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Post-Traumatic Stress Disorder after Aneurysmal- and Angiographically Negative Subarachnoid Hemorrhage: Prevalence, Temporal Progression, and Impact on Societal Participation

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Abstract

Background and objectives: A psychological consequence commonly associated with subarachnoid hemorrhage (SAH) is post-traumatic stress disorder (PTSD). The current study investigates differences in PTSD prevalence between aneurysmal SAH (aSAH) and angiographically negative SAH (anSAH) patients, and examines the temporal progression of PTSD and its impact on societal participation after aSAH and anSAH. **Methods:** The sample included 88 patients (aSAH: $n= 61$, anSAH: $n=27$), acquired from the University Medical Centre Groningen, that were assessed 6 months (T0), 1 year (T1) and 2 years post-SAH (T2). Post-traumatic stress was assessed with the Dutch translation of the Impact of Events Scale (IES) and societal participation with the Utrecht Scale for Evaluation of Revalidation-Participation. **Results:** Results revealed no significant difference in mean IES score between aSAH and anSAH patients, nor an association between clinically significant PTSD and SAH type 6 months post-SAH. IES scores remained stable in aSAH, but decreased in anSAH patients over 2 years. Higher post-traumatic stress levels appeared moderate to strongly related to increased societal participation restrictions in anSAH patients, whereas relationships were weak or non-existent for aSAH patients over a period of 2 years. In both aSAH and anSAH patients strengthening relationships between post-traumatic stress and societal participation restrictions were found. **Conclusion:** The results emphasize the importance to screen for PTSD irrespective of the SAH type. Managing post-anSAH expectations seems essential in reducing PTSD risk and its impact on societal participation. PTSD might be a valuable treatment target, as it restricts patients in societal participation. Since ongoing and medical factors possibly underlie PTSD persistence, patients might benefit from adapted treatment programs when the PTSD source is somatic.

Keywords: aSAH, anSAH, PTSD, Prevalence, Temporal Progression, Societal Participation

Post-Traumatic Stress Disorder after Aneurysmal- and Angiographically Negative Subarachnoid Hemorrhage: Prevalence, Temporal Progression, and Impact on Societal Participation

A subarachnoid hemorrhage (SAH) is a severe type of stroke, characterized by the acute onset of an extreme headache, possibly accompanied by neurological deficits, and lowered responsiveness or even coma. With a mean age of 55 years (Tang et al., 2023), the patients sustaining a SAH are relatively young, considering the mean age for (non-fatal) strokes is around the age of 74 years (Akyea et al., 2021). A SAH is most often caused by the rupture of an aneurysm, which is called aneurysmal SAH (aSAH). This type of SAH is seen as a severe condition, in which cognitive deficits, mood disturbances and fatigue are common (Buunk et al., 2016). In 15% of cases no structural cause is found for the SAH. This type of SAH is defined as angiographically negative SAH (anSAH) (Buunk et al., 2016). Due to the relatively little neurological complications reported and seemingly adequate neurocognitive recovery shown by these patients, anSAH is less studied. However, these patients still report problems in daily life related to their SAH (Canhão et al., 1995; Germanò et al., 1998). Hütter and Andermahr (2014) have found that psychological changes and subjective complaints can be present in SAH patients, even when the degree of neurological problems is low. Recently it has been demonstrated that there appear to be no significant differences in neuropsychological performance, cognitive deficits and cognitive complaints between aSAH and anSAH patients in the long-term (Khosdelazad et al., 2023). Depression and anxiety rates turned out to be comparable for both types of SAH as well, emphasizing the importance to pay attention to cognitive and psychological problems irrespective of the SAH type.

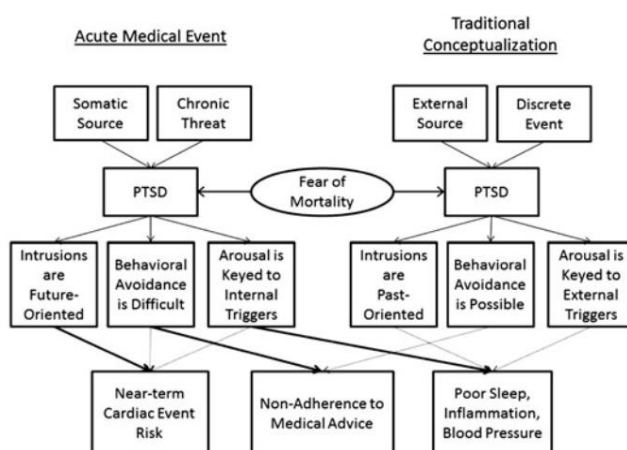
Another psychological consequence commonly associated with SAH is post-traumatic stress disorder (PTSD), with PTSD rates ranging from 18% to 37% in aSAH patients (Wajer et al., 2013; Hedlund et al., 2011; Visser-Meily et al., 2013). The prevalence of PTSD after anSAH to date remains unclear. One of the criteria for PTSD according to the latest edition of

PTSD AND SUBARACHNOID HEMORRHAGE

the Diagnostic and Statistical Manual of Mental Disorders (DSM-5) (American Psychiatric Association, 2013) pertaining to SAH is ‘exposure to actual or threatened death, serious injury or sexual violence’. Characteristics of PTSD comprise intrusive symptoms, persistent avoidance, and negative alterations in cognition, mood, arousal and reactivity associated with the traumatic event (American Psychiatric Association, 2013). Traditionally, PTSD is thought of as a consequence of a traumatic external event. However, PTSD can also occur after acute life-threatening medical events (Edmondson, 2014). According to the Enduring Somatic Threat (EST) Model, several important distinctions can be made between PTSD due to external traumatic events and PTSD due to acute life-threatening medical events (Edmondson, 2014) (Figure 1). After an acute medical event, intrusions are future- rather than past-oriented, behavioral avoidance is difficult and arousal is related to internal instead of external triggers (e.g. being highly aware of headaches after stroke) (Edmondson, 2014), attributable to the somatic source of the traumatizing event.

Figure 1

EST model of PTSD due to an acute medical event vs. traditional conceptualization



Note. Dark arrows represent associations with empirical evidence that was strongest/most consistent, light arrows represent associations with some empirical evidence. From ‘An enduring somatic threat model of posttraumatic stress disorder due to acute life-threatening

medical events', by D. Edmondson, 2014, *social and personality psychology compass*, 8 (3), p. 118-134 ([10.1111/spc3.12089](https://doi.org/10.1111/spc3.12089)). PMC Copyright notice.

