescentes, casi la mitad de los sobrevivientes cumplían criterios diagnósticos de insomnio.

Objetivos: El objetivo de este estudio fue investigar: (1) si la exposición a un único evento de violencia masiva durante la adolescencia aumenta el riesgo de insomnio casi una década después por encima de lo esperado para una población no expuesta y (2) si la exposición previa a la violencia interpersonal y las reacciones postraumáticas tempranas predicen el insomnio posterior.

Método: Los participantes fueron supervivientes del ataque terrorista de la isla de Utøya de 2011 ($n = 279$), y controles del estudio de población general noruego HUNT ($n = 35.664$). El insomnio en la edad adulta temprana se evaluó utilizando 4 ítems del Cuestionario Karolinska del Sueño 8,5 años después del ataque. Los participantes que también habían completado oleadas anteriores de recogida de datos para ambos estudios ($n = 116$ y 2.382 respectivamente) se incluyeron en modelos de regresión logística que probaban las asociaciones entre los predictores durante la adolescencia y el insomnio posterior.

Resultados: Casi 10 años después del atentado de Utøya, el 38,4% ($n = 56$) de los sobrevivientes declararon síntomas de insomnio indicativos de insomnio probable, en comparación con el 20,5% ($n = 5771$) de los controles. La exposición al terror durante la adolescencia fue un predictor significativo de insomnio posterior (OR = 3,18, CI = 2,05–4,87,

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PALABRAS CLAVE

Alteración del sueño; trauma; jóvenes; longitudinal; tiroteo masivo

HIGHLIGHTS

- Nearly twice as many young adults exposed to a terror attack during adolescence report insomnia compared to a general population sample.
- Exposure to the attack and early post-trauma symptoms of anxiety, depression, and weekly headaches were significant predictors of insomnia around a decade later.
- Long-term assessment and treatment is needed for survivors of mass violence attacks.

$p < .001$). Los síntomas postraumáticos tempranos de ansiedad y depresión ($OR = 1,34$; $IC = 1,02-1,76$; $p = ,033$) y las cefaleas semanales ($OR = 1,64$; $IC = 1,08-2,47$; $p = ,018$) también fueron predictores significativos al controlar los factores de fondo y otros predictores.

Conclusiones: La evaluación y el tratamiento a largo plazo son necesarios para los sobrevivientes de violencia masiva para mejorar la resiliencia y la recuperación.

1. Introduction

Mass violence attacks, including acts of terrorism, are becoming increasingly common worldwide, with many targeting families and children. However, the long-term impact of such events, especially in children and adolescents, is practically unknown. Insomnia, and sleep disturbance more broadly, is very common following a traumatic event and becoming increasingly recognized as more than merely a consequence of other post-traumatic symptomatology (Hall Brown & Garcia, 2020). In a previous study, we found that 8.5 years after the 2011 Utøya Island terrorist attack in Norway, 47.7% of the survivors, who were primarily adolescents at the time of the attack, met diagnostic criteria for insomnia (Porcheret et al., 2022). Although similar rates of insomnia have been reported in the first 1–2 years after a traumatic event (Fan et al., 2017; Geng et al., 2019; Gronli et al., 2017; Zhang et al., 2020), it was concerning to find these rates 8–9 years after the attack. The potential consequences of insomnia in young people are extensive, adversely impacting physical and mental health, social relationships with family and friends, school attendance and performance, and daily activities (Bauducco et al., 2015; Dewald et al., 2010; Roberts et al., 2008), as well as increasing the risk of a range of long-term physical and mental disorders and functional impairment, hampering current and future

