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The association of posttraumatic stress disorder, depression and head injury with mid-life cognitive function in civilian women

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Abstract

Background: Despite evidence linking posttraumatic stress disorder (PTSD), depression, and head injury, separately, with worse cognitive performance, investigations of their combined effects on cognition are limited in civilian women.

Methods: The Cogstate Brief Battery assessment was administered in 10,681 women from the Nurses' Health Study II cohort, mean age 64.9 years (SD=4.6). Psychological trauma, PTSD, depression, and head injury were assessed using online questionnaires. In this cross-sectional

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analysis, we used linear regression models to estimate mean differences in cognition by PTSD/depression status and stratified by history of head injury.

Results: History of head injury was prevalent (36%), and significantly more prevalent among women with PTSD and depression (57% of women with PTSD and depression, 21% of women with no psychological trauma or depression). Compared to having no psychological trauma or depression, having combined PTSD and depression was associated with worse performance on psychomotor speed/attention (β=−0.15, p=0.001) and learning/working memory (β=−0.15, p<0.001). The joint association of PTSD and depression on worse cognitive function was strongest among women with past head injury, particularly among those with multiple head injuries.

Conclusions: Head injury, like PTSD and depression, was highly prevalent in this sample of civilian women. In combination, these factors were associated with poorer performance on cognitive tasks, a possible marker of future cognitive health. Head injury should be further explored in future studies of PTSD, depression and cognition in women.

Keywords

cognition; depression; posttraumatic stress disorder; women; head injury; mild traumatic brain injury; Cogstate

Introduction

Mid-life cognitive decline is an early predictor of later risk of dementia, a common cause of death with no existing treatments (Elias et al., 2000; James et al., 2014). Cognitive decline is a significant public health issue that is exacerbated by a growing aging population (Tejada-Vera, 2013). As women live longer than men on average, the burden of cognitive decline falls disproportionately on women (Kontis et al., 2017; Snyder et al., 2016). Cognitive decline begins in mid-life, and cognitive function in healthy individuals has been shown to predict subsequent risk of poor cognitive health and in some cases, Alzheimer's disease (Elias et al., 2000; Singh-Manoux et al., 2012). It is therefore important to identify modifiable risk factors for mid-life cognitive function, particularly in women.

Posttraumatic stress disorder (PTSD), depression, and head injury are prevalent conditions in women that have independently been associated with cognition (Cobb Scott et al., 2015; Perry et al., 2016; Rock, Roiser, Riedel, & Blackwell, 2014). PTSD, depression, and head injury often co-occur but few studies have investigated their combined effects on cognition, with extant studies focused on treatment seeking populations or predominantly male veteran samples (Levin et al., 2001; Phipps et al., 2020; Seal et al., 2016). While the importance of PTSD and depression for cognition in women has been recognized in our previous work and that of others (Günak et al., 2020; Sumner et al., 2017), the impact of past head injuries in mid-life cognition among civilian women has largely been ignored except in specific populations, such as domestic violence survivors (Valera, Campbell, Gill, & Iverson, 2019). Additionally, the lifetime prevalence of head injuries in women in the general population has been rising (Centers for Disease Control and Prevention, 2016). In recent years, there has been growing recognition that head injuries are common, are associated with PTSD and depression, and may combine with psychological distress to influence cognitive function

adversely (Kaup et al., 2019); however, to our knowledge, no study has examined these factors jointly in civilian women.

In this study, using cross-sectional data, we examine the joint effects of PTSD, depression, and history of head injury on cognitive function in a large cohort of middle or older-aged professional women. In previous work with a subsample from the same cohort, we found that higher PTSD symptom levels were related to poorer cognitive function in women aged 61 years on average (Sumner et al., 2017). Secondary analyses suggested that these negative associations were stronger in women who also reported depression (Sumner et al., 2017). In the present study, first, we build on these early results using more recent data, including a more comprehensive assessment of PTSD. Second, for the first time in this sample, we consider the lifetime prevalence of self-reported head injury and examine its relationship with PTSD and depression. Third, we examine the joint effects of PTSD, depression, and past head injury on cognitive function. Fourth, we conduct exploratory analyses to elucidate possible connections between PTSD and history of head injury, focusing particularly on psychological trauma exposure and type. We hypothesize that combined PTSD and depression will have the largest negative association with cognitive function, compared to no psychological trauma or depression, and that these relations will be most apparent in women with past head injury.

Materials and methods

Study sample

The Nurses' Health Study II (NHSII), an ongoing cohort study of U.S. female registered nurses, enrolled 116,429 women ages 24 to 42 years at baseline in 1989 and has measured an extensive range of sociodemographic, medical, and behavioral factors, via biennial questionnaires. In 2018, a substudy was conducted which measured lifetime psychological trauma exposure and symptoms of PTSD and depression. A total of 51,486 women were invited to complete a web-based questionnaire (Sampson et al., 2021). Between August 2018 and January 2020, 32,834 women who responded to the online survey were invited to complete the Cogstate Brief Battery, a self-administered online cognitive assessment. A total of 10,987 women completed the Cogstate assessment (33% of those invited). We excluded women based on established integrity thresholds for cognitive tasks and women missing PTSD/depression status (final analytical sample n=10,681). Within our analytic sample, 5,591 women were also in a previous substudy that measured cognitive function in 2014 (Sumner et al., 2017)). The study protocol was approved by the Institutional Review Boards (IRB) of the Brigham and Women's Hospital and return of completed questionnaires implied consent.