In addition, SAH survivors are left with a range of ongoing consequences, like mood disturbances, cognitive deficits, fatigue, hospital check-ups, and physician appointments. These ongoing consequences can continue for years after the SAH (Buunk, 2019), reminding patients of the traumatizing event and their vulnerability. Studies have suggested that a stroke itself is traumatizing at first, in view of the sudden onset of the bleed and the severe symptoms accompanied by it, but that the ongoing consequences of the event are the factors strongly associated with the persistence of PTSD (Wajer et al., 2018).

PTSD can further complicate and add to the ongoing consequences after SAH, by the impact that it has on daily life. Four studies demonstrated PTSD was significantly associated with a lower QoL in an aSAH group (Visser-Meily et al., 2013), and a combined group of aSAH and anSAH patients (64% aSAH, 36% anSAH) (Hütter & Kreitschmann-Andermahr., 2014), (73% aSAH, 27% anSAH) (Noble et al., 2008), (58% aSAH, 42% anSAH) (McIntosh & Thomas., 2015). The World Health Organization (WHO, 2012) defines QoL as 'an individual's perception of their position in life, in the context of the culture and value systems in which they live, and in relation to their goals, expectations, standards and concerns'. According to this definition, QoL is somewhat subjective, in light that it is concerned with the perception of the individual. In the current study we focus on a more objective construct, namely societal participation, with a focus on resuming and maintaining work, leisure activities and social relationships, which make up a great part of life at the age of most SAH survivors. According to the most recent systematic-analysis of Tang et al. (2023), the impact of PTSD, after both aSAH and anSAH, on work and leisure has never been examined.

The current study aims to document the prevalence of PTSD and possible differences in prevalence between aSAH and anSAH patients at the initial measurement (6 months post-SAH), and aims to build on past research by investigating the temporal progression of PTSD over 2 years after aSAH and anSAH. In addition, the impact of PTSD on societal participation will be investigated in both aSAH and anSAH patients 6 months, 1 year and 2 years post-SAH.

Previous studies have found that 7 in 10 people don't seek treatment for PTSD, even when the disorder negatively affects their daily life (Wajer et al., 2018). Investigating the prevalence and temporal progression of PTSD in aSAH and anSAH patients can help healthcare workers to be more alert of post-traumatic stress symptoms after SAH, especially if extensive assessment of PTSD would be desired in a more timely manner. In addition, the impact that PTSD has on societal participation after SAH can have important implications for rehabilitation and treatment.

Methods

Participants

The sample included 88 patients, of which 61 patients suffered an aSAH ($M_{age} = 58.3$) and 27 patients an anSAH ($M_{age} = 53.5$). Patients were acquired from the Neurosurgery Unit of the University Medical Centre Groningen (UMCG). An aSAH or anSAH diagnosis demonstrated by computed tomography (CT) scan was required for patients to be included in the study. Further requirements included sufficient knowledge of the Dutch language and being at least 18 years of age. Patients were excluded from the study when their physical condition was not sufficient to undergo neuropsychological assessment and/or MRI scan. Patients with a history of severe neurological disorders were also excluded.

Research Design and Procedure

The study is a longitudinal, prospective, single-center cohort study. Demographic- and medical data were collected from patients' medical records. Six months (T0), 1 year (T1) and 2 years (T2) post-SAH patients received online questionnaires concerning societal participation and post-traumatic stress symptoms. The questionnaires were sent via the secure web app Research Electronic Data Capture (REDCap) or, if preferred by the patient, by post.

The current study is part of the Imaging, Cognition and Outcome of Neuropsychological functioning after Subarachnoid hemorrhage (ICONS) study (Khosdelazad et al., 2022). Written informed consent was obtained from all included patients. The ICONS study was conducted according to the principles of the Declaration of Helsinki (World Medical Association Declaration of Helsinki, 64th World Medical Association General Assembly, Fortaleza, Brazil, October 2013) and the national and international standards of Good Clinical Practice. Ethical approval of the study protocol was obtained from the Medical Ethical Committee of the UMCG (2019/346).

Measures

IES

Symptoms of post-traumatic stress were assessed with the Dutch translation of the Impact of Events Scale (IES) [*Schok Verwerkingslijst*]. Post-traumatic stress symptom scores were categorized according to their severity (0-8 subclinical, 9-25 mild, 26-43 moderate, >43 severe). Patients exhibiting a score above 25, which is considered a clinically significant score according to the IES, are regarded as in need of specific healthcare for their post-traumatic stress symptoms. Based on several research populations (n= 1588), the IES is regarded as a valid and reliable instrument after shocking experiences (Ploeg et al., 2004).

USER-P

Societal participation was assessed with the Utrecht Scale for Evaluation of Revalidation-Participation (USER-P) [*Utrechtse Schaal voor Evaluatie van Revalidatie-*

Participatie]. In the current study we focused solely on the domain of daily life restrictions due to the SAH. This domain contains a total of 10 questions about work (1), leisure (3-7) and social relationships (8-11). Item 2 did not comprise a statement of relevance to the research aims and therefore was not included in the analysis. On the USER-P patients had the option to check the box 'not applicable'. This would result in the patient not being included for that item. The sum scores of the daily life restrictions per domain were converted to a score on a scale ranging from 0-100, where higher scores indicate better levels of participation. The USER-P is evaluated by de Graaf et al. (2022) as a valid and useful instrument in a population of stroke patients.

Statistical analysis

The statistical analyses were performed with the use of IBM SPSS Statistics 28, with exception of a nonparametric analysis that was performed with the nparLD Software Package in R studio (Noguchi et al. 2012). To provide an overview of the patient demographics and SAH characteristics in the sample, descriptive statistics were calculated. The educational level was measured with the Dutch classification of education according to Verhage (1964), on a 7-point scale ranging from 'no primary school' to 'university degree'. The scale was dichotomized into low (1-4), average (5) and high (5-7) levels of education. The sum scores of the items from the IES at T0 were calculated and categorized according to the severity of post-traumatic stress symptoms into 'No clinically significant post-traumatic stress' with the subcategories 'subclinical' and 'mild', and 'Clinically significant post-traumatic stress' with the subcategories 'moderate' and 'severe', for both types of SAH. Due to violation of normality (Appendix), a Mann-Whitney U test was computed to compare mean IES scores between aSAH and anSAH patients at T0. To examine associations between clinically significant PTSD scores (>25) from the IES at T0 and SAH type, a Chi-square test was performed. A Friedman's test was used to investigate significant changes in mean IES scores

PTSD AND SUBARACHNOID HEMORRHAGE

across T0, T1 and T2 for both aSAH and anSAH patients. When a significant effect was shown over time, a Wilcoxon Signed Ranks test would be performed to determine which time points significantly differed from each other. A Mann-Whitney U test was used to compare mean IES scores between aSAH and anSAH patients in the long term, at T1 and T2. Since no suitable nonparametric alternatives are available for a two-way repeated measures ANOVA in SPSS, a nonparametric analysis of longitudinal data for factorial settings was performed with the R software package nparLD (Noguchi et al., 2012), to investigate interactions between SAH type and time for the IES. To examine the impact of post-traumatic stress on societal participation, a correlation analysis was carried out between IES scores and scores on each aspect of societal participation (work, leisure, social relationships) at T0, T1, and T2, as measured by the USER-P. For all the analyses the level of significance was restricted to $p < 0.05$.