prospects (Roberts et al., 2008; Sivertsen et al., 2014; Zhang et al., 2012). A better understanding of the factors that may contribute heavily to the development of insomnia in young people is vital not only to identify individuals most at risk, but also to uncover potential underlying mechanisms and areas for early intervention. Trauma exposure could be a particularly potent risk factor. Exploring the impact of past exposure to a single trauma on insomnia a decade later could help us to understand how insomnia may be affected by past experiences, alongside other well-known predictors of insomnia (Falch-Madsen et al., 2021; Hall Brown et al., 2015; Wang et al., 2016; Zhou et al., 2014, 2019). Furthermore, assessing early common symptoms following trauma as markers for later insomnia may highlight the most salient targets for screening individuals. Post-traumatic reactions are the hallmark for screening individuals following a traumatic event. However, individuals may experience a wide range of both mental and physical health symptoms, including symptoms of depression, general anxiety, somatic complaints, pain, and headaches (Hogg et al., 2023; Stensland et al., 2018, 2020), all of which have been associated with the development of insomnia (Brennan & Charles, 2009; Someren, 2021). However, to date, there has been limited assessment of the contribution of both mental and physical health symptoms to long-term insomnia in trauma-exposed populations. Using a cohort of survivors of the Utøya Island attack, with a comparative general population sample, spanning a 7–13 year period, this study aims to investigate: (1) whether exposure to a single mass violence event during adolescence increases the risk of insomnia almost a decade later, in early adulthood; and (2) whether prior interpersonal violence (IPV) exposure and early post-traumatic reactions predict later insomnia.

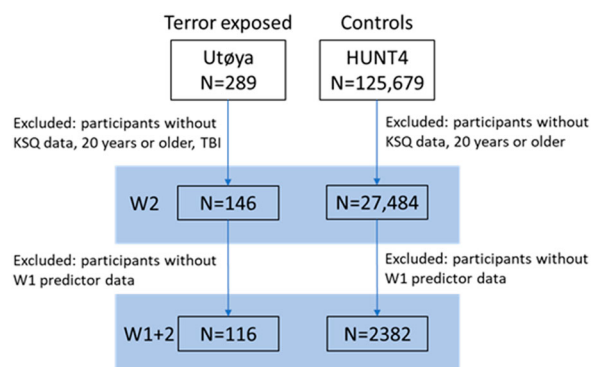


Figure 1. Study flowchart. In wave 2 (W2), 146 terror-exposed participants were included from a possible 289 participants, and 27,484 out of 125,679 controls from the general population sample. Participants were excluded if they had missing data for the Karolinska Sleep Questionnaire (KSQ), were 20 years old or older around the time of the attack and, for the terror exposed, if they had experienced a traumatic brain injury (TBI) during the attack. Of those participants, 116 terror exposed and 2382 controls also completed wave 1 (W1).

2. Method

2.1. Participants and procedure

On 22 July 2011, a mass shooting terrorist attack took place on Utøya Island, Norway. At the time of the attack, 564 people were on the island for a youth labour summer camp. Sixty-nine people were killed and 33 people were severely injured; all survivors were highly exposed to the attack, and most lost friends, family, or a partner (Dyb et al., 2014). The

Utøya study invited all survivors of the attack ($n = 502$), including seven individuals who were returning to the island and witnessed the attack from the mainland, to take part in the study. Semi-structured face-to-face interviews were conducted by trained personnel, including at 4–5 months [wave 1 (W1)] and approximately 8.5 years [wave 2 (W2)] after the attack. Participants in this study were survivors of the Utøya attack ($n = 146$) who completed the insomnia measure at W2, were aged under 20 years at the time of W1, and did not sustain a traumatic brain injury during the attack (Figure 1). Control participants were drawn from the general population-based HUNT study, Trøndelag, Norway (<https://www.ntnu.edu/hunt>). For comparison to W2, data were taken from HUNT 4, conducted in 2017–2019 ($n = 27,484$), with participants being matched for the age range of terror-exposed participants. Early predictors of insomnia were assessed from W1 of the Utøya study. Comparators for W1 were taken from YoungHUNT3 conducted in 2006–2008, and included participants of the same age range as the Utøya study. For these analyses, 116 terror-exposed participants and 2382 controls were included who had participated in both W1 and W2, with assessments of both insomnia in early adulthood and predictors during adolescence. Terror-exposed participants included in this study were on average 25.89 ($SD = 1.35$) years old 8.5 years after the attack, and 58.9% ($n = 86$) were female. Controls were 26.04 ($SD = 4.17$) years old, and 61.4% ($n = 16874$) were female. The age and sex of participants during adolescence are shown in Table 1. Adjusted for age in adolescence and sex, terror-exposed participants were more likely to have both parents born outside Norway. No other sociodemographic factors were significantly different between the populations (Table 1).

