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Research paper

The effects of childhood trauma on stress-related vulnerability factors and indicators of suicide risk: An ecological momentary assessment study

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ABSTRACT

Background: Childhood trauma is experienced by approximately one third of young people in the United Kingdom and has been shown to confer an increased risk for mental health difficulties in adulthood. Understanding the associations between these factors before negative health outcomes manifest in adulthood is imperative to help inform the development of interventions. The aims of this study were two-fold; first, to investigate the effects of childhood trauma on daily stress-related vulnerability factors over a period of 7 days and to test whether any observed relationships were moderated by protective or risk factors. Second, to explore the indirect effects of childhood trauma on reasons for living, optimism, daily suicide ideation, defeat and entrapment through the daily stress-related vulnerability factors.

Methods: 212 participants were recruited to an ecological momentary assessment study to complete three diaries per day for a 7-day period. Participants completed daily measures of stress, hassles, executive functioning, impulsivity, sleep quality (stress-related vulnerability factors) as well as measures of reasons for living, optimism, daily thoughts of suicide, defeat and entrapment. The Childhood Trauma Questionnaire was also completed at baseline.

Results: Analyses found that childhood trauma was significantly associated with higher scores on the daily stress-related vulnerability factors and positively related to each of the daily indicators of suicide risk. The study also uncovered key pathways whereby trauma had indirect effects on reasons for living, optimism, daily thoughts of suicide, defeat and entrapment through executive functioning, impulsivity, sleep quality and stress.

Limitations: The measures of executive function and sleep were self-reported and future research ought to replicate the current findings using more objective methods.

Discussion: The findings from this study highlight the complexity of childhood trauma and its damaging effects on stress-related vulnerability factors and poorer mental health outcomes. Greater understanding of pathways by which trauma may impact later health outcomes is essential for development of interventions.

1. Introduction

Childhood trauma is experienced by approximately one third of young people in the UK and two thirds of adults in the US and is associated with poorer health outcomes with detrimental impacts on physical and mental health (Lewis et al., 2019; Swedo et al., 2023). Trauma exposed young people have been found to be twice as likely to develop a mental health condition compared to non-trauma exposed young people and they have also an increased risk of suicide (Lewis et al., 2019; Marshall et al., 2013). Additionally, experiences of trauma are associated with a variety of pre-psychopathological outcomes: dysregulated hypothalamic pituitary adrenal (HPA) axis functioning (O'Connor et al., 2018, 2020), retrospective assessments of greater perceived stress (Gouin et al., 2012), poor executive functioning (Gould et al., 2012), impulsive behaviours (Lovallo, 2013) and sleep disruption (Tinajero et al., 2020). Each of these pre-psychopathological factors has been shown to confer an increased risk for mental health difficulties in adulthood such as depression, self-harm and suicide; questioning whether a pathway exists whereby childhood trauma confers an increased risk for future mental and physical health outcomes by

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influencing key pre-psychopathological, or stress-related vulnerability factors, before negative health outcomes manifest.

1.1. Effects of childhood trauma on stress-related vulnerability factors

The experience of childhood trauma is associated with a plethora of poor health outcomes, specifically impacting upon daily functioning. There is growing evidence showing that fluctuations in within-person daily stressors are important to understanding stress-outcome processes (Almeida et al., 2005; Gartland et al., 2014; Smyth et al., 2018). Previous research has found childhood abuse to be associated with greater daily hassles (Tinajero et al., 2020) and adverse childhood experiences to significantly predict self-reported stress (Kalmakis et al., 2020). Furthermore, stress, including early life adversity, acute stress, chronic stress and daily hassles can increase the likelihood an individual will experience suicidal ideation and later suicidal behaviour (Howarth et al., 2020; Liu and Miller, 2014).

Childhood trauma has been found to impact on a diverse array of stress-related vulnerability factors such as sleep, impulsivity, executive functioning, defeat and entrapment. Indeed, a recent study found that a greater number of traumatic events during childhood was associated with poorer sleep health as assessed by both actigraphy and sleep diaries in adulthood (Hamilton et al., 2018) and childhood abuse was associated with poorer sleep quality (Tinajero et al., 2020). In addition, impulsivity has also been shown to play a key role in numerous adverse outcomes such as drug addiction (Argyriou et al., 2018) and suicide (Anestis et al., 2014). Moreover, poorer executive function performance has also been found in adults who have been exposed to childhood trauma and in one study, when considering specific facets of trauma, childhood abuse and neglect were found to be associated with poorer reported and behavioural executive function difficulties (Gould et al., 2012; Tinajero et al., 2020).

As outlined above, childhood trauma is an established risk factor for suicide. A leading model of suicide behaviour, the Integrated Motivational-Volitional Model (IMV), has identified psychological vulnerability factors such as defeat, entrapment, stress and impulsivity contribute to an increased risk of suicidal ideation and behaviour (Branley-Bell et al., 2019; O'Connor and Kirtley, 2018). The first part of the model, outlining the pre-motivational and motivational phases, summarises the complex interplay of the aforementioned stress related vulnerability factors, in relation to childhood trauma (as well as other factors), *prior* to the development of suicidal ideation. Specifically, the model postulates that feelings of defeat can trigger feelings of entrapment which in turn predicts suicidal ideation as an escape from unbearable psychological distress. However, there is a lack of evidence linking childhood trauma to daily feelings of defeat and entrapment in adulthood, therefore a key aim of the current study was also to investigate the extent to which childhood trauma is associated with daily feelings of defeat and entrapment.

Furthermore, in the IMV model, there are stage-specific motivational moderators that facilitate or impede the emergence of suicidal ideation. Motivational moderators include resilience, social support, social connectedness and loneliness, as well as previous suicidal history, all influencing the transition from entrapment to suicidal ideation. Recent research has reported lower levels of social support, connectedness and resilience in individuals vulnerable to suicide compared to individuals with no history of suicidal ideation or behaviour, suggesting that these factors are protective (O'Connor et al., 2021a). Therefore, another aim of the current research was to understand whether the associations between childhood trauma and defeat, entrapment and the other aforementioned daily stress-related vulnerability factors were moderated by known protective-factors (resilience, social support, social connectedness) and/or risk-factors (loneliness and suicide history).

1.2. Do stress-related vulnerability factors mediate the childhood trauma – suicide risk relationship?

The final aim of the current study was to investigate the factors that may mediate the effects of childhood trauma on suicide risk. In particular, we were interested in exploring whether childhood trauma had indirect effects on key indicators of suicide risk (i.e., reasons for living, optimism, defeat, entrapment and suicide ideation) through influencing the aforementioned stress-related vulnerability factors (i.e., daily stress, executive functioning, impulsivity and sleep). Determining the mechanisms by which childhood trauma is associated with suicide risk factors, *prior* to the development of mental and physical health problems may help further elucidate the pathways that increase future vulnerability and may uncover key targets for intervention.