Research questions and hypotheses

Prevalence

Research question: Are there significant differences in mean PTSD scores (mean IES score) between aSAH and anSAH patients 6 months (T0) post-SAH?

Hypothesis: There are no significant differences in mean PTSD scores between aSAH and anSAH patients 6 months (T0) post-SAH, as shown by a Mann-Whitney U test comparing mean IES scores.

Research question: Is there a significant association between PTSD prevalence (IES>25) and SAH type (aSAH, anSAH) 6 months (T0) post-SAH?

Hypothesis: There are no significant associations between PTSD prevalence (IES>25) and SAH type (aSAH, anSAH) 6 months (T0) post-SAH, as shown by a Chi-square test comparing aSAH and anSAH patients exhibiting an IES score above 25 (category 'clinically significant post-traumatic stress').

Temporal progression

Research question: Are there significant changes over time (across T0, T1, T2) in mean PTSD score (mean IES score) after aSAH?

Hypothesis: There are no significant changes in mean PTSD score (mean IES score) from 6 months to 1 year (T0-T1), 1 year to 2 years (T1-T2), and 6 months to 2 years (T0-T2) after aSAH, as shown by a Friedman's test.

Research question: Are there significant changes over time (across T0, T1, T2) in mean PTSD score (mean IES score) after anSAH?

Hypothesis: There are no significant changes in mean PTSD score (mean IES score) from 6 months to 1 year (T0-T1), 1 year to 2 years (T1-T2), and 6 months to 2 years (T0-T2) after anSAH, as shown by a Friedman's test.

Research question: Are there significant differences in mean PTSD scores (mean IES scores) between aSAH and anSAH patients in the long-term (T1, T2)?

Hypothesis: There are no significant differences in mean PTSD scores (mean IES scores) between aSAH and anSAH patients 1 year (T1) and 2 years (T2) post-SAH, as shown by a Mann-Whitney U test comparing mean IES scores.

Research question: Are there significant differences in temporal progression of PTSD between aSAH and anSAH patients (interaction of SAH type x time for the IES)?

Hypothesis: There is no significant interaction between SAH type and time for the IES, as shown by a nonparametric analysis of longitudinal data for factorial settings, with the use of a nparLD R software package.

Societal participation

Research question: Is post-traumatic stress (IES score) significantly related to restrictions in all societal participation domains (USER-P; work, leisure, social relationships) 6 months (T0), 1 year (T1) and 2 years (T2) after aSAH and anSAH?

Hypothesis: Higher post-traumatic stress levels (higher IES scores) are significantly related to increased restrictions (lower USER-P scores) in all societal participation domains (work, leisure, social relationships) 6 months (T0), 1 year (T1) and 2 years (T2) after aSAH and anSAH, as shown by negative Pearson correlations.

Results

Patient population

During the recruitment period, a total of 92 patients met the inclusion criteria and were willing to participate in the study. Due to the COVID-19 lockdown, 4 patients that had already given informed consent were unable to participate, which led to 88 patients that were included for the statistical analyses. In total, we obtained data from 61 aSAH patients and 27 anSAH patients at T0. Data were obtained from 53 aSAH patients and 25 anSAH patients on the USER-P, and 32 aSAH patients and 15 anSAH patients on the IES at T1 and T2, due to the fact that some patients had not (yet) completed all follow-up assessments. Demographics and characteristics of the sample are listed in table 1. Outliers in the data were checked for by means of a boxplot. Merely true outliers were found, and were therefore retained in the dataset.

Table 1

Patient characteristics

Characteristic	aSAH (<i>n</i> =61)	anSAH (<i>n</i> =27)
Sex, Female (%)	43 (70.5%)	12 (44.4%)
Age at the time of SAH, years <i>M</i> (<i>SD</i>)	58.3 (12.5)	53.5 (9.6)

PTSD AND SUBARACHNOID HEMORRHAGE

Handedness (%)

Right	54 (88.5%)	26 (96.3%)
Left	4 (6.6%)	1 (3.7%)
Ambidexter	2 (3.3%)	

Educational level (%)

Low (1-4)	13 (21.3%)	5 (18.5%)
Average (5)	24 (39.3%)	12 (44.4%)
High (6-7)	24 (39.3%)	10 (37.0%)

WFNS (%)

Low (1-3)	54 (88.5%)	27 (100.0%)
High (4-5)	7 (11.5%)	

Treatment (%)

Clipping	10 (16.4%)
Coiling	37 (60.7%)
Stenting	4 (6.6%)
WEB device	10 (16.4%)

Note. aSAH, aneurysmal subarachnoid hemorrhage; anSAH, angiographically negative subarachnoid hemorrhage; WEB device, Woven EndoBridge device; WFNS, World Federation of Neurological Surgeons Scale.

PTSD prevalence

There was no significant difference in mean IES score between aSAH ($M= 15.5$, $SD=14.9$, $n= 61$) and anSAH patients ($M= 17.7$, $SD= 16.6$, $n= 27$) at T0 ($U= 861$, $p= .639$). Table 2 shows frequencies of aSAH and anSAH patients within the different IES categories and subcategories. No significant association was found between SAH type and clinically

PTSD AND SUBARACHNOID HEMORRHAGE

significant post-traumatic stress (IES >25) ($\chi^2(1) = .96, p = .328$) at T0. A little less than 1 in 4 (22.9%) aSAH patients and 1 in 3 (33.3%) anSAH patients showed a clinically significant (>25) score on the IES at T0 (Figure 2).