All procedures contributing to this work comply with the ethical standards of the relevant national and institutional committees on human experimentation and with the Declaration of Helsinki of 1975, as revised in 2008. Written informed consent was obtained in both the Utøya study and HUNT study at each time-point, with parents providing consent for participants aged under 16 years. The current study was approved by the Norwegian Regional Committee for Medical and Health Research Ethics in Norway (document 551224, 2011/1625, 2014/246).

2.2. Measures

Insomnia in early adulthood (W2) was assessed using four items from the Karolinska Sleep Questionnaire (KSQ) (Nordin et al., 2013) assessing three night-time symptoms (difficultly falling asleep, waking up during the night, and waking up too early) and one daytime symptom (poor daytime functioning) during the past three months. Each item was rated as ‘Never/

rarely’, ‘Sometimes’, or ‘At least three times a week’. Probable insomnia was operationalized as having at least one night-time symptom at least three times a week and having poor daytime functioning at least sometimes. This definition was based on a recent validation study of the KSQ in a subset of the HUNT4 study (Filosa et al., 2021) using a range of different definitions compared to insomnia diagnosed using the Norwegian St Olavs Hospital semi-structured face-to-face interview for insomnia (SOHSFI). Of the possible definitions in this study, based on the items used, the aforementioned definition produced the most comparable prevalence compared to the face-to-face interviews, although it is acknowledged that this is still likely to be an underestimation of the rates of insomnia.

Exposure to IPV during adolescence was assessed using a lifetime trauma screen derived from the University of California at Los Angeles Post-traumatic Stress Disorder Reaction Index (UCLA PTSD RI) (Steinberg et al., 2004) adapted for a Norwegian context, including removal of neighbourhood shootings and revision of sexual abuse items to meet ethical requirements. Eleven potentially traumatic events were assessed, with five items relating to IPV being included in this study. These included two items assessing sexual abuse, and experiencing physical violence, witnessing physical violence, and bullying (being threatened or physically harassed by other students at school for a long time), each assessed with one item. For controls, response options were ‘No’, ‘Yes in my lifetime’, and ‘Yes in last year’, with both ‘Yes’ options collapsed for this study. For terror-exposed participants, response options were ‘No’, ‘Yes before attack’, and ‘Yes after attack’. Only responses for ‘Yes before attack’ were included as an exposure to IPV during adolescence for the terror-exposed individuals. In the Utøya study, lifetime exposure to prior IPV was assessed at an additional time-point 14–15 months after the attack, as it was deemed too sensitive to be assessed immediately after the attack. In addition, terror exposure for participants of the Utøya study was defined as participating as a survivor of the terrorist attack in that study.

2.3. Early post-traumatic symptomatology during adolescence (W1)

Anxiety and depression symptoms were assessed using five items of the Symptom Checklist (SCL). Symptoms were assessed for the past two weeks, and included being constantly scared or anxious, feeling tense or uneasy, feeling hopeless when thinking of the future, feeling dejected or sad, and worrying too much about various things. The items were rated 1–4, from ‘Not bothered’ to ‘Very much bothered’. The Cronbach’s alpha for each study showed good internal consistency:

Table 1. Participants' characteristics.