Psychological trauma, PTSD and depression assessment

Lifetime psychological trauma exposure was measured in 2018 with a 16-item modified version of the Brief Trauma Questionnaire (Morgan 3rd et al., 2001; Schnurr, Vielhauer, Weathers, & Findler, 1999). Participants indicated whether they had experienced any traumatic event and which event they considered the worst. For exploratory analysis, we classified the 16 psychological trauma items into 7 broad categories adapted from Breslau et

al. (1998) (e.g., interpersonal/sexual violence). Lifetime PTSD symptoms were assessed in 2018 using a modified PTSD Checklist for the Diagnostic and Statistical Manual of Mental Disorders, fifth edition (DSM-5) (PCL-5) (Blevins, Weathers, Davis, Witte, & Domino, 2015; Weathers et al., 2013). Women who reported psychological trauma were asked whether they had *ever* experienced each symptom with respect to their worst psychological trauma. A symptom was considered present if women endorsed ever experiencing the symptom, and we categorized women as having probable lifetime history of PTSD based on DSM-5 criteria (American Psychiatric Association, 2013) as follows: presence of at least 1 out of 5 re-experiencing or intrusion symptoms, at least 1 out of 2 avoidance symptoms, at least 2 out of 7 negative alterations in cognitions/mood symptoms, and at least 2 out of 6 alterations in arousal/reactivity symptoms. PTSD symptoms that were not endorsed were set to 'never' (which likely reflect not experiencing the symptom but could also be missing values). Current depressive symptoms were measured using the 10-item Centers for Epidemiologic Study of Depression (CESD-10) screener in 2018. We classified missing as women with no information on more than 3 individual symptoms and mean-imputed the individual symptoms for those missing fewer than 3. A score of ≥10 was then used to categorize women as having probable depression in the past month (Andresen, Malmgren, Carter, & Patrick, 1994; McManus, Pipkin, & Whooley, 2005).

We combined these measures of psychological trauma, PTSD, and depression into a single 6-level exposure, similar to previous work in this cohort (Sumner et al., 2017): psychological trauma, PTSD, depression; psychological trauma, no PTSD, depression; psychological trauma, PTSD, no depression; psychological trauma, no PTSD, no depression; no psychological trauma, depression; no psychological trauma, no depression (reference group) (see Table 1).

Head injury assessment

We derived two head injury measures from the assessment in 2018: history of head injury and frequency of previous head injuries. Women were classified as having history of any head injury if they indicated having ever experienced a blow to the head, neck, or upper body followed by loss of consciousness or experiences of: headaches, dizziness, nausea, disorientation, memory problems, visual problems, feeling unsteady on their feet (Roberts et al., 2019). Women who experienced a head injury were asked how many times this had happened to them, and we derived frequency of head injury by categorizing women into having none, one, or multiple previous injuries.

Cognitive assessment

Cognitive function was measured in 2018 using the Cogstate Brief battery, a 15-minute self-administered online assessment consisting of four tasks: Detection, Identification, One Card Learning, and One Back (see Fredrickson et al., 2010, for details). Scores for the Detection, Identification, and One Back tasks were based on speed and calculated by $\log_{10}$ transforming mean response times for correct responses (Koyama et al., 2015). For the One Card Learning task, scores were based on accuracy and calculated by arcsine transforming the square root of the proportion of correct responses (Koyama et al., 2015). Task scores were then z-scored to the mean and standard deviation of all NHSII Cogstate responders

for this 2018 substudy. Following previous studies (e.g., Koyama et al., 2015 and Sumner et al., 2017), our main outcomes were two composite scores, one capturing psychomotor speed/attention and another capturing learning/working memory. The psychomotor speed/attention composite score represents the averaged Detection and Identification task z-scores. The learning/working memory composite score represents the averaged One Card Learning and One Back task z-scores. Composite scores were only derived for women not missing either task included in the composite. Prior work has suggested that these composite scores may be more sensitive measures of cognitive function than each individual task and have high test-retest reliability (Maruff et al., 2013). Additionally, a confirmatory factor analysis in a subsample from the same cohort showed high factor loadings for each task and excellent model fit indices (Sumner et al., 2017). Additionally, a global score for cognitive function was derived as the average of the z-scores of the abovementioned psychomotor speed/attention and learning/working memory. All scores were coded so that higher scores indicated better cognitive performance and z-scores greater than 7 or less than −7 were considered outliers and excluded from analyses (n=5 for Identification; n=5 for Detection; n=7 for psychomotor speed/attention).

Covariates

We accounted for a range of covariates, including sociodemographics, health factors, and health-related behaviors, using available measures closest to 2018. Sociodemographic factors included age at cognitive assessment (in years), race/ethnicity (non-Hispanic white, black, Hispanic, Asian, or other racial/ethnic groups; measured in 1989), parental education (high school, some college, more than college; measured in 2005), and participant's education (associates degree, bachelors, masters, doctorate; measured in 2018). We further included covariates for body mass index (BMI) (continuous; derived using self-reported height in inches and weight in pounds (Rimm et al., 1990); measured in 2015), smoking status (never, past, current: 1–14, 15–24, 25+ cigarettes per day; measured in 2015), alcohol use (none, 0-<5, 5-<10, 10-<20, 20+ g/d; measured in 2015), physical activity (<3, 3-<9, 9-<18, 18-<27, 27+ MET-hrs/wk; measured in 2013), and diet quality (continuous; based on Alternative Healthy Eating Index (Chiuve et al., 2012) and excluding alcohol use; higher scores represent a better quality diet; measured in 2015). Measures of menopausal status (premenopausal, postmenopausal, unknown; measured in 2015), parity (no children, 1 child, 2–3 children, 4+ children; measured in 2009), and oral contraceptive use (never, past; measured in 2011) were also considered. For variables measured in 2015, missing data were imputed using previous data collected from the 2013 biennial NHS II questionnaire (when available). Other/remaining missingness (all missing <5%) was captured as an indicator variable for categorical variables and mean imputed for continuous variables.