Table 2

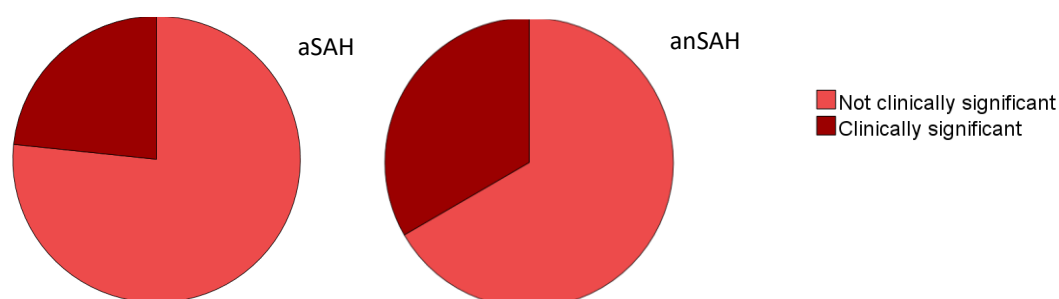
Severity categorization IES at T0

	aSAH (n=61)	anSAH (n=27)
Not clinically significant	46 (75.4 %)	18 (66.6%)
Subclinical (0-8)	26 (42.6%)	13 (48.1%)
Mild (9-25)	20 (32.8%)	5 (18.5%)
Clinically significant	14 (22.9%)	9 (33.3%)
Moderate (26-43)	11 (18.0%)	6 (22.2%)
Severe (>43)	3 (4.9%)	3 (11.1%)
Missing values	1 (1.6%)	

Note. aSAH, aneurysmal subarachnoid hemorrhage; anSAH, angiographically negative subarachnoid hemorrhage; IES, Impact of Events Scale; T0, 6 months post-SAH.

Figure 2

Clinically significant post-traumatic stress in aSAH and anSAH patients at T0



Note. aSAH, aneurysmal subarachnoid hemorrhage; anSAH, angiographically negative subarachnoid hemorrhage; T0, 6 months post-SAH.

Temporal progression of PTSD

Table 3 shows mean IES scores at T0, T1, and T2 for aSAH and anSAH patients. Both the Wald-Type Statistic and ANOVA-Type Statistic indicate a significant interaction between SAH type and IES timepoints, revealing significant differences in temporal progression of IES scores between aSAH and anSAH patients (Table 4). No significant effect was shown on the Friedman's test for aSAH patients across T0, T1, and T2 ($X^{2(2)} = .65, p = .723$), indicating that mean PTSD rates remained stable over 2 years in aSAH patients. For anSAH patients there was a significant difference shown in IES scores on the Friedman's test across the timepoints ($X^{2(2)} = 11.48, p = .003$). A post-hoc Wilcoxon Signed Ranks test revealed a significant decrease in mean IES score between T0 and T1 ($Z = -2.32, p = .021$), and T0 and T2 ($Z = -2.16, p = .031$), demonstrating a decrease in PTSD rates from 6 months to 1 year in anSAH patients, thereafter remaining relatively stable up to 2 years (Figure 3). In the long-term, no significant differences were found in mean IES scores between aSAH and anSAH patients at T1 ($U = 540, p = .187$) and T2 ($U = 242, p = .893$).

Table 3

Mean IES scores at T0, T1, and T2

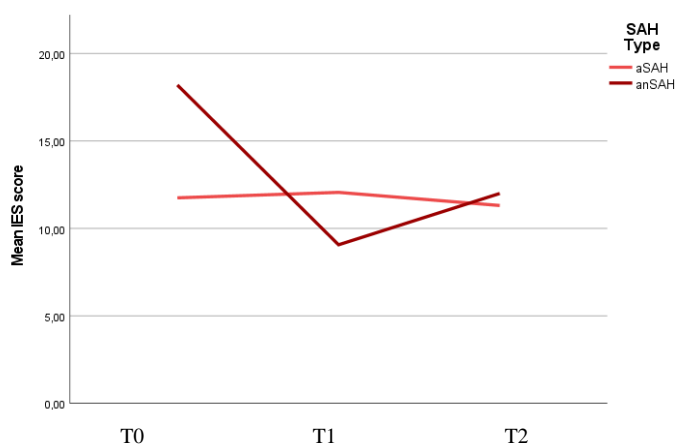
	aSAH ($n=32$)	anSAH ($n=15$)
	$M (SD)$	$M (SD)$
T0	11.8 (12.4)	18.2 (17.1)
T1	12.1 (12.6)	9.1 (11.7)
T2	11.3 (13.4)	12.0 (16.7)

Note. aSAH, aneurysmal subarachnoid hemorrhage; anSAH, angiographically negative subarachnoid hemorrhage; IES, Impact of Events Scale; T0, 6 months post-SAH; T1, 1 year post-SAH; T2, 2 years post-SAH.

Table 4*Association between SAH type and timepoints from the IES*

	Wald-type statistic			ANOVA-type statistic		
	Statistic	Df	<i>p</i> -value	Statistic	Df	<i>p</i> -value
SAH type x time	8.34	2	.015	3.28	1.85	.041

Note. SAH, subarachnoid hemorrhage; IES, Impact of Events Scale.

Figure 3*Mean IES scores across T0, T1, and T2*

Note. aSAH, aneurysmal subarachnoid hemorrhage; anSAH, angiographically negative subarachnoid hemorrhage; IES, Impact of Events Scale; T0, 6 months post-SAH; T1, 1 year post-SAH; T2, 2 years post-SAH.

Impact of PTSD on societal participation

T0

Correlations between the IES and USER-P (restrictions) at T0 are reported in table 5 for both patient groups. No significant correlations were found between IES score and either work, leisure or social relationship scores on the USER-P for aSAH patients. In contrast, a significant, negative correlation of moderate strength was found between IES score and

USER-P score for work, leisure, and social relationship restrictions for anSAH patients. This indicates that higher levels of post-traumatic stress are related to increased restrictions in the domain of work, leisure and social relationships 6 months after anSAH.

Table 5

Pearson's correlations between IES and USER-P(restrictions) at T0

	aSAH			anSAH		
	<i>n</i>	<i>M (SD)</i>	IES	<i>n</i>	<i>M (SD)</i>	IES
USER-P						
Work	40	35.8 (40.2)	-.28	23	65.2 (21.3)	-.58**
Leisure	60	76.2 (22.3)	-.15	27	80.4 (42.0)	-.50**
Social relationships	60	85.5 (14.4)	-.22	27	86.1 (17.0)	-.61**

Note. aSAH, aneurysmal subarachnoid hemorrhage; anSAH, angiographically negative subarachnoid hemorrhage; IES, Impact of Events Scale; T0, 6 months post-SAH; USER-P, Utrechtse Schaal voor Evaluatie van Revalidatie-Participatie. ** $p < .01$.

T1

No significant correlations were found between IES scores and both leisure and social relationship restriction scores from the USER-P at T1 (Table 6) in aSAH patients. However, a significant, but weak, negative correlation was found between IES score and USER-P work restriction score after aSAH. This reveals that, to some degree, higher levels of post-traumatic stress are related to increased restrictions in the work domain 1 year after aSAH. Strong, significant, negative correlations with IES scores were found in all three of the USER-P domains (work, leisure, social relationships) for anSAH patients, revealing that higher levels

of posttraumatic stress are strongly related to increased restrictions in the domain of work, leisure and social relationships 1 year after anSAH.