Finally, it is worth noting that relatively few studies have explored the associations between childhood trauma, stress-related vulnerability factors and suicide risk indicators in naturalistic settings using an ecological momentary assessment (EMA) methodology. EMA allows the assessment of a phenomenon even if dynamic changes are unobservable when measuring at fixed time points. Moreover, an important avenue for research in this area is understanding the state-dependent dynamics that may help explain changes in daily functioning, such as impulsive behaviours (Tomko et al., 2014) and feelings of stress (van Nierop et al., 2018). Previous research has revealed that childhood trauma is associated with higher perceived daily hassles (Berhe et al., 2023) and that even in a sample of clinically healthy, asymptomatic individuals with milder forms of childhood trauma, changes in real-life wellbeing is observable as adults (Berhe et al., 2023). In a typical single point measurement study, changes in stress, wellbeing and mental health may be missed, whereas EMA methodology offers an ability to capture changes in risk-associated changes in psychological processes and behaviours within naturalistic settings. A notable recent study by Tinajero et al. (2020) provided useful insights into the links between childhood trauma and pre-psychopathological factors using an EMA approach. This study found childhood abuse to be associated with pre-psychopathological factors such as emotion regulation difficulties, daily hassles and poorer executive function. However, their sample size was relatively small ($N = 79$), participants were only sampled over 3 days and the study did not explore the possible indirect effects of childhood trauma on known risk factors for suicide through stress-related vulnerability variables. Therefore, in the current paper, we sought to recruit a larger sample, to extend the study period to 7 days and to explore whether the effects of childhood trauma on suicide risk factors were mediated through daily stress-related vulnerability variables.

Taken together, the primary aims of the current study were two-fold. First, to investigate the effects of childhood trauma on daily stress-related vulnerability factors (daily stress, hassles, impulsivity, executive functioning and sleep) over a period of 7 days and to test whether any observed relationships were moderated by protective factors (resilience, social support, social connectedness) or risk factors (loneliness and suicide history). The secondary aims were to test the indirect effects of childhood trauma on reasons for living, optimism, daily suicide ideation, defeat and entrapment through the daily stress-related vulnerability factors.

2. Methods

2.1. Design and participants

A 7-day ecological momentary assessment study was utilised whereby participants completed three surveys per day. 302 participants were recruited during June 2022 through the Prolific platform to complete a 7-day daily diary survey. Participants were paid £1.50 for the baseline survey (taking 15–20 min) and 20p for each daily survey (taking 1–2 min). This totalled a potential incentive of £5.70. Participants were sent email notifications to complete their daily surveys once

in a morning upon awakening (8 am), at 12 pm and again at 8 pm, before the participants went to bed. 211 participants (67.8 % female) completed two or more full days of surveys. Participants were required to be aged between 18 and 45 years old and fluent in the English language. Given the study aimed to recruit currently healthy participants, the participants were screened and excluded if they reported having any long-term health condition or chronic illness or a score above 14 for clinical insomnia symptoms (Insomnia Severity Index; Bastien et al., 2001). These exclusion criteria were to prevent potential confounding influences of age related decline or extreme values from sleep or long-term health conditions impacting the measures administered. The main study hypotheses were preregistered at AsPredicted.org (#98604). The current study was approved by the University Of Leeds School of Psychology Ethics Committee (PSYC-522).

The sample size was determined using a summary-statistics-based power analysis to detect a cross-level effect (Murayama et al., 2022) informed by a previous unpublished study dataset (Rogerson, 2019). The power analysis showed that a minimum sample of 220 would be required to achieve 80 % power ($t = -2.22$, $df = 130$; the cross-level effect of childhood trauma on the level 1 slope between daily stress and executive functioning). Therefore, in order to allow for 10 % attrition and drop out between completing the baseline measures and the diaries, the current study aimed to recruit 242 participants. As noted above, the final sample size included in the main analyses ($N = 211$) is 9 participants less than the minimum sample size indicated by the a priori power analysis.

2.2. Background measures

Childhood trauma was assessed using the Childhood Trauma Questionnaire Short Form (CTQ-SF; Bernstein et al., 2003). This is a 28-item questionnaire that covers five sub-categories of childhood trauma; sexual abuse, physical abuse, emotional abuse, physical neglect and emotional neglect. Each subscale is rated from '1 – Never True' to '5 – Very often true'. Composite scores for overall trauma were calculated by summing all items in the CTQ. The scale had good internal consistency $\alpha = 0.84$; internal consistency was calculated for the scores on each scale for the current sample and good internal consistency in this context is a value of $\alpha \geq 0.70$ (Nunnally and Bernstein, 1994). Example items for each sub-scale are provided; emotional abuse 'I thought my parents wished I had never been born', emotional neglect 'I felt loved', physical abuse 'I got hit so hard that I had to see a doctor', physical neglect 'I didn't have enough to eat' and sexual abuse 'someone molested me'.

Lifetime suicidal ideation and attempt were measured using the Adult Psychiatric Morbidity Survey (APMS, McManus et al., 2007) Two questions were taken from this survey to determine both lifetime suicide ideation: "Have you ever seriously thought of taking your life, but not actually attempted to do so?" and lifetime suicide attempts "Have you ever made an attempt to take your life, by taking an overdose of tablets or in some other way?" Response options were "yes", "no" or "would rather not say". The APMS measure has been frequently used to determine lifetime history of suicide behaviour (e.g., McDonald et al., 2017; O'Connor et al., 2021a; Stickley et al., 2016; Wetherall et al., 2018). Participants who answered yes to either question were classified as having a history of suicide behaviour.

Loneliness was assessed using the UCLA loneliness scale (Hughes et al., 2004). This 3-item scale (2004) asks participants "how often do you feel that you lack companionship?", "How often do you feel left out?", "How often do you feel isolated from others?". Answers range from '1 – Hardly ever', '2 – Some of the time' and '3 – Often'. The responses are summed to give a range of scores from 3 to 9. The scale demonstrated good internal consistency, $\alpha = 0.88$.

Resilience was measured using the Connor-Davidson Resilience Scale (CD-RISC 10; Campbell-Sills and Stein, 2007). This 10-item measure of resilience's items reflect the degree to which individuals have the ability to cope with adversity rated from '0 – Not true at all' to '4 – True nearly all the time'; items in the scale include, "Not easily discouraged by failure". This version has displayed good psychometric properties and is highly correlated with the original 25-item version ($r = 0.92$, Campbell-Sills and Stein, 2007; Connor and Davidson, 2003). The scale had good internal consistency, $\alpha = 0.92$.

Social connectedness was assessed using the UCLA loneliness Scale-Revised (Russell et al., 1980) which is a 20-item self-report measure. Items are rated on a four-point Likert scale from '1 – Never' to '4 – Always'; including items such as 'I have nobody to talk to'. The Cronbach's alpha value indicated good internal consistency, $\alpha = 0.97$.