	Terror exposed (<i>n</i> = 116)			General population (<i>n</i> = 2382)			<i>p</i>
	Mean	<i>SD</i>	% Included	Mean	<i>SD</i>	% Included	
Age (years) in early adulthood	25.79	1.30		26.76	1.88		< .001
Age (years) in adolescence	17.73	1.29		15.92	1.74		< .001
	Count	%		Count	%		
Female	65	56.0		1359	57.1		
Male	51	44.0	100.0	1023	42.9	100.0	.829
Socioeconomic status during adolescence							
Non-Norwegian background	5	4.3	100	24	1.1	94.0	.012 ^a
Not living with parents	25	21.6	100	246	11.0	93.7	.425 ^a
Below average family economy	17	13.6	100	178	8.5	88.4	.077 ^a
Prior interpersonal violence							
Type							
Physical violence	16	14.5	94.8	193	9.0	90.3	.504 ^a
Witnessing violence	27	24.1	96.6	474	22.0	90.3	.081 ^a
Sexual abuse	4	3.6	94.8	118	5.5	90.1	.124 ^a
Bullying	24	24.7	83.6	166	7.7	90.1	< .001 ^a
Number of types of exposure							
No prior exposure	64	57.1		1535	71.2		
One type	32	28.6		392	18.2		
Two or more types	16	14.3		229	10.6		.504 ^a

Note: ^aAdjusted for age at baseline and sex.

HUNT = 0.829, Utøya = 0.777. A mean score was calculated across all five items, ranging from 1 to 4.

Weekly headache was assessed with a validated headache interview to assess the type and frequency of headaches. Participants who reported experiencing headaches not caused by a cold or other illness were asked whether they experienced migraine, tension-type headaches, or other, based on two descriptive texts of prototypic complaints for these headache types. Participants also reported the frequency of headaches, from 'Less than monthly' to 'Daily'. Weekly headache was defined as any headache type occurring at least once a week. Experiences of weekly or more frequently recurring headaches were assessed over a time span of the past 3 months in the terror survivors compared to during the past year in the controls.

Post-traumatic stress symptoms (PTSS) were assessed using three items derived from the UCLA-PTSD-RI, part III, for children and adolescents, in collaboration with the authors of the original instrument (Steinberg et al., 2004). The items assessed common post-traumatic symptoms of intrusive memories (unwanted upsetting thoughts, pictures, or sounds of the event coming to mind, and becoming upset, afraid, or sad when reminded of the event) and avoidance (avoiding thoughts and feelings about the event). For the terror survivors, the Utøya attack was used as the index event, and in the controls the index event was exposure to any childhood trauma reported in the lifetime trauma screen. Controls reporting no exposure to childhood trauma were not asked about PTSS. Response options for each PTSS item were: Utøya – 'Never', 'Rare', 'Sometimes', 'Often', and 'Almost always'; and HUNT – 'Yes', or 'No'. For comparison between the studies, the Utøya responses were dichotomized to 'Yes' (rare, sometimes, often, and almost always) or 'No' (never) and a sum score was calculated across the items, ranging from 0 to 3.

Insomnia at baseline was assessed using one or two items, from or based on the UCLA-PTSD scale: terror exposed – 'During the past month I have trouble going to sleep, wake up often or have trouble getting back to sleep'; and controls – 'During the past three months, had difficulty falling asleep in the evening' and 'Woken too early and couldn't fall asleep again'. The control items were collapsed, and both terror exposed and controls were transformed to a 0–100 scale as they were scored on slightly different scales: terror exposed – 'Never', 'Rare', 'Sometimes', 'Often', and 'Almost always'; and controls – 'Never', 'Occasionally', 'Often', and 'Almost every night'.

Sociodemographic variables were assessed using the same items for the terror-exposed and control participants. Age and sex were determined from social security numbers. Non-Norwegian immigration background was defined as having both parents born outside Norway. Baseline economic status and living situation were assessed 4–5 or 14–15 months after the attack for terror-exposed individuals and YoungHUNT3 for controls. Low economic status was based on self-reported family economy being below average (compared to average or above average) and household structure was defined as living with: 'Mother, father, and/or adoptive parents, but not foster parents' versus 'Foster parents, other relatives, friends, partner, or living alone'.