Statistical analysis

We excluded 83 women based on established Cogstate integrity thresholds across all cognitive tasks (Fredrickson et al., 2010; Koyama et al., 2015; Sumner et al., 2017) and 223 women missing PTSD/depression status (due to missing depression scores) (analytic sample n=10,681). We compared characteristics between responders to the 2018 Cogstate Brief Battery invitation and non-responders and also examined the distribution of covariates by PTSD/depression in our analytic sample.

Associations of PTSD and depression with cognitive function—To determine whether PTSD and depression (reference group: no psychological trauma and no depression) were associated with worse cognitive function, we used increasingly adjusted linear regression models. Model 1 adjusted for age at cognitive assessment; model 2 additionally adjusted for race/ethnicity, parental education, and participant education; model 3 further adjusted for BMI, smoking status, alcohol use, physical activity, diet quality, menopausal status, parity, and oral contraceptive use. We fit the same set of models separately with composite scores, the four individual task scores, and the global cognition score as the dependent variables. As some women in the sample had participated in an earlier Cogstate assessment prior to 2018 (n=5,591) as part of other research in the cohort, we a) confirmed that the distribution of PTSD and depression was similar in these women compared to the rest of our sample, and b) accounted for practice effects in these women by standardizing their 2018 cognitive scores to the prior assessment mean and repeating our analysis. To compare magnitudes of association, we also ran a model of cognitive function on age, adjusted for race/ethnicity, producing an estimate for expected difference in cognition per one-year older age.

Role of head injury in the association of PTSD and depression with cognitive function—We calculated the lifetime prevalence of head injury in the overall sample and by PTSD and depression status. We also examined the relation of none, one or multiple head injuries with cognitive function using linear regression, adjusted for the same covariates as our main analysis. To examine whether the relationship of PTSD and depression with cognitive functioning was modified by history of head injury we repeated our main analysis, stratified by head injury and by frequency of head injury. We also tested formally for interactions between the PTSD/depression composite variable and both head injury measures by including an interaction term in model 2.

We performed exploratory analyses to better understand the inter-relations of psychological trauma, PTSD, and history of head injury using cross-tabulations with chi analysis. Within this, we assessed whether the prevalence of none, one, or multiple head injuries varied by psychological trauma type. We also examined whether the conditional risk of PTSD varied by history of head injury. All analyses were performed using SAS software Version 9.4 (SAS Institute Inc).

Results

Responders to the Cogstate Brief Battery invitation were comparable to non-responders with regards to levels of PTSD and depression, and across sociodemographics, health factors, and health-related behaviors. The mean age at cognitive assessment in our analytic sample was 64.9 years (SD=4.6) and consisted of majority non-Hispanic White women. Table 1 presents the distribution of covariates by PTSD/depression status. For brevity, we focus on reporting results of the highest risk group, women with PTSD *and* depression.

Associations of PTSD and depression with cognitive function

PTSD *and* depression were associated with lower psychomotor speed/attention (β=−0.15 standard units, p=0.001) and learning/working memory (β=−0.15, p<0.001) composite

scores, compared to no psychological trauma or depression in age- and sociodemographic-adjusted models (Figure 1; Table 2). Results were similar when additionally adjusting for adult health factors and behaviors. Overall, similar results were seen for global cognitive score and individual task scores (Supplementary Table S1). Results were consistent when accounting for practice effects, using cognitive scores standardized to prior assessment for the women that previously completed Cogstate in this cohort (e.g., β=−0.14, p=0.002 for psychomotor speed/attention).

Role of head injury in the association of PTSD and depression with cognitive function

The overall lifetime prevalence of head injury was 36%, ranging from 21% of women with no psychological trauma/depression to 57% of women with PTSD *and* depression (Figure 2). History of multiple previous head injuries was associated with worse learning/working memory performance compared to no previous injury (Supplementary table S2). Point estimates for the association of PTSD *and* depression with psychomotor speed/attention and learning/working memory were larger in women with any past head injury than in those without (Table 3; Figure 3) and in those with multiple injuries compared to one injury (Supplementary table S3). However, no interactions between our PTSD/depression composite and head injury measures were statistically significant (p-values: 0.22–0.55) (Table 3 and Supplementary table S3).

In exploratory analyses, experiencing psychological trauma was associated with past head injury χ^2 p-value <0.001). Additionally, the highest prevalence of multiple past head injuries was seen in women whose worst psychological trauma was a form of interpersonal/sexual violence (Supplementary table S4). When we examined specific psychological trauma types, multiple head injuries were most prevalent in women whose worst psychological trauma was being beaten by a caregiver in childhood (24.1%) and, next, in women whose worst psychological trauma was being attacked, beaten or mugged (22.8%), or an accident (22.0%). History of head injury was associated with PTSD (χ^2 p-value <0.001), and a higher prevalence of PTSD was seen in women with at least one prior head injury than without, with this difference most pronounced in women whose worst psychological trauma was interpersonal/sexual violence (Supplementary table S5).