Social support was measured using the ENRICHD Social Support Inventory (ESSI; Mitchell et al., 2003). A 7-item measure that is comprised of items such as "Is there someone available to you whom you can count on to listen to you when you need to talk?" rated from '1 – None of the time' to '5 – All of the time'. The Cronbach's alpha value indicated good internal consistency, $\alpha = 0.90$.

2.3. Daily measures

Stress was measured using a singular item asking participants "How stressed have you felt, since the last survey?". This item was rated from '0 – not at all stressed' to '4 – extremely stressed'. This item was developed by the research team for the purpose of the current study based on standard single item assessments of stress and has good face validity (O'Connor and Ferguson, 2016).

Sleep was measured by asking participants about last night's sleep in the first survey of the day upon waking up at 8 am. Sleep quality was assessed with one item whereby participants were asked to rate their sleep quality from '1 – Very bad' to '7 – Very good'; adapted from the Pittsburgh Sleep Quality Index (Buysse et al., 1989). Additionally, morning tiredness was assessed with one item whereby participants were asked to rate from '1 – Not at all' to '5 – Very' how tired they felt that morning; these items were adapted from Clancy et al. (2020) and have been shown to have good validity. Higher scores were indicative of poorer sleep quality and greater morning tiredness.

Daily Hassles was measured using the adapted Hassles and Uplifts Scale (DeLongis et al., 1988) as used by Tinajero et al. (2020). Seven categories were chosen which participants rated on a Likert scale from '0 – none or not applicable' to '3 – a great deal' all questions asked 'Today, how much of a hassle were __ for you?' and the categories were friends, work/school, external events, physical health, romantic partner, co-workers. The mean across all categories was taken for each day to indicate the degree of general daily hassles. The scale had an omega value of $\omega = 0.65$.

Defeat was measured using the four-item defeat scale was used from the Short Defeat and Entrapment Scale (SDES; Griffiths et al., 2015), items include "I feel defeated by life" and "I feel powerless" rated on a Likert scale from '0 – Never' to '4 – Always'. The total score indicated the sum of the items and greater feelings of defeat. The scale demonstrated good internal consistency, with an omega value of $\omega = 0.96$.

Entrapment was assessed using the Entrapment Short-Form (*E*-SF; De Beurs et al., 2020), a four-item short form of the 16-item entrapment scale. For the current study, the two items representing internal entrapment were used only. The items "I feel I'm in a deep hole I can't get out of" and "I feel trapped inside myself" were rated on a Likert scale from '0 – Not at all like me' to '4 – extremely like me'. For the current study, the sum of the two items were used to indicate daily feelings of wanting to escape from inner feelings and thoughts (Baumeister, 1990). The scale has an omega value of $\omega = 0.78$.

Executive Functioning was measured using the WEBEXEC (Buchanan et al., 2010). A short self-report measure to assess the degree of executive functioning, designed for internet research. The WEBEXEC scores have been reported to be correlated positively with the DEX and confirmed that it appears suitable for online research (Buchanan et al., 2010). The scale consists of 6-items, such as, "Do you find it difficult to keep your attention on a particular task?" rated from '1 – No problems

Table 1
Mean and standard deviations for level 1 and 2 variables in the total sample (n = 211) and in males (n = 88) and females (n = 143) separately[a].

	Total		Male		Female	
Level 1	M	SD	M	SD	M	SD
Stress	1.20	1.00	1.12	0.71	1.24	0.78
Impulsivity	5.76	2.34	5.69	1.90	5.79	1.94
Executive function	8.52	3.32	8.21	2.62	8.67	2.97
Reasons for living	5.33	1.17	5.13	1.31	5.43	1.00
Optimism	3.10	1.06	3.20	0.93	3.06	0.87
Defeat	3.98	4.23	3.33	3.29	4.26	3.71
Entrapment	1.79	2.10	1.67	1.67	1.85	1.84
Sleep quality	4.77	1.78	4.98	1.74	4.68	1.80
Morning tiredness	2.61	1.17	2.50	1.10	2.67	1.20
Hassles	0.39	0.41	0.37	0.39	0.41	0.42
Daily suicide thoughts	0.08	0.30	0.09	0.32	0.08	0.29
Level 2	M	SD	M	SD	M	SD
Age (years)	33.76	6.87	33.52	6.57	33.82	7.03
Childhood trauma	40.52	14.77	39.46	13.82	40.94	15.24
Suicide history	n = 72		n = 19		n = 53	
Resilience	35.18	7.69	37.99	7.44	33.88	7.51
Loneliness	5.38	1.93	4.97	1.87	5.58	1.93
Social support	25.84	6.24	26.40	6.71	25.62	6.02
Social connectedness	48.04	3.53	48.18	3.16	47.97	3.71

[a] Score ranges for level 1 variables: stress (0–4), impulsivity (6–30), executive function (6–24), reasons for living (1–6), optimism (0–4), defeat (0–16), entrapment (0–8), sleep quality (1–7), morning tiredness (1–5), hassles (0–3), daily suicide thoughts (0–2). Score ranges for level 2 variables: age (19–45), childhood trauma (28–140), resilience (0–40), loneliness (3–9), social support (8–34), social connectedness (0–60).

experienced' to '4 – A great many problems experienced'. The total score was calculated for each day with higher scores indicating poorer executive functioning. The scale had an omega value of $\omega = 0.92$.

*Impulsivity was measured using the M*omentary Impulsivity Scale (Tomko et al., 2014). A 6-item scale where participants were asked to "Describe how much each statement described their experience since the last completed prompt". In the current study, this item was changed to, "Please indicate how much each statement below describes your experience since the last survey" in order to be suitable for daily use. The items were rated from '1 – very slightly or not at all' to '5 – extremely'. The total score was calculated, higher scores indicated greater impulsive behaviours. The scale had an omega value of, $\omega = 0.75$.

Optimism was assessed using item 4 from the Revised Life Orientation Test (LOT-R; Scheier et al., 1994). Participants were presented with the following statement 'I feel optimistic about my future' to rate from '0 – strongly disagree' to '4 – strongly agree'. This item was adapted from 'I'm always optimistic about my future' to be suitable for daily diary use and is positively correlated with the total LOT-R scale score. The higher the score indicated a greater degree of optimism.

Reasons for living was assessed using item 4 from the Reasons for Living Inventory (RFLA; Linehan et al., 1983). 'I have a desire to live' rated on a Likert scale from '1 – not at all important' to '6 – extremely important'. This item is positively correlated with the total RFLA scale score. The higher the rated score indicated a greater desire to live.

Thoughts of suicide were assessed in the final diary of each day. The measure consisted of an item from the Beck Suicide Scale (BSI; Beck and Steer, 1991) informed by the daily diary research and shown to be reliable and valid (Coppersmith et al., 2019). Participants were asked to rate the extent to which they: "wish to live", using the following three options '0 – I have a moderate to strong wish to live', '1 – I have a weak wish to live' and '2 – I have no wish to live'.