Table 6

Pearson's correlations between IES and USER-P(restrictions) at T1

	aSAH			anSAH		
	<i>n</i>	<i>M (SD)</i>	IES	<i>n</i>	<i>M (SD)</i>	IES
USER-P						
Work	35	69.5 (34.7)	-.36*	22	68.2 (41.8)	-.84**
Leisure	53	85.2 (15.7)	-.24	25	83.9 (19.8)	-.74**
Social relationships	53	88.4 (14.5)	-.23	25	90.7 (14.3)	-.77**

Note. aSAH, aneurysmal subarachnoid hemorrhage; anSAH, angiographically negative subarachnoid hemorrhage; IES, Impact of Events Scale; T1, 1 year post-SAH; USER-P, Utrechtse Schaal voor Evaluatie van Revalidatie-Participatie. * $p < .05$, ** $p < .01$.

T2

Significant, but weak, negative correlations were found at T2 (Table 7) between IES scores and USER-P work, leisure and social relationship restrictions scores for aSAH patients, indicating that 2 years after the aSAH, higher levels of post-traumatic stress are somewhat related to increased restrictions in all societal participation domains (work, leisure, social relationships). Strong, significant correlations with IES scores were found in all three of the societal participation domains (work, leisure, social relationships) of the USER-P for anSAH patients. This reveals that higher levels of posttraumatic stress are strongly related to increased restrictions in the domain of work, leisure and social relationships 2 years after the SAH.

Table 7*Pearson's correlations between IES and USER-P(restrictions) at T2*

	aSAH		IES	anSAH		IES
	<i>n</i>	<i>M (SD)</i>		<i>n</i>	<i>M (SD)</i>	
USER-P						
Work	25	61.3 (47.8)	-.46*	13	79.5 (37.4)	-.80**
Leisure	33	82.6 (22.2)	-.46**	16	85.2 (19.9)	-.85**
Social relationships	53	88.4 (14.5)	-.45**	25	90.7 (14.3)	-.88**

Note. aSAH, aneurysmal subarachnoid hemorrhage; anSAH, angiographically negative subarachnoid hemorrhage; IES, Impact of Events Scale; T2, 2 years post-SAH; USER-P (restrictions), Utrechtse Schaal voor Evaluatie van Revalidatie-Participatie (restrictions). * $p < .05$, ** $p < .01$.

Summary across time points

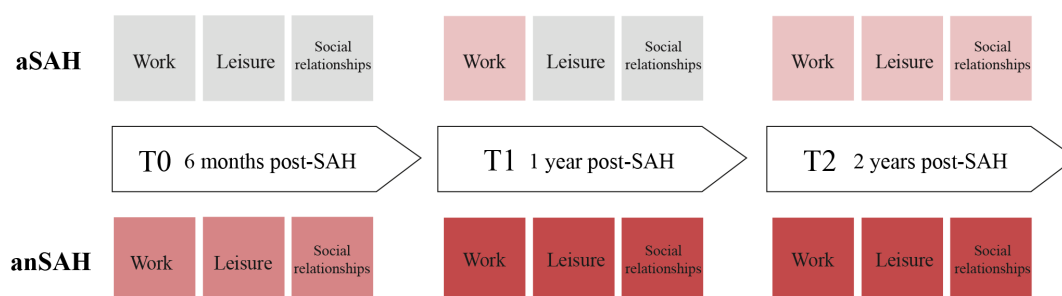
As can be seen in figure 4, there were no significant correlations found between IES scores and USER-P scores for work, leisure or social relationship restrictions 6 months after aSAH. This result remained unchanged 1 year after aSAH, with exception of increased restrictions in the work domain that appeared to be somewhat related to higher levels of post-traumatic stress. Two years after aSAH, higher post-traumatic stress levels seemed to be somewhat related to increased restrictions in all societal participations domains (work, leisure, social relationships).

According to the results, higher post-traumatic stress levels were moderately related to increased restrictions in work, leisure and social relationship domains 6 months after anSAH. After 1 year, and 2 years, there seemed to be a strong relationship between higher post-

traumatic stress levels and increased restrictions in all societal participation domains (work, leisure, social relationships) for anSAH patients.

Figure 4

Strength of associations between PTSD and work, leisure and social relationship restrictions



Note. From light to dark the colours represent weak, moderate or strong associations. Grey represents the absence of a significant relationship. aSAH, aneurysmal subarachnoid hemorrhage; anSAH, angiographically negative subarachnoid hemorrhage; PTSD, post-traumatic stress disorder; SAH, subarachnoid hemorrhage.

Discussion

The current study aimed to examine differences in prevalence and temporal progression of PTSD, and investigated whether PTSD would impact societal participation after both aSAH and anSAH. PTSD prevalence was not significantly associated with SAH type 6 months post-SAH. Also, there were no significant differences in mean PTSD rates between aSAH and anSAH patients. Results showed a non-significant, but slightly higher PTSD rate 6 months after anSAH. While PTSD rates remained stable in aSAH patients over 2 years, they decreased in anSAH patients from 6 months to 1 year. Over a period of 2 years, higher post-traumatic stress levels seemed to be moderate to strongly related to increased restrictions in societal participation for anSAH patients, while for aSAH patients no relationships or only weak relationships were found. In both aSAH and anSAH patients the

relationships between post-traumatic stress and societal participation restrictions seemed to strengthen over time.

As would be expected based on the literature (Hütter and Andermahr, 2014; Khosdelazad et al., 2023), no significant differences between aSAH and anSAH patients in mean PTSD scores, nor an association between clinically significant PTSD scores and SAH type were found 6 months post-SAH. These results support the finding from Hütter and Andermahr (2014), that psychological changes can be present irrespective of the degree of neurological problems. Approximately 23-33% of SAH patients experienced clinically significant post-traumatic stress 6 months after their SAH, with a slightly higher percentage of anSAH patients exhibiting clinically significant post-traumatic stress scores. Due to the generally more favourable medical prognosis after anSAH compared to aSAH, anSAH is considered a relatively benign condition. This message is often transferred to the patient and their social network (Khosdelazad et al. 2024), possibly leading to a reduction in social support after anSAH. Reduced social support has been shown to increase the risk for PTSD in the first months after SAH (Tang et al. 2023), explaining the slightly higher PTSD percentage in anSAH patients 6 months post-SAH.