2.4. Data analysis

Insomnia prevalence in early adulthood was compared between the terror-exposed and control participants using logistic regression controlling for age in adulthood and sex. Sociodemographics, exposure to other IPV, and early post-traumatic symptomatology during adolescence were compared between the terror-exposed and control participants using linear or logistic regression, controlling for sex and age. To test the

individual association between each predictive factor during adolescence (terror exposure, prior exposure to other IPV, and early post-traumatic symptoms of anxiety and depression, post-traumatic stress, weekly headaches, and insomnia) and later insomnia, a series of logistic regression models were used. A joint logistic model including all predictive factors was also conducted. Insomnia symptoms during adolescence were not included in this model owing to the potential for bias based on Lord's paradox (Pearl, 2016), resulting from potential inherent differences between the populations at this time-point, since this occurred after exposure to the terror attack for the participants of the Utøya study. Moreover, the use of a different measure of symptoms of insomnia during adolescence compared to in early adulthood, which was less comparable between the two populations, also increases the potential for bias. All models were adjusted for age during adolescence, sex, background, family economy, and living situation. Odds ratios (ORs) with confidence intervals (CIs) and *p*-values are presented for predictive models. All analyses included all complete cases of the terror survivors and population-based controls. Participants who had predictor data available during adolescence were slightly, but significantly older than participants who did not (participants with predictor data: mean age = 16.01 years, *SD* = 1.77; without: mean age = 15.81 years, *SD* = 1.71; *p* < .001). There was no significant difference in sex (with: females *n* = 1424, 57.0%; without: females *n* = 18934, 58.1%; *p* = .294). Statistical analyses were performed using R (version 4.1.2).

3. Results

3.1. Insomnia prevalence during early adulthood (W2)

Eight to nine years after the Utøya attack, 38.4% (*n* = 56) of the terror survivors included in this study reported symptoms of insomnia indicative of probable insomnia based on the Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition (DSM-5) diagnostic criteria in early adulthood, compared to 20.5% (*n* = 5771) of controls. In logistic regression analyses, adjusted for age and sex, the risk of exposure to the terror for insomnia

eight to nine years later was estimated at OR = 2.46, 95% CI = 1.74–3.43 (*p* < .001). Sensitivity analysis was conducted to include only participants who completed both W1 and W2, as used for subsequent analysis. A similar odds ratio was found (OR = 2.62, 95% CI = 1.73–3.01, *p* < .001), although the prevalence of insomnia was lower for this group [33.6% (*n* = 39) for terror exposed, 16.0% (*n* = 381) for controls].

3.2. Predictors during adolescence of later insomnia (W1 ± W2)

During adolescence, 42.8% (*n* = 48) of the terror survivors had experienced at least one type of IPV before the attack, compared to 28.8% (*n* = 621) of controls. Of these prior experiences of various types of IPV, only exposure to bullying was significantly different between the populations, with the terror survivors experiencing more bullying before the attack compared to the general population (Table 1). As expected, in the early aftermath of the attack, the terror survivors had higher symptom levels (Table 2) compared to the controls within the same age range.

Logistic regression analyses showed that exposure to a single mass violence event (the Utøya attack) during adolescence was a significant predictor of later insomnia (OR = 3.18, 95% CI = 2.05–4.87, *p* < .001), while exposure to IPV before the attack was not (Table 3). All early post-trauma symptoms were separate significant predictors of insomnia. In the joint model including all predictors (without insomnia during adolescence), terror exposure during adolescence remained a significant predictor of later insomnia (OR = 2.05, 95% CI = 1.21–3.44, *p* = .007), as did symptoms of anxiety and depression (OR = 1.34, 95% CI = 1.02–1.76, *p* = .033) and weekly headaches (OR = 1.64, 95% CI = 1.08–2.47, *p* = .018). All models were adjusted for age at W1, sex, background, family economy, and household structure. ORs for these factors in the joint model (Table 3) did not have a significant association with later insomnia.

4. Discussion

Almost a decade after a single mass violence event, insomnia prevalence among survivors of the Utøya

Table 2. Early post-traumatic symptomatology during adolescence.

	Terror exposed		General population		<i>p</i>
	Mean	<i>SD</i>	Mean	<i>SD</i>	
Anxiety and depression	2.11	0.68	1.50	0.55	< .001
Post-traumatic stress symptoms	2.31	0.88	0.85	1.00	< .001
Insomnia	51.52	36.62	28.99	26.73	< .001
Weekly headaches	Count	%	Count	%	
	30	27.0	212	9.3	< .001

Note: All analyses were adjusted for age at baseline and sex. Possible scores for each symptom: Anxiety and depression: 1–4; Post-traumatic stress symptoms: 0–3; Insomnia: 0–100; Weekly headaches: yes/no.