2.4. Statistical analysis

Analyses were conducted in SPSS v.26 and multilevel models were conducted in HLM8 (Raudenbush et al., 2019). We assessed whether childhood trauma was associated with daily stress-related vulnerability factors and whether these associations were moderated by potential protective and risk factors. In addition, we determined whether childhood trauma was associated with daily reasons for living, suicide thoughts, defeat and entrapment and whether the aforementioned daily stress-related vulnerability factors mediated these relationships. Analyses were performed on individuals who completed at least 2 full days of the study (i.e., at least 6 surveys). This resulted in a total of 211 participants completing 3719 diaries over a 7-day period: 1269 morning surveys; 1236 afternoon surveys; 1214 evening surveys. The dataset was checked for outliers by scanning the data for any values ±3 standard deviations away from the mean for all continuous variables. Each measure had the ranges checked to ensure no errors were present in the dataset. Normality was assessed through utilising the Kolmogorov-Smirnov test, all values $p > .05$. Histograms and Q-Q plots were also inspected to confirm the data was normally distributed. Full details for the statistical analyses and treatment of missing data are provided in the Supplementary Materials.

Multilevel mediation analysis was conducted using the MLMED macro in SPSS (Rockwood and Hayes, 2017). Using multilevel mediation analysis, we explored whether there were indirect effects of CTQ total score on daily reasons for living, optimism, suicide thoughts, defeat and entrapment through daily stress-related vulnerability factors. In these analyses, total CTQ score (at level 2) and daily measured reasons for living, optimism, suicide thoughts, defeat and entrapment (at level 1) were the X and Y variables (respectively), the daily stress-related vulnerability factors (at Level 1) were the mediators (M variables). The indirect effects use Monte Carlo simulation to generate the confidence intervals and report the unstandardized estimates, these are summarised in Table 4.

3. Results

Descriptive statistics for the background and daily variables, measured at one or three time points are presented in Table 1. We observed similar scores to previous research assessing total CTQ (M = 40.52). Scores on the other main study variables were within normal ranges. 72 participants reported suicide ideation or a suicide attempt

Table 2
A summary of the main effects of childhood trauma on daily stress-related vulnerability factors.

	β	Coefficient	*SE*	*df*	*p* value
Hassles					
Intercept	β00	0.400	0.021	209	<0.001
CTQ	β01	0.004	0.002	209	0.029
Stress					
Intercept	β00	1.217	0.039	209	<0.001
CTQ	β01	0.010	0.003	209	<0.001
Impulsivity					
Intercept	β00	5.780	0.108	209	<0.001
CTQ	β01	0.027	0.010	209	0.005
Executive function					
Intercept	β00	8.566	0.162	209	<0.001
CTQ	β01	0.039	0.013	209	0.003
Sleep quality					
Intercept	β00	4.767	0.079	209	<0.001
CTQ	β01	−0.018	0.005	209	<0.001
Morning tiredness					
Intercept	β00	2.611	0.051	209	<0.001
CTQ	β01	0.007	0.004	209	0.048

Note: statistical significance = $p < .01$ (see supplementary materials).

history by answering 'yes' to either of the APMS questions. There were 60 individuals reporting only suicide thoughts and 12 individuals reporting both thoughts and attempts.

3.1. Effects of childhood trauma on daily stress-related vulnerability factors (hassles, stress, executive functioning, impulsivity and sleep)

The findings for each of the effects of childhood trauma on each of the daily stress-related vulnerability factors are presented in Table 2. The results showed main effects of childhood trauma on daily stress ($\beta = 0.01$, $p < .001$), executive functioning ($\beta = 0.039$, $p = .003$) and sleep quality ($\beta = -0.02$, $p < .001$) indicating that higher levels of childhood trauma were associated higher daily stress, poorer executive functioning and sleep quality (see Fig. 1). However, childhood trauma was not related to daily hassles or morning tiredness.

3.2. Moderating effects of protective factors (resilience, social support, social connectedness) and risk factors (loneliness and suicide history) on the childhood trauma - daily stress vulnerability relationships

There were no moderating effects of the childhood trauma and daily stress-related variables relationships by any of the protective or risk factors (see supplementary materials, *Table S1*). However, we did observe main effects of loneliness on all daily stress-related vulnerability factors; suggesting that higher levels of loneliness were associated with a higher number of hassles, poorer sleep quality, poorer executive function, greater morning tiredness, greater daily stress, and more impulsive behaviour (see supplementary materials, *Table S1*). Similarly, higher levels of resilience were associated with better sleep quality and executive function, lower levels of impulsivity, morning tiredness and daily stress. There were also main effects of suicide history such that individuals who had a suicide history reported greater daily stress, poorer sleep quality, greater morning tiredness and poorer executive function than individuals without a suicide history. Lastly, main effects of social support were found such that lower stress, greater executive functioning and lower impulsivity was reported in individuals who had higher social support compared to those with lower social support. For social connectedness, we observed no main effects.

3.3. Direct effects of childhood trauma on reasons for living, optimism, daily suicide thoughts, defeat and entrapment

Childhood trauma was significantly associated with all daily measured suicide risk factors such that higher levels of childhood trauma were related to lower reasons for living and optimism, and higher daily suicide thoughts, defeat and entrapment (see Fig. 2). The results of the aforementioned associations are presented in Table 3 and are the basis for the subsequent mediation analyses.

3.4. Indirect effects of childhood trauma on reasons for living, optimism, daily suicide thoughts, defeat and entrapment via daily stress-related vulnerability factors

Next, we tested whether there were indirect effects of childhood trauma on the aforementioned outcome variables through daily stress-related vulnerability factors. In these analyses, childhood trauma (at Level 2) and outcome variables (at Level 1) were the X and Y variables, respectively, and daily stress-related factors (at Level 1) acted as the mediator (M variable). All the analyses are adjusted for age and sex. A summary of the indirect effects, showing unstandardised coefficients, is shown in Table 4 and in Fig. 3.

3.5. Reasons for living

We tested whether there were indirect effects of childhood trauma on reasons for living through the daily stress-related vulnerability factors. There were indirect effects of childhood trauma on reasons for living through daily executive functioning ($B = -0.005$, $p = .006$). There were no indirect effects through daily hassles, daily impulsivity and daily morning tiredness.

3.6. Optimism

There were significant indirect effects of childhood trauma on optimism through all of the daily stress-related vulnerability factors: daily stress ($B = -0.007$, $p = .001$), daily executive functioning ($B = -0.006$, $p = .002$), daily impulsivity ($B = -0.004$, $p = .009$) and daily sleep quality ($B = -0.004$, $p = .005$).

3.7. Defeat

There were significant indirect effects of childhood trauma on defeat through all of the daily stress-related vulnerability factors: daily hassles ($B = 0.019$, $p = .008$); daily stress ($B = 0.039$, $p < .001$); daily executive functioning ($B = 0.037$, $p < .001$); daily impulsivity ($B = 0.026$, $p = .001$); daily sleep quality ($B = 0.018$, $p = .005$).