Discussion

In this sample of middle-aged civilian women, PTSD and depression were associated with worse performance on measures of psychomotor speed/attention and learning/working memory. History of head injury was associated with PTSD/depression and also associated with worse learning/working memory when multiple injuries were experienced. Interestingly, although interactions were not significant, PTSD and depression appeared to be associated with worse cognitive function among women with prior head injury, and more so if multiple previous head injuries were experienced. All associations were maintained after adjustment for sociodemographic and adult health factors/behaviors. Taken together, these findings suggest that head injuries, like PTSD and depression, are prevalent among the women in our cohort, and these factors are jointly related to worse performance in cognitive tasks. As previous studies into PTSD, depression and head injury have used

treatment-seeking or predominantly male samples (e.g., veterans (Kaup et al., 2019)), our results highlight the relevance of considering these cognitive risk factors in middle-aged women.

In exploratory analyses, we found associations between psychological trauma type, history of head injury and PTSD. We found the highest prevalence of multiple past head injuries in women whose worst psychological trauma was interpersonal/sexual violence. We also found that history of head injury was associated with PTSD, and the prevalence of PTSD in those with head injury was highest for interpersonal/sexual violence (Van Praag, Cnossen, Polinder, Wilson, & Maas, 2019). These findings suggest that head injuries in women may be linked to interpersonal traumas, in line with previous studies (Mollayeva, El-Khechen-Richandi, & Colantonio, 2018; Valera et al., 2019). Women are more likely to experience interpersonal traumas than men, and these types of psychological traumas have been linked with PTSD onset previously (Iverson, Dardis, & Pogoda, 2017; Tolin & Foa, 2006), and in the present study.

Pathways linking PTSD/depression/head injury to cognitive function

Possible pathways linking PTSD, depression and head injury to cognitive function include behavioral and biological mechanisms. Behaviorally, prior work has shown that individuals with PTSD, depression, or head injury are more likely to engage in unhealthy behaviors (e.g., less physically active) which may negatively impact cognition (Langevin et al., 2020; Roshanaei-Moghaddam, Katon, & Russo, 2009; Winning et al., 2017; Zaninotto, Batty, Allerhand, & Deary, 2018). However, our results did not substantially attenuate in models after adjustment for adult health factors/behaviors, suggesting other factors may be at play. Biologically, brain structure atrophy has independently been associated with psychological trauma, PTSD, depression, head injury, and cognitive decline (Byers & Yaffe, 2012; Childress et al., 2013; Karl et al., 2006; O'Brien et al., 2020; Woon, Sood, & Hedges, 2010). Similar to brain structure atrophy, functional brain abnormalities could also underlie the relations of PTSD, depression and head injury with cognitive function (Carron, Alwis, & Rajan, 2016; Chau, Fogelman, Nordanskog, Drevets, & Hamilton, 2017; Elzinga & Bremner, 2002; Fitzgerald, Digangi, Phan, & Biology, 2018). PTSD, depression and head injury have also been associated with inflammatory responses, which can lead to cognitive decline (Dowlati et al., 2010; Gorelick, 2010; Lozano et al., 2015; Sumner et al., 2018). It is possible that these risk factors together have compounding effects on cognition via neural and inflammatory pathways (Kaup et al., 2019) and although our study did not test biological pathways, they remain a possible mechanism for our findings.

Strengths and limitations

Limitations of the current study include lack of pre- psychological trauma cognitive function information. In this cross-sectional study it is possible that lower cognition preceded, rather than resulted from, psychological trauma, depression, or head injury (Parslow & Jorm, 2007). Second, psychological trauma, head injury, PTSD, and depression were self-reported at one time point so there is also possibility for recall bias in head injury reporting. As a result, future studies should use interview data to disentangle symptoms due to head trauma or psychological trauma when occurring together (Kerr, Marshall,

& Guskiewicz, 2012). Third, we did not conduct detailed assessment of head injury, which would have enabled more fine-grained analysis on severity. Given participants were professional women at cohort recruitment and have remained responsive to biennial and supplemental questionnaires, it is likely that the vast majority of reported head injuries were mild in nature. Fourth, we used a modified version of the PCL-5 that queried lifetime PTSD symptoms and did not measure severity which may have led to a light overestimate of PTSD. Fifth, the cognitive battery was limited in scope and not designed around PTSD, depression and head injury. The composite cognitive scores also do not capture highly refined and specific cognitive processes although they have been shown to be sensitive measures of cognitive function (Maruff et al., 2013). Sixth, selection bias is a potential concern as only active NHSII responders were eligible for the 2018 online survey, and, of those then invited to the cognitive assessment, only 33% participated. Reassuringly, however, those that responded to the Cogstate invitation were comparable to non-responders in terms of PTSD, depression, sociodemographic and health factors, and health-related behaviors. Even so, our sample consisted of majority non-Hispanic White professional women, so findings should also be tested in other racial and ethnic groups, in whom cognitive impairment is more common than in White women (Luo, Yu, & Wu, 2018).

A key strength of our study is the use of a large sample of civilian women, as most prior studies have been conducted in predominantly male veteran samples or treatment-seeking individuals, which may not generalize to the broader population of women (Cobb Scott et al., 2015). Cognitive function was assessed with the Cogstate Brief Battery, which has been shown to detect cognitive impairment in aging (Maruff et al., 2013). In addition, we expanded upon our previous work by measuring all symptoms of PTSD based on DSM-5 criteria and assessing both PTSD and depression closer to cognitive assessment (Sumner et al., 2017). We considered a range of potential confounders between PTSD/depression and cognitive function and showed that our results were robust to possible practice effects of the Cogstate Brief Battery.