The expectation that post-traumatic stress levels would not change over time for both types of SAH is partly supported by the results. The results showed a significant difference in temporal progression of PTSD between aSAH and anSAH patients. Post-traumatic stress symptoms did not change over 2 years in aSAH patients, however, they did significantly decrease in anSAH patients from 6 months to 1 year post-SAH. The EST model of Edmondson (2014) suggests that the underlying fear of mortality that is maintaining post-traumatic stress symptoms, originates from ongoing/somatic events. Ongoing consequences that are experienced on a daily basis by SAH patients, can serve as reminders of the body's vulnerability. These reminders can induce psychological reactions (Edmondson, 2014) and

lead to profound chronic distress in SAH patients (Wajer et al., 2018), explaining why PTSD would persist. Furthermore, the EST model of Edmondson (2014) proposes that, in addition to the ongoing consequences of the event (Wajer et al., 2018), the medical prognosis could be a determinant for the persistence of PTSD symptoms. Hütter and Andermahr (2014) have found that patients who were surgically treated had a greater fear of recurrence, which is also said to maintain PTSD (Edmondson, 2014). It is therefore suggested that medical factors like neurosurgical treatment, and increased risk of rebleed and neurological complications (i.e. worse medical prognosis) add to the underlying fear of mortality maintaining PTSD. These medical factors, mainly seen in aSAH patients, might play a greater role in the temporal progression of PTSD than the ongoing consequences that can be experienced irrespective of the SAH type, possibly explaining why PTSD would persist in aSAH patients, but decreases in anSAH patients from 6 months to 1 year.

Important to note, as previously mentioned, is that the level of post-traumatic stress was slightly higher in anSAH patients at 6 months post-SAH. Following the decrease in post-traumatic stress level from 6 months to 1 year in anSAH patients, there were no significant differences found between aSAH and anSAH patients at 1 year and 2 years post-SAH. This result adds to the finding of Khosdelazad et al. (2023) that there seemed to be no significant differences in the long-term between aSAH and anSAH patients in neuropsychological performance, cognitive deficits, cognitive complaints, depression and anxiety, that there also seems to be no significant difference in the long-term between aSAH and anSAH patients in PTSD.

With regard to societal participation, no significant relationships were found between restrictions in either aspect of societal participation (work, leisure, social relationships) and post-traumatic stress 6 months after aSAH. This finding remained the same after 1 year, with exception of a weak relationship between post-traumatic stress and restrictions in the work

domain. Two years after aSAH, higher post-traumatic stress levels seemed to be significantly related to increased work, leisure and social relationship restrictions, but the relationships were weak. On the contrary, moderate relationships between higher levels of post-traumatic stress and increased work, leisure and social relationship restrictions were shown 6 months after anSAH. These relationships, between higher post-traumatic stress levels and increased work, leisure and social relationship restrictions, became even stronger 1 year and 2 years post-aSAH. This shows that, while PTSD has a similar influence on QoL in both patient groups, this is not the case for societal participation. These outcomes could be explained by the instruments the studies measuring the relationship between QoL and PTSD used (Visser-Meily et al., 2013; Hütter & Kreitschmann-Andermahr; Noble et al., 2008; McIntosh & Thomas., 2015). Instruments used to measure QoL are concerned with the perception of the individual, whereas the questionnaire in the current study was focused on measuring actual societal participation abilities.

In both patient groups a stronger relationship between PTSD and societal participation is shown over time. As mentioned by Wajer et al. (2018), 7 in 10 people don't seek treatment for PTSD, even when the disorder would negatively affect their daily life. In the short-term, PTSD might have a relatively small impact on societal participation, since other factors could impact societal participation to a greater extent at this stage, for example cognitive deficits (Buunk et al., 2019; Khosdelazad et al., 2023) or physical problems (McIntosh & Thomas., 2015). These factors might become of less influence on societal participation in the long-term through better management over time, for example as a result of experience, rehabilitation or physical therapy. The lack of management of PTSD compared to other potential factors of influence, could cause PTSD to grow a relatively bigger impact on societal participation as time progresses, offering an explanation for the strengthening relationship between post-traumatic stress and societal participation.

Interestingly, a discrepancy was shown in strength of the relationship between PTSD and societal participation after aSAH and anSAH. Relationships between PTSD and restrictions in societal participation domains were weak or non-existent in aSAH patients, while moderate or strong relationships were shown between PTSD and restrictions in societal participation domains in anSAH patients. The perspective of anSAH as a relatively benign condition compared to aSAH, due to their more favourable medical prognosis, is often transferred to the patient (Khosdelazad et al., 2024). However, despite their relatively 'favourable' medical prognosis, studies have shown that anSAH patients can experience persistent cognitive deficits, cognitive complaints, and profound emotional problems, which can have a great impact on societal participation (Buunk et al., 2016; Khosdelazad et al., 2023). A mere focus on medical status, without acknowledging possible cognitive, emotional or behavioural sequelae, could cause anSAH patients to have inaccurate expectations about societal participation after their SAH. These inaccurate expectations might result in repression/denial focused coping, which has been shown to negatively impact societal reintegration after brain injury (Costa et al., 2017). Important to note is that the current literature lacks differentiation between aSAH and anSAH patients in examining the role of coping, PTSD and societal participation. Further research is therefore needed to be able to provide a concise statement about the role of coping in relation to PTSD and societal participation.

As discussed earlier, PTSD rates decreased in anSAH patients from 6 months to 1 year. At the same time, the relationship between PTSD and societal participation strengthened in anSAH patients. As stated by Wajer et al. (2018), studies have shown that a stroke is very traumatizing at first. Furthermore, the perspective of anSAH as a benign condition might lead to reduced social support and therefore higher PTSD risk. Relatively higher post-traumatic stress levels in anSAH patients 6 months post-SAH might thus result from the initial

traumatization of the stroke in combination with a lack of social support. Suggested to be related to the persistence of PTSD, are the ongoing consequences of the SAH. Patients that exhibit post-traumatic stress symptoms in the long term, might therefore be those that experience different or longer lasting consequences of the event. Inaccurate expectations about the possible sequelae after anSAH, could result in repression/denial when faced with ongoing consequences after anSAH, negatively affecting societal participation. This might explain why the percentage of anSAH patients with persisting PTSD displays a stronger relationship with societal participation restrictions.

Several important limitations have to be acknowledged when interpreting the results. The analysis of the temporal progression of PTSD was performed at a group level, failing to detect patients that develop ‘delayed PTSD’ (Wajer et al., 2018), and possibly interchanging patients with ‘delayed PTSD’ for patients with persistent PTSD from the initial measurement. Furthermore, a correlation analysis was carried out to establish relationships between PTSD and societal participation domains. Since the demonstrated relationships are correlational and not causal, careful interpretation of these relationships is warranted. Finally, worth mentioning is the relatively small sample of anSAH patients ($n=27$), which could have resulted in a reduced chance of statistically significant effects in the anSAH group reflecting actual effects.