3.8. Entrapment

There were significant indirect effects of childhood trauma on entrapment through all of the daily stress-related vulnerability factors: daily hassles ($B = 0.009$, $p = .008$); daily stress ($B = 0.019$, $p < .001$); daily executive functioning ($B = 0.017$, $p < .001$); impulsivity ($B = 0.012$, $p = .001$); sleep quality ($B = 0.008$, $p = .008$).

3.9. Suicide thoughts

There were significant indirect effects of childhood trauma on greater daily suicide thoughts through all of the daily stress-related vulnerability factors: daily hassles ($B = 0.001$, $p = .012$), daily stress ($B = 0.002$, $p < .001$), daily executive functioning ($B = 0.002$, $p = .002$) and daily impulsivity ($B = 0.001$, $p = .003$).

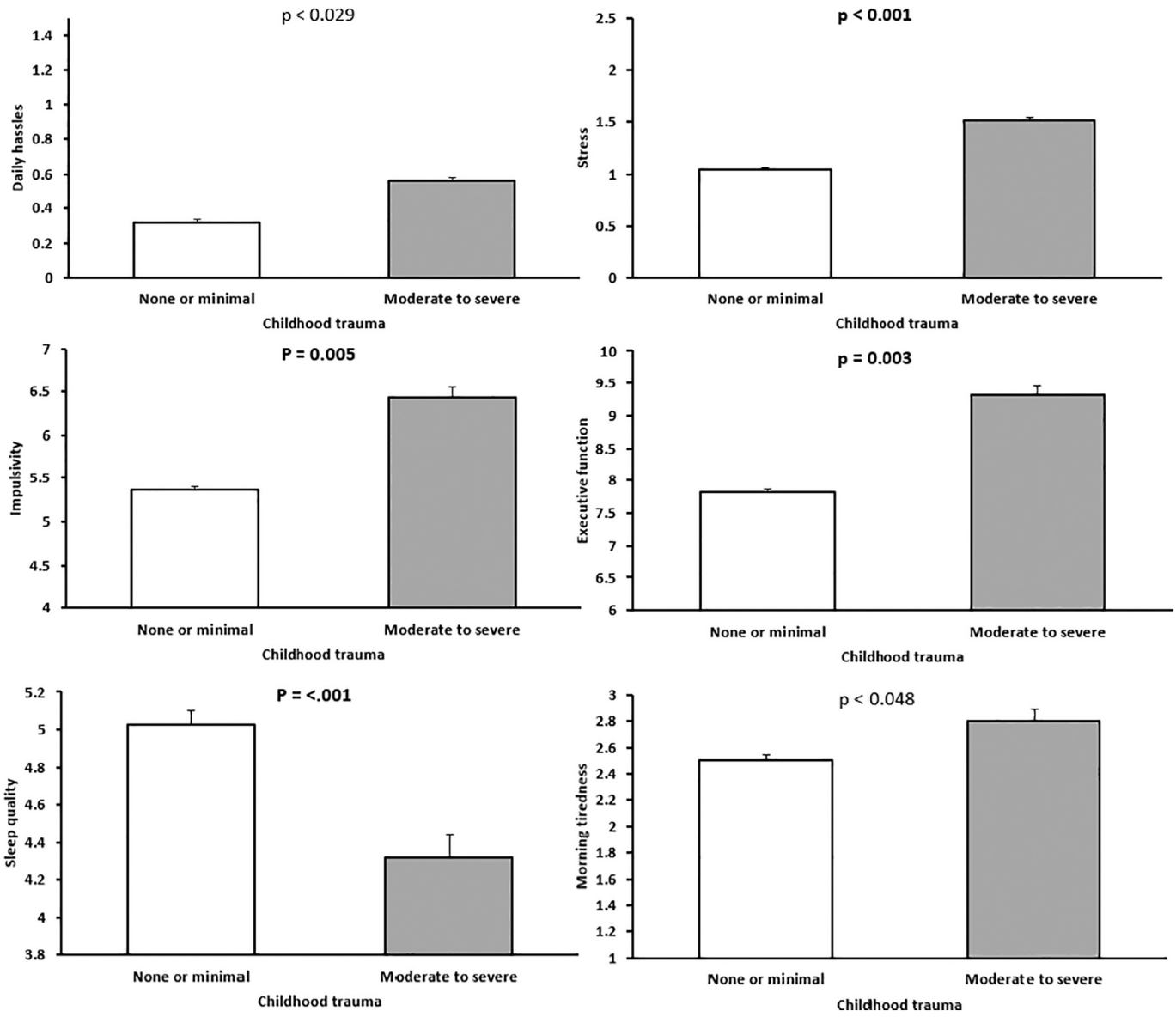

Fig. 1. Effects of childhood trauma on daily stress, impulsivity, executive function and sleep outcomes.
Note: 'none or minimal' < 37; 'moderate to severe' > 55 based on the cut-offs for the subscales reported by Bernstein et al. (2003).

Taken together, these results show that, in addition to the direct effects on key risk factors for suicide, childhood trauma has indirect effects on suicide vulnerability factors by influencing daily stress-related variables.

4. Discussion

First, childhood trauma significantly affected daily functioning by influencing stress-related vulnerability variables (while controlling for age and sex). In particular, childhood trauma was associated with greater daily stress and impulsivity and poor sleep quality and executive functioning. Second, there was robust evidence that childhood trauma affected established indicators of suicide risk (such as defeat and entrapment). Third, childhood trauma indirectly affected suicide risk factors through key daily stress-related variables. Specifically, childhood trauma had indirect effects on daily defeat, entrapment, reasons for living, optimism and suicide thoughts through daily executive functioning. There was also evidence for an indirect effect of childhood trauma on optimism, daily thoughts of suicide, defeat and entrapment through daily impulsivity and stress. Sleep quality was also found to mediate the effects of childhood trauma on optimism, defeat and entrapment. Lastly, an indirect relationship between childhood trauma and daily thoughts of suicide, defeat and entrapment through daily hassles was also found.