Conclusion

PTSD, depression, and history of head injury are prevalent among women, and particularly in combination, are related to poorer performance in psychomotor speed/attention and learning/working memory tasks. Lifetime history of head injury is not only correlated with PTSD and current depression, but also appears to exacerbate somewhat the cognitive impact of these disorders. The combination of all three conditions appeared to result in the worst performance on cognitive tasks compared to other combinations or each condition separately, which may be indicative of increased risk for subsequent cognitive disorders of aging (Elias et al., 2000). However, despite its widespread prevalence, history of head injury is not commonly assessed in civilian women, which may result in an underestimation of the long-term cognitive impacts of psychological trauma in this population. Thorough assessments of head injury should therefore be considered for both clinical applications and also in future studies of PTSD, depression and cognition in women. Identification and appropriate intervention for women experiencing PTSD and depression in the aftermath of head injury may improve cognitive outcomes and could help mitigate long-term risk.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Data availability

Data and/or research tools used in the preparation of this manuscript were submitted to the National Institute of Mental Health (NIMH) Data Archive (NDA). NDA is a collaborative informatics system created by the National Institutes of Health to provide a national resource to support and accelerate research in mental health. Dataset identifier: 10.15154/1522648. This manuscript reflects the views of the authors and may not reflect the opinions or views of the NIH or of the Submitters submitting original data to NDA.

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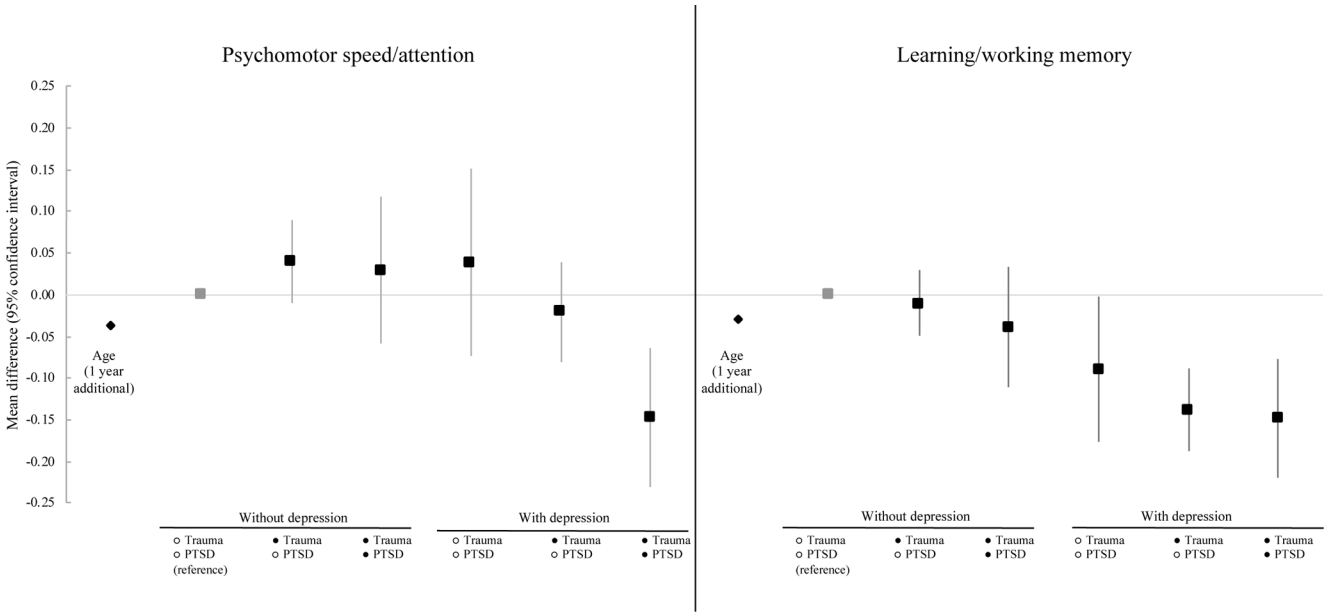

Figure 1.

Multivariable-adjusted associations between psychological trauma, PTSD, depression status (using the DSM-V criteria and CESD-10) and Cogstate composite scores for psychomotor speed/attention and learning/working memory in women in 2018

Note: Trauma refers to psychological trauma. The squares represent estimates (mean differences) for associations and lines represent 95% confidence intervals. On the X-axis, an empty circle represents absence; a filled circle represents presence. Models were adjusted for age at cognitive assessment, race/ethnicity, parental education, and participant education. Associations of cognitive function with age were estimated in models adjusted for race/ethnicity and are presented to allow for comparisons of magnitude.

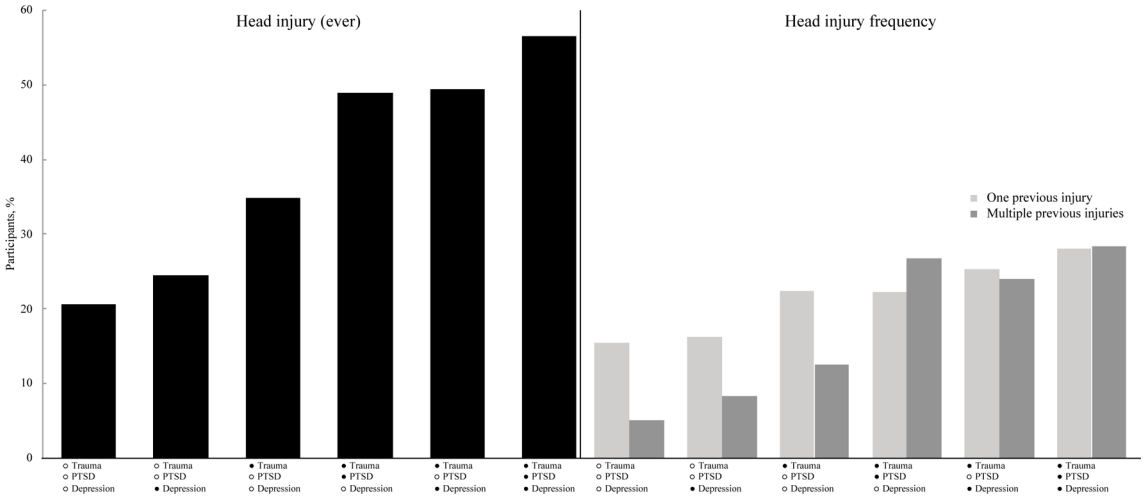

Figure 2.