Table 3. Adolescent predictors of early adulthood insomnia.

	Separate models ^a			Joint model		
	OR	95% CI	<i>p</i>	OR	95% CI	<i>p</i>
Adolescent trauma exposure						
Terror attack	3.18	2.05–4.87	< .001	2.05	1.21–3.44	.007
Prior exposure to IPV						
One type	1.91	0.87–1.61	.226	0.90	0.62–1.28	.553
Two or more types	1.13	0.76–1.65	.536	0.81	0.50–1.26	.356
Adolescent symptomatology						
Anxiety and depression	1.74	1.43–2.12	< .001	1.34	1.02–1.76	.033
Post-traumatic stress symptoms	1.32	1.16–1.51	< .001	1.13	0.96–1.33	.132
Weekly headaches	2.06	1.47–2.86	< .001	1.64	1.08–2.47	.018
Insomnia (10 points on 0–100 scale)	1.17	1.12–1.22	< .001			
Background adjustment factors						
Age at wave 1				0.96	0.87–1.05	.335
Sex				1.35	0.97–1.90	.080
Background				0.77	0.16–2.63	.702
Family economy				1.07	0.63–1.73	.805
Household structure				0.80	0.48–1.28	.364

Note: Includes all participants who completed waves 1 and 2.

^aAdjusted for age at wave 1, sex, background, family economy, and household structure.

IPV = interpersonal violence; OR = odds ratio; CI = confidence interval.

terrorist attack was 38%, twice as high as what would be expected among young adults. Results from the analyses indicate that exposure to the terror was a unique, highly pathogenic risk factor. Also, high levels of symptoms in the early phase after the trauma predicted an increased risk of long-term insomnia. In this study, childhood exposure to IPV prior to the terror was not found to be significantly associated with insomnia in young adulthood.

Long-term longitudinal assessments of survivors of trauma, especially mass trauma, are rare, which, combined with the complexity of having a non-exposed comparison group, means that data on the long-term consequences of trauma are scarce. Although it is not possible to investigate trajectories of insomnia symptoms in our study, we have previously found that rates of insomnia 2.5 years after the attack did not differ significantly from 8.5 years after the attack, when looking at the survivors without a control group (Porcheret et al., 2022). Thus, it is highly likely that insomnia is a chronic problem for more than one-third of this population. This is, therefore, a substantial problem.

The identification of risk factors for the development of insomnia is needed to enable early intervention and treatment. In this study, we found that early symptoms, within the first 4–5 months after the attack, predicted later insomnia. In particular, symptoms of anxiety and depression and experiencing weekly headaches both predicted insomnia when adjusted for sociodemographic factors and other predictors. This fits with what has previously been reported in the short term following trauma, and demonstrates that early post-trauma symptoms signify a risk factor over the long term as well. The associations between anxiety, depression, and insomnia are well established, and common mechanisms are hypothesized to underlie these conditions, which

most recently also include trauma exposure (Someren, 2021). Trauma exposure, especially in childhood, is posited to increase vulnerability to rapid eye movement (REM) sleep fragmentation, leading to inadequate emotional processing, which can contribute to the development of insomnia, anxiety, depression, and even PTSD, depending on the emotional context (Someren, 2021). Although empirical evidence supporting this relationship is still limited, these shared mechanisms could provide a target for early intervention not only for sleep problems but also for post-traumatic symptomatology more broadly. This is strengthened by research finding that sleep-focused cognitive behavioural therapy for individuals with PTSD improves not only sleep but also PTSD symptoms (Ho et al., 2016). What remains to be seen is whether sleep therapy following a trauma can prevent such later psychopathology.