The current findings are important as they confirm, and extend previous research suggesting childhood trauma predisposes individuals to poorer health outcomes through impacting a number of stress-related processes in adulthood. A conceptual model posits that exposure to childhood trauma is associated with reduced stress reactivity, altered cognitive abilities and greater impulsive behaviours which in turn contribute to greater risk of experiencing poorer health behaviours (Lovallo, 2013). We found childhood trauma to negatively impact cognitive ability indexed by daily executive functioning; echoing findings whereby exposure to childhood abuse was associated with poorer executive functioning in daily life in a sample of healthy adults (Tinajero et al., 2020). The current study fails to replicate the finding of trauma impacting daily hassles (Tinajero et al., 2020). This disparity may be, in part, due to the current study assessing general childhood trauma as opposed to childhood abuse, per se. Nevertheless, we did find that greater childhood trauma impacted daily self-reported stress; aligning

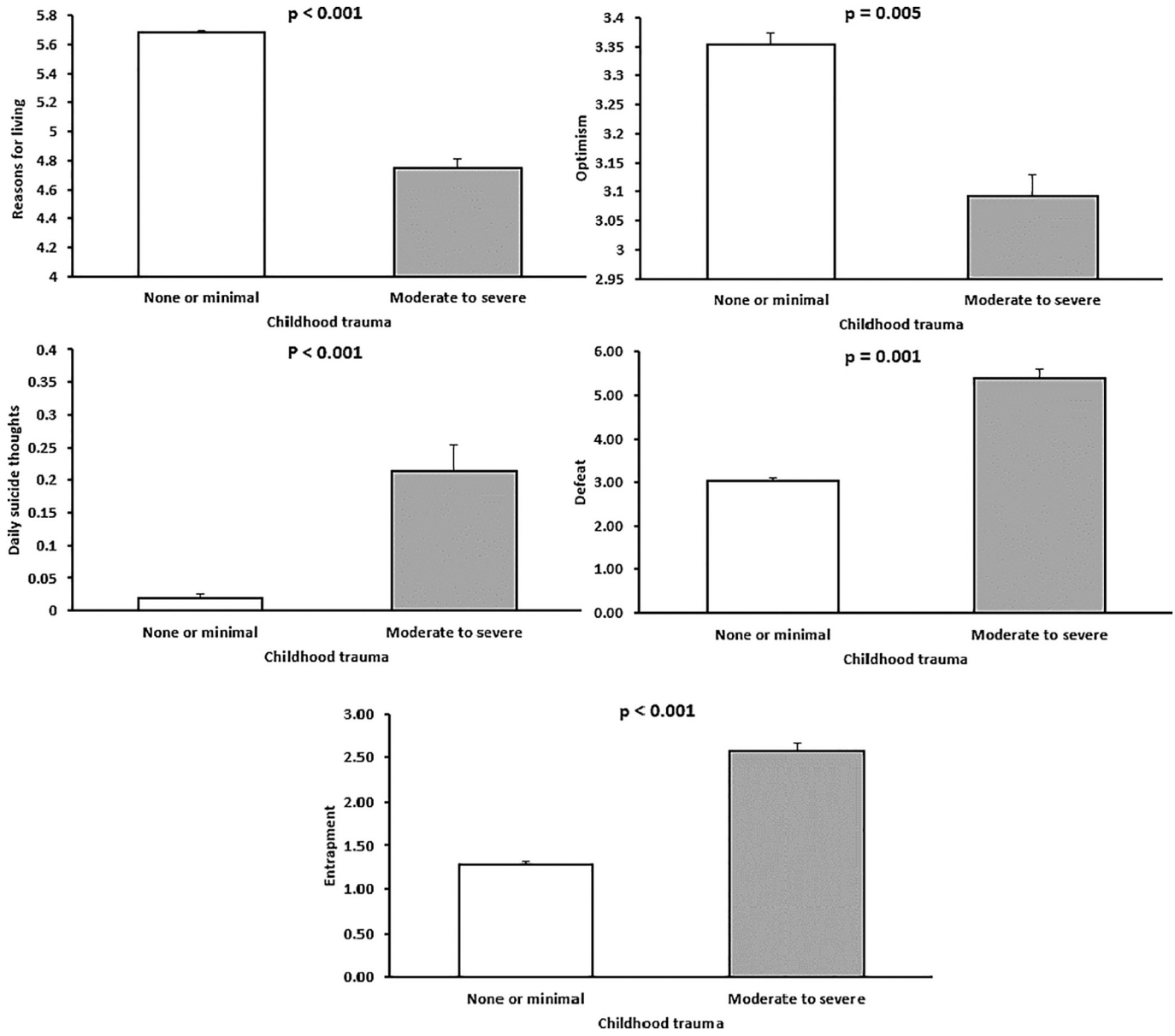

Fig. 2. Effects of childhood trauma on daily indicators of suicide risk.
Note: 'none or minimal' < 37; 'moderate to severe' > 55 based on the cut-offs for the subscales reported by Bernstein et al. (2003).

with the notion that the experience of childhood trauma may predispose individuals to poorer health outcomes in the future by influencing daily levels of stress through prolonged activation of the stress response system. It has been suggested that the cumulative burden of chronic stress and life events, such as childhood trauma, exceed the ability to cope potentially leading to allostatic overload (O'Connor et al., 2020; O'Connor et al., 2021b). Repeated activation of the stress response system can dysregulate immune, cardiovascular and endocrine systems and individuals' daily cortisol awakening response.

The results of this research are also consistent with a growing body of work that has confirmed strong links between childhood trauma and suicide risk in adulthood (Gartland et al., 2022; Lewis et al., 2019; Marshall et al., 2013; O'Connor et al., 2018). However, much of the previous research has been overly reliant on cross-sectional designs, whereas, the current study extends earlier work into naturalistic settings showing that childhood trauma is significantly associated with a range of daily indicators of suicide risk in adulthood; reasons for living, optimism, daily suicide thoughts, defeat and entrapment. Defeat and entrapment have been identified as important variables in understanding suicide risk, for example the IMV model of suicidal behaviour conceptualises suicide as a behaviour that results from a complex interplay of factors; a pathway from ideation to behaviour through defeat and entrapment (O'Connor and Kirtley, 2018). Moreover, optimism is a factor identified in the IMV model, it is predictive of suicide risk, and experiencing childhood adversity is associated with lower self-perceptions of optimism (Mumford et al., 2022). The current study found optimism to be significantly associated with childhood trauma both directly, and indirectly, through all of the daily stress-related vulnerability factors. Therefore, although the negative outcomes associated with childhood trauma are well established, these findings suggest that fostering a greater optimistic outlook may potentially help mitigate, in part, the negative effects on health outcomes, such as suicide risk.

Our findings also suggest that exposure to childhood trauma may create a generalised vulnerability in adulthood across cognitive, stress-related, behavioural and sleep domains. The current study found that childhood trauma had indirect effects on a range of daily suicide vulnerability variables (i.e., reasons for living, optimism, defeat and

Table 3
A summary of the main effects of childhood trauma on daily suicide risk factors.

	β	Coefficient	*SE*	*df*	*p* value
Reasons for living					
Intercept	β00	5.343	0.067	209	<0.001
CTQ	β01	−0.022	0.006	209	<0.001
Optimism					
Intercept	β00	3.11	0.055	209	<0.001
CTQ	β01	−0.011	0.004	209	0.005
Daily suicide thoughts					
Intercept	β00	0.004	0.002	209	<0.001
CTQ	β01	0.005	0.002	209	<0.001
Defeat					
Intercept	β00	3.986	0.223	209	<0.001
CTQ	β01	0.058	0.018	209	0.001
Entrapment					
Intercept	β00	1.792	0.109	209	<0.001
CTQ	β01	0.03	0.009	209	<0.001

entrapment) through multiple stress-related variables (daily stress/hassles, executive functioning, impulsivity and sleep quality). This is consistent with a recent study that found indirect effects of childhood trauma on recent suicidal ideation through executive functioning and impulsivity (Rogerson et al., 2023a). Importantly, these findings suggest that childhood trauma influences multiple different processes that are likely to influence future psychological health. Therefore, further research should endeavour to investigate the effects of childhood trauma across a broad range of cognitive, psychological, biological and behavioural domains.