Lifetime prevalence of head injury by psychological trauma, PTSD and depression status. Note: Trauma refers to psychological trauma. An empty circle represents absence; a filled circle represents presence. Head injury (ever) was missing in approximately 0.2% and head injury frequency was missing in approximately 0.3% of participants and these missing data are not displayed here.

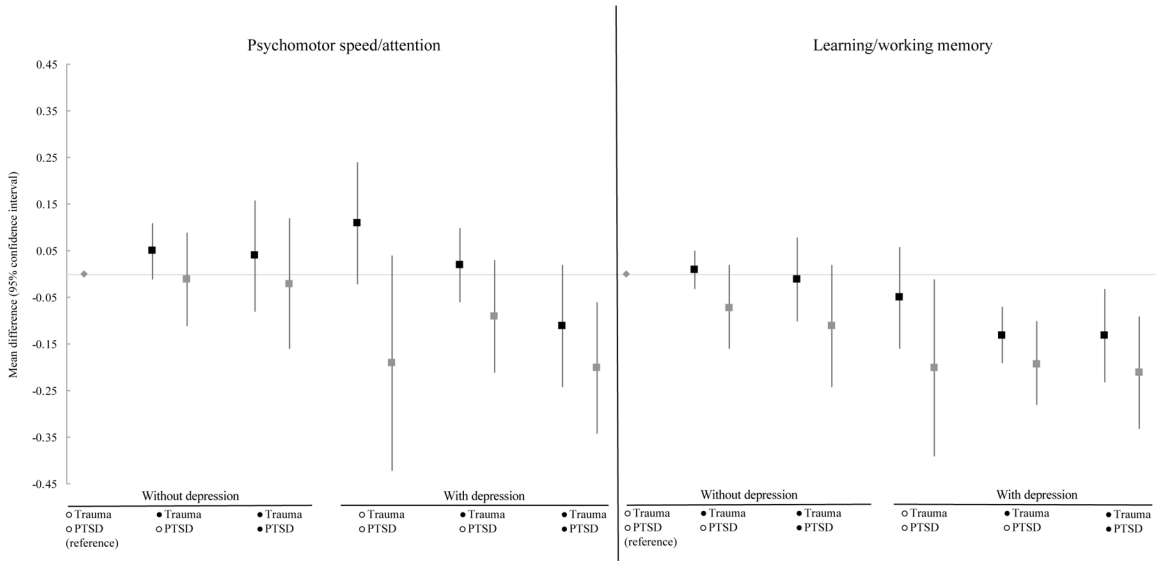

Figure 3.

Multivariable-adjusted associations between psychological trauma, PTSD, depression status (using the DSM-V criteria and CESD-10) and Cogstate composite scores for psychomotor speed/attention and learning/working memory in women in 2018: stratified by history of head injury

Note: Trauma refers to psychological trauma. The squares represent estimates (mean differences) for associations and lines represent 95% confidence intervals. The black squares represent estimates in those with no history of head injury; the grey squares represent estimates in those with history of head injury. On the X-axis, an empty circle represents absence; a filled circle represents presence. Models were adjusted for age at cognitive assessment, race/ethnicity, parental education, and participant education.

Table 1.

Age-standardized characteristics by psychological trauma, PTSD and depression status among 10,681 women in the Nurses' Health Study II.

Psychological trauma	**No**	**No**	**Yes**	**Yes**	**Yes**	**Yes**
PTSD[a]	**-**	**-**	**No**	**Yes**	**No**	**Yes**
Depression	**No**	**Yes**	**No**	**No**	**Yes**	**Yes**
N	**1,545**	**267**	**6,422**	**480**	**1,476**	**491**
%	**14.5**	**2.5**	**60.1**	**4.5**	**13.8**	**4.6**
Sociodemographic						
Age at cognitive assessment[b]	65.0 (4.6)	64.6 (4.9)	65.0 (4.5)	64.1 (4.5)	64.6 (4.5)	64.0 (4.7)
Race/ethnicity: Non-Hispanic white, %(n)	96.8 (1472)	99.4 (260)	96.9 (6174)	95.9 (451)	96.7 (1417)	97.5 (473)
Parental education: More than college, %(n)	26.8 (398)	20.0 (50)	26.6 (1640)	29.9 (134)	24.9 (346)	29.4 (136)
Participant education: Doctorate, %(n)	5.0 (74)	2.1 (5)	5.6 (350)	7.7 (37)	4.8 (68)	7.1 (34)
Body mass index and health behaviors						
Body mass index (kg/m^2)[c]	26.9 (6)	28.7 (6.4)	27.2 (6.1)	26.9 (5.7)	28.6 (6.7)	28.4 (6)
Smoking status: Current smoker, %(n)[d]	2.1 (33)	3.8 (10)	2.8 (181)	4.1 (20)	3.6 (53)	5.0 (25)
Alcohol use: 20+ (g/d), %(n)	9.9 (150)	6.8 (18)	8.9 (552)	9.4 (44)	9.9 (139)	4.9 (23)
Physical activity: 27+ (MET-hrs/wk), %(n)	43.3 (660)	28.8 (76)	42.8 (2692)	44.4 (207)	33.8 (484)	34.8 (165)
Diet quality[e]	62.5 (11.7)	61.2 (10)	62.8 (11.9)	64.3 (11.1)	61 (12.1)	62 (11.1)
Parity: 4+ children, %(n)	5.0 (77)	5.2 (14)	7.0 (449)	8.0 (38)	7.3 (107)	9.4 (46)
Oral contraceptive use: Past, %(n)	86.2 (1324)	88.4 (235)	88.9 (5667)	91.3 (435)	89.5 (1311)	90.2 (441)
Menopausal status: Post, %(n)	91.5 (1388)	93.3 (246)	92.4 (5854)	92.2 (431)	92.8 (1350)	93.0 (449)
Head injury, %(n) [f]	20.7 (320)	24.9 (66)	35.0 (2244)	49.6 (238)	50.9 (750)	57.7 (283)