Future studies should consider the role of medical factors, like neurosurgical treatment and risk of complications or recurrence in the underlying fear of mortality, maintaining SAH-induced PTSD. In addition, it might be valuable to specify which ‘ongoing consequences’ play the greatest role in the persistence of SAH-induced PTSD. This could narrow treatment targets for PTSD after SAH. Furthermore, it is suggested to perform individual analyses with regard to the temporal progression of PTSD. Finally, the mechanisms by which PTSD impacts societal participation, and the role of post-SAH expectations and coping, could be an

important area of focus for future investigations, since the relationships found between PTSD and societal participation in aSAH and anSAH patients do not seem to correspond.

The current study is, to our knowledge, the first to document the prevalence of PTSD for anSAH patients. It is also the first study to examine the effects of PTSD on work and leisure in both aSAH and anSAH patients. These results add to the existing literature by broadening the knowledge on these topics for future research. In addition, the outcomes of the study can have important practical implications. With a considerably fair amount of SAH patients showing clinically significant PTSD 6 months after the SAH (23-33%), it is recommended to screen for PTSD irrespective of the SAH type. When treatment of PTSD is desired, it might be beneficial to treat medically-induced PTSD differently than PTSD as a consequence of a discrete past event, based on the EST model (Edmondson, 2014). Many cognitive treatment programs are based on the assumption that an actual threat has passed, while this might not be the case when the source of the threat is somatic. Since PTSD prevalence and its impact on societal participation might be influenced by unrealistic expectations after anSAH, healthcare workers are encouraged to consider medical status, as well as cognitive, behavioural and emotional sequelae in the message they convey to patients. Finally, PTSD seems to be an important treatment target, as the disorder appears to play an important role in restricting SAH patients from participating in work, leisure and social relationships.

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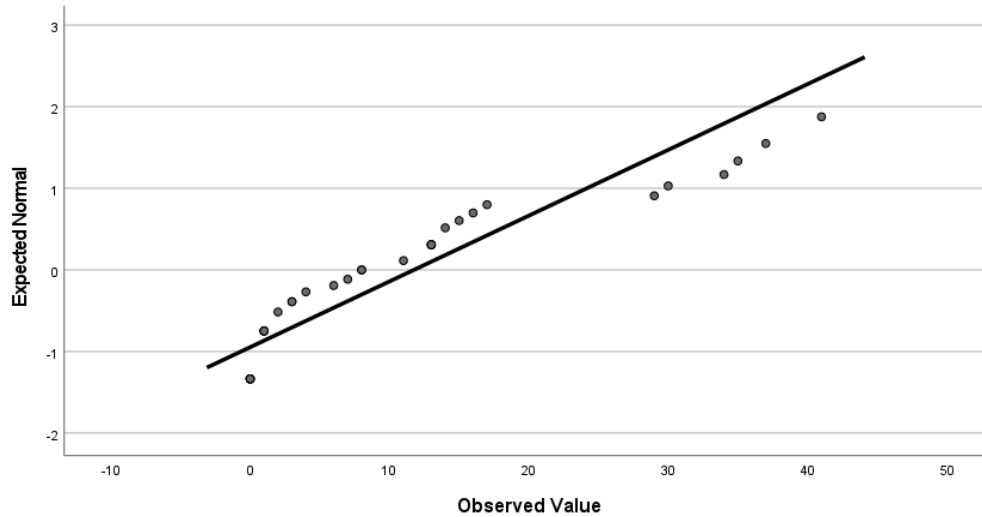
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Appendix**Violations of normality****Figure A1**

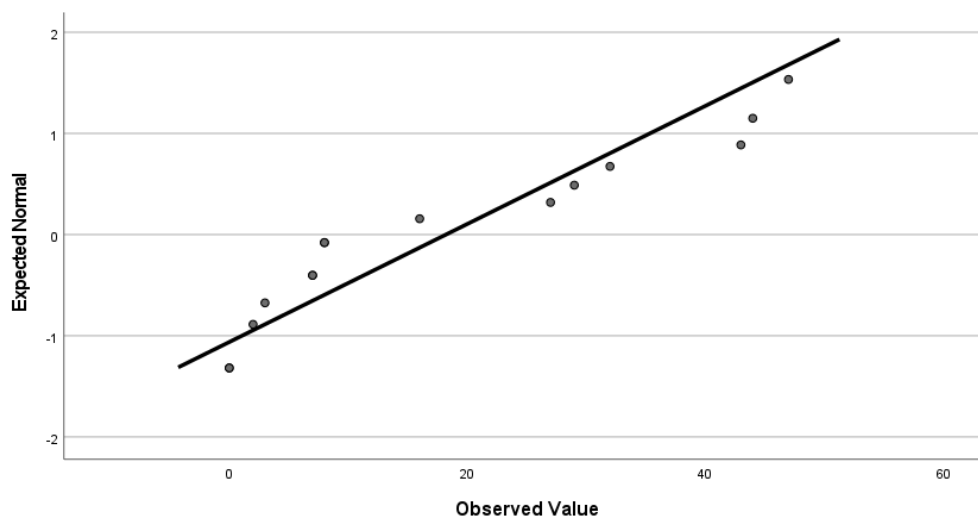
Normal Q-Q plot of IES scores at T1 for aSAH patients



Note. aSAH, aneurysmal subarachnoid hemorrhage; SAH, subarachnoid hemorrhage.

Figure A2

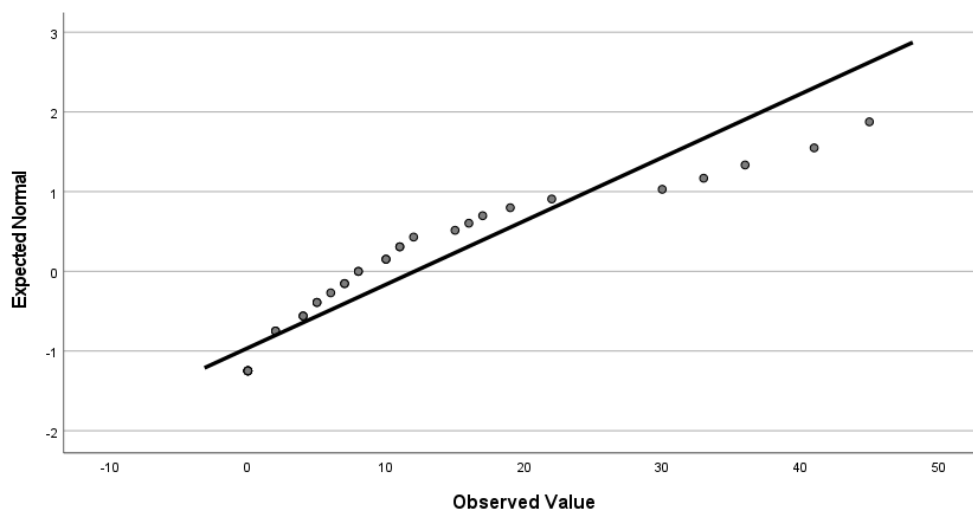
Normal Q-Q plot of IES scores at T1 for anSAH patients



Note. anSAH, angiographically negative subarachnoid hemorrhage; SAH, subarachnoid hemorrhage.