Another important finding of the current study is that childhood trauma was shown to influence suicide vulnerability, as indexed by higher levels of daily defeat and entrapment, through poorer levels of sleep quality. This is a notable observation particularly given the recent work showing links between sleep quality and suicide ideation. For example, Littlewood et al. (2019), in a sample of participants with current suicide ideation, found that days preceded with shorter sleep duration and poorer sleep quality were associated with greater levels of suicidal ideation. It is well established that childhood trauma has serious long-term negative consequences on different components of sleep, and poor sleep health in turn has been linked with numerous negative health outcomes (e.g., Buysse, 2014). Moreover, a conceptual model linking childhood trauma and sleep disturbances to poor health outcomes suggests a role for the HPA axis in understanding the relationships between

Table 4
Summary of all the indirect effects.

Indirect effects	b	SE	Monte Carlo 95 % CI		*p*
			Lower	Upper	
Outcome: reasons for living					
CTQ - hassles - reasons for living	−0.0015	0.0011	−0.0039	0.0002	0.1630
CTQ - stress - reasons for living	−0.0029	0.0015	−0.0061	−0.0004	0.0469
CTQ - executive functioning - reasons for living	−0.0050	0.0018	−0.0089	−0.0019	0.0055
CTQ - impulsivity - reasons for living	−0.0024	0.0014	−0.0054	−0.0001	0.0814
CTQ - sleep quality - reasons for living	−0.0032	0.0014	−0.0064	−0.0007	0.0288
CTQ - morning tiredness - reasons for living	−0.0017	0.0011	−0.0042	0.0000	0.1208
Outcome: optimism					
CTQ - hassles - optimism	−0.0029	0.0013	−0.0056	−0.0007	0.0211
CTQ - stress - optimism	−0.0069	0.0020	−0.0110	−0.0033	0.0005
CTQ - executive functioning - optimism	−0.0063	0.0020	−0.0105	−0.0026	0.0015
CTQ - impulsivity - optimism	−0.0036	0.0014	−0.0066	−0.0013	0.0090
CTQ - sleep quality - optimism	−0.0044	0.0016	−0.0077	−0.0017	0.0051
CTQ - morning tiredness - optimism	−0.0031	0.0016	−0.0064	−0.0002	0.0489
Outcome: daily suicide thoughts					
CTQ - hassles - daily suicide thoughts	0.0011	0.0004	0.0003	0.0021	0.0118
CTQ - stress - daily suicide thoughts	0.0018	0.0005	0.0008	0.0029	0.0006
CTQ - executive functioning - daily suicide thoughts	0.0018	0.0006	0.0007	0.0030	0.0017
CTQ - impulsivity - daily suicide thoughts	0.0013	0.0004	0.0005	0.0022	0.0033
CTQ - sleep quality - daily suicide thoughts	0.0008	0.0003	0.0002	0.0016	0.0172
CTQ - morning tiredness - daily suicide thoughts	0.0008	0.0004	0.0001	0.0016	0.0407
Outcome: defeat					
CTQ - hassles - defeat	0.0194	0.0073	0.0060	0.0352	0.0081
CTQ - stress - defeat	0.0392	0.0105	0.0193	0.0608	0.0002
CTQ - executive functioning - defeat	0.0373	0.0110	0.0161	0.0599	0.0007
CTQ - impulsivity - defeat	0.0261	0.0079	0.0114	0.0430	0.0010
CTQ - sleep quality - defeat	0.0180	0.0064	0.0068	0.0320	0.0047
CTQ - morning tiredness - defeat	0.0153	0.0075	0.0011	0.0312	0.0427
Outcome: entrapment					
CTQ - hassles - entrapment	0.0094	0.0035	0.0029	0.0170	0.0082
CTQ - stress - entrapment	0.0191	0.0051	0.0094	0.0296	0.0002
CTQ - executive functioning - entrapment	0.0172	0.0051	0.0074	0.0277	0.0008
CTQ - impulsivity - entrapment	0.0122	0.0037	0.0053	0.0202	0.0011
CTQ - sleep quality - entrapment	0.0075	0.0028	0.0026	0.0137	0.0079
CTQ - morning tiredness - entrapment	0.0067	0.0034	0.0005	0.0138	0.0457

Note: B is unstandardised.

both constructs and later health outcomes (Fuligni et al., 2021). The influence of childhood trauma on HPA axis dysregulation may negatively affect stress reactivity and cortisol awakening responses, but also sleep quality, which in turn may affect poor health outcomes (O'Connor et al., 2018, 2024). Collectively, these findings confirm that in both a healthy adult sample, and a sample with individuals at vulnerable to suicide, that childhood trauma is associated with indicators of suicide risk through a poorer sleep quality pathway. Future research ought to continue to consider the role of sleep quality as one of the putative mechanisms through which childhood trauma confers its future physical and mental health risks.

The current findings may have implications for interventions aimed at mitigating the negative impacts of childhood trauma. They suggest that such interventions should incorporate components that target modifiable risk factors such as sleep, stress, impulsivity and executive function. For example, Prudenzi et al. (2022) suggested that acceptance and commitment approaches could benefit stress and worry. There are further avenues for more targeted stress management interventions (Coppersmith et al., 2021; Rogerson et al., 2023b) and to improve sleep outcomes (e.g. Murawski et al., 2018; Saruhanjan et al., 2021). There is also promising evidence showing that cognitive enhancement interventions such as goal management training, can be effective in reducing impulsive action and choices (Anderson et al., 2021).

We recognise there are a number of shortcomings to the current research. First, the current sample falls a little short of the target sample size determined by the a priori power analysis (i.e., the main analysis was based on 9 participants less than the 220 target sample size). The main reason for this was because we wanted to perform the analysis only on individuals who completed at least 2 full days of the study (i.e., at least 6 surveys). Nevertheless, it is worth noting that the main analysis was still conducted on data from 3719 diaries and we found strong support for our main hypotheses, suggesting that the current study was adequately powered to detect the predicted effects. Moreover, in terms of research in this area, this sample is considered relatively large and the within-participants, ecological momentary assessment design, comes with several strengths such as multiple observations, and using each participant as their own control. Nonetheless, exploring the associations between childhood trauma and these important stress-related vulnerability variables in a larger sample and separated into different assessment bouts over time (e.g., Jones et al., 2024) are important next steps for research in this area.