Note: Values are means(SD) for continuous variables or percentages(Ns) for categorical variables and are standardized to the age distribution of the study population. For brevity, only certain levels are presented for categorical variables.

MET-hrs/wk: metabolic-equivalent hours per week; g/d: grams per day.

[a] PTSD is N/A when psychological trauma is absent

[b] Value is not age adjusted

[c] Body mass index is presented before mean imputation.

[d] Categories of current smokers are collapsed for brevity.

[e] Diet quality was taken from the Alternative Healthy Eating Index (excluding alcohol use) and presented before mean imputation.

[f] Head injury was defined as ever experiencing a blow to head, neck or upper body followed by: loss of consciousness/headaches/dizziness/nausea/disorientation/memory problems/visual problems/feeling uneasy on feet.

Table 2.

Associations between psychological trauma, PTSD, depression status (using the DSM-V criteria and CESD-10) and Cogstate composite scores for psychomotor speed/attention and learning/working memory in women in 2018

		Model 1		Model 2		Model 3	
	N	*b* (95% CI)	p-value	*b* (95% CI)	p-value	*b* (95% CI)	p-value
Psychomotor speed/attention (n = 10,661)							
No psychological trauma, no depression	1,543	(Reference)		(Reference)		(Reference)	
No psychological trauma, depression	266	0.04 (−0.07, 0.16)	0.45	0.04 (−0.07, 0.15)	0.50	0.04 (−0.08, 0.15)	0.52
Psychological trauma, no PTSD, no depression	6,410	0.04 (−0.01, 0.08)	0.15	0.04 (−0.01, 0.08)	0.14	0.04 (−0.01, 0.09)	0.12
Psychological trauma, PTSD, no depression	479	0.02 (−0.06, 0.11)	0.60	0.03 (−0.06, 0.12)	0.52	0.03 (−0.06, 0.12)	0.52
Psychological trauma, no PTSD, depression	1,473	−0.02 (−0.08, 0.04)	0.47	−0.02 (−0.08, 0.04)	0.51	−0.02 (−0.08, 0.04)	0.57
Psychological trauma, PTSD, depression	490	−0.15 (−0.24, −0.06)	0.001	−0.15 (−0.23, −0.06)	0.001	−0.14 (−0.23, −0.06)	0.001
Learning/working memory (n = 10,673)							
No psychological trauma, no depression	1,544	(Reference)		(Reference)		(Reference)	
No psychological trauma, depression	267	−0.09 (−0.18, 0.01)	0.07	−0.08 (−0.18, 0.01)	0.07	−0.08 (−0.17, 0.01)	0.09
Psychological trauma, no PTSD, no depression	6,416	−0.01 (−0.05, 0.03)	0.77	−0.01 (−0.05, 0.03)	0.71	−0.004 (−0.04, 0.04)	0.83
Psychological trauma, PTSD, no depression	480	−0.04 (−0.11, 0.03)	0.29	−0.04 (−0.11, 0.03)	0.30	−0.03 (−0.11, 0.04)	0.37
Psychological trauma, no PTSD, depression	1,475	−0.14 (−0.19, −0.09)	<0.001	−0.14 (−0.19, −0.09)	<0.001	−0.12 (−0.18, −0.07)	<0.001
Psychological trauma, PTSD, depression	491	−0.15 (−0.22, −0.08)	<0.001	−0.15 (−0.22, −0.08)	<0.001	−0.13 (−0.21, −0.06)	<0.001

Model 1: age at cognitive assessment.

Model 2: Model 1 + race/ethnicity (non-Hispanic white, black, Hispanic, Asian, or other racial/ethnic groups), parental education (high school, some college, more than college), participant education (associates degree, bachelors, masters, doctorate).

Model 3: Model 2 + body mass index (continuous), smoking status (never, past, current: 1–14, 15–24, 25+ cigarettes per day), alcohol use (none, 0–<5, 5–<10, 10–<20, 20+ grams per day), physical activity (<3, 3–<9, 9–<18, 18–<27, 27+ metabolic-equivalent hours per week), diet quality (continuous), menopausal status (premenopausal, postmenopausal, unknown), parity (no children, 1 child, 2–3 children, 4+ children), oral contraceptive use (never, past).

Table 3.