Figure A3

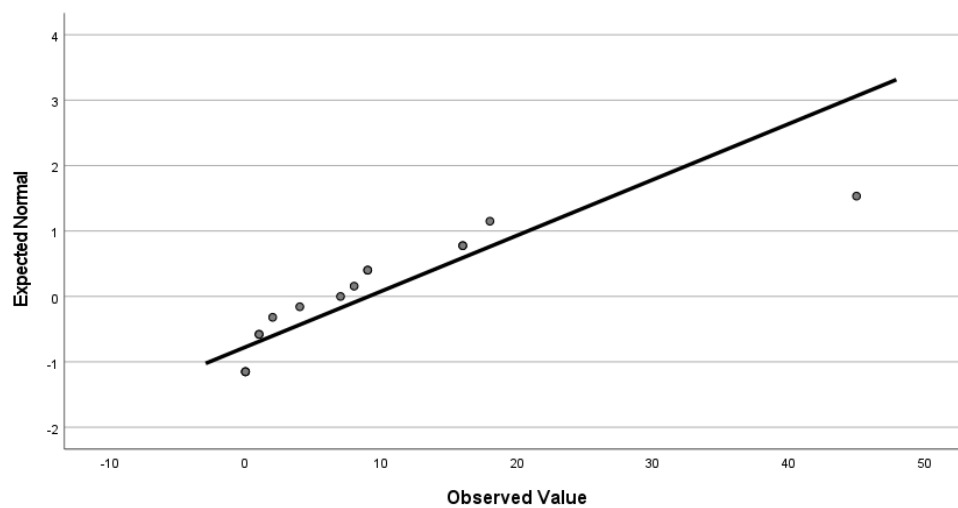
Normal Q-Q plot of IES scores at T2 for aSAH patients



Note. aSAH, aneurysmal subarachnoid hemorrhage; SAH, subarachnoid hemorrhage.

Figure A4

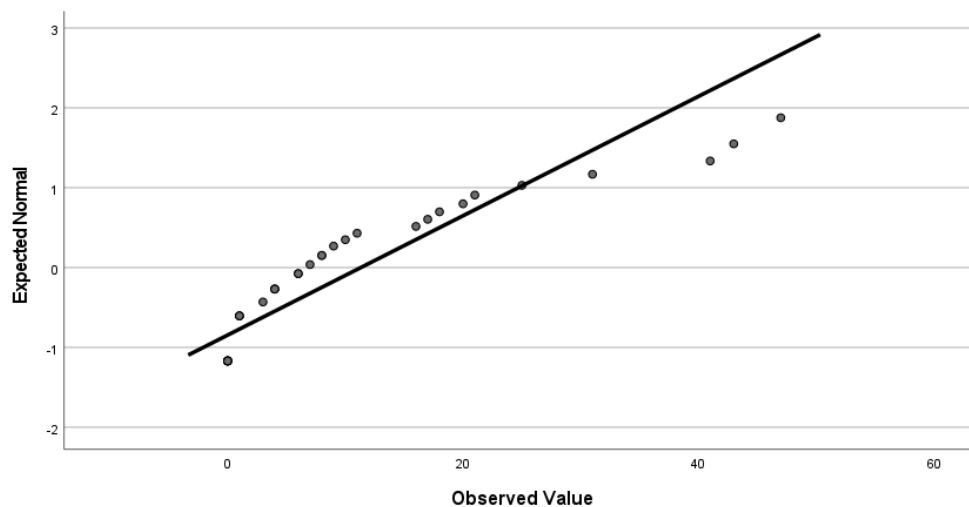
Normal Q-Q plot of IES scores at T2 for anSAH patients



Note. anSAH, angiographically negative subarachnoid hemorrhage; SAH, subarachnoid hemorrhage.

Figure A5

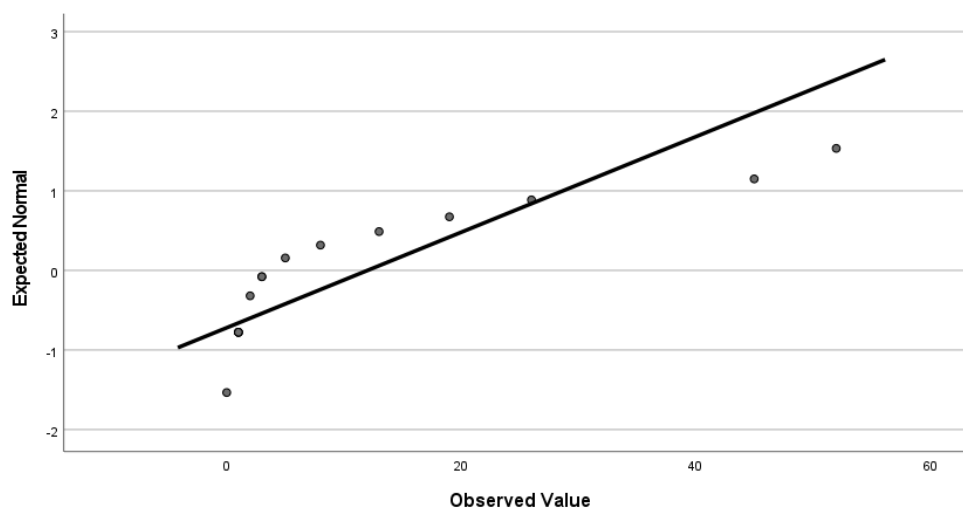
Normal Q-Q plot of IES scores at T3 for aSAH patients



Note. aSAH, aneurysmal subarachnoid hemorrhage; SAH, subarachnoid hemorrhage.

Figure A6

Normal Q-Q plot of IES scores at T3 for anSAH patients



Note. anSAH, angiographically negative subarachnoid hemorrhage; SAH, subarachnoid hemorrhage.

PTSD AND SUBARACHNOID HEMORRHAGE

Table A1*Tests of normality at T1, T2, and T3 for aSAH and anSAH patients*

		Kolmogorov-Smirnov			Shapiro-Wilk		
		Statistic	Df	Sig.	Statistic	Df	Sig.
aSAH	T1	.19	32	.01	.84	32	.00
	T2	.20	32	.00	.80	32	.00
	T3	.17	32	.02	.84	32	.00
anSAH	T1	.24	15	.03	.74	15	.00
	T2	.26	15	.01	.73	15	.00
	T3	.26	15	.01	.86	15	.03

Note. aSAH, aneurysmal subarachnoid hemorrhage; anSAH, angiographically negative subarachnoid hemorrhage; SAH, subarachnoid hemorrhage.