Second, as outlined earlier, we recruited healthy participants because we wanted to explore mechanisms by which childhood trauma may be associated with suicide risk factors, *prior* to the development of mental and physical health problems. As such, the current sample comprised of healthy young adults aged 18–45 years who were screened for sleep problems and chronic illness and as a result, the sample may not yet evidence deficits in some aspects of executive functioning. That is, it may be that longer-term exposure to stress-related dysfunction such as sleep disturbance leads to broader executive deficits over time

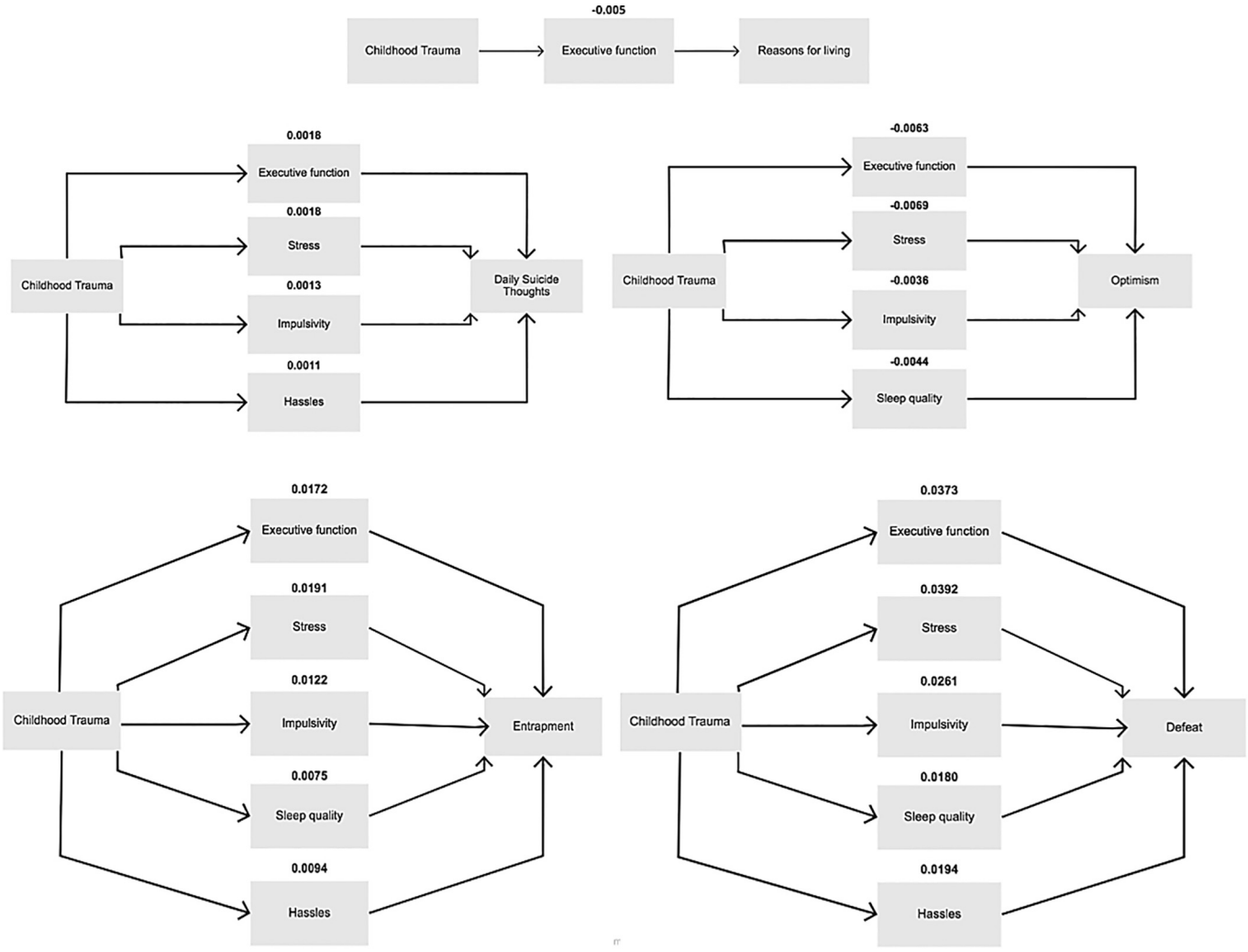

Fig. 3. Path diagrams showing the significant indirect effects on outcome variables through daily stress-related vulnerability factors. All diagrams represent unstandardized B and mediators are grouped for illustrative purposes only, each mediator was in a separate model.

(Tinajero et al., 2020). Moreover, we recognise that adopting these inclusion criteria limits the generalisability and representativeness of the sample. The generalisability of our findings to older populations where executive function, impulsivity and cognitive measures may differ is unknown and thereby further investigation is required in individuals capturing all age groups including older populations.

Third, we also note that there was limited variability in suicide ideation scores across the 7 days. This may be, in part, due to the healthy sample of adult participants included in the current research compared to other studies that recruited participants who reported suicide ideation following psychiatric hospitalisation or that targeted recruitment at participants with a history of suicide (e.g., Kleiman et al., 2017; O'Connor et al., 2024, 2020). Therefore, future research ought to attempt to replicate these findings in a more representative sample that includes individuals with and without a mental and physical health conditions.

Finally, we are aware that there are a number of potential shortcomings relating to the measures included in the current study. We note that our measures of executive function and sleep are self-reported and future research ought to attempt to replicate our results using more objective methods such as polysomnography and laboratory-based neuropsychology tests. We also recognise that we assessed suicide ideation and history using only two questions from the Adult Psychiatry Morbidity Survey. Although these questions are used widely in the literature (e.g., McDonald et al., 2017; O'Connor et al., 2021a; Stickley et al., 2016; Wetherall et al., 2018), we note that such brief assessments may have limitations and do not provide more detailed and nuanced data on suicidal ideation, plans, intent, gestures or type of suicide attempts. Future research should endeavour, where possible, to include more comprehensive assessment tools such as Self Injurious Thoughts and Behaviours Interview (Nock et al., 2007).

In conclusion, the current study found that childhood trauma was significantly associated with higher scores on daily stress-related vulnerability variables and daily indicators of suicide risk. Moreover, it identified key pathways whereby childhood trauma had indirect effects on suicide vulnerability through executive functioning, impulsivity, sleep quality and stress in adulthood. Taken together, these findings highlight the complexity of childhood trauma and its potentially damaging effects on stress-related vulnerability factors and poorer mental health outcomes. A greater understanding of the pathways by which childhood trauma influences later health outcomes is essential for development of appropriate, and timely, intervention.

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CRediT authorship contribution statement

Olivia Rogerson: Conceptualization, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Writing – original draft, Writing – review & editing. **Rory C. O'Connor:** Conceptualization, Methodology, Writing – original draft, Writing – review & editing. **Daryl B. O'Connor:** Conceptualization, Formal analysis, Methodology, Supervision, Writing – original draft, Writing – review & editing.

Declaration of competing interest

The authors have no declaration of interests to declare.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jad.2024.02.029.

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Further reading

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