Associations between psychological trauma, PTSD, and depression status (using the DSM-V criteria and CESD-10) and Cogstate composite scores for psychomotor speed/attention and learning/working memory in women in 2018: stratified by history of head injury

		Model 1		Model 2		Model 3	
	N	*b* (95% CI)	p-value	*b* (95% CI)	p-value	*b* (95% CI)	p-value
No history of head injury							
Psychomotor speed/attention (n = 6786)							
No psychological trauma, no depression	1,224	(Reference)		(Reference)		(Reference)	
No psychological trauma, depression	200	0.12 (−0.01, 0.24)	0.08	0.11 (−0.02, 0.24)	0.09	0.11 (−0.02, 0.24)	0.09
Psychological trauma, no PTSD, no depression	4,161	0.05 (−0.01, 0.10)	0.09	0.05 (−0.01, 0.10)	0.10	0.05 (−0.004, 0.11)	0.07
Psychological trauma, PTSD, no depression	244	0.03 (−0.09, 0.15)	0.58	0.04 (−0.08, 0.16)	0.50	0.05 (−0.07, 0.17)	0.42
Psychological trauma, no PTSD, depression	744	0.02 (−0.06, 0.10)	0.61	0.02 (−0.06, 0.10)	0.58	0.03 (−0.05, 0.11)	0.48
Psychological trauma, PTSD, depression	213	−0.12 (−0.24, 0.01)	0.07	−0.11 (−0.24, 0.01)	0.08	−0.11 (−0.23, 0.02)	0.09
Learning/working memory (n = 6794)							
No psychological trauma, no depression	1,225	(Reference)		(Reference)		(Reference)	
No psychological trauma, depression	201	−0.06 (−0.16, 0.05)	0.30	−0.05 (−0.16, 0.05)	0.34	−0.05 (−0.16, 0.06)	0.35
Psychological trauma, no PTSD, no depression	4,166	0.02 (−0.03, 0.06)	0.50	0.01 (−0.03, 0.06)	0.59	0.01 (−0.03, 0.06)	0.54
Psychological trauma, PTSD, no depression	245	−0.01 (−0.1, 0.09)	0.92	−0.01 (−0.10, 0.09)	0.91	0.001 (−0.10, 0.10)	0.99
Psychological trauma, no PTSD, depression	744	−0.13 (−0.19, −0.06)	<0.001	−0.13 (−0.19, −0.06)	<0.001	−0.12 (−0.18, −0.05)	<0.001
Psychological trauma, PTSD, depression	213	−0.13 (−0.23, −0.02)	0.02	−0.13 (−0.23, −0.03)	0.01	−0.11 (−0.22, −0.01)	0.03
History of head injury							
Psychomotor speed/attention (n = 3851)							
No psychological trauma, no depression	318	(Reference)		(Reference)		(Reference)	
No psychological trauma, depression	65	−0.19 (−0.42, 0.04)	0.11	−0.19 (−0.42, 0.05)	0.12	−0.20 (−0.43, 0.04)	0.10
Psychological trauma, no PTSD, no depression	2,232	−0.01 (−0.11, 0.09)	0.84	−0.01 (−0.11, 0.10)	0.90	−0.01 (−0.11, 0.09)	0.87
Psychological trauma, PTSD, no depression	234	−0.02 (−0.17, 0.12)	0.76	−0.02 (−0.16, 0.13)	0.83	−0.03 (−0.18, 0.12)	0.71
Psychological trauma, no PTSD, depression	726	−0.10 (−0.21, 0.02)	0.09	−0.09 (−0.21, 0.02)	0.11	−0.10 (−0.21, 0.02)	0.11
Psychological trauma, PTSD, depression	276	−0.21 (−0.34, −0.07)	0.004	−0.20 (−0.34, −0.06)	0.005	−0.20 (−0.34, −0.06)	0.01
Learning/working memory (n = 3855)							

		Model 1		Model 2		Model 3	
	N	***b* (95% CI)**	**p-value**	***b* (95% CI)**	**p-value**	***b* (95% CI)**	**p-value**
No psychological trauma, no depression	318	(Reference)		(Reference)		(Reference)	
No psychological trauma, depression	65	−0.20 (−0.39, −0.002)	0.05	−0.20 (−0.39, −0.005)	0.04	−0.18 (−0.38, 0.01)	0.06
Psychological trauma, no PTSD, no depression	2,233	−0.07 (−0.16, 0.01)	0.10	−0.07 (−0.16, 0.01)	0.10	−0.07 (−0.15, 0.02)	0.12
Psychological trauma, PTSD, no depression	234	−0.11 (−0.24, 0.01)	0.07	−0.11 (−0.24, 0.01)	0.07	−0.11 (−0.24, 0.01)	0.07
Psychological trauma, no PTSD, depression	728	−0.19 (−0.29, −0.10)	<0.001	−0.19 (−0.28, −0.09)	<0.001	−0.18 (−0.27, −0.08)	<0.001
Psychological trauma, PTSD, depression	277	−0.22 (−0.33, −0.10)	<0.001	−0.21 (−0.33, −0.09)	<0.001	−0.20 (−0.32, −0.08)	0.001

Note: the p-interaction was 0.23 for psychomotor speed/attention and 0.55 for learning/working memory

Model 1: age at cognitive assessment.

Model 2: Model 1 + race/ethnicity (non-Hispanic white, black, Hispanic, Asian, or other racial/ethnic groups), parental education (high school, some college, more than college), participant education (associates degree, bachelors, masters, doctorate).

Model 3: Model 2 + body mass index (continuous), smoking status (never, past, current: 1–14, 15–24, 25+ cigarettes per day), alcohol use (none, 0–<5, 5–<10, 10–<20, 20+ grams per day), physical activity (<3, 3–<9, 9–<18, 18–<27, 27+ metabolic-equivalent hours per week), diet quality (continuous), menopausal status (premenopausal, postmenopausal, unknown), parity (no children, 1 child, 2–3 children, 4+ children), oral contraceptive use (never, past).