Headaches and sleep also have bidirectional associations and share anatomical and physiological pathways that may interact on multiple levels, yet the treatment of sleep and headaches is often not integrated or coordinated in practice (Brennan & Charles, 2009). In the survivors of the Utøya attack, recurrent migraine and tension-type headaches occurring weekly or daily since the trauma have been found to be three times more prevalent compared to a general population sample (Stensland et al., 2018), with somatic symptoms including headaches in the first 4–5 months after the attack predicting later PTSS (Stensland et al., 2020). Results from the present study indicate that frequent headaches in the early post-traumatic phase also predict insomnia 8.5 years after the attack. More research is needed to understand the associations between sleep and headaches, especially following trauma, as this could provide a novel treatment target for the prevention of long-term consequences of trauma.

PTSD symptoms have previously been associated with the development of insomnia during adolescence in the first 1–2 years post-trauma (Geng et al., 2019; Zhang et al., 2020; Zhou et al., 2014). In our study, we found while controlling for sociodemographic factors, PTSS significantly predicted insomnia, although this did not remain when controlling for other predictive factors. Since PTSS were assessed 4–5 months after the attack in the terror survivors and all individuals were all highly exposed to a very distressing event, the levels of symptoms in particular may not make a unique contribution over the impact of exposure to the terror attack in general or other early symptoms. The measure of PTSS was also limited in this study, so it may not be as robust an assessment of PTSS compared to previous findings, with the potential to underestimate the level of PTSD symptoms. It should be noted, however, that previous studies tended not to control for background factors or other predictors, as we have done in this study. Thus, more work is needed to understand the association between PTSS and insomnia over the long term. Baseline symptoms of insomnia were also a significant predictor of later insomnia in this study. Prior insomnia is a well-established risk factor for later insomnia (Falch-Madsen et al., 2020). The inclusion of baseline measures of outcome variables in statistical analysis is a topic of debate, and owing to the limited measure of insomnia during adolescence available in this study we erred on the side of caution and did not include it in our joint model. Thus, it is not possible to determine the contribution of early insomnia over the other predictors in this study. Nevertheless, our measure of early insomnia symptoms does lend support to the stability of insomnia almost a decade following a traumatic event, advocating for the early treatment of sleep disturbances.

Unlike in previous studies (Hall Brown et al., 2015; Hall Brown & Garcia, 2020; Kovachy et al., 2013; Wang et al., 2016), exposure to IPV during childhood or adolescence, other than the terror attack, was not found to significantly predict later insomnia in this study. Although initially this may seem contradictory, previous findings tend to come from studies looking at populations either specifically with exposure to childhood/adolescence trauma or with a diagnosis of later disorders such as insomnia or PTSD. Thus, our population represents a more general population in terms of childhood exposure to trauma, including those who were exposed to the Utøya attack, as exposure to other types of IPV was reported prior to the attack. Hence, lower rates of childhood trauma exposure are likely to be present in our population. Moreover, the items used to assess childhood IPV in this study covered relatively broad categories and hence the severity of trauma exposure may also be less than in previous studies. An additional explanation may be that

exposure to the terror attack for participants in the Utøya study may have overwhelmed the associations with previous experiences of childhood IPV and later insomnia.

Taken together, this study suggests that both mental and physical health symptoms are predictive of early adulthood insomnia following exposure to a mass violence event during adolescence. A broader assessment of symptoms and reactions post-trauma is needed not only to better understand the associations and mechanisms involved but also to fully identify those individuals most at risk. Moreover, integrated treatment pathways are needed to ensure that all aspects of post-traumatic health are considered and that adequate and timely treatment is provided.

5. Methodological considerations

The main strength of this study is the inclusion of a large, representative, comparative sample of the general population, which is followed over a similar period and allows a number of factors to be directly compared to the survivors of a terror attack. Moreover, both populations follow adolescents as they transition into adulthood, which is a period that is not often investigated. However, there are several limitations in this study that could affect the generalizability of the findings. First, although the best measures available were used, some may have reduced validity. In particular, as discussed in Section 2, the measure for insomnia was limited by the items available, which may have underestimated the prevalence of insomnia. Although not a direct comparison, the validation paper (Filosa et al., 2021), assessing different configurations of items on the Karolinska Sleepiness Scale (KSS), also assessed the Insomnia Severity Index (ISI) at three cut-offs: ≥ 11 , ≥ 12 , and ≥ 15 . The KSS items used in our study performed comparably to ISI ≥ 15 , which was the original cut-off for the ISI. However, they underperformed compared to ISI ≥ 11 , which has been shown to be a better cut-off for large population-based studies. Accurate determination of prevalence rates of insomnia from self-reported questionnaires is limited in general, as a result of how symptoms are assessed and which diagnostic criteria are used (Porcheret et al., n.d.). Previously, we reported that 47.7% of the survivors of the Utøya attack met DSM-5 criteria for insomnia 8.5 years after the attack (Porcheret et al., 2022). This is compared to 33.6% in this study. The main difference between these studies is the scales used to assess insomnia, with a short version of the KSQ being used in this study, compared to the Bergen Insomnia Scale previously. Although this short version of the KSQ allowed a direct comparison with the general population sample, the use of these items has been found to underestimate the prevalence of

insomnia by about 10%, which could go some way towards explaining the disparity between studies (Filosa et al., 2021). This study also only included participants who were adolescents (under 20 years) around the time of the attack, while a larger age range was included previously. These differences however, do not negate the finding that, using the same type of assessment, levels of insomnia were twice as high in the survivors of the Utøya attack, 8.5 years after the attack, compared to a general population sample of the same age range. The prevalence of insomnia could further be influenced by other factors or conditions that could preclude a diagnosis of insomnia, such as another sleep disorder, medication, or comorbid mental health symptoms, which were not addressed here. Baseline assessments of insomnia and post-traumatic stress reactions were also limited to just a couple of items; however, this is not uncommon in the wider literature. Future research should aim to include more robust measures of sleep, particularly when investigating the effects of trauma exposure. Secondly, exposure to other types of IPV was based on retrospective self-report, which could introduce bias, as well as such events representing relatively broad categories, which could have a varying degree of severity. Nevertheless, in this study, the terror survivors reported higher levels of bullying prior to the attack. Although we cannot be definitive as to the reason for this during the attack, the survivors were targets of extreme politically motivated terror. Politically active individuals commonly report higher levels of exposure to threats and hate speech, which we have also seen in the survivors of the Utøya attack (Glad et al., 2023), which could explain the differences seen. Alternatively, experiences of bullying may have made individuals more likely to become politically active or to seek to join groups or societies of like-minded individuals. These higher levels of bullying may suggest that the terror survivors were a somewhat more vulnerable population prior to the attack. However, since prior IPV did not have a significant association with later insomnia in this study, we do not think that this is likely to have impacted the findings of this study. Thirdly, only a subset of each population was able to be included in the logistic regression models as not all participants completed both waves, which could limit the representation of these populations. Finally, the generalizability of these findings to other traumatic events is unknown. In this study, the terror survivors were exposed to a highly distressing event, which occurred over a prolonged period and was the subject of extensive national and international attention. There are still too few studies following the survivors of mass violence events to know which characteristics of the event may be important for long-term well-being, making it unclear how generalizable our findings are to other events.

6. Clinical importance

The key finding of this study is that exposure to a single highly distressing traumatic event is a potent risk factor for long-term sleep problems. Individuals exposed to such an event require long-term assessment and care. Early post-traumatic reactions can help to identify those most at risk. Importantly, we demonstrate that both mental and physical health symptoms are associated with later insomnia, highlighting the need to provide more extensive screening of trauma survivors to provide adequate treatment and follow-up over the long term.

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Disclosure statement

No potential conflict of interest was reported by the authors.

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Authors' contributions

K. P. formulated the research questions, created the analytical plan, analysed the data, and drafted the article. G. D. and S. S. designed the Utøya study and collected data for all four time-points. G. D., T. W.-L., and S. S. contributed to formulating the research questions and analytical plan for this paper and editing the article. T. W.-L. additionally contributed to the data analysis. All authors approved the final version of the manuscript.

Data availability statement

The data that support the findings of this study can be made available upon reasonable request to the corresponding author (Kate Porcheret). The data are not publicly available as they contain information that could compromise the privacy of the research participants.

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